SUBMARINE OPERATIONS

World War II Submarines

There were three general classifications: pre-war, 300 foot test depth, and 400 foot test depth. The 300 foot submarine class were built quickly to increase the size of the fleet in response to immediate need resulting from the attack on Pearl Harbor. The 400 foot class was in response to the Japanese knowledge of the 300 foot depth limits in the design of their depth charges. Neither class had the snorkel capability which required submarines to remain on the surface to maintain a full battery charge for imminent offensive submerged operations. In short, they operated as surface ships with a capability to submerge. As such, it was important they could submerge in minimum time should they be detected or attacked - when submerging to periscope depth in less than fifty seconds was of paramount importance. The significant conclusion of offensive actions on the surface is born out by the fact that all five Medal of Honor winners were five submarine commanding officers for offensive combat performed when on the surface which did not diminish the many successful attacks performed at periscope depth. With today's technology, offensive attacks will most likely be performed below periscope depth.

Historical surface operations came to an end with the installation of the snorkel which permitted running the diesel engines while still submerged.

Description of diesel electric submarine operations'

The ability to perform all established submarine missions, including offensive operations such as sinking ships with torpedoes, or the laying of mines was common to all diesel electric submarines. Adding the snorkel meant they were no longer required to daily surface to permit running diesel engines in order to charge batteries. This new capability also increased their ability to conduct peacetime intelligence related missions when remaining undetected was of paramount importance.

All World War II submarines had two torpedo rooms fore (six torpedo tubes) and aft (four tubes). Those built after the war had a single torpedo room because they had a single screw. The dominant torpedo was the steam driven Mk 14 with two speeds (45 knot in high speed; 30 knot in low speed with a maximum range of 4,500 yards (low speed and 2,500 yards in high speed). Battery driven/electric motor torpedoes with independent active sonar capability became available after the war. A later version included "wire-guided" torpedoes which trailed a wire connected to the firing submarine to permit transmitting steering signals to the torpedo as well as mode activation (passive/active) of the sonar capability installed in the torpedo.

Living space on all submarines was limited and prized. Indeed, a characteristic of an experienced submariner was his ability to identify "storage space" that could accommodate a storage locker of any size. Crew living space was also limited; there was no such thing as an unused berth. Officers and Chief Petty Officers had their own separate assigned berthing above the "Forward Battery Compartment"; even then, with the exclusion of the Commanding Officer, berthing consisted of three bunks to a given space which included a shared desk, such as it was, and a single wash bowl. The crew had berthing in the upper space over the after battery with three, or four as a function of location, vertical bunks in a space which was dedicated to bunking. There was additional crew bunking in each torpedo room with torpedomen getting first choice since bunks were second priority to reload torpedoes. Indeed, should there be a need for temporary personnel assignments, there was only two options - hot-bunking with two people on separate watch times assigned to a single bunk; or, portable mattresses that could be spread out anywhere there may be space - usually in the torpedo room walk-ways.

Water was always at a premium on diesel electric submarines. The ability to make fresh water from the sea was generally reliable but was limited to that which assured the replenishment of necessary make-up water for the two batteries (an essential requirement for a diesel electric submarine), and anticipated water for food preparation. Water for crew cleanliness was not a design feature and was limited to any excess water from battery maintenance and food preparation; there was no laundry. Compounding this condition was the limited amount of space allocated to personal needs - typically a small locker and whatever amount that could be stowed under the mattress. These conditions had a major impact when "loading out" for an extended operation.

The shortage of space becomes painfully inconvenient when the ship was scheduled for an extended period at sea - sixty days, and more, were common with no opportunity to replenish food or fuel. A typical loadout was for 90 days when assigned "special operations" which typically meant the addition of a ten or twelve-man intelligence team to the normal 65 man crew. Because of limited frozen food storage, submariners did have the benefit of having all meats "deboned" acknowledging the limited refrigerated space in the submarine as well as the reduction in the amount of waste that had to be disposed of. As an example, turkeys were deboned, then compacted into large hot-dog like packages which earning them the descriptive title "hydraulic turkey" with both dark and light meats compressed together. After a few days at sea, reliance on the use of powdered eggs and milk were common as well as the use of dehydrated items such as shrimp (popular) and vegetables (unpopular). Yet, on "loading out," the last items brought on board were fresh vegetables, fruit, milk and eggs which were stored wherever there was room. For example, It was common to fill the showers with potatoes (couldn't take a shower anyway), while milk, vegetables, fruit, and eggs wherever there was any space at all. Grapefruit and oranges were consigned to either one of two escape trunks - the very last items to be stowed which would be the first to disappear off the menu; followed by milk and fresh eggs.

Because peacetime periods at sea were typically longer than those war patrols during the war, there was never enough room for cased food when loading out for an extended deployment. Thus, it was necessary to store additional cased goods in passageways/aisles to a depth that would make it necessary to stoop over to walk through the submarine. In short, the crew ate their way down to the deckplates. Cardboard from these cased goods was used to absorb the condensation in both torpedo rooms whenever submarines operated in abnormally cold waters.

Crew entertainment on a submarine was limited due to the lack of space. While there was a limited library (hard to find the space), there was very little room to read a book when in a submarine bunk. Movies were the most popular form of recreation of most crews which were held in the dining spaces for both the crew and the wardroom - except, of course, for those not qualified in submarines - this time was devoted to "getting qualified."

The one other thing most enjoyed/appreciated by those at sea was the food - even when the ship's cook had to rely on powdered milk and eggs. Fresh bread was made daily in the early morning hours followed by freshly made do-nuts (submarines do have deep-fat fryers - despite the fact they are a significant fire risk) or breakfast rolls and any freshly baked desserts for the upcoming day.

The Submarine Environment.

It is essential the environment in which we live is sufficient to support life. It was routine for submarines to surface daily before the addition of the snorkel - almost always at night to minimize visual detection - in order to run all the diesel engines while charging batteries to minimize time on the surface (detection time). It also allowed forced ventilated of the submarine for fresh air. With the installation of the snorkel and no longer the requirement to surface to run the diesel engines, air was taken through a large snorkel induction valve hydraulically raised to periscope height just above the water surface when at periscope depth. However, the diesel exhaust was not discharged at the deck level, as when surfaced, but through exhaust piping that terminated two feet below the water when at periscope depth which was an infernal part apart of the induction mast itself. This worked great when snorkeling up wind but, as was often the case, it was many times necessary to return to the area of interest which was often downwind allowing the exhaust to be taken into the submarine through the induction valve. It became routine to spend half the night with clean air and the other half with very dense exhaust smoke inside the submarine.

To complicate this "normal evolution," the operating engines draw air directly from the interior of the submarine creating some level of vacuum within the submarine which increases with the number of running engines. Replacement air comes through the induction valve which is designed to shut any time there may be water coming into it such as a wave or the submarine does not maintain "snorkel depth" - a depth measured in inches. To protect the engines from overheating resulting in this manufactured partial vacuum a level of vacuum was established equivalent to 7,200 feet of altitude when operating engines would automatically shut down any time the induction valve would shut. The reduced pressure in the submarine would occur within a matter of seconds depending on the number of running engines which making it necessary to go through a lengthy process to resume snorkeling. Thus, it was riskier to snorkel on more than one engine making the period of snorkeling longer to achieve the desired level of battery charge with a commensurate increase in time of noise from snorkeling and increased exposure to detection.

The internal submarine environment became more significant with the elimination of routine surface operations following the installation of the snorkel. While the ability to measure the concentration of oxygen existed chemically, it was more common to rely on knowing oxygen was low when it became difficult to light a cigarette. As for carbon monoxide, there would always be someone in the crew who would develop a headache from this airborne gas. We were fortunate on Razorback for it was the commanding officer who developed the headache who would direct the Officer of the Watch to proceed to periscope depth to ventilate the ship which was done with a blower through the snorkel induction valve. Carbon dioxide can also be a problem but reliance on maintaining safe levels coincided with the maintenance of oxygen; this became an issue on nuclear submarines.

On board trash is a special problem on all submarines, both conventional and nuclear. Household trash from the galley, routine wastebasket trash, and general trash such as unusable remains from maintenance activities must be disposed of in such a way that it cannot be recovered by the opposition. Rubbish is placed in screened bags that will fit into the Garbage Disposal Unit (GDU) (a large diameter "pipe") from inside the submarine (usually in the proximity of the galley) through the hull to the sea with valves on both ends. Smaller valved piping is connected to permit flooding and draining. The volume of the bag is known as well as the necessary weight of the filled bag to ensure it will not float to the surface which would allow recovery by a potential interested party - the contents could identify the fact a submarine was operating in the area; each bag is weighed and additional metal weights (called "hockey pucks" due to their size and general appearance) to ensure the required weight. Trash disposal was always done at periscope depth and at varying hours at night to avoid establishing an identifiable schedule. The process consisted of ensuring the inner valve was verified shut, flooding the GDU, raising the pressure of the tube to sea pressure which allowed opening the external valve. Trash is then pumped to sea. Restoration of the GDU required shutting the outer valve, pumping the water from it, then venting the pressure from the tube into the submarine which permitted opening the inner valve to repeat the process. While considered a mundane activity, it was a very important one such that improper loading the GDU could result in unintended potential detection of the submarine. Caps on bottles had to be removed and light bulbs broken because these will implode with sea pressure as they sink to the bottom with a most recognizable sound (much like that of a hand grenade) which is counter to the submarine practice of remaining undetected.

Routine Submarine Operations - Submerging

While submerging might be considered a routine evolution, it may be infrequent for those on extended submerged operations. Sixty day submerged operations is considered routine for nuclear submarines; my own longest submerged operation was over eighty days - which was on a conventional submarine. Submerging is accomplished by opening vent valves to ballast tanks located fore and aft external to the pressure hull which allows water in these tanks to be discharged. The initial dive following a period in port is performed with strict adherence to a "diving procedure" which includes securing storage of everything on the ship, the determination of the predicted "trim" estimating the location of the weight versus the displacement of the ship versus the weight of displaced ocean water (if too light, the submarine drifts towards the surface at very low speeds; if too heavy the submarine will sink without speed of the ship and/or angle of the ship). The initial dive is normally to periscope depth (the most shallow operating depth) to verify initial trim; then down to a safe depth for final trim at slow speed. Weight is discharged/flooded in as well as moved forward or aft in "trim tanks" located forward, aft, and amidships. While onboard weight changes little throughout the cruise, routine trim changes occur with changes in ocean temperature as well as depth changes since the hull compresses as depth increases. This can be demonstrated by tying a string from hull to hull when at deep depth which will break as depth decreases and the hull expands.

Once submerged, conditions are established for the degree of quietness the ship will operate; the normal condition is "Patrol Quiet" which controls the performance of noisy evolutions within the ship. The next level is typically called "Ultra Quiet" which prohibits additional shipboard evolutions. The Wahoo had one unique additional level which was named "Squeaky Quiet" which was used only during a special condition when trying to track/record a particular foreign submarine. This involved the shutting down of all electrical equipment - including propulsion, prohibiting the movement of personnel except in their stocking feet and then hovering by resting either on top of, or below a temperature gradient so as to be in the same layer as the target submarine; it was an evolution that required remaining in this state for several hours at a time.

Routine Submarine Operations - Surfacing

Coming to periscope depth in preparation for surfacing is one of the most hazardous evolutions routinely performed by submarines. The potential for a collision when coming to periscope depth is not zero. Initial preparations start at a depth that is above any sound layer (sharp underwater temperature change) to improve the probability of sonar detecting any surface contact. Since submarine sonar cannot hear aft, the ship "clears baffles" in both port and starboard directions. Sound powered phone connections are made in all compartments and all watertight doors are "placed on the latch". The submarine then proceeds to a safe depth (collision proof), then proceeds to periscope depth; on the way up, the conning officer raises number two periscope (the longest periscope with no special features built into the number one periscope; also the more expendable periscope should it collide against a "solid object) on the way up so he can quickly scan the horizon in "low power" as soon as it breaks water to verify no close contacts threatening immediate collision followed by a more careful search in high power (more magnification) search for contacts on the horizon. The threat in this evolution results being directly ahead of the surface contact where its radiated sound is the least - noise from all ships radiates mainly from its screws; the bulk of the ship blocks out this screw noise from being transmitted forward. This condition magnifies as ships get larger and commensurate deeper drafts. Most submariners have experienced a near miss performing this routine evolution. The final step in surfacing is to blow the water out of the ballast tanks with high pressure air.

Routine Submarine Operations - Sonar

There are two types of sonar - active and passive. Active sonar involves the transmission of a pulse of energy which most identify as a "ping" with a return echo reporting both bearing and range of the target. Passive sonar emits no energy pulse such that it is limited to "listen" only and is the normal mode of operation for all submarines. Skilled submarine operators learn to classify all sonar contacts whether including all manner of sea life well as all contacts including both surface ships or submarines based on the quality of their screw noise. Target speed can be determined by classifying the type of target, then taking a propellor "turn count" (counting the rpm of the screw) to estimate the speed. What cannot be directly determined is the range (distance) to the target which requires considerable analysis. This has changed significantly in the newest submarines with the use of computers supporting both target classification and fire control solutions when engaging in combat.

Contacts by passive sonar are dependent on environmental conditions as well as target aspect and can range out to a hundred miles or more. The major environmental condition is the magnitude of the temperature change (the depth is termed the "sound layer) followed by the location of both the submarine and the "contact." The quality of the signal is when both the submarine are on the same side of the sound layer. The strength of this layer can be very significant. I had one experience when we wanted to leave periscope depth and get below the sound layer which happened to be at 125 feet. It was necessary to take a near 30 degree down angle and to increase speed to standard in order to penetrate this layer. (Needless to say, this was exceptional). This layer is used tactically. If limiting detection from sonar equipped surface ships, it is prudent to remain below the layer.

Standard Routines.

Commonly called "Fix, Fox, Pump and Dump." The "Fix" part is to obtain a navigational determination of the ship's position. When at sea this is done traditional by getting a land fix, by radar or Loran. When these are not available (most often when not in home waters, the navigator must rely on star fixes which requires considerable skill when determining star altitude through a periscope on a platform that is in constant motion.

The "Fox" activity is to receive any radio messages transmitted by the supporting organization under which the submarine is operating. A typical single message would be retransmitted over an eight hour time frame at predetermined times. Outgoing communications were not permitted - again, to avoid potential detection by opposing forces except in emergencies or high value reports.

The "Dump" part refers to disposition of all accumulated human and galley waste. These wastes are accumulated in "Sanitary Tanks" located in several locations throughout the ship. All inlet supplies to these tanks, called Sanitary Tanks, are verified "shut" to ensure non- use until the evolution is complete (bathrooms and galley drains). Air is applied to the tanks to exceed external sea pressure, then opening the discharge valves. When completed, discharge valves are shut and internal valves are "cracked open" to slowly vent the pressure off through carbon filters into the submarine itself. There is always the submarine sea story of the individual who, in the very early hours of the new day, will ignore the warning tags of the evolution in progress, will flush the toilet to be brought to his most alert attention when the contents of the sanitary are "blown into his face." Tradition requires the offender to clean up the mess.

Training and Qualification.

Training on submarines never ends. The initial training of a new submariner is to "get qualified;" training received in submarine school is considered only an introduction, as well as a means to weed out those who have been identified as "unqualifiable." Once on board his initial submarine, he is expected to learn, in detail, all systems, how to perform all evolutions, how to operate all ship components, and to become proficient at all watch stations. The screening includes an on-board adaptability assessment which, typically includes close observation of the candidate the first time he goes to sea which usually includes a round-the-clock drills lasting for three to four days resulting in minimum opportunities for rest. The candidate will, typically, complain he can't sleep and begins to cast doubt about his new environment. He is then observed more closely and should he not respond to counseling and assuring him that the next time he goes to sea, it will be a duration much longer than three or four days, he will usually become a nonvolunteer and is transferred upon return to port. The time to qualify requires approximately one year to complete and is rewarded by being designated "Qualified in Submarines" and awarded his "dolphins" (silver for enlisted and gold for officers). This becomes more challenging when approximately one fifth of the crew changes between major deployments. It is typical for many watchstanders to initially stand port-and-starboard, sometimes called "heel-and-toe", when the standard is one in three, until replacement watchstanders can qualify for their initial watch stations.

Special Operations.

Deployed peacetime submarine operations requires the maintenance of the proper number of submarines to a given area, asa well as for aircraft carriers, destroyers, air wings, marines, or army assignments. Deployed submarines spend part of their time in supporting integrated fleet operations while some of it is devoted to "Special Operations." These are assignments to forward areas normally considered foreign waters for observation of the activities of foreign navies to assess their capabilities. Further, it provides submariners to gain experience in potential operational areas in any future conflict. As might be expected, submariners are most interested in potential opposition submarine capabilities including tactics, offensive weapons, submarine search capabilities, and offensive/defensive missiles. The most basic requirement was to “Remain Undetected” which was rigorously enforced. To be a confirmed detection by a foreign navy typically resulted in loss of command on return to port.

Remaining undetected was of such priority that fuses powering any equipment of inadvertently radiating any electronic signal such as radar, active sonar, or radio were removed which were attached near their normal positions should there be an emergency need their use.

Deployment time was spent at periscope depth where electronic and foreign communications signals could be intercepted as well as sonar and visual contacts. Most of this is accomplished by the exposure of a single, but detectable, object above the water - number one periscope which had the installed capability to intercept radar and communication as well as normal visual capability.

Standard practice was to remain in international waters with very few exceptions.

NUCLEAR SUBMARINES

USS SHARK (SSN 591), a “nuclear attack submarine” commissioned in the mid-60's and one of a class of five submarines designed for offensive operations which included the Scamp and the Scorpion which was lost in May 1968 near the Azores returning home from an operation in the Mediterranean. Shark was named after two predecessors identified asa “Shark I” that was the last submarine to depart from Manila following the Japanese attack in December 1941. She was the first submarine lost during her first patrol in February 1942 by a Japanese surface craft. The second Shark 2 was commissioned in 1944 sinking 4 ships for 21,672 tons on her third patrol over a four day period. She was lost off Luzon when counter attacked following her sinking of a troop transport.

USS SCAMP (SSN 588) was also commissioned in the mid-60's and a sistership to the Shark and the Scorpion. Her namesake was commissioned in1944 and was credited with sinking 5 ships, including one Japanese submarine for a total of 34,100 tons over a period from July to January 1944. She was lost in December 1944 when counter attacked by Japanese aircraft off the entrance to Tokyo Bay.

USS HENRY CLAY (SSBN 625) was a Ballistic Missile submarine carrying sixteen Polaris missiles with each missile carrying multiple warheads whose mission was deterrence.

Description of nuclear attack submarines. Nuclear power gives these submarines unlimited capabilities in underwater warfare in that the only limitation they have is the food supply they can carry on board resulting in the ability to never having to come to periscope depth to charge batteries. In addition, they have complete control over the internal submarine environment by being able to make unlimited fresh water from the sea, then making their oxygen from the fresh water. They are also in complete control of the internal environment including oxygen, carbon monoxide/dioxide, and potential cooking odors. Showers are routine and an onboard laundry increases the morale of all on board. Because they have a single propeller, they have but a single torpedo room.

Nuclear power enhances their tactical offensive capabilities by speeds approaching thirty knots submerged and deeper operating depths. They are designed for quiet operation by eliminating internal sounds from operating components transmitted to the hull which can then be radiated through the sea to potential listeners. High speeds, in combination with expanded maneuverability, includes larger potential angles and sharper turns. At higher speeds, a sharp turn results in a rolling response which causes the vertical rudders (upper and lower) to act as the horizontal diving planes resulting in an unintended downward spiral. For submarine safety, high speeds at near test depth are discouraged. Angles approaching thirty degrees are limited, and then only in an upward direction. At the same time, a significant angle will be typically taken in the early days of a deployment to verify proper storage throughout the ship. Operating the submarine at various controlled angles is routine for the training of ship plainsmen and helmsmen.

Living on board a nuclear submarine means that the environment one starts out with is the same one ends with. It is not uncommon that the first ten days of any deployment all on board will be exposed to the minor airborne ailments brought on board followed by no further minor ailments for the remainder of the deployment.

While one would believe those living on a nuclear submarine would be exposed to higher levels of radiation, the truth is that they receive significantly lower doses than those at home due to both the design of nuclear related components, high standards of operational controls. operator training, and the commitment to maintenance and cleanliness.

The modern nuclear submarine is designed for deployments lasting up to ninety, or more days. The inconveniences on diesel electric submarines of lacking environmental control, storage space, and the need to recharge batteries do not exist on nuclear submarines.

Weapons systems have expanded such that some are now equipped with cruise missiles as well as more sophisticated torpedoes. They now have the capability to tow sonar hydrophones to enhance computer driven target identification, tracking, and sophisticated attack capabilities.

<u>Nuclear Missile Submarines</u>.

These submarines are, with the exception of that portion dedicated to the storage, and launching, of long range ballistic missiles, are very similar to nuclear attack submarines including their propulsion systems, torpedoes (for self defense and to carry out normal submarine offensive operations after a missile launch), normal submarine systems common to all submarines. Their crews are larger to accommodate operation and support of the missile systems (launch control and maintenance of support systems) requiring more crew accommodations. These missile submarines have the capability to launch ballistic missiles having multiple warheads at ranges in excess of four thousand miles.

Their patrol operations, however, are quite different. While the attack submarines are designed to establish contact with contacts of interest for potential offensive operations, missile submarines are expected to avoid potential contact by any means.

The missile launches are tightly controlled and only when specifically authorized by the President of the United States (the president's launch codes are carried by a military escort at all times) which is communicated by a dedicated communications system (receiving only) making the highest priority to maintain communications at all times; patrolling submarines are graded on the percentage of time communications was lost - 100% of time on line is the achievable goal. Communications systems are designed to accommodate the normal patrol depth which is deeper than the submerged launching depth.

The two-man rule is the standard in the launching of a missile from the time a "launch message" is received on board until missiles are launched. This includes the verification of the coded launch message by more than a single person (not the commanding officer) against two separate codes (stored in two different limited access safes. Likewise, two separate individuals must simultaneously hold down separate dedicated launch keys (Commanding Officer and the Weapons/Missile Officer). Each missile is assigned prearranged specific targets which may change when directed by proper authority in support of an integrated attack plan that integrates other offensive weapons whether by land-based missile silos or manned aircraft. Simulated missile launches occur randomly throughout the week.

Missiles are launched underwater towards the surface when the missile propulsion system is activated. A special ballast system is installed to accommodate the large weight changes that take place during the launch sequence. The first is the loss of weight when the missile leaves the submarine followed by the increase in weight as the empty missile tube fills with sea water. These weights are approximately equal depending on the time for the missile hatch to shut.