Analysis 2 - The Market for Surface Electronic Warfare Systems - Archived 2/98

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Figures, Charts and Graphs (all data refer to 1997-2006 time frame)

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The Market for Surface Electronic Warfare Systems

Executive Summary

In the current geopolitical climate, the threat to peace is dominated by regional conflicts scattered about the globe rather than one big standoff between two superpowers, as in the recent past. With the crumbling of communist government in the USSR as well as the former Soviet Bloc countries, national security requirements and defense industry priorities have profoundly changed. The previously envisioned deep-sea confrontation has broken down into smaller, more unpredictable littoral conflicts.

In this environment, the identity of the enemy can no longer be taken for granted; the likely interplay of military and political influences are no longer easily defined and understood entities. The opponent's strategy, objectives and methods of combat must be newly assessed and grappled with as each conflict emerges and unfolds. The playing field is fluid with constantly shifting ground rules. This environment emphasizes the value of electronic warfare.

Significant technology advances have been made in both land- and sea-based electronic warfare (EW). Transmitter improvements have made it possible to generate powerful, stable jamming signals. New receiver techniques, the introduction of integrated circuit technology, and the replacement of analog hardware with digital processing have revolutionized the capabilities of EW systems. Missiles using laser-designation, laser beam-riding, TV, imaging infrared (IIR), and other optical guidance systems have been introduced in anti-ship roles and created new challenges for EW. These missiles are not subject to decoy by standard EW methods and are prompting the development of Infrared/Electro-Optical countermeasures.

In the competitive EW market environment of today - though the US leads in the airborne electronics sector - Europe dominates the land- and sea-based market. Three US manufacturers ranked among the top ten in this analysis (Lockheed Martin, Motorola and Hughes). However, it should be kept in mind that contracts are yet to be awarded on one major program, AIEWS (Advanced Integrated and Electronic Warfare System). AIEWS, which will upgrade or replace the electronic warfare suites on most US surface combatants, will afford significant market opportunities over the next ten years. The contract is going to be awarded to a US-led team and the contractor or consortium of contractors winning this program could push the team nearly to the top of the listings. It is likely that one or more major European companies will be on bidding teams, so if any company in Europe wins a substantial part of those programs, that company will likely become a dominant force in the European EW industry.

The procurement system of the US has been undergoing major improvements over the past few years. President Clinton and Vice President Gore have acted to cut costs and improve efficiency by simplifying the overall system. They have led the Pentagon to create a new system to develop pilot programs while seeking out COTS-based procurement strategies whenever feasible. This effort will impact the way many electronics systems, especially the computer and processing components, will be purchased. It will also open the market to suppliers who formerly could not or would not get involved in DoD-sponsored projects. Ushering in this reform, the President signed the *Federal Acquisition Streamlining Act of 1994* in September 1994, and further revised it in 1995.

Published the following year, *The Partnership Process for Electronic Warfare Acquisition: Status Report, June 1996* acknowledges the military worth of EW systems to the warfighter. The new Partnership Process is to focus on the voice of the warfighter; its stated mission is to "transform the electronic warfare acquisition process to consistently put superior solutions in the hands of America's warfighters as quickly and inexpensively as possible."

The Western European and international EW markets are significantly larger than those of the US, and are marked by radical differences in industrial structure, competitive environment, and acquisition procedures. The markets are divided among a large number of British, French, Italian, German, and Swedish electronics houses that design their systems based on their perceived "unique in-house expertise." Once available, these systems are offered on the export market. The result is a chaotic and competitive environment that favors rapid technology development and quick exploitation of successful R&D efforts. Too many companies are competing for limited procurement resources. With continued progress toward the establishment of a single European market, the pressure to merge groups and form viable transnational entities has become irresistible. Rationalization was needed and is now well underway.

Although radar continues to be a primary sensor in both naval and land-based environments, passive electronic support measures (ESM) have become a full and equal contributor to the situational awareness of military units. ESM sensors are becoming more and more important, making the 1990s the decade of the passive sensor.

Tracked and wheeled armored vehicles represent an increasingly lethal and expensive weapons inventory around the world, one that warrants its own EW to increase its survivability. The Gulf War brought this requirement to the fore, and the US and its allies are developing and fielding interim systems, and working on more advanced solutions to counter anti-armor munitions.

By the end of the decade, the number of ground vehicles deployed by modern, highly mechanized armies will make protecting these assets a major market opportunity. This will provide business opportunities on a worldwide basis for a large segment of the defense industry. In common with other aspects of electronic warfare, protective systems will stimulate attempts to develop new offensive systems, which will in turn call for improved protection. And on and on. Much of the effort diverted to this sector will be investigating relatively unexplored territory. This could lead to intriguing new technical developments.

There is a distinct difference in character between the projected markets of land-based systems and sea-based electronic warfare equipment. Sea-based programs are tied to shipbuilding and overhaul programs and reflect a downsizing of the world's naval forces. In numerical terms, the market for naval EW is not going to grow, since the cost of modern warships limits the number of ships that can be built. This high price, however, serves to increase the value of those assets and thus render their protection more important. Although fewer systems will be needed, these systems will be more expensive. This will lead in turn to a rapid growth in the upgrade market, replacing or enhancing the electronic warfare fit of older ships. Such is particularly the case with large numbers of ex-British, ex-US and ex-Russian ships finding their way into the secondhand market. The trend has now been very well established.

Over the ten-year forecast period, a total procurement of over US$20 billion is expected. Procurement for 1997 is forecast at US$1.8 billion; it should reach a peak of US$2.4 billion by 2000. In the early years of the 21st century, procurement should then slip gradually to US$1.6 billion for 2006. These figure covers the gamut of land- and sea-based EW equipment, from passive electronic support and detection measures to active radar and jamming systems.

Production data culled for this analysis project a figure of over 347,000 units built during the next ten-year period. For the year 1997, approximately 44,700 units are projected; this figure should drop steadily (though gradually) to 39,300 by 2000 and further to 24,300 by 2006. Data (for procurement as well as production) are based on an analysis of 126 programs or systems in, or going into, production. Thirty-five individual companies and one joint venture team were included for the analysis statistics. One major US program (AIEWS) has not yet selected a contractor(s).

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The Market for Surface Electronic Warfare Systems

Introduction

The Market Analysis for Land and Sea Electronic Warfare (EW) Systems looks ten years into the future of these EW market segments. The analysis encompasses the majority of non-airborne EW measures, including an estimate of expendable and decoy countermeasures procurement.

At sea, electronic countermeasures date back to the earliest known deployment of naval electronics systems. The first recorded instance of electronic warfare took place during the Russo-Japanese war in 1905 when a Japanese radio operator onboard the battleship *Mishima* intercepted strange Morse code signals. He was able to determine that these originated from the Russian flagship *Petropavlovsk*, and by manipulating his own aerials, managed to get a bearing on the battleship's position. He was also able to blank out the Russian transmissions by holding his own morse key in the down position.

During the World War I, the British Royal Navy introduced the first systematic monitoring of enemy radio communications. The intercepts were used to analyze the patterns of transmission and their relationship to events, as well as to decipher the contents. The problem, which persists to the present day, is that intelligence gained by SIGINT is often so valuable that its very use compromises the means by which it was gained.

Prior to the development of radar, the only long-range sensors available to detect enemy commerce raiders were onboard seaplanes and radio interception and direction-finding capabilities. The latter, used to locate the raiders' radio messages as well as the distress signals of attacked merchantmen, would be used to key searches by the seaplanes. Admiralty requirements specified that the ships should be able to intercept wireless communications within a 950-mile radius. For this, the cruisers required tall masts to extend the interception horizon as far as possible and long aerials to provide accurate bearings on the medium- and long-wave radios then used. This requirement to carry ESM antennas high and to provide for accurate direction finding has been and is becoming, once more, a significant design driver on modern warships.

The earliest known systematic ELINT operation took place in 1938 when the German airship *Graf Zeppelin* undertook a series of flights around the UK to investigate research known to be underway on land-based air surveillance radar technology. These flights revealed that British radar development at that time was still experimental and at a very primitive level. No additional investigations took place, so the major pre-war developments in UK radar technology and operational technique went undetected. Once again a key element, the need for ELINT investigations to be repeated over a prolonged period had been demonstrated at an early stage.

The true beginnings of specific radar-oriented ELINT operations took place in the Pacific. On Guadalcanal, in August 1942, US Marines discovered a crude radar, a Japanese Navy Type II early warning radar. This chance discovery gave birth to the idea that an electronic reconnaissance effort was needed to find the extent to which Japanese forces in the Pacific were radar-equipped. The submarine USS *Drum* specifically searched for enemy radar signals with its rudimentary equipment, even though this was done "when the crew was not otherwise engaged." It returned from the cruise off the Japanese coast with the first ELINT log of Japanese radars. This cruise was the ancestor of a long series undertaken by the US submarine fleet. These have continued up to the present day, with US, Russian and British submarines continuing to use their ESM systems to probe and record radar systems of potential (and actual) enemies.

World War II saw the development of most forms of land- and sea-based EW equipment. The Battle of the Atlantic marked the beginning of several characteristics of electronic combat that continue today. Initially, new hardware was introduced and assimilated into a force at such a pace that a defeatable device could have a useful career before the opponent realized that a device had been employed, identified it, and introduced a counter device. It also introduced the tactic of not making full use of an exploit capability for fear of tipping one's hand and having the foe change their equipment or tactics, effectively neutralizing the original capability.

High-frequency direction finding (HF/DF or Huff-Duff) allowed the Allies to localize submarines by their responses to U-boat Command's messages. This Huff-Duff system proved effective, but the Allies were reluctant to make full use of the ability to compromise these German rendezvous messages out of fear that the Germans would change their Enigma system and rob the Allies of an important capability. This continues as an operational fear today, since often the means and sources of intelligence are more closely guarded than the information gathered.

At sea in the Pacific, Japanese destroyers started to carry radar warning receivers to warn them of US Navy surface search and gun-laying radars. Initially crude, these were rapidly developed to provide octantal bearings on those radars and to differentiate between search and fire-control modes. US aircraft carriers in the Pacific and the British air defense system were both faced with the problem of distinguishing enemy intruders from returning bomber formations; the result was the development of the first IFF (Identification Friend or Foe) systems. Over 50 years later, this problem has yet to be satisfactorily solved.

On the allied side, warships threatened by the new German *Fritz-X* and HS-293 guided bombs were equipped with jammers for the search radars and radio controls involved. German submarines running the gauntlet of allied aircraft in the Bay of Biscay also started to carry radar warning receivers. The first were deployed on U-boats in September 1942.

With the end of World War II, the naval electronic warfare effort was cut back. From the US point of view, there was little credible surface threat to the overwhelming power of the US Navy. The Soviet Navy was weak and ill-equipped, so little effort in countering its limited effectiveness could be justified. There was little interest in procuring operational versions of jamming equipment being tested. During the late 1940s, combat-tested EW equipment was removed from the ships and stored to reduce manning and maintenance requirements. The shattered countries of Europe had far more urgent priorities than the development of EW capabilities, while the British were immersed in the problems of dismantling the Empire and adjusting to grossly reduced resources. Even as late as 1960, many British warships still carried the same electronics fits as they had mounted in 1945.

As the Cold War progressed, Soviet defensive capabilities started to improve as captured German technology and derivatives of US equipment obtained under Lend-Lease appeared. Russian land-based ELINT (Electronics Intelligence) and SIGINT (Signals Intelligence) technology were oriented toward intercepting USAF navigation radar aids (SHORAN and MPQ) used to assist bomber aircraft and attempts to turn those aids against the bombers by using them to locate anti-aircraft batteries in optimal positions. Land-based EW interest remained slight and was primarily involved with simple direction-finding receivers. Overall, ground forces were more interested in listening than in jamming. The US Army electronic warfare effort was nearly nonexistent and stayed that way until the late 1960s.

At sea, the prime concerns emerged as the threat of Soviet submarines and of missile-armed long-range bombers. Long-range communications ESM, developed from Huff-Duff, was seen as a primary tool for the initial location of submarines, much the same as the anti-raider policy adopted by the Royal Navy prior to World War II. The lack of a distinct, perceived need for surface EW tended to slow development efforts. In the late 1950s, the US Navy received the ULQ-6 false target generator to protect against missile attack. The design and operational doctrine of these systems was weak; they were difficult to use and were of limited effectiveness. In fact, their use was considered by many commanders to increase the chance of attack. The ULQ-5 systems, installed on many US Navy escorts, were "blip enhancers" intended to decoy inbound missiles by making the aircraft carrier indistinguishable from its escorts. By implication, this resulted in the loss of expendable escorts, not irreplaceable carriers. Not surprisingly, this equipment had an abysmally low serviceability rate.

The Korean War renewed interest in airborne tactical electronic warfare, primarily to counter "Chinese" radars being introduced into the combat arena. The Russian ground-based EW systems turned out to be quite effective in determining the SHORAN arcs used by the B-29 medium bombers and, as planned, enabled the defensive anti-aircraft guns to be deployed along these arcs, maximizing their effect. During the night of June 10, 1952, communist anti-aircraft guns positioned using these techniques shot down three out of four B-29 aircraft attacking a railway bridge at Kwaksan. The night no longer belonged to the bombers; ground-based EW had proved an effective defensive force multiplier.

Not content with passive use of EW, the Russian air defenses also started to experiment with ground-based jamming of USAF navigational aids and bomber radars. The objective was to distort the SHORAN and other navaid systems to lure the bombers into anti-aircraft traps. As Soviet air defenses improved, the US began to react with developments in electronics and signals intelligence improvements, as well as strategic airborne equipment. Land-based listening posts were built around the periphery of the Soviet Union, and their work was supplemented by the ELINT mapping operations carried out by submarines and surface ships (AGI). The early appearance of Soviet "fishing trawlers" festooned with intercept antennas led to an equally early appreciation of the virtues of emissions control (EMCON) for warships.

In the US services, the Air Force led in EW philosophical development throughout the early 1960s. Naval efforts remained concentrated on providing Navy aircraft with jamming or ELINT capabilities and in developing its fleet of AGIs. It seems that, at the time, the US Army did not truly appreciate the value of countermeasures. In fact, US Army EW development programs tended to overreach realistic possibilities, creating costly failures that soured planners on EW. It would not be until the 1970s that US Army EW capability would see significant advances.

In Europe, the dramatic economic improvements during the 1950s had finally resulted in the modernization of the armed forces. The closer proximity of the European forces to the potential battle zones and the need to secure advance warning of intentions led to greater emphasis being placed on EW techniques. In particular, the European navies faced a bloody close-range brawl in the North Sea, Baltic and English Channel, rather than a blue-water engagement. The provision of radar warning equipment, jammers and chaff launchers, therefore, received greater priority. The sinking of the Israeli destroyer *Eilat* by a P-15 missile attack in 1968 added impetus to this trend.

The Royal Navy in particular introduced comprehensive EW fits to its ships by first installing integrated ESM/ECM/decoy capability, then further integrating those systems with the overall command system of the ships. Interestingly, the installation of EW equipment took priority over modernization of radar fits. During this time, the Royal Navy became a world leader in naval EW technology and operational technique.

As transmitters improved, the ability to generate powerful, stable jamming signals was enhanced. Receiver techniques have also improved dramatically. Vacuum tubes were replaced by solid-state devices and circuit boards improved the way equipment was built, enhancing both durability and reliability. Electronic data processing, although in its infancy, began to open what has proved to be a flood-gate of new capabilities. Upgrades are replacing many processors which, though performing adequately, are less powerful than many of today's PCs. Advanced processing algorithms are making possible quantum leaps in system performance. Better antennas were also introduced.

In the US, most of the work was applied to airborne jamming and ELINT collection developments, while the limited operational philosophy and weak interest by surface forces continued. The technological foundation was laid and command appreciation of surface EW began to follow. In Europe, the new technologies have been applied across a broad span of the EW spectrum. This has resulted in the development and operational deployment of large numbers of land- and sea-based electronic warfare systems.

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Trends

The Naval EW Environment. Warships employ three categories of EW systems: decoy dispensers, jamming devices and electronic intercept equipment. As electro-optically guided weapons have spread, the equipment needed to counter them has evolved from a few anomalous systems, including electro-optical countermeasures intended to blind electro-optical or FLIR equipment and/or the operators, to a significant market sector.

Decoys & Dispensers. Decoy dispensers were originally designed to fire chaff clouds that would seduce inbound anti-ship missiles from their target. They have three distinct modes of operation. Firing at long range, the launcher provides an inbound missile with multiple targets, so the attack on the genuine target is diluted and shipboard point defense systems have a better chance of dealing with the attack. At intermediate range, the chaff clouds are deployed to seduce the missile guidance system away from the ship targeted onto the decoy cloud, resulting in a clean miss. Finally, as a last-ditch measure, at close range the chaff clouds can be used for centroid seduction in which a large cloud of chaff will distort the ship's return, causing the missile to pass above or astern.

As missiles become more and more intelligent, conventional chaff has become increasingly less effective, and thus less used. Long-range chaff decoys can be countered by an MTI (Moving Target Indicator) in the missile guidance system. The chaff clouds move more slowly than the ship and the movement is likely to present a different pattern. A modern radar homing seeker can take advantage of these differences to distinguish chaff clouds from the genuine targets. Many modern chaff launching systems counter this by recommending an optimum course to be employed to take full advantage of the chaff cloud. An intelligent missile seeker attempts to counter intermediate range seduction by range-gating the target echoes. Using this approach, a narrow band of returns around the expected target's position is defined and any echoes outside this gate are ignored. These provisions can be countered by an active ECM system that uses range-gate pull-off techniques to move the missile's seeker into the chaff cloud some distance from the ship. Centroid seduction is best countered by setting the radar altimeter on the missile to keep the flight path at the lowest practical altitude.

All current types of expendable decoys are launched either by mortars or rocket. Mortars, such as the US SRBOC system produced by Lockheed Martin, have the advantage of being more compact, as do their ammunition. They are, however, inherently short-range, and their launchers have to be strong enough to withstand the impact of firing. The weight penalties resulting from the adoption of a mortar solution are severe, since it must not only include a robust launcher but considerable strengthening of the ship's superstructure around the firing point. Rockets have a much more flexible range bracket, require only the simplest launch rails, and transmit virtually no firing stress to the ship's structure. Their major disadvantage is the need to provide protection against the rocket exhaust on firing. A variety of rocket and mortar chaff dispensing systems are available; however, the current trend favors the rocket solution.

A simple method of beating a defense based on decoys is to run it out of ammunition. This can be achieved by firing a stream of missiles, prolonging the period of the attack over several minutes. A re-attack mode is now available for anti-ship missiles, so a missile may have to be decoyed more than once. Since most existing decoy dispensers are loaded manually, this can be a time-consuming process; these missile developments can only be countered by increasing the number of ready-use rounds held in the launcher. The earliest naval decoy launchers were single-barreled; but capacity has been systematically increased until the average is around 12 rounds per launcher, with the number of launchers increased from two to six or eight per ship. As the number of rounds per launcher is increased, mortar-style systems become even less attractive and the push toward rocket-based systems is reinforced.

A different approach to the problem of providing prolonged decoying capability has been the development of towed floating decoys. The leading system in this category is the Replica. The Royal Navy first adopted this as an emergency fit for the Falklands Campaign and subsequently extended the fit throughout the surface fleet. Ironically, Replica was originally copied from a Soviet system and spread to the US Navy under the designation SLQ-49. The original concept went through successive upgrades, improving its efficiency and reliability. The latest version, DLF-3, is undergoing trials. This will have an enhanced radar cross section, while retaining the rapid deployment, low ship impact, and other ready-use characteristics of the DLF-2 system.

Another threat to the viability of decoy launchers as anti-missile defense comes from the steady improvement in the performance and flexibility of missiles. In 1982, inquiry into the sinking of the destroyer *HMS Sheffield* by an Exocet missile indicated that visual warning of the missile attack could provide, at most, 20 seconds warning. Since the chaff cloud decoys require about 15 seconds to deploy from firing, the crew had, at best, five seconds to see the threat, classify it, and initiate the launch procedure. This is just not possible, with the result that a visual alert system is already nonviable.

Since 1982, the speed of inbound missiles has increased drastically. The "new" generation of hypersonic sea-skimming anti-ship missiles can cover the intercept zone from horizon to target in around 6-12 seconds. This rules out chaff as an effective defense. Two readily available missiles fall into this category: the Chelomey P-80 *Zubr* (industrial designation 3M-82), which makes its attack run at mach 2.5, and the *Raduga* P-270 (industrial designation 3M-80), which cruises to its target at mach 2.3, but then accelerates to mach 3.5 from the final ten-kilometer attack run.

The P-80 missile has another feature that vitiates the effect of chaff clouds. The radar guidance system in the P-80 uses Inverse Synthetic Aperture Radar (ISAR) technology to create a radar picture of the target ship. This is accurate enough to allow the firing ship to recognize the proposed target and is also accurate enough for the missile homing head to detect and recognize the forming chaff clouds and to discount them from the target picture.

The US is actively engaged in developing similar abilities to avoid deception. Engineers are attempting to capitalize on state-of-the-art processing techniques, new signal analysis algorithms, IR sensors, and a variety of terminal maneuvers (to get a different look at the target). The creative use of Global Positioning System receivers will help missiles find the target rather than the decoy. Advances in components and improved radar systems for missile warheads are bearing fruit in this area. Advances are being closely held by US Navy planners.

The development of adaptive radar altimeters means that anti-ship missiles can fly much closer to the surface of the sea. They automatically sense sea conditions and adjust the cruise altitude of the missile accordingly. The combination of this technology with hypersonic flight has made the provision of a separate rapid response radar warning system for the chaff launchers essential. A number of suitable RWRs are already available, for example, Shiploc (produced by Thomson-CSF). The need to keep weight and cost to a minimum means that these detectors are prone to a high false-alarm rate and are best used in conjunction with a full-scale ESM system. The engagement pattern becomes the ESM system triggering the chaff dispenser RWR when it picks up the missile launch platform search radar. The chaff dispenser RWR then fires the chaff launchers when it picks up the missile homing head. Direct triggering of the chaff launchers by the main ESM system is not regarded as a viable solution because of the time taken for the full-scale equipment to analyze and classify the threats. It is desirable to reduce the workload on an already heavily utilized system.

The existence of alternative guidance methods means that a radar warning receiver can no longer be relied on to give infallible warning of a missile approach. Other technologies are needed. Naturally, in these cases, the programming of the dispensing system is designed to ensure that the correct munition is fired to counter a specific threat. The most promising are infrared alerting systems that pick up the ultra-violet energy in the heat plume generated by the missile's engine. The French Navy already has a system of this type (Vampir) in service, while the Royal Navy is acquiring a derivative of the British Army's ADAD infrared detector. (These systems are fully described in Forecast International's *Electro-Optical Systems Forecast* service.)

Systems in this category are designed to give 360-degree, 24-hour coverage with filters to reduce the number of false alerts. As a bonus, they can also detect missiles while they are still over the visual and radar horizons, buying priceless seconds for the defensive systems to deploy. As laser-guided missiles become more common, laser warners have already established themselves as a part of the standard decoy dispenser alerting package. These may be used to ignite smoke pots on the bow of a ship to generate a laser-reflective smoke screen. An installation of this type was recently observed on the Russian BPK *Admiral Kharlamov*.

In addition to electronic counter-countermeasures, traditional chaff clouds can also be defeated by the use of secondary guidance methods or alternatives. Numerous anti-ship missiles have infrared guidance backup to their primary radar seekers, while others use imaging infrared or optical command guidance. Few modern decoy launchers are now restricted to chaff rounds. Nearly all offer infrared decoy flares as an alternative payload. Smoke, laser obscurant smoke, and thermal smoke rounds are becoming common, since the disappearance of steam turbine ships makes the traditional means of laying smoke screens impossible.

The growing sophistication of missile homing heads is driving decoy operators to adopt the concept of active expendable jammers. This is effectively a lightweight disposable jammer installed within a decoy round and kept airborne for a period of several minutes by a parachute or hovering rocket. The chaff used in decoy rounds has changed radically over the last few years. Aluminum foil has been replaced by metalized glass fibers. These provide greatly enhanced bloom time, remain airborne for considerably longer, and are much lighter, resulting in greater quantities being packaged into smaller rounds.

Jammers and Other Active Systems. Active countermeasures can employ a wide range of tactics, from simple noise jamming to false-target transmitters sequenced to confuse scanning radars. Noise jamming can blot out signals over a wide range of frequencies (barrage jamming). This type of noise jamming can be defeated by increasing the transmitted power of the emitters to "burn through" the jamming. Since the signal energy is spread over a wide band, the amount at any one frequency is relatively low and burn-through energies can be achieved readily. A more subtle countermeasures approach is to concentrate the jamming energy on a particular narrow frequency band (spot jamming). This frequently can be determined by the ESM (Electronic Support Measures) equipment. The preferred option for countering spot jamming is frequency agility, quickly moving and "hopping" away from the jamming signals. As the frequency range of the radar increases, the broader becomes the range of frequencies through which the system can hop. This complicates the design and operation of a jammer that will follow the hops.

A more sophisticated and effective jamming procedure is deception jamming. Deception jamming depends upon measuring the radar pulse repetition frequency (PRF), scan rate, and pulse width. For this data, the jammer is dependent upon a companion ESM system. Since radars have finite side-lobes (i.e., cannot concentrate all their emitted energy or their reception in one direction), jamming signals can enter the receiver via those side-lobes and appear to be coming from the direction in which the radar is pointed at the moment. Once a false echo has been generated, it can be used to confuse the radar with range-gate pull-off (or in bearing by exploiting the side lobes). There are multi-antenna anti-monopulse techniques. Varying the PRF is a simple counter-countermeasure, since the radars can be programmed to reject received signals that do not conform to a precise preset pattern in PRF variation.

Regardless of the type of jamming and the generation system used, effective ECM requires the jamming beam to be concentrated on the target. The jammer antennas must be paired with a tracking system. In some cases, for example the Racal systems originally developed by Thorn-EMI, the tracking and jammer antennas are combined. The US Navy's SLQ-32 system goes one stage further and combines the initial detection, target tracking and jamming functions into a single antenna array. Although the tracker can function as a search antenna, its beam is too narrow for efficient search. A more usual solution is to have a separate course direction finding system for initial detection.

Developments in antenna technology are influencing designs. Driven primarily by research and development for airborne radar systems, the development of module-based active arrays will make very capable, small, lightweight arrays available for naval systems. This will enhance the ability to install rapidly steerable, highly flexible antennas higher and higher on a ship's superstructure. MIMIC and GaAs components are shrinking the size but increasing the capability of individual antenna elements. Combining arrays of these elements with powerful control processors will make it possible to shape and steer both transmit and receive patterns at electronic speed without physical motion. Next-generation designs can be expected to begin capitalizing on this technology.

The point at which jamming should be initiated is the subject of heated debate. One argument stresses the importance of initiating jamming against hostile target acquisition radars as early as possible. This forces missiles launched with less than accurate targeting data to turn their seekers on earlier and to search a much larger area to acquire their targets. By implication, they must also fly higher to search efficiently. There is evidence that long-range jamming enhances the effectiveness of chaff clouds and ship maneuvers in evading attack.

Supporters of this approach point out that active jamming can be performed indefinitely without running out of munitions. However, there is another school of thought which suggests that this long-range jamming is counterproductive in that it can be detected by hostile ESM systems and used to localize the jamming platforms. Jammers present the same hazards in operation as do the radar systems they counter - their radio frequency emissions can be detected by passive means from ranges considerably greater than the effective range of the system in question. Just as a ship using its radars reveals its position, so does any ship initiating active jamming procedures.

Thus, for all of the range and sophistication of jamming techniques available, the deployment of active jammers on warships is a contentious issue, with spirited debate as to whether the jammers are worth installing and, indeed, whether they do not represent a more serious threat to their platform than their utility warrants. The tactical and operational significance of this debate ultimately depends upon the circumstances involved. If the ship has already been detected, localized and placed under attack, the emissions of its jamming systems do not compromise it further. Under such circumstances, attempting to jam target acquisition, fire-control radars and missile homing heads is viable, although the desired results may be achievable by other means. If, on the other hand, a ship has not been detected and attempts to use jamming systems to prevent localization by hostile radars, the emissions of the onboard jammers will achieve the opposite effect and highlight its position.

Much here depends upon the relative levels of technology of the combatants. A sophisticated ship facing a primitively equipped opponent with a poorly trained crew can use jamming techniques with devastating effect, while the same approach would be counterproductive against a ship equipped to a comparable or superior level of EW technology and operated by well-trained and experienced personnel. This also points to the need for continuously training crews in EW technique and a corresponding requirement for both updating and using shore-based and shipboard simulators.

Another area of concern lies in the jammer transmitting a radar-like signal. This is vulnerable to exploitation by anti-radar missiles (ARM) used in the home-on-jam mode. Home-on-jam is sometimes presented as a radical or mysterious technology; but it is simply an extension of the already well-known and widespread anti-radar missile systems. Although it is not widely advertised, most ARMs have a home-on-jam capability, and this facility is built into most of the large Russian air-to-surface and surface-to-surface missiles as an alternative to radar and/or IR homing. The attack pattern either uses a mixture of normal and home-on-jam missiles or provides the capability to switch from one homing mode to the other in flight.

A counter to home-on-jam is to move the jammer off the ship completely by putting it into a decoy round. This concept, the offboard expendable jammer, is mentioned briefly in the section on decoy dispensers. Two approaches are being explored. The first is to package a relatively sophisticated jamming package into a decoy rocket and fire the round, one-on-one, against individual missiles leaking through active defenses. The decoy round deploys a parachute and uses blip enhancement and seduction jamming to lure the inbound missile away from its target and into chaff clouds.

A second technique is to install the jamming package on top of a platform that can be controlled to emulate the movements of a ship. This system can also be used to decoy search radars by giving a totally false idea of the potential target's course and speed so that the missiles are launched on an incorrect course.

Whichever solution is finally adopted, the characteristics of modern anti-ship missiles make it essential to include some form of continuous wave jamming capability. The ECCM capability of modern missile seeker heads can easily filter out pulse jamming emissions. The ISAR guidance system used on the P-80 missile is quite immune to pulse jamming, yet its target image can be wiped out completely by continuous wave jamming. The problem with continuous-wave jamming is that it is particularly vulnerable to home-on-jam.

The limited role of jamming systems, the hazards presented by their use, and the availability of the offboard jamming solution all strongly point to a reduction in the importance of these systems. However, the jammers retain tactical value by deflecting attacks on their platforms and supporting strikes by jamming the defensive systems of hostile platforms. We believe that the most likely course will be the replacement of the existing large, complex and expensive jammers by new, lightweight systems that exploit advanced electronic technology at dramatically reduced costs, while reducing capability to a much lesser degree. The emphasis in warship fits will switch partly to acquisition and perfecting of offboard expendable jammers and partly to major enhancement of passive ESM capability.

ESM Systems. The electronic surveillance measures equipment fitted to a modern warship has become a ship's most important sensor. ESM provides a covert and unobtrusive way to gather data on the tactical situation as well as hostile forces that are either threats or potential targets. ESM coverage is both offensive and defensive, providing passive detection of naval and airborne systems well beyond the radar horizon. Where the level of capability is sufficient, an effective ESM system can make over the horizon targeting (OTHT) for missiles possible. The attack warning function requires coverage of the I-, J- and K-bands used by fire-control radars and missile guidance seekers. OTHT requires coverage of the D- and E/F-bands used for air and surface search and, preferably, screening of HF communications facilities.

The primary function of an ESM receiver is to determine the main parameters of an intercepted emitter, including the bearing, intensity, frequency, pulse width, PRF, scan rate, and frequency hopping pattern (if any). These data are then compared with a threat library, the emitter identified by comparison with known parameters or marked down as previously unknown, and the operator informed accordingly. In some cases the data are immediately conclusive - Royal Navy UAA-2 operators found the signature of the US SPY-1 radars so specific that it could be identified instantly. In other cases, the presence of similar radars on friendly and hostile platforms (Cyrano IV on the Mirage F1 being a good example) or the adoption of war-only modes made the contact ambiguous and identity had to be resolved by course and motion analysis or the coordinated use of other sensors. A problem is that software-controlled radars have a far greater range of operational characteristics than older types and can be programmed to emulate other radars to deter ESM identifications.

Parameter determination can be accomplished by a number of different types of systems. One is a broadband crystal video receiver (CVR). It is very simple and lightweight, but is not suited for serious ESM duties. These systems are best used as radar warning receivers, set-on receivers for decoy launchers, and for platforms too small to carry proper ESM. They are very useful as backup when the primary ESM system is inoperative due to malfunction or battle damage. CVRs are ideally suited for storing as emergency upgrades for ships about to go in harm's way.

A second approach is the tunable receiver, known as the scanning superheterodyne receiver (SHR). Modern radars typically employ pulse widths of a few microseconds, degrading the efficiency of even the electronically scanned systems. The third common technique for emitter parameter analysis is Instantaneous Frequency Measurement (IFM). These receivers are open to the entire frequency band all the time and have a high chance of intercepting a signal. They tend to be less sensitive than an SHR because they have to respond to such a broad frequency band (as a rule of thumb, sensitivity is generally inversely proportional to channel width). IFM is becoming increasingly common in shipboard systems as the argument that excessive concentration on sensitivity is counterproductive receives greater acceptance. The main drawback with IFM is that, since a finite time is required to process each intercepted signal, the system may be unable to cope with a string of intercepts in quick succession. This problem is not insoluble, but it does increase the complexity of the system.

The key parameter determined by an ESM system is the bearing of the threat. An octantal bearing is adequate for radar warning purposes, while for many years a bearing accuracy of about six degrees was regarded as adequate for ELINT operations. This is now regarded as obsolete, and the latest British and European ESM systems offer a combat-demonstrated angular resolution of 0.5 degree. Three techniques are used to provide directional data. These are interferometric, monopulse, and single directional antenna.

Interferometers are the oldest form of direction-finding device. They consist of a series of omni-directional antennas, each of which detects a signal with a slightly different time delay depending on the signal bearing. Monopulse direction finders compare the strength of signals as they are detected by a series of antennas oriented in different directions. These antennas are usually spirals or broadband cones. Monopulse DF is used extensively in wide-open systems for warships; the monopulse arrays can be seen on the masts of British frigates, usually just underneath the main search radar. Monopulse techniques are usable only against radar wavelengths, since the individual antennas must be large enough (in wavelengths) to generate non-overlapping beams. The requirement for DF against HF, VHF and UHF radios requires a different design solution.

In contrast to interferometer and monopulse units, directional antennas have a narrow beam pattern and scan over the direction of an incoming signal. This provides greater gain, resulting in increased range, but coverage of a given signal is intermittent. The current trend is to rely on monopulse for radar direction finding and to reserve high gain equipment for trackers associated with jammers.

Even the most advanced electronic warfare equipment will not perform correctly unless it is properly located within the ship. Effectively, this means that the need to place the ESM antennas in optimum positions drives the design of the superstructure. The degree to which superstructure design is dictated by ESM antenna placement is a good indicator of the priority placed on EW by the design teams. It is noticeable that the ESM fits on British ships are far more extensive than on US warships and that a number of subtle design compromises have been made by British designers to ensure that the ESM antennas are carried in the optimum positions- high and providing uninterrupted 360-degree coverage. Most US warships carry their SLQ-32 antennas low, either on the superstructure or, as on the CG-47 class cruisers, actually fitted to the superstructure sides. This position, however, may well degrade the performance of the intercept and jamming systems due to multi-pathing and may limit the intercept horizon. Worse, wooding caused by the superstructure and masts eliminates coverage directly ahead and above, creating dangerous blind arcs.

Outside the US Navy, a new generation of ESM systems is entering service. These feature elaborate ELINT capabilities and 0.5-degree bearing resolution as standard. In the UK, the new Outfit UAT ESM receiver, a Royal Navy derivative of the Sceptre XL system produced by Thorn EMI (now Racal), is being installed on the Type 23 frigates and retrofitted to the rest of the Royal Navy's aircraft carriers, frigates and destroyers. The British submarine fleet is being fitted with either the Racal Outfit UAL system, a submarine-mounted version of Sceptre XL, or with Outfit UAP. Both UAL and UAP are designed to provide OTHT capabilities for Sub-Harpoon. Racal is working with AEG on providing the FL-1800S and FL-1800U systems for German surface ships and submarines, respectively. Racal also supplies a family of systems based on the Cutlass/Cygnus integrated jammer/ ESM equipment to the export market. All these Racal systems are closely related and share much of their technology.

The US Navy's surface ESM effort will be dominated by the AIEWS (Advanced Integrated Electronic Warfare System) project to develop a replacement or follow-on for the Fleet-standard SLQ-32. The effort is part of the Navy's consolidated Ship Self-Defense research and development program. As the Navy changes its emphasis to operations in the littoral (coastal waters) from deep-sea operations against the former Soviet Navy, it is changing the way the Fleet will defend itself. The Advanced Integrated Electronic Warfare System (AIEWS) has become a cornerstone for future surface-ship EW system development. In addition to the AIEWS program, Ship Self-Defense funds efforts to develop a protection against anti-ship missiles and addresses sensors, command and control, data processing, and weapons improvements.

The AIEWS concept is to extend the ship's battle space by improving detection and countermeasures capabilities. The resulting system would be better able to detect threats with passive surveillance equipment, introduce more effective countermeasures throughout the engagement, and better integrate with the ship's sensor and combat systems. Production is planned to begin late in the decade. The new system will incorporate a command system that can provide a fully passive targeting capability for surface-to-air and surface-to-surface missiles and guns. The AIEWS program is to be split into high- and low-capability systems.

Information Warfare. In October 1995, the Navy opened its Fleet Information Warfare Center (FIWC). Located in Norfolk, Virginia, the new facility will concentrate on developing equipment, doctrine, and tactics to protect the information-intensive Fleet from corruption by adversaries. As warfighters become increasingly dependent on information, protecting this information becomes increasingly important. All services are focusing on this area as a priority. As these efforts mature and develop, systems and requirements will begin to emerge. Many efforts will be an outgrowth of current EW programs; but a few may become new, unique efforts. This market will develop through the end of the century and become active into the next decade.

Electronic Counter-Countermeasures. The anti-ship missile technology evolved by the Russians to beat anti-missile defenses is based on the concept of building the fastest possible missile in order to give the defensive systems the minimum possible reaction time. For this reason, no attempts are made to adopt evasive attack runs or to adopt any maneuver that would increase the time taken to reach the target. This approach has numerous penalties in terms of missile size and tactical indiscretion. The rapid reduction in the cost of computer processing power and the dramatic fall in the size of processing components has opened up other possible routes.

Most anti-missile gun systems work by closed-loop tracking. With this technique, the fire-control radar tracks both the inbound missile and the stream of outbound shells and re-aims the gun so as to bring them together. New-generation anti-ship missiles have the capability to turn this technique against itself. The missile can sense the radar emissions from the point defense gun and, using phase comparison, locate the position of the gun relative to itself. The missile then uses its own course and speed data, plus processing algorithms similar to those in the CIWS gun, to predict the aiming correction being applied by the gun and, thus, the point in space at which the stream of shots will be aimed. The missile then goes somewhere else. This is, of course, an iterative process; the CIWS detects the course change and corrects accordingly while the missile recomputes its quasi-firing solution and adopts a different "somewhere else."

As a result of this battle of electronic wits, an anti-ship missile of this type gives the appearance of dancing with the stream of shots from the CIWS. The objective is not to produce an immune missile, but to stretch the time the CIWS takes to splash each target. The longer this time, the fewer inbound missiles will be engaged and the more will get through to score hits. This technology is not applicable to a hypersonic missile (simple aerodynamics prevent a Mach 3.5 missile from making the maneuvers in question) but gives a smaller, simpler subsonic missile a good chance of penetrating a defense screen.

The US is actively involved in developing missile components that are making this type of performance possible. VHSIC and MIMIC developments are packing more power and enhanced capabilities into missile guidance systems. Combining these rapidly developing techniques with smaller and better-built RF and processing building blocks will greatly stretch the envelope of offensive and defensive systems.

Laser Countermeasures. Systems that help protect ships from laser-guided and other electro-optical sensors is becoming an increasingly important market. See the Forecast International/DMS *Electro-Optical Systems Forecast* Market Intelligence Report binder for an in-depth treatment of the overall IR/EO market.

Electric Weapons. Shipboard weapons using electricity to generate some form of destructive beam are under development. Much of the technology has been worked out; what is needed is a source of sufficient power that could be installed aboard combatants. Once these power supplies become available, we will likely see the use of directed-energy weapons (DEWs), responding to missile threats at nearly the speed of light. One such system is the HELWEPS (High Energy Laser Weapon System) for potential use aboard Aegis cruisers and destroyers. HELWEPS is based on a megawatt-class deuterium/ fluorine chemical laser, replacing the standard 5-in gun mount. HELWEPS, it is said, could be used to destroy missiles out to a range of about 4 km. It could also be used to burn out electro-optical sensors at about 10 km.

TRW, which worked on the HELWEPS design, also has built the laser now used on the US/Israeli joint Nautilus program, the MIRACL (Mid-Infrared Advanced Chemical Laser). MIRACL was originally intended for the USN-sponsored Sea Lite program. In testing, the laser has intercepted missiles traveling at up to M2.2.

Also under testing for such weapons application are high-power microwaves. The US Defense Special Weapons Agency has pioneered a promising source. Called the repetitive frequency-agile (RFA) method, this approach couples microwave energy effectively into targets and interferes directly with circuit operation. The US Army and Navy have participated in trials demonstrating ranges up to several tens of kilometers.

Millimeter-Wave Threat. A market should begin emerging for naval electronic support measures and EW receiver systems capable of detecting a new kind of threat that is just appearing: millimeter-wave radar for anti-ship missile/munitions-guidance and target-tracking systems. Currently few detection or countermeasures systems operate in the spectrum commonly used by millimeter-wave radar, which is the 35-GHz (Ka-band) and 94-GHz (W-band) ranges. This radar technology is an outgrowth of MMIC (monolithic microwave integrated circuit) technology. As it has matured, MMIC technology has enabled designers to achieve the necessary cost-performance requirements.

Systems Integration. A theme echoed repeatedly in the above sections has been the interrelationship between the various forms of naval EW and the synergistic benefits of using different EW techniques in mutual support. A less obvious, but no less important, relationship exists between electronic warfare equipment (and techniques) and other aspects of naval technology. In effect, these relationships mean that relevant EW requirements must be included at the earliest stage of the ship design process. This applies to both the electronic aspects of design (integration with other sensors and with the command system) and the physical design of the ship (position of sensors and survivability considerations).

The US Navy's Ship Self-Defense efforts are coordinating sensor, countermeasures, weapons, and data processing/ communications to apply this integration principle better than in the past. US battle groups will come to fight as a more integrated team rather than independent ships as these programs bear fruit.

The interrelationships between the various naval EW systems make integration by including passive detection, active jamming, and OTHT within a single package conceptually attractive. This approach was adopted for the US Navy SLQ-32. The problem is that the resulting antenna system is frequently too heavy to be mounted mast-top height and must be carried on top of, or even on the sides of, the superstructure. On the other hand, using separated ESM, jamming, and OTHT arrays reduces the problems of carrying the equipment high-up at the cost of integration problems. This situation again indicates the extent to which superstructure design must be driven by the requirements of the EW suite, and the problem will only be resolved as the advances in electronics technology move into lighter and more compact antenna arrays. As mentioned earlier, antenna design changes will begin to influence the design of future systems.

It is also necessary to integrate data presented by sonar with ESM and radar information. This reflects the possibility of a missile submarine, hunted by a frigate, firing a salvo of subsurface-to-surface anti-ship missiles. Fired at point blank range, the frigate could have under two seconds to respond. In this case, the launch transients detected by sonar would add precious seconds to the warning time, permit chaff clouds to be deployed, and allow active jamming to be initiated. ESM equipment could be readied to verify that the missile was radar-guided by picking up the homing head. Finally, fire-control radars would be pointed at the launch point to engage the missile as soon as it emerges from the sea.

The US Navy is thought to be behind in this area, although the Advanced Combat Direction System (ACDS) currently being implemented fleetwide will significantly improve matters. While Aegis is often presented as being an integrated command system, this has not exactly the case, since it concentrated on the air defense function. A significant pointer is that the Japanese *Kongo* class destroyers, equivalent to the US *Arleigh Burke* class, mount a separate, fully integrated combat system, OYQ-6, which is fed with data by the onboard AEGIS AAW and SQQ-89 ASW combat direction systems and integrates the information from them. The Navy has been actively involved in upgrading the Aegis system into a more coordinated, more inclusive combat control rather than air defense system. Recent tests indicate these efforts are bearing fruit.

On a simpler level, FFG-7 class frigates sold to Spain were refitted with a new, fully integrated combat system that includes a license-built Nettuno integrated EW fit. Spanish sources credit these modifications with significantly increasing the combat efficiency of these ships. As more and more US warships are sold to other users, a market for upgrading their combat systems to European standards will develop. Plans for the SLQ-32 follow-on, the AIEWS, include increased integration requirements.

The interrelationships between a warship's EW effectiveness and other aspects of its design are frequently very subtle and can lead to some unexpected conclusions. The seeker in an anti-ship missile generally homes in on the center of the target's return. It follows that careful design of the ship's hull and superstructure can distort the radar image presented to the missile and deflect it from the center of the ship. Once the missile is deflected away from the center of the ship, decoying by chaff becomes easier, and hits are likely to be in less vulnerable sections of the vessel.

This leads to the question of ship survivability. At first, the provision of armor protection (steel or Kevlar) to a ship seems unrelated to its EW capability. In fact, built-in provisions for ship survivability have numerous direct benefits to its EW performance. If ships are made more difficult to sink (with improved compartmentation, armor protection to vital areas, quadruplicated vital facilities, and other similar provisions), enemy missiles must be equipped with significantly larger warheads to defeat these protective measures. Finally, if the damage inflicted by near misses can be contained, the acceptable margins for decoying missiles are reduced with proportional increases in success rates. In this respect, ship damage control is also a vital component of EW efficiency.

The ability of an individual ship to survive hits is of key importance to the EW defense of the battle fleet as a whole. As long as a ship stays afloat, even as a helpless wreck, it will continue to attract missiles and dilute attacks on other, as-yet undamaged, warships. If surviving radars can continue to radiate or if their emissions can be simulated by jammers, the problems in determining the ship's status are multiplied. Most naval exercises have demonstrated that "attacking" warships will continue to pump missiles into their targets until the victim "sinks." The converse of this situation is that ESM and related technologies have some use in determining whether damaged ships are crippled or merely hurt. Attack damage assessment remains, however, a largely insoluble problem in the naval environment until the victim of the attack finally sinks.

Russian EW Equipment and Doctrine. The decisions made by the Russian Federation to release most of their advanced military technology for export has revolutionized our understanding of their electronic warfare doctrine. The Russians rely on tightly integrated systems in which a number of subsystems are integrated to provide complete coverage. The crucial difference between this doctrine and that of Western countries is that there is little distinction made between the units of the system, or between electronic warfare equipment and radars. ESM receivers are considered to be passive radars and carry the same name (RLS). There is no separate electronic warfare plot; the information from the equipment is automatically integrated into the standard tactical display. The EW operators' actions are controlled by the integrated data emerging from the warship command system.

Russian naval EW doctrine emphasizes the primary importance of complete EMCON. Radars are designed to transmit briefly, then to project target positions ahead from the partial data thus obtained. When ships operate in formation, radar transmissions are minimized by designating one ship as a short-range guard-ship and another as an air-warning guard-ship. Surface-search radars are operated in a single sweep mode, often cued by ESM, to avoid interception. All radars are restricted to a single frequency in peacetime to avoid disclosing war reserve modes (WARMs). This EMCON policy extends to communications that are subject to severe restrictions, with a single ship in the formation being designated as the communications center. All between-ships communications are by line-of-site radio, loudhailer or signal lamp. Any commander making unauthorized transmissions is obliged to submit a detailed report, which is likely to result in serious disciplinary action. For all of this detailed EMCON planning, the Russian fleet failed to comply with the ideals, and passive targeting by its opponents is still a valuable technique.

Modern Russian ESM systems tasked with radar intercept and analysis are believed to be based on Signaal technology and bear some architectural relationships to the Rapids system used by the Canadian Navy. Their operational characteristics and performance capabilities are also reminiscent of Rapids. The Russian systems concentrate heavily on the F- to J-bands, using a digital frequency readout, a signal/strength/PRF B-scope and a PPI for bearing. Russian ESM is routinely capable of gaining bearing accuracies of around two degrees.

The communications intercept system covers the VHF bands using horizontal loop and dipole antennas on the yardarms. These have considerable blind zones, forcing the operators to switch between antennas to maintain coverage. This procedure generates significant self-noise and, combined with electronic interference from other ship systems, limits maximum range to around 12-15 nm and bearing accuracy to around five degrees. Thus, the systems are, at best, of limited tactical utility.

Russian interest in chaff and flare decoys is more recent and can only be traced back to the widespread introduction of radar-guided anti-ship missiles into Western navies. Soviet doctrine appeared to say that such weapons could not be defeated by the active countermeasures systems available to the fleet and that the provision of decoys was essential. Chaff launchers are now standard equipment on all Soviet-designed warships from the *Nanutchka* class missile corvettes upwards. Smaller ships carry a ten-barreled rocket launcher while larger units carry 16-barreled systems.

Soviet-designed warships also carry provision for launching chaff balloons and are equipped with floating decoys. These latter are equivalent to the Royal Navy's Replica decoys and are reported to have provided the inspiration for the British system. In spite of being seen since the early 1980s, the Soviet floating radar reflectors have spread slowly through the fleet and many high-value platforms still have not received their scheduled outfit.

The Russian Navy was the first to introduce an offboard jammer to its warships. This system is fired from a twin-barreled, 150 mm heavyweight launcher fed from a below-decks magazine where the rounds are stored and maintained. Inspection of the decoy round revealed it to be fitted with a parachute for prolonging its deployment time, rather than the hovering rocket favored by NULKA. As a secondary function, the 150 mm launcher can also fire chaff clouds with a chaff cutting room below decks.

The Land-Based EW Environment. Land-based electronic warfare as a separate specialty developed later than naval and airborne EW. Originally, efforts only involved the location of enemy forces based on intercepted communications and intelligence gathering by listening in on opponents' command net. As long as ground combat command and control was based on voice communications, opposing commanders tended to focus on exploiting enemy systems rather than disruption or other overt action. In contrast to the air and naval environment, ground combat control tended to be very reliant on visual coordination, through the Korean War.

Tactics concentrated on maneuver and firepower rather than on technical exploitation. Through the late 1950s, communications and EW technology was such that the communicator had the advantage. Because command and control could be accomplished with short, coded or scrambled voice transmissions using high-powered ground equipment capable of operating over a relatively wide frequency spectrum, jamming was not practical. It was not uncommon for a skilled radio operator to come up on a frequency, transmit the message, and be off the air before a jammer could detect the transmission, determine its frequency, and tune jamming equipment. Because the equipment was on the ground, large high-power transmitters made the jammer's task nearly impossible. More effort went into securing the intelligence in one's own message traffic and finding ways to decode the information in the enemy's transmissions than in trying to design jammers.

Soviet tactical doctrine and emphasis on Radio-Electronic Combat (REC) doctrine prompted planners to rethink many aspects of their approach to ground electronic warfare. Their concept of "radioelectronic struggle" combined electronic warfare techniques with surprise maneuvers, deceptive tactics, and firepower into a unified tactical plan. The Soviet military's focus was to deny opposing forces the effective use of the electromagnetic spectrum while protecting their own command and control capabilities. Tactics were to paralyze the enemy long enough to make a smashing attack by massed forces possible.

The beginnings of change were supported by the development of digital data processing; high-power, wide-bandwidth transmitters; and rapid-tuning frequency generators. Western forces began to use these developments as ways of avoiding or minimizing the impact of Soviet-planned operations. Command links began to depend more and more on transferring increasingly complicated data streams. Even in the presence of interference or jamming, skilled operators can often extract enough of the message to make the communication effective.

High-speed data, on the other hand, is far more susceptible to interference. This made it possible for a jammer to disrupt communications with less power or shorter transmission times. Advances on the ground still lagged behind naval systems and especially the airborne EW field. The armies of the West still emphasized firepower rather than jamming power.

Through the 1980s, this began to change. Progress in electronics components increased the capability of communications hardware, information processing equipment, and electronic combat equipment. Transmitter power increased, bandwidth and stability increased, and data-rate transmission speed grew by orders of magnitude. Receiver sensitivity increased, as did the ability to change frequency. New communications techniques developed to meet the ever-increasing demands of data processing support for battlefield operations. The nature of combat changed. Movement and control replaced mass and power; distributed data processing replaced centralized control. But countermeasures continued to concentrate on the application of power to disrupt communication signals.

Through the decade, improvements in radios and techniques of data security were the focus of planners and designers. Command concepts began to rely on front-line processing of massive amounts of information distributed from multiple sources and transmitted to multiple elements. Operational tactics began to rely more on the rapid transmission of data than voice communications. Efforts to develop countermeasures to these developments lagged behind until the latter half of the decade.

Developments in communications technology and data processing made it possible to deploy very capable equipment to the front lines. Tactical use of the frequency spectrum improved as systems began transmitting more data over narrower bandwidths and enhanced antennas were becoming much more directive. Radios could change frequencies rapidly, broadcast significant information quickly, and move to another frequency. Other equipment could operate over wide portions of the spectrum, making the effective application of debilitating jammer power next to impossible. And improved coding algorithms made the unauthorized decoding of communications information next to impossible, especially in short time-frame tactical operations. By the late 1980s, fiber-optic cable made for nearly jam-proof, detection-proof short-range networks.

A side-effect of this quantum leap in the use of RF communications was an overcrowding of the frequency spectrum. Modern combat is characterized by an extreme clutter of signals in a relatively limited area. Jamming did not receive as much emphasis as the efforts to clear the RF environment for more effective communications. Some field commanders felt that combat communications had become self-jamming through mutual interference. This over-crowding and interference continues today and was a major contributor to friendly-fire incidents during the Persian Gulf War. In part, these resulted from an inability to communicate effectively because of over-crowding on the radio links.

Slowly the methods and equipment for electronic warfare developed, often as a side effort during this period. The advantages of electronic eavesdropping were known and exploited. Some of the jamming techniques were not applied as readily because field commanders still tended to feel that it was more valuable to gain intelligence from enemy communications than from interference with their links. Through the late 1970s and into the 1980s, this philosophy changed. Observing the ineffectiveness of troops on the modern battlefield whose communications were disrupted, field commanders began to incorporate this as a tactic. Equipment and techniques began to be developed, and studies into the vulnerability of both friendly and potential enemy equipment were intensified.

Electronic warfare systems on the battlefield tend to be simpler than naval warfare systems, primarily due to the nature and makeup of the environment. Tactical decoys on land are not as valuable as those at sea because of the totally different nature of weapons targeting. The traditional army use of smoke shells and grenades remains useful in defeating optically guided weapons, while new types of smoke screens are available to defeat thermal sights and even laser guidance systems.

On the tactical level, complex deception is usually not worth the effort beyond avoiding/delaying initial detection or masking. Once units engage, however, electronic intelligence gathering becomes important. Even if a commander cannot decode all of the message traffic, factors such as quantity, source, and message length can be important intelligence indicators. With the increases in number and sophistication of communications devices on the battlefield, the number and sophistication of battlefield EW hardware have had to increase. This has been paralleled by the effort to explore the exploitability potential of hostile equipment as well as of friendly equipment. The US Army has an ongoing program to catch up with requirements in this vulnerability assessment effort.

At the operational level, deception and decoying operations start to come into their own. Although it is impossible to hide a modern armored corps, it is possible to give a misleading idea of its strength and axis of advance. The Soviet armed forces had long placed great faith in this ability, with a wide range of techniques collectively designated "*Maskirovka*." Recent manifestations of the art have included the use of static and mobile radar corner reflectors to confuse and degrade the battlefield image presented by JSTARS and similar systems. These can be easily defeated by the incorporation of MTI and synthetic aperture technology into the surveillance radars, and such provisions are now standard in all the proposed battlefield surveillance systems. The use of radar for target location has reduced the value of the traditional inflatable armored vehicle decoys, a development countered by Iraqi troops who coated the decoys with aluminum cooking foil to give them a radar image. A more sophisticated version is available wherein the rubber decoy is coated with a radar-reflecting mesh similar to that used on the naval Replica (sometimes called “Rubber Duck”) floating decoys.

A traditional method of operational deception has been the dissemination of falsified radio traffic to disguise command routes and mislead potential eavesdroppers. As techniques for communications intelligence have become more sophisticated, the efforts made toward the preparation and use of deceptive measures has had to keep pace. Such operations were of key importance in the days leading up to the Desert Storm land attack that ended the Persian Gulf War. Elaborate electronic deception was used to conceal the movement of two tank-heavy corps hundreds of miles to the west of their previous positions. Each corps left behind a battalion-sized signal unit that transmitted large numbers of false radio and data stream messages. They transmitted simulations of HAWK and Patriot anti-aircraft missile battery radars to add strength to the illusion.

The US has made increasing use of several different electronic warfare systems to collect intelligence on opponents, locate their formations, and transmit jamming signals to interfere with their operations. Through the 1980s, the Army began to increase the operational efficiency and priority of these activities by fielding more capable systems and strengthening the operational units dedicated to these efforts. Growth for an early HF/VHF jammer family is exemplified by the late 1960s GLQ-3 through the TLQ-17 series of TRAFFIC JAM equipment and to today's MLQ-34 mobile communications jamming system.

The US Army has embarked on a program to combine and standardize many of its electronic warfare efforts into the Intelligence and Electronic Warfare Common Sensor (IEWCS) which is to be fielded by the end of the decade. This has become one of the major US ground-based efforts through the turn of the century. The MSR-3 TACJAM-A will be the key ground-based asset for this integrated system. It will replace a variety of smaller, less capable, less flexible systems previously fielded with combat forces. This is all part of the Army's *Modernization Plan*, an effort to bring the combat capability of the front-line forces into the 21st century – in time for the 21st century’s actual arrival.

The European land EW sector is difficult to cover due to tight national security restrictions on the equipment in service and scales of deployment. The companies producing the equipment also maintain stiff security on their export sales, and no accurate data are available. In the UK, ground EW capability is concentrated in the hands of the 14th Signals Regiment, which is equipped with Racal-supplied COMINT and jamming systems. A considerable quantity of Marconi-supplied equipment is also in service. German equipment is supplied largely by TST, while the French Army equivalents are the products of Thomson-CSF.

Most European emphasis, however, appears to be concentrated on the development of battlefield electronic warfare tactical data handling systems for collecting, processing and exploiting information rather than on the sensors themselves. The perception is that the capabilities of the current generation of ELINT, COMINT, and SIGINT systems are adequate to conduct the level of operations expected of them. What is essential is to improve the speed with which information from these sources can be systematically evaluated and used to generate an overall electronic map of the battlefield. An essential task is to get the information obtained by the systematic exploitation of EW assets into the hands of the troops who can best exploit it.

This has led to the development of information-handling systems and electronic warfare database systems that can receive inputs from field electronic warfare assets, then identify the signals they have picked up and fit them into an emerging pattern of battlefield deployment. Where these systems work at all, they can quickly produce a chart of enemy deployment that can be inserted into trunk communications systems so that, for example, artillery units can take the locations under fire. The problem is that the current generation of systems do not work well enough or often enough, nor do they have the electronic processing power to handle the immensely complicated battlefields typical of the modern environment.

An additional trend, resulting directly from the ongoing miniaturization of electronic components, is the development of man-portable jamming equipment. This equipment, GEC-Marconi's new Badger (recently ordered by a NATO country) being the most advanced example, offers a level of electronic warfare capability that would previously have required an all-terrain vehicle such as a Land Rover or a Humvee as a platform. It is not difficult to predict a situation where man-portable electronic warfare packages, including both ESM and jammers, will be as much a part of the standard infantry squad equipment as their tactical radio.

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Competitive Environment

United States. The US has an active electronic warfare industry and is considered a world leader, although the land- and sea-based market segment is not nearly as strong in the US as is the airborne segment. Two US companies ranked among the top five in terms of value of production this year, Lockheed Martin and Motorola.

Major market opportunities come from the TACJAM-A land-based ESM/jammer program and AIEWS replacement/upgrade for the SLQ-32 naval EW system used throughout the Fleet. Competing for the AIEWS contract are a team led by Hughes and one by Lockheed; each company submitted a concept exploration and definition study in September 1996. Based on the results of these studies, the Navy will issue a two-phase RFP in Spring 1997; award should be made sometime in 1998.

Most companies in the US EW industry used to specialize in a particular market segment; but the shrinking budget climate of the 1990s has made it good business to expand product lines and expertise in multiple areas and product lines. The leading US teams combine companies with significant airborne as well as surface EW experience.

As funding declines, the market is not able to support more than a few companies, programs, or competitions at any one time. This has encouraged teaming arrangements, mergers, and a concerted industry effort to trim overhead and find applications for excess capacity. Teaming, in which several traditional competitors join together to share expertise and costs, is a cost-effective way to secure new contracts, and for some companies the only way to survive the worldwide narrowing of the defense industry. In the surface EW market, bringing an international partner onto teams is a way of accessing other technology and making it possible to access other markets formerly closed to non-national companies. Just about all bidding teams for US naval programs will eventually have an international component. The land-based EW market will tend to move in the same direction.

Another survival technique has been the merger, the most impressive example being that of Lockheed and Martin Marietta combining to form Lockheed Martin in 1995. Larger companies are absorbing needed skills and production facilities by purchasing or establishing subsidiary arrangements with smaller operations. Many companies have moved out of defense into civilian markets or have gone out of business altogether, and some were bought out by larger companies with successful markets. Congress and the Clinton Administration have been trying to minimize some of the impact of defense cutbacks. However, the defense industry will not return to the size and robustness of the past decade.

In the surface EW arena, most of the shrinkage has already taken place. And there is little likelihood that the Department of Defense will significantly expand future market opportunities beyond the major programs already identified. Future developments are limited to one major naval system, the AIEWS, and the underway TACJAM-A portion of the Intelligence and Electronic Warfare System (IEWCS) program. Other US programs will be far smaller and of limited overall potential. Upgrades and retrofits to existing equipment are likely; but these awards will not be of a size to significantly change the makeup of the market rankings.

<u>The Clinton Administration.</u> Upon taking office, President Clinton began pushing to convert from a defense to a civilian economy. Such a shift in focus promised to have a significant long-term impact on the overall US defense industry. On the positive side, it offered possibilities for cutting defense spending to fit into a shrinking-budget, deficit-reduction climate. One of the goals of those efforts would be to develop manufacturing expertise for state-of-the-art technologies and innovative new products. This would, it was hoped, provide new opportunities for high-tech manufacturers to apply their specialized expertise, skill, and capabilities to new products. It was hoped that spin-off possibilities would develop as a result of this plan.

Those companies in the defense industry that accepted the inevitability of these changes and worked to prepare for them and reap the benefits have been faring well during the conversion. Numerous companies that sought dual-use technologies and civilian-oriented opportunities for production capacity found their bottom line in-tact. It has been necessary to scale down and make radical infrastructure adjustments to compete successfully in this new defense-industry environment.

In the FY95 defense budget request, the DoD requested $2.1 billion for these programs. The Technology Reinvestment Program (TRP) accounted for $625 million of this request. In addition to reinvestment initiatives, the request included programs to help small manufacturers upgrade their capabilities to meet commercial and defense needs as well as fund electronics and materials initiatives. Cost-sharing held out the promise of an economic boon for some companies who could not, or were reluctant to, invest in high-risk advanced technology. The TRP was pushed hard by the administration.

On October 13, 1994, President Clinton signed the *Federal Acquisition Streamlining Act of 1994.* The legislation was the result of a joint effort by the General Services Administration, Department of Defense, and NASA; although DoD was a major driver in the reform. Many of the principles and major changes resulted from Pentagon initiatives. Milspecs and archaic buying practices had long been a source of complaint from industry as well as government procurement officials. *Blueprint For Change*, a report issued by the Secretary of Defense, listed 88 recommendations, to include the adoption for performance-based standards or non-government specifications unless no other alternative existed, the elimination of excessive contract requirements, the implementation of new management tools, and the inclusion of training and new management approaches to change existing behavior and long-established buying patterns. The *Federal Acquisition Streamlining Act* was revised and re-issued in 1996.

In June 1996, *The Partnership Process for Electronic Warfare Acquisition* status report was issued. This report described a new federal EW acquisition system in which three Integrated Process Teams (IPTs) would work together to make the acquisition process better, faster and cheaper. The IPTs operate in three areas: Process, Military Worth, and Best Solutions. The Process IPT identifies and maps the most efficient path for electronics warfare systems through the DoD 5000 process. The Military Worth IPT provides, quantifies and proves the military worth of EW systems. This effort addresses a major problem Electronic Warfare has experienced in obtaining funding: it has often failed to establish the military worth of such systems to the warfighter. The Best Solutions IPT strives to attain the best solutions to EW problems/needs through analysis of the competing variables of effectiveness, cost, suitability and schedule.

Readiness and modernization were emphasized by the Pentagon in its FY96 defense budget; and Congress is looking favorably to this approach. This may convert into some maintenance, upgrade, and sustainment opportunities for the electronic warfare industry. During its initial work on the FY96 Defense Authorization, the House of Representatives added nearly $9.5 billion to the request, calling for some additional procurement of weapon systems and aircraft, some additions to readiness-related accounts, and (again) increases in missile defense efforts.

Western Europe. As with the airborne EW sector, the Western European EW industry is marked by radical differences in industrial structure, competitive environment, and acquisition procedures. Although Western Europe is the next biggest EW market outside the US, it is divided among a large number of British, French, Italian, German, and Swedish electronics houses. These rarely design their systems in response to a stated military requirement, but attempt to exploit their perceived "unique in-house expertise" to develop equipment as private ventures. Once available, these are offered on the export market and used as a design basis from which domestic requirements can be met.

The result of this situation is a chaotic and highly competitive environment which, at its best, favors rapid technology development and quick exploitation of successful R&D efforts. At its worst it has resulted in too many companies competing for a small EW-market pie, ensuring that none gain adequate rewards for their efforts and causing many promising and efficient systems to be discarded due to the lack of necessary resources for their further development. Too many systems over the last decade have been expensively developed and then abandoned when the necessary customers failed to emerge.

The end result is resources wasted duplicating R&D, testing, and production efforts in mutual electronic fratricide. In addition to the operational liabilities resulting from this unnecessary dispersion of funding, another, less obvious problem has been caused. The long history of low production runs to meet finance-limited domestic requirements has left most of the European EW industry incapable of providing surge production to meet rapidly emerging requirements.

A further influence on the European EW industry has been the indiscriminate introduction of competitive tendering for projects. Originally, this process was conceived as a means of introducing market force-led efficiency into the defense industry, and of breaking up an undesirable close relationship perceived to have existed between procurement agencies and certain major contractors. The concept has now degenerated into the selection of the lowest cost option compliant with the minimum required performance standards. This approach neglects other, equally important, considerations, including the ability for surge production, holding sufficient stocks of production supplies to cater for component provision bottlenecks, and the maintenance of an adequate research and development/product support base.

The need for rapid-response field support has been systematically underestimated. The commencement of combat operations during the Persian Gulf War quickly revealed that the existing ELINT and radar warning receiver libraries were of only marginal value. Most of the hostile radars had turned to War Reserve Modes (WARMS) that required urgent detection, classification and analysis. The results then had to be incorporated into the ELINT, ESM, and RWR libraries on an emergency basis.

The importance of the export market to European EW systems producers cannot be overstated. US-style economy-of-scale production levels simply cannot be reached in Europe on the back of domestic orders. As an example, the entire strength of the European navies combined does not equal the number of platforms in the US Navy. This one factor explains the grim determination of European electronic warfare houses to gain a substantial part of the US Navy AIEWS program. If any company in the European EW industry does win a substantial part of those programs, that company will dominate the European EW.

A common European pattern is to use existing in-house expertise to develop a new system up to prototype stage, reveal it to the market, and then await the initial order. If a launch order is forthcoming, further trials, pre-production testing, and production tooling are undertaken. If not, further development funding is curtailed and directed to more promising projects. Analysis of previous programs indicates that a system following this route has two years from unveiling to make its mark. If it does not achieve orders in that time, it is defunct. A side-effect of this policy is the willingness of many companies to undertake ludicrously short "production" runs, often as low as two or three systems. These are not production in any real sense, but sets hand-built in a laboratory to specific order.

The French military electronics industry is highly unusual in this respect. French companies have shown a willingness to maintain the ability to produce systems in small batches and at long intervals to meet specific customer requirements. A classic example here is the French Janet naval jammer. Although still widely described and promoted, it has only been installed on four ships (the Saudi Arabian *Madina* class) and no orders have been received since 1982. This policy gives French companies the ability to penetrate niche markets with order quantities others would consider uneconomic, then exploit that penetration into more profitable areas.

The dependence of European EW companies on the export market has had some unexpected side-effects. Few developing nations have the skilled manpower or trained operators required to use their systems. This problem is either ignored (with the result that the systems rapidly become unusable) or countered by hiring foreign personnel to maintain and operate the kit. The Arabian Gulf is a traditional area where the latter route is followed, with both naval and land-based systems being supported under contract by the British defense industry and operated by British military personnel under contract from the British armed forces. The immediate result was that a level of common approach and common expertise was present in the Arabian Gulf forces with immediate benefits on operational integration. Another benefit was that the British defense companies supporting equipment in Saudi Arabia already had teams of skilled engineers in place. Their services were offered to the coalition forces, the offer was accepted, and they remained at work throughout the Persian Gulf War. This greatly eased liaison with the companies in question and enabled equipment upgrades and modifications to be pushed through quickly.

The flip side of this reliance on exports is an unpleasant tendency to end up facing one's own equipment or that designed by one's allies. One of the great surprises felt in European EW circles during the Persian Gulf War was that the radio-electronic combat environment over Iraq was as demanding as that anticipated for the Central European front in any NATO/Warsaw Pact confrontation. The signals environment was found to be intense, with very large numbers of signals crowding the airwaves. The ability to pick out the signals required from the mass of other military and civil transmissions proved to be a demanding criterion. The electronic order of battle was exceptionally complex and made more arduous by the appearance of similar systems on both sides. Any expectations that "out-of-area" or "Third World" confrontations would be a relatively benign radio-electronic combat environment have been squashed.

This implies that systems sold to the export market have to cover a much wider threat environment than those destined for the more conventional "central front" scenario. The Persian Gulf War demonstrated that the air defense systems supplied to export customers by European countries, for example Crotale and Roland, were no less lethal than those available from Russia. ESM systems have to carry libraries listing all potential threat systems, while jammers have to cover much wider frequency ranges and be easily reprogrammable to meet highly sophisticated hostile emissions. Again, this also throws heightened emphasis on the need to provide flexible front-end software reprogramming of these systems. Hard-wired libraries that have to be returned to the manufacturer for updating are of no value.

Other Players. Outside of the US and Western Europe, the naval EW industry has become established in Russia, Japan, Israel, and China. In each of these cases, the route adopted has been by the licensed production of equipment from either the US or from Europe. In the case of Japan, treaty restraints imposed after World War II theoretically prevent Japanese industry from moving into EW export production and have limited the industry to supplying domestic military needs. In fact, this treaty restriction is a great convenience to the Japanese and does not prevent them, for example, from selling military radars and other similar equipment. There is a more convincing explanation for Japanese reluctance to enter the international EW market. The key weakness appears to be in producing the software required.

Japanese naval requirements are met using license-built derivatives of US systems. In theory, the technology obtained by this route could be used to develop an indigenous range of equipment that could then be offered on the international market. However, Japan will find the EW market highly protective, as the major users will continue to rely on domestic suppliers in order to maintain an EW industry base. Those countries that do not have internal manufacturers will be open to imports but are more likely to turn to established producers offering products with proven track records. Reinforcing this perception is the experience of the Persian Gulf War. This revealed that the key to effective EW operations was not the equipment as supplied but how quickly that equipment could be modified to accommodate the changing circumstances of hostilities. The ability, for example, to rapidly reprogram threat libraries is essential but is dependent on the extensive availability of ELINT (electronic intelligence) resources. The Japanese will not succeed in penetrating the international EW market until they can make a convincing show of providing these facilities.

Israel has established itself as a serious EW manufacturer by improving existing designs as well as creating new applications for EW systems. There is strong evidence to suggest that the Israeli naval EW industry was founded on the basis of imported Italian technology. As an example, the Israeli MN-53 integrated EW system for fast attack craft is a license-built version of Elettronica's Newton Alpha. However, the latest range of Israeli equipment, the NS-9000 family, is original in design. These systems have been sold to a number of export customers including South Africa, Chile and Singapore. Reports on the system from Singapore are mixed, some being highly favorable but others suggesting that the service performance of the equipment over extended periods has not been so good. While having established a reputation for sophisticated and reliable designs, the potential of Israeli EW sales, as with all areas of its defense industries, suffers because of the country's pariah status within the international political community. With the exception of the United States and NATO members, those who procure Israeli military equipment do so in a low-key manner.

The People's Republic of China (PRC) produces a very limited range of naval EW equipment. The Chinese market a number of systems, including chaff countermeasures dispensers and surface-ship and submarine ESM systems. These are mostly derived from Soviet systems of the late 1950s, which are in turn based on US equipment obtained under lend-lease during the Second World War, or on captured German technology. Although China has imported small numbers of Western naval EW systems, there is no indication that it has managed to back-engineer the technology into its own EW products. Recent Chinese warships carry French EW systems installed as "black box packages," while it is believed that production licenses have been granted for some older French systems, most notably the DR-2000 ESM set and the Alligator jammer.

In spite of this limited infusion of Western technology, the level of sophistication and reliability of Chinese equipment lags far behind that of the US and Western Europe. Chinese equipment remains fundamentally inadequate for use against the complex environment that has become the yardstick against which EW systems are judged.

Russia and Associated States. With large-scale reduction in Russian force levels, many recently built ex-Russian warships are being sold to other users.

This will affect the Western EW industry in a number of ways. The availability of these relatively new and powerful platforms at bargain-basement prices will be exploited by nations seeking cost-effective enhancements to their maritime capability. In this respect, the availability of ex-Russian hulls will depress Western naval EW sales by satisfying demand for platforms from Russian sources. On the other hand, the EW and integrated command system capability of the ex-Russian warships are optimized for radically different tactical concepts from those adopted in the West. Technical/operational support by the original owner is also lacking, leading to a prospective market for re-equipping these ships with Western systems.

This trend is already underway in India, where the Indian Navy fleet of Project 877EKM submarines was reported to have received ARGO AR-900 ESM systems in place of their existing Zhaliv-P equipment. A more elaborate venture is the construction of Project 1241 Molniya (NATO codename Tarantul) class FAC in Indian yards. These are being progressively equipped with Western command systems and EW equipment, which greatly enhances the value of an already-formidable warship. This approach may well evolve into joint ventures between Russian and Western companies in which hulls are built inexpensively in Russian shipyards and equipped with Western EW and command systems.

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Market Statistics

This market analysis examines the worldwide market for land- and sea-based electronic warfare equipment. In the far term, new programs developed in response to requirements that may emerge are unknown at this time. The long-term projections have been estimated and will be adjusted as these developments begin.

Methodology. This sample correlates the individual ten-year forecasts into an overall analysis of the market. Each individual program report is based on detailed research, involving data obtained from various government agencies, industry sources, United States and foreign publications, as well as individual contacts in the aerospace and electronics industry. This broad base of information is used to develop an overall picture of the market environment and market potential of each system.

The analysis uses a computer-based approach to combine data from the individual reports and to perform several statistical analyses. Using this method, Forecast has produced graphic presentations of projected unit and value production by system and by calendar year through 2006. Discussion of the leaders in our sample of this market area is also included. As future programs become known, they will be added to the next analysis.

The manufacturer listed for each system is the prime contractor, even though there are sometimes second sources and subcontractors for some of the programs. It is difficult to assign a particular market percentage value to a second source unless specific contract awards have been made. Likewise, unless specific information is available, in teaming situations the overall value of the program is carried.

Pricing of Systems. Precise pricing of electronic warfare systems can be difficult. Unit prices in government contracts vary, depending upon quantities ordered, adjustments for inflation, discounts, and additional services that may be included in contracts. Foreign military sales may also affect domestic prices. However, in order to do an effective market analysis, it is necessary to have the best possible estimates of unit prices. Sources for the unit prices vary. In some cases, the prime contractor provided an average or typical unit cost. When price quotes were not supplied by the manufacturer, the unit cost was estimated based on contract awards, funding and numbers ordered. There are some pitfalls to this approach. RDT&E costs do not always appear in the unit cost, especially if development was government-funded. In other cases, government funding documents had been sanitized. In those cases where no source information was available, the unit cost is estimated based on the type of system, its complexity, prices of comparable systems, and a general understanding of the radar marketplace. While price information may not be exact, unit cost estimates are in the proper order of magnitude.

Spares. Unlike airborne systems, most land- and sea-based electronic warfare systems operators do not maintain complete spare systems. Spares of major components are maintained depending on the projected mean time between failure for each part. Frequently, when these systems are purchased, certain spare components are part of the initial funding. It is customary to add 10 to 20 percent to the numbers required for the scheduled platforms to allow for these acquisitions. Additional replacement parts are funded and contracted for separately, as needed. Consequently, spares have not been factored separately.

Analysis. This analysis is based on a sampling of the known land- and sea-based electronic warfare systems. From this analysis certain conclusions about the future of this market can be inferred. Charts and graphs follow text to illustrate different elements of this dynamic electronics market.

Initial Observations. Electronic warfare systems represent a wide range of unit values in the electronics marketplace. Prices can range from over US$11 million for an integrated shipboard ESM/ECM system to US$0.89 for a chaff cartridge.

Over the ten-year forecast period, a procurement of over US$20 billion is anticipated. (See Figures 1 through 4.) This figure rises as out-year production moves into the analysis period. (See Figures 1 and 2.) One program has not yet had a contractor(s) selected (AIEWS). During this period, the production of 347,000 EW systems has been projected. This figure is based on an analysis of a variety of programs with 126 programs or systems in or going into production. Thirty-five individual companies and one joint venture team were included in the analysis.

Expendables have been deleted from the forecast due to the large number of low-cost items they represent. To give some idea of production in the expendables area, over 150 million chaff cartridges will be produced worldwide during the ten-year forecast period. A substantial proportion of these will not be used for their designed purposes.

There is also a distinct difference in character between the projected markets of land-based systems and sea-based electronic warfare systems. Sea-based programs are clearly tied to shipbuilding and overhaul programs. Within the near and medium term, the market for naval EW is not going to grow, primarily because modern warships take so long to build that completions within that period reflect existing construction. It continues to be more cost-effective to upgrade older ships, replacing or enhancing the electronic warfare fit. This is now particularly the case with large numbers of ex-British, ex-US Navy and ex-Russian ships finding their way into the secondhand market.

Land-based EW responds to service needs and funding patterns. Once a system is identified as needed by a service, a push is made to acquire systems as funding and production capacity permits. This is natural since EW systems are now conclusively shown to enhance the likelihood of mission success, and it is logical to bring all service units to the highest level of capability and preparedness as rapidly as possible.

Market Leaders. While neither unit production nor value of production necessarily defines a manufacturer as a market leader, some criterion was needed to rank EW companies (Figures 4 and 6). The value of production was selected, since it is a more accurate representation of the market as it can be related to by industry. The individual discussions that follow present the top five manufacturers based on their standing within the market sample, using value of production as the ranking criterion.

Thomson-CSF - 23.4 percent- US$4.8 billion - 1.7 billion units

The French Government-owned Thomson-CSF Group overwhelmingly dominated the naval ESM system market during the late 1970s and early 1980s with its DR-2000 system. This became virtually the world standard submarine ESM system and was also extensively deployed on surface ships and maritime aircraft. However, the system offers inadequate directional accuracy for over-the-horizon targeting (OTHT), and as submarine-launched anti-ship missiles have become more widespread, the DR-2000 systems have been replaced by more advanced equipment. Indeed, the replacement of DR-2000 by more advanced ESM systems is a useful pointer to a navy having made an unannounced acquisition of subsurface-to-surface missiles. The frequency coverage of the DR-2000 was also limited in comparison with later systems. Thomson-CSF has attempted to reduce this problem by improving the basic DR-2000U and by the introduction of the much larger and more complex DR-4000. This failed to achieve the success of the DR-2000. The DR-4000 has repeatedly lost out to the lighter, more effective and more flexible systems offered by Racal and Thorn-EMI.

Thomson-CSF has regained the initiative with the introduction of the DR-3000 system and the related DBI-3000 integrated ESM/ECM equipment. This brings the group back to technical parity with its rivals. In spite of entering the market (in production form) up to two years later than, for example, Thorn-EMI's Sceptre, it has managed to establish itself successfully, primarily as a form-and-fit replacement for older DR-2000 systems in fast attack craft and submarines. This provided a valuable entry point into the market, which was exploited by an astute and effective marketing campaign.

The technical problems faced by Thomson-CSF during the 1980s are reflected in the design of the company's electronic warfare systems. Most Thomson-CSF naval EW equipment is designed to operate as closely integrated EW subsystems. These are then linked to the warship command system as a whole. This design philosophy was adopted as a result of the shortcomings of the centralized warship command systems developed by Thomson-CSF that were deficient in computer processing power. In contrast, the current generation of British systems employ individual ESM, jammer, COMINT and decoy systems that are integrated at command system level. This reflects the enormous computing power of the fully distributed British warship command systems. However, it suggests that Thomson-CSF will not be in a good position to exploit the opportunities offered by the Anglo-Italian-French Common New Generation Frigate but may be well placed to participate in the US AIEWS program, since US warship command systems, such as they are, are also highly centralized.

Deficiencies in naval EW technology have been made up by a resumption of R&D expenditure and by the acquisition of Signaal. This effectively gave Thomson-CSF access to the same basic technology as is used by Thorn EMI. The rising dominance of the Thomson-CSF Group is a direct reflection of French Government policy and a desire to see that the French defense electronics industry is in a strong and healthy enough condition to prosper in the European unified market.

The influx of new EW technology has led Thomson-CSF to reestablish its position in the forecast period. This period will see Thomson-CSF continuing to replace its older systems, developed during the 1970s, with upgraded and improved systems exploiting the latest available technology. The limited plans for French naval construction during the 1990s will limit the domestic market to the upgrade sector, while there is, at present, no indication that the company is entering the US Navy SLEWS competition. A healthy sales order book is projected for the DR-3000 system. Substantial sales of both the basic system and the DBI-3000 with integrated jammer will likely be made. The world inventory of Type 209s will account for a substantial sales volume, while further sales to surface ships will account for an additional volume. This will encompass both the new construction sector and the retrofit market.

Lockheed Martin - 6.77 percent - US$1.4 billion - 708 units

Through its acquisition strategy, particularly its purchase of Loral, Lockheed Martin has come to hold the leading position in the EW market overall. In surface-based EW, it holds second position. Lockheed's highest yielding product is its ship chaff and flare launcher, the Super Rapid Blooming Offboard Countermeasures (SRBOC). The typical configuration is two Mk 36 launchers for ships under 500 ft and double that for larger vessels. As the threat of anti-ship missiles increases, so does the demand for protection, with the Mk 36 being the premiere US system on the market.

SRBOC can launch a variety of chaff cartridges and flares. Loads include Super Chaffstar, Super Hiram III, Super Hiram IV infrared cartridges, Super Gemini Hybrid rf/IR cartridge, and the Super LOROC (Long-Range Offboard Chaff) rocket-launched decoy. In addition, NATO Sea Gnat Mk.214 and Mk.216 rocket decoy rounds can be launched from SRBOC. Sea Gnat is a joint US, UK, German, Norwegian, and Danish program active in the international market. While not interchangeable with the other SRBOC rounds, Sea Gnat does use the same Mk 36 launcher. The US/Australian NULKA hovering active decoy is being designed to use a modified SRBOC launcher.

The Mk 36 launcher can be interfaced with US and non-US electronic warfare control systems, including the Royal Navy DLA and DLH decoy systems. This has increased its popularity on the international market, with twice as many systems projected for the FMS market.

The majority of future US production is to support construction of the DDG-51 Arleigh Burke-class destroyers and LPD-17 amphibious ships. There is a limited requirement for LHD-1 and CVN-76 ships. FMS production will support KDX, Kongo, Takao construction; with limited production for *Principe de Austrias*, Project 052, and Project F25T construction.

Lockheed Martin is also manufacturer of an important new US Army system, CHALS-X, the Communications High Accuracy Location Sub-System - Exploitable SIGINT DF and targeting system. CHALS-X will provide commanders with precise location information on High Value Targets through triangulation. It is to be an important part of the Army's Intelligence and Electronic Warfare Common Sensor program (IEWCS, described below under the heading "Sanders/AEL"), to be installed in the Ground Based Common Sensor-Light/Heavy (GBCS-L/H). (It will also have an airborne application, carried onboard the EH-60A Advanced Quick Fix aircraft.)

As forces become more dependent on sophisticated communications, a natural result is the development of a way to use this to a commander's tactical advantage. CHALS-X is the result of such developmental planning. Using the sensor to accurately pinpoint forces, commanders will be able to call down artillery and other fires quickly and accurately. Advances in technology and processing capability make this accuracy possible.

The increased interconnectivity of assets and the ability to interface with other developing information systems coming to the battlefield will be important in ensuring that the Army has an electronic warfare capability suitable to future combat. Standardization will reduce the cost and complexity of logistics support-an important consideration as defense budgets are reduced. The strategy emphasizes forces that are numerically smaller but technologically superior, versatile, deployable, and lethal. IEWCS, which is combining several newly developed sensors and EC assets, will help the Army meet its tactical needs with less equipment. The award of the IEWCS build-to-model acquisition has moved the entire effort, and therefore the individual projects such as CHALS-X, into production.

Motorola Inc - 6.72 percent - US$1.4 billion - 118 units

Motorola places so highly in this surface EW analysis because of its role in JSTARS. Motorola produces the Ground Station Module (GSM), the TSQ-168; and the Common Ground Station (CGS), TSQ-179. The GSMs are tactical data processing and evaluation centers that receive radar data from JSTARS' E-8C aircraft, as well as from multiple other sources such as OV-1D Mohawk and Unmanned Aerial Vehicle (UAV) platforms. The deployment of JSTARS to Bosnia proved that the system has theater perspective, an important requirement of Joint Force commanders in a combat arena.

The TSQ-179 CGS is a Pre-Planned Product Improvement (P3I) to the JSTARS Light Ground Station Module (LGSM). The Army is developing the Common Ground Station as the Block II Ground Station Module. It will incorporate enhanced operational capabilities, improvements in functions and new technology into the GSM functional baseline. The design will maximize nondevelopmental and COTS use and re-use existing software up to 84 percent.

In the CGS, JSTARS data will be augmented by UAV video from areas of high-interest, signal intelligence sent from the Commander's Tactical Terminal Radio broadcast networks. Automated messages will be transmitted to and received from ASAS and TACFIRE/AFATADS nets and the system will interface with the TROJAN SPIRIT II satellite ground terminal and the MSE network. It will support the maneuver brigade commander and eventually see its role expanded to provide support at all echelons through Corps as well as fire support. The CSG will become the key node on the electronic battlefield.

The Common Ground Station is considered the objective JSTARS ground station. It will be functionally equivalent, although build-to-print is not required, to the LGSM with the incorporation of a Secondary Imagery Dissemination (SIDs) capability.

Although significant attention is usually given to the airborne leg of JSTARS, the E-8C; the Ground Station Modules should not be overlooked. They are what enable commanders to use JSTARS' data. The Army has wisely decided to make them a key node in the electronic battlefield of the future, Force XXI. Not only will the Common Ground Station make effective use of JSTARS data, it will fuse that information with inputs from many other sources. This data/information/communications fusion is a must for commanders; as is the ability to make JSTARS data available to users beyond the range of the dedicated aircraft/GSM link.

JSTARS has accumulated a record of service and capability that assures it a healthy international career. Like AWACS, JSTARS is becoming ubiquitous in combat, contingency and peacekeeping operations – and this is based on prototype and initial production systems. Full production has just been approved, and the Air Force has accepted only one actual production aircraft so far. To fill US Army requirements, we estimated that about 22 GSMs will have been produced by the end of the forecast period, 2006; about 73 CGSs will have been produced. Foreign military sales of GSMs are placed at around 43.

To acquire JSTARS-like capability, NATO is pursuing an Airborne Ground Surveillance (AGS) system. The alliance has plans to acquire a combination capability, one that includes JSTARS and/or the UK's ASTOR (Airborne Stand-Off Radar) system (for which, confusingly, JSTARS is also a candidate), and possibly two helicopter platforms, such as the French Horizon and Italian Creso. The US is marketing JSTARS heavily in Europe trying to overcome the barriers created by cost, politics, and technical/operational considerations. The Clinton Administration embarked on a major initiative to sell the aircraft to the alliance.

The AGS decision will be driven by technical and political considerations. There is an operational need for both large JSTARS-type aircraft and smaller surveillance platforms in Europe. The exact mix is yet to be determined, as are answers to questions about ownership and control of the assets and what the European industry share in the program will be. A decision was hoped for in 1996; but is going to be delayed. In the long run, the JSTARS program will follow the general plan current today.

There was talk at the highest US levels of increasing the eventual procurement. Cost, however, is a limiting factor. Due to the performance of the JSTARS in the Persian Gulf and Balkans, there is not as much pressure to cut back as has been felt by other programs. Congress added funds in the FY97 budget to increase procurement in FY98 by one aircraft. Increases such as this could field the platforms faster; but because of JSTARS's high cost and the need to have a variety of capabilities available, a major increase in the total is unlikely to survive the temporary enthusiasm that may surface from time to time.

In the outyears, if FMS procurement is as significant as anticipated, the USAF may be able to rely on NATO and other allied assets for extended coverage during international operations, impacting the size of the American fleet. NATO is very interested in developing a joint JSTARS/AWACS asset team and planners are investigating other platforms for meeting surveillance needs in a variety of operational scenarios. None of those systems would replace JSTARS, only limit the overall number procured.

The cost of the E-8C is a limiting factor in FMS procurement, precluding many allies from acquiring JSTARS. NATO and the major European allies are the only nations that can afford them. The British ASTOR decision will have an impact. Although the E-8C is being considered for ASTOR, its selection could reduce the overall NATO buy. If another sensor platform is selected, NATO may procure that platform for some of its surveillance needs and reevaluate the overall number of JSTARS needed.

The Pacific Rim is priced out of the JSTARS market. Besides, the needs of these countries can be better met with smaller, less technician-intensive systems designed for maritime surveillance. Most of them would have neither the money nor the maintenance force to buy and support JSTARS. Possible cost reductions could be achieved by an effort underway to install the APY-3 radar, or a smaller variant, on platforms other than a refurbished Boeing 707

Middle Eastern forces such as Israel, Saudi Arabia and Egypt may seek procurement of some JSTARS aircraft in the late 1990s. Approval of such sales is uncertain due to political factors and would be made on a case-by-case basis. The Persian Gulf War proved that some nations of the Middle East could call on the US and NATO forces to provide military assets in crisis situations. Thus a decision on acquiring a JSTARS fleet would have to be made in light of the question: does the desire for individual military clout warrant the huge cost imposed by this system?

Ericsson Radar Systems AB - 5.54 percent - US$1.1 billion - 581 units

Ericsson's most impressive market performers are its ground-based radars ARTHUR and HARD. ARTHUR is a fully coherent G/H band counter-battery artillery location radar. It will be mounted onboard the tracked Hagglund BV208 all-terrain vehicle. The radar has been developed and funded as a joint project between Norwegian and Swedish armed forces. Delivery of the first production radars is expected to commence this fall (1997).

Demand for counter-battery radars is likely to surge as the earlier less-capable systems are replaced by those using more advanced technology. The destruction of the Iraqi artillery batteries by radar-directed allied counter-battery fire during the Gulf War has driven home the value of counter-battery radars. It has also clearly demonstrated the futility of investing large sums in artillery without providing adequate fire control facilities.

ARTHUR will benefit from this surge and should gain a healthy market share. The basic similarities between ARTHUR and the Giraffe family of radars will assist the former in its efforts to enter the export market. Giraffe has found widespread acceptance around the world and gives the Ericsson sales teams a good foundation from which to work. The current development schedule for ARTHUR indicates that it will enter service before its most likely rival for the counter-battery market, the EuroArt COBRA. This will also aid in marketing the radar.

Tactical studies by the Swedish and Norwegian Armies have clearly indicated that weapons-location radar is the most cost-effective method for localizing hostile artillery. These studies also indicate the potential for trading off detection range in favor of improved systems mobility. ARTHUR is understood to represent a sacrifice of range to improve the overall mobility of the system. This, combined with its provision of a direct C3I link with artillery batteries, will improve the chances for the system's survival in an artillery-intense scenario.

However, the system will not come into service until late in the decade, and the survivability of a relatively short-range radar in the conditions then prevailing must be questioned. Even a highly-mobile tracked system will have to halt to operate, and it will be a close-run matter as to whether it can localize enemy artillery before it is itself localized by its own radiation. This is a consideration that affects all counter-battery radar systems. The extent of the problem is illustrated by a recent exercise in which the highly distinctive radiation of the Hughes TPQ-36 counter-mortar radars were identified and localized within seconds ("less than 5") of operational initiation. The self-propelled configuration and added mobility of ARTHUR may well prove to be a wise investment and a considerable market advantage.

A potential market for approximately 60 systems exists in the Swedish and Norwegian armed forces, presumably to be delivered in the late 1990s. Export orders for the system are expected to arrive later this decade and will push production out beyond the forecast period. Based on the large customer base already existing for Ericsson radars and the very high reputation of the company, ARTHUR will likely achieve substantial success. Production should thus continue well beyond the end of the forecast period.

HARD is an I/J band frequency agile pulse-Doppler search and acquisition radar for land-based and naval air defense systems. It is primarily intended for vehicle mounting, and is ideally suited for self-propelled anti-aircraft gun (SPAAG) or mobile SAM applications. The Swedish Army is deploying HARD mounted on the BV-208 all-terrain vehicle, as a local surveillance radar for the RBS-70 missile.

The decision to deliberately restrict the power - and thus the detectability - of the HARD radar is an astute recognition of the vulnerability of such radars on a modern battlefield. It does have the qualification of forcing the radar to operate within the coverage of a larger surveillance system which can cue it to the appropriate targets. The development of the C3I-oriented Giraffe-75 radar has provided a framework in which the capabilities of HARD can best be exploited. The Swedish Army has adopted this system with each of its six anti-aircraft units having three Giraffe-75 radars each controlling three HARD systems.

The hope for HARD now is that the disclosure of the new RB-3 area-defense anti-aircraft missile system will open other potential markets for the radar. Sweden has established a sound reputation with the RBS-70 and should find little difficulty in obtaining customers for the new missile as well. In this respect it will be aided by the large and enthusiastic client base already achieved for the Giraffe radars. In fact, Giraffe and HARD often go hand in hand in this particular niche.

Sixty HARD radars ordered by the Swedish Army were delivered over three years ending in 1994; deliveries of the final radars in the initial production order had been stretched to maintain the production line while export orders were awaited. The German order in the fall of 1995 initiated export sales sooner than had been anticipated. A conservative output of 10-20 units a year on a rising scale is anticipated, assuming that the client's applications will grow as the level of familiarity rises. Eventually the German sales will merge with the larger deliveries of about 45 units per year that had been projected for 1999 onwards, as part of the BAMSE (a new family of medium-range SAMs to consist of a surveillance radar based on the Giraffe family, and two missile trailers; each trailer carries four missile rounds plus a mast-mounted target acquisition radar based on HARD) missile system. No export sales of the HARD/ BAMSE system are foreseen yet within the forecast period but could start soon after.

Siemens AG - 4.37 percent - US$898.4 mllion - 104 units

Siemens' high ranking in surface EW sales is based largely on two very successful radars, the Type 996 and Watchman. Type 996 is an E/F-band 3-D surveillance and target identification radar; it is the Royal Navy's standard target acquisition radar. It provides automatic target indication for Seawolf and Sea Dart missile systems on surface ships of frigate and larger size. Capable of detecting every form of airborne threat, Type 996 also provides surveillance, long-range aircraft detection and control, together with point and area defense.

The Type 996/2, intended for installation on the Type 23 Duke class frigates, will be standard equipment for new builds over the next few years. It will be the primary search radar on the new British LPH and probably the two new LPD(R)s. The export derivative of Type 996, ASW-9, has potential as retrofit equipment aboard a wide range of foreign surface units. It offers a satisfactory compromise between the tactical requirements of the 1990s and the very high cost of many radar now coming into the market. This factor led to its selection by Turkey to equip all four ships forming the second batch of MEKO-200 frigates.

At least 40 ex-USN and ex-RN warships are in the process of being transferred to other navies during the 1990s. Many of these will require upgrading, and AWS-9 will stand to benefit from this market opportunity. Current trends indicate that new construction for foreign navies is likely to be awarded to yards outside the UK, putting Siemens-Plessey up against strong competition from indigenous manufacturers. However, the cost/performance balance of the radar and the cachet used by the Royal Navy appears to be winning it significant success.

The marketing future of this radar looks bright, in view of the retrofit program for Type 42 destroyers and Illustrious class aircraft carriers and on the new construction rate for Type 23 frigates. Furthermore, AWS-9 production covers the two firm Turkish orders plus two more projected, as well as future retrofit/new-construction contracts. The growing success of the radar and the discovery of its almost unique ability to localize enemy jamming efforts (as far as can be determined, only the US SPY-1 has similar capabilities) has led to this promising forecast.

Watchman is an E/F-band medium-range 2-D radar whose surface EW role is to provide surveillance (and surface vessel movement for the CSR version. It is also tasked with air traffic control. Watchman radars can be deployed in mobile or fixed configuration. Current operational deployment consists of a spectrum of commercial and military surveillance applications. An advanced-technology solid-state transmitter upgrade is under development.

Watchman continues to provide a valuable development ground for radar technology. Much of the effort put into Watchman has paid valuable dividends in the subsequent evolution of the AWS-6 and Type 996 radars. The radar remains attractive because of its excellent bad-weather performance and its availability in fixed or mobile configurations to support a variety of civil or military applications ranging from independent operation to integration as part of an air defense system. However, competition from Thomson-CSF, the world's largest ATC equipment supplier, has definitely cut into Watchman's territory. An example is its loss in mid-1989 to Thomson-CSF of an Australian ATC radar contract that included the procurement of eight primary surveillance radars.

Watchman has an assured place in the domestic market. It is being procured or on order for the United Kingdom Ministry of Defence to provide airfield surveillance at all of the RAF's and RN's air stations (both at home and abroad). In addition, the Royal Aircraft Establishment's (RAE) three airfields are to receive Watchman. A major boost for the system was its adoption by the UK CAA for their now completed Airport Radar Replacement program. This involved the installation of Watchman radars at Heathrow, Gatwick, Stanstead, Manchester and Glasgow, with upgrades at Edinburgh and Prestwick.

Of the three members of the Watchman family, the coastal surveillance version has had the least success. The only known sales of this system are the two sets sold to Pakistan some years ago. This version can therefore be considered defunct. Much of its technology was incorporated in the development of AWS- 6, and this has led to a new coastal surveillance radar, Guardsman, being developed. Sales of this version, if any, are unknown, and the lack of success for this system is unlikely to be changed by the announcement of Guardsman-C.

Siemens plans to market its new Watchman S globally and is keeping close tabs on advanced programs including the FAA ASR-11 program. The marketing strategy is to provide high performance with low overall cost of ownership. The technology incorporated in this system is most appropriate for detecting small targets around the airfield. Within a range of 60-80 nm, it can distinguish between different aircraft with particular accuracy.

The United Kingdom MoD's requirement will likely extend to 40 systems. A further four Watchman systems are forecast for Finland, excluding the four ordered in 1988 in exercise of an option to the three previously delivered. Sales of the system have slowed in recent years, possibly because of the competition from Thomson-CSF, the dominant force in the world ATC products market area. The current trend is strongly in favor of large-scale packaged acquisitions of systems, further enhancing the prospects for the Thomson-CSF equipment and limiting those for Watchman. Thus, in the near term it appears that only a small number of additional sales of the Watchman T configuration for both military and commercial applications will be made.

In the longer view, Siemens' decision to develop the solid-state Watchman S should enhance its competitive position for future procurements as solid-state radars gain maturity and acceptance. (Solid-state prototypes have also been developed by a Thomson-CSF/ITT Gilfillan joint venture, as well as Raytheon, Westinghouse and Alenia.)

Overall, production of Watchman should continue at around three sets per year in the early part of the forecast period, trailing off toward the mid term, and becoming revitalized during the long term with the introduction of the upgraded Watchman S version.

Sanders/AEL 1.3 percent - US$ 260.0 million - 89 units

Sanders, a Lockheed Martin Company, has joined forces with AEL to build the TACJAM-A, which is the ground-based portion of the US Army's Intelligence and Electronic Warfare Common Sensor (IEWCS). Planned for operation by the end of the decade, IEWCS will replace several older systems. It will combine multiple capabilities in a single microprocessor-based system, serving as the baseline ESM system and ground jammer for the foreseeable future. The TACJAM-A system has completed field testing by the Army and has been officially given the AN/ nomenclature MSR-3. Delivery of nine EMD units has been completed.

The IEWCS program will result in increased commonality in the overall airborne and battlefield EW effort. TACJAM-A/MSR-3 will become the EW portion of the Ground Based Common Sensor (Light & Heavy), GBCS-L/H. Components of IEWCS will also be part of the Advanced Quick Fix helicopter and, furthermore, part of the US Marine Corps Mobile EW Support System (MEWSS). An overall development contract for IEWCS has recently been awarded; final development is programmed for completion by the turn of the century. Production contracts for TACJAM-A and other portions of the IEWCS program are possible sometime during 1997.

AEL Defense Corporation has been a major ground EW provider for the US. It has also been active in producing Band 9/10 transmitter components for the ALQ-99 airborne jammer, and has become a major partner in the development of the ALR-67 Advanced Special Receiver for the US Navy. Its product line also includes the APR-43A and APR-44 radar warning receivers components. Other product lines include PACJAM and the MACCS/Piranha II communications jamming systems.

Sanders is a key airborne player and technology house. This teaming gives Sanders access to a new market niche and makes it possible for AEL to take advantage of proven technology from its teammate's airborne line. The company has significant expertise in ground radar, naval ESM, and anti-submarine warfare equipment, and has recently become prime on two major US EW systems. The team benefits from the history and reputation of both companies, and has significant combined manufacturing capacity; a capability which saw major expansion with the Lockheed Martin merger.

Contractor To Be Selected - 1.75 percent - US$ 360.0 million - 36 units

AIEWS. The Advanced Integrated Electronic Warfare System (AIEWS) has become a cornerstone for future surface-ship EW system development. It is to develop an advanced EW system to operate as an integral component of a ship's combat system, providing increased ECM capability to support ship defense and introducing the next generation of EW technology. The AIEWS effort is part of PE#0604755N, Ship Self-Defense. Under this PE, Project U0954 (Shipboard EW Improvements) funds development of a replacement for the fleet standard SLQ-32.

The US Navy places a major focus on ship self-defense. Equipping the fleet with effective protection will be a major RDT&E and procurement effort through the remainder of the decade. This is a multifaceted program that concentrates on weapons upgrades, sensor enhancements, and data communications/processing innovations.

Despite its importance, AIEWS has had a convoluted history. At one point, it was prematurely given the SLQ-54 nomenclature. It was designated an upgrade to the existing SLQ-32, and was then terminated while the Navy reorganized itself. AIEWS has now become a more focused program which will have to stand on its own merits.

Phase I is a holdover from the original efforts and consists of a console and computational upgrade to existing SLQ-32 suites. Phase II, which will develop the next generation ESM, is planned for an FY97 EMD. An ECM segment, which may well include IR/EO countermeasures as well, is planned for later in the forecast period.

The Navy began the revised program by awarding small study contracts. From contract winners the Navy requested a comprehensive examination of the AIEWS' key ES and EA subsystems. Specifically, studies were to include recommendations and specifications on promising system/subsystem concepts; cost, performance and schedule risks; and a phased development plan.

Hughes (teamed with ITT Avionics, Tracor/AEL and Lockheed Martin Tactical Data Systems) was awarded a US$750,000 concept exploration and definition study contract in early 1996. Lockheed Martin (teamed with Sanders, Litton Amecom and CSC Inc) received a similar contract. Both teams delivered their finished study contracts on September 27, 1996.

The Navy is now preparing for a 1997 engineering and manufacturing development (EMD) phase. For the EMD, the Navy is expected to release a two-phased RFP, one for the ES and one for the EA. However, the service may decide to consolidate them into a single tender. Release of the RFP is scheduled for next spring, with the award following in 1998.

Competing contractor Hughes has a major production capacity, much of it becoming excess as its airborne programs are reduced in size. The company has a solid component engineering base flowing from its major airborne electronic warfare and fire-control radar hardware and software programs. With the SLQ-32 design technology transferred from Raytheon, Hughes can expand its overall expertise base by adding proven design work and manufacturing skills to a developed naval system architecture.

Contender Lockheed Martin, needless to say, represents formidable competition in any defense industry showdown. Formed by the merger of defense giants Martin Marietta and Lockheed in 1995, the company further fortified its defense holdings in 1996 with the acquisition of Loral. An extremely diversified high-technology company, Lockheed Martin is the largest contractor to the US Departments of Defense and Energy and NASA.

While Hughes and Lockheed Martin are the major US contenders for production of AIEWS, this award has sparked serious interest among European manufacturers. Ultimately, a development team is likely to include European partner(s). European participation would add significant experience in littoral operations and introduce a unified command system philosophy to the development of a new EW suite. Having a partner with proven experience in these areas could be a tie-breaker when source selection takes place. A US/European team could capitalize on one or more proven designs used in international systems and could make selection of AIEWS for a certain number of European and Pacific Rim combatants possible. In turn, this fortifies the likelihood that the program will become a leading procurement by the turn of the century.

Other Players

Racal Electronics plc - 3.72% - US$764.7 million - 511 units

Multicontractors - 3.64% - US$747.2 million - 331,000 units

Alenia Elsag - 3%- US$617.5 million- 154 units

Hughes Aircraft Co - 2.96% - US$608 million- 367 units

Euro-Art Consortium - 2.88% - US$592.8 million - 38 units

GEC plc - 2.37% - US$486.6 million - 2,586 units

Sippican Inc - 1.01% - US$208.5 million - 2,085 units

Boeing Co - 0.85% - US$174 million - 45 units

Northrop Grumman Corp - 0.79% - US$161.9 million - 76 units

Elettronica SpA - 0.69% - US$141.5 million - 24 units

ITT Corp - 0.60% - US$124 million - 155 unit

Z-Factor Projection Adjustment. The ten-year forecast is adjusted in the out-years by what is called the Z-Factor. This is addition to the data base totals to bring the projected market up to what the analysts, in their best estimate, think it will be. This adjustment figure includes additions and new-starts not included in the existing programs database. The title Z-Factor was chosen for database purposes only.

These additions and new-starts cannot be specifically identified as yet, but will begin to develop mid-way through the forecast period. This adjustment eliminates the likelihood that the projected market figures in the out-years, using only today's established programs, underestimate the size of the market.

The problem is that, during our ten-year period, technology is advancing so fast that capabilities available by the end of the midterm are quite unimaginable today.

A new generation of systems will be required to exploit those technologies. Since the exact capabilities of the newly available arts are unknown, the exact nature of the Z-factor programs cannot be projected; what can be projected is the extent of likely sales for new platforms and retrofit for existing equipment. This is the Z-factor.

The Z-factor is particularly marked in the naval sector. A major upswing in naval construction during the latter part of the forecast period is anticipated. Not only will large numbers of ships be ordered by newly emerging maritime powers, these ships will be a considerably more capable and well-equipped breed than those previously sold on the export market. Due to the very long planning and construction cycle for warships, the Z-factor is particularly pronounced. Also, for the large number of programs designated as Frigate-2000, Destroyer-2000 and other similar titles nominally indicating orders in the year 2000, these projects will likely be spread out over a number of years in the early 21st century.

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The Market for Surface Electronic Warfare System Units of Production by Program

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - AEL													
MSR-3 (TACJAM-A)	TACJAM (US ARMY)	2.500	6	12	5	4	0	0	0	0	0	0	27
AEL			6	12	5	4	0	0	0	0	0	0	27
Corporation - ALENIA-ELSAG													
ALENIA RAT-31	LONG RANGE 3D RADAR (VARIOUS)	9.000	13	9	5	0	0	0	0	0	0	0	27
EMPAR	DD (ITALY)	12.000	0	1	0	3	2	0	0	0	0	0	6
SCLAR MK 2	CVH/CVHL/DD/FF/FFL (ITALY)	0.500	0	0	0	0	0	0	0	0	0	0	0
ORION	CVH/DD/FF/FAC-M (VARIOUS)	2.500	25	16	16	16	12	12	12	12	0	0	121
ALENIA-ELSAG			38	26	21	19	14	12	12	12	0	0	154
Corporation - ALLIEDSIGNAL AEROSPACE CO													
PRM RADAR	AIR TRAFFIC APPROACH CONTROL (FAA & VARIOUS)	4.200	2	1	0	0	0	0	0	0	0	0	3
ALLIEDSIGNAL AEROSPACE CO			2	1	0	0	0	0	0	0	0	0	3
Corporation - AWA INDUSTRIES													
NULKA	NAVAL DECOYS (AUSTRALIAN NAVY)	0.100	50	50	50	50	50	20	20	10	10	0	310
AWA INDUSTRIES			50	50	50	50	50	20	20	10	10	0	310
Corporation - BOEING CO													
APECS II/III	KAREL DOORMAN FRIGATE (NETHERLANDS)	4.000	2	1	0	0	0	0	0	0	0	0	3
APECS II/III	DD/FF/FFL (VARIOUS)	4.000	4	3	2	3	3	3	3	3	2	2	28
APECS II/III	KDX FF (S KOREA)	4.000	1	0	1	2	2	1	0	1	2	2	12
WLR-1H(V)	VARIOUS (VARIOUS)	1.000	1	1	0	0	0	0	0	0	0	0	2
BOEING CO			8	5	3	5	5	4	3	4	4	4	45
Corporation - CELSIUSTECH													
MATILDE	FAC/FFL/MCMV (VARIOUS)	0.100	2	0	0	0	0	0	0	0	0	0	2
CELSIUSTECH			2	0	0	0	0	0	0	0	0	0	2
Corporation - CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP													
CEIEC JY-8/8A	AIR DEFENSE (CHINA)	0.050	0	0	0	0	0	0	0	0	0	0	0
CEIEC JY-8/8A	AIR DEFENSE (UNSPECIFIED)	0.050	0	0	0	0	0	0	0	0	0	0	0
CEIEC MW-5	AIR DEFENSE (UNSPECIFIED)	0.040	0	0	0	0	0	0	0	0	0	0	0
CEIEC TYPE-702	AIR DEFENSE (UNSPECIFIED)	0.150	60	60	60	60	60	60	30	20	10	5	425
CEIEC-408C	AIR DEFENSE (ZIMBABWE)	1.000	0	0	0	0	0	0	0	0	0	0	0
CEIEC-408C	AIR DEFENSE (UNSPECIFIED)	1.000	0	0	0	0	0	0	0	0	0	0	0
CEIEC-921A	SSK (CHINA)	0.200	0	0	0	0	0	0	0	0	0	0	0
CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP			60	60	60	60	60	60	30	20	10	5	425
Corporation - CONTRACTOR TO BE SELECTED													
AIEWS	SURFACE SHIPS (USN)	10.000	2	5	5	5	5	4	3	2	3	2	36
CONTRACTOR TO BE SELECTED			2	5	5	5	5	4	3	2	3	2	36
Corporation - CONTRAVES													
SEAGUARD	FF (TURKEY)	6.000	1	1	0	0	0	0	0	0	0	0	2
SEAGUARD	FF (INDIA)	6.000	1	1	1	1	1	1	1	0	0	0	7
SKYGUARD	AA FCS (VARIOUS)	4.000	0	0	0	0	0	0	0	0	0	0	0
CONTRAVES			2	2	1	1	1	1	1	0	0	0	9
Corporation - CSEE													
DAGAIE/SAGAIE	FF/FFL/FAC-M (VARIOUS)	1.000	2	2	1	1	0	0	0	0	0	0	6
DAGAIE/SAGAIE	CV/DD/FF (VARIOUS)	2.500	0	0	0	1	0	0	0	0	0	0	1
CSEE			2	2	1	2	0	0	0	0	0	0	7
Corporation - DASSAULT ELECTRONIQUE													
SALAMANDRE	CV/FF (FRANCE)	1.000	1	3	1	1	1	0	0	0	0	0	7
SALAMANDRE	FF/FFL (VARIOUS)	1.000	4	2	4	6	6	3	3	2	2	2	34
DASSAULT ELECTRONIQUE			5	5	5	7	7	3	3	2	2	2	41
Corporation - ELETTRONICA SPA													
ALDEBARAN	SHIPBOARD EW (SPAIN)	6.000	1	1	1	1	1	0	0	0	0	0	5
NETTUNO/NEWTON	FF (CHINA)	4.500	2	2	1	2	2	1	1	1	2	1	15
NETTUNO/NEWTON	CVH/DD (ITALY)	11.000	0	0	2	2	0	0	0	0	0	0	4
NETTUNO/NEWTON	FF (MALAYSIA)	4.500	0	0	0	0	0	0	0	0	0	0	0
NETTUNO/NEWTON	SHIPBOARD EW (SPAIN)	6.000	0	0	0	0	0	0	0	0	0	0	0
ELETTRONICA SPA			3	3	4	5	3	1	1	1	2	1	24
Corporation - ERICSSON RADAR SYSTEMS AB													
ARTHUR	COUNTER-BATTERY (VARIOUS)	2.500	20	20	20	20	20	20	18	18	12	12	180
GIRAFFE	AIR DEFENSE (SWEDEN)	2.500	15	15	15	15	15	15	0	0	0	0	90
GIRAFFE	AIR DEFENSE (NORWAY)	2.500	0	0	0	0	0	0	0	0	0	0	0
GIRAFFE	AIR DEFENSE (EXPORT)	2.500	6	8	6	4	4	6	8	8	8	8	66

Figure 1
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - ERICSSON RADAR SYSTEMS AB (continued)													
GIRAFFE	AIR DEFENSE (FINLAND)	2.500	0	0	0	0	0	0	0	0	0	0	0
HARD	AIR DEFENSE (SWEDEN)	1.250	10	20	45	45	45	45	0	0	0	0	210
SEA GIRAFFE	DD/FF/FFL/FAC-M (VARIOUS)	1.000	2	2	2	2	2	2	2	2	2	2	20
SEA GIRAFFE	FF (AUSTRALIA)	1.000	1	1	1	1	1	1	1	1	1	0	9
SEA GIRAFFE	FF (CANADA)	1.000	0	0	0	0	0	0	0	0	0	0	0
SEA GIRAFFE	FAC-M (SWEDEN)	1.000	0	0	0	2	0	0	0	0	0	0	2
SEA GIRAFFE	FF (NEW ZEALAND)	1.000	1	1	0	0	1	1	0	0	0	0	4

SEA GIRAFFE	FAC-M (KUWAIT)	1.000	0	0	0	0	0	0	0	0	0	0	0
SEA GIRAFFE	FF (MALAYSIA)	1.000	0	0	0	0	0	0	0	0	0	0	0
ERICSSON RADAR SYSTEMS AB			55	67	89	89	88	90	29	29	23	22	581
Corporation - ESCO CORP													
MSTAR	MAN-PORTABLE RADAR (US)	0.045	0	0	20	20	20	20	20	20	20	20	160
MSTAR	MAN-PORTABLE RADAR (CANADA)	0.045	25	25	0	0	0	0	0	0	0	0	50
ESCO CORP			25	25	20	20	20	20	20	20	20	20	210
Corporation - EURO-ART CONSORTIUM													
COBRA	COUNTER-BATTERY (PRE PRODUCTION)	15.600	0	0	0	0	0	0	0	0	0	0	0
COBRA	COUNTER-BATTERY (FRANCE)	15.600	0	3	3	3	3	0	0	0	0	0	12
COBRA	COUNTER-BATTERY (GERMANY)	15.600	0	4	4	5	4	0	0	0	0	0	17
COBRA	COUNTER-BATTERY (UK)	15.600	0	3	3	3	0	0	0	0	0	0	9
EURO-ART CONSORTIUM			0	10	10	11	7	0	0	0	0	0	38
Corporation - FREQUENCY ENGINEERING LABORATORIES INC													
SLQ-25A NIXIE	SURFACE SHIPS (USN)	0.450	0	0	0	0	0	0	0	0	0	0	0
SLQ-25A NIXIE	SURFACE SHIPS (FOREIGN)	0.450	0	0	0	0	0	0	0	0	0	0	0
FREQUENCY ENGINEERING LABORATORIES INC			0	0	0	0	0	0	0	0	0	0	0
Corporation - GEC PLC													
OUTFIT DLH	CVHG/DD/FF (UK)	0.075	120	120	180	180	180	180	120	60	60	60	1260
SIREN	DD/FF/FFL (VARIOUS)	0.075	0	24	24	36	36	24	36	48	24	18	270
SIREN	CVHG/DD/FF (VARIOUS)	0.075	24	24	36	42	48	96	120	160	200	240	990
SHIELD	PCFG (SINGAPORE)	0.370	0	6	6	0	0	0	0	0	0	0	12
SHIELD	FF (BRAZIL)	0.370	2	0	0	0	0	0	0	0	0	0	2
SHIELD	FFG (BRAZIL)	0.370	2	0	0	0	0	0	0	0	0	0	2
MARCONI S1800	DD/FF/FFL (VARIOUS)	1.400	3	4	3	3	2	3	3	2	3	2	28
MARTELLO	AIR DEFENSE (GREECE)	11.000	0	0	0	0	0	0	0	0	0	0	0
MARTELLO	AIR DEFENSE (UNSPECIFIED)	11.000	0	2	2	0	2	2	1	0	0	0	9
MARTELLO	AIR DEFENSE (UK)	8.000	0	0	0	2	0	0	0	0	0	0	2
SMARTELLO	CNGF DD (UK)	12.500	0	0	1	0	0	1	1	2	2	1	8
SMARTELLO	CNGF DD (ITALY)	12.500	0	0	0	0	0	1	0	1	1	0	3
GEC PLC			151	180	252	263	268	307	281	273	290	321	2586
Corporation - HUGHES AIRCRAFT CO													
PPN-20	LOCATOR TRANSPONDER (US ARMY & MARINE CORPS)	0.048	45	60	50	25	10	10	10	10	0	0	220
HADR	AIR DEFENSE (VARIOUS)	9.000	0	0	0	0	0	0	0	0	0	0	0
MARK 23 TAS	INTERNATIONAL SHIPS (VARIOUS)	9.519	1	0	0	0	0	0	0	0	0	0	1
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (US ARMY)	4.000	20	24	36	20	0	0	0	0	0	0	100
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (VARIOUS NATO)	4.000	3	6	12	12	6	6	0	0	0	0	45
TPQ-37(V)	ARTILLERY LOCATION (FMS)	8.000	1	0	0	0	0	0	0	0	0	0	1
HUGHES AIRCRAFT CO			70	90	98	57	16	16	10	10	0	0	367
Corporation - INISEL													
ARINE	MAN-PORTABLE RADAR (SPAIN)	0.045	30	30	30	30	20	0	0	0	0	0	140
INISEL			30	30	30	30	20	0	0	0	0	0	140
Corporation - IRVIN GREAT BRITAIN LTD													
REPLICA	MCMV (SPAIN)	0.100	0	1	1	2	2	2	0	0	0	0	8
REPLICA	MCMV (SAUDI ARABIA)	0.100	0	1	1	1	0	0	0	0	0	0	3
REPLICA	DD/FF/MCMV (EXPORT)	0.100	4	6	6	6	6	6	6	6	4	4	54
RUBBER DUCK	CVHG/DD/FF/MCMV/AOR (UK)	0.100	10	10	10	10	10	10	10	10	10	8	98
SLQ-49	WARSHIPS (US NAVY)	0.100	75	75	75	0	0	0	75	75	75	75	525
IRVIN GREAT BRITAIN LTD			89	93	93	19	18	18	91	91	89	87	688
Corporation - IRWIN DESMAN LTD													
OUTFIT DEC	OPTIC COUNTERMEASURE (UK)	0.500	10	10	10	10	10	10	10	5	5	5	85
IRWIN DESMAN LTD			10	10	10	10	10	10	10	5	5	5	85
Corporation - ITT CORP													
TLQ-32 ARM DECOY	DECOY SYSTEM (USAF)	0.800	30	15	10	10	10	20	25	25	10	0	155
ITT CORP			30	15	10	10	10	20	25	25	10	0	155
Corporation - KELVIN HUGHES													
TYPE 1007	CVHG/DD/FF/SSBN/SSN/SSK/AOR (UK)	0.600	9	8	7	6	0	0	0	0	0	0	30
TYPE 1007	MCMV (SAUDI ARABIA)	0.500	0	0	0	1	1	1	0	0	0	0	3
TYPE 1007	MCMV (SPAIN)	0.500	0	3	3	2	0	0	0	0	0	0	8
TYPE 1007	COLLINS SSK (AUSTRALIA)	0.500	1	1	1	1	1	1	0	0	0	0	6

Figure 1
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - KELVIN HUGHES (continued)													
TYPE 1007	FF (MALAYSIA)	0.500	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	FAC-M (OMAN)	0.500	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	FAC-M (QATAR)	0.500	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	CVH/DD/FF/FFL/FAC-M (VARIOUS)	0.500	6	6	6	6	6	6	6	6	6	6	60
TYPE 1007	HALIFAX FF (CANADA)	0.500	0	0	0	0	0	0	0	0	0	0	0
KELVIN HUGHES			16	18	17	16	8	8	6	6	6	6	107
Corporation - LOCKHEED MARTIN CORP													
WLQ-4	SSN-637, SSN-685, SSN-671, SSN-21	10.300	1	0	0	0	0	0	0	0	0	0	1
FPS-117(V)	AIR DEFENSE SYSTEM (VARIOUS)	7.500	5	2	0	0	0	0	0	0	0	0	7
SPY-1(V)	SC-21 (US NAVY)	20.000	0	0	0	0	0	0	1	0	3	3	7
SPY-1D	DDG-51 (US NAVY)	20.000	2	3	3	3	3	3	3	3	0	0	23
SPY-1D	DESTROYER (JAPAN)	20.000	0	0	0	0	0	0	0	0	0	0	0
SPY-1D	DESTROYER (SPAIN)	20.000	0	0	0	0	1	1	1	1	0	0	4
SLQ-503	DD/FF (CANADA)	2.500	1	0	0	0	0	0	0	0	0	0	1
MARK 92 CORT	INTERNATIONAL FRIGATES (VARIOUS)	8.500	0	0	0	0	0	0	0	0	0	0	0
MPR (MICROBURST PRED RAD)	WINDSHEAR DETECTION/PREDICTION (TBD)	0.600	6	20	24	24	15	15	20	24	12	6	166
WSR-88D (NEXRAD)	WEATHER RADAR (NWS, FAA, DOD)	2.250	6	5	0	0	0	0	0	0	0	0	11
SRBOC (MK 36)	SURFACE SHIPS (USN)	0.750	12	16	22	16	22	8	10	8	8	0	122
SRBOC (MK 36)	SURFACE SHIPS (FMS)	0.750	30	24	30	34	34	28	24	16	16	10	246
SSQ-72/108	SELECT SURFACE SHIPS (ROYAL NAVY)	3.200	3	3	2	2	0	2	0	2	0	1	15
ALQ-126B	F/A-18C/D (MALAYSIA)	0.500	4	4	0	0	0	0	0	0	0	0	8
LSDIS (BATTLEFIELD RADAR)	BATTLEFIELD AIR SURVEILLANCE (US ARMY)	0.045	10	0	0	0	0	0	0	0	0	0	10
LSDIS (BATTLEFIELD RADAR)	BATTLEFIELD AIR SURVEILLANCE (VARIOUS FMS)	0.045	10	5	10	0	0	0	0	0	0	0	25
MSR-3 (TACJAM-A)	TACJAM (US ARMY)	2.500	6	12	5	5	0	0	0	0	0	0	28
CHALS-X	AQF, GBCS-L/H (US ARMY)	3.600	12	12	10	0	0	0	0	0	0	0	34
LOCKHEED MARTIN CORP			108	106	106	84	75	57	59	54	39	20	708
Corporation - ML AVIATION LTD													
SUPER BARRICADE	DD/FF/FAC (INDIA)	0.150	0	6	6	0	6	6	0	6	6	0	36
SUPER BARRICADE	MCMV (AUSTRALIA)	0.250	2	2	2	2	2	2	0	0	0	0	12
RAMPART	AIRFIELD DEFENSE (UNSPECIFIED)	0.100	3	2	0	0	0	0	0	0	0	0	5
BARRICADE	MCMV (UK)	0.625	12	8	6	6	6	6	2	2	0	0	48
BARRICADE	FFL (ITALY)	0.150	0	0	0	0	0	0	0	0	0	0	0
BARRICADE	PC (US)	0.150	6	7	0	1	2	0	0	0	0	0	16
BARRICADE/SUPER BARRICADE	FAC/FFL/MCMV (VARIOUS)	0.150	6	12	12	12	12	12	12	12	12	12	114
ML AVIATION LTD			29	37	26	21	28	26	14	20	18	12	231
Corporation - MOTOROLA INC													
TSQ-168	JSTARS (US ARMY)	11.700	6	0	0	0	0	0	0	0	0	0	6
TSQ-168	JSTARS (VARIOUS (FMS))	11.700	6	8	6	5	6	2	4	2	0	0	39
TSQ-179	COMMAND & CONTROL (US ARMY)	11.700	6	12	12	12	12	12	7	0	0	0	73
MOTOROLA INC			18	20	18	17	18	14	11	2	0	0	118
Corporation - MULTI-CONTRACTORS													
SEA GNAT	MUNITIONS (US)	0.002	20000	17500	15000	15000	15000	12500	12500	12500	10000	10000	140000
SEA GNAT	MUNITIONS (UNSPECIFIED)	0.002	15000	15000	15000	15000	12000	12000	12000	10000	10000	10000	126000
SEA GNAT	MUNITIONS (UK)	0.002	7000	7000	7000	7000	7000	7000	5000	5000	5000	3000	60000
SEA GNAT	MUNITIONS (AUSTRALIA)	0.002	500	500	500	500	500	500	500	500	500	500	5000
MULTI-CONTRACTORS			42500	40000	37500	37500	34500	32000	30000	28000	25500	23500	331000
Corporation - NORTHROP GRUMMAN CORP													
SPQ-9B	SURFACE SHIPS (USN)	2.100	0	1	2	3	4	6	12	15	10	6	59
SPS-67(V)	SURFACE SHIPS (VARIOUS)	0.250	5	5	0	0	0	0	0	0	0	0	10
ASDE-3	AIRPORT SURFACE TRAFFIC CONTROL (FAA)	4.500	1	4	0	0	0	0	0	0	0	0	5
ARSR-4	EN-ROUTE AIR TRAFFIC CONTROL (FAA/USAF)	6.500	2	0	0	0	0	0	0	0	0	0	2
ASR-9	AIR TRAFFIC CONTROL (VARIOUS)	3.700	0	0	0	0	0	0	0	0	0	0	0
TPS-63(V)/TPS-65	BATTLEFIELD SURVEILLANCE (VARIOUS)	5.000	0	0	0	0	0	0	0	0	0	0	0
NORTHROP GRUMMAN CORP			8	10	2	3	4	6	12	15	10	6	76
Corporation - RACAL ELECTRONICS PLC													
ULQ-19(V) RACJAM	VHF TACTICAL COM JAMMER SYSTEM (VARIOUS)	0.100	0	0	0	0	0	0	0	0	0	0	0
CUTLASS/CYGNUS	FAC-M (EGYPT)	5.000	0	0	0	0	0	0	0	0	0	0	0
CUTLASS/CYGNUS	DD/FF/FFL/FAC-M (VARIOUS)	5.000	2	3	3	5	5	8	7	8	9	9	59
CUTLASS/CYGNUS	FAC-M (BRAZIL)	5.000	1	0	1	0	0	0	0	0	0	0	2
CUTLASS/SABRE	FFL/OPV (DENMARK)	5.000	1	0	0	0	0	0	0	0	0	0	1
CUTLASS/SCORPION	FF (TURKEY)	4.000	1	2	2	1	1	2	2	2	0	0	13
OUTFIT UAA UPGRADE	DD/FF (UK)	2.500	0	2	4	4	4	4	4	2	2	2	28
OUTFIT UAF	TYPE 23 FF (UK)	2.500	0	0	0	0	0	0	0	0	0	0	0
OUTFIT UAP	SSBN/SSN/SSK (UK)	2.500	1	0	0	0	0	0	0	0	0	0	1
SEA LION	SSK (VARIOUS)	2.500	1	1	0	0	0	0	0	0	0	0	2
MSTAR	MAN-PORTABLE RADAR (UK)	0.045	0	30	30	30	30	0	0	0	0	0	120
MSTAR	MAN-PORTABLE RADAR (VARIOUS)	0.045	0	0	0	20	20	20	20	20	20	20	140

Figure 1
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - RACAL ELECTRONICS PLC (continued)													
MANTA	AGOSTA SSK (SPAIN)	2.500	0	0	0	0	0	0	0	0	0	0	0
MANTA	A-19 SSK (SWEDEN)	2.500	1	0	0	0	0	0	0	0	0	0	1
MANTA	SSN/SSK (VARIOUS)	2.500	2	2	3	3	3	4	4	3	3	2	29
MANTA	SUBMARINE 2000 SSK (SWEDEN)	2.500	0	0	0	3	0	4	5	0	0	0	12
OUTFIT UAH/UAL	SSBN/SSN/SSK (UK)	2.500	0	1	1	1	1	1	0	0	0	0	5
OUTFIT UAT	TYPE 23 FF (UK)	2.500	0	3	0	2	0	0	0	0	0	0	5
OUTFIT UAT	DD/FF (UK)	2.500	2	4	4	4	4	4	0	0	0	0	22
PHILAX	FAC (FINLAND)	0.100	0	0	0	0	0	0	0	0	0	0	0
PHILAX	FAC/FFL/MCMV (SWEDEN)	0.100	2	2	0	0	0	0	0	0	0	0	4
PROTEAN	FF/FFL (SOUTH KOREA)	0.100	4	4	4	4	0	0	0	0	0	0	16
SCEPTRE LENS	YSM-2000/YSB (SWEDEN)	2.500	2	2	2	2	2	2	0	0	0	0	12
SCEPTRE O	ANZAC FF (NEW ZEALAND)	1.500	1	0	0	0	0	0	0	0	0	0	1
SCEPTRE XL	ANZAC FF (AUSTRALIA)	2.500	1	1	1	1	1	1	0	0	0	0	6
SCEPTRE XL	FF (VARIOUS)	2.500	4	4	4	4	4	4	4	4	0	0	32
RACAL ELECTRONICS PLC			26	61	59	84	75	54	46	39	34	33	511
Corporation - RAFAEL ARMAMENT DEVELOPMENT AUTHORITY													
BEAMTRAP (RAFAEL)	FAC (VARIOUS)	0.010	400	400	400	300	300	200	200	100	0	0	2300
LRCR	FAC (VARIOUS)	0.010	150	100	100	50	50	50	0	0	0	0	500
SRCR	FAC (VARIOUS)	0.003	100	100	100	50	50	50	50	50	0	0	550
RAFAEL ARMAMENT DEVELOPMENT AUTHORITY			650	600	600	400	400	300	250	150	0	0	3350
Corporation - RAYTHEON CO													
ATNAVICS	TACTICAL AIR TRAFFIC CONTROL (US ARMY)	0.000	1	4	10	14	14	14	7	0	0	0	64
SIDEKICK	SURFACE SHIPS (USN)	1.200	0	0	0	0	0	0	0	0	0	0	0
SIDEKICK	SURFACE SHIPS (UNSPECIFIED)	1.200	0	0	0	0	0	0	0	0	0	0	0
SLQ-32(V)	SURFACE SHIPS (USN/USCG)	5.000	3	0	0	0	0	0	0	0	0	0	3
SLQ-32(V)	SURFACE SHIPS (FMS) (UNSPECIFIED)	5.000	0	0	0	0	0	0	0	0	0	0	0
COSSOR ATC SYSTEMS	ATC RADARS (UNSPECIFIED)	0.750	3	2	2	2	0	0	0	0	0	0	9
SPS-49(V)	SURFACE SHIP (USN)	3.700	0	0	0	0	0	0	0	0	0	0	0
SPS-49(V)	SURFACE SHIP (CANADA)	3.700	0	0	0	0	0	0	0	0	0	0	0
SPS-49(V)	SURFACE SHIP (TAIWAN)	3.700	2	1	0	0	0	0	0	0	0	0	3
TDWR	ATC (FAA)	3.200	0	0	0	0	0	0	0	0	0	0	0
TDWR	ATC (VARIOUS)	3.200	2	0	0	0	0	0	0	0	0	0	2
SPS-64(V)	SURFACE SHIPS (VARIOUS)	0.040	5	0	0	0	0	0	0	0	0	0	5
RAYTHEON CO			16	7	12	16	14	14	7	0	0	0	86
Corporation - SIEMENS AG													
SAMPSON	CVHG/DD/FF (VARIOUS)	15.000	0	0	2	4	4	6	6	6	6	6	40
AR-327	LONG-RANGE 3D RADAR (VARIOUS)	8.000	0	0	0	0	0	0	0	0	0	0	0
AWS-4/5	UPGRADES (VARIOUS)	1.500	0	0	0	0	0	0	0	0	0	0	0
AWS-6	FF/FFL (DENMARK)	2.000	0	0	0	0	0	0	0	0	0	0	0
AWS-6	FAC (OMAN)	2.000	0	0	0	0	0	0	0	0	0	0	0
AWS-6 DOLPHIN	FF/FFL (VARIOUS)	2.000	0	2	2	0	0	0	0	0	0	0	4
TYPE 996	DD/AOR (UK)	6.400	0	0	0	0	0	0	0	0	0	0	0
TYPE 996	LPH/FF (UK)	6.400	2	2	2	2	0	0	0	0	0	0	8
TYPE 996	EXPORT AWS-9 (VARIOUS)	6.400	3	3	4	3	2	3	2	3	3	2	28
WATCHMAN	ATC RADAR (VARIOUS)	2.500	1	2	2	2	2	3	3	3	3	3	24
SIEMENS AG			6	9	12	11	8	12	11	12	12	11	104
Corporation - SIPPICAN INC													
NULKA	NAVAL DECOYS (US NAVY)	0.100	500	750	300	200	150	75	0	0	0	0	1975
NULKA	NAVAL DECOYS (VARIOUS)	0.100	0	0	0	20	20	20	20	10	10	10	110
SIPPICAN INC			500	750	300	220	170	95	20	10	10	10	2085
Corporation - TELSTRA													
JINDALEE	AIR DEFENSE (AUSTRALIA)	83.000	0	0	0	0	0	0	0	0	0	0	0
TELSTRA			0	0	0	0	0	0	0	0	0	0	0
Corporation - THOMSON-CSF													
JUPITER	FF (SAUDI ARABIA)	8.000	1	0	0	0	0	0	0	0	0	0	1
JUPITER	FF (TAIWAN)	8.000	2	2	1	0	0	0	0	0	0	0	5
DR-2000/4000	DD/FF/FFL/FAC-M (VARIOUS)	0.750	0	0	0	0	0	0	0	0	0	0	0
DR-3000	DD/FF/FFL (VARIOUS)	3.000	15	14	10	9	10	12	14	16	17	17	134
ARABEL	CV/DD/FF (FRANCE)	6.500	1	2	2	2	1	1	0	0	0	0	9
ARABEL	GROUND-BASED RADAR (VARIOUS)	6.500	2	3	10	10	10	10	5	0	0	0	50
CASTOR IIB/C/J	FAC/FFL (VARIOUS)	1.000	3	4	3	3	2	2	0	0	0	0	17
CASTOR IIB/C/J	CV/DD/FF (FRANCE)	1.200	1	1	1	0	0	0	0	0	0	0	3
CASTOR IIB/C/J	FF (VARIOUS)	1.200	2	2	1	1	1	0	0	0	0	0	7
FLAIR TRS-2140	AIR SURVEILLANCE (VARIOUS)	4.500	3	5	7	6	5	8	9	5	3	0	51
GERFAUT	AIR DEFENSE (SWEDEN)	0.210	20	20	10	0	0	0	0	0	0	0	50
GERFAUT	AIR DEFENSE (TURKEY)	0.210	24	24	24	16	0	0	0	0	0	0	88
GRIFFON	AIR DEFENSE (TURKEY)	0.210	0	0	0	0	0	0	0	0	0	0	0
GRIFFON/GERFAUT	AIR DEFENSE (VARIOUS)	0.210	10	16	16	20	20	20	20	20	0	0	142
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (FRANCE)	11.000	2	1	0	0	0	0	0	0	0	0	3
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (TURKEY)	11.000	0	0	0	0	0	0	0	0	0	0	0
THOMSON-CSF 3D ADGE RADAR	AIR-DEFENSE (KUWAIT)	11.000	0	1	0	1	1	0	0	0	0	0	3
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (UNSPECIFIED)	11.000	3	0	2	0	3	0	2	0	3	0	13
THOMSON-CSF ATC SYSTEMS	ATC RADARS (UNSPECIFIED)	1.000	30	45	45	45	50	50	50	50	50	50	465
SIGNAAL APAR	DD (CANADA)	9.600	0	0	1	3	3	2	2	2	0	0	13

Figure 1
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - THOMSON-CSF (continued)													
SIGNAAL APAR	DD (GERMANY)	9.600	0	1	2	1	0	2	2	2	2	2	14
SIGNAAL APAR	DD (NETHERLANDS)	9.600	0	1	1	0	1	1	0	0	0	0	4
SIGNAAL APAR	DD (SPAIN)	9.600	0	0	1	1	1	1	0	0	0	0	4
SIGNAAL APAR	DD (EXPORT)	9.600	0	0	0	0	1	1	2	4	4	3	15
SIGNAAL DA.08	ELLI FF (GREECE)	6.000	0	1	0	1	0	0	0	0	0	0	2
SIGNAAL DA.08	CVL/CL/FF (VARIOUS)	6.000	3	3	2	3	0	0	0	0	0	0	11
SIGNAAL DA.08	FF (MALAYSIA)	6.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL DA.08	DD (GERMANY)	6.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL DA.08	FF (PAKISTAN)	6.000	2	0	0	0	0	0	0	0	0	0	2
SIGNAAL LW.08	FF (AUSTRALIA)	8.000	1	1	1	1	1	1	0	0	0	0	6
SIGNAAL LW.08	FF (GERMANY)	8.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL LW.08	CVL/DD/FF (INDIA)	8.000	1	1	1	0	0	0	0	0	0	0	3
SIGNAAL LW.08	DD/FF (NETHERLANDS)	8.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL LW.08	FF (NEW ZEALAND)	8.000	1	1	0	0	0	0	0	0	0	0	2
SIGNAAL LW.08	CVL/CL/DD/FF (UNSPECIFIED)	8.000	4	2	4	2	4	2	1	1	0	0	20
SIGNAAL LW.08	FF (SOUTH KOREA)	6.000	1	1	2	2	2	2	2	2	0	0	14
SIGNAAL LW.08	FF (THAILAND)	6.000	0	0	2	0	0	0	0	0	0	0	2
SIGNAAL MW.08	FF (GREECE)	6.500	0	1	0	1	0	0	0	0	0	0	2
SIGNAAL MW.08	FFL (OMAN)	6.500	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL MW.08	FF (SOUTH KOREA)	6.000	3	0	1	2	3	0	1	2	3	0	15
SIGNAAL MW.08	FF (TURKEY)	6.000	3	0	3	0	0	0	2	2	0	0	10
SIGNAAL SMART-L	DD (NETHERLANDS)	12.500	2	2	2	0	2	2	2	0	0	0	12
SIGNAAL SMART-L	DD (GERMANY)	12.500	2	2	2	2	0	2	2	0	0	0	12
SIGNAAL SMART-L	DD (SPAIN)	12.500	1	1	1	1	0	0	0	0	0	0	4
SIGNAAL SMART-L	DD (CANADA)	12.500	0	0	1	1	1	0	0	0	0	0	3
SIGNAAL SMART-S	FF/DD (GERMANY)	10.000	0	1	2	3	2	2	1	0	0	0	11
SIGNAAL SMART-S	FF (NETHERLANDS)	6.500	1	1	2	1	0	0	0	0	0	0	5
SIGNAAL SMART-S	DD (SPAIN)	10.000	1	1	1	1	0	0	0	0	0	0	4
SIGNAAL SMART-S	DD (CANADA)	10.000	0	0	1	1	1	0	0	0	0	0	3
SIGNAAL SMART/MW.08	DD/FF/FFL (UNSPECIFIED)	8.500	6	8	8	8	10	10	8	8	8	6	80
SIGNAAL STIR	DD/FF (CANADA)	2.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	DD/FF (GERMANY)	2.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	FF (GREECE)	2.000	2	2	2	0	0	0	0	0	0	0	6
SIGNAAL STIR	DD/FF (NETHERLANDS)	2.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	YAVUZ FF (TURKEY)	2.000	2	3	0	0	0	0	0	0	0	0	5
SIGNAAL STIR	FF/FFL (ARGENTINA)	2.000	0	0	0	3	0	0	0	0	0	0	3
SIGNAAL STIR	FF (SOUTH KOREA)	2.000	4	4	4	4	4	4	4	4	0	0	32
SIGNAAL STIR	DD/FF (TAIWAN)	2.000	1	1	1	1	0	0	0	0	0	0	4
SIGNAAL STIR	CVH/FF (THAILAND)	2.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	FFL (OMAN)	2.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	FAC-M (QATAR)	2.000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	DD/FF/FFL/FAC-M (VARIOUS)	2.000	8	10	10	8	8	8	8	8	0	0	68
SIGNAAL STIR	OPV (AUSTRALIA/MALAYSIA)	2.000	0	5	12	11	8	4	1	1	1	1	44
WM-20 FCS	WARSHIPS (VARIOUS)	7.000	0	3	2	3	3	2	2	0	0	0	15
WM-20 FCS	UPGRADES (SIGNAAL)	1.000	12	8	6	6	6	4	4	4	4	4	58
SMARTELLO	CNGF DD (UK)	12.500	0	0	0	0	0	0	0	1	1	2	4
SMARTELLO	CNGF DD (FRANCE)	12.500	0	0	0	0	0	1	0	1	1	1	4
SMARTELLO	CNGF DD (ITALY)	12.500	0	0	0	0	0	0	0	1	1	1	3
RASIT	BATTLEFIELD SURVEILLANCE (VARIOUS)	0.350	2	0	0	0	0	0	0	0	0	0	2
RB-12	MAN PORTABLE RADAR (FRANCE)	0.060	10	10	20	10	10	0	0	0	0	0	60
RB-12	MAN-PORTABLE RADAR (UNSPECIFIED)	0.060	0	8	8	12	12	8	8	8	4	4	72
THOMSON-CSF			192	223	238	206	186	162	152	142	102	91	1694
Corporation - WEGMANN/BUCK													
HOT DOG/SILVER DOG	FAC/MCMV/AD (GERMAN NAVY)	0.020	0	0	0	0	0	0	0	0	0	0	0
WEGMANN/BUCK			0	0	0	0	0	0	0	0	0	0	0
Corporation - WHITTAKER ELECTRONIC SYSTEMS													
VLQ-9/10	BATTLEFIELD PROTECTION (US ARMY)	0.060	0	24	40	60	120	100	75	40	24	24	507
WHITTAKER ELECTRONIC SYSTEMS			0	24	40	60	120	100	75	40	24	24	507
Corporation - Z-FACTOR													
L&S EW ANALYSIS	FORECAST ADJUSTMENT (N/A)	10.000	0	0	0	1	6	6	7	6	8	0	34
L&S RADAR ANALYSIS	FORECAST ADJUSTMENT (N/A)	10.000	0	0	0	41	40	37	100	100	90	90	498
Z-FACTOR			0	0	0	42	46	43	107	106	98	90	532
Printout Total -			44709	42556	39697	39347	36254	33477	31309	29100	26321	24272	347042

Figure 1

The Market for Surface Electronic Warfare System

Value of Production by Program

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - AEL													
MSR-3 (TACJAM-A)	TACJAM (US ARMY)	2.50	15.00	30.00	12.50	10.00	0.00	0.00	0.00	0.00	0.00	0.00	67.50
AEL			15.00	30.00	12.50	10.00	0.00	0.00	0.00	0.00	0.00	0.00	67.50
Corporation - ALENIA-ELSAG													
ALENIA RAT-31	LONG RANGE 3D RADAR (VARIOUS)	9.00	117.00	81.00	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	243.00
EMPAR	DD (ITALY)	12.00	0.00	12.00	0.00	36.00	24.00	0.00	0.00	0.00	0.00	0.00	72.00
SCLAR MK 2	CVH/CVHL/DD/FF/FFL (ITALY)	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ORION	CVH/DD/FF/FAC-M (VARIOUS)	2.50	62.50	40.00	40.00	40.00	30.00	30.00	30.00	30.00	0.00	0.00	302.50
ALENIA-ELSAG			179.50	133.00	85.00	76.00	54.00	30.00	30.00	30.00	0.00	0.00	617.50
Corporation - ALLIEDSIGNAL AEROSPACE CO													
PRM RADAR	AIR TRAFFIC APPROACH CONTROL (FAA & VARIOUS)	4.20	8.40	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.60
ALLIEDSIGNAL AEROSPACE CO			8.40	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.60
Corporation - AWA INDUSTRIES													
NULKA	NAVAL DECOYS (AUSTRALIAN NAVY)	0.10	5.00	5.00	5.00	5.00	5.00	2.00	2.00	1.00	1.00	0.00	31.00
AWA INDUSTRIES			5.00	5.00	5.00	5.00	5.00	2.00	2.00	1.00	1.00	0.00	31.00
Corporation - BOEING CO													
APECS II/III	KAREL DOORMAN FRIGATE (NETHERLANDS)	4.00	8.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
APECS II/III	DD/FF/FFL (VARIOUS)	4.00	16.00	12.00	8.00	12.00	12.00	12.00	12.00	12.00	8.00	8.00	112.00
APECS II/III	KDX FF (S KOREA)	4.00	4.00	0.00	4.00	8.00	8.00	4.00	0.00	4.00	8.00	8.00	48.00
WLR-1H(V)	VARIOUS (VARIOUS)	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
BOEING CO			29.00	17.00	12.00	20.00	20.00	16.00	12.00	16.00	16.00	16.00	174.00
Corporation - CELSIUSTECH													
MATILDE	FAC/FFL/MCMV (VARIOUS)	0.10	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
CELSIUSTECH			0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Corporation - CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP													
CEIEC JY-8/8A	AIR DEFENSE (CHINA)	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEIEC JY-8/8A	AIR DEFENSE (UNSPECIFIED)	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEIEC MW-5	AIR DEFENSE (UNSPECIFIED)	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEIEC TYPE-702	AIR DEFENSE (UNSPECIFIED)	0.15	9.00	9.00	9.00	9.00	9.00	9.00	4.50	3.00	1.50	0.75	63.75
CEIEC-408C	AIR DEFENSE (ZIMBABWE)	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEIEC-408C	AIR DEFENSE (UNSPECIFIED)	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEIEC-921A	SSK (CHINA)	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP			9.00	9.00	9.00	9.00	9.00	9.00	4.50	3.00	1.50	0.75	63.75
Corporation - CONTRACTOR TO BE SELECTED													
AIEWS	SURFACE SHIPS (USN)	10.00	20.00	50.00	50.00	50.00	50.00	40.00	30.00	20.00	30.00	20.00	360.00
CONTRACTOR TO BE SELECTED			20.00	50.00	50.00	50.00	50.00	40.00	30.00	20.00	30.00	20.00	360.00
Corporation - CONTRAVES													
SEAGUARD	FF (TURKEY)	6.00	6.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
SEAGUARD	FF (INDIA)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	42.00
SKYGUARD	AA FCS (VARIOUS)	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONTRAVES			12.00	12.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	54.00
Corporation - CSEE													
DAGAIE/SAGAIE	FF/FFL/FAC-M (VARIOUS)	1.00	2.00	2.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00
DAGAIE/SAGAIE	CV/DD/FF (VARIOUS)	2.50	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	2.50
CSEE			2.00	2.00	1.00	3.50	0.00	0.00	0.00	0.00	0.00	0.00	8.50
Corporation - DASSAULT ELECTRONIQUE													
SALAMANDRE	CV/FF (FRANCE)	1.00	1.00	3.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	7.00
SALAMANDRE	FF/FFL (VARIOUS)	1.00	4.00	2.00	4.00	6.00	6.00	3.00	3.00	2.00	2.00	2.00	34.00
DASSAULT ELECTRONIQUE			5.00	5.00	5.00	7.00	7.00	3.00	3.00	2.00	2.00	2.00	41.00
Corporation - ELETTRONICA SPA													
ALDEBARAN	SHIPBOARD EW (SPAIN)	6.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	0.00	0.00	30.00
NETTUNO/NEWTON	FF (CHINA)	4.50	9.00	9.00	4.50	9.00	9.00	4.50	4.50	4.50	9.00	4.50	67.50
NETTUNO/NEWTON	CVH/DD (ITALY)	11.00	0.00	0.00	22.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	44.00

Figure 2
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - ELETTRONICA SPA (continued)													
NETTUNO/NEWTON	FF (MALAYSIA)	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NETTUNO/NEWTON	SHIPBOARD EW (SPAIN)	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ELETTRONICA SPA			15.00	15.00	32.50	37.00	15.00	4.50	4.50	4.50	9.00	4.50	141.50
Corporation - ERICSSON RADAR SYSTEMS AB													
ARTHUR	COUNTER-BATTERY (VARIOUS)	2.50	50.00	50.00	50.00	50.00	50.00	50.00	45.00	45.00	30.00	30.00	450.00
GIRAFFE	AIR DEFENSE (SWEDEN)	2.50	37.50	37.50	37.50	37.50	37.50	37.50	0.00	0.00	0.00	0.00	225.00
GIRAFFE	AIR DEFENSE (NORWAY)	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GIRAFFE	AIR DEFENSE (EXPORT)	2.50	15.00	20.00	15.00	10.00	10.00	15.00	20.00	20.00	20.00	20.00	165.00
GIRAFFE	AIR DEFENSE (FINLAND)	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HARD	AIR DEFENSE (SWEDEN)	1.25	12.50	25.00	56.25	56.25	56.25	56.25	0.00	0.00	0.00	0.00	262.50
SEA GIRAFFE	DD/FF/FFL/FAC-M (VARIOUS)	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	20.00
SEA GIRAFFE	FF (AUSTRALIA)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	9.00
SEA GIRAFFE	FF (CANADA)	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEA GIRAFFE	FAC-M (SWEDEN)	1.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
SEA GIRAFFE	FF (NEW ZEALAND)	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	4.00
SEA GIRAFFE	FAC-M (KUWAIT)	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEA GIRAFFE	FF (MALAYSIA)	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ERICSSON RADAR SYSTEMS AB			119.00	136.50	161.75	158.75	157.75	162.75	68.00	68.00	53.00	52.00	1137.50
Corporation - ESCO CORP													
MSTAR	MAN-PORTABLE RADAR (US)	0.05	0.00	0.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	7.20
MSTAR	MAN-PORTABLE RADAR (CANADA)	0.05	1.13	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25
ESCO CORP			1.13	1.13	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	9.45
Corporation - EURO-ART CONSORTIUM													
COBRA	COUNTER-BATTERY (PRE PRODUCTION)	15.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COBRA	COUNTER-BATTERY (FRANCE)	15.60	0.00	46.80	46.80	46.80	46.80	0.00	0.00	0.00	0.00	0.00	187.20
COBRA	COUNTER-BATTERY (GERMANY)	15.60	0.00	62.40	62.40	78.00	62.40	0.00	0.00	0.00	0.00	0.00	265.20
COBRA	COUNTER-BATTERY (UK)	15.60	0.00	46.80	46.80	46.80	0.00	0.00	0.00	0.00	0.00	0.00	140.40
EURO-ART CONSORTIUM			0.00	156.00	156.00	171.60	109.20	0.00	0.00	0.00	0.00	0.00	592.80
Corporation - FREQUENCY ENGINEERING LABORATORIES INC													
SLQ-25A NIXIE	SURFACE SHIPS (USN)	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SLQ-25A NIXIE	SURFACE SHIPS (FOREIGN)	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FREQUENCY ENGINEERING LABORATORIES INC			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporation - GEC PLC													
OUTFIT DLH	CVHG/DD/FF (UK)	0.08	9.00	9.00	13.50	13.50	13.50	13.50	9.00	4.50	4.50	4.50	94.50
SIREN	DD/FF/FFL (VARIOUS)	0.08	0.00	1.80	1.80	2.70	2.70	1.80	2.70	3.60	1.80	1.35	20.25
SIREN	CVHG/DD/FF (VARIOUS)	0.08	1.80	1.80	2.70	3.15	3.60	7.20	9.00	12.00	15.00	18.00	74.25
SHIELD	PCFG (SINGAPORE)	0.37	0.00	2.22	2.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44
SHIELD	FF (BRAZIL)	0.37	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
SHIELD	FFG (BRAZIL)	0.37	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
MARCONI S1800	DD/FF/FFL (VARIOUS)	1.40	4.20	5.60	4.20	4.20	2.80	4.20	4.20	2.80	4.20	2.80	39.20
MARTELLO	AIR DEFENSE (GREECE)	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MARTELLO	AIR DEFENSE (UNSPECIFIED)	11.00	0.00	22.00	22.00	0.00	22.00	22.00	11.00	0.00	0.00	0.00	99.00
MARTELLO	AIR DEFENSE (UK)	8.00	0.00	0.00	0.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00
SMARTELLO	CNGF DD (UK)	12.50	0.00	0.00	12.50	0.00	0.00	12.50	12.50	25.00	25.00	12.50	100.00
SMARTELLO	CNGF DD (ITALY)	12.50	0.00	0.00	0.00	0.00	0.00	12.50	0.00	12.50	12.50	0.00	37.50
GEC PLC			16.48	42.42	58.92	39.55	44.60	73.70	48.40	60.40	63.00	39.15	486.62
Corporation - HUGHES AIRCRAFT CO													
PPN-20	LOCATOR TRANSPONDER (US ARMY & MARINE CORPS)	0.05	2.16	2.88	2.40	1.20	0.48	0.48	0.48	0.48	0.00	0.00	10.56
HADR	AIR DEFENSE (VARIOUS)	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MARK 23 TAS	INTERNATIONAL SHIPS (VARIOUS)	9.52	9.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.52
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (US ARMY)	4.00	80.00	96.00	144.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	400.00
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (VARIOUS NATO)	4.00	12.00	24.00	48.00	48.00	24.00	24.00	0.00	0.00	0.00	0.00	180.00
TPQ-37(V)	ARTILLERY LOCATION (FMS)	8.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
HUGHES AIRCRAFT CO			111.68	122.88	194.40	129.20	24.48	24.48	0.48	0.48	0.00	0.00	608.08
Corporation - INISEL													
ARINE	MAN-PORTABLE RADAR (SPAIN)	0.05	1.35	1.35	1.35	1.35	0.90	0.00	0.00	0.00	0.00	0.00	6.30
INISEL			1.35	1.35	1.35	1.35	0.90	0.00	0.00	0.00	0.00	0.00	6.30
Corporation - IRVIN GREAT BRITAIN LTD													
REPLICA	MCMV (SPAIN)	0.10	0.00	0.10	0.10	0.20	0.20	0.20	0.00	0.00	0.00	0.00	0.80
REPLICA	MCMV (SAUDI ARABIA)	0.10	0.00	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.30

Figure 2
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - IRVIN GREAT BRITAIN LTD (continued)													
REPLICA	DD/FF/MCMV (EXPORT)	0.10	0.40	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.40	0.40	5.40
RUBBER DUCK	CVHG/DD/FF/MCMV/AOR (UK)	0.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80	9.80
SLQ-49	WARSHIPS (US NAVY)	0.10	7.50	7.50	7.50	0.00	0.00	0.00	7.50	7.50	7.50	7.50	52.50
IRVIN GREAT BRITAIN LTD			8.90	9.30	9.30	1.90	1.80	1.80	9.10	9.10	8.90	8.70	68.80
Corporation - IRWIN DESMAN LTD													
OUTFIT DEC	OPTIC COUNTERMEASURE (UK)	0.50	5.00	5.00	5.00	5.00	5.00	5.00	5.00	2.50	2.50	2.50	42.50
IRWIN DESMAN LTD			5.00	5.00	5.00	5.00	5.00	5.00	5.00	2.50	2.50	2.50	42.50
Corporation - ITT CORP													
TLQ-32 ARM DECOY	DECOY SYSTEM (USAF)	0.80	24.00	12.00	8.00	8.00	8.00	16.00	20.00	20.00	8.00	0.00	124.00
ITT CORP			24.00	12.00	8.00	8.00	8.00	16.00	20.00	20.00	8.00	0.00	124.00
Corporation - KELVIN HUGHES													
TYPE 1007	CVHG/DD/FF/SSBN/SSN/ SSK/AOR (UK)	0.60	5.40	4.80	4.20	3.60	0.00	0.00	0.00	0.00	0.00	0.00	18.00
TYPE 1007	MCMV (SAUDI ARABIA)	0.50	0.00	0.00	0.00	0.50	0.50	0.50	0.00	0.00	0.00	0.00	1.50
TYPE 1007	MCMV (SPAIN)	0.50	0.00	1.50	1.50	1.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
TYPE 1007	COLLINS SSK (AUSTRALIA)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	3.00
TYPE 1007	FF (MALAYSIA)	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TYPE 1007	FAC-M (OMAN)	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TYPE 1007	FAC-M (QATAR)	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TYPE 1007	CVH/DD/FF/FFL/FAC-M (VARIOUS)	0.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	30.00
TYPE 1007	HALIFAX FF (CANADA)	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KELVIN HUGHES			8.90	9.80	9.20	8.60	4.00	4.00	3.00	3.00	3.00	3.00	56.50
Corporation - LOCKHEED MARTIN CORP													
WLQ-4	SSN-637, SSN-685, SSN-671, SSN-21	10.30	10.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.30
FPS-117(V)	AIR DEFENSE SYSTEM (VARIOUS)	7.50	37.50	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.50
SPY-1(V)	SC-21 (US NAVY)	20.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	60.00	60.00	140.00
SPY-1D	DDG-51 (US NAVY)	20.00	40.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	0.00	0.00	460.00
SPY-1D	DESTROYER (JAPAN)	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SPY-1D	DESTROYER (SPAIN)	20.00	0.00	0.00	0.00	0.00	20.00	20.00	20.00	20.00	0.00	0.00	80.00
SLQ-503	DD/FF (CANADA)	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50
MARK 92 CORT	INTERNATIONAL FRIGATES (VARIOUS)	8.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MPR (MICROBURST PRED RAD)	WINDSHEAR DETECTION/PREDICTION (TBD)	0.60	3.60	12.00	14.40	14.40	9.00	9.00	12.00	14.40	7.20	3.60	99.60
WSR-88D (NEXRAD)	WEATHER RADAR (NWS, FAA, DOD)	2.25	13.50	11.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.75
SRBOC (MK 36)	SURFACE SHIPS (USN)	0.75	9.00	12.00	16.50	12.00	16.50	6.00	7.50	6.00	6.00	0.00	91.50
SRBOC (MK 36)	SURFACE SHIPS (FMS)	0.75	22.50	18.00	22.50	25.50	25.50	21.00	18.00	12.00	12.00	7.50	184.50
SSQ-72/108	SELECT SURFACE SHIPS (ROYAL NAVY)	3.20	9.60	9.60	6.40	6.40	0.00	6.40	0.00	6.40	0.00	3.20	48.00
ALQ-126B	F/A-18C/D (MALAYSIA)	0.50	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
LSDIS (BATTLEFIELD RADAR)	BATTLEFIELD AIR SURVEILLANCE (US ARMY)	0.05	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
LSDIS (BATTLEFIELD RADAR)	BATTLEFIELD AIR SURVEILLANCE (VARIOUS FMS)	0.05	0.45	0.23	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
MSR-3 (TACJAM-A)	TACJAM (US ARMY)	2.50	15.00	30.00	12.50	12.50	0.00	0.00	0.00	0.00	0.00	0.00	70.00
CHALS-X	AQF, GBCS-L/H (US ARMY)	3.60	43.20	43.20	36.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	122.40
LOCKHEED MARTIN CORP			209.60	213.28	168.75	130.80	131.00	122.40	137.50	118.80	85.20	74.30	1391.63
Corporation - ML AVIATION LTD													
SUPER BARRICADE	DD/FF/FAC (INDIA)	0.15	0.00	0.90	0.90	0.00	0.90	0.90	0.00	0.90	0.90	0.00	5.40
SUPER BARRICADE	MCMV (AUSTRALIA)	0.25	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	3.00
RAMPART	AIRFIELD DEFENSE (UNSPECIFIED)	0.10	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
BARRICADE	MCMV (UK)	0.63	7.50	5.00	3.75	3.75	3.75	3.75	1.25	1.25	0.00	0.00	30.00
BARRICADE	FFL (ITALY)	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BARRICADE	PC (US)	0.15	0.90	1.05	0.00	0.15	0.30	0.00	0.00	0.00	0.00	0.00	2.40
BARRICADE/SUPER BARRICADE	FAC/FFL/MCMV (VARIOUS)	0.15	0.90	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	17.10
ML AVIATION LTD			10.10	9.45	6.95	6.20	7.25	6.95	3.05	3.95	2.70	1.80	58.40
Corporation - MOTOROLA INC													
TSQ-168	JSTARS (US ARMY)	11.70	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.20
TSQ-168	JSTARS (VARIOUS (FMS))	11.70	70.20	93.60	70.20	58.50	70.20	23.40	46.80	23.40	0.00	0.00	456.30
TSQ-179	COMMAND & CONTROL (US ARMY)	11.70	70.20	140.40	140.40	140.40	140.40	140.40	81.90	0.00	0.00	0.00	854.10
MOTOROLA INC			210.60	234.00	210.60	198.90	210.60	163.80	128.70	23.40	0.00	0.00	1380.60
Corporation - MULTI-CONTRACTORS													
ASSEP	SUBMARINE ESM (US NAVY)	0.00	2.40	3.60	4.40	4.30	4.30	4.40	4.50	4.50	4.70	5.00	42.10
SEA GNAT	MUNITIONS (US)	0.00	30.00	26.25	22.50	22.50	22.50	18.75	18.75	18.75	15.00	15.00	210.00
SEA GNAT	MUNITIONS (UNSPECIFIED)	0.00	22.50	22.50	22.50	22.50	18.00	18.00	18.00	15.00	15.00	15.00	189.00
SEA GNAT	MUNITIONS (UK)	0.00	10.50	10.50	10.50	10.50	10.50	10.50	7.50	7.50	7.50	4.50	90.00

Figure 2
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - MULTI-CONTRACTORS (continued)													
SEA GNAT	MUNITIONS (AUSTRALIA)	0.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	7.50
STTT	SURFACE WARFARE TRAINING (US NAVY)	0.00	3.40	3.50	2.20	0.50	0.50	0.30	0.20	0.00	0.00	0.00	10.60
SUBMARINE COMMUNICATIONS	VARIOUS SUBMARINE COMMUNICATIONS (US NAVY)	0.00	20.00	19.00	20.00	20.00	19.00	19.00	19.00	20.00	21.00	21.00	198.00
MULTI-CONTRACTORS			89.55	86.10	82.85	81.05	75.55	71.70	68.70	66.50	63.95	61.25	747.20
Corporation - NORTHROP GRUMMAN CORP													
SPQ-9B	SURFACE SHIPS (USN)	2.10	0.00	2.10	4.20	6.30	8.40	12.60	25.20	31.50	21.00	12.60	123.90
SPS-67(V)	SURFACE SHIPS (VARIOUS)	0.25	1.25	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50
ASDE-3	AIRPORT SURFACE TRAFFIC CONTROL (FAA)	4.50	4.50	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.50
ARSR-4	EN-ROUTE AIR TRAFFIC CONTROL (FAA/USAF)	6.50	13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00
ASR-9	AIR TRAFFIC CONTROL (VARIOUS)	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TPS-63(V)/TPS-65	BATTLEFIELD SURVEILLANCE (VARIOUS)	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NORTHROP GRUMMAN CORP			18.75	21.35	4.20	6.30	8.40	12.60	25.20	31.50	21.00	12.60	161.90
Corporation - RACAL ELECTRONICS PLC													
ULQ-19(V) RACJAM	VHF TACTICAL COM JAMMER SYSTEM (VARIOUS)	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CUTLASS/CYGNUS	FAC-M (EGYPT)	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CUTLASS/CYGNUS	DD/FF/FFL/FAC-M (VARIOUS)	5.00	10.00	15.00	15.00	25.00	25.00	40.00	35.00	40.00	45.00	45.00	295.00
CUTLASS/CYGNUS	FAC-M (BRAZIL)	5.00	5.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
CUTLASS/SABRE	FFL/OPV (DENMARK)	5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
CUTLASS/SCORPION	FF (TURKEY)	4.00	4.00	8.00	8.00	4.00	4.00	8.00	8.00	8.00	0.00	0.00	52.00
OUTFIT UAA UPGRADE	DD/FF (UK)	2.50	0.00	5.00	10.00	10.00	10.00	10.00	10.00	5.00	5.00	5.00	70.00
OUTFIT UAF	TYPE 23 FF (UK)	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OUTFIT UAP	SSBN/SSN/SSK (UK)	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50
SEA LION	SSK (VARIOUS)	2.50	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
MSTAR	MAN-PORTABLE RADAR (UK)	0.05	0.00	1.35	1.35	1.35	1.35	0.00	0.00	0.00	0.00	0.00	5.40
MSTAR	MAN-PORTABLE RADAR (VARIOUS)	0.05	0.00	0.00	0.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	6.30
MANTA	AGOSTA SSK (SPAIN)	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MANTA	A-19 SSK (SWEDEN)	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50
MANTA	SSN/SSK (VARIOUS)	2.50	5.00	5.00	7.50	7.50	7.50	10.00	10.00	7.50	7.50	5.00	72.50
MANTA	SUBMARINE 2000 SSK (SWEDEN)	2.50	0.00	0.00	0.00	7.50	0.00	10.00	12.50	0.00	0.00	0.00	30.00
OUTFIT UAH/UAL	SSBN/SSN/SSK (UK)	2.50	0.00	2.50	2.50	2.50	2.50	2.50	0.00	0.00	0.00	0.00	12.50
OUTFIT UAT	TYPE 23 FF (UK)	2.50	0.00	7.50	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50
OUTFIT UAT	DD/FF (UK)	2.50	5.00	10.00	10.00	10.00	10.00	10.00	0.00	0.00	0.00	0.00	55.00
PHILAX	FAC (FINLAND)	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PHILAX	FAC/FFL/MCMV (SWEDEN)	0.10	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
PROTEAN	FF/FFL (SOUTH KOREA)	0.10	0.40	0.40	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00	1.60
SCEPTRE LENS	YSM-2000/YSB (SWEDEN)	2.50	5.00	5.00	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	30.00
SCEPTRE O	ANZAC FF (NEW ZEALAND)	1.50	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
SCEPTRE XL	ANZAC FF (AUSTRALIA)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	0.00	0.00	0.00	0.00	15.00
SCEPTRE XL	FF (VARIOUS)	2.50	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.00	0.00	80.00
RACAL ELECTRONICS PLC			61.10	74.95	77.25	91.65	78.75	108.90	86.40	71.40	58.40	55.90	764.70
Corporation - RAFAEL ARMAMENT DEVELOPMENT AUTHORITY													
BEAMTRAP (RAFAEL)	FAC (VARIOUS)	0.01	4.00	4.00	4.00	3.00	3.00	2.00	2.00	1.00	0.00	0.00	23.00
LRCR	FAC (VARIOUS)	0.01	1.50	1.00	1.00	0.50	0.50	0.50	0.00	0.00	0.00	0.00	5.00
SRCR	FAC (VARIOUS)	0.00	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.00	0.00	1.65
RAFAEL ARMAMENT DEVELOPMENT AUTHORITY			5.80	5.30	5.30	3.65	3.65	2.65	2.15	1.15	0.00	0.00	29.65
Corporation - RAYTHEON CO													
ATNAVICS	TACTICAL AIR TRAFFIC CONTROL (US ARMY)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIDEKICK	SURFACE SHIPS (USN)	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIDEKICK	SURFACE SHIPS (UNSPECIFIED)	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SLQ-32(V)	SURFACE SHIPS (USN/USCG)	5.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00
SLQ-32(V)	SURFACE SHIPS (FMS) (UNSPECIFIED)	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COSSOR ATC SYSTEMS	ATC RADARS (UNSPECIFIED)	0.75	2.25	1.50	1.50	1.50	0.00	0.00	0.00	0.00	0.00	0.00	6.75
SPS-49(V)	SURFACE SHIP (USN)	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SPS-49(V)	SURFACE SHIP (CANADA)	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SPS-49(V)	SURFACE SHIP (TAIWAN)	3.70	7.40	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.10
TDWR	ATC (FAA)	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TDWR	ATC (VARIOUS)	3.20	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.40
SPS-64(V)	SURFACE SHIPS (VARIOUS)	0.04	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
RAYTHEON CO			31.25	5.20	1.50	1.50	0.00	0.00	0.00	0.00	0.00	0.00	39.45

Figure 2
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - SIEMENS AG													
SAMPSON	CVHG/DD/FF (VARIOUS)	15.00	0.00	0.00	30.00	60.00	60.00	90.00	90.00	90.00	90.00	90.00	600.00
AR-327	LONG-RANGE 3D RADAR (VARIOUS)	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AWS-4/5	UPGRADES (VARIOUS)	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AWS-6	FF/FFL (DENMARK)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AWS-6	FAC (OMAN)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AWS-6 DOLPHIN	FF/FFL (VARIOUS)	2.00	0.00	4.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
TYPE 996	DD/AOR (UK)	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TYPE 996	LPH/FF (UK)	6.40	12.80	12.80	12.80	12.80	0.00	0.00	0.00	0.00	0.00	0.00	51.20
TYPE 996	EXPORT AWS-9 (VARIOUS)	6.40	19.20	19.20	25.60	19.20	12.80	19.20	12.80	19.20	19.20	12.80	179.20
WATCHMAN	ATC RADAR (VARIOUS)	2.50	2.50	5.00	5.00	5.00	5.00	7.50	7.50	7.50	7.50	7.50	60.00
SIEMENS AG			34.50	41.00	77.40	97.00	77.80	116.70	110.30	116.70	116.70	110.30	898.40
Corporation - SIPPICAN INC													
NULKA	NAVAL DECOYS (US NAVY)	0.10	50.00	75.00	30.00	20.00	15.00	7.50	0.00	0.00	0.00	0.00	197.50
NULKA	NAVAL DECOYS (VARIOUS)	0.10	0.00	0.00	0.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00	11.00
SIPPICAN INC			50.00	75.00	30.00	22.00	17.00	9.50	2.00	1.00	1.00	1.00	208.50
Corporation - TELSTRA													
JINDALEE	AIR DEFENSE (AUSTRALIA)	83.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TELSTRA			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporation - THOMSON-CSF													
JUPITER	FF (SAUDI ARABIA)	8.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
JUPITER	FF (TAIWAN)	8.00	16.00	16.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
DR-2000/4000	DD/FF/FFL/FAC-M (VARIOUS)	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DR-3000	DD/FF/FFL (VARIOUS)	3.00	45.00	42.00	30.00	27.00	30.00	36.00	42.00	48.00	51.00	51.00	402.00
ARABEL	CV/DD/FF (FRANCE)	6.50	6.50	13.00	13.00	13.00	6.50	6.50	0.00	0.00	0.00	0.00	58.50
ARABEL	GROUND-BASED RADAR (VARIOUS)	6.50	13.00	19.50	65.00	65.00	65.00	65.00	32.50	0.00	0.00	0.00	325.00
CASTOR IIB/C/J	FAC/FFL (VARIOUS)	1.00	3.00	4.00	3.00	3.00	2.00	2.00	0.00	0.00	0.00	0.00	17.00
CASTOR IIB/C/J	CV/DD/FF (FRANCE)	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
CASTOR IIB/C/J	FF (VARIOUS)	1.20	2.40	2.40	1.20	1.20	1.20	0.00	0.00	0.00	0.00	0.00	8.40
FLAIR TRS-2140	AIR SURVEILLANCE (VARIOUS)	4.50	13.50	22.50	31.50	27.00	22.50	36.00	40.50	22.50	13.50	0.00	229.50
GERFAUT	AIR DEFENSE (SWEDEN)	0.21	4.20	4.20	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.50
GERFAUT	AIR DEFENSE (TURKEY)	0.21	5.04	5.04	5.04	3.36	0.00	0.00	0.00	0.00	0.00	0.00	18.48
GRIFFON	AIR DEFENSE (TURKEY)	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRIFFON/GERFAUT	AIR DEFENSE (VARIOUS)	0.21	2.10	3.36	3.36	4.20	4.20	4.20	4.20	4.20	0.00	0.00	29.82
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (FRANCE)	11.00	22.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.00
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (TURKEY)	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
THOMSON-CSF 3D ADGE RADAR	AIR-DEFENSE (KUWAIT)	11.00	0.00	11.00	0.00	11.00	11.00	0.00	0.00	0.00	0.00	0.00	33.00
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (UNSPECIFIED)	11.00	33.00	0.00	22.00	0.00	33.00	0.00	22.00	0.00	33.00	0.00	143.00
THOMSON-CSF ATC SYSTEMS	ATC RADARS (UNSPECIFIED)	1.00	30.00	45.00	45.00	45.00	50.00	50.00	50.00	50.00	50.00	50.00	465.00
SIGNAAL APAR	DD (CANADA)	9.60	0.00	0.00	9.60	28.80	28.80	19.20	19.20	19.20	0.00	0.00	124.80
SIGNAAL APAR	DD (GERMANY)	9.60	0.00	9.60	19.20	9.60	0.00	19.20	19.20	19.20	19.20	19.20	134.40
SIGNAAL APAR	DD (NETHERLANDS)	9.60	0.00	9.60	9.60	0.00	9.60	9.60	0.00	0.00	0.00	0.00	38.40
SIGNAAL APAR	DD (SPAIN)	9.60	0.00	0.00	9.60	9.60	9.60	9.60	0.00	0.00	0.00	0.00	38.40
SIGNAAL APAR	DD (EXPORT)	9.60	0.00	0.00	0.00	0.00	9.60	9.60	19.20	38.40	38.40	28.80	144.00
SIGNAAL DA.08	ELLI FF (GREECE)	6.00	0.00	6.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
SIGNAAL DA.08	CVL/CL/FF (VARIOUS)	6.00	18.00	18.00	12.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	66.00
SIGNAAL DA.08	FF (MALAYSIA)	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL DA.08	DD (GERMANY)	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL DA.08	FF (PAKISTAN)	6.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
SIGNAAL LW.08	FF (AUSTRALIA)	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	0.00	0.00	0.00	48.00
SIGNAAL LW.08	FF (GERMANY)	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL LW.08	CVL/DD/FF (INDIA)	8.00	8.00	8.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00
SIGNAAL LW.08	DD/FF (NETHERLANDS)	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL LW.08	FF (NEW ZEALAND)	8.00	8.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00
SIGNAAL LW.08	CVL/CL/DD/FF (UNSPECIFIED)	8.00	32.00	16.00	32.00	16.00	32.00	16.00	8.00	8.00	0.00	0.00	160.00
SIGNAAL LW.08	FF (SOUTH KOREA)	6.00	6.00	6.00	12.00	12.00	12.00	12.00	12.00	12.00	0.00	0.00	84.00
SIGNAAL LW.08	FF (THAILAND)	6.00	0.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
SIGNAAL MW.08	FF (GREECE)	6.50	0.00	6.50	0.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00	13.00
SIGNAAL MW.08	FFL (OMAN)	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL MW.08	FF (SOUTH KOREA)	6.00	18.00	0.00	6.00	12.00	18.00	0.00	6.00	12.00	18.00	0.00	90.00
SIGNAAL MW.08	FF (TURKEY)	6.00	18.00	0.00	18.00	0.00	0.00	0.00	12.00	12.00	0.00	0.00	60.00
SIGNAAL SMART-L	DD (NETHERLANDS)	12.50	25.00	25.00	25.00	0.00	25.00	25.00	25.00	0.00	0.00	0.00	150.00
SIGNAAL SMART-L	DD (GERMANY)	12.50	25.00	25.00	25.00	25.00	0.00	25.00	25.00	0.00	0.00	0.00	150.00
SIGNAAL SMART-L	DD (SPAIN)	12.50	12.50	12.50	12.50	12.50	0.00	0.00	0.00	0.00	0.00	0.00	50.00
SIGNAAL SMART-L	DD (CANADA)	12.50	0.00	0.00	12.50	12.50	12.50	0.00	0.00	0.00	0.00	0.00	37.50
SIGNAAL SMART-S	FF/DD (GERMANY)	10.00	0.00	10.00	20.00	30.00	20.00	20.00	10.00	0.00	0.00	0.00	110.00
SIGNAAL SMART-S	FF (NETHERLANDS)	6.50	6.50	6.50	13.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00	32.50
SIGNAAL SMART-S	DD (SPAIN)	10.00	10.00	10.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
SIGNAAL SMART-S	DD (CANADA)	10.00	0.00	0.00	10.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	30.00
SIGNAAL SMART/MW.08	DD/FF/FFL (UNSPECIFIED)	8.50	51.00	68.00	68.00	68.00	85.00	85.00	68.00	68.00	68.00	51.00	680.00
SIGNAAL STIR	DD/FF (CANADA)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL STIR	DD/FF (GERMANY)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL STIR	FF (GREECE)	2.00	4.00	4.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
SIGNAAL STIR	DD/FF (NETHERLANDS)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL STIR	YAVUZ FF (TURKEY)	2.00	4.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
SIGNAAL STIR	FF/FFL (ARGENTINA)	2.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00

Figure 2
(continued)

Program	Application (Operator)	Unit Cost (MM)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total 97-06
Corporation - THOMSON-CSF (continued)													
SIGNAAL STIR	FF (SOUTH KOREA)	2.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	0.00	64.00
SIGNAAL STIR	DD/FF (TAIWAN)	2.00	2.00	2.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
SIGNAAL STIR	CVH/FF (THAILAND)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL STIR	FFL (OMAN)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL STIR	FAC-M (QATAR)	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIGNAAL STIR	DD/FF/FFL/FAC-M (VARIOUS)	2.00	16.00	20.00	20.00	16.00	16.00	16.00	16.00	16.00	0.00	0.00	136.00
SIGNAAL STIR	OPV (AUSTRALIA/MALAYSIA)	2.00	0.00	10.00	24.00	22.00	16.00	8.00	2.00	2.00	2.00	2.00	88.00
WM-20 FCS	WARSHIPS (VARIOUS)	7.00	0.00	21.00	14.00	21.00	21.00	14.00	14.00	0.00	0.00	0.00	105.00
WM-20 FCS	UPGRADES (SIGNAAL)	1.00	12.00	8.00	6.00	6.00	6.00	4.00	4.00	4.00	4.00	4.00	58.00
SMARTELLO	CNGF DD (UK)	12.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50	12.50	25.00	50.00
SMARTELLO	CNGF DD (FRANCE)	12.50	0.00	0.00	0.00	0.00	0.00	12.50	0.00	12.50	12.50	12.50	50.00
SMARTELLO	CNGF DD (ITALY)	12.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50	12.50	12.50	37.50
RASIT	BATTLEFIELD SURVEILLANCE (VARIOUS)	0.35	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
RB-12	MAN PORTABLE RADAR (FRANCE)	0.06	0.60	0.60	1.20	0.60	0.60	0.00	0.00	0.00	0.00	0.00	3.60
RB-12	MAN-PORTABLE RADAR (UNSPECIFIED)	0.06	0.00	0.48	0.48	0.72	0.72	0.48	0.48	0.48	0.24	0.24	4.32
THOMSON-CSF			510.24	532.98	662.08	583.08	573.82	520.88	459.28	381.48	334.84	256.24	4814.92
Corporation - WEGMANN/BUCK													
HOT DOG/SILVER DOG	FAC/MCMV/AD (GERMAN NAVY)	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WEGMANN/BUCK			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporation - WHITTAKER ELECTRONIC SYSTEMS													
VLQ-9/10	BATTLEFIELD PROTECTION (US ARMY)	0.06	0.00	1.44	2.40	3.60	7.20	6.00	4.50	2.40	1.44	1.44	30.42
WHITTAKER ELECTRONIC SYSTEMS			0.00	1.44	2.40	3.60	7.20	6.00	4.50	2.40	1.44	1.44	30.42
Corporation - Z-FACTOR													
L&S EW ANALYSIS	FORECAST ADJUSTMENT (N/A)	10.00	0.00	0.00	0.00	10.00	60.00	60.00	70.00	60.00	80.00	0.00	340.00
L&S RADAR ANALYSIS	FORECAST ADJUSTMENT (N/A)	10.00	0.00	0.00	0.00	410.00	400.00	370.00	1000.00	1000.00	900.00	900.00	4980.00
Z-FACTOR			0.00	0.00	0.00	420.00	460.00	430.00	1070.00	1060.00	980.00	900.00	5320.00
Printout Total -			1828.02	2078.62	2152.10	2394.08	2173.65	1971.21	2344.66	2119.16	1864.03	1624.33	20549.86

Figure 2

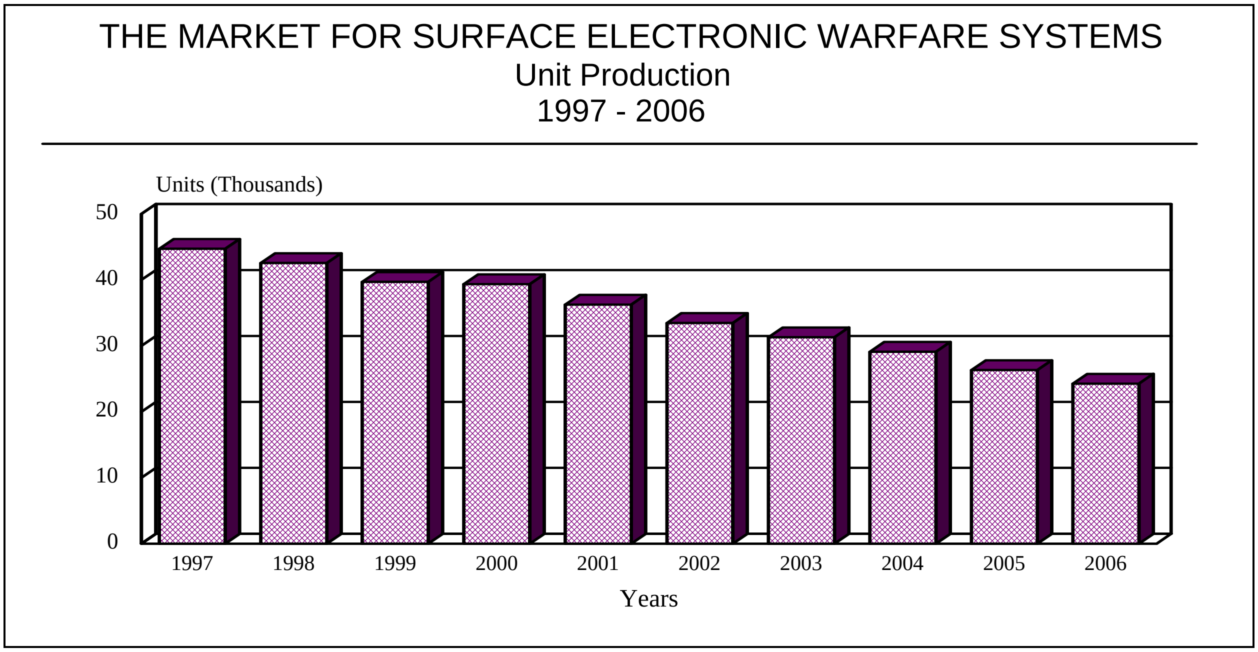

Figure 3

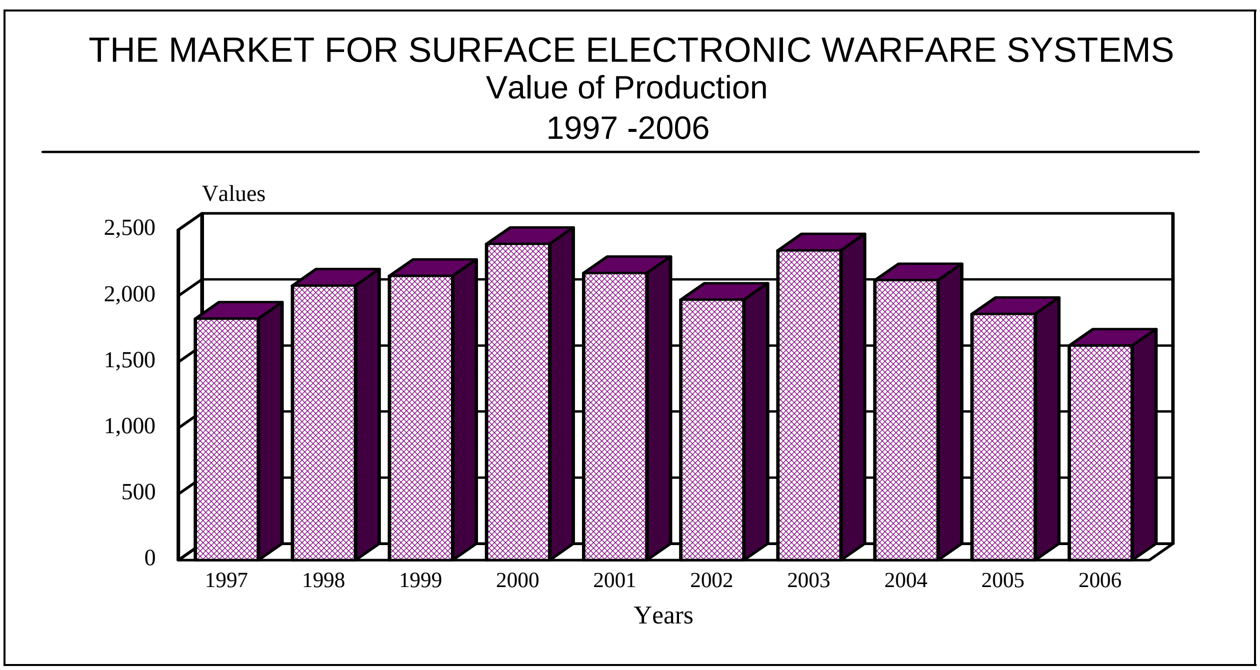

Figure 4

The Market for Surface Electronic Warfare System
Units of Production % Market Share by Company

Company	Total 97-01	% Mkt Share	Total 02-06	% Mkt Share	Total 97-06	% Mkt Share
AEL	27	0.01%	0	0.00%	27	0.01%
ALENIA-ELSAG	118	0.06%	36	0.02%	154	0.04%
ALLIEDSIGNAL AEROSPACE CO	3	0.00%	0	0.00%	3	0.00%
AWA INDUSTRIES	250	0.12%	60	0.04%	310	0.09%
BOEING CO	26	0.01%	19	0.01%	45	0.01%
CELSIUSTECH	2	0.00%	0	0.00%	2	0.00%
CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP	300	0.15%	125	0.09%	425	0.12%
CONTRACTOR TO BE SELECTED	22	0.01%	14	0.01%	36	0.01%
CONTRAVES	7	0.00%	2	0.00%	9	0.00%
CSEE	7	0.00%	0	0.00%	7	0.00%
DASSAULT ELECTRONIQUE	29	0.01%	12	0.01%	41	0.01%
ELETTRONICA SPA	18	0.01%	6	0.00%	24	0.01%
ERICSSON RADAR SYSTEMS AB	388	0.19%	193	0.13%	581	0.17%
ESCO CORP	110	0.05%	100	0.07%	210	0.06%
EURO-ART CONSORTIUM	38	0.02%	0	0.00%	38	0.01%
GEC PLC	1,114	0.55%	1,472	1.02%	2,586	0.75%
HUGHES AIRCRAFT CO	331	0.16%	36	0.02%	367	0.11%
INISEL	140	0.07%	0	0.00%	140	0.04%
IRVIN GREAT BRITAIN LTD	312	0.15%	376	0.26%	688	0.20%
IRWIN DESMAN LTD	50	0.02%	35	0.02%	85	0.02%
ITT CORP	75	0.04%	80	0.06%	155	0.04%
KELVIN HUGHES	75	0.04%	32	0.02%	107	0.03%
LOCKHEED MARTIN CORP	479	0.24%	229	0.16%	708	0.20%
ML AVIATION LTD	141	0.07%	90	0.06%	231	0.07%
MOTOROLA INC	91	0.04%	27	0.02%	118	0.03%
MULTI-CONTRACTORS	192,000	94.79%	139,000	96.21%	331,000	95.38%
NORTHROP GRUMMAN CORP	27	0.01%	49	0.03%	76	0.02%
RACAL ELECTRONICS PLC	305	0.15%	206	0.14%	511	0.15%
RAFAEL ARMAMENT DEVELOPMENT AUTHORITY	2,650	1.31%	700	0.48%	3,350	0.97%
RAYTHEON CO	65	0.03%	21	0.01%	86	0.02%
SIEMENS AG	46	0.02%	58	0.04%	104	0.03%
SIPPICAN INC	1,940	0.96%	145	0.10%	2,085	0.60%
THOMSON-CSF	1,045	0.52%	649	0.45%	1,694	0.49%
WHITTAKER ELECTRONIC SYSTEMS	244	0.12%	263	0.18%	507	0.15%
Z-FACTOR	88	0.04%	444	0.31%	532	0.15%
Total -	202,563	100.00%	144,479	100.00%	347,042	100.00%

Figure 5

The Market for Surface Electronic Warfare System
Value of Production % Market Share by Company

Company	Total 97-01	% Mkt Share	Total 02-06	% Mkt Share	Total 97-06	% Mkt Share
AEL	67.500	0.64%	0.000	0.00%	67.500	0.33%
ALENIA-ELSAG	527.500	4.96%	90.000	0.91%	617.500	3.00%
ALLIEDSIGNAL AEROSPACE CO	12.600	0.12%	0.000	0.00%	12.600	0.06%
AWA INDUSTRIES	25.000	0.24%	6.000	0.06%	31.000	0.15%
BOEING CO	98.000	0.92%	76.000	0.77%	174.000	0.85%
CELSIUSTECH	0.200	0.00%	0.000	0.00%	0.200	0.00%
CHINA NAT'L ELECTRONICS IMPORT & EXPORT CO	45.000	0.42%	18.750	0.19%	63.750	0.31%
CONTRACTOR TO BE SELECTED	220.000	2.07%	140.000	1.41%	360.000	1.75%
CONTRAVES	42.000	0.40%	12.000	0.12%	54.000	0.26%
CSEE	8.500	0.08%	0.000	0.00%	8.500	0.04%
DASSAULT ELECTRONIQUE	29.000	0.27%	12.000	0.12%	41.000	0.20%
ELETTRONICA SPA	114.500	1.08%	27.000	0.27%	141.500	0.69%
ERICSSON RADAR SYSTEMS AB	733.750	6.90%	403.750	4.07%	1137.500	5.54%
ESCO CORP	4.950	0.05%	4.500	0.05%	9.450	0.05%
EURO-ART CONSORTIUM	592.800	5.58%	0.000	0.00%	592.800	2.88%
GEC PLC	201.970	1.90%	284.650	2.87%	486.620	2.37%
HUGHES AIRCRAFT CO	582.639	5.48%	25.440	0.26%	608.079	2.96%
INISEL	6.300	0.06%	0.000	0.00%	6.300	0.03%
IRVIN GREAT BRITAIN LTD	31.200	0.29%	37.600	0.38%	68.800	0.33%
IRWIN DESMAN LTD	25.000	0.24%	17.500	0.18%	42.500	0.21%
ITT CORP	60.000	0.56%	64.000	0.64%	124.000	0.60%
KELVIN HUGHES	40.500	0.38%	16.000	0.16%	56.500	0.27%
LOCKHEED MARTIN CORP	853.425	8.03%	538.200	5.42%	1391.625	6.77%
ML AVIATION LTD	39.950	0.38%	18.450	0.19%	58.400	0.28%
MOTOROLA INC	1064.700	10.02%	315.900	3.18%	1380.600	6.72%
MULTI-CONTRACTORS	415.100	3.91%	332.100	3.35%	747.200	3.64%
NORTHROP GRUMMAN CORP	59.000	0.56%	102.900	1.04%	161.900	0.79%
RACAL ELECTRONICS PLC	383.700	3.61%	381.000	3.84%	764.700	3.72%
RAFAEL ARMAMENT DEVELOPMENT AUTHORITY	23.700	0.22%	5.950	0.06%	29.650	0.14%
RAYTHEON CO	39.450	0.37%	0.000	0.00%	39.450	0.19%
SIEMENS AG	327.700	3.08%	570.700	5.75%	898.400	4.37%
SIPPICAN INC	194.000	1.83%	14.500	0.15%	208.500	1.01%
THOMSON-CSF	2862.200	26.93%	1952.720	19.68%	4814.920	23.43%
WHITTAKER ELECTRONIC SYSTEMS	14.640	0.14%	15.780	0.16%	30.420	0.15%
Z-FACTOR	880.000	8.28%	4440.000	44.74%	5320.000	25.89%
Total -	10626.474	100.00%	9923.390	100.00%	20549.864	100.00%

Figure 6

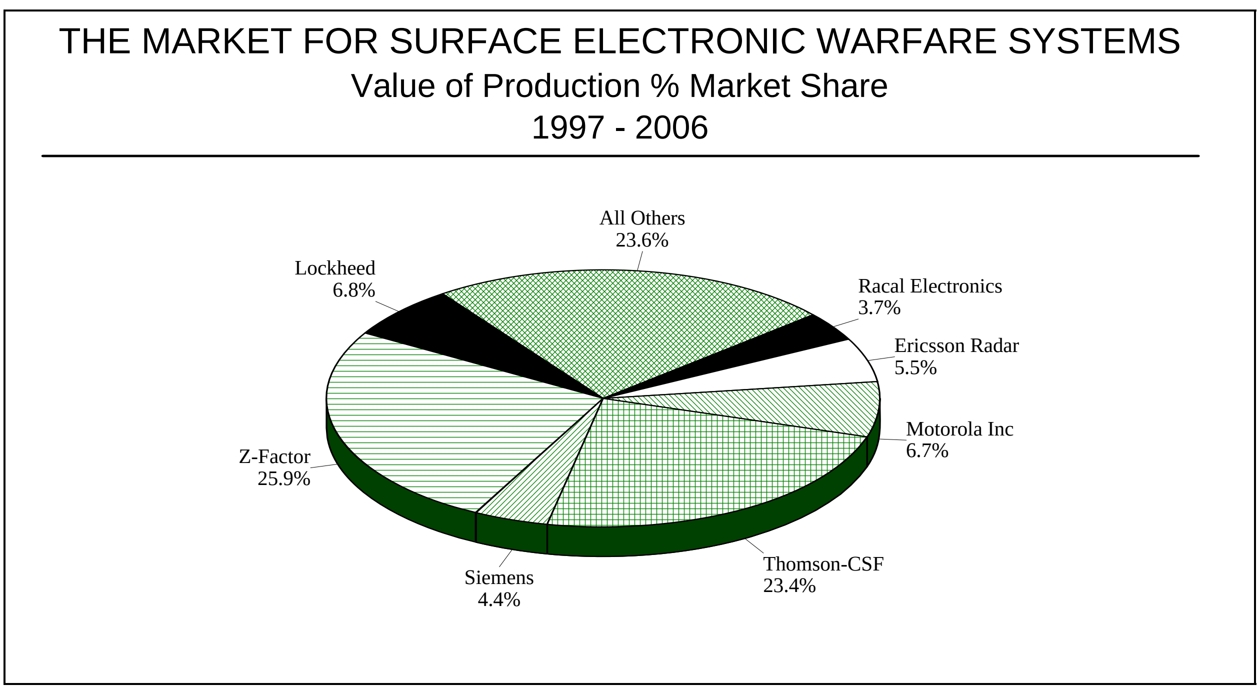

Figure 7

Conclusion

Near-Term Outlook. Looking at the market prospects offered by sea-based EW equipment, one should keep in mind that the manufacture and sales of such items are tied to shipbuilding and overhaul programs. The cycle time for a naval construction program often exceeds twenty years from initial design work to the first ship commissioning. Thus, factors now emphasizing the desirability of increased naval construction will not affect the naval EW market until the far term. Arguably, it continues to be more cost-effective to upgrade older ships, replacing or enhancing the electronic warfare fit. This is particularly the case with large numbers of ex-British, ex-US, and ex-Russian ships that are finding their way into the secondhand market. However, the limited number of ships means that those that remain are each of increased value, enhancing the attractiveness of comprehensive upgrades.

Advanced surface-skimming missiles have changed the electronic warfare needs of navies around the world. Existing defenses are not entirely effective against the sophisticated guidance systems of today's hypersonic or highly agile anti-ship missiles. Until a new generation of enhanced self-protection systems enter service, jamming offers the major significant defense against these weapons. As the missiles become more sophisticated, jamming them becomes more difficult.

These advanced missiles are widespread and entering the inventories of what used to be poorly equipped nations. Western navies face significant threats in future conflicts, even against "Third World" opponents. Active countermeasures are needed, and they must be able to cope with a wide variety of both "enemy" and "friendly" systems.

Many naval jamming systems are reaching the end of their serviceable lives, or cannot be modified to counter new threats. Within the forecast period, many will have to be replaced by a combination of highly sophisticated ESM/ECM systems; expendable, active offboard jammers; and cheap, relatively simple onboard systems. There is a critical need to integrate the new systems into the overall combat control environment of the ship. And the US Navy is beginning to search for ways to extend this integration throughout a battle group.

Although radars continue to be the prime sensor in both the naval and land-based environments, passive ESM and electro-optical sensors are full and equal contributors to situational awareness. The importance of passive ESM sensors for specialist missions, such as early warning and maritime or battlefield surveillance, is making the '90s the decade of the passive sensor.

The Persian Gulf War proved the value of battlefield electronic warfare. Coalition forces were successful in effectively exploiting and totally disabling the Iraqi command and control network. However, the reliance on airborne assets was a misplaced confidence. Getting intelligence to the front-line commander proved difficult during the Gulf War. There is a crucial need to provide the battlefield commander with an increasingly sophisticated EW capability, both intelligence gathering and offensive.

JSTARS' role in gathering and disseminating data in both the Persian Gulf War and the Bosnian peace-enforcement mission can hardly be overestimated. Having accumulated an impressive service record so early in its career (based on the use of prototype and initial-production systems), JSTARS is assured healthy sales order book, both in the US and internationally. Of concern in this analysis are the ground-based portions of system: the Ground Station Module (TSQ-168) and the Common Ground Station (TSQ-179). These are manufactured by Motorola and earn that company position number two in terms of surface-based EW value of production.

Tracked and wheeled armored vehicles represent both an increasingly lethal and expensive weapons inventory, and they warrant their own EW to increase survivability. The US and its allies are at various stages in fielding interim systems and developing advanced solutions to counter anti-armor munitions. Products that go into production will have to be cost- and operationally effective. Aircraft ECM systems can cost upwards of hundreds of thousands of dollars each. In contrast, the ECM system for a tank or an APC must be low-cost.

There are presently thousands of armored vehicles in world inventories, but only top-of-the-line vehicles and high-value systems will get an ECM capability in the beginning. Less expensive and capable systems will eventually come into the market to equip support vehicles, including large truck fleets.

The trend toward consolidation of the military electronics industry means fewer individual manufacturers, especially in the United States. The trend is broadly illustrated by defense giant Lockheed Martin, with it consolidation of Lockheed and Martin Marietta followed by its acquisition of Loral. For this analysis Martin Marietta placed second in value of production over the ten-year forecast period (although in the overall EW market, airborne as well as surface-based, Lockheed Martin ranks as number one). The company's highest yielding product is its ship chaff and flare launcher, the Super Rapid Blooming Offboard Countermeasures (SRBOC). SRBOC is compatible with

NATO's Sea Gnat Mk.214 and Mk.216 rocket decoys. It is also used to launch Super Chaffstar, Super Hiram III and Super Hiram IV infrared cartridges; the Super Gemini Hybrid rf/IR cartridge; and the Super LOROC (Long-Range Offboard Chaff) rocket-launched decoy. The majority of future US production is to support construction of the DDG-51 Arleigh Burke-class destroyers and LPD-17 amphibious ships.

Lockheed Martin is also the manufacturer of CHALS-X, a new precision direction-finding system which is part of the US Army's Intelligence and Electronic Warfare Common Sensor (IEWCS). It is to be installed on the Ground Based Common Sensor-Light/Heavy (GBCS-L/H). It is planned that IEWCS will increase commonality in the overall airborne and battlefield EW effort.

Teaming of traditional competitors to share expertise and costs continues to spread as a popular, cost-effective way to secure new contracts. For example, Sanders, a Lockheed Martin Company, is teamed with AEL to build the TACJAM-A/MSR-3, which is the ground-based portion of the US Army's IEWCS.

In the surface EW market, bringing an international partner onto US teams will help the industry access international technology and make inroads into the international market. This may well be the case for the US Navy's AIEWS program. While the top contenders are US-based Hughes and Lockheed, it is likely that these companies will bring European partners onto their teams.

Much of the defense-industry shrinkage has taken place. Many of companies involved in US programs through the 1980s have either moved out of this market segment to concentrate on other defense niches or the commercial market, given up defense, or just given up. Many of the major companies are merging and teaming for survival. Except for a developing requirement for large numbers of ground vehicle self-protection systems, there is little likelihood that the Department of Defense will significantly expand future market opportunities beyond the major programs already identified. It will, however, provide opportunities for most of the existing electronic warfare companies, both from the surface and airborne market arena.

Western Europe is the biggest EW market outside of the US. In this analysis of surface EW systems, the UK's Thomson-CSF ranked number one in terms of value of production over the next ten years. It has reached this position largely on the strength of sales of its new DR-3000 system and the related DBI-3000 integrated ESM/ECM equipment. It has also gain significant market strength through its acquisition of Signall. Acquiring Signall effectively gave Thomson-CSF access to the same basic technology that is used by Thorn EMI (which has been acquired by Racal).

The Western European market is divided among a large number of British, French, Italian, German, and Swedish electronics houses that attempt to exploit their perceived "unique in-house expertise" to develop equipment as private ventures. Once available, these are offered on the export market and used as a design basis from which domestic requirements can be met. The result of this situation is a chaotic and highly competitive environment that favors rapid technology development and quick exploitation of successful R&D efforts. This has resulted in many companies competing for a limited market, prompting duplicated R&D, testing, and production efforts.

Far-Term Outlook. After the turn of the century, an entirely new generation of naval ESM systems will be entering widespread service, offering full target detection and OTHT capabilities with accuracies comparable to other sensors. Ships equipped with these systems will have a significant tactical advantage over opponents relying on active sensors for target acquisition and weapons guidance.

A key program in this area will be the US Navy's AIEWS project, which is to develop a follow-on to the current SLQ-32 suite common throughout the US surface fleet. This program is now part of a larger program to integrate sensor, EW, and weapons systems across a battle group. Already common within the Royal Navy and most European fleets, the inclusion of EW data with the command and control systems will result in significant US Navy enhancements in data fusion flexible configuration. The sheer scale of the AIEWS program makes it of vital importance to the EW industry as a whole.

Looking ahead to the far term, radar detectability and the need to transmit a radio frequency signal in order to get a return must be addressed. The modern battlefield on land and sea is a dangerous place for any kind of emitter, since EW equipment is constantly being improved to enhance detection, jamming, and targeting of these sensors. There is an ongoing effort to improve capabilities of both sectors, but the danger from anti-radiation missiles and other countermeasures is increasing, not decreasing.

The development of FMCW radars has temporarily swung the balance of capability back from the passive ESM system to an active radar; but this effect is likely to be short-lived. ESM research teams are actively studying the FMCW problem and developing ways to detect such systems. Radars have a future on the battlefield of the next century, but as one part of an overall sensor network that uses high-level data fusion techniques to establish an overall picture of the area of conflict.

The naval EW market in the distant future will continue to reflect the requirements placed upon all warships - the need to achieve sea control (guaranteeing that friendly ships stay afloat) and sea denial (ensuring that hostile ships do not). In pursuit of these tasks, warships must continue to go in harm's way. It is not sufficient for emphasis to be placed on ensuring that a warship survives - the purpose of its existence is to wreak havoc on the enemy.

In EW terms, this means that ships will place greater emphasis on ESM sets and other modes of passive detection. By implication, the requirements of such equipment will become a significant design driver for the ship's superstructure, and the ESM set may well displace the radar from the optimum mast-head surveillance position. EW systems, electro-optical sensors and radars will more closely linked with the ship's integrated combat systems and associated with other sensors to maximize situational awareness.

By the end of the decade, ground vehicle protection equipment production will have become a major market opportunity because of the numbers of vehicles involved. This is a developing arena that will provide business opportunities for the defense industry around the world. Like every other EW development, protective systems will prompt the development of new offensive systems, which will in turn call for improved protection. Since this is charting relatively unexplored territory, the opportunities are going to be interesting.

Like all aspects of defense budgets around the world, the need to reduce expenditures will impact the surface EW market. The nature of the mission of these sensors will reduce the effect of much of the downturn. Although often seen as a defensive measure, EW technologies can be both defensive and offensive. Given the fact that many programs to upgrade complete systems are underway, and given the need for many smaller nations to provide themselves with a defensive capability, the land and naval EW market will continue to be healthier than many weapons-oriented programs.

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IF DATA DISKS

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