

Chapter 4: Academy Training

TEN MISSION PHASES	102
PREPARING FOR THE MISSION	102
Evaluating the Mission Objectives	102
Upgrading Your Ship	102
Choosing Your Weapon Loadout	103
RECEIVING THE LATEST MISSION DATA	104
MANEUVERING AND NAVIGATING	104
Buoyancy and Weight	104
Hydrodynamic Forces	107
Diving	108
Surfacing	108
Maneuver Hazards	109
MAINTAINING STEALTH	111
Sonar and the Ocean Environment	111
Use Thermal Layers to Your Advantage	114
Use Active Sensors	114
Avoid Cavitating	114
Limit Your Speed	115
Operate In Your Opponent's Baffles	115
Avoid Depth Stress.....	116
Raise Masts Only When Necessary	116
Use Discretion When Attacking	117
DETECTING CONTACTS.....	117
Periscope	118
Radar	119
ESM	121
Sonar	124
688(I) Sensor Comparison Table	132
CLASSIFYING CONTACTS	136
Classification Using Narrowband Sonar	136
Classification Using the Periscope	138
Classification Using ESM.....	140
Classification Using the DEMON	140
TARGETING CONTACTS	141
Targeting With Active Sensors.....	141
Targeting With Passive Sonar	142
688(I) WEAPON LAUNCHERS	152
688(I) WEAPON TYPES	154

LAUNCHING WEAPONS	157
Launching Missiles Horizontally.....	157
Vertical Launch of Missiles	157
ADCAP Torpedo Launch	157
Launching Harpoons.....	162
Launching Tomahawks	165
Launching Mines.....	168
EVASIVE MANEUVERS.....	171
Torpedo Evasion	171
SPECIAL FORCES OPERATIONS	173
Submerged Lock out Procedure.....	174
Submerged Lock in Procedure.....	174
Surfaced Launch Procedure	175
Surfaced Recovery Procedure.....	176
Launching Special Operations Forces	176
Recovering Special Operations Forces.....	177
SEARCH AND RESCUE OPERATIONS	177
Principles of the Operating Procedure	177
Surface Search and Rescue Procedure	177
DSRV Operations	178
CASUALTY PROCEDURES	178
Flooding Procedure	179
Emergency Deep	179
MISSION PROFILES	182
Anti-Submarine Warfare	182
Anti-Surface Ship Warfare	182
Strike Warfare.....	183
Mine Warfare.....	183
Naval Special Warfare	184
Surveillance	184

Only a thorough understanding of the principles of submarine warfare and the capabilities of your ship can prepare you to command the world's most sophisticated nuclear attack submarine.

Chapter 4 provides an in-depth review of the purpose and operation of every piece of equipment you will use to carry out your missions. In addition, it includes detailed principles and tactics of modern submarine warfare. Use this information to take full advantage of the 688(I).

Ten Mission Phases

Most missions involving warfare between ships can be broken down into ten distinct phases. While a mission may not unfold in exactly the sequence detailed below, it serves as a frame for the conduct of your missions. The ten phases are:

- Preparing for the mission
- Receiving the latest mission data
- Maneuvering and navigating
- Maintaining stealth
- Detecting contacts
- Classifying contacts
- Targeting contacts
- Preparing the attack
- Launching weapons
- Taking evasive maneuvers in the event of counter-attack

General considerations for each of the phases are described in the sections below.

Preparing For the Mission

Preparing for the mission includes evaluating the mission objectives, upgrading the ship when possible, and loading the appropriate ordnance to achieve the mission objectives. All preparations for the mission are made in the Port of Call—once you're underway, you can't make changes to your ship or your weapons load.

Evaluating the Mission Objectives

You can read a mission briefing at Mission Headquarters in the Port of Call. The mission briefing informs you of the general mission objectives.



Specific information on known threats and target locations are generally communicated via radio once you're underway.

Upgrading Your Ship

Each successful mission earns you points with which you can upgrade your ship and crew. The points reflect your squadron commodore's happiness with

your overall performance. The more objectives you meet in any given mission, the more “pull” you have back at base—hence, you get preferential treatment when it comes to outfitting your ship with updated equipment and trained personnel.



SHIP UPGRADES

Improved Sphere Array: Provides an estimated 25% increase in spherical array detection range.

Improved Hull Array: Provides an estimated 25% increase in hull array detection range.

Improved Towed Array: Provides an estimated 25% increase in towed array detection range.

Improved Propeller: Allows the ship to travel faster without cavitating, and increases maximum speed to 40 knots.

Improved ADCAP: Increased search cone of 120 degrees.

Own Ship Quieting: Engineering modifications and special absorption materials reduce the range at which other ships can detect you by as much as 25%.

Choosing Your Weapon Loadout

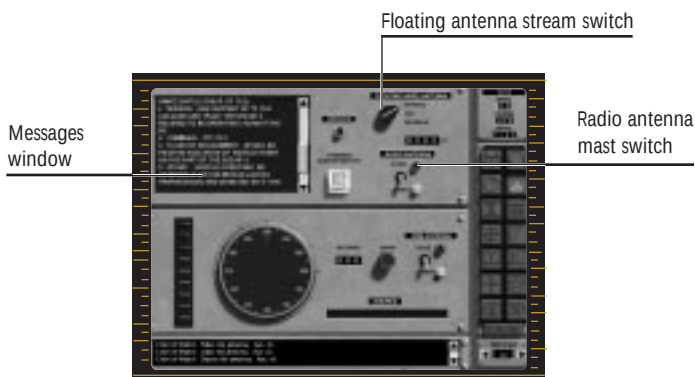
Weapon loadouts are suggested in the mission briefing. It's important that you understand the mission briefing and configure your weapons load according to the mission objectives before you leave port. Suggested weapon loadouts for various mission types are included under *Mission Profiles*, p. 182.



Receiving the Latest Mission Data

Once you begin the mission, you should always pause the game and go to the Radio/ESM station in order to review your mission orders. Your next step should be to unpause the game, go to periscope depth (60 ft), and raise the radio mast or stream the floating wire antenna.

Any additional orders and intelligence data will automatically be downloaded once the antenna clears the surface. You should periodically return to periscope depth throughout the mission to check for additional intelligence update radio messages.



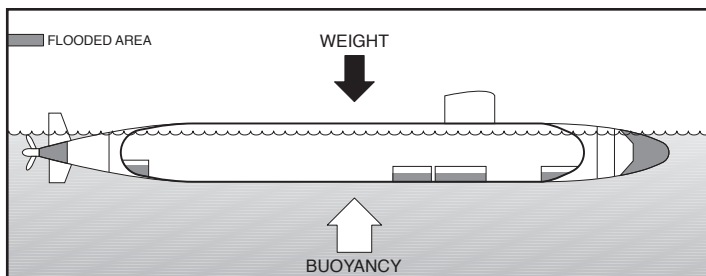
Maneuvering and Navigating

This section focuses on how the 688(I) maneuvers and navigates, and touches on aspects of theory specific to underwater maneuvering.

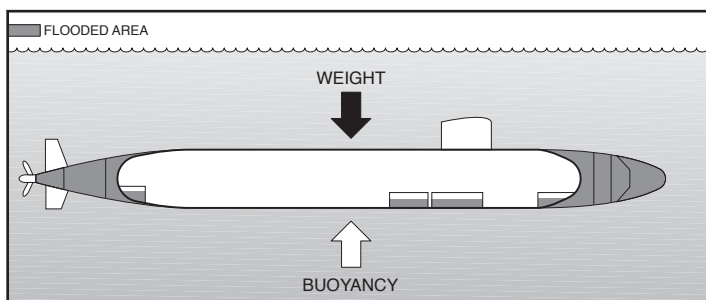
Buoyancy and Weight

Two forces act on objects in the water: *buoyancy* and *weight*. The two forces oppose each other: weight acts to submerge, or pull an object down, while buoyancy acts to lift an object toward the surface through the principle of water displacement. It is through the precise manipulation of weight and buoyancy that a submarine operates.

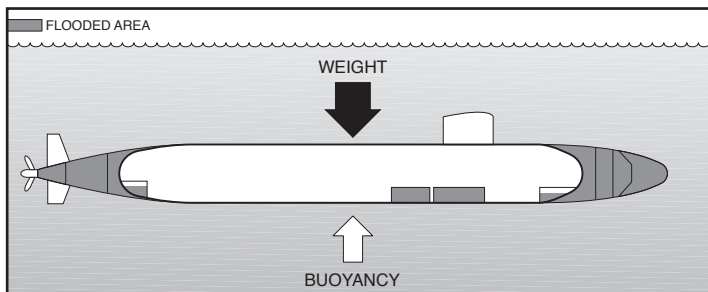
Think of a submarine as a large steel tube with several large and small water tanks inside. Consider the situation with empty tanks: the weight of the steel tube and tank walls pulls the ship toward the bottom of the sea. But, as the ship sinks, it displaces water, counteracting the force of the weight. The ship sinks until the weight of the water displaced equals the weight of ship. The 688(I) is large enough so that only 80% of the ship is under water when this equilibrium occurs. The ship sinks to this point, then remains partially above the surface unless more mass is added. This state, where $\text{weight} < \text{water displaced}$, is called *positive buoyancy*.



To submerge the ship, more weight must be added to decrease buoyancy. Since the overall physical dimensions of the ship remain the same, the amount of water displaced remains the same. The weight can be changed by adding water to the tanks. As water is added, the ship sinks. When the combined weight of the ship and water is equal to the water displaced, it's *neutrally buoyant*. The submarine remains fully submerged, but tends to not sink to the bottom or rise to the surface.



If even more weight is added, the weight exceeds the buoyant force, and the submarine sinks to the ocean floor. This state is called *negative buoyancy*.



Under normal conditions, submarines operate with neutral or slightly positive buoyancy in case a casualty occurs — in this way the ship can be forced to surface with a minimal use of power.

During this discussion, it has been assumed that the forces of weight and buoyancy are acting evenly on the submarine, but it is easy to imagine the results if this were not the case. If all the air tanks in the stern are full, but those in the bow are not, the ship will look like it is standing on its head. Keeping the submarine trim and the weight evenly distributed are very important to efficient navigation. In 688(I) *Hunter/Killer*, the crew automatically maintains a trim ship unless ordered otherwise.

PROPULSION

Two sources of power, diesel-electric and nuclear, have proven effective for submarine propulsion.

CONVENTIONAL SUBMARINES

Conventional submarines use diesel engines and electric batteries for power. On the surface, the sub can run on diesel power—a very noisy power plant, but one that is cheap and easy to maintain. Once submerged, the ship can operate silently on batteries for a number of hours, after which it must recharge its battery by running the diesel engines. This is accomplished by returning to the surface or by a snorkel tube that can be raised above the surface to draw in oxygen and expel exhaust.

Conventional submarines have the advantage of being virtually silent when operating on battery power. Unfortunately, the time they can spend submerged is very limited, and the hours they must spend on the surface make them even more vulnerable to attack. Despite these disadvantages, conventional submarines are inexpensive to both buy and operate, making them popular among the majority of the world's navies.

NUCLEAR SUBMARINES

Nuclear submarines use one or more nuclear reactors to heat water, which in turn drives a turbine connected to the propeller shaft. Reactor types vary according to the coolant used to transfer energy from the reactor to the turbine. The most common design uses pressurized water to control the power output of the reactor. These large systems allow the water coolant to circulate by natural convection, thus avoiding noisy water pumps. Less common are liquid metal-cooled reactors, which require pumps to drive their secondary water systems. While experiments such as the Soviet Alfa class SSN have proven that liquid metal-cooled systems are inherently louder, they have the advantage of being smaller and more powerful.

Nuclear submarines have many advantages over conventional subs. With no need to recharge batteries, nuclear subs can spend months at sea without surfacing. Their major drawback is strictly financial—nuclear submarines are very expensive to build and operate. So expensive, that only the most affluent countries can maintain nuclear fleets. They're larger and noisier than conventional submarines, but these negative characteristics tend to be out-

weighed by the unlimited range and tour lengths possible with nuclear power.

The 688(I) employs a single GE PWR S6G nuclear propulsion system with two turbines and one shaft. It generates 52000 hp (26 MW) and runs at a maximum 32 kts while submerged.

Hydrodynamic Forces

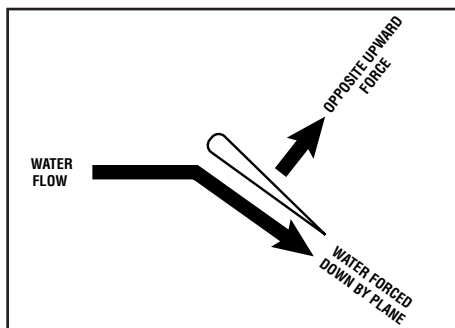
A submarine moves by exerting forces against the water. As water is pushed in one direction, an opposite force exerts drag on the ship, keeping it on course. The hydrodynamic forces are manipulated by the screw and through control surfaces, with which the submarine changes direction and depth.

Screw

The rotating screw, or propeller, moves the submarine through the water. It gives force to accelerate, decelerate, and counteract the resistance of moving through the water at a constant speed. The screw turns in either direction, depending on the desired objective.

Control Surfaces/Control Planes

A submarine uses control surfaces similar to those of an airplane to steer it up, down, right, or left. As the ship moves through the ocean, water exerts force on the planes. If the planes are parallel to the flow of water, they exert almost no force on the ship. When the planes are placed at an upward angle, they push the water downward, resulting in an opposite, upward force on the plane itself.

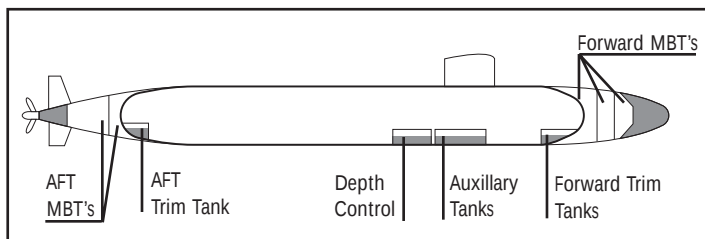


The upward force on the control plane may not result in pushing the entire ship upward. Picture the ship as being suspended by a string from its center. An upward force at the center of the ship causes the entire ship to be pushed upward. However, an upward force at the stern pushes the ship's stern up, causing the entire ship to point downward. Now the entire ship is acting as a plane surface, resulting in a greater downward push that drives the ship deeper. For this reason, the stern planes and the rudder, both located in the stern, point in the direction opposite the desired reaction when used to maneuver the ship. The 688(I)'s crew automatically adjusts the control planes and rudder when you command it to change depth or direction.

Diving

A submarine on the surface is slow, conspicuous, and susceptible to attack. Nuclear submarines operate on the surface only when in port, or on the rare occasion when a mission entails the transfer of individuals (such as a search and rescue mission). As soon as it leaves port, the 688(I) heads for deep water.

When operating on the surface, a submarine's weight is less than its buoyancy. To dive, large quantities of water must be brought into the ship until weight and overcomes buoyancy. The sub is built with two types of tanks designed to hold water: Main ballast tanks (MBTs) and trim tanks.



MBTs are large tanks designed to provide the course adjustment necessary to move a ship from a positively buoyant position to neutrally buoyant. While the submarine remains on the surface, they are filled with air; when the submarine dives, they must be filled completely with water. Vents open, allowing air to escape while water rushes in from open grates in the keel. The ship's weight increases, letting it sink into the ocean. Once submerged, the smaller trim tanks are used to fine-tune the buoyancy. Unlike MBTs, the *trim tanks* remain partially full. Seawater is constantly pumped to and from these tanks to compensate for other changes in the ship's weight. In addition to changing the buoyancy of the ship in order to dive, the screw and planes help force the sub under the water.

Note: For most operations, when you order the change in course or depth your crew responds automatically.

Surfacing

Instead of water replacing air to submerge the ship, air replaces water to restore it to a positively buoyant state. The screw and control planes also act to drive the sub to the surface. Two methods apply to surfacing: normal and emergency.

Normal Surfacing

When surfacing is a planned exercise, it progresses slowly and in a controlled manner. The submarine is driven to the surface and maintained there by the force of the planes. With the MBT vents closed, air is forced into the tanks slowly, usually by a low-pressure blower. As air is forced in, the water pushes out through open grates in the keel. This process returns the sub to its positively buoyant condition.

Emergency Surfacing

As a safety device, submarines may be equipped with the means to fill the MBTs rapidly with air. This lets the sub surface quickly in case of flooding. In such an emergency, the air to fill the MBTs comes from a bank of compressed air flasks. Since the air is stored at high pressure, it can overcome sea pressure to fill the tanks at any operating depth. The submarine then has a very large buoyancy force pushing it to the surface. It races upward, mostly uncontrolled, until it shoots out of the water and settles, one hopes, back to its surfaced condition.



Maneuver Hazards

The hazards you face while maneuvering the ship are few, but each can be catastrophic.

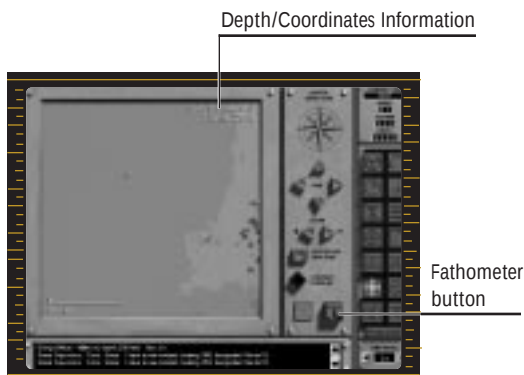
Extreme Depth

Your ship has been tested to a depth of 1900 feet. Crush depth is estimated to be around 2000 feet. Beyond this depth, the extreme pressure of the ocean will cause your hull to implode.

110

Running Aground

Always remain aware of the water depth in which you're operating. You can check current water depth at the Navigation Board. Move your mouse cursor over the map to display Depth/Coordinates Information in the top right corner of the Navigation Display.



Now you can view the depth of any spot on the map simply by pointing at it with the mouse cursor.

- You can also view the exact depth of the water below your ship's keel by clicking on the Fathometer button. The Fathometer screen appears:



Collision

Collision with other ships is a possibility when operating at or moving to periscope depth (60 ft). Because the fairwater, or sail, stands above the ship's hull, it's well within range of large surface ship keels, which are usually 30 to 40 feet below the surface but may reach a depth of 80 feet on super-tankers. Be sure to know the location of other ships before ascending to periscope depth.

Maintaining Stealth

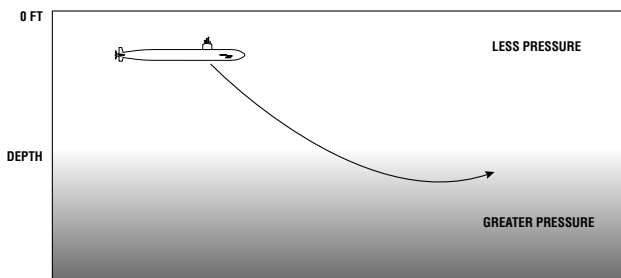
A submarine's greatest offensive and defensive asset is its ability to act undetected. This is no easy task in the face of the sophisticated sensory devices employed by modern navies.

Sonar and the Ocean Environment

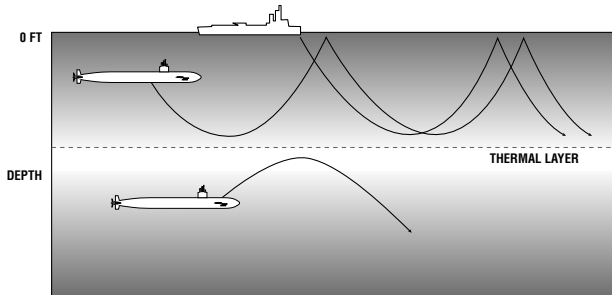
Sonar works on the principle that all objects in the ocean are subject to detection because they produce and reflect sound. Were the ocean a static environment, this would be a relatively trivial discussion of sound transmission and sensors. The ocean, however, is a dynamic environment whose unique properties greatly affect sound transmission.

Sound occurs when air or water touches a vibrating object and compresses and expands. Sound travels in waves of alternating high and low pressure. It moves out from the source in all directions, like ripples in a pond.

Sound in air tends to travel in a straight line until it fades away or is reflected. The same cannot be said for water. The density of water changes with temperature and depth. These factors tend to change with the depth of the water (i.e., the greater the depth, the colder the water and the greater the pressure). Sound waves bend according to the density of the water through which they move—they bend toward areas of decreased density and away from areas with increased density. It follows that as sound moves deeper, water density increases, and the sound bends upward.



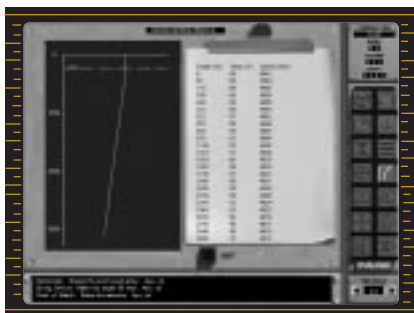
The effect temperature has on sound patterns is also great. Cold water is more dense than warm. In the ocean, changes in temperature are not gradual—instead, they tend to fall in distinct stages, with the result that the sea is made up of layers with sharply contrasting temperatures. Such stages are known collectively as *thermal layers*.



The effects of thermal layers on sound transmission have important consequences for sonar operators. Thermal layers act as “screens” or “curtains” against sonar, reflecting sound waves and creating what are essentially narrow sound channels. For a submarine avoiding detection, the reflecting and masking qualities of thermal layers provide a tactical advantage of the highest order. It's therefore critical that the submarine commander understand the typical sonar environments and their effects on detection and counter-detection. Sonar environments are best understood in relation to *sound speed profiles*.

Sound Speed Profiles (SSPs)

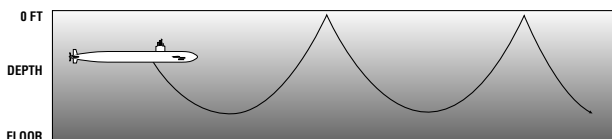
A graph of the speed of sound at various water temperatures and depth provides a convenient method of viewing the type of sonar environment in which the ship is operating. Such a graph is known as a sound speed profile or SSP.



There are three types of SSPs modeled in 688(I) Hunter/Killer: bottom limited, surface duct, and convergence zone.

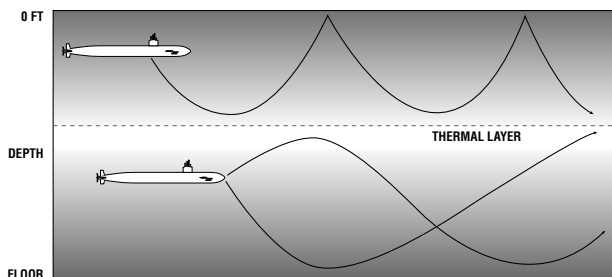
BOTTOM LIMITED

A bottom limited environment is too shallow or too constant in temperature to have multiple layers. Background noise is likely to be high in a shallow bottom limited SSP, as all noise from the surface will reflect on the shallow floor and propagate for some time. Detection ranges are relatively constant regardless of depth, except for some increased noise very near the surface.



SURFACE DUCT

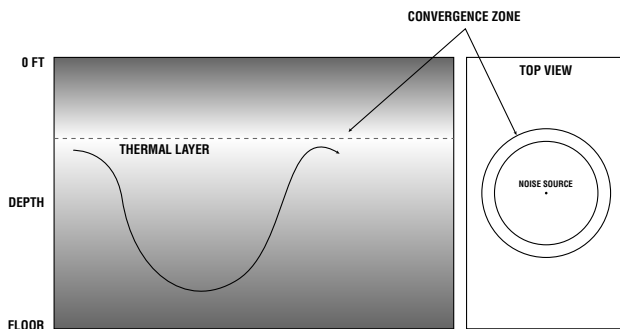
In a surface duct, the sound speed increases down to the thermal layer, then decreases to the bottom. Detection ranges are the same above and below the layer; across the layer, detection ranges are cut in half.

**CONVERGENCE ZONE**

In a convergence zone, the sound speed increases down to the layer and then decreases to the main *thermocline* (approximately 3000ft), below which temperature is constant. In the thermocline, sound speed increases again all the way to the bottom.

Like the surface duct environment, detection ranges in a convergence zone are basically the same above and below the layer, with sound transmission cut in half across the layers. However, the convergence zone has another interesting characteristic. Sound below the layer bends towards the thermocline instead of the bottom, resulting in a sine wave path that can travel significantly farther than under normal conditions.

The “convergence” occurs at the areas at the top of the sine wave, and the effects on detection can be dramatic. For example, in this type of environment it's possible to gain contact at 20nm, lose it for a while, then regain at less than 6nm!



Use Thermal Layers to Your Advantage

As shown above, thermal layers impede or enhance the transmission of sound within the ocean environment. Thermal layers can be used to great advantage depending on the type of enemy ship your facing. When operating against surface ships, it's best to operate below the thermal layer in order to cloak your movements as best as possible. On the other hand, if you're engaging a submarine traveling below the thermal, you may choose to operate above in the surface duct.

Keep in mind that thermal layers inhibit your sensors while simultaneously cloaking your movements. The tradeoff is clear, and no simple formula can be suggested that will fit every situation. Using thermals to your advantage depends entirely on whether you're attempting to remain undetected or optimizing your sonar range.

Use of Active Sensors

All military ships carry passive receivers that warn when another ship is using an active range-finding device. For instance, your own ship is equipped with passive ESM sensors for the detection of surface radar emissions, and a sonar "intercept" device that detects another ship's use of active sonar.

If you employ active radar or active sonar, be aware that you are communicating four things to other ships in your area, whether they are friendly, neutral, or hostile:

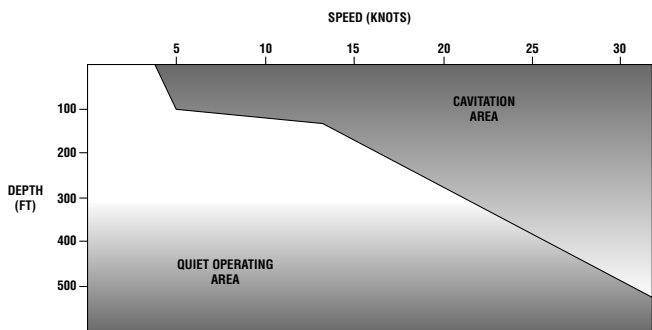
- Your presence. If you had been operating covertly up to this point, you no longer are.
- Your bearing. Any ships that picked up your active emission are immediately aware of your bearing to them. If they have weapons to spare, they may not hesitate to fire a snapshot at you.
- Your proximity. Other ships may not know the exact range to your submarine, but the relative strength of your active signal will give them a general idea of your proximity.
- Who you are. While all active sonar and active radar systems are similar, each uses unique frequencies. Other ships can quickly determine that you are a US attack submarine by analyzing the frequencies of your sonar or radar.

Avoid Cavitating

When a ship's propeller moves so fast that the water around it can't fill the cavity created by its motion, partial vacuums form around the blades. This phenomenon—known as *cavitation*—is particularly noisy. A high level of cavitation can advertise a submarine's presence as surely as surfacing.

Cavitation is a dynamic interaction between the submarine's *speed* and *depth*. Speed tends to increase cavitation, while depth tends to reduce it. The care-

ful submarine commander limits his speed according to the submarine's depth. The graph below shows the speeds you should not exceed at a given depth. The only exceptions are when evading enemy torpedoes (see p. 171 for more on evasive maneuvers).



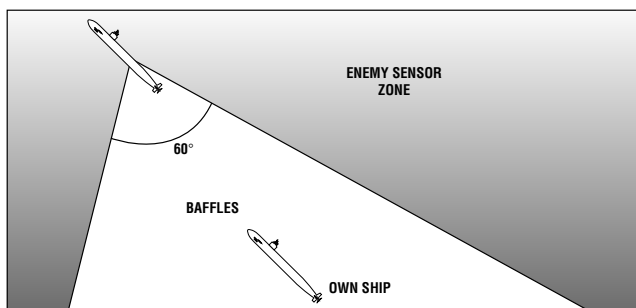
As you can see from the graph, at periscope depth it's best to maintain a speed no greater than five knots.

Limit Your Speed

In a combat environment, you may even choose to limit your speed to four knots *no matter what depth you're at*. Remember that even when you're not cavitating, you're still making noise — and obviously you make more noise going ten knots than going five. In short, never go any faster than required by the task at hand.

Operate In Your Opponent's Baffles

All bow-mounted sonar arrays are omni-directional with the exception of the stern area, which is masked by own ship sound and the wash of the propeller. This area is known as the ship's *baffles*.



Both surface ships and submarines overcome the inherently limiting effects of the baffled area in one of two ways:

They occasionally change course to "listen" behind them (known as *clearing the baffles*).

They drag a towed array behind the ship that provides detection in the stern quarters.

Ships do not always travel with the towed array deployed, so it can sometimes be highly advantageous to travel behind a target. While there's no way for you to know if an enemy ship has streamed its towed array, you should attempt to track ships from the stern quarters when safely possible.

Avoid Depth Stress

Beyond 950 feet, your ship's hull is subjected to the stress of extreme water pressure. This can result in creaking or groaning sounds that may be detected by other ships in the area. In general, avoid traveling below 900 feet in a combat situation, as this is a clear sign that a submarine is operating in the area.

Raise Masts Only When Necessary

Any of the submarine's masts — periscope, radio antenna, ESM mast, or radar — will create a wake when raised above the surface. Surface ships employing active radar in the area may detect the wake, or it may be spotted visually by ASW helicopters flying overhead.

Never leave a mast out of the water longer than is necessary to complete the task at hand. Also, stay alert to whether radar is being used in the area you're operating in. The ESM mast is designed specifically for the passive detection of radar emissions. It can tell you not only the bearing of the radar source but the type of ship employing it. The periscope, too, is fitted with a passive radar detection device. In both cases, the signal strength will give you an idea of the proximity to the radar source.

Signal level
indicator



ESM station



Periscope ESM
signal level
indicator

Use Discretion When Attacking

Naval weapons are not subtle. The launching of any weapon is an inherently noisy affair that greatly decreases your covert posture. Depending on both the type of weapon you launch and the type of enemy you face, you run the risk of revealing not only your presence but your position as well.

Submerged Weapons

The propeller on a torpedo rotates at a very high speed, alerting enemies to its presence almost as soon as it's free from the tube. Your weapon makes an immediate impression on other ships in the area. Not only are they now aware of you, they realize your intentions (decidedly hostile) and your bearing to them.

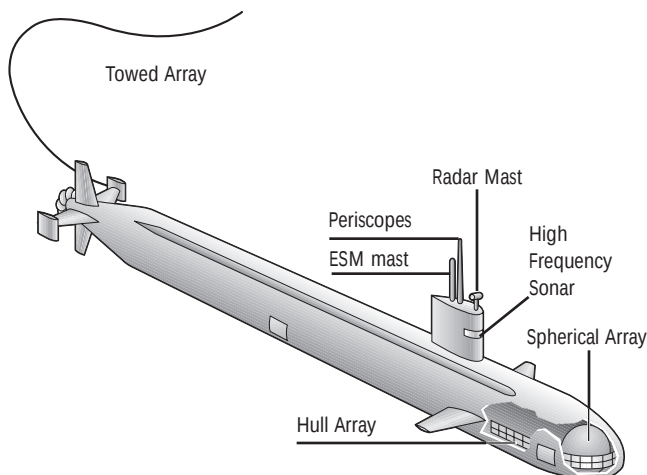
If possible, torpedo attacks should be made from positions that help reduce your chances of being detected—from across a thermal layer or within the target's baffles. Be prepared to change course, speed, and depth immediately after launching weapons.

Surface-Breaching Weapons

Missiles erupting from the surface (Harpoons and Tomahawks) are even more revealing than torpedo attacks. Your bearing and position may be immediately evident to any surface ships or helicopters operating in the area. Be prepared to change course, speed, and depth immediately after launching weapons.

Detecting Contacts

A submarine's sensors are essential for detecting, classifying, and targeting other ships, as well as for the more prosaic tasks of navigating and maneuvering. At all times, the goal is to form the clearest possible picture of the operating environment and tactical situation. To this end, the crew employs as many sensors as possible without compromising the ship's stealth.



Periscope

Once a fairly straightforward optical device, the modern periscope has developed into a highly sophisticated piece of equipment. Los Angeles class SSNs actually have two periscopes: a general-purpose search periscope (Type 18), and a short-range attack periscope (Type 2). In *688(I) Hunter/Killer*, both are modeled as a single periscope.

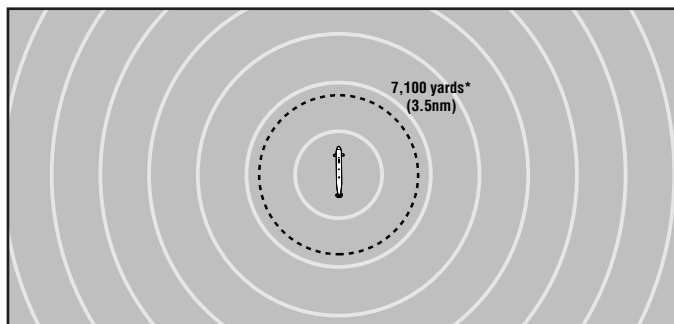
Targeting a contact visually provides a wealth of information. Bearing is known immediately upon contact. With use of the stadimeter, accurate target classification and range can be determined as well, and even target course can be estimated. Thus you can achieve a nearly instant target solution with the periscope alone.

Compared to the submarine's other sensors, the periscope has a relatively short range (approximately 3.5nm), which is its only real drawback. You can expect that the first contact you get on a surface ship will be with some other sensor, and that you'll use the periscope during the final stages of your attack.

You must be at a depth of 60 ft or higher to use the periscope, and your speed should not exceed 5 knots or you risk damaging the mast.

Specifications

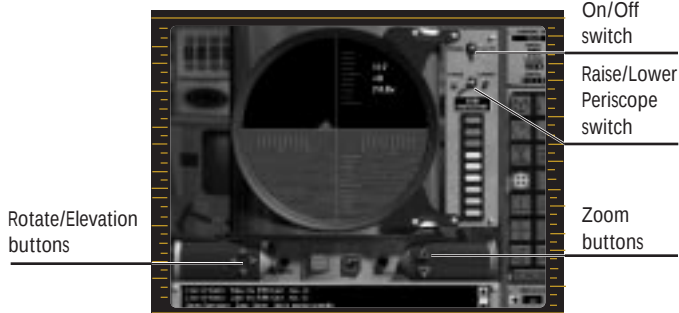
The Type 18 is an optical/electro-optical search periscope. It has an elevation range of -10° to $+60^{\circ}$ and offers x1.5, x6, x12, and x24 magnification. Fields of view are 32° (x1.5), 8° (x6), 4° (x12), and 2° (x24). The electro-optical sensor is a low-light TV camera providing RS 170 standard monochrome images. The Type 2 attack periscope is a bifocal instrument with an integrated stadimeter.



* Assumes periscope is 9ft. above water.

Detecting Contacts with the Periscope

- Select the Periscope station.



To detect contacts with the periscope:

1. Ensure that the ship is at periscope depth (60 feet) and your speed is under 10 kts.
2. Raise the periscope. Click on the Raise Periscope switch. Wait a moment as the periscope is raised.
3. When operating at night, toggle the Low Light Level TV (LLTV) switch on.
4. Rotate the periscope. Click on the Rotate Right or Rotate Left arrow buttons to rotate the periscope 360°. To increase the speed at which the periscope is rotated, hold down the Shift key while clicking the mouse button.
5. Zoom your view. Click on the Zoom In arrow button to increase magnification.
6. Mark targets to send visual sighting to the Target Motion Analysis station. Once you detect a target, click on the Mark button to send the contact's bearing to the TMA station.

Radar

The radar is an active electronic search system used to discover the presence and location of surface ships and aircraft in the area.

The main advantage of radar is that it provides accurate bearing and range data on any surface or air contact, which can be used to target and launch an attack. The radar doesn't provide classification information, so it should only be employed for attack *after* you've classified the contact by other means.

The main drawback of radar is that it's an active sensor — as such, it puts your ship at great risk of detection by hostile surface ships and aircraft. Keep in mind that heavy reliance on radar may be an invitation for counterattack.

You must be at a depth of 58 ft or higher to use radar. Since the radar mast is particularly delicate, your speed should not exceed 5 knots while the radar mast is raised.

Specifications

The AN/BPS-15 is a submarine radar designed for surface search, navigation, and limited air warning facilities. It operates in I-band using a horn array antenna.

Frequency: I-band

Peak power: 35 kW

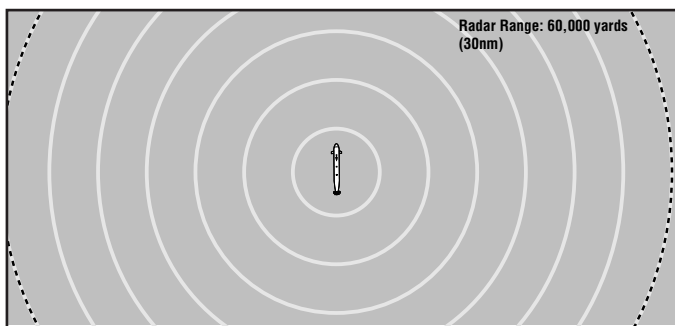
Pulse width: 0.1; 0.5 μ s

PRF: 1500; 750 pps

Scan rate: Up to 9.5 rpm

Antenna dimensions: 101 cm

Antenna weight: 76 kg



Using Radar for Detection

Select the Radar station.



To detect contacts with radar:

1. Ensure that the ship is at the correct depth (58 feet) and your speed is under 5 kts.
2. Click on the Raise Radar Antenna switch. Wait a moment as the mast is raised. The device begins emitting radar automatically.
3. Select a Range Scale. Longer Range Scales are appropriate for initial



search. Once a contact is detected, you can adjust the Range Scale in order to get higher resolution and accuracy.

4. Conduct a thorough search. A valid contact appears as a bright spot or “blip” on the radar screen. Land also appears brighter than the background — be careful not to confuse small islands for contacts.
 5. Place Bearing/Range Cursor on target. When a contact is seen on the display, position the bearing and range cursors by clicking and dragging Bearing/Range Cursor to the target. Both the range and bearing of the potential contact will be displayed. Mark target.
- To send contact information to the TMA station, ensure that the Bearing/Range Cursor is centered on the contact and click the Mark button.

Note: Radar information is sent to the TMA station only when the Mark button is pressed. The crew will not automatically send updated radar information to the TMA station. You must manually mark the contact to send updated information to TMA.

ESM

The ESM (Electronic Support Measures) system provides tactical radar detection and analysis.

The ESM contact's bearing and classification are known instantly. While this data doesn't allow you to target a contact, it can literally point you in the right direction when searching for a specific surface ship. Thus its usefulness in maneuvering into an attack position can't be overstated.

Compared to the submarine's other sensors, the ESM system has a relatively long range. When searching for surface ships, use the ESM mast as your initial means of direction-finding and classification.

Specifications

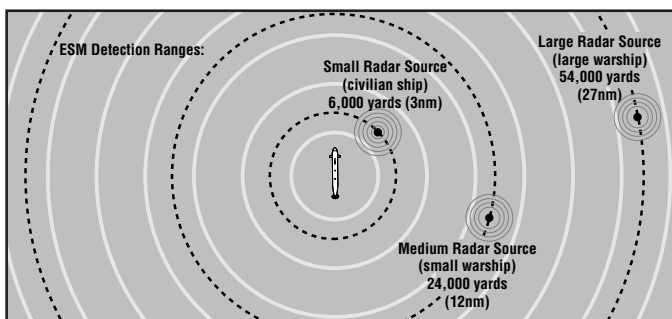
The AN/WLR-8 is a tactical electronic warfare and surveillance receiver designed for fitting in both surface ships and submarines of the US Navy. The system is of modular construction and provisions are made for operation in conjunction with numerous types of direction-finding or omni-antennas, and a wide range of optional peripheral equipment, to provide comprehensive ESM facilities.

Two digital computers are incorporated: a Sylvania PSP-300 for system control, automatic signal acquisition and analysis, and file processing; and a GTE PSP-200 microcomputer for hardware level control functions. Digital techniques are employed throughout the WLR-8 system, which is all solid-state.

Operational facilities include:

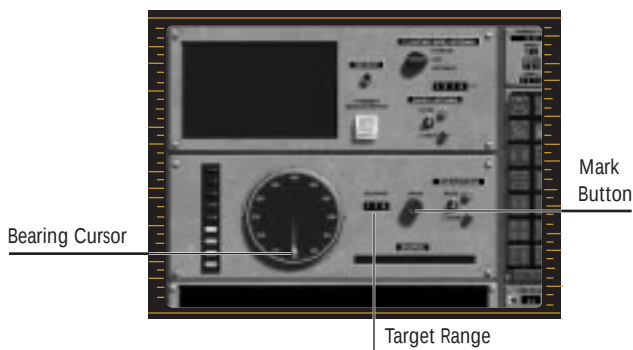
- Automatic measurement of signal bearing
- Signal classification and recognition
- Sequential or simultaneous scanning over a wide frequency
- Signal activity detection for threat warning
- Analysis of signal parameters such as frequency, modulation, pulse width, amplitude, and scan rate

Direct reporting to onboard computers permits response times in the millisecond range with minimal operator involvement.



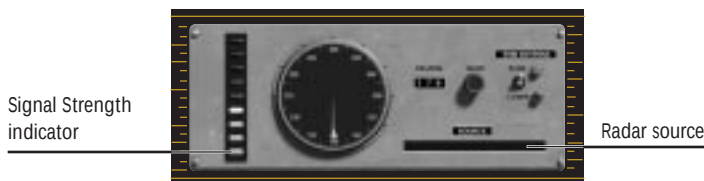
Using ESM for Detection

Select the Radio/ESM station.



To detect contacts with ESM:

1. Ensure that the ship is at periscope depth (60 feet) and your speed is under 5 kts.
2. Click on the Raise ESM Mast switch. Wait a moment as the mast is raised. The device begins detecting radar sources automatically.
3. Observe the ESM display. ESM contacts appear as bright wedges on the circular display. The brighter the contact, the stronger the signal. (Signal strength is also indicated by the Signal Strength indicator.)



- Notice that any contact fades in and out as the radar transmitter on the other ship rotates. (The ESM receiver picks up the transmission only when radar waves wash over the sensor.)
4. Classify the contact. You can quickly classify the ESM contact. Point the mouse cursor at the triangular Bearing Cursor on the display. Hold down the left mouse button and drag the cursor until it's on top of the contact. The contact classification appears in the Classification display.



5. Mark target. To send contact information to the TMA station, ensure that the Bearing Cursor is centered on the contact and click the Mark button. Note: The Bearing Cursor must be white when you press Mark in order for the bearing to be sent to the TMA.
- ESM information is sent to the TMA station *only* when the Mark button is pressed. The crew will not automatically send updated ESM bearing information to the TMA station. You must manually mark the contact each time you want a new bearing sent to TMA.

Sonar

Sonar (Sound Navigation Ranging) is the submarine's only means of detecting other submerged submarines, and below periscope depth it's the only means of detecting surface ships, too. For a hunter/killer, whose primary role is anti-submarine and anti-surface ship warfare, sonar is the most important sensor on board. Because sonar is inherently complex, its use requires a more extensive explanation than the surface sensors.

Sound Processors

Submarines use three devices to process sound signals underwater: *hydrophones*, *projectors*, and *transducers*. Hydrophones listen to sound, while projectors transmit sound. A transducer both listens and transmits.

Signals are detected over two different frequency ranges: *broadband* and *narrowband*. All contacts emit both broadband and narrowband signals.

Broadband contacts are those that put out significant acoustic energy over a wide range of frequencies. The sonar receiver can look at a wide range of frequencies and see all of the contacts that emit energy somewhere within that frequency range. Broadband is used to detect a contact, but it can also give a limited amount of information on contact range (via signal strength).

Narrowband contacts are those that emit acoustic energy at discrete frequencies, usually attributable to a specific piece of machinery (motor, engine, pump, etc.). By eliminating the noise that is received at all other frequencies and looking only for a specific frequency, a narrowband sonar receiver may be able to detect the discrete frequency at longer ranges than the same contact could be detected by a broadband receiver.

Narrowband signals give additional information about the contact. The specific frequencies emitted by a contact are akin to its fingerprint, readily and uniquely identifiable. These are commonly referred to as a *sonar signature*. See *Classifying Contacts* on p. 136 for more information.

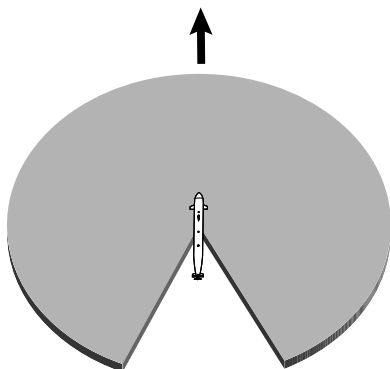
Sonar Arrays

An *array* is an interconnected group of hydrophones or transducers that focus either the transmission or reception of sound. The 688(I) is equipped with three arrays: a spherical array, hull array, and towed array. Together the arrays provide omni-directional sonar detection capabilities; however, no array in itself provides full 360° detection. This is because the ship itself masks a certain amount of the environment from the sensor.

SPHERICAL ARRAY

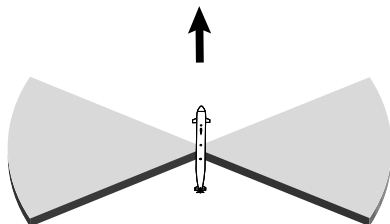
The spherical array in the bow is used at up to 25 knots and can track broadband as well as narrowband contacts. Passive detection ranges from 750 Hz to 2.0 kHz. In active mode, the array transmits and detects at a higher frequency range of 2.0 kHz to 10 kHz.

The spherical array processes broadband signals better than other arrays. Bearing accuracy is particularly good. At higher speeds, there is some degradation of performance because of flow noise caused by the water moving across the surface of the array. It is not as sensitive to low frequencies, so it's not the array of choice for narrowband contacts emitting only low frequencies.



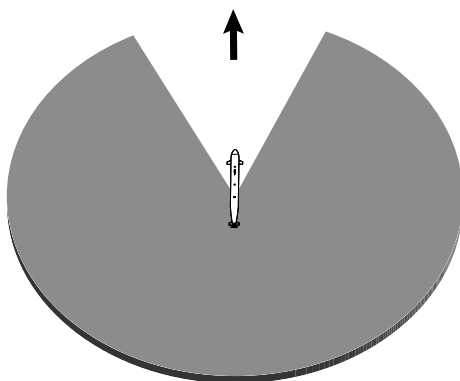
HULL ARRAY

The hull array, also at the bow of the ship, is a linear array that provides low speed capability to detect low frequency narrowband contacts (50 Hz -to- 1.0 kHz). As such, its primary use is for classifying targets.



TOWED ARRAY

The towed array—pulled behind the submarine on a long tow cable so it won't pick up the submarine's own machinery noise—is used for both broadband and narrowband tracking (10 Hz–1.0 kHz). It is used at low to medium speeds, and is optimized for lower frequencies, making it approximately 20% more effective in processing signals.



Specifications

The AN/BQQ-5 sonar, the US Navy's first active/passive digital sonar system, is the principal sensor system of the US Navy's 'Los Angeles' class nuclear attack submarines. The AN/BQQ-5 is a digital, multi-beam system employing hull-mounted, sphere-mounted and towed acoustic hydrophone arrays. The polyethylene-covered tow cable, which has a maximum length of about 800 m, is 9.5 mm in diameter, and the array at the end of the cable, where the hydrophones and electronics are located, is 82.5 mm in diameter. The array is tapered fore and aft to minimise flow noise. Drag is stated to account for a maximum reduction in speed of 0.5 kts, with no serious inhibition on submerged manoeuvres and little adverse effect on surface manoeuvres with the one exception of those entailing going about.

During the late 1970s the US Navy became concerned that the AN/BQQ-5 would not be able to handle the developing threats and embarked on a programme to update the capabilities of the system. An improved control display console has been developed and sonars that have been upgraded with the new consoles are known as the AN/BQQ-5B. A further modification to the system developed under this programme is the AN/BQQ-5C(V) Expanded Directional Frequency Analysis and Recording System (DIFAR), which replaces the original signal processor with the AN/UYP-1 standard signal processor. The AN/BQQ-5D uses a thin-line array and utilises some of the technology common to the AN/BSY-1 system. It became operational in 1988. A contract for the development of the AN/BQQ-5E was awarded in December 1988. A new thin-line array for passive ranging is to be integrated with the AN/BQQ-5E, the first of which will go to sea in late 1993.

The US Navy has been developing a thin-line tow array and handling system and other modifications for the AN/BQQ-5 system (see operational status). The thin-line towed array, known as the TB-23, forms part of the AN/BSY-1(V) combat suite. It is a lightweight system that can be reeled into the vessel's main ballast tank, instead of being housed on the side of the submarine, and will replace the TB-16 'thick-line' array currently employed in the AN/BQQ-5.

The AN/BQQ-5 provides improved detection, tracking and classification of low frequency data. The latest development also provides processing capability for the new TB-29 towed array and interfacing to the new fire-control system CCS Mk 2. The combining of the AN/BQQ-5E, TB-29, and CCS Mk 2 will result in a system referred to as QE2 that was scheduled for Technical Evaluation in 1993. The AN/WLR-9A acoustic intercept receiver, produced by Norden, has been successfully evaluated and forms an integral subsystem of the AN/BQQ-5 and AN/BQQ-6 on new attack and Trident missile submarines. The subsystem features a CRT display, a digital readout and a remote unit for the submarine commander. A 'sensitivity improvement' kit for the AN/WLR-9A has been developed by Norden and deliveries to the US Navy are in progress.

Passive Sonar

Passive sonar uses arrays of hydrophones to pick up sound waves. These arrays are located on various surfaces of the ship.

The hydrophone arrays transmit sound to the sonar station. Here you must sift through the noise for familiar patterns created by natural and man-made sources. The detection process involves picking up signals on the broadband or narrowband display using one or more arrays, and then designating contacts for tracking. Once a contact has been designated, the crew automatically tracks the contact (as long as it remains in sensor range) and periodically sends updated bearing information to the Target Motion Analysis station (see *Ship's Stations* on p. 62).

Passive sonar provides only bearing information on any contact. To classify or target a contact using passive sonar, further analysis is required at different stations. Classification takes place in Narrowband mode (see *Ship's Stations* on p. 62), while determining the target's range, speed, and course is done at the Target Motion Analysis station. (See *Targeting with Passive Sonar* on p. 142.)

TRACKING BROADBAND CONTACTS

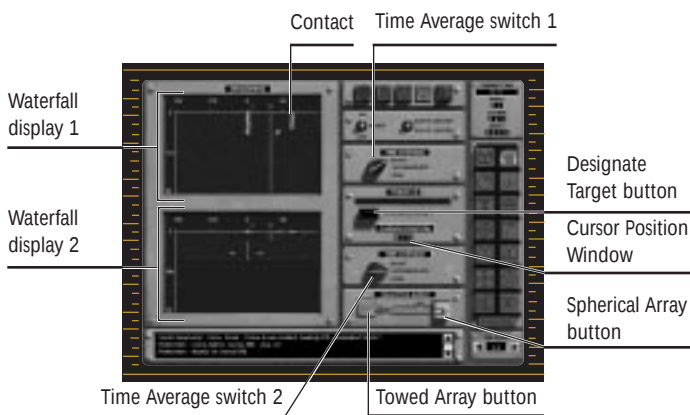
Select the Sonar station, and then click on the Broadband button.

Broadband button



128

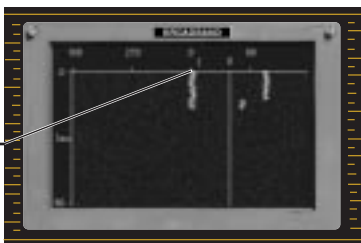
The Broadband Sonar screen appears.



To track a broadband contact:

1. Select an array. Click on the Spherical Array or Towed Array button.
2. Set a time average for each of the waterfall displays. Click on Short, Intermediate, or Long time averaging for each display. One of the displays should be set on Short to permit the detection of short duration, transient noises. The other display should be set on Intermediate or Long, either of which will help you make out weaker contacts in the area.
3. Observe the waterfall display. Increased noise on any bearing will result in a coherent trace that can be distinguished from the random background noise.
4. Select North Center or South Center, as desired. North Center places 000 degrees (north) in the center of the display; South Center places 180 degrees (south) at the center of the display.
5. Investigate traces on either waterfall display. When you notice a contact trace in the waterfall display, point at the top of the trace and click.

Click at top of display to place cursor on marker



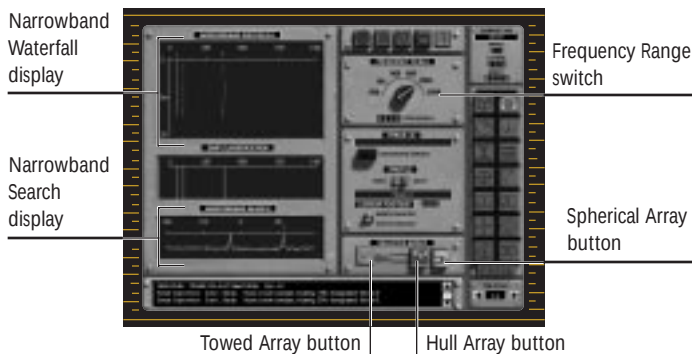
6. The true bearing of the cursor will be displayed in the Cursor Position window. Audio may be selected On to aid in deciding if the trace is a contact or biologics.
7. Designate target for sonar tracking.
 - To track a contact, ensure that the cursor is directly over the contact in the waterfall display. Click on the Designate Target button. Observe that a letter designation of a tracker appears above the contact trace. Observe that the next sequential contact number appears in the Track ID window.

TRACKING NARROWBAND CONTACTS

- Select the Sonar station, and then click on the Narrowband button.



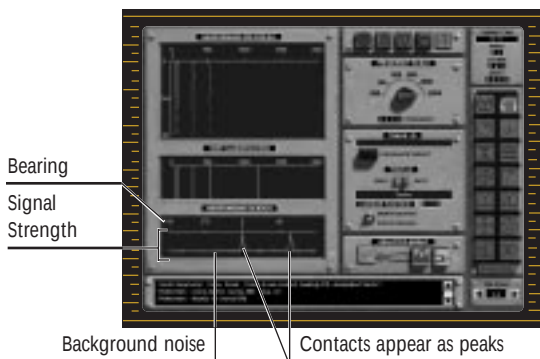
The Narrowband Sonar screen appears.



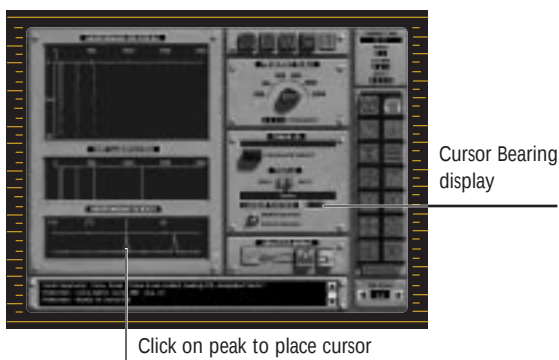
130

To track a narrowband contact:

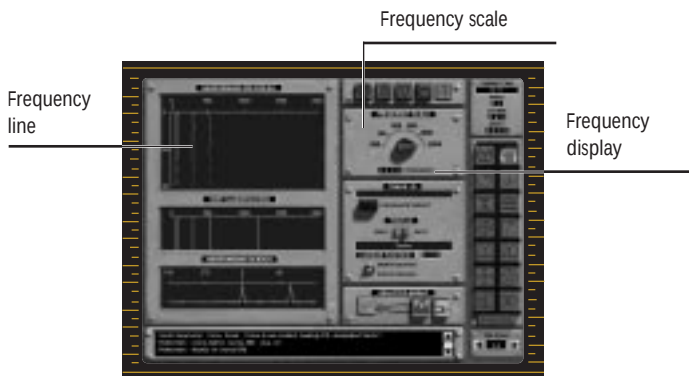
1. Select an array. Click on the Spherical Array, Hull Array, or Towed Array button.
2. Observe the Narrowband Search display. The Narrowband Search display shows 360 degrees of narrowband energy. Raised peaks indicate contacts. The height of the peaks above the horizontal axis indicates the strength of the signal.



3. Click to place the bearing cursor on the Narrowband Search peak. The bearing appears in the Cursor Bearing display.



4. Observe the Narrowband Waterfall display. This display shows the narrowband frequencies emanating from the contact.
5. Set the Frequency Scale. Set the Frequency Scale by clicking on the switch. It is recommended to begin with the highest range and then to select a lower range if better resolution is needed. The frequency of any displayed line may be measured by dragging the cursor to that line and reading the value in the Frequency display.



- Designate contact for sonar tracking. When a contact of interest is to be tracked, click on contact "peak" in the Narrowband Search display. Notice that frequency "traces" appear in the Narrowband Waterfall display. Choose a frequency to track (preferably a stable one) and place the frequency cursor over it. Click on the Designate Target button. The next sequential target number will be displayed in the Track ID display.

SONAR TRACKING LIMITATIONS

Each array—spherical, hull, and towed—may track only four contacts at a time. Once you've designated a target (using the Designate Target button), the crew automatically assigns a sonar tracker to the contact. Alphabet letters are used to refer to the trackers.

Spherical Array: A-D

Hull Array: E-H

Towed Array: I-L

Sonar tracker letters appear in the waterfall displays and in the DEMON.



688(I) Sensor Comparison Table

Sensor	Device	Type	Detects	Raw Target Data Provided	Maximum Speed Allowed	Maximum Depth Allowed
Periscope	Optical/ Electro-optical	Passive	Surface ships	Bearing, classification, range, (est.) course	10	60 ft.
ESM	Electro-magnetic	Passive	Surface ships	Bearing, classification	10	60 ft.
Radar	Electro-magnetic	Active	Surface ships, aircraft	Bearing, range	5 knots	58 ft.
Spherical Array (passive)	Acoustic	Passive	Surface ships, submarines	Bearing	25	Test Depth
Spherical Array (active)	Acoustic	Active	Surface ships, submarines	Bearing, range	25	Test Depth
Towed Array	Acoustic	Passive	Surface ships, submarines	Bearing	32	Test Depth
Hull Array	Acoustic	Passive	Surface ships, submarines	Bearing	32	Test Depth

If more than four contacts are present for any given array and you designate a new contact, the tracker will be removed from the oldest contact and moved to the new target.

In busy environments, you may have to “time-share” trackers between contacts. Any tracker that has been previously assigned can be dragged to a new contact, as long as the contact has already been designated. It's recommended that lower priority contacts be the candidates for this type of time-sharing.

Active Sonar

The spherical array in active mode can be used to detect surface ships and submarines in the area and estimate their range with a high degree of precision. By transmitting a pulse of energy and then “listening”, an active sonar is able to determine both the bearing and range to another ship or object. The range is determined by knowing the speed of sound in water and the time delay before the reflected pulse (or “echo”) is received.

The major drawback to using active sonar is that the active transmission gives away your bearing and alerts any ship in the area to your presence. Since active sonar is used effectively for targeting purposes, the ship will also realize that your intentions are probably hostile.

DETECTING CONTACTS WITH ACTIVE SONAR

- Select the Sonar station, and then click on the Active button.

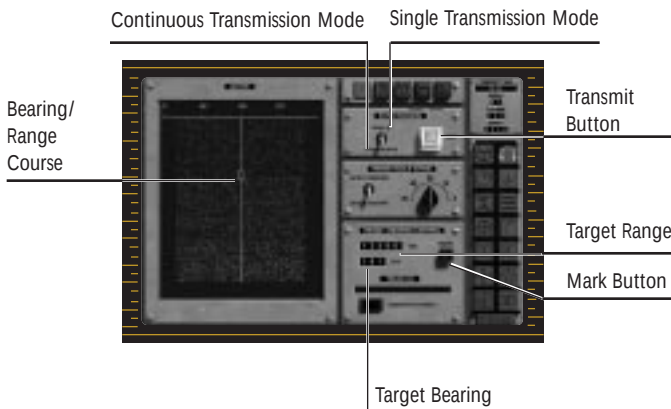


Active Sonar



134

The Active Sonar screen appears.



To track a contact with active sonar:

1. Select a Range Scale. Longer Range Scales are appropriate for initial search. Once a contact is detected, you can adjust the Range Scale of subsequent pings in order to get higher resolution and accuracy.
2. Select Single or Continuous. On Single, only one active sonar ping is transmitted. On Continuous, active sonar pings are transmitted periodically until the switch is reset to Single.
3. Select the XMIT button. Click once to lift the cover on the transmit switch (XMIT); click again to press the button.
4. Conduct a thorough search. For search purposes, multiple transmissions are required to provide confidence that there are or are not contacts present. A valid contact will give consistent visual returns that are brighter than background noise or reverberations. The audio return will have a distinctive metallic ring to it and will be distinguishable from reverberations.
5. Place Bearing/Range Cursor on target. When a potential active return is seen on the display, position the bearing and range cursors by clicking and dragging Bearing/Range Cursor to the target. Both the range and bearing of the potential contact will be displayed.
6. Mark target. To send contact information to the TMA station, ensure that the Range Cursor is centered on the most recent return from the contact and click the Mark button. Note: Active sonar information is sent to the TMA station *only* when the Mark button is pressed. The crew will not automatically send updated active sonar information to the TMA station, even when the system is set on Continuous. You must manually mark the contact to send updated information to TMA.

Factors Affecting Sonar Detection Ranges

When talking about the detection ranges for your sonar arrays, two factors must be addressed: the strength of the signal, and the amount of noise interference between your sensors and the contact. This is known as the Signal to Noise Ratio, or SNR.

SIGNAL STRENGTH

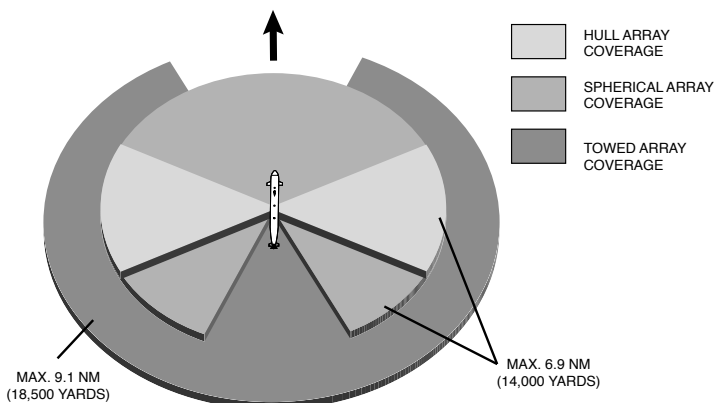
Signal strength is the amount of noise generated by the contact. Three factors contribute to signal strength: the *type of contact*, its *range*, and its *speed*. What's important to remember here is that a louder signal doesn't necessarily indicate a closer contact. A merchant ship may be louder at 20 miles than a quiet submarine at 5 miles; the same merchant ship would be significantly quieter traveling at a lower speed; and so on.

NOISE

Three factors contribute to the noise between you and the contact: *thermal layers*, *sea state*, and *own ship noise*. If the contact is on the opposite side of a thermal layer, it may appear as a very faint contact (for more information on thermals, see *Sonar & The Ocean Environment*, p. 111). The sea state, i.e., the amount of turbulence caused by weather, has an additional effect. The more violent the sea state, the more interference over the entire acoustic spectrum.

Finally, your own movement has an adverse effect on your sensors. As speed increase, array sensitivity decreases. If you go too fast, the arrays will no longer be able to pick out any sounds from the environment at all. The maximum speed varies by array: 20 kts for the spherical array, 5 kts for the hull array, and 25 kts for the towed array.

All that being said, the relative sensitivity of the various arrays can be communicated through example. The diagram below depicts a submarine listening to a merchant ship traveling at low speed in a low sea state environment. If the merchant ship were going faster, the sensor ranges displayed below would increase; however, if the submarine were below a thermal layer in a surface duct environment, detection would be cut in half.



Classifying Contacts

Once a contact has been detected, it's imperative that you figure out *what it is*. There are three reasons why classification is a necessary step:

Your main concern is to figure out if the contact is friendly, neutral, or hostile, since it's obviously important to attack only enemies and to avoid harming innocents or allies. If the contact turns out to be hostile, you also want to determine what *type* of ship you're facing. Knowing an enemy's capabilities, such as top speed, weapons, etc., can help you make the right decisions in combat.

Correctly classifying a target also provides critical information about the contact which you can use to determine the contact's speed using passive sonar.

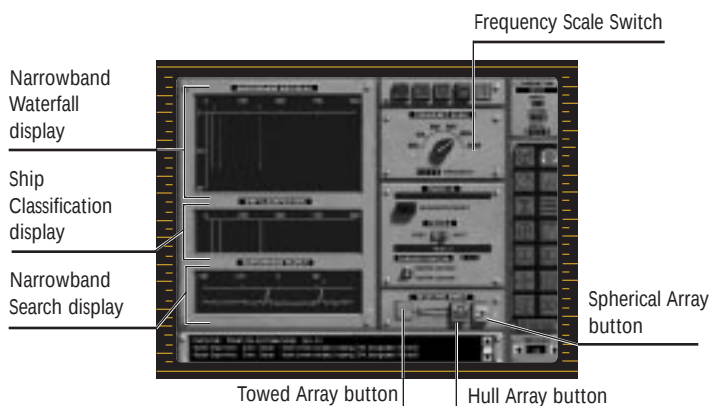
You can classify a target using narrowband sonar, the periscope, or ESM.

Classification Using Narrowband Sonar

Select the Sonar station, and then click on the Narrowband button.



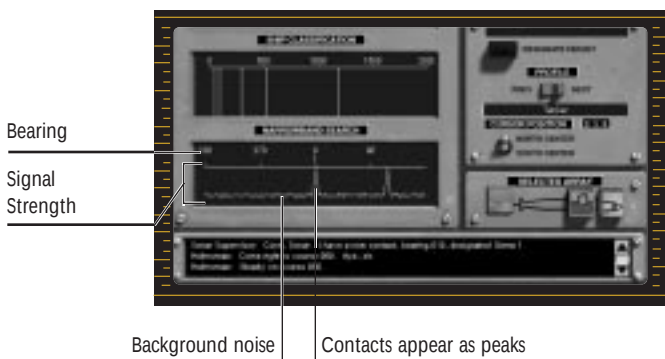
The Narrowband Sonar screen appears.



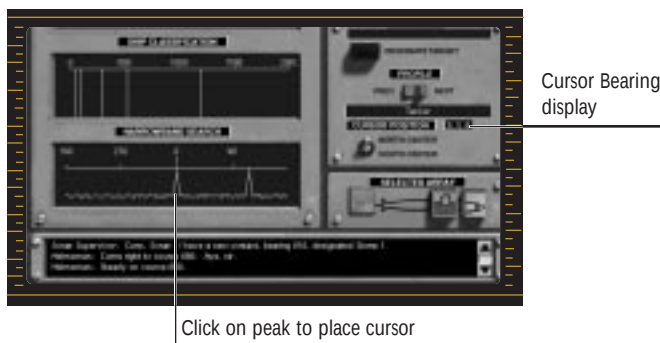
To classify a contact using narrowband:

1. Select an array. Click on the Spherical Array, Hull Array, or Towed Array button.

2. Observe the Narrowband Search display. The Narrowband Search display shows 360 of narrowband energy. Raised peaks indicate contacts. The height of the peaks above the horizontal axis indicates the strength of the signal.

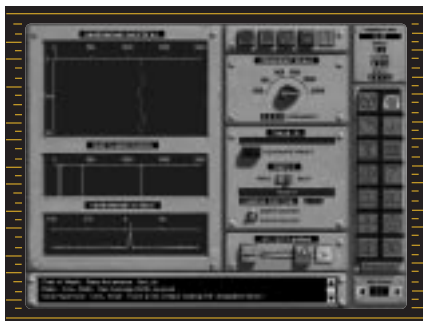


3. Click to place the bearing cursor on a Narrowband Search peak. The bearing appears in the Bearing Cursor display.



4. Observe the Narrowband Waterfall display. The display shows the narrowband frequencies emanating from the contact.
5. Set the Frequency Scale. Set the Frequency Scale by clicking on the switch. It is recommended to begin with the highest range and then to select a lower range if better resolution is needed. The frequency of any displayed line may be measured by dragging the cursor to that line and reading the value in the Frequency display.

6. Cycle through the ship profiles. Click on the Ship Profiles switch to view the narrowband signatures for all of the ships in the simulation. The signatures appear in the Ship Classification display. Hint: If you know the type of ship you're looking for, start with that profile.
7. Switch between arrays. Click on the Spherical Array, Hull Array, and Towed Array button. Since each array covers a different portion of the narrowband spectrum, you'll generally have to view them all in order to compare the contact with the profile in the Ship Classification window. By trying different arrays and frequencies, you should be able to obtain a match.



- If an array doesn't seem to be picking up the contact, make sure that the contact is still visible in the Narrowband Search display and that the Bearing Cursor is still over the contact. If the array still doesn't report any information, the contact may be in the array's blind spot (See *Sonar* on p. 124.) or out of the array's range.

Classification Using the Periscope

Select the Periscope station.

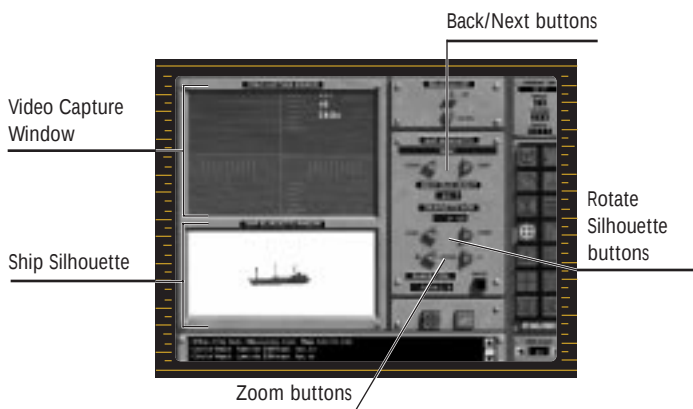


Stadimeter button

Photo button

To classify contacts with the periscope:

1. Ensure that the ship is at periscope depth (60 feet) and your speed is under 5 kts.
2. Raise the periscope. Click on the Raise Periscope switch. Wait a moment as the periscope is raised.
3. When operating at night, switch to Low Light Level TV. Click on the LLLTV switch.
4. Find the contact. Click on the Rotate arrow buttons to rotate the periscope to the target's bearing. Click on the Zoom In arrow button to increase magnification.
5. Photograph the contact. Once you detect a target, click on the Photo button to take a picture of it.
6. Switch to the stadimeter. Click on the Stadimeter button to switch to the Stadimeter screen.



The stadimeter allows you to classify ships by letting you compare the photograph you took with a library of ship silhouette images.

- Match silhouette to the photo. Click on the Back or Next button to cycle through the images in the ship silhouette library.
- Rotate and zoom silhouette. Click on the Rotate buttons to match the silhouette angle to that of the ship in the photo. If necessary, click on the Zoom buttons adjust the magnification of the silhouette.

140

Silhouette
matches
photo



Classification Using ESM

The ESM mast provides instant classification of any surface ship or aircraft in the vicinity currently employing radar. For instructions on ESM detection and classification, see *ESM*, p. 76

Classification Using DEMON

The sonar DEMON can't be used to classify targets with any certainty; however, the DEMON can be used initially to figure out what kind of contact you're looking at, i.e., whether it's a ship, a submarine, etc.

- Select the Sonar station, and then click on the DEMON button.

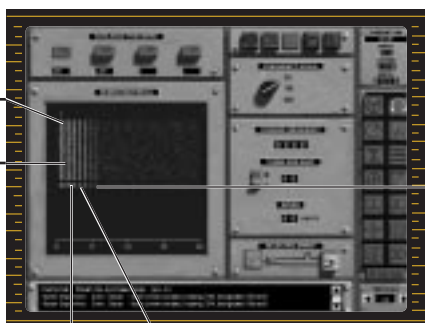
To classify a contact using DEMON:

1. Select a sonar array. Click on the Spherical Array or Towed Array button.
2. Select a sonar tracker. Click on one of the four tracker buttons at the top of the display to choose the contact you wish to analyze. The associated sonar number is displayed under the button. A series of vertical frequency lines appear on the display.

Shaft
rotation

Blade 1

Blade 4



Blade 2 Blade 3

- The shaft rotation speed is indicated by the first line on the left. The other lines indicate individual blades on the propeller.
3. If necessary, adjust the frequency scale. If the lines in the display seem to blur together, click on the Frequency Scale switch to lower the frequency range, if the lines run off the right edge of the display, increase the frequency range.
 - Use the blade count, contact audio, and general behavior patterns to determine the type of ship you're looking at.
 - Merchant Vessels/Tankers: Typically three or four blades; noisy; often maintains predictable course.
 - Warships: Typically five-bladed propellers; quieter, smoother sound than merchant ships; possibly unpredictable course changes.
 - Submarines: Five or seven-bladed propellers; very quiet when submerged and at low speed; unpredictable course changes.
 - Fishing Vessels/Trawlers/Pleasure Craft: Three- or four-bladed propellers; noisy; erratic courses and speeds, frequently stopping and starting.

Targeting Contacts

Target Motion Analysis (TMA) is the method of taking the information received from the ship's sensors and developing a solution for the target's *bearing, range, speed, and course* — that is, locating the contact's position and movement in space.

Targeting With Active Sensors

Active sonar and radar provide both bearing and range. This in itself is often enough data with which to launch weapons at the target, since range is a critical piece of information. However, the more information with which to guide the weapon, the greater your chances of successfully hitting the target.

If the target's bearing and range are known at two different times, a full solution can be readily found by connecting the dots and drawing a line for the course and speed. Obviously the solution would get better with more than two points since any errors in the data would be less harmful over a longer period.

To perform TMA on active sonar contacts:

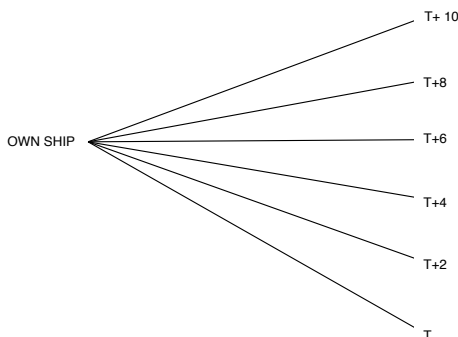
1. Select a contact. Click on the Selected Track pull-down menu. All designated contacts for which there is sensor information appear in the list. Select the contact you're interested in.
2. Center view of your submarine. Click on the Zoom and Pan arrow buttons to adjust the scale and centering of the display.
3. Note the location of bearing/ranges you've marked. Contact bearing/ranges are displayed by a line with a bubble at the end. The bubble indicates the range to the contact when you pressed the mark button.

4. Find the ruler. If you can't locate the ruler on the TMA display, click on the Center on Ruler button. You use the ruler to draw a line between the contact bearing ranges. This will automatically estimate the contact's course and speed.
5. Adjust the ruler to fit the bearing lines. Adjust the ruler on the display until the "tick marks" are aligned with the bearing/range lines. Click on the bubble in the middle of the ruler to move the entire ruler. Click on the ends of the ruler to move just the end or to adjust the length of the ruler.
6. Enter Target Solution. When a good match between the ruler and the bearing/range lines has been achieved, click on Enter Solution to enter the solution in the TMA system. The solution appears in the lower right hand data fields as the TMA Solution. *This is the target solution which would be used to direct weapons should they be launched.*

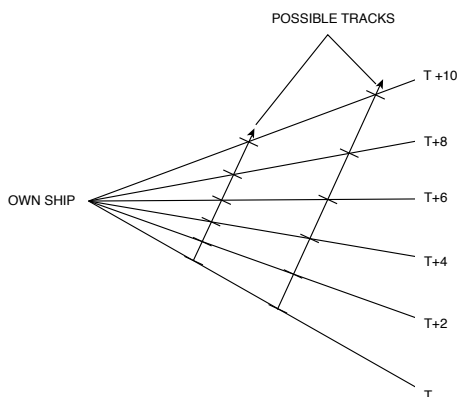
Targeting With Passive Sonar

A more complex situation arises when only the target's bearing is known, as is the case with passive sonar.

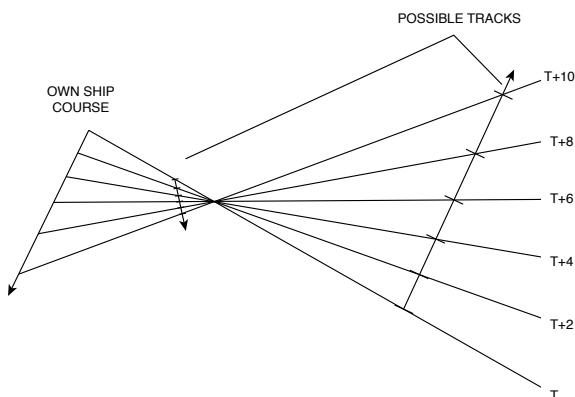
When you designate a contact using passive sonar, the sonar operator automatically tracks the contact and periodically sends a bearing update to the target. Think of the bearing as a line extending from the submarine toward the contact. As far as you know, the target can be anywhere along the bearing line extending from the submarine. A second bearing is taken a few minutes later. Now two bearing lines can be drawn—one for the first bearing, and the second taken a few minute later. After several minutes a bearing fan is created. It represents the lines of bearing for the target over a specific time period. First consider how this would look if your submarine weren't moving.



Since you don't have the precise range (i.e., distance of the contact from your ship) when using passive sonar, several solutions for the target might match this bearing fan. For example, the contact could be close to you but moving slowly, or distant and moving much more quickly.



Because your ship moves as well as the contact, a new factor is added to the bearing rate, though the principle remains the same.



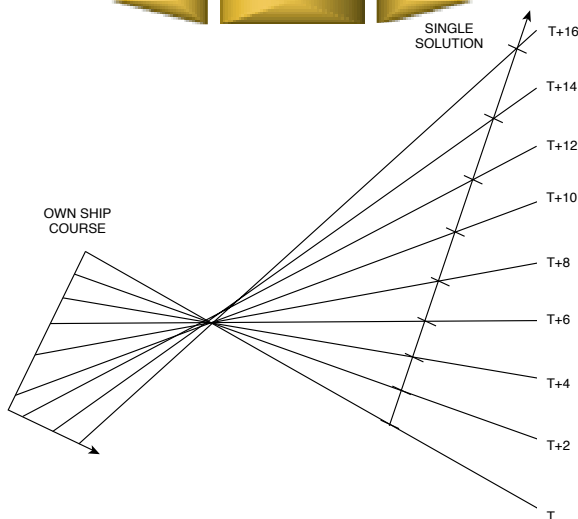
One way to refine the solution into a single possible track is to change own ship course and/or speed. By changing your contribution to the bearing rate, you mathematically reduce the number of solutions to the available data. The more you change your contribution to the bearing rate, the more dramatic the change in the data. Assuming the target maintains its course and speed, two or three own ship maneuvers, or legs, will result in a single possible solution.



180

FT

144



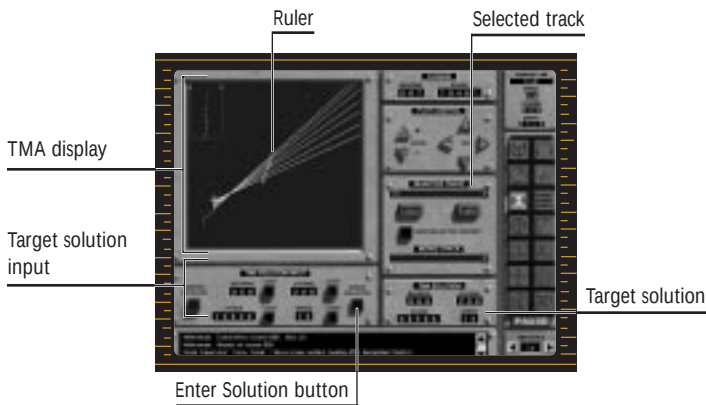
At all times you want to bring as much information to bear on the problem as possible. Educated guesses based on intelligence estimates can make the problem simpler. For example, if intelligence data provided in your mission briefing implies that the contact is traveling on certain course or at a particular speed, enter those values in your TMA solution. If the geography of the area constrains the ship to steer a certain course, use that information.

Of course, TMA would be easier if you had more information than *just* the change in the target's bearing. Knowing a second value, such as speed, eliminates a large number of possible target solutions. As you'll see in the TMA instructions, if you've classified the contact, you can estimate its current speed using a special sonar mode known as DEMON.

Performing TMA on Passive Sensor Contacts

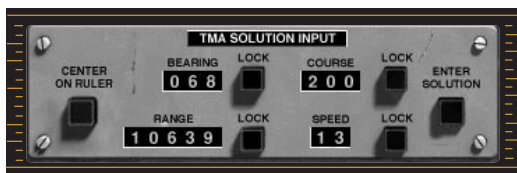
To perform TMA on passive sensor contacts, you need to have already designated a contact in broadband or narrowband.

- Select the TMA station.



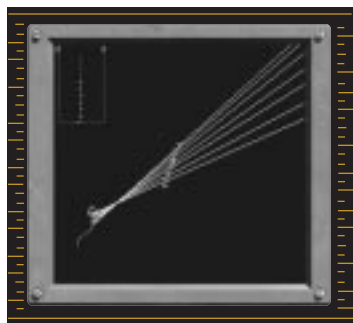
To perform TMA on passive sonar contacts:

1. Select a contact. Click on the Selected Track pull-down menu. All designated contacts for which there is sensor information appear in the list. Select the contact you're interested in.
2. Center view of your submarine. Click on the Zoom and Pan arrow buttons to adjust the scale and centering of the display.
3. Find the ruler. If you can't locate the ruler on the TMA display, click on the Center on Ruler button.
 - You use the ruler to estimate a target solution from the given data. The ruler represents your best estimate of the target's speed and course. The tick marks on the ruler correspond to each bearing line sent by sonar to the TMA station.
 - Where you place the ruler on the TMA display is your estimate of the target's range.
 - If this is the first time that TMA has been performed on the selected contact, the ruler will represent the default solution of Target Range 10,000 yards, with a closing course and speed matching own ship at time of designating the target. These values will appear in the TMA Solution Input data fields and activate its corresponding Lock button. This will lock in your entered data and allow you to manipulate the speed strip without overriding it.
 - If there was a previous TMA solution, the ruler will be positioned on the display accordingly and the appropriate values will be seen in the data fields and activate its corresponding Lock button. This lock in your entered data and allow you to manipulate the speed strip without overriding it.
4. Enter any known data in the Target Solution Input data fields. If you have additional data on the contact's range, course, or speed, click on the digits in the appropriate data field.



For instance, you may know the target's course from an intelligence message received while underway. Or you may have used DEMON to analyze the contact's shaft rotation in order to determine its speed (see *Determining Contact Speed Using DEMON* on p. 147).

5. Adjust the ruler to fit the bearing lines. Adjust the ruler on the display until the "tick marks" align well with the contact bearing lines. Click on the bubble in the middle of the ruler to move the entire ruler. Click on the ends of the ruler to move just the end or to adjust the length of the ruler.



6. Enter solution. When a good match between the ruler and the sensor bearings has been achieved, click on Enter Solution to enter the trial solution in the TMA system. The solution appears in the lower right hand data fields as the TMA Solution. This is the target solution which would be used to direct weapons should they be launched.
7. Refine your solution. Continue to adjust the ruler or enter new data in the TMA Solution Input area in order to achieve a better target solution; however, the system solution will not be changed until you click the Enter Solution button again. (Remember to always keep the TMA Solution updated with your best solution.) Note: if you leave the TMA window without entering your solution, your solution will be replaced by the system solution when you return to the TMA window.
8. Change course and/or speed. The TMA solution can be refined by changing your course and/or speed, which will change the relative motion between the submarine and the contact. After steadying on the new course and/or speed, adjust the ruler to achieve the best fit. This second "leg" should help to eliminate solutions that are unreasonable. A third "leg" or more will refine the solution further.
 - With experience, you'll learn when the solution is good enough to support a weapon launch. (Note: Depending on the tactical situation, continued TMA may not be prudent anyway.)
 - If one TMA solution does not fit all of the observed sensor bearing data, consider the fact that the contact itself may have changed course and/or speed. Attempt to achieve a better fit of the ruler by disregarding some of the earlier data and looking only at recent bearings.
9. Merge contacts when necessary.
 - If information from more than one sensor pertains to the same contact (e.g., a contact tracked by sonar and seen through the periscope), the data can be merged into a "master" contact. Select a

contact from the Merge Track pull-down menu, and then click on the Merge button. This decision can be undone by clicking on the Split button. Merging contacts held on the sphere and towed array can help give an estimation of range triangulation: the point where matching sphere and towed array bearings cross is a good approximation of the contact's range. This method is most accurate on close range contacts a beam of ownship, but is highly susceptible to bearing error off the bow or stern of ownship, or at great ranges.



Determining Contact Speed Using DEMON

The Sonar station in DEMON mode can be used to determine a contact's speed, so long as you've already classified the contact.

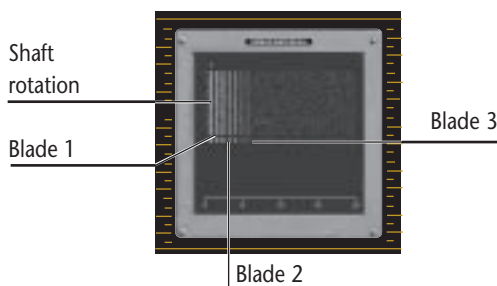
DEMON stands for *demodulated* noise, and is used to determine the speed of a known contact. DEMON passes the sound of the contact's propeller through a specialized set of acoustic filters. This is then fed into a spectrum analyzer, which determines the *rotation speed* of the propeller shaft. If you know what the contact is, you know how many times its propeller shaft must turn in order to produce one knot of speed. This is called *turns per knot*, or TPK. The two together—*rotation speed* and *turns per knot* - provide you with a fairly precise measurement of target speed.

■ Select the Sonar station, and then click on the DEMON button.

To analyze a contact using DEMON:

1. Select a sonar array. Click on the Spherical Array or Towed Array button.

2. **Select a sonar tracker.** Click on one of the four tracker buttons at the top of the display to choose the contact you wish to analyze. The associated sonar number is displayed under the button. A series of vertical frequency lines appear on the display.



The shaft rotation speed is indicated by the first line on the left. The other lines indicate individual blades on the propeller.

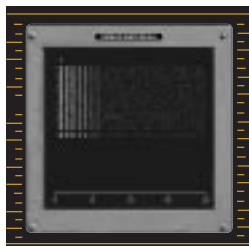
3. **If necessary, adjust the frequency scale.** If the lines in the display seem to blur together, click on the **Frequency Scale** switch to lower the frequency range, if the lines run off the right edge of the display, increase the frequency range.
4. **Set the Turns Per Knot for the known target.** Click on the **Turns Per Knot** switch to set the known TPK value for the contact. Turns Per Knot for military ships can be found in the ship descriptions in the On-line Information section. The estimated TPK for generic ships are as follows:

GENERIC CIVILIAN SHIP TPKs

Small craft:	30
Medium craft:	20
Medium shipping:	15
Large shipping:	10

In general, the larger the propeller, the lower the speed at which it is designed to turn. Warships and large merchant ships would have turns per knot ratios of seven to twelve. Smaller propellers on smaller ships and boats would turn at much higher shaft speeds for the same speed through the water.

5. Place the Frequency Cursor on the most prominent left-hand line on the display.



Point the mouse cursor at the right edge of the most prominent line on the left and click. This will be the shaft line. The frequency will be displayed in the Cursor Frequency display. (Shaft RPM can be calculated by multiplying this frequency by 60.)

6. Note estimated contact speed. Look at the Speed display and note the estimated speed of the contact.

AN/BSY-1 Submarine Combat System

The system is the first submarine combat system in the US Navy to integrate navigation, sonar and weapons system data for improved target detection, classification, localisation, combat control and weapons launch. BSY-1(V) integrates the medium to low frequency bow-mounted Submarine Active Detection System (SADS) sonar used for the detection and fire-control solutions on hostile subsurface to surface targets. This operates over 360° in long-range search, and provides a passive listening mode. The system also integrates the high frequency, active Mine and Ice Detection Avoidance System (MIDAS) mounted in the sail and which is used for close-range detection of mines and polar navigation.

The integrated combat system will carry out target motion analysis and calculate a fire-control solution for Mk 48 ADCAP torpedoes, Harpoon and Tomahawk cruise missiles.

The system is designed to improve data processing and management capabilities using new and more capable computers, new data displays and additional software and increased automation in areas such as surveillance, detection and tracking of targets. This will enable operators to perform multiple tasks and handle multiple targets simultaneously. The aim is to reduce the response time between initial detection and launching of the weapon.

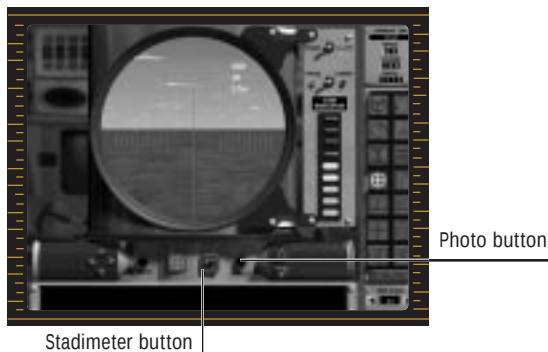
The distributed processing architecture system comprises 117 units, including 64 general-purpose and 35 specialised processors, digital beamformers, signal conditioners, displays and disk storage devices. Some 3.6 million lines of tactical software code are used in this system.

150

Determining Range and Course Using the Periscope Stadimeter

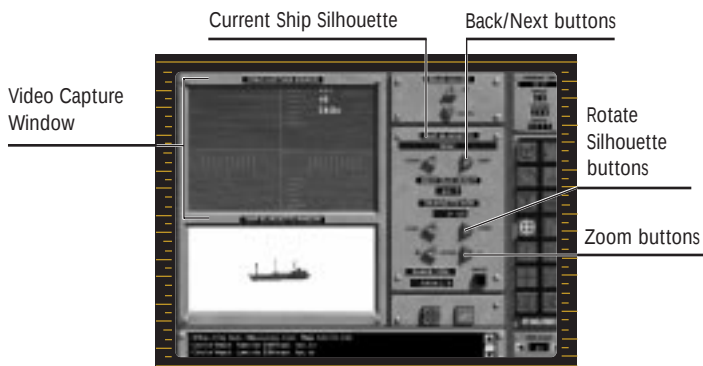
The periscope stadimeter can be used to estimate a surface ship's range. Likewise, a ship's course can be determined by observing the target aspect or angle on the bow (AOB).

Select the Periscope station.



To determine a contact's range and course with the periscope:

1. Ensure that the ship is at periscope depth (60 feet) and your speed is under 5 kts.
2. Raise the periscope. Click on the Raise Periscope switch. Wait a moment as the periscope is raised.
3. When operating at night, switch to Low Light Level TV. Click on the LLLTV switch.
4. Find the contact. Click on the Rotate arrow buttons to rotate the periscope to the target's bearing. Click on the Zoom In arrow button to increase magnification.
5. Photograph the contact. Once you detect a target, click on the Photo button to take a picture of it.
6. Switch to the stadimeter. Click on the Stadimeter button to switch to the Stadimeter screen.



7. Match silhouette to the photo. Click on the Back or Next button to cycle through the images in the ship silhouette library.
8. Rotate and zoom silhouette. Click on the Rotate buttons to match the silhouette angle to that of the ship in the photo. If necessary, click on the Zoom buttons adjust the magnification of the silhouette.



Silhouette matches photo

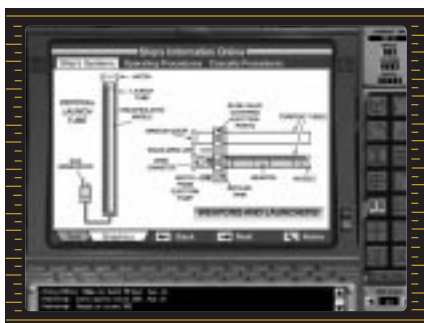
9. Adjust the image to find range. Click on the Image Adjust buttons to separate the two halves of the image. Adjust the image such that the top of the highest mast is even with the waterline on the other half of the image.



The estimated range to the ship is displayed in the Range display.

10. Mark the contact. To send contact information to the TMA station, click the Mark button. Note: Periscope information is sent to the TMA station *only* when the Mark button is pressed. The crew will not automatically send updated periscope information to the TMA station. You must manually mark the contact to send updated information to TMA.

Weapon Launchers



Torpedo Tubes

The main weapon launcher in a sub is the torpedo tube launching system. The tubes have a muzzle door between the tube and the sea, and a breech door between the tube and the submarine's interior. Weapons are loaded by shutting the muzzle door, opening the breech door, sliding the weapon into the tube, and shutting the breech door. Modern weapons have electronic connections from the weapon through the breech door to the fire control system. This allows transmission of target information to the weapon. When a torpedo is "fired", it is actually pushed out of the tube before it begins running.

The normal method of launching weapons is called the "impulse" method. Surrounding each pair of torpedo tubes is an impulse tank filled with water. Each torpedo tube has openings in it near the inner end that will allow water to enter behind the weapon to push it out. A slide valve normally covers the openings, but when a tube is made ready to fire, the muzzle door and slide valve open together. High pressure air operates a turbine ejection pump that forces a large quantity of water at high pressure into the impulse tank. The only place that water can go is into the torpedo tube ejection ports. This water flow into the tube flushes the weapon out even though the ship may be moving through the water at high speed.

The muzzle door (and the shutter that fits in the curvature of the hull when the muzzle door is shut) and the slide valve are operated hydraulically. Weapons are moved within the Torpedo Room and loaded into the tubes hydraulically. The torpedo tube breech door is manually operated.



There are four horizontal torpedo tubes, two on each side of the ship. Because of the large sonar sphere at the bow, the torpedo tubes are angled outward slightly.

Vertical Launch Tubes

Vertical launchers for TLAMs (Tomahawk Land Attack Missile) work differently. They are loaded at the pier and cannot be reloaded once the boat is underway. (Hence, the importance of a thorough briefing, with weapon requirements. If you are out at sea and haven't loaded enough TLAMs, there's nothing you can do.) The vertical launch tube is pressurized with air, using a diaphragm at its top as a boundary to the sea. The muzzle door is then opened. When fired, a solid propellant gas generator produces the gas that forces the missile from the tube. Once clear, the missile ignites, beginning its flight toward its target.

Eight Los Angeles class submarines and 23 Improved Los Angeles class submarines have twelve vertical launch tubes installed at the bow. This was made possible by a redesign of the forward main ballast tank structure and the air banks located there.

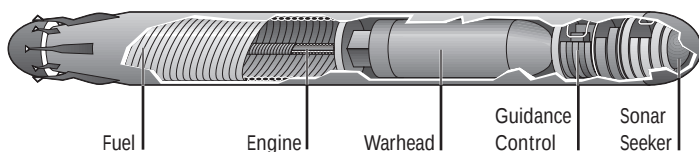
Signal Ejector

Similar in principal to the torpedo tubes, the signal ejector is actually a two-barreled installation. Located on the port side of the middle level of the Forward Compartment, there are two three-inch diameter tubes that are used to launch a variety of pyrotechnic signals, countermeasures, and decoys.

Weapon Types

Submarines are equipped with a variety of weapons, each designed for specific objectives.

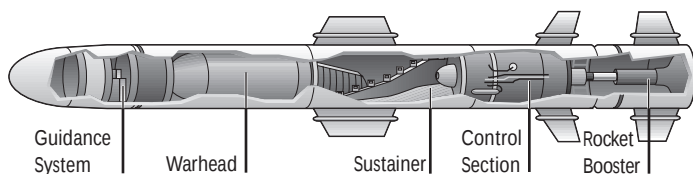
Mk 48 ADCAP Torpedoes



The classic submarine weapon since WWII, torpedoes are fired from reloadable tubes in the sub. They travel under their own power for distances up to 20 miles. Torpedoes may use sonar, either active or passive, to locate the target. Some can even be steered by receiving commands over a wire connected to the submarine. Also remember that when setting the speed of the torpedoes, one affects the range of the weapon.

ADCAP, which stands for “advanced capability” is a major upgrade of the Mk 48 heavyweight torpedo. ADCAP is a wire-guided, acoustic homing torpedo that is propelled by the combustion of a monopropellant fuel (self-oxidizing fuel). ADCAP is 21 inches in diameter, carries a warhead in excess of 500 pounds of high explosive, can reach speeds of 55 knots, has a range in excess of 20 nautical miles (nm), and can dive to depths of nearly 3,000 feet. Major improvements were made in acoustic and search/homing logic.

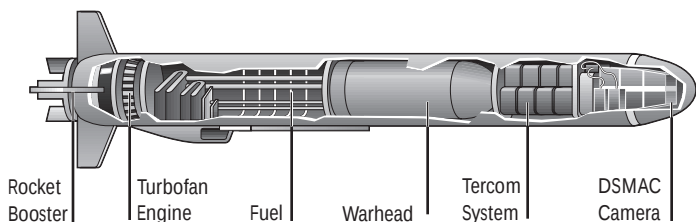
UGM-84 Harpoon Anti-Ship Missile



The encapsulated Harpoon missile can be launched from a submarine torpedo tube. When the capsule broaches the surface of the water, a solid rocket booster ignites to begin flight. When the booster separates, the missile descends to a low altitude and is powered by a turbojet cruise engine. Terminal guidance is provided by an active radar homing system. A highly maneuverable missile with extensive on-board computer logic circuitry, Harpoon has considerable ability to discriminate between targets and countermeasures.

Harpoon has a range of over 50 nm and flies at sub-sonic speed. It carries a 500 pound high explosive, blast type warhead. Several block improvements have been made to the weapon. Block 1C has increased range, waypoints, and selectable terminal trajectories.

UGM-109 Tomahawk Cruise Missile



Cruise missiles can be launched by submarines from either the torpedo tubes or from vertical launch tubes specifically designed for this purpose. They can be used against either surface ships or land targets. An attack with a cruise missile from a submerged ship is particularly devastating and surprising.

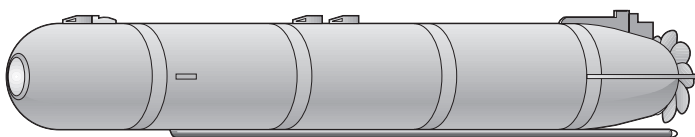
Tomahawk missiles were produced in anti-ship (TASM) and land attack (TLAM) variants. The TASM uses inertial guidance and either active radar or anti-radiation terminal homing. It flies at Mach 0.7 to deliver a 1,000 pound conventional warhead at ranges out to approximately 250 nm. The TLAM-C delivers a 1,000-pound single warhead and the TLAM-D delivers sub-munitions. TLAM-C and TLAM-D have ranges of approximately 485 nm.

If launched from the horizontal torpedo tubes, the Tomahawk missiles must be encapsulated. The launch process is similar to that of the Harpoon; how-

ever, the solid propellant booster ignites after the missile has cleared the torpedo tube. Regardless of whether it is launched from a horizontal or vertical tube, the Tomahawk begins powered flight even before leaving the water. Once the booster has been burned up and separates, the missile continues powered flight on its turbofan engine.

TLAM uses inertial guidance and predetermined waypoints to fly to its target. Once over land, it is able to use terrain contour matching (TERCOM) to confirm and update its flight path. TASM variants fly at a low cruise altitude to avoid detection and switch on the active radar homing at a predetermined distance.

Mk 67 Submarine Launched Mobile Mine (SLMM)



Since their early days, submarines have been used to place mines in harbors. This remains a useful application of a submarine's stealth capabilities. Today, however, mines can be fired from a sub, just as torpedoes are. Like torpedoes, mines can "swim" to a location that may be in an area too shallow for the sub to operate submerged.

The SLMM is self-propelled, so it provides the capability of covertly mining from a submarine and placing the mines in water that would be too shallow for submerged operations. The SLMM is essentially a modified Mk 37 electric torpedo. The torpedo warhead was replaced with mine components and the torpedo propulsion and guidance are used to place the mine.

Countermeasures



Countermeasures are defensive weapons. Use them to prevent an enemy's torpedo from destroying the sub. The most common countermeasures are



launched from the submarine and remain in the location where they are launched. A Jammer raises the noise level between the torpedo and your submarine, creating a fog bank that inhibits a torpedo's active sonar ability. A Decoy emits a signal designed to draw the enemy torpedo away from the sub and toward the decoy. Both types of countermeasure can be preset to stay deep or shallow.

Launching Weapons

One of your primary objectives is to seek out and destroy enemy ships, weapons, and strongholds.

Preparations can be lengthy and noisy, so it is a good idea to have tubes loaded, flooded, and equalized and have muzzle doors open before coming within the detection range of the enemy. It takes several people to load a torpedo and connect both the A-cable (which gives the torpedo its presets and orders before launch) and the guidance wire (which can be used after the launch). The torpedo should also be checked to ensure that it properly receives commands.

A torpedo can be impulse launched up to the maximum speed of the submarine as long as the ship is on a steady course and the trim angle is no more than a few degrees above or below the horizontal ("zero bubble").

Launching Missiles Horizontally

Advanced preparations are advised but not for the same reasons. When launching a missile, the enemy is probably farther away so noise is not as much of a consideration. Being ready to launch is important so that coordinated strikes can be initiated when the operational situation dictates.

Harpoon and Tomahawk missiles should be launched at low speeds (e.g., 4 knots or less) and at shallow depths (e.g., keel depth of 150 feet or less). If at periscope depth, it is possible to confirm that the missile is flying normally.

Vertical Launch of Missiles

The vertical launchers have to be loaded in port, so the preparation consists only of pressurizing the tubes and opening the hatches. Targeting information also has to be sent to the missile prior to launch. Speed and depth limits are the same as for the horizontal launch of missiles.

ADCAP Torpedo Launch

The ADCAP torpedo, the U.S. Navy's heavy-weight torpedo, can be used against submarines and surface ships. It is a wire-guided, acoustically homing torpedo carrying a warhead of more than 500 lbs. of high explosive and capable of speeds up to 55 knots. It has a maximum range in excess of 20 nautical miles.

The ADCAP is launched from a horizontal torpedo tube. Prior to launch, the torpedo is loaded into the tube, and the A-cable and guidance wire are con-

nected. (The A-cable is the means of providing the weapon with presets and inputs from the TMA system prior to time of launch.) After electrical checks are satisfactorily completed, the tube is flooded, and the pressure is equalized with sea pressure before the muzzle door is opened.

Note: Because some of this process is noisy, it is best to do it early if the ship is in a situation which could require the launching of torpedoes.

The TMA solution for the target (bearing, course, speed, and range) must be refined to the point that the weapon will be placed close enough so that the target is within the acquisition range of the torpedo. Following launch, the torpedo steers an intercept course until it is close enough to detect the target and begin homing.

The Weapons Control Coordinator (usually the Weapons Officer) oversees the preparation of the torpedo and advises the Approach Officer (usually the Commanding Officer) concerning the capabilities of the torpedo and its placement. The Fire Control Coordinator (usually the Executive Officer) oversees the refinement of the firing solution until, in his opinion, it is good enough to place the weapon within acquisition range. The Approach Officer has the final approval of the firing solution and the settings that are sent to the torpedo prior to launch.

Torpedo Firing Procedure

PREPARING THE WEAPON FOR LAUNCH



1. Clicking on the Select Target arrow provides a list of contacts for which there are solutions in the TMA system. Select a target from this list. The system solution for the selected target will be displayed in the TARGET DISPLAY area, including a depth estimate based on the TMA solution.
2. Select a firing tube by clicking on the number of a torpedo tube in which an ADCAP is loaded. A tube can be unassigned by clicking again on the tube number.

3. Select weapon presets by clicking on "P" (PRESETS) and then making choices from the options list presented.

For a submarine target, DEPTH should be at the best estimate of the target depth or at least on the same side of the layer. For a surface ship target, set DEPTH to be just below the keel depth of the ship.

CEILING can be used to provide protection to the operator's submarine or other friendly forces.

FLOOR can be used to provide protection for the operator's submarine or other friendly submarines or to keep the weapon from running into the bottom in shallow water.

ACOUSTICS is used to select the mode of acoustic homing.

RUN TO ENABLE sets the distance the torpedo travels before it begins to search. (The torpedo search can alert the enemy. Run to Enable should not be short unless the target range is short or there is doubt about the accuracy of the TMA solution. Allow approximately 3000 yards for the torpedo to search if possible.)

SPEED selects the torpedo speed until it begins to home on the target. Once homing it will speed up to maximum speed. Default values of the presets are: Depth 200 feet; Ceiling 0 feet; Floor 3000 feet; Acoustics Active; Run to Enable 1000 yards; and Speed High.

LAUNCHING THE WEAPON



1. Order the selected torpedo tube flooded and equalized with sea pressure by clicking on the F and E buttons. These actions are complete when the lights stop flashing.
2. Order the muzzle door opened by clicking on the M button. The muzzle door will not open until the tube is properly flooded and equalized.
3. Steps 1 and 2 may be done at any time to make tubes ready before being close enough to the enemy to make noise a concern.
4. Observe the I indication is bright which means that all conditions for launch are met and the firing interlocks are closed. If the firing interlocks are not closed, check that the tube is properly prepared, that the target

has been properly assigned, and that there is no inconsistency between the torpedo presets and the TMA solution.

5. Ensure the ship meets the operational conditions for launch: near horizontal, steady on course, and the proper speed and depth for the specific ordnance.
6. The torpedo is launched from the tube by clicking twice on the covered FIRE button (once to open the cover and once to depress the button). Observe the indicators all return to the non-ready state and the torpedo tube contents indicator goes dark.

POST-LAUNCH CONTROL OF THE WEAPON



1. Select W (WIRE GUIDE) to display the controls that send commands to the torpedo after launch.
2. Observe the torpedo symbol on the display marked by the number of the tube from which it was launched. The torpedo should be proceeding toward the target on an intercept course (torpedo is leading the target).
3. Once the torpedo has enabled, it begins to search and the acquisition cone symbol is seen on the display. Steering will only be necessary if it appears that the acquisition cone will not sweep over the target's position at any time.
4. If wire commands are necessary, select the number of the tube fired before sending commands. This is necessary to ensure that the correct torpedo gets the commands in the event that more than one torpedo was fired.

RELOADING TUBES

1. Once the tube has been fired, it should be reloaded for future use. Press the Weapon Load Out button to see the available weapons on the racks. Press OK when done.

Note: Reloading tubes will cut the wire if the weapon is wire-guided.

2. Click on the Content Label until the desired weapon appears. The loaded weapon can be changed any time by the same method.

Snapshot (Quick Reaction Firing) Procedure**PREPARING THE WEAPON FOR LAUNCH**

1. Clicking on the Select Target arrow will provide a list of contacts for which there are solutions in the TMA system. Select Snapshot from this list.
2. Select a firing tube by clicking on the number of a torpedo tube in which an ADCAP is loaded. A tube can be unassigned by clicking again on the tube number.
3. Select weapon presets by clicking P (PRESETS). Type in the bearing of the threat in SNAPSHOT Bearing. The remaining presets will be set to the default values. Make changes as required by the existing situation (e.g., depth of water).

LAUNCHING THE WEAPON

1. Order the selected torpedo tube flooded and equalized with sea pressure by clicking on the F and E buttons. These actions are complete when the lights stop flashing.
2. Order the muzzle door opened by clicking on M. The muzzle door will not open until the tube is properly flooded and equalized.
3. Steps 1 and 2 may be done at any time to make tubes ready before being close enough to the enemy to make noise a concern.
4. Observe the I indication is bright: this means all conditions for launch are met and the firing interlocks are closed. If the firing interlocks are not closed, check that the tube is properly prepared, that the target has been properly assigned, and that there is no inconsistency between the torpedo presets and the TMA solution.
5. Ensure the ship meets the operational conditions for launch: near horizontal, steady on course, and the proper speed and depth for the specific ordnance.
- 6 The torpedo is launched from the tube by clicking twice on the covered Fire button (once to open the cover and once to depress the button). Observe the indicators all return to the non-ready state and the torpedo tube contents indicator goes dark.

Launching Harpoons

The HARPOON missile is an anti-ship cruise missile that can be launched from the horizontal torpedo tubes of a submarine. It is an active radar homing missile with a range of over 50 nautical miles and a sub-sonic cruise speed. It carries a warhead of 500 lbs. of high explosive. Prior to launch, the encapsulated missile is loaded into the torpedo tube and the A-cable is connected to provide fire control system inputs to the missile. Electrical checks are completed and the tube is flooded and equalized with sea pressure. The outer muzzle door is opened to make the launch tube fully ready. This process should be completed well before the anticipated time of launch.

The TMA solution for the missile need only be accurate enough to allow the submarine to place the missile such that the seeker search pattern will include the position of the target. It is also necessary to know where other surface contacts are so that the area searched by the missile will not unintentionally include neutral or friendly ships.

While the Fire Control Coordinator is refining the solutions for all contacts, the Weapons Control Coordinator adjusts the seeker search pattern and the missile course so that only the primary target will be swept by the seeker of the missile. The Approach Officer must be satisfied that the contact solutions are known with a high degree of certainty and that the prelaunch orders being sent to the HARPOON will result in the highest probability that the missile will acquire the target and only the target.

Harpoon Firing Procedure

PREPARING THE WEAPON FOR LAUNCH



1. Click on the Select Target arrow to get a list of contacts for which there are solutions in the TMA system. Select a target from this list. The system solution for the selected target will be displayed in the TARGET DISPLAY area.
2. Select a firing tube by clicking on the number of a torpedo tube in which a Harpoon is loaded. A tube can be unassigned by clicking again on the number.
3. Select weapon presets by clicking P (PRESETS) and making choices from the options list presented.

DESTRUCT RANGE is the range at which the missile will self-destruct if it has not encountered a target. This can be used to protect friendly and neutral forces. SEEKER RANGE is the range at which the missile will begin to home. It can be used to protect friendly or neutral forces that are at shorter range than the target. SEEKER PATTERN determines whether the area searched will be wide or narrow. This can prevent the missile from acquiring an unintentional target that is nearby. The default values of the HARPOON presets are: Destruct Range 50 nm; Seeker Turn On 0 nm; Seeker Pattern: Wide.

LAUNCHING THE WEAPON

1. Order the selected torpedo tube flooded and equalized with sea pressure by clicking on the F and E buttons. These actions are complete when the lights stop flashing.
2. Order the muzzle door opened by clicking on the M button. The muzzle door will not open until the tube is properly flooded and equalized.
3. Steps 1 and 2 may be done at any time to make tubes ready before being close enough to the enemy to make noise a concern.
4. Observe the I indication is bright which means that all conditions for launch are met and the firing interlocks are closed. If the firing interlocks

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2. Click on the content label until the desired weapon appears. The loaded weapon can be changed any time by the same method.

Launching Tomahawks

The TOMAHAWK missile is primarily a land-attack cruise missile that can be launched from either the horizontal torpedo tubes of the submarine or the vertical launch tubes. It is an inertially guided missile that uses terrain contour matching (TERCOM) for position updates when over land. It has a range of approximately 485 nautical miles and a cruise speed of Mach 0.7. It carries either a single 1000 lb. high explosive warhead or sub-munitions. The vertical launch tubes must be loaded before leaving port. The actions necessary to launch a TOMAHAWK from a vertical tube include pressurizing the tube, opening the muzzle hatch, and sending flight guidance information to the missile.

Prior to launch from a torpedo tube, the encapsulated missile must be loaded and the A-cable connected to provide fire control system inputs needed for flight guidance. Electrical checks are completed, and the torpedo tube is flooded and equalized with sea pressure. The muzzle hatch can then be opened to make the tube fully ready to fire. The flight guidance information sent to the missile includes waypoint data and target data. Waypoints are used to guide the missile around defensive positions or to adjust the time of flight so that missiles fired at different times can arrive at the target at the same time.

Preparations for the launch of a TOMAHAWK are begun well before the desired launch time. The submarine must be correctly positioned, and, during the transit to the launch point, the Combat Systems Officer (CSO) (usually just called "Weps") oversees the planning for each missile (or sortie). He reviews the target data and ensures that it is assigned to the correct missile. He also reviews the flight path of each missile, looking for threats to the missile along the way and checking the time-on-target (TOT). Prior to launching any missiles, the CSO will brief the Commanding Officer (CO) and Executive Officer (XO) on the complete mission as a final check on the planning and the compliance with the tasking that the ship received.

Tomahawk Firing Procedure (Vertical Launch)

PREPARING THE WEAPON FOR LAUNCH



1. Select a firing tube by clicking P (PRESETS) beneath the tube number on the Target Display Panel. The target is selected by assigning waypoints. Click on Define Target Waypoints and then click in the area of the desired target in the TARGET DISPLAY area using the targeting crosshairs. Four waypoint icons should appear on the map.
2. Using the tasking message, precisely position the forth and third waypoints over the coordinates for the target and landfall waypoint respectively. This can be done by clicking and dragging the waypoint icons on the TARGET DISPLAY area or by changing the waypoint position boxes in the Weapon Presets Display. The weapon will not be able to compensate for errors greater than 1 nm, which is one minute of latitude (or longitude at the equator). Additional waypoints can be used to avoid defenses.
3. DESTRUCT RANGE is the range at which the missile will self-destruct if it has not encountered its target. This can be used to protect friendly and neutral forces. The default value of Destruct Range is the weapon's maximum range.

Note: If the total distance of flight from the ship to the target as increased by the waypoints exceeds the missile's maximum range, a red marker will indicate the point of maximum flight.

LAUNCHING THE WEAPON

1. Order the selected launch tube pressurized equal to sea pressure by clicking on the P button. This action is complete when the light stops flashing.
2. Order the muzzle hatch opened by clicking on the M button. The muzzle hatch will not open until the pressure is equalized.
3. Steps 1 and 2 may be done at any time to make tubes ready before being close enough to the enemy to make noise a concern.

4. Observe the I indication is bright which means that all conditions for launch are met and the firing interlocks are closed. If the firing interlocks are not closed, check that the tube is properly prepared, that the target has been properly assigned, and that there is no problem with the missile flight path as planned.
5. Ensure the ship meets the operational conditions for launch: speed less than 5 knots, depth less than 150 feet.
6. The missile is launched from the tube by clicking on the FIRE button. Observe the indicators all return to the non-ready state and the launch tube contents indicator goes dark.

POST-LAUNCH DISPLAY



1. Observe the missile symbol on the display marked by the number of the tube from which it was launched. The missile should be proceeding toward the target on the course laid out by the operator.
2. Since there is no communication with the missile(s) after time of fire, the display is only a representation of what was intended to happen. The missile(s) will be DR'd to the target at nominal flight speed.

Tomahawk Firing Procedure (Torpedo Tube)

PREPARING THE WEAPON FOR LAUNCH

The procedure is the same as when launching from a Vertical Launch tube.

LAUNCHING THE WEAPON

1. Order the selected torpedo tube flooded and equalized with sea pressure by clicking on the F and E buttons. These actions are complete when the lights stop flashing.
2. Order the muzzle door opened by clicking on the M button. The muzzle door will not open until the tube is properly flooded and equalized.
3. Steps 1 and 2 may be done at any time to make tubes ready before being close enough to the enemy to make noise a concern.

4. Observe the I indication is bright which means that all conditions for launch are met and the firing interlocks are closed. If the firing interlocks are not closed, check that the tube is properly prepared, that the target has been properly assigned, and that there is no problem with the missile flight path as planned.
5. Ensure the ship meets the operational conditions for launch: speed less than 5 knots, depth less than 150 feet.
6. The missile is launched from the tube by clicking on the FIRE button. Observe the indicators all return to the non-ready state and the torpedo tube contents indicator goes dark.

POST-LAUNCH DISPLAY

1. Observe the missile symbol on the display marked by the number of the tube from which it was launched. The missile should be proceeding toward the target on the course laid out by the operator.
2. Since there is no communication with the missile(s) after time of fire, the display is only a representation of what was intended to happen. The missile(s) will be DR'd to the target at nominal flight speed.

RELOADING TUBES

1. Once the tube has been fired, it must be reloaded for future use. Press the Weapon Inventory button to see the available weapons on the racks. Press OK when done.
2. Click on the Content Label until the desired weapon appears. The loaded weapon can be changed any time by the same method.

Using the Signal Ejector

Loading the signal ejector is a manual process that can be time consuming. In a hostile environment, it is a good idea to have a jammer and a decoy loaded at all times. Although the launch success rate may be higher for lower ship speeds, in extremis (e.g., torpedo evasion) it is appropriate to launch countermeasures regardless of the ship's speed or rate of course change.

Launching Mines



The Mk 67 Submarine Launched Mobile Mine (SLMM) is loaded and launched in a similar manner to that used for torpedoes. Basically a modified Mk 37 electric torpedo (mine components replace the torpedo warhead), the SLMM can be launched a long distance from its intended position. It will travel to the aim point where it will wait until it has detected a target.

A mine insertion has to be carefully planned. The submarine must know where the mines are to be located, what the depth of water is and what type of bottom exists, and what the strength and direction of currents will be between the launch point and the aim point.. The launch rate will be determined by the number of tubes being used and the speed with which the reload party can load additional mines in the tubes as they are fired. An advantage of the mobile mine is that it can be planted in water shallower than the submarine would choose to enter. If this is the case, the submarine may make repeated passes along a launch course in water sufficiently deep for submerged operations. After launching all mines loaded in the tubes, the submarine can turn toward deeper water while reloading and then make another pass along the launch course. This can be repeated as many times as necessary to plant the mine field. The SLMM is loaded into a torpedo tube and the A-cable is connected. After electrical checks are completed, the tube may be flooded and equalized and the muzzle door may be opened. All the tubes that are to be used for mines would be loaded and made ready.

Fire control information will be pre-computed for each mine. Launch points will be selected along the launch course so that the range and bearing to the aim point will be known in advance. Teamwork is required. The navigation party must keep the submarine exactly on the launch course, the reload party must reload the tubes as quickly as possible, and the fire control party must shift quickly from one tube to the next to get the correct inputs to the next mine to be launched before the submarine reaches the next launch point.

Mine Launch Procedure

PREPARING THE WEAPON FOR LAUNCH



1. Select a firing tube by clicking on P (PRESETS) of the desired tube in the Target Display Panel. The target is selected by assigning a waypoint. Click on Define Target Waypoints and then click in the area of the desired target in the TARGET DISPLAY area.
2. Using the tasking message for the location of the mine field and a plan for laying the field, position the mine destination by dragging the waypoint to the desired location. The coordinates of the waypoint can be viewed by clicking on the waypoint on the chart
3. If the total distance of travel from the ship to the position exceeds the SLMM's maximum range a red marker will indicate the maximum range the SLMM will travel.
4. DEPTH preset should be the desired run depth to the aim point. Default value: 100 feet.

LAUNCHING THE WEAPON

1. Order the selected torpedo tube flooded and equalized with sea pressure by clicking on the F and E buttons. These actions are complete when the lights stop flashing.
2. Order the muzzle door opened by clicking on the M button. The muzzle door will not open until the tube is properly flooded and equalized.
3. Steps 1 and 2 may be done at any time to make tubes ready before being close enough to the enemy to make noise a concern.
4. Observe the "I" indication is bright which means that all conditions for launch are met and the firing interlocks are closed. If the firing interlocks are not closed, check that the tube is properly prepared, that the target has been properly assigned, and that there is no inconsistency between the presets and the fire control solution.
5. The SLMM is launched from the tube by clicking on the FIRE button. Observe the indicators all return to the non-ready state and the torpedo tube contents indicator goes dark.

POST-LAUNCH DISPLAY

1. Observe the mine symbol on the display marked by the number of the tube from which it was launched. The SLMM should be proceeding toward the aim point.
2. Since there is no communication with a SLMM after it has been launched, the SLMMs will be DR'd to the aim point as planned by the operator.

RELOADING TUBES

1. Once the tube has been fired, it must be reloaded for future use. Press the Weapon Load Out button to see the available weapons on the racks. Press OK when done.

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2. Left-click on the Content Label until the desired weapon appears. The loaded weapon can be changed any time by the same method.

Evasive Maneuvers

The best defense is never to be caught. However, when something goes wrong—an enemy has detected your submarine and launched weapons against you—evasive maneuvers are required.

Torpedo Evasion

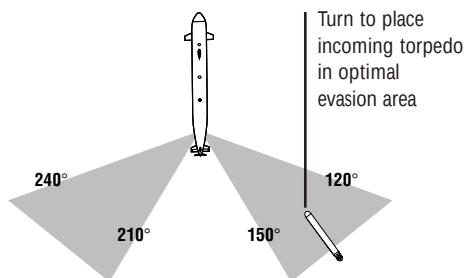
No submarine can outrun a modern anti-submarine torpedo. Survival of a torpedo attack will depend on whether or not the torpedo is able to detect the submarine and begin to home on it. The submarine will be successful if it can manage to remain undetected by the torpedo or can confuse the torpedo homing logic.

If the torpedo is well placed (the enemy had a good fire control solution on your submarine prior to launching the torpedo), early detection is essential. The sonar operators must be able to recognize a torpedo even before it begins active homing. As soon as the torpedo is reported, the submarine must maneuver so that the firing solution of the enemy is no longer valid, and the torpedo will not pass close enough to your submarine to be able to detect it. The submarine maneuver should include a course change to get away from the projected track of the torpedo, an increase in speed (probably to maximum), and possibly a depth change. Depending on the local conditions, it may be possible to put the submarine on the opposite side of a thermal layer from the torpedo (you have to know the water depth and the sound-speed profile (SSP)) by going shallow or deep. If the water is shallow, being near the bottom may help by giving the torpedo false target returns from the bottom.

Evasion plans may also include the use of countermeasures. Countermeasures can be of two types: decoys and jammers. Decoys give false returns to the torpedo that is homing and will cause the torpedo to home on the decoy instead of the submarine. Jammers produce very loud noise over a broad spectrum and make it difficult for the torpedo or the platform that launched it detect the submarine by acoustic means. Whenever the submarine is in a potentially hostile situation, the Commanding Officer should know in advance what they will do to evade torpedoes. His plan must take into consideration all factors in the local environment.

Torpedo Evasion Procedure

1. When Sonar reports a "torpedo in the water" or the active intercept receiver indicates that a torpedo is actively homing, accelerate to maximum speed.



2. Place the bearing of the incoming torpedo at 120–150 degrees or 210–240 degrees relative to the submarine. Placing the torpedo at 180 degrees relative, i.e., astern, will not work because the torpedo can overtake the submarine in a tail-chase.
3. Launch countermeasures from the three-inch launcher. (A decoy and a jammer should be pre-loaded and ready for launch at all times.)
4. Change depth drastically if the overall depth of water will permit, especially if the sound-speed profile shows that a torpedo at the submarine's present depth won't be able to hear the submarine at the new depth.
5. If the incoming torpedo was not air-dropped, launch an ADCAP torpedo at the bearing on which the torpedo was initially detected. (This will put the launching platform on the defensive.)

SUPPLEMENTARY ACTIONS

- Plot the bearings to the incoming torpedo and attempt to determine its course.
- When it is clear that the torpedo will miss or when the torpedo has shut down, slow to reduce noise and regain tactical control.
- Reload the three-inch launcher and the torpedo tubes as required.

Be especially wary if enemy ASW helicopters are patrolling your sector. ASW helicopters search for submarines using *dipping sonar*—sonar arrays that dangle from a cable and dip into the ocean. These helicopters can detect both torpedo and missile launches. When they do, they hurry to the suspected launch point and begin a thorough search for submarines.

Once a helicopter gets a fix on your position, it may drop torpedoes into the water. The submarine commander is now caught in a difficult situation. If he



increases speed to outrun the torpedoes, the helicopters can track him more easily and will dump more torpedoes. If the commander decides to keep his speed down and attempt to outmaneuver the torpedoes, he runs the risk of taking a hit. Neither scenario is good, and both can be avoided by keeping a low profile when making attack runs.

Special Forces Operations

Naval Special Warfare (NSW) may involve the insertion of special operations forces (SOF) into a hostile territory. SOF include such units as Army Rangers, Marine Reconnaissance (Force Recon) units, or Navy Sea-Air-Land (SEAL) units. The SEALs have the most experience working from submarines and are capable of submerged launch and recovery. Other units can be deployed from a submarine, but that would require surfaced launch and recovery. A submerged launch or recovery of SEALs requires the submarine to hover at a shallow depth. There must be a minimum of water flow over the deck so that the swimmers don't have to work against a strong current while they handle equipment. Being shallow means that it will be easier and faster to get the swimmers in and out of the submarine.

Los Angeles class submarines use the escape trunk to lock out two swimmers at a time with whatever equipment they can also fit into the cramped chamber. Larger equipment and substances that are not brought into the submarine atmosphere (such as gasoline for the outboard motors) must be stored external to the pressure hull. To lock out, the divers enter the escape trunk and flood it to a pre-determined level. The remaining volume is pressurized with air to a pressure equal to sea pressure. When the pressure is great enough, the hatch can be opened. The divers then leave the pressurized air bubble and exit the hatch, using self-contained underwater breathing apparatus (SCUBA). Once outside the submarine, the SEALs begin to rig their equipment while others are locking out. The equipment may include combat rubber raiding craft (CRRC) with outboard motors if there is a long distance to go. When the entire team has locked out, the SEALs depart and the submarine can either loiter on station or go to another area to await the recovery operation.

To recover the SEALs, the submarine would most likely be at a pre-determined location at a specified time. Waiting at periscope depth, the submarine will search for the SEALs visually and with passive sonar while listening on designated radio circuits. Once the rendezvous is made, the submarine again hovers for the recovery. The SEALs will stow some of their equipment topside and take the rest below decks as they lock in. To effect a surfaced launch or recovery of SOF personnel, the submarine should surface as quickly as possible and have personnel standing by to help with the movement of equipment to the hatch and then topside. The sooner the evolution can be completed and the submarine can re-submerge, the less the chance of detection and attack by enemy forces.

Submerged Lock out Procedure

Note: The following procedure is for information purposes, indicating in part the complexity of the operation. The actual procedural requirements are listed in the section, Launching Special Operations Forces, below.

Initial Conditions

- The submarine has arrived at the mission launch point and has conducted surveillance in order to ascertain that there is no immediate threat to the SEALs.
- Depending on the sea state, the submarine is shallow or at periscope depth with no more than approximately 1 knot of water flow across the deck. The submarine may be hovering instead of trying to control depth with the normal control surfaces.
- SEAL teams have been briefed and are fully ready to commence the mission.
- All necessary personnel are on station.

Actions

The Officer of the Deck must give permission to conduct each step of the procedure. The Commanding Officer must authorize any change in the rig for dive.

1. Open the drain valve to check the escape trunk dry. Shut the drain valve.
2. Open the lower hatch. Trunk operator and two SEALs with necessary equipment enter the trunk and secure the hatch.
3. Flood the trunk to the bubble line.
4. Undog (open) the upper hatch. (It will not open yet due to sea pressure.)
5. Pressurize the escape trunk using high-pressure air until the pressure is equal to that of the surrounding sea water.
6. Push open the upper hatch. SEALs depart the trunk one at a time.
7. Shut and dog the upper hatch.
8. Open the vent valve and then open the drain valve to drain the water from the trunk. Shut the drain valve.
9. Repeat steps 2 through 8, as required, to lock out the SEAL team(s).
10. When the lock out evolution is complete, rig the escape trunk for dive.

Submerged Lock in Procedure

Initial Conditions

- The submarine has arrived at the designated recovery point and made contact with the SEAL teams returning from their mission.
- Depending on the sea state, the submarine is shallow or at periscope depth with no more than approximately 1 knot of water flow across the deck. The submarine may be hovering instead of trying to control depth with the normal control surfaces.
- All necessary personnel are on station.

Actions

The Officer of the Deck must give permission to conduct each step of the procedure. The Commanding Officer must authorize any change in the rig for dive.

1. Open the drain valve to check the escape trunk dry. Shut the drain valve.
2. Flood the trunk to the bubble line.
3. Undog (open) the upper hatch. (It will not open yet due to sea pressure.)
4. Pressurize the escape trunk using high pressure air until the pressure is equal to that of the surrounding sea water.
5. Push open the upper hatch. Two returning SEALs can enter the trunk, one at a time.
6. Shut and dog the upper hatch.
7. Open the vent valve and then open the drain valve to drain the water from the trunk. Shut the drain valve.
8. Open the lower hatch to allow the SEALs to re-enter the submarine.
9. Repeat steps 2 through 8, as required, to lock in the SEAL team(s).
10. When the lock in evolution is complete, rig the escape trunk for dive.

Surfaced Launch Procedure

Initial Conditions

- The submarine has arrived at the mission launch point and has conducted surveillance in order to ascertain that there is no immediate threat to the SOF that will disembark. The submarine is at periscope depth.
- The SOF have all been briefed and are fully ready to begin the mission.
- All necessary personnel are on station.

Actions

The Officer of the Deck must give permission to conduct each step of the procedure. The Commanding Officer must authorize any change in the rig for dive.

1. Surface the ship with a short (5 second) emergency main ballast tank blow.
2. Immediately start an air charge to replenish the high-pressure air banks.
3. Run the low-pressure blower on the main ballast tanks if the additional noise will not result in a significant increase in the probability of detection by threat forces.
4. Man the bridge with the minimum amount of equipment for the Officer of the Deck.
5. Drain and open the weapons shipping (forward) hatch and/or the escape trunk (midships) hatch. Move SOF personnel and equipment topside expeditiously.
6. If the situation warrants it, station personnel on the bridge and on deck with weapons to provide self-defense capability against hostile forces.
7. As soon as the SOF have been launched, rig the hatches and the bridge for dive. Secure the low-pressure blower if that was used.

8. Verify the rig for dive and submerge the ship.

Surfaced Recovery Procedure

Initial Conditions

- The submarine has arrived at the mission recovery point and has conducted surveillance in order to make contact with the SOF that will embark.
- The submarine is at periscope depth.
- The SOF have been detected. Communications were established to determine the time of the rendezvous, whether there are enemy forces in the area, and whether there are any wounded.
- All necessary personnel are on station.

Actions

The Officer of the Deck must give permission to conduct each step of the procedure. The Commanding Officer must authorize any change in the rig for dive.

1. Surface the ship with a short (5 second) emergency main ballast tank blow.
2. Immediately start an air charge to replenish the high pressure air banks.
3. Run the low pressure blower on the main ballast tanks if the additional noise will not result in a significant increase in the probability of detection by threat forces.
4. Man the bridge with the minimum amount of equipment for the Officer of the Deck.
5. Drain and open the weapons shipping (forward) hatch and/or the escape trunk (midships) hatch.
6. If the situation warrants it, station personnel on the bridge and on deck with weapons to provide self-defense capability against hostile forces.
7. Move SOF personnel and equipment below decks expeditiously. As soon as the SOF have been recovered, rig the hatches and the bridge for dive. Secure the low pressure blower if that was used.
8. Verify the rig for dive and submerge the ship.

Launching Special Operations Forces

Initial Conditions

- The submarine has arrived at the mission launch point and has conducted surveillance in order to ascertain that there is no immediate threat to the SEALs.
- The submarine is at periscope depth or shallower with no more than approximately 1 knot of water flow across the deck.

Actions

- When all conditions for launch have been met, the XO will announce that "All SEALs are away."

Recovering Special Operations Forces

Initial conditions

- a. The submarine has arrived at the designated recovery point at the designated time.
- b. The submarine is at periscope depth or shallower with no more than approximately 1 knot of water flow across the deck.

Actions

When all conditions for recovery have been met, the XO will announce that "All SEALs have been recovered."

Search and Rescue Operations

Principles of the Operating Procedure

Search and rescue (SAR) operations are conducted by submarines in various situations. Since one of the most important factors in SAR is to conduct the operation in the quickest manner possible, a submarine may be tasked to conduct the operation if it is the closest to the point of rescue. If the rescue is to be conducted in a hostile area, the submarine's stealth makes it a good choice for the job. A problem with using the submarine for SAR is the vulnerability of the sub while surfaced.

There are two types of SAR operations for a submarine. The first is rescuing a person on the surface, such as a downed pilot or sailors from a ship. This operation is very similar to the surfaced special forces recovery, with the exception that the person in the water is not trained in the procedure. The submarine learns the best known location of the person(s), and travels to the location to search. The submarine is better able to search from the surface, but is much more vulnerable to enemy detection and attack. Once the person(s) is located, the submarine approaches the person, surfaces, and slows to conduct the rescue. The quicker the rescue can be conducted and the submarine can be submerged, the safer the operation.

Submarines can also be used as the mother ship for a Deep Submergence Rescue Vehicle (DSRV) which can be used to rescue personnel from a downed submarine. A submarine can carry the DSRV to the location of the search, using intelligence and the ship's sensors to locate the downed sub. The sub then slows to near zero speed and hovers in place while the DSRV conducts the rescue. This operation may be long, depending on the number of trips necessary to rescue all the survivors.

Surface Search and Rescue Procedure

Initial Conditions

- The submarine has arrived at the best known location of the person.
- Depending on the level of hostility in the area, the ship is on the surface or at periscope depth.
- All necessary personnel are on station.

Actions

1. The ship uses all sensors (periscope, radar if surfaced, sonar, ESM) to search the area for the person while maintaining safe position with respect to threat contacts.
2. Once the person is located, the ship drives as close as possible.
3. If not already on the surface, the ship quickly surfaces the ship by conducting a 5 second emergency blow (raise the Emergency Blow Valve handle; lower it after 5 seconds). Immediately commence ventilating (push Ventilate button) and start an air charge (push HP Air button) to replenish the HP air banks.
4. When the ship has met the speed and depth requirements (slow and surfaced), the rescue will be conducted. When complete, the XO will report that the person is on board.
5. Quickly submerge the ship and continue operation, keeping in mind the possible detection of the submarine during the SAR.

DSRV Operations

Initial Conditions

- The submarine is in the correct area to conduct the SAR.
- The DSRV is attached with personnel standing by for operations.

Actions

1. Slow to near zero speed and hover at a safe depth.
2. DSRV operations will be conducted. The XO will report "Conn, XO. The DSRV is away."
3. After some time, the operation will be complete. (The submarine may have waited on station or may have departed and returned to the recovery point.) The XO will report "Conn, XO. The DSRV is mated to the hatch."

Casualty Procedures

Flooding is one of the most feared of submarine casualties. The ability to survive a flooding casualty depends on submarine design factors and the training of the crew. A submarine has a certain amount of positive buoyancy when it is on the surface. If more water is taken aboard than the maximum positive buoyancy, then the submarine will be negatively buoyant and will sink. (If propulsion can be maintained, additional weight can be compensated for with speed and an up-angle on the hull.)

The amount of water taken aboard during a flooding casualty is proportional to the size of the hole, the depth at which the flooding occurs, and the length of time it takes to stop the flow of water into the submarine. (Depth matters because submergence pressure increases by 44.4 pounds per square inch for every 100 foot depth increase. That is almost three atmospheres increase in pressure for every 100 feet.) The time to stop the flooding can be decreased by having emergency closure valves that operate remotely on all sea water systems of significant size. Crew training is also important to be

able to locate, isolate, and repair the source of flooding.

If flooding occurs, speed should be used to achieve an upward depth rate. If propulsion power is lost because of flooding in the engine room, the residual speed will still get the submarine moving toward the surface. The ship control party should keep a moderate up-angle on the ship; a large angle could keep the damage control parties from being able to move in the ship, and too large an angle could result in the loss of air from the ballast tanks when the emergency main ballast tank blow system is used.

Flooding Procedure

Immediate Actions

- Flooding most likely occurs as a result of a close explosion. The person discovering the flooding should report, by the fastest means, the location of the flooding and the source of the water if that can be determined.
- The Chief of the Watch (COW) will announce on the general announcing system "Flooding in the _____ (compartment or space)", sound the Collision Alarm, and pass the word passed again.
- Flooding results in reduced propulsion, reduced ability to control ship's depth, and an angle on the ship.
- The Officer of the Deck (OOD) should order the Diving Officer to bring the ship to a shallow depth without using a large trim angle on the ship.
- The OOD should use enough speed to maintain the ordered depth as long as propulsion is available.
- The OOD should emergency surface the ship if the ship was very deep at the beginning of the casualty, if propulsion is lost, or if the amount of water flooded into the ship begins to have a noticeable effect on ship control. (Emergency surfacing means conducting an emergency blow of the main ballast tanks by raising the Emergency Blow Valve.)

Supplementary Actions

- The ship will recover depth control and speed over time as the crew conducts damage control operations.
- If the ship emergency surfaced, pass the word to "Prepare to surface" and complete the normal surfacing procedure. Recharge the main air banks following the emergency blow.

Emergency Deep

Principles of the Casualty Procedure

The most vulnerable time for the submarine with regard to encountering another vessel unexpectedly is when proceeding to periscope depth. If the OOD believes that a risk of collision exists, he will announce "Emergency Deep" which will cause the members of the ship control party to quickly take actions to get the submarine back to a safe depth.

Initial Conditions

- The submarine is at or approaching periscope depth.
- The Approach Officer (CO) or the OOD is manning the periscope.
- The officer on the periscope sees a contact that is an immediate collision threat.

Immediate Actions

- The officer on the periscope immediately lowers the periscope.
- The OOD rings up All Ahead Full on the Engine Order Telegraph and orders a safe depth (150ft or deeper).

Supplementary Actions

- The OOD slows the sub as soon as the ship is at a safe depth.

The Future Of Seapower

by Admiral Guven Erkaya Commander-in-Chief, Turkish Naval Forces

Generally speaking, weapon ranges were shorter than detection and identification ranges until the 1950s. Hence, the effectiveness of naval platforms was limited by the range and capabilities of onboard weapons and sensors. Naval strategy and tactical doctrines reflected these limitations. However, over the last 50 years, we have witnessed the development of guided weapons and cruise missiles with greater precision, larger warheads and ranges far beyond those of onboard detection and identification sensors.

These improvements made it necessary to obtain target data through external sensors in order to target long-range weapons effectively. In the meantime, continuous and real-time transfer of data obtained through off-board sensors to weapon platforms became necessary.

Today, those navies possessing long-range weapons, wide area surveillance and targeting systems and advanced datalinks maintain a significant advantage. These developments have resulted in significant changes to naval strategy and tactics, which will continue into the next century. The accuracy, range and destructive power of missiles will further improve, while naval guns will benefit from the wider use of smart munitions.

The importance of constant surveillance, the collection, correlation and fusion of data, and the real-time dissemination of processed data to individual platforms will further increase. Without this real-time data transfer, the potential firepower offered by modern weapons and surveillance systems will not translate into tactical and strategic advantage. Improvements are expected in stealth technology, leading to marked reductions in radar, acoustic, infrared and electromagnetic signatures.

The role of the ballistic missile in global deterrence will continue, and nuclear-powered submarines will remain the most suitable platform. Indeed, submarines will continue to cause problems for surface forces by virtue of their stealth. Aircraft carriers, in addition to sea control and power projection, will continue to form the back-

bone of the blue-water task force. Cruisers and other large escorts will maintain their importance.

The effectiveness of cruise missiles will also increase. Launched from naval platforms at standoff ranges, these weapons will reduce the importance of manned aircraft as strike assets. As such, naval forces will be able to control larger sea areas, whilst at the same time being capable of neutralising point targets located deep inland.

The economic use of the seas and the sea bed has increased over the last half century. While national sovereignty over the seas was limited to just three miles (4.8km) in the past, the exclusive economic interest of countries has now expanded to 200 miles (322km) and even further in some cases. Given the ever greater exploitation of maritime resources, it appears likely that international conflicts may increasingly shift to sea areas.

With the development of a new world order, the resolution of emerging new crises requires multi-polar and multi-national arrangements. Before the end of the Cold War, reaching a consensus on the threat was not difficult beyond some minor points. Today, countries are faced with a multitude of potential threats including:

- ☐ ideological and cultural conflicts which have existed throughout history;
- ☐ rising nationalism and racism;
- ☐ increasing terrorism;
- ☐ the spread of organised crime;
- ☐ the proliferation of weapons of mass destruction;
- ☐ expansionist foreign policies;
- ☐ imbalances in the distribution of finite world resources among a rising global population; and
- ☐ the requirement for urgent action to protect the environment.

Addressing these security risks requires the combination, or at least the harmonisation, of various policies. Foreign and defence policies - once seen as separate - need to be combined. Meanwhile, economic, social and other national policies must be aligned with the main thrust of a common foreign and security policy.

From an international perspective, the protection of global security interests necessitates the need for multinational maritime forces, and countries which participate in coalition operations will naturally increase their stature and influence on the world stage.

Traditional tasks - such as defence against threats from the sea; protection of sea lines of communication, natural maritime resources, and national interests overseas - will continue. Navies will also find a greater role in low intensity conflicts (including the support of peacekeeping operations), humanitarian aid, search and rescue, environmental protection, and cooperation with other agencies against organised crime.

Navies, exploiting the additional capabilities obtained through the revolution in technology, and their inherent attributes of mobility, flexibility and endurance, will continue to offer invaluable options to politicians in the maintenance and protection of the national interests into the next century.

Mission Profiles

Anti-Submarine Warfare

PURPOSE: Detect, determine a fire control solution (bearing, course, speed, range), fire a weapon, and achieve a hit without being destroyed yourself.

SENSORS: The initial data to assist you in detecting the enemy submarine will be your mission orders or a message about a possible general location of the submarine. With that data, you will proceed to the indicated location and search using your sonar system. You may use either passive or active sonar, but active could allow the enemy to detect you first.

WEAPON: Mk 48 ADCAP torpedo.

TACTICS: If you are detected by the other submarine, you may fail in your mission, or at least be delayed as you run from the incoming torpedo. You must detect without being detected. Part of this is to stay stealthy. Move slowly and shut off any unnecessary noisy equipment. Once you have detected a submarine, identify it quickly and determine its capabilities to detect you. Control the situation to prevent the enemy from getting close enough to detect you. Choosing the proper depth with respect to the sound speed profile (SSP) will help you detect the enemy sooner. Consider the mission of the sub you are hunting. SSBNs will be hiding and will tend to run from conflict. SSNs will be looking for targets just like you are, and may turn and fight once they detect you. Always be prepared to attack and evade an attack because as quiet as you are, firing a weapon can be like a flashing an "I am here" sign over your submarine. If you are part of a battle group, you will be assigned an area to search. Remember that other units are searching other areas, and will attack anything that moves in their areas, so stay within your sector of the ocean.

Anti-Surface Ship Warfare

PURPOSE: Find and destroy the surface ship of interest. Get the highest value ships first, as the others will be more difficult to get after the first weapon explodes. Avoid being detected and attacked by enemy ships or aircraft.

SENSORS: Again, your mission will tell you where to begin. From there, you can use sonar, ESM, and the periscope, each of which will help you to detect and classify the targets. ESM detection of the target ship's surface search radar may be your first detection.

WEAPONS: Mk 48 ADCAP torpedo for closer ranges (5 to 15 nautical miles (nm)), Harpoon (UGM-84) anti-ship missiles for farther ranges (out to 50 nm). The torpedo will inflict more damage and is less susceptible to being destroyed. The Harpoon is a better weapon for small targets like a patrol boat.

TACTICS: Once you detect the contact, drive toward the contact (close range) to within torpedo or missile range. While closing range, determine the fire control solution. The periscope is an excellent source of bearing and range data, but makes you slow and vulnerable to detection by radar.

Choose your weapon based on range and detection threat. A missile cannot be traced to its origin unless waypoints are used. Many ships will be able to detect the torpedo when it enables (begins active search). The sooner the torpedo enables, the sooner the target is alerted. Remember that a torpedo is not a bullet; a ship can simply drive away from a good torpedo shot if it has enough of a head start. Use Info Online to assist in classifying ships and determining their capabilities. Use your position and the torpedo settings to help you target the desired ship first. Being detected by *anything* can be a problem. All ships have some anti-submarine capability, even if it is just a sail boat with a radio to tell a warship where you are.

Strike Warfare

PURPOSE: Covertly place the submarine in position and fire Tomahawk missiles at shore target(s).

SENSORS: Passive sonar, ESM and the periscope will help you locate and identify any threats to you or the missile. The navigation chart may show threats and obstacles. A good navigational fix is important to get the missile to the correct position. The fathometer will help you prevent grounding in the potentially shallow waters near shore.

WEAPON: Tomahawk (UGM-109) land attack missile.

TACTICS: The last waypoint should be placed at the coordinates of the target, and the third waypoint at the coordinates of the landfall waypoint. The waypoints can be dragged to position, or selected on the display and positioned by typing in the desired coordinates. Other waypoints can be used to avoid obstacles or threats to the missile. If you are firing multiple missiles (sorties), you can use waypoints to delay the arrival of earlier fired sorties. If you choose to destroy the interfering threats, realize that drawing attention to yourself will make it more difficult to fire your missiles on time and safely. Verify that you are at the correct speed and depth prior to firing the missile. After firing, be ready to defend yourself against all the enemy can throw at you.

Mine Warfare

Laying a Mine Field

PURPOSE: Use the stealth of the submarine and the travel distance of the mine to covertly place a field of mines in enemy territory.

SENSORS: Use sonar defensively. Use your position information (fix, estimated position (EP), dead reckoning (DR)) and the chart to position the mines. The fathometer will help prevent grounding the submarine.

WEAPON: Mk 67 submarine-launched mobile mine (SLMM).

TACTICS: It is vital to place the mines quickly and accurately. Choose the desired location of the individual mines by defining the waypoint in the weapon presets screen. The mines may be precisely positioned by selecting the waypoint and typing in the desired coordinates. Mines must have a flat or gently sloping bottom to stay in position. You will likely need to reload mines after the first launch. You should always keep one torpedo loaded in case of attack. Since you will probably be in shallow water, constantly be aware of the depth of water below the ship.

Navigating a Mine Field

PURPOSE: Find a course through or around the mine field, marking the position of any mines encountered.

SENSORS: Outside information (intelligence data) on location of the mine field and high frequency active sonar.

TACTICS: A submarine may be capable of navigating through a mine field, but it is much safer to go around. To avoid the mine field, drive through an area that is difficult to mine. If you must go through, high frequency (HF) sonar can be used to locate the mines. Remember that any active sonar transmission may be detected by a capable ship or submarine. Once a mine is located, maneuver quickly to avoid it by the largest possible margin.

Driving slowly will give you the best reaction time. Keep track of the location of the mines to ease your return trip. One method to find a safe route is to follow another ship's path.

Naval Special Warfare

PURPOSE: Insert and/or recover Special Operations Forces (SOF)

SENSORS: The periscope, sonar and ESM will help detect forces that could endanger you or the SOF.

TACTICS: Stealth is key to a successful mission. The submarine is vulnerable during both insertion and recovery. Recovery may be even more dangerous if the enemy has become aware of your presence. Prior planning will speed the process. The procedure must be carefully controlled to prevent flooding. Two types of insertion/ recovery are possible. SEAL forces can be locked in/out while the ship is shallow (at or just below periscope depth). This is a more difficult operation, but more covert and, therefore, safer for both the submarine and the SOF. Other forces, such as Marines, will need to use a surfaced launch/recovery. This is easier and quicker, but more easily detected by enemy forces. Both procedures must be done with the submarine operating at very slow speeds, making ship control more difficult. Rough seas can make the operation very difficult for the SOF and the ship.

Surveillance

PURPOSE: Monitor enemy forces (submarines, surface ships, port movements, communications, etc.) while remaining undetected.

SENSORS: The periscope, ESM, and passive sonar will all be used to monitor the area for threats. Radio will also be important to send and receive information about the contacts.

TACTICS: The art of surveillance is to be close enough to get the important data while being far enough to prevent detection by the enemy. Again, even a sailboat or a fisherman can detect a submarine and radio for help. You must balance the need to have your sensors (ESM and the scope) up against the risk of being detected visually or by radar. Being at periscope depth also severely limits submarine speed. Send any discovered information back to your command when it is safe to transmit. Always be ready to defend yourself if you get detected.

QUICK START
TUTORIAL

MAIN MENU
OPTIONS

SHIP'S
STATIONS

ACADEMY
TRAINING

ADVANCED
TUTORIAL

APPENDICES

