Analysis 2 - The Market for Surface Radar Systems - Archived 11/2001

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The Market for Surface Radar Systems

Executive Summary

This analysis projects a total world radar market valued at US$10.401 billion between 2000 and 2009. The value of this market is US$6.915 billion between 2000-2004 and US$3.486 billion between 2005 and 2009. The top two companies control 53.19 percent of the market through the decade. The other three companies in the top five control a combined 22.62 percent of the market. A total of 25,849 units are expected to be produced during the forecast period.

Four of the top five companies remained the same, although there was some reshuffling of rank after Lockheed Martin moved out of the vanguard and the Euro-Art Consortium stepped in. Production for Lockheed's major sea-based radar programs end in the latter half of the period when the construction of the ship classes is complete. The EURO-ART Consortium moved into the top five because of its high-cost, multinational counter-battery radar production taking place in the first part of the forecast period. Examining the market in detail through the period reveals variation in the standings from year to year; but the power and size of the players are relatively unchanged overall.

The United States has essentially completed its defense industry consolidation relative to the surface radar market. In Europe, BAE Systems is combining major players, and next year GEC plc will be covered as part of that giant organization. The impact of the trans-European EADS (European Aeronautic Defense and Space Co) is yet to be determined, although its initial direct impact on the surface radar market structure will probably be limited.

Future battlefield radars will have to be able to detect and track stealthy targets which may be using advanced electronic countermeasures; discriminate between and track the different aircraft in a mixed raid; and be integrated with other sensors for air defense cueing. They will be required to provide enhanced high- and low-altitude coverage, multifunctional abilities and faster response times.

Radar design efforts are reducing antenna sidelobe emissions, making phased array improvements and capitalizing on new, powerful processors. Advanced data fusion algorithms, artificial intelligence, and improved components are going to be fielded in existing systems. Upgrades rather than new developments will remain the trend in the near-term market.

Increasing the mobility of long-range surveillance radars is a major requirement, as it decreases their vulnerability and makes it possible for them to keep up with the fast-moving force of the future.

Planners have been rethinking defense procurement. Some systems are no longer affordable, others have taken on new importance, and strategic warning equipment once thought critical has been relegated to a secondary role in the overall defense scheme. As new missions are defined, the characteristics of existing systems are modified to preserve the viability of the equipment, allowing it to serve as an interim system while new equipment is designed or where the full level of capability required is unaffordable. The US National Missile Defense program requires that a new radar be built in Alaska and several existing strategic sensors be upgraded.

Regional instability will be the cause of most future conflicts, while UN peacemaking/peacekeeping missions will be typical of tomorrow's military action. AWACS and JSTARS have proven capable of providing radar coverage of the battlefield and military planners have confidence in the abilities of these systems. Tactical plans call for the application of the airborne sensors in place of ground radars as the prime command and control resources.

Although air defense and air traffic control radars make up the major ground radar market, there are many applications for radars in weapon-locating and battlefield surveillance. Future conflicts will require the rapid deployment of equipment to the battlefield, and high-mobility forces make fast-moving defense systems essential. The one-vehicle unit, where target acquisition radars, fire-control radars, and missiles are mounted on a single chassis, is a must.

There is a distinct difference in the character of the projected markets for land-based systems compared to that of sea-based radars. Sea-based programs are tied to shipbuilding and overhaul programs which are clearly defined years in advance and represent a long-term commitment. Naval shipbuilding programs have a very long initiation-to-completion cycle, with warship building times ranging from three to seven years and design periods sometimes taking twice that. Thus, the market for systems used by the naval sector is slow to respond to changing environments. The swing to investment in naval capability is worldwide; the long

cycle time means that the effects on the radar sector will not be seen until the far term.

Land-based radars respond to changing service needs and funding patterns. Once a system is identified as being needed by a service, it can be acquired as quickly as funding and production capacity permit. This is natural, since a radar system enhances the likelihood of mission success; it is only logical to bring all service units to the highest level of capability and preparedness as rapidly as possible.

Projected outyear production figures do not cover new programs, currently unknown, that will be coming into play and generating production in addition to that represented in the data. Actual production within the evolving market will not drop off in the outyears as much as it appears to. As a result of reader input, this analysis covers only established programs that have entered production or are scheduled to do so within the forecast period. As important new surface radar programs take shape and enter production, they will be included in the analysis.

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Introduction

This market analysis for surface (land- and sea-based) radar systems projects a 10-year overview of the radar sub-segment of the land- and sea-based electronics market. Such a perspective would be difficult to obtain from reading each report individually.

The radar systems covered represent a broad segment of the industry with a variety of applications and missions. Industry interest should be in both the systems themselves as well as in market opportunities for the many high-value components they contain and upgrades to existing equipment. The radar systems covered in the analysis are representative of the surface and naval radar market.

This analysis is not an exhaustive survey of the entire radar market. A combination of technology evolution and an unpredictable world political environment during the ten years addressed make it probable that new radar programs and development of major variants of existing systems will be initiated to counter newly emerging threats. These radar programs will be introduced and added to the present coverage as they become significant contributors to the market segment.

International events are having a major impact on the overall market. The signing of arms limitation treaties, a war in the Persian Gulf, regional conflicts, and events in Bosnia have caused a rethinking of national security procurement. Some systems are no longer affordable, and others are taking on new importance as new threats are defined and existing systems are modified to preserve their viability or create an interim capability while new equipment is designed. In some cases, this is a "least-worst" solution where the full level of capability desired is unaffordable.

This analysis attempts to evaluate how various influences will impact the surface radar market through the decade. The goal is to provide a comprehensive and knowledgeable frame of reference for business decisions.

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Trends

Technology and Applications. Radars are now part of an overall data-fusion scheme that exploits major developments in infrared and electro-optical sensor technology. Because of this data fusion, sensor systems no longer rely on radar alone, and thus the network is less vulnerable to countermeasures. Data fusion technology also complicates the masking and decoy problem for an aggressor.

New-generation radars will have the following characteristics:

- The ability to detect stealthy targets which may also be using advanced electronic countermeasures
- The ability to discriminate between and track the different aircraft in a mixed raid
- Enhanced high- and low-altitude coverage
- Increased multifunctional abilities
- Integration with other radars and sensors for applications, such as air defense cueing
- Use of advanced processing techniques
- Faster response times
- Increasing automation of many functions

A further requirement will be more mobile long-range surveillance radars to decrease their vulnerability.

Today's radars depend on advanced signal processing to get much more precise target data. Reliability improvements make operations from more remote, less accessible outposts possible. Maintenance personnel require less frequent access to the radar. Early warning and battlefield defense networks can be extended and enhanced, and moved further forward into more remote locations. Systems can be installed to fill gaps where coverage is below par. The sensor can be positioned based on visibility and coverage while positioning of the operations center is based on operational practicality and physical security.

Many nations establishing air defense systems do not have the required technical specialists needed to maintain the equipment. The military has to compete with the civilian sector for the services of skilled personnel, a civilian sector that usually offers higher wages and better working conditions. Increasing reliability reduces the demands on these scarce human resources, while remote operation enables the support facilities to be centralized and deployed on an as- and where-needed basis rather than keeping them permanently on site.

Vulnerability Considerations. A radar must emit radio frequency energy to operate, leaving a battlefield or naval radar vulnerable to detection and location by electronic warfare systems that in turn generate jamming or decoy signals. The emitted signals can also provide targeting data to anti-radiation missiles (ARMs). Methods of reducing a radar's emission signature, and thus its vulnerability, are always being sought. Radars, like aircraft, are being made stealthy. The energy emitted by antenna sidelobes can be reduced with antenna design and the use of electronically steerable, phased-array radars. Developing low-signature antennas has been a major effort, as has research and development in reducing the ability of sophisticated electronic and destructive radar suppression systems to locate and target a network's sensors. These competing efforts will continue and intensify.

Processing technology advances make it possible to track a target with fewer pulse returns. When coupled with infrared (IR) and electro-optical (EO) sensor fusion systems, tracking can be accomplished with less radio frequency (RF) energy being emitted.

Low-cost, more effective decoys are of major interest, and variable power techniques are being perfected, reducing the radiation of more energy than needed to track a target. Control and steering techniques for phased arrays make selective radiation by radars possible. This reduces emissions in non-target directions. The United States has fielded the TLQ-32(V) anti-radiation missile (ARM) Decoy system for its TPS-75(V) tactical radar. Application of this or similar techniques is being considered for other systems.

Military Planning Factors. Battlefield and naval radars are critical to the survival of combat forces and ships. The likelihood that hostilities can and will break out anywhere on the globe is causing a reconsideration of defense priorities and sensor system requirements. Smaller armies have a demonstrated ability to use advanced sensors and use them creatively against sophisticated forces.

The Persian Gulf War and other contingency operations proved that airborne radars, particularly AWACS and JSTARS, can provide superb radar coverage of a battlefield. Upgrades to these systems are overcoming the operational deficiencies found during these operations and expanding their operational capabilities. Military planners have become enthralled with the systems and their advantage of mobility. Major upgrades are planned for both systems, including an increase in the power of their processors by several orders of magnitude.

Tactical plans use these airborne systems in place of ground radars as the main sensors, so some aspects of the surface radar market are underappreciated. But planners are reconsidering the value of multiple sensors and looking for new and novel ways to use UAVs as adjunct sensors for JSTARS. New synthetic aperture radars which have been developed for the Global Hawk and Pioneer UAVs are proving quite capable and the development of datalink/data-fusion capabilities has gone from technological curiosity to planned capability.

Future conflicts may require rapid deployment of equipment to the battlefield, and high-mobility forces make fast-moving defense systems essential. Future Coalition forces might be faced with "Hot LZs" and have to fight their way into their beachheads and landing strips. The one-vehicle unit, where target acquisition radars, fire-control radars, and missiles are mounted on a single chassis, is needed. Downsizing is made easier by component advances and software improvement.

Defense against sea-skimming missiles will have to be based on missile systems such as Evolved Sea Sparrow and Seawolf, boosting the market for both target acquisition and fire-control radars. Missiles that have speeds in the Mach 2.5 to Mach 3.5 range are virtually non-interceptable by gun-based CIWS. If they are to be intercepted by point defense missiles, over-the-horizon detection is required. One concept is a radar specifically designed to use surface ducting to obtain over-the-horizon fire-control solutions. Italy introduced a radar of this type that can detect inbound sea-skimming missiles at ranges exceeding 70 kilometers, according to Italian sources. US designers have been working in this area also.

The US Navy Cooperative Engagement Capability is another approach, linking a fleet's ships and aircraft to provide this over-the-horizon detection and engagement capability. CEC has been successfully tested at sea, and is being fielded with the Fleet. This data exchange/ data-fusion system forms an effective airborne/surface radar team for ship and fleet protection. Efforts are being made to overcome the problems that have arisen with the exceedingly complex software needed to run such a system.

The collapse of Soviet power threw the former members of the Warsaw Pact back on their own resources. Much defense infrastructure, including both civil and military air traffic control, was dismantled and returned to Russia (or was just plain falling apart). These nations need to bring both their air defense and air traffic control facilities up to a reasonable (and safe) standard. In some cases, a complete replacement is what is needed. Economic factors make it fiscally wise to establish systems that can be used for both early warning and air traffic control.

This came as nations were feeling the pinch of defense spending and faced the need to find savings. Investing in air traffic control (ATC) instead of military systems means that the increasingly international air traffic system could begin to use the nation's air space. This produces overflight fees, a double incentive to give ATC improvements attention. Many such efforts are under way.

Application Considerations. While analysts tend to separate radars according to land and sea applications, the distinction between these blurs with respect to processing, components and antenna technology. Still, enough important differences exist between the two environments, and therefore between their market segments, to warrant separate attention. Some manufacturers make both ground and naval systems and usually use much of the same technology in both. There is R&D cross-pollination as well. Even where this approach is adopted, the impact of the different environments causes the systems to evolve in different directions with steady reductions in commonality.

Land-Based Radar

Air Defense. Defending a nation's airspace is a universal military imperative. Radars continue to be the main sensors used in an air defense network, with three-dimensional systems becoming the norm for most users. Solid-state systems which combine physically rotating antennas with phased-array scanning are commonplace.

The ability to detect incoming aircraft at long range and track intruders through heavy ground clutter and intense countermeasures is the most important task of these systems. The outputs are processed with specialized computer systems and distributed to command and control networks for real-time information management by an integrated defense system. Advances in digital processing and network architecture created upgrade opportunities and are receiving resources. The emphasis continues to be on data processing, distribution and fusion as well as improved command and control centers that make best use of the radar-supplied data.

Mobility is important. An air defense radar mounted on an all-terrain vehicle, rather than a trailer, to enhance mobility is standard. Technology insertion is making it possible to achieve improved performance with smaller and lighter components, making it easier to design mobility into new systems or upgrade old but proven hardware.

The fundamental nature of radars in integrated air defense systems is being reconsidered. A highly centralized concept of integrated air defense systems is particularly vulnerable to systematic degradation. Now, the trend is toward a multilayered defense with decoys and missiles or guns to protect the prime radar network. The affordability question centers on how deep a defense is possible (and affordable), and how many assets can be devoted to protecting the sensor. As the depth and complexity of the system grows, so do the problems of designing software to run it, as increasing system complexity escalates vulnerability to attack.

A partial solution is the establishment of extensive cross-networking within the system, where multiple anti-aircraft systems are linked to each radar and each radar is cross-linked to numerous anti-aircraft systems. Each radar is provided with enough integral C^3I capability to conduct its own localized IADS operation until contact with higher echelons can be restored. The Swedish Giraffe radar family adopted this approach with integral C^3I facilities for land use and integrated warship command control in the naval equivalents.

But a high-tech solution is not always the answer. The F-117 downed by the Serbs in Kosovo was the victim of a cleverly designed system of visual observation. The airplane was watched since takeoff, and accurate estimation of its flight time and flight path gave the Serbs a good indication of when the *Night Hawk* would reach different points. Gunners were alerted and would attempt the shoot-down once the airplane was spotted visually or with radar. The stealth fighter was hit after making its bombing attack, the point at which the explosion of a 2,000 pound bomb makes stealth a somewhat moot point.

Over-the-Horizon and Strategic Early Warning. New methods are being explored to enhance the detection and tracking capability of radars. Most systems are range-limited to the radar horizon (slightly beyond the optical horizon), which limits their detection of low-flying targets. There has been significant effort by the United States, Britain, Australia, France, the People's Republic of China, and Russia to develop and field OTH systems. One radar technique receiving attention is the over-the-horizon (OTH) radar.

Two basic OTH radar types are the OTH-B and the surface-wave OTH. The Over-the-Horizon Backscatter (OTH-B) relies on bouncing radio waves off the ionosphere to extend radar range, on the order of thousands of kilometers. The limitation of OTH-B performance comes from a characteristic close-in dead zone where OTH-B will not work because some radio waves pass through the ionosphere and out into space rather than illuminate the surveillance area.

OTH-B's potential is limited both by its sensitivity to atmospheric conditions and by low resolution at long ranges. Several OTH-B systems were fielded. Significant efforts have been made to upgrade and enhance the processing capabilities of the radars, especially against low-altitude small targets such as cruise missiles.

US Navy plans to deploy a relocatable ROTHR were overcome by events. Originally intended to be a key naval tactical wide-area surveillance radar for over-the-horizon early warning of approaching naval and airborne threats, the ROTHR was developed as part of the US Navy's effort to support the "outer air battle" concept. The growing emphasis on littoral warfare made this irrelevant. The single system has been relegated to anti-drug duty in the Caribbean, and continues to be successful in this.

The sensors' low-altitude, small-target capability could be used to detect and track drug smuggling aircraft and boats in the Gulf of Mexico, Atlantic Ocean, and Caribbean Sea. There was an active effort to enhance the processing of both the Air Force OTH-B and Naval ROTHR. Both systems have been responsible for successful drug interdiction missions, and the Department of Defense earmarked some of its drug interdiction budget for studying increased application of these radars to anti-narcotics efforts; Congress rejected DoD plans to build a Central OTH-B Radar as an anti-narcotics sensor.

Budget cutbacks and a re-ordering of priorities in the aftermath of the Cold War then caused the USAF to decide that it could no longer afford to continue operating the East Coast OTH-B radar even on a limited schedule. So the Air Force put that radar in "warm storage." That was preferred to a complete closure of the OTH-B radars since that would expose the service to an estimated cost of $420 million per year for at least two years for environmental restoration of the sites.

Surface Adhesion Radars. It is possible to design an OTH radar that uses the ground (actually sea) wave instead of the sky (ionosphere-reflected) wave employed by more conventional OTH types. The basic idea is not new: early Second World War radars, which transmitted at relatively low frequencies, were credited with both ground- and sky-wave ranges. Similarly, wartime shipboard HF/DF sets generally detected the ground waves of U-boats transmitting beyond the horizon. The great barrier to using this physics for radar purposes was the long wavelength used by a system with a worthwhile range, hence the sheer size of the antenna required. That ceased to be a problem when electronic switching (for beam-forming) became inexpensive and reliable.

A vertically polarized HF signal will follow a conducting surface path, extending between the surface and the ionosphere, and can detect icebergs as gaps in the conducting sea surface. This principle can be used both for very-long-range detection over the sea (from a large land site) and for shorter-range detection by a ship. Because the signal fills the space between the sea and the ionosphere, the radar can detect aircraft such as airliners at 60,000 feet, and even low-flying missiles.

Range depends on the frequency chosen, and the choice in turn depends in part on the available base length for reception. At 2 MHz, a typical range is 500 nm; at 10 MHz, this figure drops to about 100 nm. The lower the frequency, the more susceptible the radar is to the movement of the ionosphere; and the higher the frequency, the greater the attenuation of the signal. The appropriate balance varies with the application. Since the returning signals are weak, the bulk of the effort has gone into a combination of signal coding and signal processing.

Some years ago, Marconi, working with ARE, put receiving loops over the side of a frigate, using the usual vertical wire antennas to transmit signals. In effect, the entire length of the ship became the antenna aperture. This arrangement achieved better than three times the usual microwave range, albeit with less precision. A coastal site could be spread out over a larger area, and thus operate at a lower frequency. Marconi has been operating a land site since 1980, its transmitter derived from the company's H1141 10 kW unit. The prototype demonstrated an accuracy of 2 kilometers and 3 degrees, and it detected aircraft flying at altitudes of 990-40,000 feet. On this basis, Marconi saw the HF radar as a possible and much less expensive substitute for AEW radars.

A nearly identical system was produced by a Russian organization, Niidar, which is promoting the Irida HF over-the-horizon surface-wave (OTH-SW) radar as a coastal surveillance aid. Irida is a relocatable bistatic system which uses separate transmitting and receiving complexes located 500 to 1,500 meters apart, with the principal hardware elements being housed in five standard containers. Two prototype installations, one on the Black Sea and the other at Nakhodka on the Sea of Japan, completed three years of trials.

The transmitter complex has a maximum pulse power output of 64 kW (up to 16 kW average) in the 7-15 MHz frequency range, and covers 90 degrees in azimuth. Irida can detect surface targets at 280-300 kilometers, depending on sea-surface conditions and the size of the vessel; minimum range is 15-20 kilometers. The radar can also monitor the movements of low-flying aircraft at extended ranges, tracking up to 100 targets simultaneously with bearing and range accuracies of 3-5 degrees and 3-4 kilometers, respectively.

The transmitter consists of four 4 kW (average) power amplifiers, an exciter, and antenna commutation switch. The associated antenna, set up within 50 meters of the waterline, is described as having eight "symmetric vertical vibrators" placed in two bars parallel to a wire reflector. The receive array comprises 16 active loop antennas, connected to 16 main and two auxiliary receivers under the control of a digital beamformer. The signal processors have a combined throughput of approximately 200 MOPS.

Irida may turn out to be significant. In its coastal defense form, it provides non-maritime nations with the ability to detect naval targets far over the radar horizon. Although the position provided by the radar will not be very accurate, a missile with an active radar system can obtain an accurate-enough location on the target. P-80 anti-ship missile has an ISAR homing system that can transmit a radar picture of the proposed target back to the launch point for verification or instructions to seek a more lucrative target.

A Royal Navy program tested a shipboard OTH radar system onboard the Royal Fleet Auxiliary RFA *Grey Rover*. Ranges as great as 100 kilometers were achieved by coupling special signal processors to the ship's high-frequency radio system. HF signals commonly propagate well beyond the horizon, and there is always some backscatter. The British developed a means of reliably setting up interference patterns between the outgoing and backscattered waves. This interference indicates a probable target. The tests showed that no single ship is large enough to provide sufficiently accurate beams for much more than basic warning. The British are conducting experiments of a bistatic mode in which reception and transmission would be onboard separate ships.

Since 1990, the US Navy has been evaluating High Frequency Surface Wave Radar (HFSWR) prototypes as an enhancement to its anti-ship protection. The 15 to 25 MHz sensors demonstrated some counter-stealth capability in addition to extending the detection range of threat targets. Sea trials were scheduled to begin in 1997; if successful, full-scale engineering development could start immediately. Production is planned for the self-defense suites of CG-47, DDG-51, and LSD-41 class ships.

Long-wavelength radar is attractive because it is unlikely that stealth technology can be made effective at such wavelengths. It is not clear that OTH radar wavelengths are needed, although some years ago Australian scientists reportedly demonstrated that the Jindalee OTH radar could detect incoming stealthy aircraft with high probability. It is possible that the longer (but still quite conventional) wavelengths from a system that can be practicably installed on the hull of a warship would suffice.

Ballistic Missile Early Warning. There is an effort to upgrade current systems to maintain the capability based on new technology as well as maintainability and reliability enhancements. Most of the work will focus on submarine-launched ballistic missile (SLBM) detection, although the sensors will have to receive additional enhancements if they are to become part of the ongoing and controversial National Missile Defense program. A new radar will be built at Shemya, Alaska; but the existing missile detection net will have to adapt to the NMD plan. At the present time, this area is marked by flexibility as technical challenges and political considerations collide.

Bistatic Radar. In a re-manifestation of the original 1930s radar technology, interest in bistatic radars is increasing. These radars have the receiver and transmitter located some distance apart. This configuration is the possibility of enhancing coverage of targets which exhibit tangential movement, and therefore a Doppler signal interference component.

A bistatic radar typically uses one transmitter and multiple receivers located in a different area. An array configuration can be set up to avoid Doppler blind spots. Other benefits include enhanced protection from directional jamming, electronic intelligence, and anti-radiation missiles. Also, some indications are that bistatic techniques can result in enhanced radar cross-section detection, thus negating some of the value of stealth aircraft technology.

In a further development of the concept, there is ongoing research into multistatic systems, which are basically bistatic systems using several transmitters. The resulting redundancy is valuable in that during illumination, one can use "blinking" techniques to foil ARMs and still maintain the basic coverage.

A different slant on bistatic sensors is being investigated in the Silent Sentinal™ program which uses radio frequency reflections of signals from commercial TV and radio stations as the system transmitters. Eliminating the need for special transmitters reduces the threat faced by a warning network.

Passive Phased Arrays. Passive phased-array antenna technology is mature and an accepted part of the radar technology base. Phased-array antennas are increasingly common on the battlefield and for naval radars. While phased-array antenna radars are capable and popular, cost and complexity are considerations in large ground-based radars applications. One major problem is that three or four "faces" are needed for complete 360º coverage. Another difficulty is finding an efficient way to combine missile guidance capabilities into a system without degrading other functions at the same time. The frequency difference is an engineering hurdle, but increases in processing capabilities and advanced software algorithms are overcoming some limitations.

The large number of modules that make up the face of the radar increases the cost of individual systems and of the processing needed for beam forming. Weight is a limiting factor for naval applications. Phased-array systems exhibit a "fail-soft" characteristic where the failure of individual transmit/receive modules has little effect on overall system performance. Some experts, however, feel that this reliability argument is overrated, that many high power tubes can be just as, if not more, reliable.

Module production cost has gone down significantly, lowering radar cost while improving the power of affordable processing computers. Research and development continues on ways to improve the efficiency of multifunction operation and reduce distortion at wide squint angles.

Active Phased Arrays. An outgrowth of phased-array technology is the active array where each module in the antenna array acts as both transmitter and receiver, producing RF energy for transmission. The result generates a cumulative energy front with steering plus modulation signals applied to phase shift components in the individual modules to steer the transmit and receive beams. On receive, the components act very much like a passive phased array.

To exploit active array radar system requirements, industry had to reduce the production cost of individual modules so that the complete radar systems are affordable. The key was to create mass markets for the modules so that economy of scale will bring costs down. Chips that cost US$1,300 to US$1,400 a decade ago were running US$400 to US$500 by 1998, with cost nearing US$300 per module today.

During 1993, Signaal initiated the product development phase of the APAR (Active Phased Array Radar) multifunction radar. This was the result of a Memorandum of Understanding (MoU) among Canada, Germany and the Netherlands. The agreement committed the three participants to the development of a naval AAW system to equip a new generation of air warfare ships and stated the intent to develop, build, and test the APAR radar as part of this system. This MoU also committed the three countries to proceeding with the Product Development Phase.

APAR is a multifunction radar capable of performing various tasks simultaneously, including: detection and tracking of low-altitude targets (e.g., seaskimmers) by searching the horizon (Horizon Search-HS), detection and tracking of all targets within a certain range (Target Acquisition-TA), and the support of a ship's own missiles by gathering and providing the necessary information (Missile Support-MS). APAR is designed to provide guidance for all modern missiles.

The antenna of APAR consists of three active arrays, each composed of a large number of T/R modules. The combination of thousands of these T/R modules in one plate can generate narrow beams which can be pointed in any desired direction within a cone of about 90°. Switching from one beam to another can be done very rapidly. The use of so many T/R modules gives this radar unique performance and high operational availability. The inherent agility of APAR guarantees a high performance in the most adverse conditions, under severe electronic counter measures (ECM); it will be very useful in the gathering of more specific information about detected targets (Non-Cooperative Target Recognition – NCTR).

Air Traffic Control. Budget constraints have made it necessary and desirable for some to use the same surveillance radars for both air traffic control and early warning missions. As the threat changed, so did the sophistication needed to address both military and commercial air traffic requirements. Thus, both low- and high-level capabilities can be included, along with discrimination and targeting capabilities.

The development continues to focus on ways to effectively and economically combine the operational characteristics required for both purposes, tracking reliability of cooperative targets for air traffic control and long-range detection of non-cooperative targets for air defense operations. Design compromises have been effective, with much of the discrimination taking place in data processing. Both uses have benefited and nations are eliminating the cost of maintaining separate air defense and air traffic control nets. This is especially practical in remote regions and with cash-strapped nations.

Weather detection radars, such as NEXRAD (Next Generation Weather Radar) and TDWR (Terminal Doppler Weather Radar), have been a major air traffic control focus area. Wind shear and microbursts are the greatest threats to airliner safety, especially during approach, landing, and departure. Designers found an effective and reliable way to detect and inform pilots of the existence of microbursts and similar weather phenomena that have proven disastrous to many flights. New airborne radars can alert a pilot if the aircraft is approaching wind shear or microburst activity. Ground-based systems can provide crucial warning so a pilot can avoid areas where trouble lurks.

Counter-Battery and Fire-Control Radars. Although air defense and air traffic control radars make up much of the ground radar market, there are many applications for radars in weapon-locating and battlefield ground surveillance. Weapon-locating (i.e., spotting the batteries or mortars by tracking the path of the projectile) has generated significant interest these days, and systems such as the FIREFINDER family and the Cymbeline have been quite popular.

Interest in counter-battery sensors is ongoing. Although FIREFINDER systems are popular (systems were sent to Bosnia, and South Korea may acquire units to counter the North Korean threat), other non-US systems are being developed, exploiting newer technology. Development programs are under way to develop man-portable and other weapons-locating radars. Even though advances have constantly been incorporated into the system, the competition is offering comparable equipment at affordable prices. Upgrades continue, taking advantage of the latest technology and improvements in software techniques to enhance system performance.

The United States has developing a FIREFINDER replacement, the TPS-47(V). It is more mobile than the current systems, operates automatically, has increased accuracy, and incorporates the latest available technology.

The efficiency of radar-controlled counter-battery fire has placed correspondingly greater emphasis on the ability to score first-round hits, so that if an artillery battery does not score with its first salvo, it may not survive to fire a second.

Counter-battery radars are likely to gain significance as they parallel the development of laser weapons that can shoot down artillery rounds in flight. Israel has recently bought into the US Nautilus tactical laser program in the hope that it will provide a means of shooting down inbound artillery rockets. If this is successful, it would provide a reliable means of defending civilians (and expeditionary force troops) against salvo rocket attack. These anti-artillery weapons will, of course, require target detection radars. These provide an interesting bridge to the next section.

Tactical Air Defense Radars. Modern combat makes increased use of combat helicopters, so the need exists to provide detection and cueing information for short-range surface-to-air missiles being deployed with combat units. The US Army procured a version of the P-STAR portable radar to provide defense capabilities for its light infantry divisions. The Light/Special Division Interim Sensor (LSDIS) was designed to be a lightweight, portable, state-of-the-art system. In addition to the US procurement, Sanders obtained export licenses for sales to more than 20 countries, with negotiations under way with other nations.

The Forward Area Air Defense System (FAADS) program will modernize the Army's short-range air defense capabilities, with the program being specifically aimed at countering the low-altitude air threat over and beyond divisional areas of operation. The first MPQ-64(V) production system was delivered in 1993. On January 30, 1995, the Army began initial low-rate production, with contract options that could bring the procurement to 154 systems.

Battlefield Surveillance Radars. Today's battlefield surveillance radars trace their ancestry back to the Vietnam War. Their performance left much to be desired; however, they showed enough promise that a second generation of systems was developed. These overcame the maintenance and reliability problems experienced with the earlier systems, and operational experience with these second-generation sets led to fundamental changes in the perception of their roles and usage.

Instead of using high output power for wide area coverage, a third generation of battlefield radars deliberately restricted output power. This reduced their vulnerability to battlefield ESM while the reduction in range coverage (from 30+ kilometers to 6 or less) proved tactically insignificant. Once the reduced range was accepted, major savings in weight and cost became possible.

The current generation of battlefield surveillance radars weigh between 60 and 70 kilograms (132.3 to 154.4 pounds) and are thus man-portable (albeit as two loads). They have a range of around 6 kilometers (3.7 miles) but retain the capability of higher output powers. The unit cost has dropped to between US$45,000 and US$65,000. Typical examples of such radars are the Thorn-EMI MSTAR and the Thomson-CSF RB-12B. MSTAR is now being procured for the US armed forces as the PPS-5C.

The next radars will feature further weight and cost savings because development of smaller and more capable integrated circuits made major reductions in the bulk and power consumption of the electronics possible. The massive commercial use of this technology has evolved techniques where such circuitry can be produced at rates of thousands per hour. Antenna design has been simplified by the development of metalized fiberglass. This will permit a shift from the present high J-band used in the current sets to the K- or even L-bands, reducing antenna size and required output. One estimate for the next generation of battlefield surveillance radars puts weight as low as 10 kilograms and cost as little as US$10,000.

The power to run them can pose a problem as standard military batteries are bulky and cumbersome. However, the power demands of the new radars are low, and the prospect of using the same batteries to power the radars, radio communication system, and GPS receiver has emerged. From this it is only a short step to producing a squad-level electronics pack that combines a small surveillance radar, the GPS receiver, tactical communications radio, and a datalink. This would weigh about the same, occupy the same bulk, and have roughly similar power requirements as a current tactical radio.

Such a system could operate either as a stand-alone unit (in which case the operator would see the output from his own system only) or as part of a network covering the battlefield. In this configuration, each small radar could datalink its information back to a central data processing unit that would integrate all the information arriving and send the data back to the field radars. Thus, the output seen by the individual operator would not only be that of his own set but the integrated picture obtained from all sets within his operational area. This type of system will be further enhanced by the inclusion of passive, multisensor systems that combine IR, acoustic, seismic, or other detection methods. All of this ties in readily with the Force XXI concept of a tactical internet and digitized battlefield.

Fewer individual systems will be needed in Europe as force levels are reduced. Experience in the Persian Gulf, and during multiple contingency operations since, showed that nations must evaluate the number and type of sensors needed for contingency operations around the world; the market requirement will change accordingly.

Front-line forces are adopting a variety of non-emitting sensors to meet protection needs. These include passive infrared, laser warning, and night vision equipment. The third-generation IR staring array can produce TV-like results day or night and can combine many capabilities in a single system, with many of the previous limitations of IR/EO sensors reduced or eliminated. The new technology will become very popular and able to replace battlefield radars in many applications.

There is a growing interest in UAVs for many surveillance requirements. Synthetic Aperture Radars are becoming small and light enough to be carried by these non-piloted platforms. The amazing performance of many of these new sensors is taking attention away from the consideration of 'old' technology like battlefield radars. This trend can be expected to continue for years. Eventually, some balance will be achieved.

Non-cooperative Identification and Battlefield IFF. The effort to develop non-cooperative identification capabilities that do not depend on an aircraft operating its IFF equipment is ongoing. Both the commercial and military sectors need such technology. Air defense equipment will use this capability to identify intruders by type; and thus their mission, as well. The commercial sector needs to better identify all aircraft, especially VFR traffic in local airspace.

Research and development efforts work to increase the level of discrimination and processing. This is one place where data fusion and the incorporation of multiple technologies applies. The Department of Defense has been actively seeking research into basic approaches that will develop into a reliable non-cooperative identification capability. Approaches include a high-level analysis of radar, infrared, and electro-optical signal characteristics. The application of artificial intelligence techniques to this arena is being actively pursued.

Sea-Based Radars

Since the end of World War II, warships have undergone a design revolution. The fighting power of a ship is no longer measured in terms of the numbers of guns and torpedoes it carries but by its electronic outfit, which is limited by its electrical generating capacity. Yet the importance of the sensor fit to a modern ship is almost always overlooked. Most naval reference books list a ship's missile magazine capacity and the number of launch rails, but rarely the number of guidance channels. A modern warship lives or dies by its sensor systems. Of these, the most important and undoubtedly the most expensive are its radars. Area for area, there are more radar systems on a modern warship than anywhere else on earth.

Four classes of radars are carried by such ships. These are the navigational radars, search radars, target acquisition radars, and fire-control radars. To this should be added a number of special-purpose sets: for example, precision approach radars permitting helicopter operations under adverse conditions (these are often listed as navigation radars), closed-loop tracking systems for point-defense guns, and a variety of others. In addition, the boundaries between the different groups are blurred; a system serving as a navigation radar on a missile cruiser may also be the primary surface search radar on a missile-armed FAC. Allowing for these blurred distinctions, the four categories still give a general framework for market analysis.

Navigational Radars. Every ship in naval or paramilitary service, from a small harbor defense motor launch or utility landing craft to the largest nuclear-powered aircraft carriers, has at least one navigational radar. These vary in sophistication from ruggedized versions of commercial sets sold for use on privately owned yachts to specialized military systems with capabilities approximating those of surface-search sets. The prime function of these sets is exactly what their name suggests: the provision of precise and accurate navigational data.

The uses of this information differ radically from their civilian counterparts. In addition to straightforward navigation and collision avoidance, the military navigational radars can be used for staging ambushes, mine-laying operations, inserting special forces and policing the seas in anti-piracy and anti-smuggling operations. They can also be used for controlling helicopter operations and assisting in ASW operations by providing ATC coordinating facilities for the aircraft involved in the hunt. During search-and-rescue operations, these sensors can provide radar coverage which the larger surface search sets, intended for detection at greater ranges, cannot match. The navigation radar on a warship is probably its most heavily worked sensor.

In many of these roles, the situation where precise navigation is most essential is also where the possibility of the radar being detected by ESM sensors is highest. A possible solution is the frequency-modulated, continuous wave (FMCW) radar. This exploits the fact that ESM equipment and the anti-radar missile function on peak-power outputs. FMCW radars utilize a very low average power output of 1 W, much less than the 10 kW peak and 10 W average power of conventional pulse radars. Because of this low power output, the radar is often only detectable from distances of 1.3 nm or less.

Another approach to covert operation is to bury the radar transmissions within the civilian traffic. An example is the ruggedized version of Racal's Decca 1226 – probably the most widely used maritime radar in the world. In a busy shipping lane, it can be quite impossible to distinguish the warships using such radars from commercial traffic. The US Navy's PC-1 Cyclone class patrol craft uses commercial radars for its navigation and other sensor needs, making it easier to hide in commercial traffic lanes. This is important for Special Operations missions.

Although the prospect of a major or superpower confrontation at sea is now slight, maritime crime is spreading and escalating in seriousness. Drug smuggling attracts most attention in the US and Europe, while piracy and slavery are endemic and growing problems in Far Eastern waters and off the west African coast near Nigeria. Policing the world's shipping lanes calls for large numbers of small patrol boats operated by navies and the police. Equipping all such craft with navigational radars essential for the effective performance of their duty will be a major market opportunity.

Search Radars. There are two basic groups of search radars, one provides coverage against air and one against surface targets. Overlap between these two groups is considerable, with a number of sets being promoted as dual-purpose. In general, air search systems operate in the D-band, while surface search sets operate in the E/F band. The design of a search radar allows it to rapidly sweep an area, with a high probability of being able to detect a target at greatest possible range. It uses a broad search beam to maximize the number of pulses on the target per scan. These systems usually feed directly into the ship's command system and are a primary contributor to the overall tactical picture.

No substitute exists for radar as an area surveillance sensor. Passive sensors are viable only as long as the opponents continue the indiscriminate use of their radar systems. As strict EMCON (emission control) techniques become universal, the role of ESM will decrease. This implies that the counter to ESM technology lies not so much in terms of the radars themselves but with the command and control system into which they are integrated. Even with modern ESM systems, it is relatively safe to allow radars to emit quick flashes at irregular intervals, although the risk increases with the duration and frequency of the transmission bursts. The challenge is to gain as much information as possible from those brief, infrequent transmissions.

Over the next decade, the integrated radar/C^3I systems will replace the current generation of surveillance systems. The US Navy's AEGIS system is an example of an integrated air search/air warfare combat direction system. The Swedish Giraffe radar has such capabilities built into its land-based variants, and these were extended to the Sea Giraffe as the core of an integrated warship C^3I fit.

All the standard technologies being developed to reduce the vulnerability of search radars to anti-radar techniques are applicable to naval radars, including power management, LPI, sidelobe reduction, etc. Changes in radar technology will so alter the nature of naval search radar systems that upgrading existing sets to the new standards will not be possible. Ship mid-life refits could involve the replacement of existing radars by new systems. This will reverse the trend set in the 1980s whereby radar systems were upgraded rather than replaced.

The US has programs to replace its long-time standard SPS-48 and SPS-49 surveillance radars, incorporating a variety of new, state-of-the-art requirements for the new systems. This Volume Search Radar program is awaiting the award of a source selection/contract.

Target Acquisition Radars. These radars provide an intermediate level of capability between the long-range search and detection capability of the surveillance radars and the precise short-range fire-control systems.

The use of these radars highlights a major difference in electronic outfit philosophy between US ship designers and those in the rest of the world. The US Navy has the luxury of operating within concentric rings of defenses many hundreds of miles deep, starting with the outer air battle and ending with the Phalanx point defense guns. European navies do not have this luxury. The result is that the US Navy can trade off efficiency in one ring in order to gain advantages elsewhere. One such tradeoff is that the USN frequently merges the search and target acquisition roles. Other navies cannot afford to do this.

Except for in the US Navy, a warship rarely has more than two defensive rings surrounding it, and often only one. It is therefore essential that each phase of the defensive system should operate at maximum efficiency, which requires the provision of the separate target acquisition sets. This is a major reason for the export success of the European integrated naval radars. US naval sources suggest that another factor is that the electronic congestion resulting from the addition of a target indication radar would be unjustifiable. The same sources point out that their ships typically have more fire-control channels than equivalent European designs have. As such, the results are significant and will enhance the roles of target-acquisition radars. If the stealth techniques used to get attack aircraft close to their targets undetected are relatively ineffective, naval attack aircraft will have to rely more on standoff weapons in order to engage warships. This, in turn, implies that the ships will have to acquire the attacking launch platforms at greater ranges. It also implies that designers of anti-shipping weapons systems will concentrate on designing performance into the stand-off missile rather than the launch platform.

The latest versions of the Exocet missile use an adaptive evasive flight profile with the final approach to the target coming from a variety of different attack angles. This has been shown to be so successful that the French Navy has abandoned plans to install close-in gun systems on its ships and will rely purely on missiles for its defenses. A detailed Royal Navy operational evaluation showed that a Goalkeeper 30 mm close-in weapon system (CIWS) was likely to destroy an inbound "today-standard" surface-to-surface missile (SSM) less than 800 meters from its platform while the 20 mm Phalanx is likely to kill its target no more than 300 meters out. At these distances, wreckage from the missile will still strike the ship, causing widespread damage and fires. This is why the new Type 23 ASW frigates have not been equipped with gun-based CIWS.

The next generation of anti-ship missiles will retain the complex evasive courses of the current weapons and combine them with high supersonic speeds and greatly increased ranges. Available details of Russian anti-ship missiles confirm that these very high attack speeds are available. Representatives of the Raduga Design Bureau responsible for the P-270 Mosquito (3M-80) anti-ship missile have suggested that evasive courses at these speeds are actually counter-productive. Following an extensive series of simulations against an AEGIS cruiser, Raduga came to the conclusion that it was crucial to cover the distance between the initial detection point and the target as fast as possible. An attack speed of Mach 3.5 was selected (as opposed to Mach 2.5 on the older P-80 missile known to NATO as the SSN-22 Sunburn), as was a straight-in attack run. This does not preclude the use of dog-leg approach trajectories, so the target will be faced with several Mach 3.5 missiles skimming 7 m above the sea surface from a number of directions at once.

Anti-sea-skimming missile defenses will have to be based on point defense missiles. In order to counter the high-speed anti-ship missiles, horizon-scanning target acquisition radars are needed. Ships may have to carry two fire-control complexes, one for over-the-horizon detection and a second to actually engage the missiles. These developments also suggest that the replacement of existing Phalanx systems with CIWS missiles such as RAM is very urgent.

The littoral environment is complex and confusing, a situation that demands targeting information be displayed in a concise and unambiguous form. This is being achieved by the use of multicolor presentation of a clear, easily assimilated picture. Displays can present alphanumeric representation of electronic bearing lines and variable range markers, and range-adjustable intrusion alarms against potential collision dangers. This trend has been criticized by some operational analysts in Europe who believe that because the use of color allows much more information to be presented, it can lead to information overload.

As older US-built frigates and destroyers find their way onto the export market, these ships are removed from their protective cocoon of defensive screens and find themselves operating alone or in small groups. They will need to be updated to cope with the new realities. Some of these ships may receive new sensor fits with the full range of search, target acquisition and fire-control radars.

Fire-Control Radars. These precise, short-range radars, operating in the I/J or K bands, are the teeth of the ship's radar system. They steer missiles to their targets and provide the range and bearing solutions for both anti-air and anti-surface gunnery. Fire-control radars require precise tracking, thus a narrow radar beam, which in turn means the radar can scan only a fairly narrow area with any kind of efficiency.

The changing nature of the threats facing modern warships, particularly in the NATO navies, is affecting the development of fire-control radars. The shift from superpower confrontation to regional conflict has meant that the danger from mass swamping attacks containing perhaps hundreds of air-to-surface missiles has lessened. The likely opponents in a regional conflict simply do not have these resources.

The fire-control radar will not be replaced. No other sensor has the range, precision, and foul-weather performance. Electro-optical, infrared and laser techniques are being integrated into fire-control complexes in order to provide complementary backup and alternatives to the radar, but the radar remains prime.

The "One-Radar" Ship. With four classes of radar and the largest modern warships carrying as many as 15-20 separate radar systems, the complexity of the setup has caused considerable concern. The sheer number of radars and other electronic systems raises problems of mutual interference. The number of missile launchers on a ship is predicated by electronic interference between the missile guidance beams, not by space, weight or cost. A resolution to this problem may be a move to fewer individual systems, where many functions are combined into a single set.

A first step toward this is the development of multifunctional radars. In Europe, interest is high in developing and fielding common naval radars, with the focus on phased arrays. Several new radars are being designed, including a downsized version of the SPY-1(V) called Frigate Array Radar System, and the multinational EMPAR (European Multi-function Phased-Array Radar). The Arabel, which appears to be aimed at meeting French Navy requirements, is also a possible candidate for common European requirements.

However, the multifunctional radar, due to its very nature, is a bundle of compromises and needs support from other sensors, including radars. One problem is the fact that modern MFRs will be expected to handle simultaneously something on the order of 200 targets while providing surveillance coverage. However, when carrying out long-range searches at high data rates, the processing requirements can be so expensive that very little excess capacity can be left for other tasks. The same high processing requirements can be applied to low-level detection and tracking.

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Competitive Environment

The ground and naval radar market has shrunk. Shake-outs and mergers have been numerous. Shrinking defense budgets around the world have combined with the market re-focus, weeding out weak and ill-prepared manufacturers.

United States. As the market for new strategic radars disappeared, the demand for battlefield and new air traffic control radars grew. It was good business to expand product lines and expertise into multiple areas, usually through acquisition and merger. Ground radar houses began producing naval systems, defense-oriented producers branched into air traffic control, and all investigated ways to penetrate civilian markets with their design and production capacity. In recent years, some companies in the defense industry produced more for their commercial sector products than for the defense market.

Major US ground- and sea-based radar houses include the Raytheon Systems Company, Lockheed Martin, and Northrop Grumman as a limited player. They all do significant business in airborne radar and electronic warfare equipment as well as surface radars. These companies are strong on development and often are at the leading edge of technology. Yet, they do not have the market presence of their rivals when considered on a worldwide basis.

The United States technological advantage is being able to develop the highly specialized radar techniques and processing algorithms necessary to detect and analyze air movements at long range and convert this information into detailed weather analyses, as characterized by the NEXRAD and TDWR. Due to their Persian Gulf TV exposure, JSTARS and AWACS in many minds epitomize the state of the radar art and also influence where many assume the US will fall in the overall market. But fantasy and reality do not always coincide.

US companies had the US government as a primary customer for so long that they neglected to develop an ability to deal effectively with non-US governments. Companies have not made a distinction between lobbying and selling or mastering the nuances of the different techniques. That void was willingly filled by European companies. Attempts to expand outside their traditional customer base met entrenched opposition from established suppliers.

Teaming with international partners was once anathema to US companies which were afraid that their trade secrets would leak out to competitors. This further increased the distance between the US industry and potential international customers, and erected a barrier between US companies and suppliers that could have helped with entry to the international market. There is a new willingness to pursue teaming arrangements now, much of it driven by ongoing mergers, shrinking the number of companies in a position to be prime contractor on major programs. This came late, and the US surface radar industry let itself get behind the Euro-giants and found it difficult to catch up. Mergers have been responsible for the successful positions of the top-five-ranked US companies.

Another limitation that faced US companies was perceived unreliability of the US as a supply source. The degree of accuracy associated with this perception is not really relevant – there are enough examples of inconsistent US behavior and problems with export licenses to give buyers pause. Some of these problems were caused by Congress writing requirements into the annual defense authorization and appropriations legislation in an effort to protect constituent companies from “overseas” competition or as a result of political pressure over all manner of narrowly focused issues. Naturally, competitors have done their best to publicize and exaggerate such events, usually to the disadvantage of potential US suppliers. Of late, many of these situations are turning around. There is still a long way to go, but some militaries are forced to rely on the US for sensors.

A further problem stems from the opinion that US equipment reflects the demands and operational philosophies of the *US* armed forces, making it unsuitable for armed forces that do not use the same doctrine. Open architecture and flexibility had not been pressing design requirements until the last few years, and the US industry is just beginning to successfully transition to a new way of doing things, mostly because US forces now need more adaptable equipment, and the moves away from military-unique hardware makes one-of-a-kind, single-purpose systems undesirable.

Export control problems have not helped. What are considered arcane, tedious, and sometimes downright silly regulations interfere with the acquisition of many systems. In some cases, potential customers adopted a policy of avoiding considering procurements of US equipment because dealing with the Cold-War rules had become much too difficult.

Europe. Outside the US, the competition is essentially concentrated in Western Europe. The French Thomson-CSF group continues to dominate the surface radar industry. Thomson-CSF manufactures the widest array of land and naval radar products in the world. Its international position is enhanced by a policy of developing systems for the export market which are then adapted to meet French military requirements. The takeover of the Dutch firm Signaal provided Thomson with an innovative and dynamic division, especially strong in the naval segment.

UK, Italian, and Swedish companies have established positions in what can be called the second-tier players. In the UK, the major player is GEC, plc. In Sweden, Ericsson Radar Systems AB has established a market position in the top five with its family of radars based on its Giraffe system.

Commercial Sector. In the commercial sector, the main applications are air traffic control for ground-based radars, and ship navigation for commercial craft radars. Major players in the ATC market are Northrop Grumman and Raytheon in the US and Thomson-CSF in France. For commercial naval radars, the major players are Raytheon in the US, Furuno in Japan, as well as Racal Decca and Kelvin Hughes in the UK. One driver in the commercial ship radar market is the recent requirement that all ships over 15,000 grt include a collision avoidance capability.

National Industries. Because of ongoing problems in the Russian economy, it is impossible for that country to support a large defense industry at this time; although planners would like very much to be able to develop its export market to generate large amount of much-needed hard currency. Since the former USSR primarily concentrated on producing enormous quantities of military hardware, the restructuring of the economy did not have as significant an effect on the technology side of its industry as it did on heavy industry.

If anything, more of the increasingly scarce assets are becoming available for long-wanted technology development, to include radar. Arms treaties and closer alliance with the West will encourage some technology transfer and the application of more up-to-date techniques to what some expect to be a newly revamped multi-use, military/civilian radar industry. Such joint effort has become common in the aircraft sector.

Much more than a simple technology infusion is required. The Soviet practice was to concentrate production on units of equipment rather than on adequate supplies of spare parts. Maintenance of this equipment was by replacement rather than repair, so that a major proportion of production was used to replace unserviceable systems rather than as force enhancements. This approach is no longer practical and the design teams are rethinking their basic philosophy from scratch. It will be several more years before the change is noticeable.

The People's Republic of China is determined to become an active player on the world radar and high-tech market. In the past, products tended to be modified versions of old (often very old) Soviet radars. These were "modernized" and "upgraded" using Western technology obtained during the 1970s. In a number of cases, substantial increases in performance were achieved. The resulting hybrid radars lagged behind comparable Western systems in capability and have interested only those customers who could not afford, or would not be sold, more advanced Western systems.

Domestic efforts to boost the high-technology end of the Chinese radar industry are becoming marginally successful. Attempts at the construction of OTH-B and phased-array radars have remained at the early prototype phase, and an attempt to build a naval anti-aircraft missile using local designs for the system (rather than Russian or French derivatives) was apparently a failure. Chinese engineers are very active participants in IEEE radar conferences, reflecting a very strong science capability.

China is trying to get a toehold in some segments of the world radar market. Practical problems have been quality control deficiencies and production standard weaknesses. Production and test capabilities lag and continue to restrict China to the role of niche player through sales at "friendship" prices made possible by putting political considerations ahead of practical realities until the Chinese can bring the scientific and production efforts together.

India has continued to make its defense industry self-sufficient and made a major commitment to establishing an indigenous electronics capability, although recent nuclear activity may indicate that priority has shifted for a while. The country already claims to have designed a number of sophisticated radars, including a high-power coherent radar. Projects presently announced include a mobile three-dimensional air defense radar with a planar-array antenna (joint development with Thomson-CSF), a solid-state mobile low-level air defense radar, and the 16-kilometer-range Multi-Target Field Artillery

Radar (some components from Thorn-EMI's Cymbeline radar used in development).

Naval radars in service are based on Signaal products, while the "new" Trishul SAM guidance radar and missiles were derived from information from the British Seawolf program. Other programs for developing the technology for 3D, electronically scanned, phased-array radars with multiple-target, track-while-scan capability, and technology areas, such as millimeter wave, are also based on imported technology. Most of the work is being done by Bharat Electronics, which claims that it can offer radars at a price 15 percent less than the competition.

Other countries, such as Israel and Japan, continue to do significant work in radar development; however, both are constrained in their international sales. Israel tends to concentrate on airborne systems, with its ground equipment being US or joint Israeli/US produced. Israeli naval radar systems tended to be evolutionary developments of Italian equipment. But Japan produces licensed derivatives of US systems. It introduced a new active-array 3D naval radar, the OPS-24. If this system becomes a service radar rather than a prototype/ technology demonstrator, it will mark a major milestone in the development of Japanese military electronics. It will also be the first major innovative radar development outside the traditional US/Soviet/Western European suppliers.

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Market Statistics

This market analysis examines the market for land- and sea-based radars in terms of systems and manufacturers. This sample consists of radar systems with a broad spectrum of demand, applications, and costs. Both domestic and foreign systems are included, and most units are in production. In the outyears, new programs may develop that are currently unknown and therefore are not included in the available data. The long-term projections will be adjusted as these developments begin.

Methodology. The sampling that follows correlates the individual 10-year forecasts into an overall analysis of the market. Each individual report is based on detailed research, involving data obtained from various government agencies, industry sources, United States and foreign publications, and individual contacts in the aerospace and electronics industry. This broad base of information is used to develop an overall picture of each system.

The market analysis uses a computer-based approach to combine data from the individual reports and to perform several statistical analyses. Using this method, we have provided several graphic presentations of projected unit and value production by system and by calendar year. We also discuss the leaders in our sample of this market area. As future programs become known or are announced, they will be added to the analysis.

The manufacturer listed for each system is the prime contractor, even though there are second sources for some of the programs. It is very difficult to assign a particular market percentage value to what a second source will be handling, unless specific contract awards have been made. Likewise, unless specific information is available, in teaming situations it will usually be the team leader and key partners listed along with overall value of the program carried.

System Pricing. Precise pricing of radar 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 our unit prices vary. In some cases, the prime contractor provided an average or typical unit cost. When the manufacturer did not supply price quotes, estimates are based on contract awards, funding and numbers ordered.

RDT&E costs do not always appear in the unit cost, especially if development is government-funded and contracted separately. In other cases, government funding documents have been sanitized. In such cases where no source information was available, we estimated the unit cost based on the type of system, its complexity, prices of comparable systems, and a general understanding of the radar marketplace. In those cases where available price information may not be exact, unit cost estimates are in the proper order of magnitude.

Spares. Unlike airborne radar systems, most land- and sea-based radar 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. Additional replacement parts are funded and contracted for separately, as needed. Consequently, we have not factored spares separately.

Analysis. Our analysis is a sampling of the known land- and sea-based radar systems. However, using an analysis of the included radars we can draw some conclusions about the future of this market. A variety of charts and graphs are included to illustrate different elements of this dynamic electronics market.

(**NOTE:** In reviewing projected outyear production figures, one should take into account that new programs, currently unknown, will be coming into existence and generating production over and above what is in the data presented. Actual production within the evolving market will not drop off in the outyears as much as it appears to. As a result of client requests, this analysis covers only established programs that have entered production or are scheduled to do so within the forecast period. As important new surface radar programs take shape and enter production, they will be included in the analysis.)

Radar systems are high-value items in the electronics marketplace. This analysis projects a total world radar market valued at US$10.401 billion between 2000 and 2009. The value of this market is US$6.915 billion between 2000-2004 and US$3.486 billion between 2005 and 2009. The top two companies control 53.19 percent of the market through the decade. The other three companies in the top five control a combined 22.62 percent of the market. A total of 25,849 units are expected to be produced during the forecast period.

Four of the top five companies remained the same, although there was some reshuffling of rank after Lockheed Martin moved out of the vanguard and the Euro-Art Consortium stepped in. Production for Lockheed's major sea-based radar programs end in the latter half of the period when the construction of the ship classes is complete. The EURO-ART Consortium moved into the top five because of its high-cost, multinational counter-battery radar production taking place in the first part of the forecast period. Examining the market in detail through the period reveals variation in the standings from year to year; but the power and size of the players are relatively unchanged overall.

The United States has essentially completed its defense industry consolidation relative to the surface radar market. In Europe, BAE Systems is combining major players, and next year GEC plc will be covered as part of that giant organization. The impact of the trans-European EADS (European Aeronautic Defense and Space Co) is yet to be determined, although its initial direct impact on the surface radar market structure will probably be limited.

There is a distinct difference in character between the projected markets of land-based systems and sea-based radars. Sea-based programs are clearly tied to shipbuilding and overhaul programs, and the swing toward investment in naval capability is worldwide. This is because many countries have decided to enhance their maritime presence – in effect, build new navies.

Program rates are defined years in advance and represent a long-term commitment. Naval shipbuilding programs have a long initiation-to-completion cycle with warship building times ranging from three to seven years. Thus, the market for systems used by the naval sector is slow to respond to changing environments. The long cycle time means that the effects on the radar sector will not be seen until the far term.

Land-based radars, on the other hand, respond to changing service needs and funding patterns. Once a service identifies a system as needed, it can often be acquired as funding and production capacity permit. Since a radar system enhances the likelihood of mission success, it is only logical to bring all service units to the highest level of capability and preparedness as rapidly as possible.

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Market Leaders

While neither unit production nor value of production fully define a market leader, we had to choose some criterion by which to rank radar companies. The value of production is a relatively accurate representation of the market. The individual discussions that follow present those US and European manufacturers whose market share exceeds 1 percent.

While US and European companies had been involved in corporate mergers and acquisitions, European mergers were aimed more at exploiting complementary areas rather than eliminating competition in any given sector. The European governments have much more power than the US in business affairs and are much more likely to intervene to protect national interests. The European Union adds another dimension, seen in some cases as a way of joining the capabilities of member nations into a more potent single market force.

A European giant, EADS, has been formed, though its impact on the radar market is yet to be determined. Nationalistic emotions initially had a chilling effect on enthusiasm for the idea of a single, joint industrial entity. Instead, a trend is developing for companies to join and re-organize into sectors so the new team can compete on a global scale. The electronics sector tends to be the leader in this, with BAE Systems as an example.

1. Raytheon Systems Company: US$3.264 billion, 31.38 percent of market sampling

Raytheon's position is supported by several air traffic control system upgrades. The ASR-10/11 terminal radar remains a solid program throughout the forecast period. The FAA award to replace its ASR-7/8 terminal radars is using a modified version of the Digital Airport Surveillance Radar (DASR), the ASR-11. The original ASR-10, already successful on the international market, captured over US$500 million in potential new business. As a result, Raytheon has informally (based on customer reaction) split the world with Northrop Grumman; with Raytheon's ASR-10 attracting the Asian market and the Northrop ASR-12 being selected to enhance Latin American airports. COSSOR ATC Systems nearly doubled Raytheon's market share by providing the Secondary Radars for the installations.

A significant naval radar upgrade for the US Coast Guard combines a commercial radar and specialized control system into a two-configuration system that meets the needs of the entire fleet of today's Coast Guard. Production is expected throughout the ten-year period and beyond. A future variant of the tried and true FIREFINDER will further boost the order book as procurement plans include up to 154 systems for the United States. FMS buyers are interested, especially since the *Sentinel* is proving so capable in Army combat exercises. It will be the backbone battlefield defense sensor through at least the next two decades.

The Multi-Function Radar (MFR) is planned to be the basic sensor suite for the DD-21 next-generation surface combatant land-attack destroyer and CVN-77 next-generation aircraft carrier. In June, 1999, the Naval Sea Systems Command awarded Raytheon a US$140.4 million cost-plus-award-fee agreement for the development and construction of one multifunction radar engineering and manufacturing development prototype, and associated supplies and services. The effort is to be completed by April 2004, followed by LRIP. Production will be driven by the DD-21 construction schedule, something that may be somewhat fluid in the near term as issues such as changes to an electric drive system are accommodated by designers. Initial estimates put the requirement at up to 45 systems.

A multifunction radar, by its nature, must be computer intense, and some of the features the Navy will be seeking were unavailable just a few years ago. An active array antenna is a must, so the power of the controlling computers will have to be massive. Data processing will be a challenge, with enormous software files driving a system that must effectively and efficiently accommodate competing and sometimes mutually exclusive functions.

This system will be the US ship sensor foundation for the 21st century. The MFR is planned to become a technological baseline for future ships, including the follow-on CG-21 Cruiser. The Navy developed a Radar Roadmap in 1999 which did not include AEGIS in future plans. This solidifies Raytheon's grip on the naval sensor market through the forecast period. As a result, Raytheon and Thomson-CSF have been established as the surface radar leaders throughout the forecast period.

The Navy plans to develop a new Volume Surveillance Radar (VSR) to replace the SPS-48(V) and SPS-49(V) series radars on non-AEGIS ships. One of the new radar's missions will be to provide tracking of threats such as aircraft, missiles, unmanned air vehicles (UAVs), and helicopters with rapid hand-off to engagement systems. Other missions would include situational awareness and air traffic control, IFF and fire finding. These mission goals were considered desirable, if not cost drivers. The DD-21 Program Office considers both radars part of the next-generation ship's sensor suite and crucial to the air dominance mission of the ships. A development/production plan has not been completed, but is can be assumed to parallel the MFR effort, since the two will complement one another. A development contract award is anxiously awaited by the market.

2. Thomson-CSF: US$2.268 billion, 21.81 percent of market sampling

Thomson-CSF continues to be a world powerhouse in the land and surface radar market by a large margin. It consistently captures nearly a quarter of the overall market, and is usually neck and neck with Raytheon for first or second place.

The Thomson-CSF Group dominates the land and naval sectors with a large portfolio of naval, battlefield, and ATC equipment. It has achieved its position with a combination of export-led increases in sales and successful acquisitions. Many of the radars helping the company establish its position are Signaal products. The Thomson organization has a leading role in almost every major European multinational defense electronics project.

The dominance of the Thomson-CSF Group reflects the French government policy of keeping the nation's defense electronics industry strong and healthy enough to prosper in a European unified market. The purchase of the Signaal division of Phillips gave Thomson-CSF a much-needed boost in its naval radar operations and converted that sector to a position of world leadership.

During the 1970s, Thomson-CSF cut back on corporate research and development at about the time major advances in computing and processing technology were taking place. This led to the group falling behind the technology curve. This problem affected the electronic warfare and airborne radar sectors. Thomson-CSF compensated for deficiencies in naval radar technology by acquiring Signaal, while its massive presence in the civil ATC market, and that sector's devotion of at least 25 percent of revenue to R&D, ensured that its land-based surveillance sector remained fully up to date.

The Arabel is a particularly strong performer, with production of several Signaal systems continuing throughout the forecast period.

Thomson-CSF and Raytheon Systems Company, combined, will capture almost half of the market throughout the forecast period, and will consistently exceed the combined market value of the other three of the top five. Thomson-CSF will profit as older systems developed during the 1970s are replaced by upgraded versions exploiting the latest technology. This will include active-array radars for both land and naval use.

3. Motorola Inc: US$1.193 billion, 11.47 percent of market sampling

Motorola continues to be in the top five because of the JSTARS Ground Station Module (GSM) and the newly-developed Common Ground Station (CGS). The near-term market is substantial as users acquire an initial stock of GSMs. Motorola holds its third-place rank consistently through this analysis.

The ground stations make it possible to use the data generated by the JSTARS airborne radar as data are downlinked to a single or multiple GSMs/CGSs for processing and use by commanders. The GSM is an automatic data processing complex that uses an AYK-14(V) computer, 80 Megabyte disk storage unit, and magnetic tape unit. Two work stations allow ground operators to interact with a radar database and display needed information.

The Army's Common Ground Station is a Pre-Planned Product Improvement (P^3I) to the JSTARS Light Ground Station Module. It incorporate enhanced operational capabilities, advanced improvements in functions and new technology into the GSM functional baseline. The design will maximize non-developmental and COTS use and re-use existing software up to 84 percent. The CGS is to be the standard JSTARS ground station and adaptable for UAV sensor downloads as well.

Although the Air Force has cut back the total number of JSTARS E-8s it will procure, the requirement for ground stations will be strong. As JSTARS competes with European sensors to meet a NATO surveillance requirement, Ground Station Modules remain popular. Even if JSTARS is not selected to meet the requirement, or total acquisition is reduced, NATO will need GSMs to interface with JSTARS aircraft operating in conflict areas. This was also a requirement of the UK's ASTOR program.

The new Boeing 737-700 airborne surveillance system selected by Australia for its Wedgetail AEW program calls for JSTARS ground stations in its requirement. Since this Multirole Electronically Scanned Array (MESA) could become a popular system on the international market, the need for ground stations can be expected to be strong throughout the forecast period.

The Air Force is expanding existing doctrine to include counter-land and counter-sea missions, with JSTARS a major player in that role. This will have a positive impact on GSM requirements, possibly increasing the total needed as new users request units and as existing GSMs are upgraded. Most of these enhancements will be software based.

Another significant factor is the Combat Identification-Dismounted Soldier System (CIDDS) program. This rifle/helmet mounted anti-fratricide device helps distinguish between friendly and unfriendly soldiers on the battlefield. Although the individual unit cost is low, a very large number of required initial systems and ongoing requirement will result in significant ongoing purchase.

4. Ericsson Radar Systems: US$586.0 million, 5.63 percent of market sampling

The Swedish Army's decision to use the Giraffe radar as the primary target acquisition system for the new BAMSE medium-range air defense missile system strengthened Ericsson's position in the top-five. This program adds substantially to the number of sets projected for sale and, since the radar is costly, increased the total value of sales. Ericsson has benefited from a large and loyal home market which permitted it to develop a popular series of radars. Swedish government policy promotes independence from foreign suppliers of military equipment whenever possible. Combined with Ericsson's astute management, the company has anticipated trends and technical developments. The result is a military radar producer whose capability and influence are far greater than would otherwise be expected, given the size of the company. Even though some of its programs were completed, exports boosted ongoing production, and the company moved to fourth place.

Ericsson has steadily enhanced its ability to provide for most user requirements and accommodate their budgets. Other development directions have created a range of naval variants that followed a separate evolution and now are quite distinct from the land-based equivalents, but which share much basic technology and engineering.

Giraffe technology migrated into the Arthur counter-battery radar, while the Giraffe radars themselves are complemented by the HARD fire-control radar. A good example of Ericsson's prescience is the inclusion of limited C^3I facilities within the new generation of Giraffe radars when these were introduced more than three years ago. They are fully capable of operating as a limited-area integrated defense system until such time as contact with higher echelons is reestablished.

The same basic technology that gives Giraffe its provisions for local air defense command control has also been used to provide the core of a naval command control system, extensively used on fast attack craft and small frigates. This system, the 9LV-453, uses a Sea Giraffe 150HC radar as its prime sensor and has won substantial acceptance. As the forecast period continues, the land- and sea-based C^3I systems could be used to expand and develop this line of operational profiles.

5. Euro-Art Consortium: US$574.2 million, 5.52 percent of market sampling

The multifunctional, 3-D phased array weapons-locating radar singularly accounts for the Consortium's ranking. US, French, German and British companies make up the design and production team. Operation is similar to that of the FIREFINDER system; but the design capitalized on newer technology to create a smaller, lighter, more capable system. It is being fielded in a single vehicle configuration and was designed from the beginning to take advantage of the newest in processing equipment.

The program was a long time in the making, with initial feasibility studies dating to the late '70s. It was eight and a half years before a production contract for 29 systems – down from an originally-planned 53 – was awarded. The program capitalizes on the expertise of the world's most accomplished radar houses; but as is typical of multinational efforts, coordination has been difficult.

The unit cost of these radars boosted the program enough to move it into the top five, especially since Lockheed Martin moved out of the top tier of the analysis. Another contract to support the UK's Royal marines is pending and could change the ranking – not enough to take over any of the top three positions, but possibly swapping for number four. The system is being marketed internationally. No sales are yet reflected in the analysis.

A Note on the Outyears. The 10-year forecast does not reflect estimated new activity in the outyears. These are programs that have not been identified or formalized. New programs will develop toward the end of the forecast period which will increase the market estimate through new-start production. It is known that the defense electronics market will remain relatively strong in the future and that the surface radar market will not fall off to the extent shown by the charts.

Based on today's established programs, the projected market figures in the outyears underestimate the size of the market. By the end of the reporting period, new programs will be added to the forecast to bring those levels closer to actual levels. This is especially applicable to the FY04 and beyond forecast. By this time, the market should be stabilizing around the 2004 level and changing with market variations. It will not be climbing back to turn-of-the-century levels.

In the naval sector, construction could experience an upswing during the latter part of the forecast period. Large numbers of ships may be ordered by newly emerging maritime powers, ships that will be considerably more capable and well-equipped than those previously sold on the export market. A large number of programs around the world are likely after 2000. This is pure public relations, since these projects can be expected to be spread out over a number of years in the early 21st century. The US has formally begun conceptual development of a new Volume Surveillance Radar for non-AEGIS ships and awarded a development contract for a multifunction radar for future ships and possible retrofit to select vessels in the Fleet.

By the end of the reporting period, the need will emerge to upgrade, enhance, and replace some of the radar systems currently in use or going into production. The respective programs have not yet been formalized, but this adjustment attempts to estimate the effect of these efforts on the overall market.

A significant market exists in the outyears, a market for which the requirements have not yet been established nor contracts awarded. Much of it is up for grabs and is going to be driven by the need to replace many current systems which will have reached the end of their physical and technological lives. We anticipate, however, that the major players will remain the major players, and will garner most of the new market share.

* * *

Table 1
The Market for Surface Radar Systems
Unit Production by Manufacturer by Program

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total 00-09
Corporation - ADVANCED ELCTRONICS COMPANY													
MSTAR	MAN-PORTABLE RADAR (SAUDI ARABIA)	0.045000	0	0	0	5	10	10	10	10	10	10	65
ADVANCED ELCTRONICS COMPANY			0	0	0	5	10	10	10	10	10	10	65
Corporation - ALENIA MARCONI SYSTEMS													
ALENIA RAT-31DL	AIR DEFENSE (TURKEY)	8.500000	0	0	0	0	0	0	0	0	0	0	0
ALENIA RAT-31DL	AIR DEFENSE (DENMARK)	8.500000	0	0	0	0	0	0	0	0	0	0	0
ALENIA RAT-31DL	AIR DEFENSE (VARIOUS)	8.500000	1	2	2	1	0	0	0	0	0	0	6
ALENIA RAT-31SL	AIR DEFENSE (ROYAL NORWEGIAN AF)	8.500000	3	0	0	0	0	0	0	0	0	0	3
ALENIA MARCONI SYSTEMS			4	2	2	1	0	0	0	0	0	0	9
Corporation - ALENIA-ELSAG													
EMPAR	DDG (ITALIAN NAVY)	12.000000	0	0	1	0	1	0	1	0	1	1	5
ORION	CVH/DD/FF/FAC-M (VARIOUS)	2.500000	16	12	12	12	12	0	0	0	0	0	64
ALENIA-ELSAG			16	12	13	12	13	0	1	0	1	1	69
Corporation - CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP													
CEIEC JY-8/8A	AIR DEFENSE (CHINA)	0.050000	0	0	0	0	0	0	0	0	0	0	0
CEIEC JY-8/8A	AIR DEFENSE (UNSPECIFIED)	0.050000	0	0	0	0	0	0	0	0	0	0	0
CEIEC-408C	AIR DEFENSE (ZIMBABWE)	1.000000	0	0	0	0	0	0	0	0	0	0	0
CEIEC-408C	AIR DEFENSE (UNSPECIFIED)	1.000000	0	0	0	0	0	0	0	0	0	0	0
CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP			0	0	0	0	0	0	0	0	0	0	0
Corporation - CONTRAVES													
SKYGUARD	AA FCS (VARIOUS)	4.000000	0	0	0	0	0	0	0	0	0	0	0
CONTRAVES			0	0	0	0	0	0	0	0	0	0	0
Corporation - DRS ELECTRONIC SYSTEMS INC													
SPS-67(V)3	F-100 MEKO FRIGATE (SPANISH NAVY)	0.300000	0	1	1	1	1	0	0	0	0	0	4
SPS-67(V)3	DD 21 DESTROYER (USN)	0.300000	0	0	0	1	0	1	2	1	3	2	10
SPS-67(V)3	DD 51 DESTROYER (USN)	0.300000	1	2	3	1	0	0	0	0	0	0	7
DRS ELECTRONIC SYSTEMS INC			1	3	4	3	1	1	2	1	3	2	21
Corporation - ERICSSON RADAR SYSTEMS AB													
ARTHUR	ARTILLERY LOCATION & FIRE CONTROL (SWEDISH & NORWEGIAN ARMIES)	6.000000	2	0	0	0	0	0	0	0	0	0	2
ARTHUR	ARTILLERY LOCATION & FIRE CONTROL (ROYAL DANISH ARMY)	6.000000	3	0	0	0	0	0	0	0	0	0	3
ARTHUR	ARTILLERY LOCATION & FIRE CONTROL (VARIOUS)	6.000000	0	0	2	2	2	0	0	0	0	0	6
GIRAFFE	AIR DEFENSE (SWEDEN)	2.500000	10	8	8	5	0	0	0	0	0	0	31
GIRAFFE	AIR DEFENSE (NORWAY)	2.500000	0	0	0	0	0	0	0	0	0	0	0
GIRAFFE	AIR DEFENSE (EXPORT)	2.500000	9	8	12	16	16	20	16	18	22	20	157
GIRAFFE	AIR DEFENSE (FINLAND)	2.500000	1	1	0	0	0	0	0	0	0	0	2
HARD	AIR DEFENSE (VARIOUS)	1.250000	1	1	0	0	0	0	0	0	0	0	2
HARD	AIR DEFENSE (GERMAN ARMY)	1.250000	2	4	4	0	0	0	0	0	0	0	10
SEA GIRAFFE	DD/FF/FFL/FAC-M (VARIOUS)	1.000000	2	2	2	2	2	2	2	0	0	0	14
SEA GIRAFFE	FF (AUSTRALIA)	1.000000	1	1	1	0	0	0	0	0	0	0	3
SEA GIRAFFE	FAC/FL/MCMV (SWEDEN)	1.000000	2	2	2	2	2	2	0	0	0	0	12
SEA GIRAFFE	FFG (NEW ZEALAND)	1.000000	0	0	0	0	0	1	0	0	0	0	1
ERICSSON RADAR SYSTEMS AB			33	27	31	27	22	25	18	18	22	20	243
Corporation - EURO-ART CONSORTIUM													
COBRA	COUNTER-BATTERY (FRANCE)	19.800000	2	2	2	4	0	0	0	0	0	0	10
COBRA	COUNTER-BATTERY (GERMANY)	19.800000	3	3	4	2	0	0	0	0	0	0	12
COBRA	COUNTER-BATTERY (UK)	19.800000	3	3	1	0	0	0	0	0	0	0	7
EURO-ART CONSORTIUM			8	8	7	6	0	0	0	0	0	0	29
Corporation - GEC PLC													
SEASPRAY	UNSPECIFIED (VARIOUS)	2.800000	10	10	8	11	10	10	9	9	8	6	91
SEASPRAY	P-37BRL (KUWAIT)	2.800000	2	0	0	0	0	0	0	0	0	0	2
MARTELLO	AIR DEFENSE (VARIOUS)	11.000000	0	0	0	1	2	2	2	2	3	2	14
MARTELLO	AIR DEFENSE (OMAN)	8.000000	2	3	2	0	0	0	0	0	0	0	7
GEC PLC			14	13	10	12	12	12	11	11	11	8	114
Corporation - INISEL													
ARINE	MAN-PORTABLE RADAR (SPAIN)	0.045000	30	30	0	0	0	0	0	0	0	0	60
INISEL			30	30	0	0	0	0	0	0	0	0	60
Corporation - ITT INDUSTRIES													
TLQ-32(V) ARM DECOY	DECOY SYSTEM (USAF)	0.800000	2	5	10	10	5	10	12	6	0	0	60
SPS-48E	LPD-17 (VARIOUS)	7.000000	2	2	2	2	2	0	0	0	0	0	10
ITT INDUSTRIES			4	7	12	12	7	10	12	6	0	0	70

(TABLE 1 - continued)

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total 00-09
Corporation - KELVIN HUGHES LTD													
TYPE 1007	COLLINS CLASS (AUSTRALIA)	0.600000	1	0	0	0	0	0	0	0	0	0	1
TYPE 1007	HUON CLASS (AUSTRALIA)	0.600000	2	1	1	0	0	0	0	0	0	0	4
TYPE 1007	TYPE 212 CLASS (GERMANY)	0.600000	0	1	0	1	1	1	0	0	1	0	5
TYPE 1007	KAKAP CLASS NAV V (INDONESIA)	0.600000	0	1	0	1	0	0	0	0	0	0	2
TYPE 1007	ASSAD CLASS (MALAYSIA)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	QAHIR CLASS (OMAN)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	BARZAN (VITA) CLASS (QATAR)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	SANDOWN CLASS (SAUDI ARABIA)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	SEGURA CLASS (SPAIN)	0.600000	2	0	0	0	0	0	0	0	0	0	2
TYPE 1007	CHAKRI NARUEBET CLASS (THAILAND)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	MODIFIED KHAMRONSIN CLASS (THAILAND)	0.600000	1	0	1	0	0	0	0	0	0	0	2
TYPE 1007	VANGUARD CLASS (UK)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	ASTUTE CLASS (UK)	0.600000	0	0	0	0	0	0	1	1	1	0	3
TYPE 1007	INVINCIBLE CLASS (UK)	0.600000	0	1	0	0	0	0	0	0	0	0	1
TYPE 1007	TYPE 23 (UK)	0.600000	1	1	0	0	0	0	0	0	0	0	2
TYPE 1007	OCEAN CLASS (LPH) (UK)	0.600000	0	0	0	0	0	0	0	0	0	0	0
TYPE 1007	ALBION CLASS (LPD) (UK)	0.600000	0	1	1	0	0	0	0	0	0	0	2
TYPE 1007	SANDOWN CLASS (MHC/SRMH) (UK)	0.600000	2	2	0	0	0	0	0	0	0	0	4
TYPE 1007	TYPE 45 DD (UK)	0.600000	0	0	0	0	0	0	0	1	0	2	3
KELVIN HUGHES LTD			9	8	3	2	1	1	1	2	2	2	31
Corporation - LOCKHEED MARTIN CORP													
JINDALEE	AIR DEFENSE (AUSTRALIA)	83.000000	0	0	0	0	0	0	0	0	0	0	0
WSR-88D (NEXRAD)	WEATHER RADAR (NWS, FAA, DOD)	2.250000	0	0	0	0	0	0	0	0	0	0	0
FPS-117(V)	AIR DEFENSE/ATC (VARIOUS)	8.200000	1	2	2	0	0	0	0	0	0	0	5
SPY-1D	DDG-51 (US NAVY)	20.000000	3	3	2	2	1	1	0	0	0	0	12
SPY-1D	DESTROYER (JAPAN)	20.000000	0	0	1	0	0	0	0	0	0	0	1
SPY-1D	A-200 FRIGATE (SPAIN)	20.000000	0	1	1	1	1	0	0	0	0	0	4
MARK 92 CORT	INTERNATIONAL FRIGATES (VARIOUS)	8.500000	0	0	0	0	0	0	0	0	0	0	0
LSDIS/PSTAR	BATTLEFIELD AIR SURVEILLANCE (VARIOUS FMS)	0.045000	8	12	0	0	0	0	0	0	0	0	20
LOCKHEED MARTIN CORP			12	18	6	3	2	1	0	0	0	0	42
Corporation - ML AVIATION LTD													
RAMPART	AIRFIELD DEFENSE (UNSPECIFIED)	0.100000	0	0	0	0	0	0	0	0	0	0	0
ML AVIATION LTD			0	0	0	0	0	0	0	0	0	0	0
Corporation - MOTOROLA INC													
CIDDS	COMBAT IDENTIFICATION (US ARMY, USMC)	0.001200	125	450	900	1200	1200	3500	2000	3500	3000	3500	19375
TSQ-179(V)	COMMAND & CONTROL (US ARMY)	11.700000	12	12	18	18	12	10	12	6	0	0	100
MOTOROLA INC			137	462	918	1218	1212	3510	2012	3506	3000	3500	19475
Corporation - NORTHROP GRUMMAN CORP													
SPQ-9B	SURFACE SHIPS (USN)	2.100000	3	4	6	12	15	10	6	0	0	0	56
SPS-67(V)	SURFACE SHIPS (VARIOUS)	0.250000	0	0	0	0	0	0	0	0	0	0	0
SPS-67(V)3	LPD-17 (USN)	0.250000	5	2	0	0	0	0	0	0	0	0	7
ASDE-3	AIRPORT SURFACE TRAFFIC CONTROL (FAA)	4.500000	0	0	0	0	0	0	0	0	0	0	0
TPQ-36(V) OCG UPGRADE	MORTAR/ARTILLERY LOCATION (US ARMY/USMC/FMS)	1.548500	0	2	6	10	0	0	0	0	0	0	18
TPQ-36(V)9	MORTAR/ARTILLERY LOCATION (EGYPTIAN ARMY)	1.548500	0	2	3	1	0	0	0	0	0	0	6
ARSR-4	EN-ROUTE AIR TRAFFIC CONTROL (FAA/USAF)	6.500000	0	0	0	0	0	0	0	0	0	0	0
ASR-12	AIR TRAFFIC CONTROL (VARIOUS)	3.700000	1	3	4	4	2	6	5	4	4	4	37
ASR-9	AIR TRAFFIC CONTROL (VARIOUS)	3.700000	0	0	0	0	0	0	0	0	0	0	0
TPS-63(V)/TPS-65	BATTLEFIELD SURVEILLANCE (VARIOUS)	5.000000	0	0	0	0	0	0	0	0	0	0	0
NORTHROP GRUMMAN CORP			9	13	19	27	17	16	11	4	4	4	124
Corporation - RACAL ELECTRONICS PLC													
CUTLASS/CYGNUS	DD/FF/FFL/FAC-M (VARIOUS)	4.000000	3	3	3	2	2	2	2	2	1	1	21
CUTLASS/SCORPION	FF (TURKEY)	4.000000	1	0	0	0	0	0	0	0	0	0	1
UAF-1 CUTLASS	DD/FF (UK)	4.000000	2	1	0	0	0	0	0	0	0	0	3
MSTAR	TRACER/FSCV (UK/US)	0.080000	0	12	20	22	30	30	30	30	30	30	234
RACAL ELECTRONICS PLC			6	16	23	24	32	32	32	32	31	31	259
Corporation - RAYTHEON CO													
COSSOR ATC SYSTEMS	ATC RADARS (UNSPECIFIED)	2.900000	2	3	3	4	4	4	4	4	4	0	32
COSSOR ATC SYSTEMS	ATC RADAR (DOD/FAA)	2.900000	19	19	19	19	19	19	19	19	19	0	171
COSSOR ATC SYSTEMS	ATC RADAR (CYPRUS)	0.750000	0	0	0	0	0	0	0	0	0	0	0
COSSOR ATC SYSTEMS	ATC RADAR (NORWAY)	2.900000	0	0	0	0	0	0	0	0	0	0	0
COSSOR ATC SYSTEMS	ATC RADAR (CHINA)	2.900000	0	0	0	0	0	0	0	0	0	0	0
COSSOR ATC SYSTEMS	ATC RADAR (AUSTRALIA)	0.750000	0	0	0	0	0	0	0	0	0	0	0
SPS-49(V)	SURFACE SHIP (USN)	3.700000	0	0	0	0	0	0	0	0	0	0	0
SPS-49(V)	SURFACE SHIP (CANADA)	3.700000	0	0	0	0	0	0	0	0	0	0	0
SPS-49(V)	SURFACE SHIP (TAIWAN)	3.700000	0	0	0	0	0	0	0	0	0	0	0
TDWR	ATC (FAA)	3.200000	0	0	0	0	0	0	0	0	0	0	0
TDWR	ATC (VARIOUS)	3.200000	0	0	0	0	0	0	0	0	0	0	0
MPQ-53(V)	BATTLEFIELD DEFENSE (ROK)	2.500000	2	4	6	2	0	0	0	0	0	0	14

(TABLE 1 - continued)

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total 00-09
Corporation - RAYTHEON CO (continued)													
MPQ-53(V)	BATTLEFIELD DEFENSE (VARIOUS)	2.500000	2	4	6	2	0	0	0	0	0	0	14
MULTI-FUNCTION RADAR	DD21, CVN 77 (USN)	4.200000	0	0	0	1	0	1	2	1	3	2	10
ASR-10 DASR	AIRPORT SURVEILLANCE (VARIOUS)	2.900000	2	0	0	0	0	0	0	0	0	0	2
ASR-11/GPN-30(V)	AIRPORT SURVEILLANCE (FAA, USAF, USN)	2.900000	6	12	20	24	24	36	30	12	12	12	188
ASR-23SS	ATC SURVEILLANCE (VARIOUS)	3.500000	3	0	0	0	0	0	0	0	0	0	3
ATCBI-6	SECONDARY SURVEILLANCE (FAA)	1.200000	12	20	24	36	24	8	0	0	0	0	124
ATNAVICS/FBPAR	TACTICAL AIR TRAFFIC CONTROL (US ARMY)	3.900000	10	24	20	8	6	4	0	0	0	0	72
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (US ARMY)	4.000000	11	3	0	0	0	0	0	0	0	0	14
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (VARIOUS NATO)	4.000000	10	6	6	0	0	0	0	0	0	0	22
PPN-20	LOCATOR TRANSPONDER (US ARMY & MARINE CORPS)	0.048000	25	10	5	0	0	0	0	0	0	0	40
SPS-73(V)	SURFACE SHIPS (USCG/USN)	0.085000	30	40	50	45	36	24	24	12	12	12	285
TPQ-47(V)	ARTILLERY LOCATION (US ARMY)	5.000000	2	0	3	6	10	15	12	14	10	10	82
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (AUSTRALIA)	2.900000	0	0	0	0	0	0	0	0	0	0	0
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (CHINA)	2.900000	4	0	0	0	0	0	0	0	0	0	4
SSR/MSSR ATC RADAR SERIES	ASR-11 DASR (DOD/FAA)	2.900000	5	5	15	35	35	35	35	35	0	0	200
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (JAMAICA)	2.900000	0	0	0	0	0	0	0	0	0	0	0
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (NETHERLANDS ANTILLES)	2.900000	0	0	0	0	0	0	0	0	0	0	0
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (DANISH ROYAL AIR FORCE)	2.900000	1	1	1	0	0	0	0	0	0	0	3
SSR/MSSR ATC RADAR SERIES	ATCBI-6 UPGRADE PROGRAM (FAA)	2.900000	15	15	15	15	15	15	15	15	15	0	135
RAYTHEON CO			161	166	193	197	173	161	141	112	75	36	1415
Corporation - SIEMENS PLESSEY SYSTEMS													
AWS-9	OSLO CLASS (NORWAY)	6.400000	0	0	0	0	0	0	0	0	0	0	0
AWS-9	BARBAROS CLASS (TURKEY)	6.400000	1	0	0	0	0	0	0	0	0	0	1
TYPE 996	DUKE CLASS (TYPE 23) (UK ROYAL NAVY)	6.400000	1	1	0	0	0	0	0	0	0	0	2
TYPE 996	OCEAN CLASS (LPH) (UK ROYAL NAVY)	6.400000	0	0	0	0	0	0	0	0	0	0	0
TYPE 996	ALBION CLASS ASSUALT SHIP (LPD) (UK ROYAL NAVY)	6.400000	1	1	0	0	0	0	0	0	0	0	2
WATCHMAN	SURVEILLANCE/ATC RADAR (VARIOUS)	2.500000	0	0	1	1	1	0	0	0	0	0	3
SAMPSON	TYPE 45 DESTROYER (UK)	15.000000	0	0	0	0	1	2	3	2	0	0	8
SAMPSON	TYPE 23 FRIGATE (UK)	15.000000	2	2	2	2	2	2	2	2	2	0	18
SAMPSON	DDG/FFG (VARIOUS)	15.000000	0	0	0	1	2	1	2	1	1	1	9
SIEMENS PLESSEY SYSTEMS			5	4	3	4	6	5	7	5	3	1	43
Corporation - SYSTEMS & ELECTRONICS (SEI)													
AN/PPS-5C	STRIKER II (VARIOUS)	0.045000	0	0	0	0	0	20	20	20	20	20	100
AN/PPS-5C	STRIKER II (US)	0.045000	13	13	0	0	30	30	30	30	30	30	206
SYSTEMS & ELECTRONICS (SEI)			13	13	0	0	30	50	50	50	50	50	306
Corporation - THOMSON-CSF													
JUPITER	FF (SAUDI ARABIA)	8.000000	1	0	0	0	0	0	0	0	0	0	1
ARABEL	CV/DD/FF (FRANCE)	13.000000	2	1	1	0	0	0	0	0	0	0	4
ARABEL	GROUND-BASED RADAR (FRENCH ARMY)	13.000000	6	10	10	10	10	9	0	0	0	0	55
ARABEL	HORIZON (FRANCE)	13.000000	0	0	1	0	0	1	0	0	0	0	2
ARABEL	SAWARI 2 (SAUDI ARABIA)	13.000000	0	0	0	0	0	0	0	0	0	0	0
ARABEL	GROUND-BASED RADAR (ITALIAN ARMY)	13.000000	4	7	7	7	7	7	0	0	0	0	39
CASTOR 2B/C/J	DDG (CHINA)	1.000000	1	1	0	0	0	0	0	0	0	0	2
FLAIR TRS-2140	AIR SURVEILLANCE (VARIOUS)	4.500000	3	4	5	4	2	3	2	2	2	0	27
GERFAUT	AIR DEFENSE (VARIOUS)	0.210000	20	10	6	0	0	0	0	0	0	0	36
GERFAUT ADAS	AIR DEFENSE (SWEDEN)	0.210000	0	0	0	0	0	0	0	0	0	0	0
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (TURKEY)	11.000000	0	0	0	0	0	0	0	0	0	0	0
TRS 22XX	AIR DEFENSE (FRANCE)	11.000000	0	0	0	0	0	0	0	0	0	0	0
TRS 22XX	AIR-DEFENSE (KUWAIT)	11.000000	1	0	0	0	0	0	0	0	0	0	1
SIGNAAL APAR	DD/FFG (CANADIAN NAVY)	9.600000	0	0	3	3	3	3	0	0	0	0	12
SIGNAAL APAR	FFG (GERMAN NAVY)	9.600000	1	1	1	1	0	0	0	0	0	0	4
SIGNAAL APAR	FFG (RNLN)	9.600000	0	1	1	1	1	0	0	0	0	0	4
SIGNAAL APAR	DDG/FFG (ROYAL AUSTRALIAN NAVY)	9.600000	0	0	2	2	2	2	0	0	0	0	8
SIGNAAL APAR	DDG/FFG (EXPORT)	9.600000	0	0	0	1	1	2	2	2	0	0	8
SIGNAAL DA.08	MEKO-200HN (GREECE)	6.000000	1	0	0	0	0	0	0	0	0	0	1
SIGNAAL LW.08	CVL/DD/FF (INDIAN NAVY)	8.000000	1	0	0	0	0	0	0	0	0	0	1
SIGNAAL MW.08	FFG (SOUTH KOREA)	6.000000	1	1	1	1	1	1	0	0	0	0	6
SIGNAAL SMART	FFG (DE ZEVEN PROVINCIEN) (RNLN)	12.500000	1	0	0	1	1	0	1	0	0	0	4
SIGNAAL SMART	FFG (GERMAN NAVY)	12.500000	0	1	0	1	1	1	0	0	0	0	4
SIGNAAL STING	FFG (SPAIN)	2.500000	1	0	1	1	0	0	0	0	0	0	3
SIGNAAL STIR	DD/FF (CANADA)	2.000000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	FF (GREECE)	2.000000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	FFG/FAC-M (TURKEY)	2.000000	0	0	0	0	0	0	0	0	0	0	0
SIGNAAL STIR	FF (SOUTH KOREA)	2.000000	2	2	2	2	2	0	0	0	0	0	10
SIGNAAL STIR	FFL (OMAN)	2.000000	0	0	0	0	0	0	0	0	0	0	0
WM-20 FCS	UPGRADES (VARIOUS)	1.000000	7	6	5	4	4	4	3	3	3	2	41
T-1850L "SMARTELLO"	CNGF HORIZON (FRANCE)	12.500000	0	0	1	0	0	1	0	0	0	0	2

(TABLE 1 - continued)

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total 00-09
Corporation - THOMSON-CSF (continued)													
T-1850L "SMARTELLO"	CNGF HORIZON (ITALIAN NAVY)	12.500000	0	0	1	0	1	0	1	0	0	0	3
T-1850L "SMARTELLO"	TYPE 45 DESTROYER (UKRN)	12.500000	0	1	2	3	3	3	3	0	0	0	15
RASIT	BATTLEFIELD SURVEILLANCE (VARIOUS)	0.350000	0	0	0	0	0	0	0	0	0	0	0
RB-12	MAN-PORTABLE RADAR (UNSPECIFIED)	0.060000	12	12	8	8	8	4	4	4	4	0	64
THOMSON-CSF			65	58	58	50	47	41	16	11	9	2	357
Corporation - TO BE SELECTED													
VOLUME SEARCH RADAR	SURFACE SHIPS (NON-AEGIS) (USN)	10.000000	0	0	0	1	0	1	2	1	3	2	10
TO BE SELECTED			0	0	0	1	0	1	2	1	3	2	10
Corporation - TRW													
BCIS (VSX-3(V))	COMBAT VEHICLE PROTECTION (US ARMY, USMC)	0.014000	40	75	125	250	300	300	400	500	600	500	3090
TRW			40	75	125	250	300	300	400	500	600	500	3090
Corporation - UNITED TECHNOLOGIES CORP/SPERRY MARINE													
BPS-15H/J/16(V)	SUBMARINES (US NAVY)	5.000000	2	4	4	2	0	3	2	0	0	0	17
UNITED TECHNOLOGIES CORP/SPERRY MARINE			2	4	4	2	0	3	2	0	0	0	17
Printout Total -			569	939	1431	1856	1885	4179	2728	4269	3824	4169	25849

(TABLE 1 - end)

Table 2
The Market for Surface Radar Systems
Value of Production by Manufacturer by Program

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL 00-00	TOTAL 05-09	TOTAL 00-09
Corporation - ADVANCED ELCTRONICS COMPANY															
MSTAR	MAN-PORTABLE RADAR (SAUDI ARABIA)	0.04500	0.00	0.00	0.00	0.23	0.45	0.45	0.45	0.45	0.45	0.45	0.68	2.250	2.925
ADVANCED ELCTRONICS COMPANY			0.00	0.00	0.00	0.23	0.45	0.45	0.45	0.45	0.45	0.45	0.68	2.250	2.925
Corporation - ALENIA MARCONI SYSTEMS															
ALENIA RAT-31DL	AIR DEFENSE (TURKEY)	8.50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
ALENIA RAT-31DL	AIR DEFENSE (DENMARK)	8.50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
ALENIA RAT-31DL	AIR DEFENSE (VARIOUS)	8.50000	8.50	17.00	17.00	8.50	0.00	0.00	0.00	0.00	0.00	0.00	51.00	0.000	51.000
ALENIA RAT-31SL	AIR DEFENSE (ROYAL NORWEGIAN AF)	8.50000	25.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.50	0.000	25.500
ALENIA MARCONI SYSTEMS			34.00	17.00	17.00	8.50	0.00	0.00	0.00	0.00	0.00	0.00	76.50	0.000	76.500
Corporation - ALENIA-ELSAG															
EMPAR	DDG (ITALIAN NAVY)	12.00000	0.00	0.00	12.00	0.00	12.00	0.00	12.00	0.00	12.00	12.00	24.00	36.000	60.000
ORION	CVH/DD/FF/FAC-M (VARIOUS)	2.50000	40.00	30.00	30.00	30.00	30.00	0.00	0.00	0.00	0.00	0.00	160.00	0.000	160.000
ALENIA-ELSAG			40.00	30.00	42.00	30.00	42.00	0.00	12.00	0.00	12.00	12.00	184.00	36.000	220.000
Corporation - CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP															
CEIEC JY-8/8A	AIR DEFENSE (CHINA)	0.05000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
CEIEC JY-8/8A	AIR DEFENSE (UNSPECIFIED)	0.05000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
CEIEC-408C	AIR DEFENSE (ZIMBABWE)	1.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
CEIEC-408C	AIR DEFENSE (UNSPECIFIED)	1.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
CHINA NAT'L ELECTRONICS IMPORT & EXPORT CORP			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
Corporation - CONTRAVES															
SKYGUARD	AA FCS (VARIOUS)	4.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
CONTRAVES			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
Corporation - DRS ELECTRONIC SYSTEMS INC															
SPS-67(V)3	F-100 MEKO FRIGATE (SPANISH NAVY)	0.30000	0.00	0.30	0.30	0.30	0.30	0.00	0.00	0.00	0.00	0.00	1.20	0.000	1.200
SPS-67(V)3	DD 21 DESTROYER (USN)	0.30000	0.00	0.00	0.00	0.30	0.00	0.30	0.60	0.30	0.90	0.60	0.30	2.700	3.000
SPS-67(V)3	DD 51 DESTROYER (USN)	0.30000	0.30	0.60	0.90	0.30	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.000	2.100
DRS ELECTRONIC SYSTEMS INC			0.30	0.90	1.20	0.90	0.30	0.30	0.60	0.30	0.90	0.60	3.60	2.700	6.300
Corporation - ERICSSON RADAR SYSTEMS AB															
ARTHUR	ARTILLERY LOCATION & FIRE CONTROL (SWEDISH & NORWEGIAN ARMIES)	6.00000	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	0.000	12.000
ARTHUR	ARTILLERY LOCATION & FIRE CONTROL (ROYAL DANISH ARMY)	6.00000	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00	0.000	18.000
ARTHUR	ARTILLERY LOCATION & FIRE CONTROL (VARIOUS)	6.00000	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00	0.00	0.00	36.00	0.000	36.000
GIRAFFE	AIR DEFENSE (SWEDEN)	2.50000	25.00	20.00	20.00	12.50	0.00	0.00	0.00	0.00	0.00	0.00	77.50	0.000	77.500
GIRAFFE	AIR DEFENSE (NORWAY)	2.50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
GIRAFFE	AIR DEFENSE (EXPORT)	2.50000	22.50	20.00	30.00	40.00	40.00	50.00	40.00	45.00	55.00	50.00	152.50	240.000	392.500
GIRAFFE	AIR DEFENSE (FINLAND)	2.50000	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.000	5.000
HARD	AIR DEFENSE (VARIOUS)	1.25000	1.25	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.000	2.500
HARD	AIR DEFENSE (GERMAN ARMY)	1.25000	2.50	5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50	0.000	12.500
SEA GIRAFFE	DD/FF/FFL/FAC-M (VARIOUS)	1.00000	2.00	2.00	2.00	2.00	2.00	2.00	2.00	0.00	0.00	0.00	10.00	4.000	14.000
SEA GIRAFFE	FF (AUSTRALIA)	1.00000	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.000	3.000
SEA GIRAFFE	FAC/FL/MCMV (SWEDEN)	1.00000	2.00	2.00	2.00	2.00	2.00	2.00	0.00	0.00	0.00	0.00	10.00	2.000	12.000
SEA GIRAFFE	FFG (NEW ZEALAND)	1.00000	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.000	1.000
ERICSSON RADAR SYSTEMS AB			88.75	53.75	72.00	68.50	56.00	55.00	42.00	45.00	55.00	50.00	339.00	247.000	586.000
Corporation - EURO-ART CONSORTIUM															
COBRA	COUNTER-BATTERY (FRANCE)	19.80000	39.60	39.60	39.60	79.20	0.00	0.00	0.00	0.00	0.00	0.00	198.00	0.000	198.000
COBRA	COUNTER-BATTERY (GERMANY)	19.80000	59.40	59.40	79.20	39.60	0.00	0.00	0.00	0.00	0.00	0.00	237.60	0.000	237.600
COBRA	COUNTER-BATTERY (UK)	19.80000	59.40	59.40	19.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	138.60	0.000	138.600
EURO-ART CONSORTIUM			158.40	158.40	138.60	118.80	0.00	0.00	0.00	0.00	0.00	0.00	574.20	0.000	574.200

(TABLE 2 - continued)

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL 00-00	TOTAL 05-09	TOTAL 00-09
Corporation - GEC PLC															
SEASPRAY	UNSPECIFIED (VARIOUS)	2.80000	28.00	28.00	22.40	30.80	28.00	28.00	25.20	25.20	22.40	16.80	137.20	117.600	254.800
SEASPRAY	P-37BRL (KUWAIT)	2.80000	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60	0.000	5.600
MARTELLO	AIR DEFENSE (VARIOUS)	11.00000	0.00	0.00	0.00	11.00	22.00	22.00	22.00	22.00	33.00	22.00	33.00	121.000	154.000
MARTELLO	AIR DEFENSE (OMAN)	8.00000	16.00	24.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.00	0.000	56.000
GEC PLC			49.60	52.00	38.40	41.80	50.00	50.00	47.20	47.20	55.40	38.80	231.80	238.600	470.400
Corporation - INISEL															
ARINE	MAN-PORTABLE RADAR (SPAIN)	0.04500	1.35	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	0.000	2.700
INISEL			1.35	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	0.000	2.700
Corporation - ITT INDUSTRIES															
TLQ-32(V) ARM DECOY	DECOY SYSTEM (USAF)	0.80000	1.60	4.00	8.00	8.00	4.00	8.00	9.60	4.80	0.00	0.00	25.60	22.400	48.000
SPS-48E	LPD-17 (VARIOUS)	7.00000	14.00	14.00	14.00	14.00	14.00	0.00	0.00	0.00	0.00	0.00	70.00	0.000	70.000
ITT INDUSTRIES			15.60	18.00	22.00	22.00	18.00	8.00	9.60	4.80	0.00	0.00	95.60	22.400	118.000
Corporation - KELVIN HUGHES LTD															
TYPE 1007	COLLINS CLASS (AUSTRALIA)	0.60000	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.000	0.600
TYPE 1007	HUON CLASS (AUSTRALIA)	0.60000	1.20	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.000	2.400
TYPE 1007	TYPE 212 CLASS (GERMANY)	0.60000	0.00	0.60	0.00	0.60	0.60	0.60	0.00	0.00	0.60	0.00	1.80	1.200	3.000
TYPE 1007	KAKAP CLASS NAV V (INDONESIA)	0.60000	0.00	0.60	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.000	1.200
TYPE 1007	ASSAD CLASS (MALAYSIA)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	QAHIR CLASS (OMAN)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	BARZAN (VITA) CLASS (QATAR)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	SANDOWN CLASS (SAUDI ARABIA)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	SEGURA CLASS (SPAIN)	0.60000	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.000	1.200
TYPE 1007	CHAKRI NARUEBET CLASS (THAILAND)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	MODIFIED KHAMRONSIN CLASS (THAILAND)	0.60000	0.60	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.000	1.200
TYPE 1007	VANGUARD CLASS (UK)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	ASTUTE CLASS (UK)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.60	0.60	0.00	0.00	1.800	1.800
TYPE 1007	INVINCIBLE CLASS (UK)	0.60000	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.000	0.600
TYPE 1007	TYPE 23 (UK)	0.60000	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.000	1.200
TYPE 1007	OCEAN CLASS (LPH) (UK)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 1007	ALBION CLASS (LPD) (UK)	0.60000	0.00	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.000	1.200
TYPE 1007	SANDOWN CLASS (MHC/SRMH) (UK)	0.60000	1.20	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.000	2.400
TYPE 1007	TYPE 45 DD (UK)	0.60000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	1.20	0.00	1.800	1.800
KELVIN HUGHES LTD			5.40	4.80	1.80	1.20	0.60	0.60	0.60	1.20	1.20	1.20	13.80	4.800	18.600
Corporation - LOCKHEED MARTIN CORP															
JINDALEE	AIR DEFENSE (AUSTRALIA)	83.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
WSR-88D (NEXRAD)	WEATHER RADAR (NWS, FAA, DOD)	2.25000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
FPS-117(V)	AIR DEFENSE/ATC (VARIOUS)	8.20000	8.20	16.40	16.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.00	0.000	41.000
SPY-1D	DDG-51 (US NAVY)	20.00000	60.00	60.00	40.00	40.00	20.00	20.00	0.00	0.00	0.00	0.00	220.00	20.000	240.000
SPY-1D	DESTROYER (JAPAN)	20.00000	0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.000	20.000
SPY-1D	A-200 FRIGATE (SPAIN)	20.00000	0.00	20.00	20.00	20.00	20.00	0.00	0.00	0.00	0.00	0.00	80.00	0.000	80.000
MARK 92 CORT	INTERNATIONAL FRIGATES (VARIOUS)	8.50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
LSDIS/PSTAR	BATTLEFIELD AIR SURVEILLANCE (VARIOUS FMS)	0.04500	0.36	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.000	0.900
LOCKHEED MARTIN CORP			68.56	96.94	96.40	60.00	40.00	20.00	0.00	0.00	0.00	0.00	361.90	20.000	381.900
Corporation - ML AVIATION LTD															
RAMPART	AIRFIELD DEFENSE (UNSPECIFIED)	0.10000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
ML AVIATION LTD			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
Corporation - MOTOROLA INC															
CIDDS	COMBAT IDENTIFICATION (US ARMY, USMC)	0.00120	0.15	0.54	1.08	1.44	1.44	4.20	2.40	4.20	3.60	4.20	4.65	18.600	23.250
TSQ-179(V)	COMMAND & CONTROL (US ARMY)	11.70000	140.40	140.40	210.60	210.60	140.40	117.00	140.40	70.20	0.00	0.00	842.40	327.600	1170.000
MOTOROLA INC			140.55	140.94	211.68	212.04	141.84	121.20	142.80	74.40	3.60	4.20	847.05	346.200	1193.250
Corporation - NORTHROP GRUMMAN CORP															
SPQ-9B	SURFACE SHIPS (USN)	2.10000	6.30	8.40	12.60	25.20	31.50	21.00	12.60	0.00	0.00	0.00	84.00	33.600	117.600
SPS-67(V)	SURFACE SHIPS (VARIOUS)	0.25000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SPS-67(V)3	LPD-17 (USN)	0.25000	1.25	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.000	1.750
ASDE-3	AIRPORT SURFACE TRAFFIC CONTROL (FAA)	4.50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000

(TABLE 2 - continued)

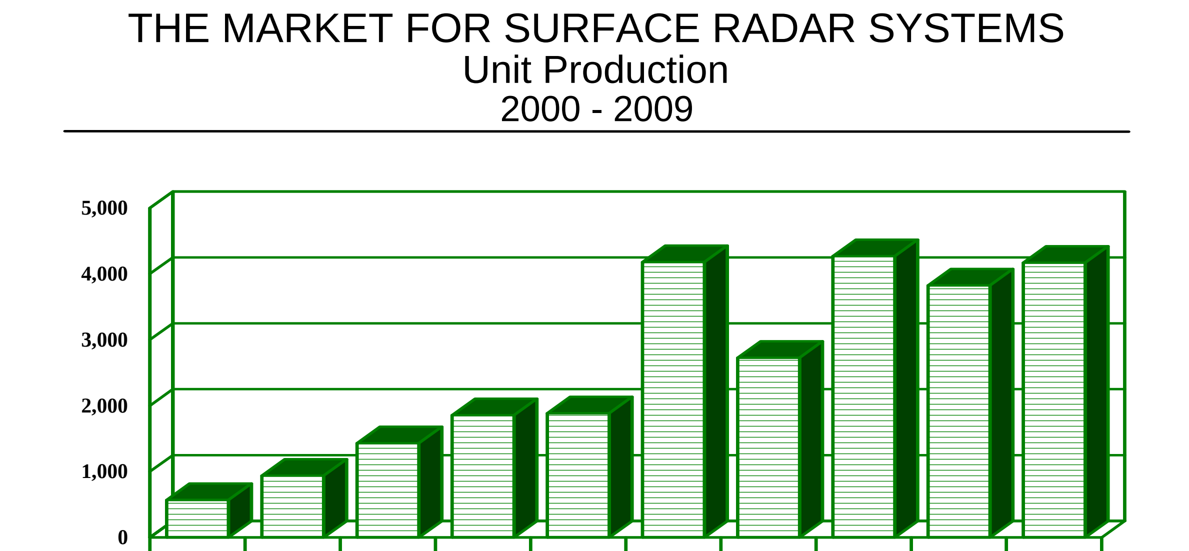
Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL 00-00	TOTAL 05-09	TOTAL 00-09
Corporation - NORTHROP GRUMMAN CORP (continued)															
TPQ-36(V) OCG UPGRADE	MORTAR/ARTILLERY LOCATION (US ARMY/USMC/FMS)	1.54850	0.00	3.10	9.29	15.49	0.00	0.00	0.00	0.00	0.00	0.00	27.87	0.000	27.873
TPQ-36(V)9	MORTAR/ARTILLERY LOCATION (EGYPTIAN ARMY)	1.54850	0.00	3.10	4.65	1.55	0.00	0.00	0.00	0.00	0.00	0.00	9.29	0.000	9.291
ARSR-4	EN-ROUTE AIR TRAFFIC CONTROL (FAA/USAF)	6.50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
ASR-12	AIR TRAFFIC CONTROL (VARIOUS)	3.70000	3.70	11.10	14.80	14.80	7.40	22.20	18.50	14.80	14.80	14.80	51.80	85.100	136.900
ASR-9	AIR TRAFFIC CONTROL (VARIOUS)	3.70000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TPS-63(V)/TPS-65	BATTLEFIELD SURVEILLANCE (VARIOUS)	5.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
NORTHROP GRUMMAN CORP			11.25	26.19	41.34	57.03	38.90	43.20	31.10	14.80	14.80	14.80	174.71	118.700	293.414
Corporation - RACAL ELECTRONICS PLC															
CUTLASS/CYGNUS	DD/FF/FFL/FAC-M (VARIOUS)	4.00000	12.00	12.00	12.00	8.00	8.00	8.00	8.00	8.00	4.00	4.00	52.00	32.000	84.000
CUTLASS/SCORPION	FF (TURKEY)	4.00000	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.000	4.000
UAF-1 CUTLASS	DD/FF (UK)	4.00000	8.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	0.000	12.000
MSTAR	TRACER/FSCV (UK/US)	0.08000	0.00	0.96	1.60	1.76	2.40	2.40	2.40	2.40	2.40	2.40	6.72	12.000	18.720
RACAL ELECTRONICS PLC			24.00	16.96	13.60	9.76	10.40	10.40	10.40	10.40	6.40	6.40	74.72	44.000	118.720
Corporation - RAYTHEON CO															
COSSOR ATC SYSTEMS	ATC RADARS (UNSPECIFIED)	2.90000	5.80	8.70	8.70	11.60	11.60	11.60	11.60	11.60	11.60	0.00	46.40	46.400	92.800
COSSOR ATC SYSTEMS	ATC RADAR (DOD/FAA)	2.90000	55.10	55.10	55.10	55.10	55.10	55.10	55.10	55.10	55.10	0.00	275.50	220.400	495.900
COSSOR ATC SYSTEMS	ATC RADAR (CYPRUS)	0.75000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
COSSOR ATC SYSTEMS	ATC RADAR (NORWAY)	2.90000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
COSSOR ATC SYSTEMS	ATC RADAR (CHINA)	2.90000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
COSSOR ATC SYSTEMS	ATC RADAR (AUSTRALIA)	0.75000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SPS-49(V)	SURFACE SHIP (USN)	3.70000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SPS-49(V)	SURFACE SHIP (CANADA)	3.70000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SPS-49(V)	SURFACE SHIP (TAIWAN)	3.70000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TDWR	ATC (FAA)	3.20000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TDWR	ATC (VARIOUS)	3.20000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
MPQ-53(V)	BATTLEFIELD DEFENSE (ROK)	2.50000	5.00	10.00	15.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	35.00	0.000	35.000
MPQ-53(V)	BATTLEFIELD DEFENSE (VARIOUS)	2.50000	5.00	10.00	15.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	35.00	0.000	35.000
MULTI-FUNCTION RADAR	DD21, CVN 77 (USN)	4.20000	0.00	0.00	0.00	4.20	0.00	4.20	8.40	4.20	12.60	8.40	4.20	37.800	42.000
ASR-10 DASR	AIRPORT SURVEILLANCE (VARIOUS)	2.90000	5.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.80	0.000	5.800
ASR-11/GPN-30(V)	AIRPORT SURVEILLANCE (FAA, USAF, USN)	2.90000	17.40	34.80	58.00	69.60	69.60	104.40	87.00	34.80	34.80	34.80	249.40	295.800	545.200
ASR-23SS	ATC SURVEILLANCE (VARIOUS)	3.50000	10.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.50	0.000	10.500
ATCBI-6	SECONDARY SURVEILLANCE (FAA)	1.20000	14.40	24.00	28.80	43.20	28.80	9.60	0.00	0.00	0.00	0.00	139.20	9.600	148.800
ATNAVICS/FBPAR	TACTICAL AIR TRAFFIC CONTROL (US ARMY)	3.90000	39.00	93.60	78.00	31.20	23.40	15.60	0.00	0.00	0.00	0.00	265.20	15.600	280.800
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (US ARMY)	4.00000	44.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.00	0.000	56.000
MPQ-64 (FAADS GBS)	BATTLEFIELD AIR DEFENSE SENSOR (VARIOUS NATO)	4.00000	40.00	24.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	88.00	0.000	88.000
PPN-20	LOCATOR TRANSPONDER (US ARMY & MARINE CORPS)	0.04800	1.20	0.48	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.92	0.000	1.920
SPS-73(V)	SURFACE SHIPS (USCG/USN)	0.08500	2.55	3.40	4.25	3.83	3.06	2.04	2.04	1.02	1.02	1.02	17.09	7.140	24.225
TPQ-47(V)	ARTILLERY LOCATION (US ARMY)	5.00000	10.00	0.00	15.00	30.00	50.00	75.00	60.00	70.00	50.00	50.00	105.00	305.000	410.000
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (AUSTRALIA)	2.90000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (CHINA)	2.90000	11.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.60	0.000	11.600
SSR/MSSR ATC RADAR SERIES	ASR-11 DASR (DOD/FAA)	2.90000	14.50	14.50	43.50	101.50	101.50	101.50	101.50	101.50	0.00	0.00	275.50	304.500	580.000
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (JAMAICA)	2.90000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (NETHERLANDS ANTILLES)	2.90000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SSR/MSSR ATC RADAR SERIES	MKII ATC RADAR (DANISH ROYAL AIR FORCE)	2.90000	2.90	2.90	2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.70	0.000	8.700
SSR/MSSR ATC RADAR SERIES	ATCBI-6 UPGRADE PROGRAM (FAA)	2.90000	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	0.00	217.50	174.000	391.500
RAYTHEON CO			328.25	336.98	391.99	403.73	386.56	422.54	369.14	321.72	208.62	94.22	1847.51	1416.240	3263.745
Corporation - SIEMENS PLESSEY SYSTEMS															
AWS-9	OSLO CLASS (NORWAY)	6.40000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
AWS-9	BARBAROS CLASS (TURKEY)	6.40000	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.40	0.000	6.400
TYPE 996	DUKE CLASS (TYPE 23) (UK ROYAL NAVY)	6.40000	6.40	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.80	0.000	12.800

(TABLE 2 - continued)

Program	Application (Operator)	Unit Cost (MM)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL 00-00	TOTAL 05-09	TOTAL 00-09
Corporation - SIEMENS PLESSEY SYSTEMS (continued)															
TYPE 996	OCEAN CLASS (LPH) (UK ROYAL NAVY)	6.40000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TYPE 996	ALBION CLASS ASSUALT SHIP (LPD) (UK ROYAL NAVY)	6.40000	6.40	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.80	0.000	12.800
WATCHMAN	SURVEILLANCE/ATC RADAR (VARIOUS)	2.50000	0.00	0.00	2.50	2.50	2.50	0.00	0.00	0.00	0.00	0.00	7.50	0.000	7.500
SAMPSON	TYPE 45 DESTROYER (UK)	15.00000	0.00	0.00	0.00	0.00	15.00	30.00	45.00	30.00	0.00	0.00	15.00	105.000	120.000
SAMPSON	TYPE 23 FRIGATE (UK)	15.00000	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	0.00	150.00	120.000	270.000
SAMPSON	DDG/FFG (VARIOUS)	15.00000	0.00	0.00	0.00	15.00	30.00	15.00	30.00	15.00	15.00	15.00	45.00	90.000	135.000
SIEMENS PLESSEY SYSTEMS			49.20	42.80	32.50	47.50	77.50	75.00	105.00	75.00	45.00	15.00	249.50	315.000	564.500
Corporation - SYSTEMS & ELECTRONICS (SEI)															
AN/PPS-5C	STRIKER II (VARIOUS)	0.04500	0.00	0.00	0.00	0.00	0.00	0.90	0.90	0.90	0.90	0.90	0.00	4.500	4.500
AN/PPS-5C	STRIKER II (US)	0.04500	0.59	0.59	0.00	0.00	1.35	1.35	1.35	1.35	1.35	1.35	2.52	6.750	9.270
SYSTEMS & ELECTRONICS (SEI)			0.59	0.59	0.00	0.00	1.35	2.25	2.25	2.25	2.25	2.25	2.52	11.250	13.770
Corporation - THOMSON-CSF															
JUPITER	FF (SAUDI ARABIA)	8.00000	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	0.000	8.000
ARABEL	CV/DD/FF (FRANCE)	13.00000	26.00	13.00	13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.00	0.000	52.000
ARABEL	GROUND-BASED RADAR (FRENCH ARMY)	13.00000	78.00	130.00	130.00	130.00	130.00	117.00	0.00	0.00	0.00	0.00	598.00	117.000	715.000
ARABEL	HORIZON (FRANCE)	13.00000	0.00	0.00	13.00	0.00	0.00	13.00	0.00	0.00	0.00	0.00	13.00	13.000	26.000
ARABEL	SAWARI 2 (SAUDI ARABIA)	13.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
ARABEL	GROUND-BASED RADAR (ITALIAN ARMY)	13.00000	52.00	91.00	91.00	91.00	91.00	91.00	0.00	0.00	0.00	0.00	416.00	91.000	507.000
CASTOR 2B/C/J	DDG (CHINA)	1.00000	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.000	2.000
FLAIR TRS-2140	AIR SURVEILLANCE (VARIOUS)	4.50000	13.50	18.00	22.50	18.00	9.00	13.50	9.00	9.00	9.00	0.00	81.00	40.500	121.500
GERFAUT	AIR DEFENSE (VARIOUS)	0.21000	4.20	2.10	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.56	0.000	7.560
GERFAUT ADAS	AIR DEFENSE (SWEDEN)	0.21000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
THOMSON-CSF 3D ADGE RADAR	AIR DEFENSE (TURKEY)	11.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TRS 22XX	AIR DEFENSE (FRANCE)	11.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
TRS 22XX	AIR-DEFENSE (KUWAIT)	11.00000	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	0.000	11.000
SIGNAAL APAR	DD/FFG (CANADIAN NAVY)	9.60000	0.00	0.00	28.80	28.80	28.80	28.80	0.00	0.00	0.00	0.00	86.40	28.800	115.200
SIGNAAL APAR	FFG (GERMAN NAVY)	9.60000	9.60	9.60	9.60	9.60	0.00	0.00	0.00	0.00	0.00	0.00	38.40	0.000	38.400
SIGNAAL APAR	FFG (RNLN)	9.60000	0.00	9.60	9.60	9.60	9.60	0.00	0.00	0.00	0.00	0.00	38.40	0.000	38.400
SIGNAAL APAR	DDG/FFG (ROYAL AUSTRALIAN NAVY)	9.60000	0.00	0.00	19.20	19.20	19.20	19.20	0.00	0.00	0.00	0.00	57.60	19.200	76.800
SIGNAAL APAR	DDG/FFG (EXPORT)	9.60000	0.00	0.00	0.00	9.60	9.60	19.20	19.20	19.20	0.00	0.00	19.20	57.600	76.800
SIGNAAL DA.08	MEKO-200HN (GREECE)	6.00000	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.000	6.000
SIGNAAL LW.08	CVL/DD/FF (INDIAN NAVY)	8.00000	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	0.000	8.000
SIGNAAL MW.08	FFG (SOUTH KOREA)	6.00000	6.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	0.00	30.00	6.000	36.000
SIGNAAL SMART	FFG (DE ZEVEN PROVINCIEN) (RNLN)	12.50000	12.50	0.00	0.00	12.50	12.50	0.00	12.50	0.00	0.00	0.00	37.50	12.500	50.000
SIGNAAL SMART	FFG (GERMAN NAVY)	12.50000	0.00	12.50	0.00	12.50	12.50	12.50	0.00	0.00	0.00	0.00	37.50	12.500	50.000
SIGNAAL STING	FFG (SPAIN)	2.50000	2.50	0.00	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	7.50	0.000	7.500
SIGNAAL STIR	DD/FF (CANADA)	2.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SIGNAAL STIR	FF (GREECE)	2.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SIGNAAL STIR	FFG/FAC-M (TURKEY)	2.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
SIGNAAL STIR	FF (SOUTH KOREA)	2.00000	4.00	4.00	4.00	4.00	4.00	0.00	0.00	0.00	0.00	0.00	20.00	0.000	20.000
SIGNAAL STIR	FFL (OMAN)	2.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
WM-20 FCS	UPGRADES (VARIOUS)	1.00000	7.00	6.00	5.00	4.00	4.00	4.00	3.00	3.00	3.00	2.00	26.00	15.000	41.000
T-1850L "SMARTELLO"	CNGF HORIZON (FRANCE)	12.50000	0.00	0.00	12.50	0.00	0.00	12.50	0.00	0.00	0.00	0.00	12.50	12.500	25.000
T-1850L "SMARTELLO"	CNGF HORIZON (ITALIAN NAVY)	12.50000	0.00	0.00	12.50	0.00	12.50	0.00	12.50	0.00	0.00	0.00	25.00	12.500	37.500
T-1850L "SMARTELLO"	TYPE 45 DESTROYER (UKRN)	12.50000	0.00	12.50	25.00	37.50	37.50	37.50	37.50	0.00	0.00	0.00	112.50	75.000	187.500
RASIT	BATTLEFIELD SURVEILLANCE (VARIOUS)	0.35000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
RB-12	MAN-PORTABLE RADAR (UNSPECIFIED)	0.06000	0.72	0.72	0.48	0.48	0.48	0.24	0.24	0.24	0.24	0.00	2.88	0.960	3.840
THOMSON-CSF			250.02	316.02	405.94	395.28	386.68	374.44	93.94	31.44	12.24	2.00	1753.94	514.060	2268.000
Corporation - TO BE SELECTED															
VOLUME SEARCH RADAR	SURFACE SHIPS (NON-AEGIS) (USN)	10.00000	0.00	0.00	0.00	10.00	0.00	10.00	20.00	10.00	30.00	20.00	10.00	90.000	100.000
TO BE SELECTED			0.00	0.00	0.00	10.00	0.00	10.00	20.00	10.00	30.00	20.00	10.00	90.000	100.000
Corporation - TRW															
BCIS (VSX-3(V))	COMBAT VEHICLE PROTECTION (US ARMY, USMC)	0.01400	0.56	1.05	1.75	3.50	4.20	4.20	5.60	7.00	8.40	7.00	11.06	32.200	43.260
TRW			0.56	1.05	1.75	3.50	4.20	4.20	5.60	7.00	8.40	7.00	11.06	32.200	43.260
Corporation - UNITED TECHNOLOGIES CORP/SPERRY MARINE															
BPS-15H/J/16(V)	SUBMARINES (US NAVY)	5.00000	10.00	20.00	20.00	10.00	0.00	15.00	10.00	0.00	0.00	0.00	60.00	25.000	85.000
UNITED TECHNOLOGIES CORP/SPERRY MARINE			10.00	20.00	20.00	10.00	0.00	15.00	10.00	0.00	0.00	0.00	60.00	25.000	85.000
Printout Total -			1276.38	1334.67	1548.20	1500.76	1254.78	1212.58	902.68	645.96	456.26	268.92	6914.78	3486.400	10401.184

(TABLE 2 - end)

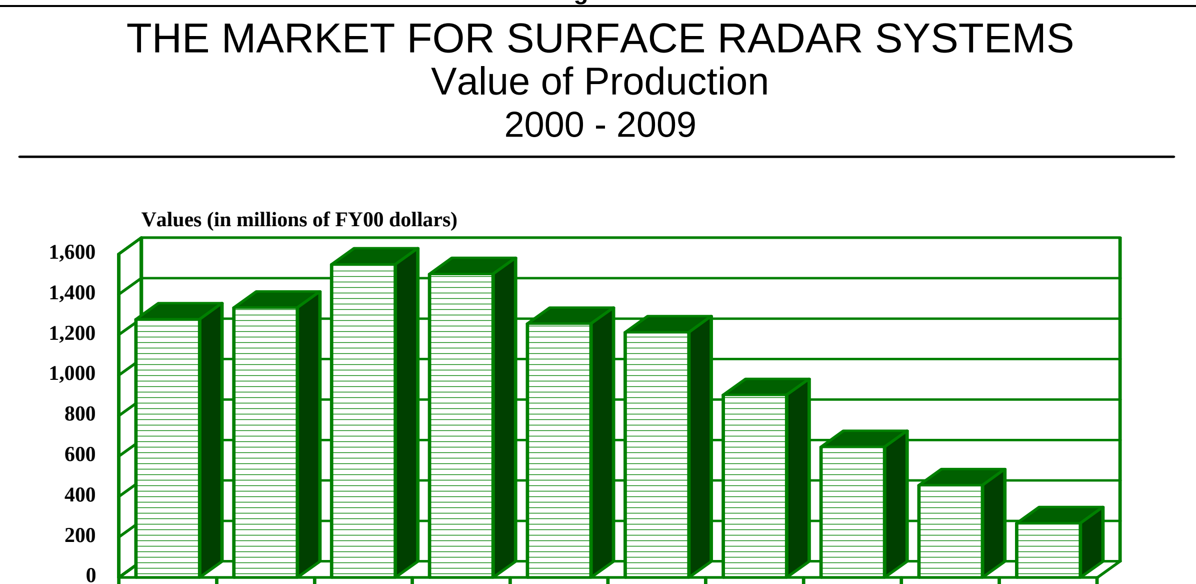
Figure 1



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	569	939	1,431	1,856	1,885	4,179	2,728	4,269	3,824	4,169

Years

Figure 2



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	1,276	1,335	1,548	1,501	1,255	1,213	903	646	456	269

Years

Table 3
The Market for Surface Radar Systems
Unit Production % Market Share by Company

Company	Total 00-04	% Mkt Share	Total 05-09	% Mkt Share	Total 00-09	% Mkt Share
ADVANCED ELCTRONICS COMPANY	15	0.22%	50	0.26%	65	0.25%
ALENIA MARCONI SYSTEMS	9	0.13%	0	0.00%	9	0.03%
ALENIA-ELSAG	66	0.99%	3	0.02%	69	0.27%
DRS ELECTRONIC SYSTEMS INC	12	0.18%	9	0.05%	21	0.08%
ERICSSON RADAR SYSTEMS AB	140	2.10%	103	0.54%	243	0.94%
EURO-ART CONSORTIUM	29	0.43%	0	0.00%	29	0.11%
GEC PLC	61	0.91%	53	0.28%	114	0.44%
INISEL	60	0.90%	0	0.00%	60	0.23%
ITT INDUSTRIES	42	0.63%	28	0.15%	70	0.27%
KELVIN HUGHES LTD	23	0.34%	8	0.04%	31	0.12%
LOCKHEED MARTIN CORP	41	0.61%	1	0.01%	42	0.16%
MOTOROLA INC	3,947	59.09%	15,528	81.01%	19,475	75.34%
NORTHROP GRUMMAN CORP	85	1.27%	39	0.20%	124	0.48%
RACAL ELECTRONICS PLC	101	1.51%	158	0.82%	259	1.00%
RAYTHEON CO	890	13.32%	525	2.74%	1,415	5.47%
SIEMENS PLESSEY SYSTEMS	22	0.33%	21	0.11%	43	0.17%
SYSTEMS & ELECTRONICS (SEI)	56	0.84%	250	1.30%	306	1.18%
THOMSON-CSF	278	4.16%	79	0.41%	357	1.38%
TO BE SELECTED	1	0.01%	9	0.05%	10	0.04%
TRW	790	11.83%	2,300	12.00%	3,090	11.95%
UNITED TECHNOLOGIES CORP/SPERRY MARINE	12	0.18%	5	0.03%	17	0.07%
Total -	6,680	100.00%	19,169	100.00%	25,849	100.00%

(TABLE 3 - end)

Table 4
The Market for Surface Radar Systems
Value of Production % Market Share by Company

Company	Total 00-04	% Mkt Share	Total 05-09	% Mkt Share	Total 00-09	% Mkt Share
ADVANCED ELCTRONICS COMPANY	0.675	0.01%	2.250	0.06%	2.925	0.03%
ALENIA MARCONI SYSTEMS	76.500	1.11%	0.000	0.00%	76.500	0.74%
ALENIA-ELSAG	184.000	2.66%	36.000	1.03%	220.000	2.12%
DRS ELECTRONIC SYSTEMS INC	3.600	0.05%	2.700	0.08%	6.300	0.06%
ERICSSON RADAR SYSTEMS AB	339.000	4.90%	247.000	7.08%	586.000	5.63%
EURO-ART CONSORTIUM	574.200	8.30%	0.000	0.00%	574.200	5.52%
GEC PLC	231.800	3.35%	238.600	6.84%	470.400	4.52%
INISEL	2.700	0.04%	0.000	0.00%	2.700	0.03%
ITT INDUSTRIES	95.600	1.38%	22.400	0.64%	118.000	1.13%
KELVIN HUGHES LTD	13.800	0.20%	4.800	0.14%	18.600	0.18%
LOCKHEED MARTIN CORP	361.900	5.23%	20.000	0.57%	381.900	3.67%
MOTOROLA INC	847.050	12.25%	346.200	9.93%	1193.250	11.47%
NORTHROP GRUMMAN CORP	174.714	2.53%	118.700	3.40%	293.414	2.82%
RACAL ELECTRONICS PLC	74.720	1.08%	44.000	1.26%	118.720	1.14%
RAYTHEON CO	1847.505	26.72%	1416.240	40.62%	3263.745	31.38%
SIEMENS PLESSEY SYSTEMS	249.500	3.61%	315.000	9.04%	564.500	5.43%
SYSTEMS & ELECTRONICS (SEI)	2.520	0.04%	11.250	0.32%	13.770	0.13%
THOMSON-CSF	1753.940	25.37%	514.060	14.74%	2268.000	21.81%
TO BE SELECTED	10.000	0.14%	90.000	2.58%	100.000	0.96%
TRW	11.060	0.16%	32.200	0.92%	43.260	0.42%
UNITED TECHNOLOGIES CORP/SPERRY MARINE	60.000	0.87%	25.000	0.72%	85.000	0.82%
Total -	6914.784	100.00%	3486.400	100.00%	10401.184	100.00%

(TABLE 4 - end)

Figure 3

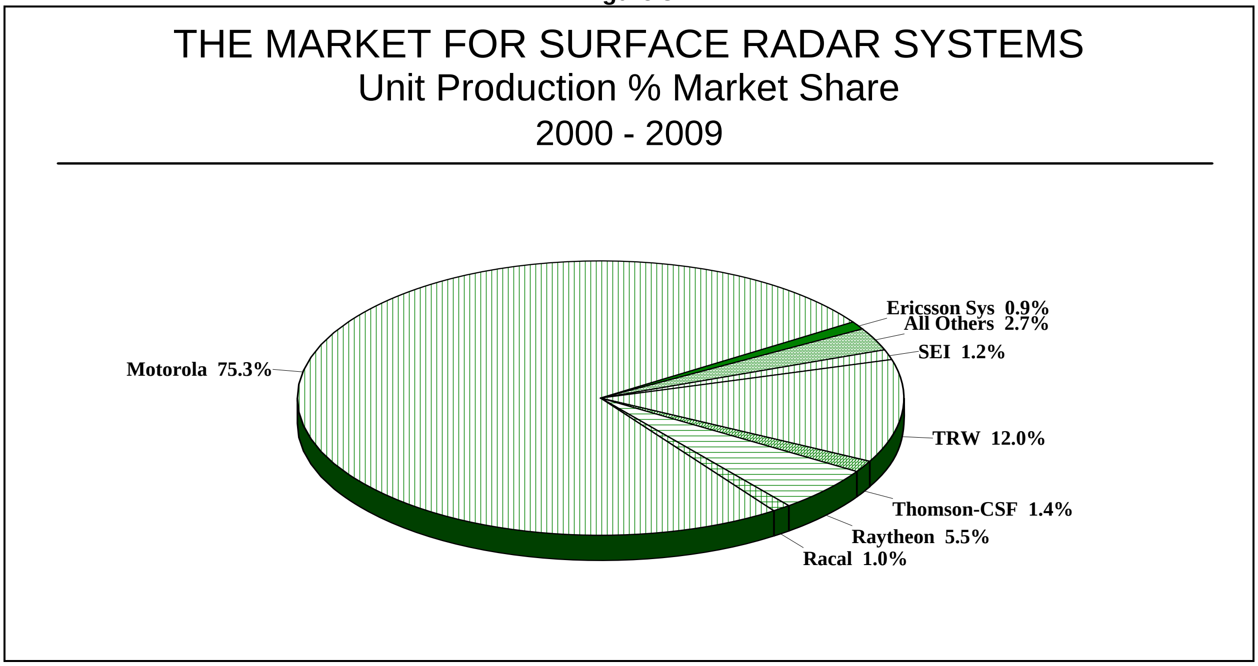
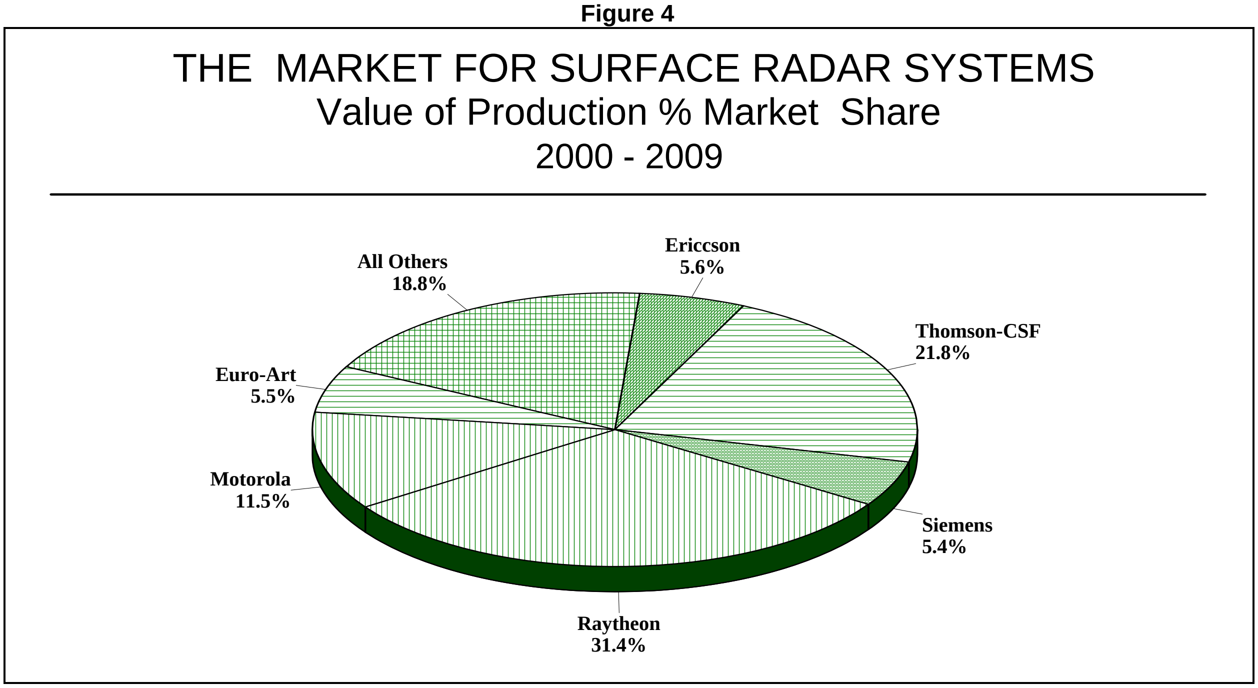


Figure 4



Conclusion

Although radars continue to be developed for specialist missions such as early warning and maritime or battlefield surveillance, the trend to consolidate many functions into a single system continues. The Multi-Function Radar capitalizes on technology being developed for the airborne market.

Electronically steered arrays with ultra-low sidelobe antennas have come into the market and are available at affordable prices. Real-time calibration measurements of arrays (with attendant built-in calibration error storage and correction) is possible as more powerful signal processors become available and are incorporated. This means better clutter rejection, better jammer rejection, and enhanced target ID (non-cooperative methods especially). Digital processors will become more standardized to allow the same basic model to be used with a wide range of radar systems.

To accommodate mobility requirements, many battlefield radars are being repackaged and mounted on quick-reaction, fast-moving vehicles. This will improve the flexibility of command and control systems.

The US tactical/battlefield capability is struggling to remain competitive with the European industry which has been interested and involved almost solely in tactical system development for decades. US radar manufacturers maintained their dominant position in airborne equipment, but are working hard to pull into parity on the international tactical radar market. Lockheed Martin and Raytheon, through acquisitions and mergers, developed enough mass to compete effectively. This combines with the price of their systems to position these companies solidly in the upper echelon of the market over the next decade. Size does matter. EADS and BAE Systems are also good examples.

The far term must address radar detectability and anti-radar (electronic as well as destructive) developments. 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. The effort to improve capabilities of both sectors is ongoing, but the danger from anti-radiation missiles and other countermeasures is increasing, not decreasing, even with new technologies. There also is a need to develop ways of avoiding the more capable electronic intelligence (ELINT) gathering systems being fielded.

There is a growing interest in radar decoys that can be deployed with a radar to draw off Anti-Radiation Missiles (ARM). The decoys are arrayed around the radar itself and generate signals designed to draw the missiles away. Survivability is being addressed by making the radars more mobile. A fixed target is easier to strike once its exact location is known, but a moving system may be able to avoid or defuse an attack. In this situation, decoys are of limited use, especially if the area is saturated with bomblets/ submunitions. Even mobile radars are vulnerable since their platform vehicles cannot move quickly enough to evade an attack once it starts.

Radar continues to be important in air traffic control. Even though the Global Positioning System and datalinks are being developed to make self-navigation more feasible, radars will be around for decades. Radar will continue to be important in ATC for blunder control and managing aircraft that will not carry the sophisticated systems needed in the new arena. Aside from tracking and navigation purposes, radar will be important for border management and detection of inbound aircraft which may not want to be detected. This has both defense and law enforcement implications.

The naval radar market of the future reflects the requirements placed upon all warships. Ships will have to carry extended-range radars to detect potential threats; multichannel, long-range target acquisition radars to localize, isolate, and engage such threats; and improved, integrated fire-control radars to defeat attack and to engage hostile platforms. Radars will become even more closely linked to a ship’s integrated combat systems and fused with other sensors to maximize situational awareness.

The radar signatures of ships are being reduced by the application of stealth technologies, including the use of radar-absorbing materials, rounding off sharp edges and sloping surfaces to deflect radar waves. The superstructure must be either reduced or profiled to reduce radar cross-section. An alternative is to design the superstructure to be radar-deceptive. Multifunction apertures could have a positive impact in this arena, but radar antennas need to be mounted as high as possible to maximize the distance to the radar horizon. This presents severe difficulties which the antenna designers will have to face.

Like all aspects of the defense budgets around the world, the need to reduce expenditures will impact the surface and naval markets. The nature of these sensors’ mission, however, will reduce some of the potential downturn. Unlike weapons, radars can be both defensive and offensive. They also perform an increasingly important treaty verification mission. The long-term radar market should reflect this.

Given the fact that many programs to upgrade complete systems over the early part of the 1990s are well under way, and considering the need for many smaller nations to develop a defensive capability, the land and naval radar market is healthier than some weapons-oriented programs. Although strategic systems will remain static and little growth is expected, some segments, such as tactical battlefield sensors, may experience a measurable upturn as nations adjust their defense needs to the demands of the 21st century.

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