Naval Antiair Warfare

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AN earlier article ("Naval Warfare: Defense Development and Acquisition," *National Defense*, November-December 1978) discussed the entire naval warfare mission area from the perspective of the Office of Naval Warfare. Here we will focus specifically on naval antiair warfare (AAW), not because it is more vital than other aspects of naval warfare, but because it is an area in which there are rapid and continuing changes, which have resulted in confusion in the minds of many.

As pointed out in the previous article, antiair warfare is not an end in itself but is, rather, a necessary means to permit us to carry out positive naval missions such as the support of land campaigns (either directly or by independent strike warfare), defense of friendly territory from maritime attack, or protection of ocean commerce. Aircraft carriers, as the main striking arm of the U.S. Navy, will undoubtedly be the principal targets of any air attacks, so that their protection must be the first priority in our AAW efforts. At the same time, however, we cannot neglect the need to defend detached surface forces and mercantile shipping.

It is instructive to put AAW in perspective by looking back to its origins. Consideration was given to means for mounting air attacks on ships prior to World War I, although the aeronautical technology of the day would not permit anything substantial to be done. At the outbreak of the war in 1914, Germany's Zeppelins posed the greatest air strike threat by virtue of having range-payload performance far superior to that of contemporary airplanes. British concern with the Zeppelin threat led to the first maritime air strike in history, and the first air attack on ships. On Christmas Day 1914, Royal Navy seaplane tenders, having penetrated to a position near Heligoland, launched nine seaplanes on a raid aimed at German Zeppelin sheds. The British force was spotted and the Germans launched two Zeppelins and three seaplanes on history's first antiship air strikes.

Neither the ships nor the Zeppelin sheds sustained any damage in the Christmas Day strikes. Indeed, no ship was sunk by air attack in World War I, despite many attempts. Nevertheless, enough ships were damaged by aircraft bombs and torpedoes to establish the airplane as at least a potential threat. Aircraft had cooperated with ships in a number of important actions, in some cases contributing directly to the destruction of enemy ships.

The direct threat of air attack was met by arming ships with antiaircraft (AA) guns. By the end of World War I most major ships had a battery of one to four semiautomatic guns in high angle mountings, supplemented by machine guns. Fired in local control, without mechanical assistance in stabilization, range finding, or lead angle computation, these early AA batteries had little chance of hitting even the slow aircraft of the day. Yet the threat was so weak that they could provide a degree of protection.

By 1918, fighter aircraft were being carried to sea by a variety of means. For the most part they were not seen primarily as protecting ships from air attack but rather as driving off scouting and surveillance aircraft, particularly airships, much as cruisers were expected to drive in the enemy's scouting line.

AA Progress

Progress in AA gunnery was rapid between the world wars. The size of AA batteries in-

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creased many times over and a good deal of mechanization was introduced into AA fire control. Any thoughts that this might allow ships to stand against air attack were shattered by the experiences of 1940-41. The naval campaigns off Norway and Crete and the loss of the *Repulse* and *Prince of Wales* demonstrated all too vividly that strong air forces, with suitable equipment and training, could always dominate unsupported (or weakly supported) surface naval forces.

The advantage of air forces lay quite simply in their ability to concentrate in superior force very swiftly. By 1941 a typical modern antiship strike aircraft, such as the German Ju-88 bomber, could cruise at 200-knots, carry four armor-piercing bombs or two torpedoes for a radius of about 300 nautical miles, and deliver its weapons with accuracy. With a few dozen such aircraft an air force could deliver a devastating strike anywhere within a few hundred miles of its bases on a few hours notice. The surface ships, only one tenth as fast, had no chance of sidestepping the blow let alone turning the tables; the surface forces were compelled to fight on the air attackers' terms.

From the Allies' standpoint, the situation was intolerable: They had to be able to make offensive use of naval surface forces if the territory they had lost was ever to be regained. Naval AAW became a matter of the highest priority. First, of course, shipboard AA armament was strengthened enormously. Rapid-fire 20-mm and 40-mm cannon, for the most part, added greatly to the weight of AA fire at short ranges, while radar ranging and, laier, proximity fuzes did much for the accuracy of the larger AA guns.

Naval Air Cover

Shipboard AA armament never reached a level of intensity or efficiency which would permit it to beat back determined and coordinated attacks; however, superiority in the air was essential. On a tactical level, this need was met by giving surface forces their own heavy air cover. In some cases this could be provided by land-based fighters. But even the best World War II fighters did not have a combat air patrol mission radius better than 400 nautical miles, and their missions usually required naval surface forces to range further than this from friendly bases. To fill the gap, carrier-based fighter forces were strengthened, both in numbers and quality, and an efficient shipboard fighter direction system was built up. The fighter strengths achieved were formidable: At the battle of the Philippine Sea in June 1944, 450 fighters rose from Admiral Spruance's 15 carriers to meet Japanese attacks.

The more efficient way to achieve air superiority, of course, was to weaken enemy air forces before they could attack. Attacks on air bases were not notably profitable in World War II, but strategic advantage could be taken of the airplane's most prominent limitation: range. Particularly in the Pacific, capture or neutralization of a relatively small number of bases could make a major difference in the extent of the areas within which ships were subject to air attack.

As the price of antiship air attacks grew steeply, the Germans, characteristically, sought technological means of redress. In August 1943 they introduced the Hs 293 and FX 1400 command-guided antiship missiles. Over the next eight months, these missiles sank a battleship, a cruiser, and a number of lesser ships, and inflicted serious damage on many other ships. The Allies responded with increased effort against the launch/command aircraft, and a variety of measures to degrade the missile guidance systems. The AAW forces won, and the Germans discarded the missiles in August 1944. But in the last months of the war the U.S. Navy's very sophisticated BAT radar-guided missile sank several units of what was left of Japan's fleet.

Kamikaze

The most vivid illustration of the power of the antiship missile was furnished, however, by the Japanese Kamikaze program, in which pilots simply flew their bomb-laden aircraft directly into their chosen targets. In effect, the Kamikazes were missiles with very flexible and adaptive guidance systems. They did a great deal of damage and stimulated the U.S. Navy efforts in AAW.

One of the most obvious weaknesses of World War II AAW was that the overwhelming majority of AA projectiles fired never came near their targets. Of course a "curtain" of AA fire could be useful in unnerving pilots even if accuracy was low, but only hits counted against guided missiles, or pilots already bent on suicide. There was much room for improvement in gun fire control, and appropriate efforts were put in hand, but the attractions of guided weapons were obvious. The U.S., Britain, Japan, and Germany all started AA guided missile programs during World War II, although only the Germans had made much progress by war's end.

In dealing with the Kamikazes, which often approached at fairly low altitudes, the U.S. Navy found that its shipboard radars often gave too little warning to permit effective employment of defending fighters. Radar picket ships were costly, vulnerable, and horizon-limited, so the Navy began working on the problem of carrying warning radars aloft in aircraft.

The end of World War II

seemed to have changed the complexion of the naval AAW problem altogether. The only visible potential threat to the Western naval powers was posed by Soviet Russia, a land power whose navy had turned in a very unimpressive performance against the Germans in World War II and possessed no sea-based air forces. The Soviet navy's large and growing submarine force seemed a far more serious threat than its short-ranged, land-based air forces, especially given the disadvantages of Russian geography.

The Nuclear Threat

On a more abstract and longer-term basis, it was easy to foresee a serious potential threat from nuclear weapons. With an atomic bomb a single bomber could devastate an entire task force, and need not come within five miles of the ships to do it. Since precision bombing was not necessary, nuclear attacks could be made in any weather.

It was difficult, under the circumstances, to see AA guns as having much relevance. AA missiles might to be able to knock down nuclear bombers before they could release their weapons, as might all weather fighters directed by airborne early warning (AEW) aircraft, and their development was pursued.

In the meantime, Soviet military thinkers had clearly been studying the lessons of the Second World War, particularly those of their erstwhile enemies, the Germans. They began to propound a doctrine of a navy whose main striking forces were comprised of submarines and aircraft, with surface ships relegated to a lesser status. They began talking about the "revolution in military affairs" resulting from the development of nuclear explosives and rocket missiles.

For a long while it was difficult for westerners to see much connection between rhetoric and reality, so far as air threats went. The Soviet navy seemed to continue much as before, a submarine and coastal navy with only the most limited of air strike potential. But then Soviet Naval Aviation (SNA) began to equip with the Tu-16 Badger swept-wing bomber. And a variety of antiship guided missiles began to appear aboard submarines, under the wings of bombers, and on surface ships of the Soviet fleet.

The West watched these developments with interest but no great sense of alarm. The Tu-16, while a great advance over anything seen in World War II, was not an especially outstanding performer for its day and could not reach the areas regarded as most vital to the West so long as it was constrained to Russian bases. And Soviet guided missiles struck most in the West as relatively crude and cumbersome; they were viewed as a second-rate substitute for the sea-based air striking power the Soviet navy so conspicuously lacked. It was nuclear attack or an armored thrust across the intra-German frontier that worried the West; among naval threats only the Soviet submarine force generated any real concern.

It was, of course, the 1967 sinking of the Israeli ship, *Eilath* that really convinced large numbers of people that there was a serious threat contained in all those Russian antiship missiles. It seemed that little could be done to prevent missile launchings by ships and, particularly, submarines—they would generally take place beyond the effective defensive envelope. Once in the air, the missiles were air threats, and very difficult ones.

The western navies, led by the U.S. Navy, made a series of improvements to their AA missile systems to improve their performance in countering antiship missiles. Heavy machine guns were brought back, with very sophisticated fire control systems, to provide terminal defense. Great if rather tentative hopes were invested in countermeasures to missile guidance systems, all the more so since ECM (electronic countermeasures) had proven valuable against Soviet-made AA missiles in the Vietnam conflict.

By the early 1970's SNA was equipping with higher-performance missiles and the variable-geometry Backfire bomber, giving it a much greater radius of strike coverage and heavier offensive strength. It began to be widely appreciated in the West that SNA was just what Soviet strategic writers had been calling it for more than a decade: One of the two major striking arms of the Soviet navy, a threat on a par with the Soviet submarine force. Its sources of strength are familiar: The ability to concentrate a great weight of attack with great swiftness. But now the radius of threat is measured in terms of a few thousand miles, instead of the few hundred of World War II.

AAW in the 1980s and 1990s

Figure 1 shows, schematically, today's AAW defensive posture. Guns, short-ranged missiles, and guidance countermeasure systems provide "point defense," intended to destroy or deflect antiship missiles at the last moment before they reach their targets. (Most of these systems would also be effective against even the lowest-flying manned tactical aircraft, should an "iron bomb" attack be mounted.) The short ranges at which they operate give these systems substantial advantages, and permit relatively inexpensive systems to have useful effectiveness.

By doing battle at the last ditch, however, the point defense systems give up any ability to trade space for time. Thus if the incoming antiship missiles are too

AAW DEFENSE IN DEPTH

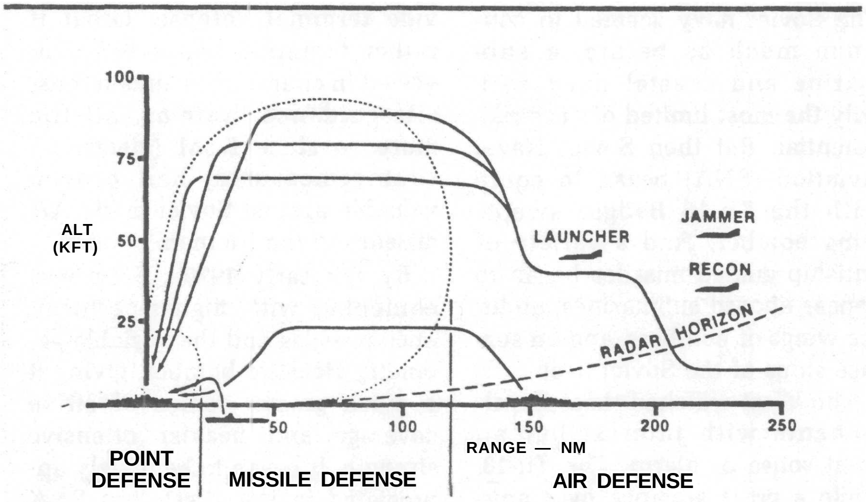

Figure 1

closely spaced or are too fast, the point defense systems may be quickly saturated, and start to let threats through their defensive screen. And of course each ship must carry point defenses strong enough to deal with the heaviest attack that ship might receive, so that the low individual cost of such systems is somewhat offset by the large numbers involved. If the enemy knew that his missiles would be opposed only by point defense systems he might concentrate all his fire against first one ship and then another, overwhelming the defenses of each in turn and defeating the force in detail. Finally, point defenses contribute little to defense against nuclear attacks, where weapon detonation may well occur beyond point-defense range.

So point defenses are supplemented by area missile defenses: Certain ships are armed with heavy AA missile systems with ranges of tens of miles, which they employ againsi all approaching antiship missiles within their assigned responsibilities, regardless of which ship they are attacking. These area defense systems give more flexibility and can achieve greater concentration of fire than can point defense systems. But they are correspondingly larger, more complex, and more costly.

In most cases, area and point defenses will have to deal with submarine-launched or ship-launched missile attacks without other help. This will probably continue to be feasible, at least with the most modern systems, both because there are fairly strict limits on the density of attack it is possible to achieve with surface- and sub-launched missiles, and because it is usually not practical for ships or submarines to jam or otherwise degrade our defensive systems. It is obviously very desirable to destroy the launching ship or submarine (though it is not, strictly speaking, an AAW function to do so) but it is not an urgent neccessity, since the launch platform's journey back to port to get more missiles will ordinarily be protracted and hazardous.

Air-Launched Threat

In the case of air-launched missiles, however, destruction of at least a portion of the launch platforms, and supporting aircraft, is essential. For one thing, the launch aircraft can return to base, rearm, and sortie for another strike in a matter of hours, raising (if nothing else) serious questions of ammunition supply for the defending ships. Beyond that, if aircraft are allowed a free ride there is nothing to prevent the attacker from mounting a concentration of jammers so overwhelming as to degrade even the most sophisticated of missile defense sytems.

For these reasons, the missile defenses must be supplemented with air defenses. Since aircraft may launch their antiship missiles at ranges of 100 nautical miles or more, these air defenses must extend out a considerable distance from the protected ships. Generally they consist of missile-armed fighters, guided by radar-equipped airborne early warning (AEW) aircraft.

The AEW aircraft play a vital role since the shipboard radars ordinarily cannot give enough warning to permit fighters to be vectored to intercept before the attacking aircraft release their missiles. Indeed, if the antiship missiles are equipped with autonomous seekers (as are the U.S. HARPOON and TOMAHAWK missiles) it is possible that they might be launched from beyond the ships' radar horizon.

Ideally, then, AAW begins with AEW aircraft giving warning while the attacking aircraft are still several hundred miles from their launch points. Fighters on combat air patrol (CAP) are vectored in and engage the strike, thinning and disorganizing it. As the surviving hostile aircraft (or the ships or submarines) launch their missiles they are detected by the shipboard radars. Soon the area defense ships engage the incoming antiship missiles with their heavy AA missiles. Finally, the "leakers" are dealt with by the individual point defense systems.

Saturation

The U.S. Navy has devoted vast resources to its AAW systems and we have great confidence in them—up to a point. Unfortunately, both analysis and experience show that all AAW systems are inherently sensitive to saturation. It is much like the levee that can contain a 10-foot flood with little damage, but will allow disastrous inundation at the 11-foot stage. The Soviets are very well aware of this and can be counted upon to do their best to exploit it, should we ever have to fight them.

One obvious means is to increase the number of attacking missiles by increasing the number of launch platforms or the number of missiles carried by each platform. Little analysis is needed to see that only good fortune can permit an enemy to get more than one or two submarines into firing position simultaneously against an alert, fast-moving naval task force. Against a carrier force, or a force with good land-based air support, missile-fir ng ships have slim chances of reaching firing position at all (barrng, always, a surprise attack prior to declaration of hostilities).

But aircraft are another story. During World War II and again in Vietnam, the U.S. Air Force was able to bring hundreds of aircraft over target with precise timing. The Soviets have never demonstrated a capability to achieve similar concentration against targets at sea (at lenst not before western observersi, and there is room for question about how large a force they could or would throw at a single naval group. But it seems clear that air-delivered missile attacks are potentially the heaviest, with missiles numbering at least in the dozens.

But brute force is not the only way to increase saturation. Rather than simply increasing their attack forces to overwhelming levels, the Soviets might well seek to dilute and divide our defenses. The simplest approach would be simply to maintain tight operational security, to prevent us from learning the timing or track of the attacking force. This is particularly crucial in the case of air attack, for our ability to marshal and concentrate our air defenses depends almost wholly on the quality and certainty of our knowledge of where and when the attack might come.

Consider, for instance, the problems of the AEW aircraft. To give effective warning and interceptor control it must be stationed well away from the ships, more or less in the direction from which the attack will come. If there is no information about attack direction then it will be necessary to have several AEW aircraft aloft, out in various directions. But if there is no information about when the attack may come it will be necessary to have several AEW aircraft aboard the carrier for each one kept aloft, in order to permit round the clock patrols while still giving time for aircraft maintenance and flight to and from station. It is not difficult to envision a need for two, three, or even four dozen AEW aircraft to defend a carrier force.

But in reality, a carrier has only four AEW aircraft, and cannot carry more without heavy sacrifice of offensive capability. Thus, unless a carrier force comprises half or more of our total fleet, it will need considerable information about possible air attacks in order to be sure of meeting each with at least one AEW aircraft in proper position. Obviously, very similar considerations apply to fighters.

Stealth

With information playing so crucial a role in AAW it is inevitable that the attacker will go to some lengths to deny it to us. Stealth, of course, has always been the submarine's entire raison d'être, and its only virtue as a missile platform. There is a very real danger that low-flying missiles launched from an undetected submarine may escape notice until too late. This problem has called forth great efforts in improving low altitude search and reaction time for shipboard AA missile systems.

Nowadays ships cannot hide from detection in the fashion of submarines. (There has been discussion in the Soviet naval press of means to render ships "invisible" to radar, but few people are prepared to take such ideas seriously.) Under certain circumstances, however, it might be possible for missile ships to hide by mingling with innocent commercial shipping, taking care to avoid tell-tale emissions. This possibility forces an effort to track and positively identify *all* traffic in the vicinity.

It has recently been revealed that the U.S. has had an active program to develop aircraft whose observability (by radar and, presumably, other sensors) is significantly less than that for other aircraft. Too little information has been released to permit any real assessment of the implications of this development, but its possibilities must be kept constantly in mind when planning AAW systems for the future.

But even without observable reduction, strike aircraft already have a variety of means available for denying us vital information. Pride of place, historically and logically, goes to jamming.

Jamming

Descriptions of new radars in the semi-technical trade press almost invariably claim that they have solved the jamming problem through some combination of better processing, cleverer waveforms, increased power, and more sophisticated antennas. Yet the jamming problem has remained little changed for nearly 40 years. The resolution of this conundrum is simple: The radar designer and the jammer designer each draw on precisely the same technology base, and thus each must run as fast as he can, simply to remain in the same relative position.

(Actually, the situation is somewhat more dismal than this might suggest. U.S. radar designers have benefited from a technology base that stayed several years ahead of that serving Russian jammer designers. As the Soviet investment in expanding their military technology base bears more and more fruit we can expect to see an evening, or even a reversal of this advantage.)

The effects of jamming go beyond the obscuration of targets lying within the jamming strobe. Radar performance can be degraded by jamming in a great many ways to an extent which is usually difficult or even impossible to judge in an operational situation. Thus, heavy jamming creates an environment of confusion and uncertainty all the way from the radar operator to the top level commander, and puts the discipline of the combat organization to a very severe test.

Hand in hand with jamming go feints and deceptions. *That broad area of jamming activity off to the right of my screen: Is it another raid coming in, to which I must immediately vecror my fighters? Or is it simply a handful of jammers, told to create a diversion and strip me of my defenses? What about that single jammer to the south? Could there he a major strike approaching under cover of his strobe? How do I find out without diluting my defensive assets?* The commander whose defensive assets are thin is very quickly reduced to playing craps for the survival of his force in such situations.

Once the antiship missiles have been launched, the shipboard area and point defenses are also subject to saturation of various sorts. Where aircraft have launched the missiles (or are available to support the other launch platforms) they can remain in the area to jam the defending ships' radars throughout the missiles' flight. The effectiveness of such jamming could be multiplied if the 1 echnology of observables reduction could be applied to antiship missiles. While the best of our shipboard radars have near-incredible jamming resistance, even they can be saturated by a sufficient concentration of jamming forces. It is essential that this be prevented, either by air defenses or by other means.

Of course, one obvious way to saturate our missile defenses is simply to hurl more missiles at them, very closely spaced in time. This implies more launch platforms, bigger launch platforms, smaller missiles, or some combination together with closer coordination between launch platforms.

Finally, our defenses can be saturated by flying the antiship missiles in the corners of (or outside of) the envelopes of our defensive systems. This is the obvious rationale for the very low and very high missile profiles to which the Soviets have increasingly gone.

In AAW, as in all aspects of war, the key to victory is concentration of superior force at the decisive place and time. The possession of superior numbers or superior technology will not in itself guarantee superiority in concentration, nor will lack of these things guarantee inferior concentration. A great deal rides upon the structure of the engagement situation, as influenced by the natural environment, the technical natures of the forces in play, and the skill of the commanders.

AAW is unusual in the fundamental asymmetries between the forces involved. It is not a matter of division against division, fleet against fleet, wing against wing: In general, there will be scarcely any point of similarity between the forces of attacker and defender. This automatically implies built-in asymmetries in the engagement situation. Simple logical analysis shows that many of these inherently favor the attacker under present conditions of naval antiair war. Some of the factors involved include:

- The attacker, being more mobile, is given wide latitude in choosing the time, place, and conditions of engagement.
- Superiority in mobility also allows the attacker to throw a large fraction of his total force against any naval target of his choice, forcing us to disperse our defenses even in the face of his concentration of offense.
- Under present technological conditions, it is more difficult and costly for us to detect and track his missile-launching submarines and aircraft than it is for him to know the locations of our surface forces.
- Loss of an antiship missile reduces the attacker's warfighting strength little; loss of a ship reduces ours a great deal.

These factors favoring the attacker are not a cause for despair; they are obstacles to be faced and overcome, or avoided through innovations in tactics and technology. It is to this end that our efforts in development and acquisition of systems for naval AAW must always be focused. •