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>
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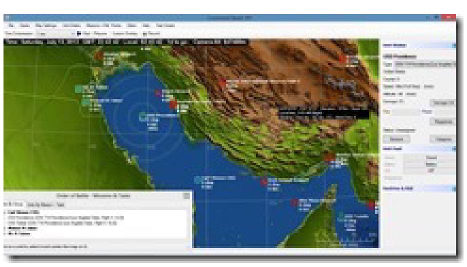

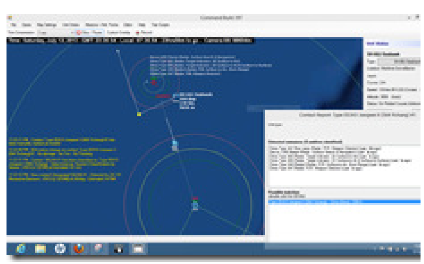

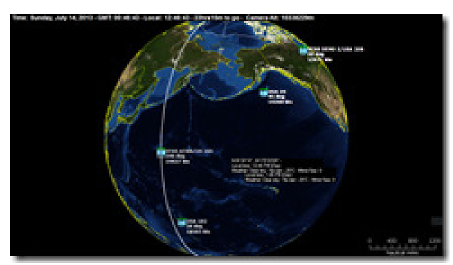

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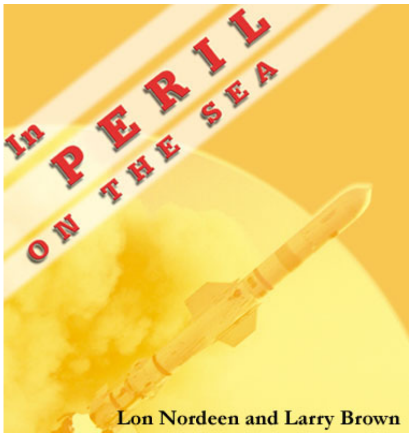

Surface combatants are facing more lethal anti-ship missiles

Missiles have changed the nature of naval warfare. Aircraft and small fast attack craft now have the same lethal punch as large ships. Anti-ship missiles increase the range of engagements and decrease the warning time available for the defender. Today more than seventy nations field sea- and land-launched anti-ship missiles, and twenty nations possess air-launched versions of these weapons. Anti-ship missiles arm warships, fast attack craft (FAC), fighters, bombers, patrol aircraft, helicopters, submarines, and mobile costal-defence batteries. Aircraft and helicopters armed with anti-ship missiles have demonstrated distinct operational advantages over ship-, submarine-, and land-based systems since they allow greater employment flexibility and superior sensor range. The largest percentage of the successful ship strikes using missiles over the past five decades has come from aircraft.

These systems have been used in numerous conflicts and despite major investments in naval missile defence systems, engagements to date have overwhelmingly favoured the attacker. Dozens of warships and nearly 200 civilian vessels have been damaged or sunk by anti-ship missiles during the past 30 years.

The Styx Surprise

On October 21, 1967, P-15s (Russian short-range tactical anti-ship missiles, a.k.a. Styx) fired from Egyptian Komar fast attack craft hit and sank the Israeli destroyer Eliat with considerable loss of life *(see "First Person...Singular", JED April 2001.)* Naval confidence was severely shaken by this successful attack and suddenly the anti-ship missile threat became the center of attention. The sinking of the Eliat was followed on May 13, 1970 by the destruction of another Israeli vessel (Israel said it was a fishing boat; Egypt, a spy ship), also with the P-15 anti-ship missiles. These attacks should not have come as a surprise since Soviet ships and bombers had been armed with these weapons since the late 1950s. Styx-equipped Osa and Komar fast attack craft and Tu-16 jet bombers armed with AS-5 Kelt anti-ship missiles were exported to many nations allied with the Soviet Union. The People's Republic of China (PRC) produced copies of the Styx design and widely exported them.

Subsequent employment of various versions of the Styx in combat has seen mixed results. Reportedly 11 of 12 P-15s fired by missile boats of the Indian Navy during the 1971 Indo-Pakistan War hit, sinking the Pakistani destroyer Kyber, a minesweeper, several cargo ships, and damaging the destroyer Shah Jahan. These missiles were also reportedly used with some success against Pakistani oil facilities. During a January 1974 engagement near the Paracel Islands in the Pacific Ocean, PRC destroyers fired a number of HY-2 Styx missiles, sinking the South Vietnamese minesweeper Nhut Tao and damaged the destroyer escort Tran Khanh Duh .

However, none of the 50-plus Styx missiles launched by Arab fast attack craft during the 1973 Arab-Israeli war reportedly hit an Israeli vessel. Israeli missile boats armed with shorter-ranged Gabriel anti-ship missiles reportedly used manouvering, electronic countermeasures (ECM), and anti-aircraft fire to evade, decoy, and shoot down Styx missiles, while closing in to strike with their own missiles and follow up with gunfire. Israel claimed to have sunk a dozen Egyptian and Syrian vessels during three engagements, but several neutral merchant vessels were also reportedly hit. Egyptian Air Force Tu-16 bombers launched several AS-5 Kelt missiles during the 1973 conflict. None of these hit Israeli ships, but they caused damage to an ammunition depot and a radar site.

The successful employment of Exocet anti-ship missiles during the 1982 Falkland Islands/Malvinas conflict against Royal Navy vessels had a major impact on the course of battle. Argentine Navy Super Etendards flew five attack missions, fired six Exocets, and hit the HMS Sheffield with one missile and the Atlantic Conveyor with two. Both of these ships were gutted by fires and later sank. An Exocet fired from a mobile land launcher hit and damaged the HMS Glamorgan. The warhead that hit the Sheffield reportedly did not explode, and it is thought that several other Argentine Exocets were decoyed by chaff or fell short of their targets *(see "EW in History: Sheffield Destroyed!" JED , March 2001).* The AM-39 Exocet air-launched missile allowed low-flying Super Etendards to attack from beyond the range of ship-based radar and the short-range defences of these ships. To defend against attack, Royal Navy Sea Harriers flew regular combat air patrols with direction from ship radars. A dozen bomb-carrying Argentine Daggers and five Skyhawks fell to Sea Harriers, and many more were lost to gun and missile fire from ships. Not a single Super Etendard was lost, again highlighting the survivability benefits for aircraft using anti-ship missiles.

British helicopters were also involved in strike operations. Royal Navy Lynx helicopters fired the 8-nm-range Sea Skua for the first time, sinking two Argentine patrol craft and damaging another, while Wessex helicopters also damaged the submarine Santa Fe with obsolete wire-guided AS-12 missiles.

During the 1980-1988 Iran-Iraq War, naval vessels and aircraft from both sides employed anti-ship missiles. Iraqi missile boats armed with P-15s sank a number of Iranian naval vessels, while Iraqi Air Force fighters and helicopters scored repeatedly with Exocet missiles. Iranian aircraft and naval vessels also sank Iraqi shipping vessels with Harpoon and Sea Killer missiles and bombs.

An important but little known aspect of the Iran-Iraq conflict was the long-running "tanker war," during which Iraqi and Iranian aircraft and naval vessels attacked some 600 oil tankers and cargo ships. Lloyds of London has classified 286 separate anti-ship missile attacks against 260 ships as they passed through the Straits of Hormuz and along the Arabian Gulf. Iraqi Super Etendard, Mirage F1s (there are reports that Iraq also bought several Falcon 50 business jets equipped with F1 radars and ECM systems and used these aircraft in anti-ship strikes because of their greater range and capability to carry two Exocets), and Super Frelon helicopters made the bulk of these attacks. Exocets were also used with some success against oil facilities at Kharg Island. Iranian jets employed bombs and rockets, while ships employed Italian-supplied Sea Killer missiles for attacks on tankers supporting Iraq and the nations buying its oil. During eight years of attacks, more than 150 ships suffered serious damage from missiles, and about 70 were put out of service but less than twenty sank, were beached, or became an immediate total loss due to missile attacks. Oil tankers and large cargo ships proved to be survivable due to their size and strong construction. Some shipping companies reinforced engine rooms and crew spaces with sand bags, water-filled compartments, and filled empty oil tanks with carbon monoxide to reduce missile warhead damage and the danger of fire. Tanker captains also hugged the shore to take advantage of Iranian air and sea cover and increase the possibility that missiles fired at the tanker would transfer radar lock to radar returns from land rather than that of the ship. Reportedly, sizable numbers of anti-ship missiles were decoyed by radar returns from land or floating radar reflectors, and a number of Exocet missiles struck their targets, but their warheads failed to explode.

In reaction to these attacks, the US and many western nations sent warships to the Arabian Gulf to escort tankers through the region to ensure the flow of oil. On May 14, 1987, the USS Stark was severely damaged, and 37 of her crew killed by two Exocet missiles fired from Iraqi aircraft. This attack was successful even though the radar operators on the Stark initially detected the Iraqi aircraft and warned them away via radio. The Stark was an FFG-7 (O.H Perry) class frigate armed with a SM-1MR Standard surface to air missile system, Phalanx radar-directed anti-missile gun, and chaff dispensers to decoy approaching missiles, but these systems were not used in defence of the ship.

The Artigliere-class frigate Bersagliere of the Italian Navy during a port call to Abu Dhabi in March 2001. The ship, classified by the Italians as a fleet patrol ship, carries eight Otomat Teseo Mk 2 anti-ship missiles in four twin launchers. A twin launcher is visible above and to the right of the gangway. Photo by Michael Puttré

The Harpoon anti-ship missile was first used in combat during operations against Libyan vessels on March 24-25, 1986. Missiles fired from A-6 bombers and the cruiser USS Yorktown sank three Libyan fast attack craft. During operations in the Arabian Gulf on 18 April 1988 Harpoons were again fired from A-6s, a USN cruiser, and a frigate, sinking two Iranian naval vessels.

The 1990-1992 Gulf War also saw effective use of anti-ship missiles. Helicopters of the Royal Navy and Saudi Navy using Sea Skua and AS-15TT missiles destroyed a fleet of Iraqi patrol boats and assault craft, which ventured into the Arabian Gulf. In January 1991, a Harpoon fired from a Saudi Navy attack craft sank an Iraqi minelayer in the Arabian Gulf.

Combat operations have demonstrated that a solid hit from an anti-ship missile will have a serious impact on a warship. A missile hit will usually neutralize a warship even if it is not sunk since fires and the disruption of combat systems and sensors will likely disable the ship. Missile hits on oil tankers and large cargo ships have had mixed results: some caught fire and were burned out but others suffered only minor damage.

While most readers will recall the shock of the destruction of the Israeli Eliat and the British Sheffield by anti-ship missiles, these were not the first large warships to fall prey to guided missiles. During World War II, German Luftwaffe bombers sank the defecting Italian battleship Roma with FX-1400 (aka Fritz-X) radio-guided bombs, and more than a dozen allied ships also fell prey to this and the similar H-293 guided bomb. In the Pacific theater, the Americans employed the Bat, a radar-guided glide bomb, which sank a Japanese destroyer in April 1945. However, the most effective anti-ship “guided missile” of World War II was the Japanese kamikaze pilot. From October 1944 until the end of the war, Japanese fighters, bombers, and their crews flew more than 3,000 kamikaze attacks, sinking some 50 allied ships and damaging more than 300. Nearly 5,000 American and British sailors were killed as a result of these attacks, while the Japanese lost some 2,300 aircraft and their crews. Japanese kamikaze lessons and tactics were studies by the Soviets and included in their war-at-sea plans.

The Soviet Naval Challenge

The Soviet Union, unable to match the United States' and allied superiority in aircraft carriers and surface combatants, turned to bombers, fast attack craft, submarines, and coastal-defence batteries armed with anti-ship missiles to provide a solution to this naval imbalance. In the late 1950s and 1960s, the Soviet Navy first deployed missile-armed jet bombers, surface ships, and submarines. Russian first-generation anti-ship missile systems included a special class of "strategic" anti-ship missiles. Most of these special-mission systems had supersonic speed and large warheads in order to overcome limitations in the technology of systems and sensors of the 1960s. Air-launched systems included the turbo-jet powered KS-1 (NATO: AS-1 Kennel), RSL-1 (NATO: AS-2 Kipper), and KSR-5 (NATO: AS-6 Kingfish), plus the rocket-propelled Kh-22 (NATO: AS-4) and KSR-11 (NATO: AS-5 Kelt). All of these were relatively large missiles and were carried by Tu-16, Tu-95, and Tu-22 bombers of the Soviet Naval Aviation Force.

Russian Echo II- and Juliet- class submarines and large Kresta and Kynda destroyers were armed with the long-range P-6/7 (SS-N-3 Shaddock). Submarines had to surface to fire these missiles, and they required external targeting. As large as fighter planes, the P-6/7, KS-1, and RSL-1 missiles were slow to bring into action. However, these missiles had radar, infrared homing sensors, or anti-radar seekers, and most were suspected of being capable of carrying nuclear (or large high-explosive) warheads, which posed a threat to American aircraft carriers and NATO naval fleets. Few of these systems were ever exported, which highlights their sophistication and special-mission focus.

Compared to Western subsonic missiles, the large Russian supersonic missiles had the advantage of long range and high speed, which compressed the defenders reaction time; and diving or low-altitude attack trajectories, which were a challenge for terminal defences. However, large supersonic missiles such as the P-6 weighed 9,900 lbs. and were 33 feet long. This size limited their launch platforms to large aircraft, ships, and submarines and reduced weapons load out. This type of missile costs much more to design, build, and maintain than the Western Exocet or Harpoon. The supersonic speed and medium altitude flight profile of the P-6/7 anti-ship missiles produced a large infrared signature and allowed early detection by ship and airborne radars. Outside of the Soviet Union and the PRC, most of the first- and second-generation anti-ship missiles developed and fielded have been subsonic systems.

Supporting these "strategic" weapons, the Soviet Union deployed large numbers of tactical anti-ship missiles on their destroyers, fast attack craft, and submarines. Ships were armed with the P-15/20/21/22/27 (NATO: SS-N-2 Styx) and P-120 Malakhit (NATO: SS-N-9 Siren), which had high-explosive warheads. These missiles flew at high subsonic speeds, with a range of 24-60nm, and were similar in performance to Western tactical anti-ship missiles. In the late 1970s, the first Charlie-class submarines armed with the 43-nm-range P-20L missile (NATO: SS-N-7 Starbright) entered service. These missiles caused quite a shock since they could be launched while the sub was submerged.

At its peak in the 1970s and early 1980s, the Soviet Union could field some 70 major warships armed with 450 anti-ship missiles, 70 guided-missile submarines with more than 400 anti-ship missiles, and 250 bombers with 500 missiles. The Soviet Navy had an offensive doctrine: if times of tension turned to hostilities, a surprise assault was planned with sufficient numbers of missiles to overwhelm US defences. Massed waves of bombers firing missiles in concert with submarine and ship attacks were designed to swamp US defences in order to disable or destroy aircraft carriers. The Soviets studied the lessons of the Japanese kamikazes and US defences and were prepared to expend enough missiles and suffer serious losses to accomplish their mission.

The US also pursued the concept of cruise missiles, and during the 1950s and 1960s, the US Navy tested the submarine-launched Regulus, Regulus II, and Rigel, while the US Air Force developed the Matador, Mace, Snark, and Navaho. However, these systems were employed in a land-strike role using nuclear warheads and were soon replaced when more efficient and faster ICBMs came on line. For tactical missions, these cruise missiles suffered from a lack of accuracy and reliability and were in competition with the large US Navy carrier-aviation force and USAF Tactical Air Command. However, improvements in technology and tactical doctrine led to the development and deployment of the Harpoon and an anti-ship version of the Tomahawk.

Threats from Many Quarters

Most Western navies opted for more compact, subsonic missiles with good lethality and range but less impact on ships and aircraft than the Russian supersonic missiles. In the 1960s, the French had already been testing an anti-ship missile and, the resulting the Exocet was rapidly brought into service. Similar systems such as the Norwegian Penguin, US Harpoon, Israeli Gabriel, and Italian Otomat were fielded in large numbers during the 1960s-80s. These lethal missiles were deployed on a variety of ships ranging from small patrol boats to battleships, and the Exocet and Harpoon could be fired from ships, aircraft, submarines, and mobile truck launchers.

The Soviet P-15/20 Styx, Chinese HY-2, French MM-38 Exocet, Norwegian Penguin, Israeli Gabriel, US Harpoon Block 1, and Italian Otomat are examples of widely deployed first-generation tactical anti-ship missiles. The Styx, HY-2, Exocet, Penguin, and Gabriel have rocket-propulsion and a range of 20-30 nautical miles, while the turbojet-propelled Otomat and Harpoon could hit targets at a range of more than 60 nautical miles. The Harpoon, Otomat, Exocet, Styx/HY-2, and later versions of the Gabriel employ active radar seekers to detect and attack ship targets. This provides all-weather capability and good open-ocean performance. The first versions of the Israeli Gabriel used semi-active radar guidance, while the Penguin and some Styx/HY-2 variants have infrared seekers. These systems were designed for short-range, point-to-point engagements in open waters. Warhead size for first-generation Western anti-ship missiles ranged from the 225 lbs. of the Penguin to the Harpoon's 500 lbs., which though smaller than the 1,058 lbs. of the P-15/20 Styx, is still large enough to produce significant damage for a mission kill. A small number of naval vessels around the world were armed with smaller anti-ship missiles such as the 170-lb., 3.8nm-range SS.12 wire-guided system and the 760-lb., 13.5nm-range radar-guided Italian Sea Killer system.

A US Air Force F-16 fires a Penguin 3 anti-ship missile. The first practical Western anti-ship missile, the Norwegian Penguin family is widely used and carried by a variety of fixed-wing aircraft, helicopters, and ships. In US service, the missile is designated AGM-119. US Air Force photo

A number of other missiles fielded during the 1970s and 1980s were designed to be fired from aircraft against ship targets. The rocket-powered German MBB AS.34 Kormoran armed the F-104 and Tornado. This 16nm-range missile had a radar seeker and a 364-lb. warhead with a fragmentation pattern designed to be especially lethal to ships. Japanese industry developed the ASM-1 (Type 80) rocket-propelled anti-ship missile, which is carried by the F-1 light strike aircraft and the P-3C of the Japan Air Self Defence Force. This missile has an active radar seeker and a 330-lb. warhead. Britain funded the development of the turbojet-powered Sea Eagle to arm its Tornado and Sea Harriers in the anti-ship role. More than 800 of these 60nm-range missiles were bought by the UK, India, and Saudi Arabia but the system is now being retired.

The Russian Kh-35 Uran (NATO: SS-N-25 Switchblade) is a medium-range anti-ship missile that entered service in the early 1990s and that closely resembles the US Harpoon (so much so that it was dubbed "Harpoonski" in Western circles). Like the Harpoon, it is deployable on a wide variety of platforms, with ship- and air-launched and coastal-defence versions available. Photo by Michael Puttré

Norway fielded an air-launched version of the infrared-guided Penguin anti-ship missile for its F-16A/B fighters, and an improved version of this system has been sold to a number of nations to arm SH-60 Seahawk naval helicopters. Swedish Air Force Lansen and Viggen strike aircraft were armed with the rocket-powered RB 04, which had radar guidance and a 600-lb. warhead. Israeli Phantoms and Skyhawks were armed with the Gabriel Mk. 3, an active radar-seeking variant of the Israeli-developed anti-ship missile. Chinese Xian (Badger) jet bombers were armed with 50nm-range CAS-1 Kraken anti-ship missiles based on the Styx design, while smaller Q-5 fighter-bombers carried YJ-1 "Eagle Strike" missiles, which were similar to the French Exocet or Japanese AS-1 in configuration and performance. The AGM-65F/G Maverick air-to- ground missile has been fitted with a passive IR seeker and a 300-lb. blast warhead with delay-option fuse for use against ship targets. The F/A-18 and P-3C patrol aircraft can carry this 7.5nm-range missile.

A lightweight and relatively inexpensive class of anti-ship missiles was developed by Western firms to arm naval helicopters to engage threatening fast attack craft and other targets. This includes the British Sea Skua, French AS.15TT, and American Hellfire. The first two employ radar guidance, while the Hellfire employs laser guidance. While the range of these systems is only 4-10nm and the warheads are small (10-25lbs), these systems have proved to be effective for their role of attacking small naval vessels. The AS.12 wire-guided system, which armed Royal Navy helicopters, was also in this class of weapons. The larger and more powerful 570-lb. Italian Marte Mk 2 is carried by helicopters of the Italian Navy. This missile has a range of 12nm and an active radar seeker for terminal guidance.

First-generation missiles such as the Exocet, Harpoon, Otomat, Penguin, and the Styx have been upgraded to increase their overall performance through the addition of more advanced seekers and propulsion systems. Improvements in fire-control, computer, seeker, and guidance technology have allowed missiles to perform a wider variety of search patterns, fly true sea-skimming profiles, and have greater off-axis capability. In addition, guidance systems fielded in the late 1980s and 1990s also had improved ECCM performance and adjustable sea skimming performance and gave the missiles better capabilities to survive terminal defences. More powerful rocket motors and upgraded fuel have also added to missile ranges. Computer and display upgrades have also dramatically improved missile mission planning, allowing military planners to employ more flexible tactics and develop multi-missile target engagements.

The Harpoon and Exocet are the most widely deployed Western anti-ship missiles today, with Russian and Chinese variants of the Styx (which are now reaching obsolescence) still probably close in total numbers - but not for long. More than a dozen firms in the US, the PRC, Russia, Asia, and Europe produce anti-ship missiles today.

During the 1980s, the US Navy bought more than 500 UGM/RGM-109B Tomahawk Anti-Ship Missiles (TASM). The subsonic TASM had a Harpoon active radar seeker, an ESM system for target detection, and a 1,000-lb. warhead. This anti-ship missile could be fired from ships and submarines and had four times the range and twice the warhead weight of the Harpoon, which put it in the class of Russian long-range anti-ship weapons. The TASM was deployed, but after several years of service, it was replaced by conventional Tomahawks as the land-strike mission overcame war at sea as the critical post-Cold War mission emphasis.

Technology Evolution

The Harpoon is a good example of the evolution of modern anti-ship missiles. The incorporation of new technology has enhanced tactical capability and mission performance, allowing the system to grow to meet the threat. Block 1, the initial version of the Harpoon, produced in 1979, was replaced in 1982 by the 1B version, which added a sea-skimming terminal-attack option. In 1984, the Block 1C Harpoon was fielded, with a longer range due to improved fuel, waypoint capability to allow the missile to fly around islands or other obstacles, and seeker ECCM improvements. The longer Harpoon Block 1D, with greater fuel capacity and additional range, was tested in 1991 but not fielded. The Harpoon Block 1G, introduced in 1995, has an improved seeker and additional mission flexibility, including the ability to re-attack a target if it was missed on the first pass. The latest version of the Harpoon is the Block II, which includes a GPS/INS, allowing for the attack of both ship and land targets.

The Russian X-31 (NATO: AS-17 Krypton) air-launched anti-ship missile is derived from the Kh-31P anti-radiation missile. It has a booster-rocket motor and four solid-fuel ramjets attached around a cylindrical body, giving the missile excellent speed - exceeding Mach 3.6 - and a maximum range 110 km. Photo by Michael Puttré

In 1990, the US Navy fielded the Stand Off Land Attack Missile (SLAM), which combined the imaging-infrared seeker from the Maverick missile, datalink from the Walleye glide bomb; and Harpoon airframe, engine, and warhead to create an air-launched, man-in-the-loop, precision-strike weapon effective against ships and land targets.

The Exocet has also developed beyond the MM38 to the MM40 version, and the third variant, the Block 2, is available today, with its longer range, a more capable seeker, and reliability upgrades.

The Swedish RBS15 is a turbojet- powered anti-ship missile, which replaced the RB04 in the air-to-surface role and is also available in ship and coastal defence variants. An upgraded variant of the Otomat known as the Mk 2 was fielded with mid-course datalink targeting capability. The Otomat Mk. 2 has been fielded in both ship- and coastal-defence versions. The Chung Shan Institute of the Republic of China (ROC, or Taiwan) has developed and fielded the Hsiung-Feng II anti-ship missile on ROC ships and aircraft. This turbojet-powered missile has a range of some 80nm and dual-mode terminal guidance with both active radar and an infrared seeker. Mitsubishi of Japan has developed an upgraded version of the ASM-1 powered by a turbojet engine and with an imaging infrared terminal seeker. Known as the Type 88, this 80nm-range missile arms ships and shore-defence batteries. Obsolete PRC Styx-class missiles are being replaced by the rocket-powered C-801, with a range of 22nm and the newer C-802 with turbojet power providing a range of 65nm. PRC supersonic anti-ship missiles are also in development, including the 27nm-range C-101 with ramjet propulsion, and the larger C-301 with a range of 97nm.

Second-generation anti-ship missiles can tackle almost any open-ocean conflict scenario where an adversary is in open battle formation while waypoints allow for engagements near land or obstructions. However, even advanced second-generation anti-ship missiles have some limitations in effectively engaging vessels close to land and cannot hit ships at the pier nor threaten shore targets such as a Silkworm site, gun battery, or radar site.

Anti-ship missiles have added considerable firepower to modern aircraft, ships, and submarines but have also added the burden of requiring some form of assistance to fire missiles accurately. Without accurate targeting information aircraft, ship, and submarine crews cannot take advantage of the range and firepower of their powerful anti-ship missile capability. Limited by its sensor horizon, the average ship radar can detect ship targets at ranges up to only 24nm. Sonar and EW sensors can detect ships at longer ranges but usually can provide only bearing information. An additional source of range data is usually necessary for effective missile firing. Aircraft radars and electronic detection systems provide much greater range and flexibility for detection and are better able to classify the target than are surface ships.

The Soviet Union and the US invested considerable sums into complex worldwide systems to develop and field ocean-surveillance and naval command and control networks. Since the side that fires first has the advantage, it has been important for naval commanders to monitor the location of potential adversaries. Both the US and the USSR fielded satellite-, ground-, and sea- based sensor networks to monitor the movement of the other's aircraft, ships and submarines. These included active radar systems able to search for and monitor ships through clouds; passive IR and EO systems; plus sonar and ESM systems that could detect, classify, and locate radar or electronic emissions. Kasatka was the name of the Soviet system. Satellite data is combined with information obtained from hundreds of other sources (such as human intelligence, surveillance platforms, etc.) to form a general picture of what is happening in important areas of the ocean.

Advances in computer and communications technology substantially reduced the information-fusion challenge. Tactical information is shared among ships, aircraft, submarines, and shore positions via datalinks to maintain up-to-the-minute information on changing conditions.

Naval commanders can call on a number of systems to collect tactical intelligence useful for targeting these missiles. US carrier battlegroups can access information from strategic networks and from E-2C Hawkeye surveillance aircraft. USN S-3B Viking or Navy fighters can evaluate air and surface contacts, while P-3 aircraft, ships, and submarines monitor submarine or surface contacts. Helicopter-equipped ships with SH-60 Seahawks, Lynx HAS3, or other advanced helicopters with their capable search radar, and datalinks are also helpful in missile targeting. NATO carrier or surface-action groups can rely on support from Royal Navy carriers, E-3 AWACS, or patrol aircraft for assistance.

Most first-generation anti-ship missiles are programmed at launch to employ inertial guidance along a path toward the planned target and then switch on an active radar or infrared sensor for terminal guidance. These were developed so that there was no interaction necessary with the launch platform after firing in order to increase independence and reduce vulnerability to jamming and deception. There are limitations on the ability of a missile seeker to discriminate among targets, and this constraint limits the tactical flexibility of these missiles. Careful targeting is required to reduce the possibility of hitting the wrong target, such as a tanker, cargo ship, or less desirable warship in a formation. Some anti-ship missiles (e.g., Soviet P-6/7 [SS-N-3], P-700 Granit [SS-N-19], Italian Otomat Mk 2) can be redirected in flight via datalink to adjust for target movement. The Soviets employed Tu-95RT Bear-D reconnaissance bombers and Ka-25RT Hormone helicopters and the Italians AB.212 helicopters to provide radar and/or visual confirmation of the target and mid-course guidance updates. While this improved missile-targeting accuracy, these bombers and helicopters were vulnerable and their presence could alert the defences. The semi-active radar homing Israeli Gabriel 1, British Sea Skua, and radio-command French AS-15TT have homing advantages, since they will only seek an illuminated target. However, these systems are limited to radar/radio line of sight, and target illumination must continue until impact; thus, the designating platforms are similarly vulnerable.

Anti-Ship Missile Defence

Naval leaders around the world responded to the anti-ship missile threat in two ways: improving their defences against anti-ship missiles and fielding similar anti-ship missile systems. The US monitored Soviet anti-ship missile investments, and the US Navy responded with an in-depth defence concept and, later, deployment of the Harpoon. This called for early warning planes to detect incoming bombers and direct USN fighters to intercept and shoot down Soviet bombers before they could launch their missiles. US carrier and land-based anti-submarine-warfare (ASW) aircraft and ships were assigned the task of destroying Soviet submarines, while US aircraft and ships blasted Soviet ships with Harpoons, bombs, and gunfire. The US Navy focused significant efforts on destroying Soviet launch platforms before a missile was fired to reduce the challenge of defending against incoming missiles. This concept made sense against large over-the-horizon anti-carrier missile systems carried on the Tu-16 Badger bombers, Juliet- and Echo-class submarines (which had to surface to fire their missiles), or Kynda and Kresta destroyers.

The Multi-Ammunition Softkill System (MASS) decoy launcher throws a pattern of dual-mode chaff and flare rounds from a German K-130 corvette. It can accommodate up to 32 rounds of varying types. The system deploys a tight decoy pattern close to the ship and is intended to counter supersonic and late-locking anti-ship missiles. Buck NT photo

Missiles that made it through the outer ring of defences were to be engaged by short-range missiles and anti-aircraft fire. To counter the threat of cruise-missile attack, new radars, infrared sensors, and EW-detection equipment were installed on naval vessels. First-generation Soviet anti-ship missiles like the P-15/20 Styx travelled at high subsonic speed (Mach 0.9) and flew about 300 feet above the sea to minimize detection. When launched at a maximum range of some 24nm, the missile took less than five minutes to reach its target. Activation of the P-15/20's terminal seeker could be detected by a warship's EW suite and give an indication of the missile's approach if the launch was not previously detected. However, this provided less than a minute of warning time before impact.

Once an incoming missile was detected, it could be countered by deceiving its seeker through a chaff screen and/or electronic jamming, or by shooting it down with gunfire or missiles. Supersonic missiles like the Russian P-6 and RSL-1 missiles were fast (Mach 1.4) and had a range of more than 200 nautical miles, but they flew at medium altitude and were good targets for fighters, as well as Talos, Terrier, and Tartar surface-to-air missiles. For area defence, many NATO ships were armed with Tartar surface to air missile systems, while the British had the Sea Slug and Sea Dart and the French the Masurca and Tartar missile defences.

Starting in the 1970s, naval vessels were equipped with self-defence suites including missile-detection radars, countermeasures dispensers for chaff and infrared decoys, and active jammers, plus terminal defensives like Phalanx, Goalkeeper, or Dardo guns and Sea Sparrow, Sea Wolf, and Crotale anti- missile missiles. In addition, multi-purpose helicopters were deployed on many warships for scouting, ASW, the detection and attack of adversary ships, and targeting for anti-ship missiles. More recently, nations have turned to improved surveillance, communications networks, and enhanced defences to counter faster and more lethal missile threats. This includes the export of Aegis radar technology to nations like Japan and Spain and the fielding of improved radar and missile systems in Europe. The US Navy and many other navies have made substantial investments ship self-defence technology. For example, the US has funded cooperative-engagement systems to detect and engage missiles and many new weapons, including the RAM, improved Phalanx, Evolved Sea Sparrow, upgraded Standard, as well as a multitude of ECM and decoy systems for improved ship self-defence.

The MBDA Polyphem missile is a multi-purpose weapon with a camera in the nose that sends real time video to the operator and command guided by means of a fiber-optic line, making it impervious to jamming. It is designed for ground and naval combat at a range of between 30 and 60 km. The image at left shows a Lynx helicopter with four Polyphem missiles on individual launch rails; the photo on the right is a mock-up of a twin-rail configuration. MBDA image, photo by Michael Puttré

Targets in the Littorals

With the shift in focus today from open-ocean to littoral or coastal operations, navies are calling for missile systems that can engage surface threats at sea, and small vessels in coastal waters or even ships in port. In addition, future systems must be able to deal with ever-increasing capabilities of deception systems and active defences.

To meet evolving tactical challenges, missile producers are developing new systems to improve the capabilities of current models in the littoral arena, and a new generation of missiles with both subsonic and supersonic performance is in advanced development. The Boeing Harpoon Block II has integrated a GPS receiver developed for the Joint Direct Attack Munitions program with a modern inertial-navigation system to eliminate missile-position uncertainty. This allows for smaller seeker search patterns and helps ensure that the designated target is found and struck. The new guidance system also allows the Harpoon Block II to attack vessels near the coast or at pier and to hit land targets with 10-meter accuracy. This capability has been developed and tested with the cooperation of the US Navy. The Harpoon Block II is now available as new-production missiles, as well as retrofit kits for older Harpoons. Harpoon Block II has been purchased by several nations and is being evaluated by the US Navy.

The Saab RBS 15 Mk 3 is also undergoing a major upgrade that will enhance the weapon's anti-ship performance and add GPS, a dual-mode seeker, and a two-way datalink to enhance littoral and land-attack performance. A major upgrade of similar proportions is planned by Otobreda for its Otomat series. Known as the Teseo 3, this enhancement includes a low- signature airframe and multi-mode electro-optical/radar seeker to allow for littoral and land attack. The Kongsberg Aerospace NSM, developed in cooperation with Aerospatiale, is a subsonic, turbojet-powered, low-observable missile intended for launch from Norwegian frigates and fast attack craft. Designed as a replacement for the Penguin, this 925-lb. missile will include GPS and an advanced infrared seeker for the attack of both ship and land targets. Smaller new missiles with enhanced anti-ship performance are also in development such as the MBDA Polyphem. This 10nm-range fibre-optically guided missile can be fired from ships, land launchers, and submarines.

Air-launched anti-ship missiles in service today include the nuclear-armed supersonic Kh-22 and Kh-26 missiles carried by Russian Tu-22M jet bombers, USAF B-52Hs armed with a dozen Harpoons, and SH-60 and Lynx helicopters armed with Sea Skuas, Penguins and Hellfires. Fighter-bombers such as the F-16, Tornado, F-4, Mirage F1, MiG-29, Su-27, the F/A-18, and Super, Etendard constitute a serious threat to ships when carrying anti-ship missiles, as demonstrated during the Falkland Island conflict and tanker war. Maritime-patrol aircraft such as the P-3 Orion, Nimrod, Atlantic/Atlantique 2, S-3B Viking, F-27/F-50 Enforcer, and other similar craft have the range, payload, and sensor systems to effectively employ Exocet, Harpoon, and ASM-1 class anti-ship missiles. Iraqi Super Frelon helicopters demonstrated their effectiveness with the Exocet during the Iran-Iraq War. Similar large helicopters such as the Cougar, Super Puma, and Sea King can fire the Exocet and other missiles.

For an air-launched weapon, the Russian Zvezda Kh-31 is one of the most capable missiles in service. This advanced Mach 2 rocket ramjet can be fired from MiG-29 and Su-27 (and now, as a training target, the F-4!) aircraft and has a range of 25-35nm. Boeing and Zvezda have teamed to provide the Kh-31 to the USN as a supersonic target. Russia also has a large number of other highly capable airborne anti-ship missiles, including the Raduga Kh-41 Moskit with a 130nm range and supersonic performance.

The first Boeing Harpoon Block II missile is fired from the USS *Decatur* , on June 7, 2001. Designed for littoral operations, the Block II missiles incorporate GPS guidance Harpoon Block II incorporates the inertial measuring unit from the Boeing Joint Direct Attack Munition (JDAM) program, and the mission computer and GPS receiver/antenna from the Boeing Standoff Land Attack Missile- Expanded Response (SLAM-ER), enabling it to execute both anti-ship missions and coastal-target suppression. Boeing photo

Many Western anti-ship missiles are capable of being launched from aircraft, but of these, only a small number have been fielded during the past decade. The Komoran 2, with an upgraded seeker and a more lethal warhead, was fielded on German Navy Tornado fighter-bombers during the 1990s. Some 737 US Navy AGM-84E Stand Off Land Attack Missiles (SLAMs) have been fielded on the F/A-18 and P-3. This interim weapon was employed on the F/A-18 during the Gulf War and used operationally in Bosnia and Kosovo on P-3Cs against land targets but, the SLAM also has capability to attack ships. A much-improved version of the system, known as the AGM-84H SLAM- ER [Expanded Response], has entered service entry with the USN. With a stand-off range of more than 150 km, an improved 500-lb. high-explosive warhead, GPS-aided inertial navigation, and man-in-the-loop terminal guidance, the SLAM-ER is likely to be the first choice weapon for the USN in littoral anti-ship operations. Development testing included several successful firings against ships, and the SLAM-ER has been successfully employed in combat against land targets.

Russia still fields the widest array of anti-ship missiles, with the 10,500-lb. P-500 Bazalt (SS-N-12 Sandbox) and upgraded (15,400-lb.) P-700 Granit (SS-N-19 Shipwreck) still in service on major naval combatants. These systems are replacements for the P-6/7 Shaddock strategic-class, anti-carrier weapons. They have a range of more than 300nm, travel at Mach 2.5, and carry large high-explosive or nuclear warheads. Another advanced Russian system is the supersonic Raduga 3M80 Moskit (SS-N-22 Sunburn), which can hit targets out to a range of 65nm and has a Mach-2 speed at low altitude. These weapons were fielded in 1984 on the Sovremenny-class destroyers and also are carried by Udaloy frigates and Tarantul-III attack craft. The Russians have also fielded the Novator 3M54E1 anti-ship missile, which resembles the Tomahawk TASM (but with a supersonic terminal dash capability) and the 3M24 (Kh-35) Uran, the later being similar to the US Harpoon and are replacing older version of the Styx and P-120 systems, as well as attracting export sales to Algeria, India, and other nations.

For the longer term, the Aerospatiale Anti-Navire Futur (ANF) was expected to be the first Western supersonic anti-ship missile, but this 100nm-range ramjet-powered replacement for the Exocet has suffered funding problems following the withdrawal of Germany from the program. The Russian firm NPO Mashinostroeniya has demonstrated the advanced supersonic Yakhont (SS-N-26) missile with a solid-rocket booster and a liquid-fuel ramjet with a range of more than 120nm as a replacement for the Moskit in air- and surface-launch variants.

Anti-ship missiles have played an important role in naval strategy for more than five decades and they are in service in all corners of the world on a variety of ship, submarine, land, and airborne platforms. Today the trend is toward missiles with greater accuracy, speed, and capability but also the performance to hit both land and ship targets. The USN is evaluating a development program to field a 600nm-range hypersonic (Mach 3.5-7) missile capable of launch from the aircraft, ships, and submarines by the year 2015. A hypersonic system effective against land and sea targets and could have a dramatic impact on the 21st-century battlefield.