MilAero Technology Service Newsletters

Dataquest

a company of The Dun & Bradstreet Corporation

1290 Ridder Park Drive
San Jose, California 95131-2398
(408) 437-8000
Telex: 171973
Fax: (408) 437-0292

Sales/Service Offices:

UNITED KINGDOM
Dataquest UK Limited
Roussel House,
Broadwater Park
Denham, Uxbridge, Middx UB9 5HP
England
0895-835050
Telex: 266195
Fax: 0895 835260-1-2

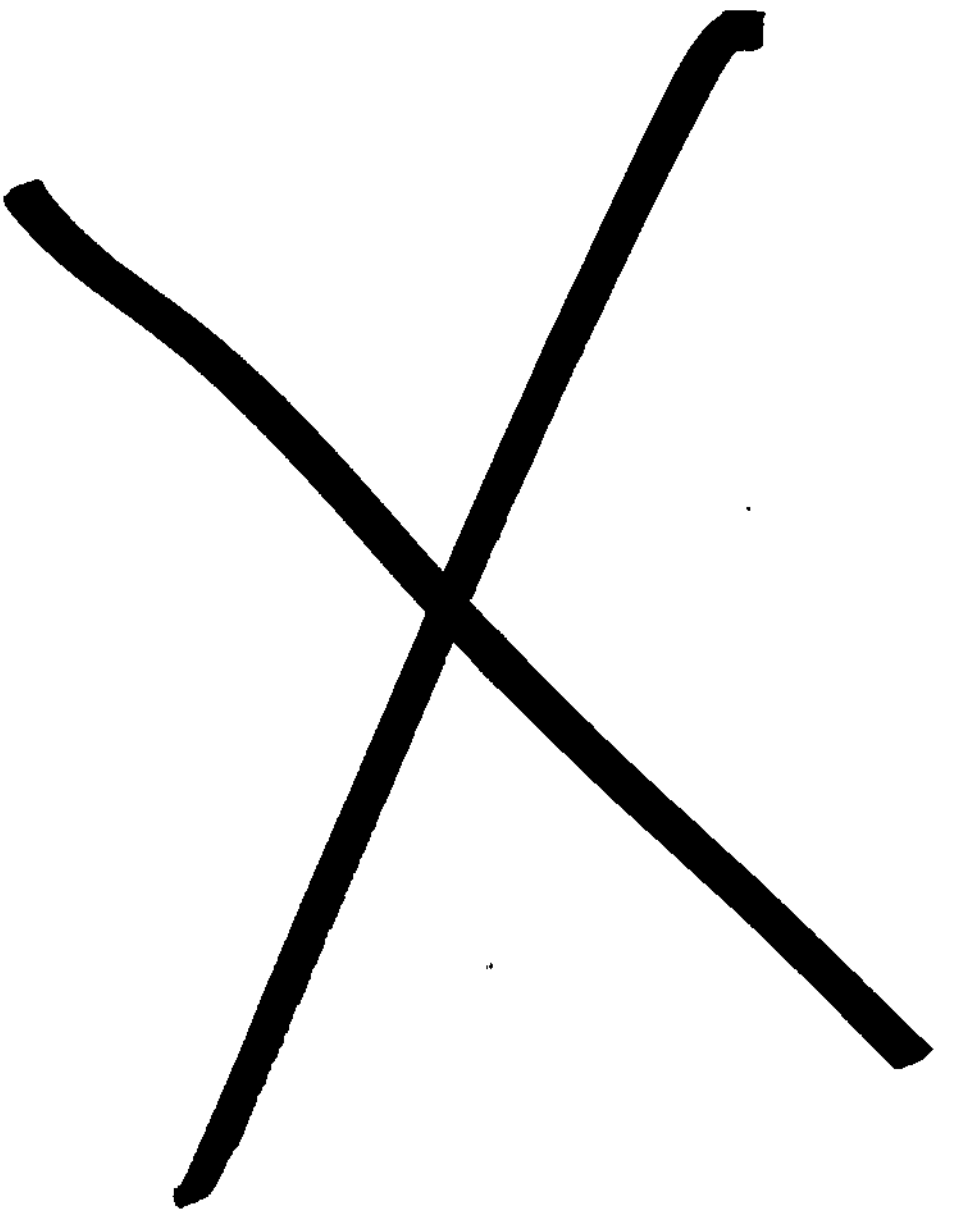
FRANCE
Dataquest SARL
Tour Gallieni 2
36, avenue Gallieni
93175 Bagnolet Cedex
France
(1)48 97 31 00
Telex: 233 263
Fax: (1)48 97 34 00

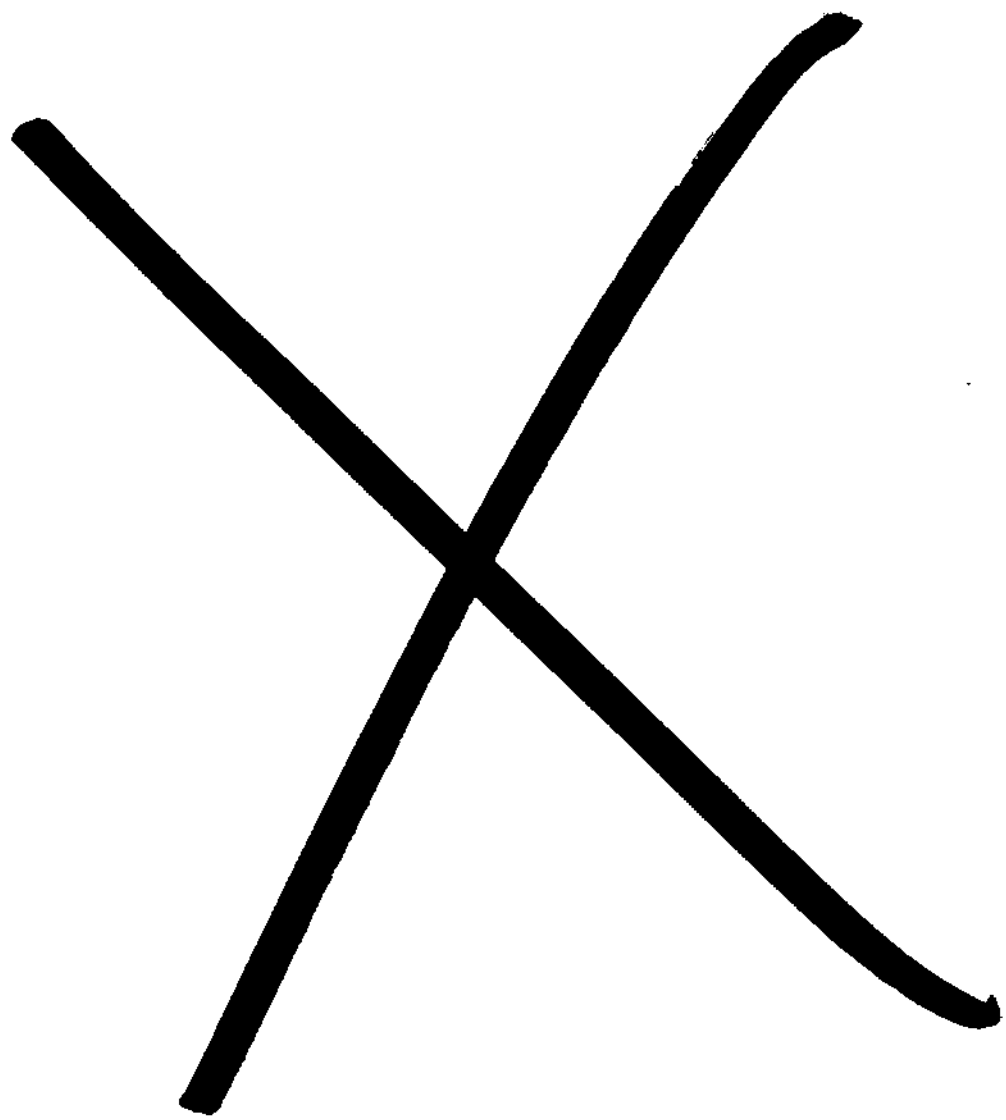
EASTERN U.S.
Dataquest Boston
1740 Massachusetts Ave.
Boxborough, MA 01719-2209
(508) 264-4373
Telex: 171973
Fax: (508) 635-0183

GERMANY
Dataquest GmbH
Rosenkavalierplatz 17
D-8000 Munich 81
West Germany
(089)91 10 64
Telex: 5218070
Fax: (089)91 21 89

JAPAN
Dataquest Japan, Ltd.
Taiyo Ginza Building/2nd Floor
7-14-16 Ginza, Chuo-ku
Tokyo 104 Japan
(03)546-3191
Telex: 32768
Fax: (03)546-3198

KOREA
Dataquest Korea
Daeheung Bldg. 505
648-23 Yeoksam-dong
Kangnam-gu, Seoul 135 Korea
011-82-2-552-2332
Fax: 011-82-2-552-2661





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Research Newsletter

UNMANNED AERIAL VEHICLES: ELECTRONICS–INTENSIVE OPPORTUNITY

Despite a decline in overall defense spending, the unmanned aerial vehicle (UAV) market continues to expand rapidly, with the Pentagon requesting nearly triple the 1991 funding levels by fiscal 1993. Some estimates place the worldwide market, which now stands at just over $200 million, at more than $1 billion by the end of the decade, with the U.S. Department of Defense (DOD) accounting for well over half of all market growth. Furthermore, UAVs are estimated to have at least 60 percent of electronics value.

GROWING UTILITY

The versatility of UAVs in performing over-the-horizon reconnaissance, communications relays, targeting, surveillance, and electronic warfare make them perfectly suitable in hostile environments to allow manned crews to stay out of harm's way. Even the most ardent UAV skeptics seem to have changed their minds since Operation Desert Storm. In lessons similar to those learned by the Israeli military nearly a decade earlier, the U.S. Army and U.S. Marine Corps, as well as elements of the U.S. Navy, relied heavily on available UAVs for a range of missions including surveillance, target acquisition, and bomb damage assessment.

The UAV that saw the most action in the Gulf War was the Pioneer. Produced by AAI Corporation of Maryland, the system is based on an earlier model developed and produced by Israel Aircraft Industries (IAI). Israel first used the UAV in combat in 1982, and IAI now serves as the primary subcontractor to AAI for the Pioneer.

The elements of each Pioneer system are representative of most current and future programs. The total system includes five air vehicles, a ground control system, a portable control station, two remote receiving stations, and rocket-assisted launchers. The vehicle can operated for up to five hours at speeds ranging from 60 to 95 knots and has a range of up to 220km.

All told, 522 missions were flown by the Pioneer in the Gulf War, with at least one Pioneer in the air throughout the conflict. Among other things, the system was used to obtain targeting information for the 16-inch guns of the navy's battleships. The DOD will procure 13 additional Pioneers to replace vehicles lost in the war, although the program is slated to be phased out beginning in October 1996 as more capable UAVs come on-line.

CURRENT U.S. UAV PLANNING

Upset over the proliferation of UAV programs in each of the military services, the United States Congress in 1988 zeroed all existing programs and established a joint program office (JPO) under the navy's control. The new office was tasked with the development and coordination of an overarching UAV Master Plan that could be used to guide all future programs and funding levels.

The original UAV Master Plan called for four types of UAVs. Table 1 contains the specifications for each of these efforts, along with more recent requirements taken from the 1991 Master Plan.

Close-Range UAV

In late July, the defense department announced 10 contracts, 6 to companies to pursue air vehicle development and 4 to companies to pursue system payloads. Table 2 highlights these contract awards, which call for flight testing to begin in January 1992. A single contractor will be

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TABLE 1
The Family of UAVs

Characteristic	Close-Range	Short-Range	Medium-Range	Endurance
Operational Needs	RS, TA, EW, MET, NBC	RS, TA, MET, NBC, C2, EW	Pre- and poststrike, reconnaissance, TA, SIGINT, EW, MET	RS, TA, C2, MET, NBC, SIGINT, EW, special operations
Launch and Recovery	Land/ship	Land/ship	Air/land	Land
Radius of Action	50km	150km beyond forward lines	650km	Classified
Speed	Not specified	Dash >110 knots; cruise <90 knots	0.9 Mach	Not specified
Endurance	3 hours minimum	8 to 12 hours	2 hours	24 hours on station
Information Timeliness	Near-real-time	Near-real-time	Near-real-time/recorded	Near-real-time
Sensor Type	Day-night, imaging, EW, MET, NBC	Day-night imaging, data relay, comm. relay, radar, SIGINT, MET, MASINT, TD, EW	Day-night imaging, SIGINT, MET, EW	SIGINT, MET, comm. relay, data relay, NBC, imaging, MASINT, EW
Air Vehicle Control	Preprogrammed/remote	Preprogrammed/remote	Preprogrammed	Preprogrammed/remote
Ground Station	Vehicle and ship	Vehicle and ship	JSIPS	Vehicle and ship
Data Link	Worldwide/low-high intensity	Worldwide/low-high intensity	JSIPS interoperable worldwide/low-high intensity	Worldwide/low-high intensity
Service Need/Requirement	Army, navy, marine	Army, navy, marine	Navy, air force, marine	Army, navy, marine

Legend:
C2 - Command and control
EW - Electronic warfare
JSIPS - Joint Service Imagery Processing System
MASINT - Measurement and signatures intelligence
MET - Meteorology
NBC - Nuclear, biological, and chemical reconnaissance
RS - Reconnaissance and surveillance
SIGINT - Signals intelligence
TA - Target acquisition/target spotting
TD - Target designator
Source: Defense industry forecasts

selected in the first quarter of fiscal 1993, full-scale development will begin in the first quarter of fiscal 1994, and production will start in the first quarter of fiscal 1997.

The close-range UAV (CR-UAV) is designed to capitalize on the experience of first-generation UAV systems, such as the Pioneer described earlier. The goal is to develop a primarily off-the-shelf system capable of operating within a 50km radius to provide forward-based forces with reconnaissance, surveillance, and target acquisition capabilities. Current plans already envision multiple upgrades to the system including capabilities to detect nuclear, biological, and chemical weapons; mine detection; electronic warfare; and communications relays for both the army and the marine corps.

Each close-range system will include four air vehicles, each capable of operating with several different payloads. Each payload will include a command and control system, a data transmission system, a navigation system, and on-board computing capability. Each close-range system also will have a complete ground-based data station, a launch and recovery subsystem, and a ground support subsystem.

Current plans call for a great deal of commonality between the CR-UAV and the short-range systems described in the following section. The UAV office has been clear in demanding that, at a minimum, the ground station of the close-range system should be able to operate short-range UAVs, meaning that the winner of the short-range UAV hardware contract will also likely provide close-range UAV support.

Short-Range UAV

The short-range system envisioned is the cornerstone of the UAV family, estimated to make up more than 50 percent of the UAV market through 1998.

Designed to provide commanders with near-real-time intelligence, reconnaissance, and battlefield surveillance, the short-range UAV (SR-UAV) will have day-night and adverse weather capability. Each complete system will include two ground control stations and remote video terminals, multiple air vehicles, modular mission payloads, ground and air data terminals, launch and recovery equipment, and integrated logistics support.

The competition for the SR-UAV began in fiscal 1989, when two teams were each awarded firm-fixed-price development contracts with operational testing for both systems slated to begin in November 1992. The two teams are McDonnell Douglas Missile Systems and Developmental Sciences Corporation, with their Sky Owl systems, and Israel Aircraft Industries and TRW Military Avionics and Surveillance Group, with their Hunter system. A final selection between the two is now

TABLE 2
Close-Range UAV Development Contract Awards

Air Vehicles	Award ($M)
McDonnell Douglas Missile Systems	0.7
International Aerospace Technologies	0.1
General Atomics	0.5
Daedalus Research Inc.	0.5
Westinghouse (Huntair UAV)	0.3
AAI Corporation	0.3
Payloads	**Award ($M)**
Hughes Electro-Optical (with Data Systems Group)	0.2
Kollomorgan Electro-Optical Division	0.1
Rockwell Defense Electronics	0.2
Rafael (Israel)	0.1

Source: Defense industry forecasts

slated for June 1992, with a potential $1.3 billion contract at stake.

Both contractors are addressing requirements for three separate planned block upgrades. Block I will develop the features necessary to make the system capable of operating from ships. Block II upgrades will add a heavy fuel engine, automatic tracking and area search capability, a manned surrogate trainer, and a variety of means to enhance survivability. Block III upgrades call for a highly integrated battlefield system with common datalink interfaces, electronic warfare suites, active imagery, and meteorological sensors.

The maritime, or Block I, SR-UAV has experienced a number of programmatic shifts; it was originally designed to operate off large battleships. With the planned decommissioning of these vessels, the navy is becoming more and more interested in a vertical take-off and landing system capable of operating from small-deck ships. One system currently being tested is Canadair Incorporated's CL-227 Sentinel system. Problems in the testing program, primarily glitches in Loral Defense Systems' software, have briefly delayed the testing, although the program is now believed to be back on track. The Sentinel can carry a variety of payloads, including Rockwell International Corporation's ARC-182 communications relay, Kollomorgan's day TV or forward-looking infrared system, and Litton's electronic support measures decoy.

Medium-Range UAV

The medium-range UAV (MR-UAV) is designed to complement manned tactical reconnaissance by providing a small-profile, high-speed, fully autonomous unmanned system capable of being launched either from aircraft (F/A-18s), or ground systems. Designated the BQM-145A, the rocket-powered system was derived from Teledyne Ryan Aeronautical's Model 324 UAV, currently in production for the Egyptian government. The new vehicle is capable of traveling nearly Mach 1 and reportedly has a range of nearly 700 nautical miles. A full-scale development contract worth $69.9 million for the BQM-145A was awarded to Teledyne Ryan in June 1989.

The BQM-145A, however, has been by far the most controversial UAV under development. Although the joint program office manages the overall program, the U.S. Air Force retains control of the Advanced Tactical Air Reconnaissance System (ATARS) payload, as well as the Joint Service Imagery Processing System (JSIPS), which is being designed to provide near-real-time processing of imagery for UAVs. The ATARS program was purchased by Martin Marietta's Electronics and Missile Systems Group in mid-1990 from Control Data Corporation, which had won the competitive development contract in 1988. Other primary subcontractors for the ATARS program include Computing Devices Eastbourne, Kodak Datatape, Loral Corporation, and Unisys Corporation. E-Systems is the prime contractor for the JSIPS.

The primary problem appears to stem from dismal coordination among the air force, navy, and JPO, leading to a scathing rebuke of the program in March by the General Accounting Office and even harsher criticism during this year's congressional hearings. Given the program's difficulties, chief of naval acquisition Dr. Gerald Cann ordered a restructuring that will allow the ceiling price to rise from $70 million to nearly $187 million, along with a near doubling of required testing.

Teledyne Ryan is now scheduled to begin production in October, using metallic airframes. By shifting away from the originally planned composite materials, the BQM-145A now appears capable of handling the heavy ATARS payload. The restructured program calls for Teledyne Ryan to deliver 22 additional metallic airframes, with the first flight test scheduled for February 1992. The total planned buy remains 237 systems, according to navy officials, although this number, along with the original operational date of 1995, is likely to slip.

Very Low Cost UAV

Although not officially part of the overall UAV Master Plan, very low cost UAVs (VLC-UAVs) are receiving increased attention for use at the platoon and squad levels, as well as with special operations forces.

The marine corps is the lead service for these systems, which currently come in two popular forms, the FQM-151A Pointer and the BQM-174A Exdrone. The Pointer is a hand-launched, battery-powered UAV that can only carry a black-and-white optical TV camera. Without question the easiest UAV to use, six systems—each including four UAVs and two ground control units—were produced and delivered to the DOD last year. The systems are built by AeroVironment of Simi Valley, California. Five of the six systems were sent to the Gulf War, but were often found to be unsuitable for

use in the high winds and flat terrain void of landmarks. Upgrades to the system, to increase its range and payload capabilities, are currently under way.

The Exdrone, which has been around for nearly a decade, was used widely during the Gulf War; some 55 were operated at different stages of the conflict. Several Exdrones, for example, were used to evaluate the perimeter defenses of Kuwait City prior to the marine assault. Produced by BAI Aerosystems of Easton, Maryland, these small, bat-winged aircraft perform a wide variety of missions, including photo reconnaissance and surveillance and electronic jamming. They can travel up to 330km at speeds between 60 and 90 knots. The military has recently stated a need to procure 110 additional systems of this kind, although the Exdrone was not mentioned by name in the request.

Endurance UAV

This final program is more or less on hold, pending the outcome of the other UAV programs under the JPO's command. A tentative date for operational status has been set for 1999, but this is strictly a paper objective.

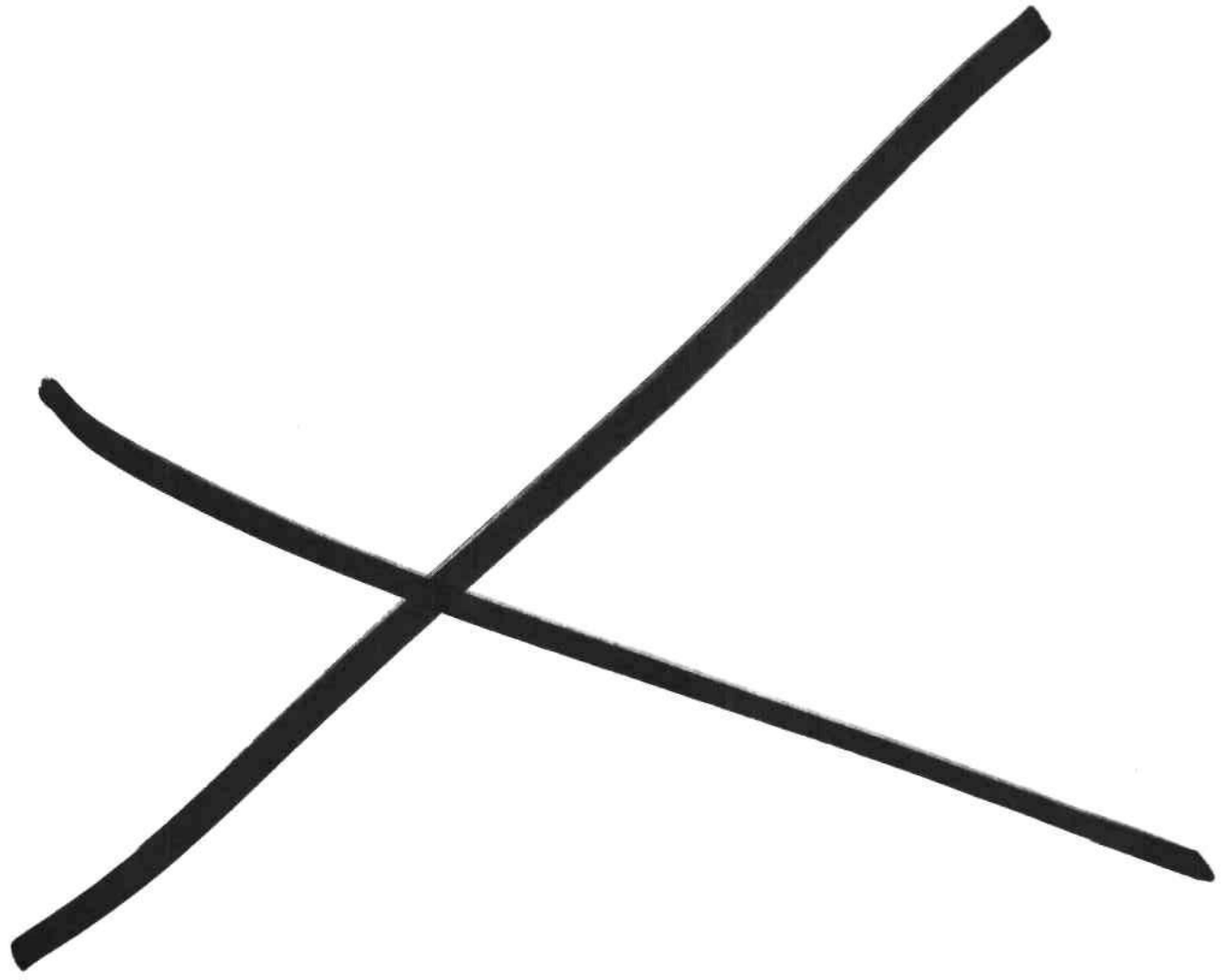
DATAQUEST CONCLUSIONS

The future looks bright for UAVs, particularly in the area of advanced payloads with high electronics content. The Defense Advanced Research Projects Agency (DARPA) will continue to dominate advanced research and development of future UAV payloads, while the navy will dominate development of the air vehicles and data-link systems.

Moreover, given the experiences of the Gulf War, the services now seem more committed than ever to ensuring their own stakes in future UAV buys. For example, the recently revised Army Aviation Master Plan calls for a totally new family of UAVs to operate alongside helicopters by 2020.

Dataquest estimates that the annual semiconductor market for UAV controls and payloads could run to $50 million worldwide by 2000. With many of the programs in the infant stage, now is the perfect time to pursue OEM team members for design-ins.

Greg Sheppard
Barry Blechman



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Research Newsletter

MIL/AERO OUTLOOK: POSITIONING FOR NEW NEEDS

DEFENSE SPENDING IMPACT

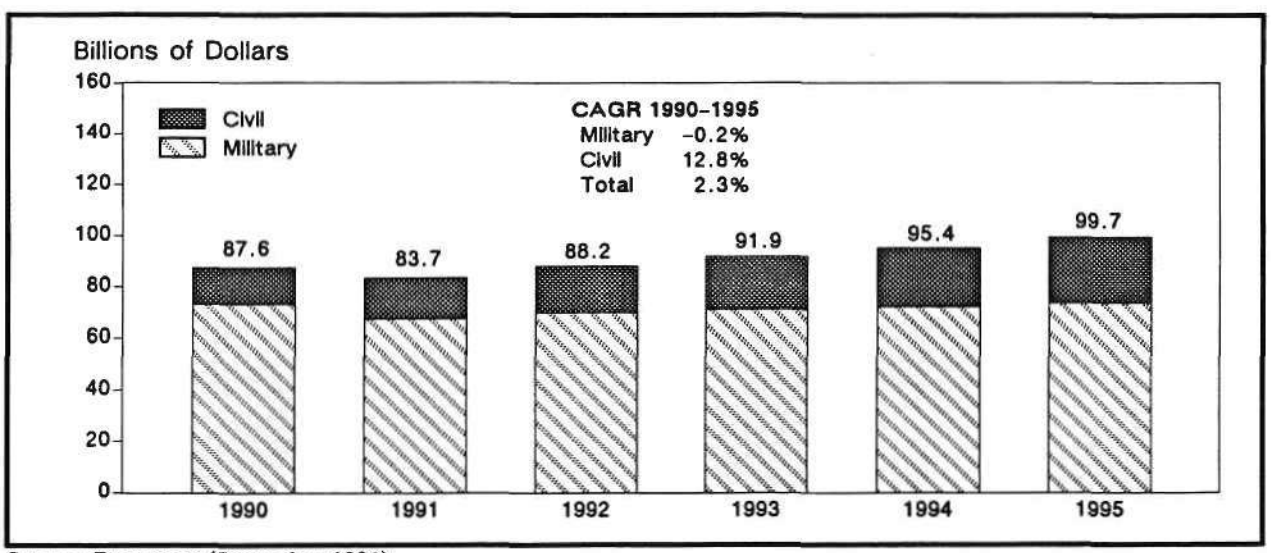
In spite of the war in the Persian Gulf and instability in the USSR, spending on military hardware is expected to decline globally for the foreseeable future. Although the war did a lot to highlight the effectiveness of electronics as the eyes, ears, and brains of weapon systems, vanishing superpower tensions are affecting political thinking the most. It is most likely that defense spending in the NATO countries will stay flat in current dollar terms as that sector shrinks to be a smaller part of the respective economies. Aside from some short-term business with NATO-friendly countries like Saudi Arabia, the export of military systems to other countries is expected to be less allowed as a result of the Iraq example.

Figure 1 presents Dataquest's forecast of military and civil aerospace electronics production. We expect military electronics production to remain roughly flat over the forecast period while the smaller civilian sector continues to have double-digit growth as a result of expanding space and aviation demands.

POCKETS OF GROWTH

In spite of an overall flat envelope, numerous growth opportunities exist in defense electronics. Many of these opportunities will come from upgrades of existing platforms (aircraft, ships, and ground vehicles) as the production of new platforms is either slowed or discontinued. Table 1 lists

FIGURE 1
Worldwide Military/Aerospace Electronic Equipment Production



Source: Dataquest (September 1991)

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TABLE 1
Defense Electronics Opportunities

Growth Application	Key OEMs	Notes
Rugged computers/peripherals	Miltope, Rugged Digital, Codar, Magnavox, DY-4	VME bus dominates, Futurebus+ for U.S. Navy
Space avionics/payloads	GE, Hughes, Matra, TRW, Lockheed, NEC, IBM, Honeywell, Loral	Need rad-hard ICs
U.S. army vehicle electronics (SAVA)	TI, Smiths Industries, Hughes	Based on 68020 and 1553 data comm.
Avionic processor and data comm. modules	Hughes, TI, Westinghouse, IBM, Harris, GEC, ESD	SEM-E size, i960 and R3000-based CPUs, PI bus, high-speed data bus, 1553 comm.
Antisubmarine warfare sensing systems	AT&T, IBM, GE, Thomson	Quieter subs make this a priority
Microwave/millimeter-wave front-ends	TRW, Westinghouse, GE, Lockheed, GEC, Thomson, Raytheon, Hughes	Modules for radar, comm elec. warfare, missiles
IR tracking/imaging	Martin Marrieta, TI, Hughes, Loral, GE, FIAR	Gulf war showed effectiveness
Unmanned aerial vehicles	McDonnell Douglas, IAI, TRW, Teledyne	Market to double by 1999

Source: Dataquest (September 1991)

some of these opportunities and some of the OEMs skilled in these technologies.

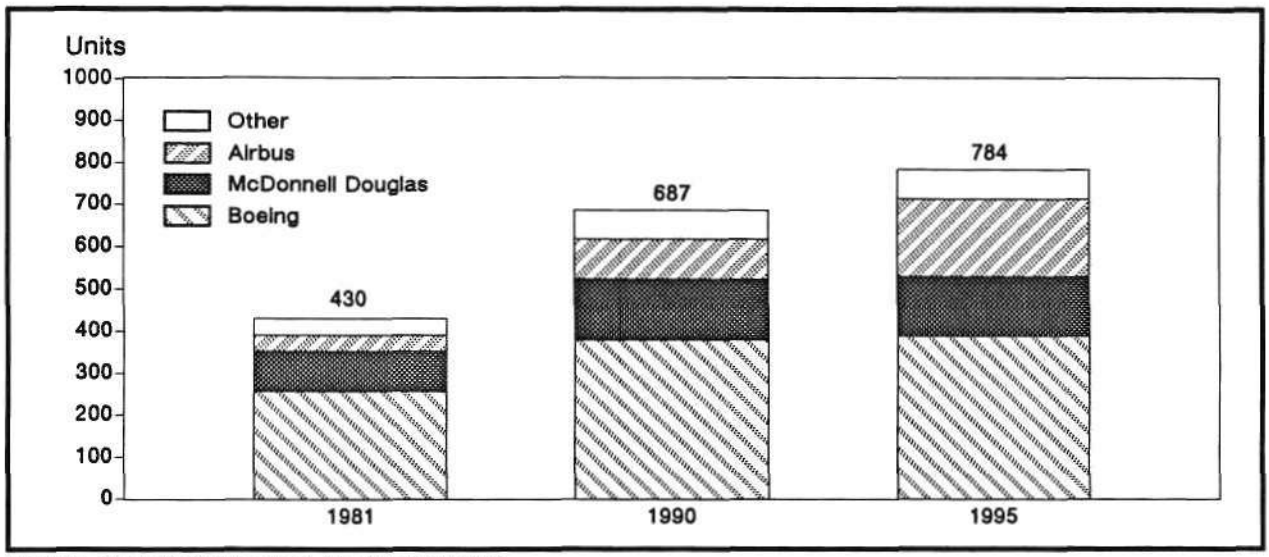
A CIVIL MARKET?

It is Dataquest's belief that the civilian space and aviation electronics sectors will witness solid growth for the bulk of the decade. Although doubt remains regarding the viability of the space station program (and its worldwide elements) there remains a multitude of government scientific and commercial communications satellite projects. The electronic content of satellite development can run as high as 60 percent, posing a significant opportunity for radiation-resistant components.

Spending by NASA (United States), ESA (Europe and Canada), and the two Japanese space agencies is expected to continue climbing significantly as earth resources and environmental monitoring programs expand. As many as 51 commercial communication satellites are expected to be delivered over the next three years, up from 39 in the previous three-year period. The need is being driven by increased demand for communication and direct-broadcast transponders. The Iridium cellular communication program promoted by Motorola could expand that number greatly, if it becomes politically feasible. The United States is expected to maintain nearly 57 percent of the satellite production, while France and the United Kingdom acquire 17 and 10 percent, respectively. France, Japan, Canada, Italy, Israel, and India are cutting into the U.S. dominance of space electronics. Companies such as MBB (Germany), Alenia (Italy), Mitsubishi and NEC (Japan), and IAI (Israel) are becoming forces in space electronics.

In civil aviation electronics, substantial opportunities remain in both avionics and ground-based air traffic control systems. Figure 2 shows the dramatic growth in aircraft deliveries over the past decade. A substantial growth of 5 percent per year in passenger air miles, especially for the Pacific region, is one of the main drivers of growth. Companies such as Honeywell, Rockwell-Collins, Allied-Signal, Sextant Avionique, and GEC are the principal civilian avionics suppliers in the world.

FIGURE 2
Commercial Airliner Deliveries



Source: Prudential/Dataquest (September 1991)

SEMICONDUCTOR MARKET: SLOWER, MAYBE PROFITABLE

The worldwide market for semiconductors used in military and civil aerospace electronics is expected to remain flat in 1991 but grow at a 5.8 percent rate from 1990 to 1995 (see Figure 3). Spending on replacement equipment for Operation Desert Storm and orders by friendly Gulf states—approximately $20 billion, mostly in the United States—is generating some one-time orders mainly for mature products. Semiconductor consumption rates are expected to continue exceeding the equipment growth rate as new equipment and upgrades have more value absorbed by complex microprocessor units (MPUs), application-specific standard products (ASSPs), application-specific integrated circuits (ASICs), microwave monolithic ICs (MMICs), and memory ICs.

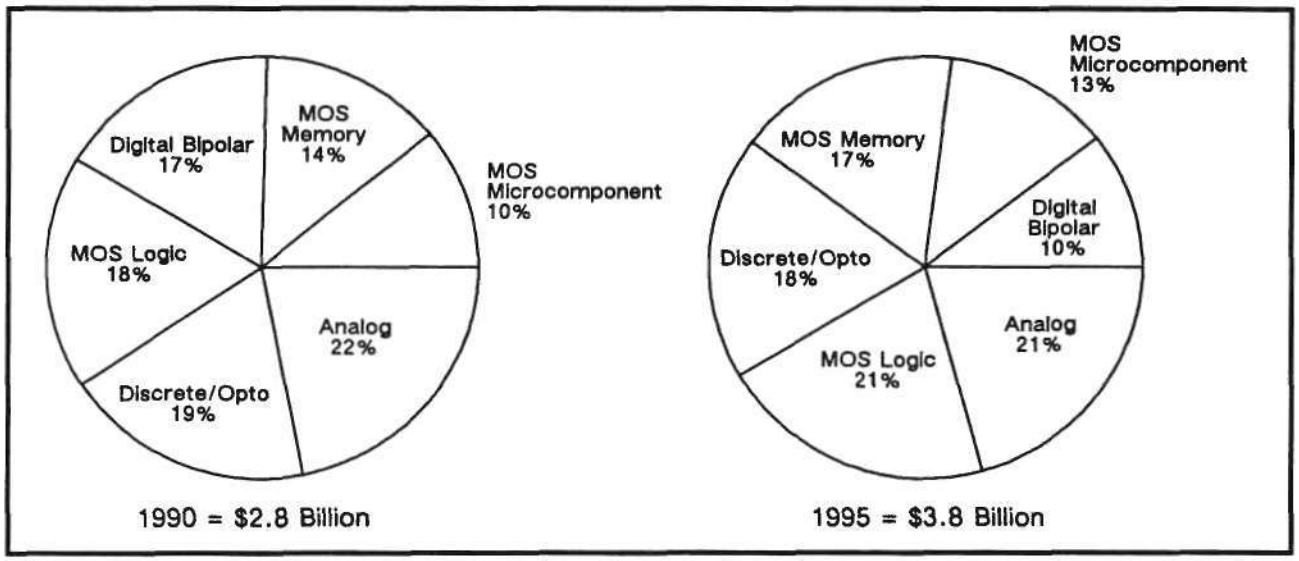
The dramatic cuts to the 1991 equipment procurement accounts in the United States, the United Kingdom, and France are cause for a bleak 1991. Some recovery is expected in 1992 as platform upgrades gain priority in spending budgets. Over the coming decade, expect the Japan/ROW market to grow larger as Japan continues developing its civilian aerospace electronics industry and countries like Taiwan and South Korea produce more of their own defense electronics.

Semiconductor Market Qualities

Earlier in this article we noted which mil/aero equipment categories are the most lucrative for semiconductor marketers and which principal OEMs are producing that equipment. In the coming years mil/aero applications will make the following requirements of semiconductor technology:

- Reduced power consumption and space, increased reliability and maintainability—These are the assumed drivers behind any upgrade or new design. Most often, this is translated into emphasis on CMOS/BiCMOS/GaAs VLSI, mixed-signal, and hybrid conversion to monolithic or multichip modules.
- Emphasis on minimizing adverse effects of radiation—Total dose, dose rate, neutron emission, and soft memory array errors lead a long list of parameters being considered by OEM designers. Enhanced bulk CMOS will continue vying with silicon on sapphire and silicon on isolator for designs.
- Testability, designability, and replaceability—These issues affect every design decision.
  - Already in the United States, VHSIC hardware definition language (VHDL) design capture is required on all new projects as platform life cycles head for multiple decades and semiconductor life cycles shrink to just a few years. A major reason is to reduce the effort in sourcing semiconductor products years after the original product has been phased out.
  - Test features such as JTAG and the TM bus, which affect chip/package design, are being required of an increasing number of programs as well.

FIGURE 3
Worldwide Military/Aerospace Semiconductor Consumption by Major Product Category



Source: Dataquest (September 1991)

- More digitally based, real-time control requiring extensive use of high-performance (CISC or RISC) MPUs, digital signal processors, memory, and real time software (principally Ada)
- More modularity and commonality—Emphasis is on standardizing on data communication standards (1553, HSDB), backplane buses (PI and Futurebus+), common modules (SEM-E or multichip module upgrade), and high-level language software portability.
- Greater bandwidth and sensitivity for front-end (analog environment) processing—This requirement translates into higher frequencies (exceeding 50 GHz) for RF components like MMICs and finer-resolution infrared.

Products In Need

Table 2 lists some products that Dataquest believes will be in strong demand over the next five years. Each of these product areas can trace its demand from one or more of the above factors. It is important to note that mature standard logic, linear ICs, and MPUs usually enjoy a long phaseout period, and the opportunity for aftermarket suppliers and emulating solutions is proving to be attractive.

DATAQUEST PERSPECTIVE

As the title of this article implies, to be a successful (profitable) supplier to the military and aerospace community, *focus* is recommended. We recommend that semiconductor companies with "design-win" class products like ASSPs, ASICs, and MPUs select a manageable list of accounts to target. As OEMs continue consolidating and reduce the length of their supplier lists, it becomes paramount for semiconductor suppliers to be responsive if they wish to remain on the list. We suggest studying which OEMs are the best positioned for growth opportunities in their respective markets. Table 1 provides one such list.

A side benefit of maintaining a strategic account focus is that a good relationship will drive the decisions regarding which commercial portfolio products should be militarized and when that should happen. It is important to note commercialization trends like the conversion to standard military drawing parts or even a rugged specification; the adoption of the qualified manufacturers list should make it easier (less costly) for semiconductor companies to serve the market. However, OEM procurement organizations are increasingly wary of interlopers in the market, and sourcing preference ultimately will reside with those companies thoroughly committed to serving the unique military quality and contracting needs.

Gregory Sheppard

TABLE 2
Key Semiconductor Products for Mil/Aero Applications in North America and Europe

Product Area	1991-1995 Market Size ($M)
Bus interface (all technologies)	790
CMOS/BiCMOS Gate Arrays	1,305
CMOS/BiCMOS Cell-Based ICs	680
(Mixed signal)	(120)
CMOS PLDs	385
(FPGAs)	(110)
Data comm. ICs (1553/SCC/HSDB, etc.)	305
Digital signal processors	170
8-bit MCU	140
16-bit MPU	245
32-bit MPU	155
SRAM	1,010
EEPROM	390
Flash memory	45
GaAs MMIC	580
Amplifiers	740
Data conversion	670
Power MOSFET	355
Rad-hard/level-S ICs	1,755

Source: Dataquest (September 1991)

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Research Newsletter

MILITARY COMPUTER SYSTEMS: RUGGEDIZATION MATURES

For decades, Pentagon watchers and congressional leaders have urged the U.S. Department of Defense to make greater use of commercially available equipment and technology, particularly in the field of computer systems. Despite an understanding that commercially available computer technology was regularly two to five years ahead of military systems, the Pentagon until recently continued to favor computer systems with extraordinarily rigid, and often outdated, specifications.

Last year, Congress stopped pleading and imposed its will through Title 10 of the fiscal 1991 Defense Authorization Act. The new law legally binds the Defense Department to conduct market research prior to the development of new system specifications for systems to determine if nondevelopment items (NDIs) are available or could be modified to meet requirements. The passage of this legislation has codified the move toward greater use of nondevelopmental computer hardware, which this year will account for nearly $1.5 billion in defense spending. This figure will rise significantly throughout the 1990s as these systems, described later in this newsletter, enter production. As a result of this trend, semiconductor manufacturers have a new opportunity and should target a growing list of OEMs producing commercially derived computer systems.

OPERATIONS DESERT STORM AND DESERT SHIELD

Operations Desert Shield and Desert Storm changed many of the Pentagon's perceptions regarding the utility and viability of commercial and ruggedized computer equipment. All three military services, but particularly the army, found nondevelopment commercial computers to be true lifesavers throughout the crisis. Soldiers in the field devised innovative methods to keep their commercial systems operational in the harsh climate of Saudi Arabia and Kuwait, such as wetting burlap with Evian water to wrap and cool the boxes. Although the services encountered some problems with these commercial systems—primarily relating to power surges and sand entering keyboards—for the most part, the systems outperformed many of the services' greatest expectations.

It is estimated that nearly 20,000 personal computers were operational in the Persian Gulf, working out to roughly one PC for every 25 soldiers. By far the most popular systems were Zenith Data Systems' Z-248 desktop and Z-184 laptop, which performed extremely well in the adverse conditions of the desert. Other systems employed included several hundred C3 Incorporated 80386- and 80486-based systems, nearly 2,000 CompuAdd Corporation systems (an 80486 model even survived the SCUD missile hit on Dhahran), and hundreds of Apple Macintoshes, Unisys desktops, and KMS Advanced Products ruggedized systems. The latter were used successfully by the Patriot missile batteries.

In short, Operation Desert Storm will surely speed the Defense Department's willingness to procure commercially available computer hardware and software and employ ruggedizing techniques to ensure effective operations under the most volatile conditions.

ARMY TACTICAL COMMAND AND CONTROL SYSTEM (ATCCS)

By far the largest buyer of commercial hardware for the foreseeable future will be the U.S. Army. Beginning with the Common Hardware and Software (CHS) program, the army plans no fewer than three additional generations of primary personal computing systems, designed for the soldier

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in the field, over the next 15 years. All told, these systems may represent approximately $4 billion to $6 billion in spending over the next decade. Although both the navy and the air force also will procure nondevelopmental computer hardware (such as laptops using Intel 80386 processors and manufactured by GRiD Systems Corporation to be sold to the Marine Corps for AV-8B aircraft mission planning), their annual buys are much smaller.

For the most part, army systems operate in command and control loops, target-acquisition and fire-control systems, and mission planning, including large-scale logistical support. By far the largest army market emerging for commercial computing and ruggedizing technology is the Advanced Tactical Command and Control System (ATCCS). ATCCS is actually an integration program intended to provide common systems and protocols for six command and control programs, all of which will utilize at least some nondevelopmental computing items. The total program cost is estimated to exceed $17 billion over its lifetime. Table 1 breaks down the program by elements and provides fiscal year 1991, 1992, 1993, and total estimated program costs.

The six components of ATCCS are the following:

- The Combat Service Support Control System (CSSCS), led by TRW and Hewlett-Packard
- The All-Source Analysis System (ASAS), led by the Jet Propulsion Laboratory
- The Maneuver Control System (MCS), led by Loral
- The Forward Area Air Defense Command, Control, and Intelligence System (FAADC2I), led by TRW
- The Army Forward Area Tactical Defense System (AFATDS), led by Magnavox and MILTOPE
- The Common Hardware and Software (CHS) program, Phase I, which was awarded to MILTOPE with SAIC Corporation and Zenith as primary players in a major subcomponent (The CHS program will make the most use of commercial products.)

Maneuver Control System

The MCS will be implemented on common PCs, designed to collect and disseminate a variety of information to all levels of forces from the battalion level upward. More than 4,500 PCs are expected to be procured through the year 2002. The primary system currently being investigated is the AN/UYQ-43 tactical computer, based on a Hewlett-Packard 330 that uses a 68020 32-bit processor and an 80286 coprocessor. Loral Command and Control Systems is charged with providing software and elements of system integration, TRW is providing systems engineering and integration, and Librascope is performing the ruggedization of the systems. The army has requested nearly $46 million for this program in fiscal 1992, with an additional $43 million requested in fiscal 1993.

Army Forward Area Tactical Defense System

The AFATDs is designed to replace the current TACFIRE system and provide field units with computerized fire control, target assessment, and intelligence. A total of 3,200 computers are estimated to be required for this program, with initial production to be completed in 1993 and a follow-on version slated to enter the field in 1995. MILTOPE is acting as the prime contractor for the hardware, while Magnavox is developing the advanced software and system integration.

All-Source Analysis System

The ASAS, which has been in development for nearly 10 years and has already consumed nearly $1 billion, remains highly classified. The Jet Propulsion Laboratory is acting as prime contractor for this advanced system designed to operate as the "central nervous system" of the future battlefield command and control network. NDI hardware is coming from Martin Marietta and Loral, with Mantech, McDonnell Douglas, and TRW providing additional program support. Rugged Digital Systems has provided four separate ruggedized chassis for the system.

As a result of long delays in the program, the army now appears to be pursuing a scaled-down ASAS program known as ASAS-Hybrid. This program apparently will utilize a new series of computers called Hawkeyes. Hawkeyes are commercially ruggedized systems designed under DARPA sponsorship and built by Sun Microsystems. Estimates are that nearly 34 Hawkeye computers will be needed to fully meet the ASAS-Hybrid program needs, with tests scheduled for 1992.

Combat Service Support Control System

The CSSCS is designed to provide primarily logistical information for planning and operations. Such information would include medical, personnel, and financial data. TRW is acting as the integrator for this program, which will utilize computers developed under the CHS program.

Common Hardware and Software Program

The CHS program was originally thought to be worth nearly $1.3 billion, providing the army with up to 27,000 computer systems. In the initial orders, however, the figures appear to be significantly lower.

The CHS concept was pursued as a means of containing the proliferation of tactical computer systems. The program's goal is to offer a common, reconfigurable, commercially derived computer that can provide the military with a highly reliable, ruggedized system to fulfill nearly every mission function mentioned above.

In 1988, MILTOPE Corporation was awarded the prime contract for the initial phase of the program, beating Unisys and Magnavox. The award called for two versions of an NDI personal computer system along with a hand-held unit. The PC versions are both based on the Hewlett-Packard 300 series computer, using a Motorola 68020 microprocessor operating at 16.67 MHz and a 68881 floating-point coprocessor. Version one, to be operated behind the front lines, is strictly a commercial system, while version two offers the user a more rugged counterpart. The hand-held unit, which is being developed by MILTOPE along with Tadiran of Israel, is based on an 80C286 processor. GTE provides the adaptive programmable interface unit.

The common software consists of a UNIX common operating system with real-time extensions, along with off-the-shelf software components. The systems are designed to provide UNIX V.2 command set, Ada applications, an SQL database, word processing, spreadsheets, and a variety of other capabilities.

To date, the rate of procurement of CHS systems has been disappointing, with a total of only about 2,000 systems reaching the army. Although MILTOPE can hope for continued sales, it now appears unlikely that even half the originally planned buy will ever materialize.

LIGHT COMPUTER UNIT (LCU)

MILTOPE suffered a second setback in June when it lost a contract, potentially worth nearly $500 million, to provide the army with the Light Computer Unit, a subset of the CHS program. The LCU laptop prime contract was awarded to SAIC Corporation, which had teamed with Zenith Data Systems to provide up to 21,000 commercial and ruggedized systems to the army. Magnavox Electronic Systems will produce the advanced tactical communications interface module, while Loral Command and Control Systems, formerly part of Ford Aerospace, will develop the software.

Current plans call for two versions of laptops divided along commercial and ruggedized lines. The commercial unit will be based on Zenith's existing laptops. SAIC will produce a second, ruggedized version using Zenith components. Both are designed to operate with Intel 80486 32-bit microprocessors, 8MB RAM, and DOS 4.1 and Windows. The system is estimated to weigh about 20 pounds. With the success of laptops in Desert Storm, military specifications have been further loosened in this program to avoid production delays.

DEVELOPMENTAL SYSTEMS

Plans are already under way to award contracts for the CHS II program, which is designed primarily to provide follow-on computers for the army's ATCCS. A total of 11,000 battlefield computers may be procured over the next seven years at a total program cost of $1.2 billion. Moreover, some industry observers estimate that an additional 15,000 units may be required by other forces, including reservists, although these large figures are reminiscent of the promised buys associated with the CHS I program and are unlikely to be fully realized.

The award of this contract is not expected to be announced until late 1992 or early 1993, with Magnavox, MILTOPE, Unisys, and Zenith all expected to bid for the four types of computers covered under the program. The plan calls for 6,300 hand-held computers, 3,600 transportable computers, a yet-undetermined number of portable systems, and a small number of powerful units for the ASAS intelligence program.

Further out in development planning is the revolutionary Soldier's Computer, under development by the army's Communications & Electronics Command (CECOM) Research, Development & Engineering Center at Fort Monmouth, New Jersey.

TABLE 1
ATCCS Major Program Elements
(Millions of Dollars)

System	Contractors (Primes and Principal Subs)	FY90 Funding	FY91 Funding	FY92 Request	FY93 Request	Total Estimated Program Cost
ATCCS (system & element integration)	US CECOM	63.5	29.3	49.6	25.2	17,000
CSSCS	TRW Hewlett-Packard	5.8	9.1	24.6	21.3	NA
ASAS	Jet Propulsion Laboratory Loral Martin Marietta McDonnell Douglas Rugged Digital Systems TRW	Classified	Classified	Classified	Classified	2,400
MCS	Loral Librascope MILTOPE	30.4	23.0	77.3	72.6	1,440
FAADC2I	TRW	NA	NA	NA	NA	3,400
AFATDS	Magnavox MILTOPE	28.7	40.8	48.4	45.5	1,100
CHS	MILTOPE SAIC Corp. Zenith GTE Hewlett-Packard Motorola	NA	NA	NA	NA	1,000

NA = Not available
Source: U.S. Department of Defense

Considered by some to be the third generation of CHS equipment, the Soldier's Computer is designed to be a ruggedized one-pound system offering hands-free operation, helmet-mounted display, hand-held joystick, voice/data links, and access to the Global Positioning System of satellites.

The display is being designed so that it attaches to either a helmet or an internal headset to allow the user to focus on a virtual image. The mass memory will be solid state for added ruggedness, and the processor will be an 80386. The computer will contain numerous interchangeable modules, similar to floppy disks, for differing functions including processing, memory, graphics, digital radio, and voice recognition. In addition, it is hoped that eventually the system will be capable of monitoring the health of soldiers and relaying infrared images captured through a soldier's rifle scope.

Realizing that the most innovative ideas often come from small research-oriented companies, both the army and DARPA, which is assisting with technological development, are hoping to have initial contracts awarded through the Small Business Innovative Research Program (SBIR). Two companies are already working on the system—Texas Microsystems and Integrated Systems Research Corporation, which was given $1.3 million by DARPA. Field demonstrations of the concept are expected to begin as early as next year, with a request for full-scale development expected to be released in the mid-1990s.

Although some people are skeptical of this program, the army is quick to point out that many were skeptical 20 years ago when the air force decided to place computers aboard aircraft; yet today no one would think of designing an airplane without on-board systems. Likewise, the army argues, as technology develops to allow qualitative enhancement of the individual soldier's capability, in 10 years it will be unthinkable to send soldiers into battle without the Soldier's Computer. The army hopes eventually to outfit every serviceperson with the system.

TRENDS AND PLAYERS

Larger corporations such as Magnavox, MILTOPE, Unisys, and Zenith are likely to continue dominating the market for ruggedized computers, although there does appear to be ample room for smaller, more specialized vendors. For example, Paravant Computer Systems of Florida has been successful in ruggedizing commercial equipment for use on a wide variety of military systems, such as army tactical missile batteries. Often, these types of contract are awarded through the platform's prime contractor—in this case, Raytheon.

Rugged Digital Systems, a pioneer in commercial ruggedizing, is well placed to continue to offer a wide variety of systems to the military. Rugged Digital Systems already delivers commercial ruggedized systems for a wide variety of platforms, from the navy's P-3 ASW aircraft to the army's AN/TSQ-173 ground mobile satellite terminal. In all, the company offers nearly 75 different ruggedized chassis to fit everything from Poqet's hand-held PC XT to MasPar's 30,000-mips SIMD massively parallel processor.

Other companies cashing in on the ruggedizing of nondevelopmental systems include Librascope, mentioned earlier, and Genisco Technology's Solaris Systems Division, which is supplying ruggedized servers and workstations to Sun Microsystems under two contracts worth $4.5 million. The company is ruggedizing Sun 4/400 servers for the marines and a variety of Sun workstations for the army.

The market will continue to expand; however, many corporate planners are beginning to emphasize the need to get ahead of the trend line. Companies such as MILTOPE, Paravant, and Ramtron are exploring the possible incorporation of nonvolatile main memory for use in military systems. If successful, this development would greatly decrease the power needed and enhance system reliability.

Larger corporations, also recognizing a growing military market for their commercial systems, are beginning to team with ruggedizing specialists, such as Librascope, MILTOPE, and Rugged Digital Systems. For example, Digital Equipment Corporation announced recently that it had signed with Codar Technology to produce ruggedized versions of its personal computers, while SAI Technology has signed with Paravant to adapt the former's commercial systems to military use. Still other major players, such as Loral, have experienced a near tripling of revenue from commercial hardware sold to the military over just the last three years and are sure to be aggressive in pursuing what promises to be a growing market.

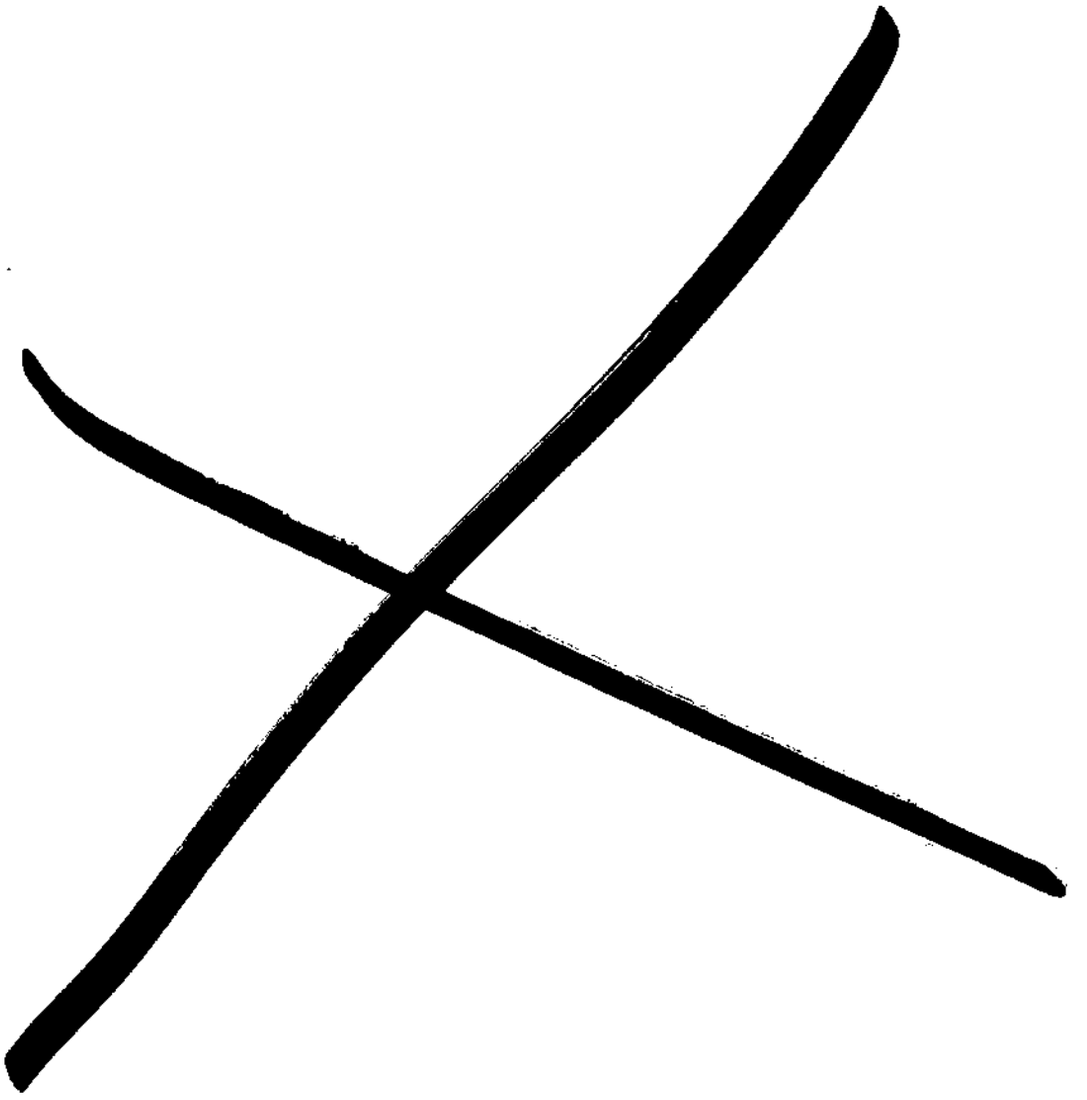
DATAQUEST CONCLUSIONS

Dataquest believes that one of the more visible impacts on semiconductor companies will be a shift toward using more commercial and

industrial temperature range components in an emerging part of the market. Life-critical computer systems most likely will continue needing the highest of reliability levels. However, much of the NDI hardware is using the same base commercial product (e.g., motherboard), and the ruggedization is applied to the rigid disk or general inclosure.

Speculating a little further, standard mil drawing (SMD) products or some form of standard mil-temp product based on commercial quality processes might become desirable in this cost-sensitive application.

Gregory Sheppard
Barry Blechman



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Research Newsletter

EUROPEAN DEFENSE ELECTRONICS: OPPORTUNITIES REMAIN

OVERVIEW

The dissolution of the Warsaw Pact and the unification of Germany have eroded public European support for defense expenditures, playing havoc with previous plans for European defense modernization. As in the United States, European governments began extensive modernization programs in the late 1970s and early 1980s; these programs are now ready for production and therefore require substantial expenditures.

After rising substantially between 1975 and 1985, European defense spending has been relatively constant in real terms since 1986. Indeed, if Turkey's 50 percent increase in spending from 1985 to 1990 is omitted, spending by non-U.S. NATO nations has dropped in real terms, with Germany experiencing the largest decline.

The trend line will continue to decline through 1995, resulting in numerous program delays, stretch-outs, and some outright cancellations. The reduced spending levels will also stimulate a move toward industry consolidation and greater cooperation among European defense manufacturers across national boundaries.

A COMPETITIVE EUROPE

The consolidation of European defense companies will not only make them more competitive in Europe but will also enable them to compete for exports to the Middle East and elsewhere. For example, Eurocopter, the merger of Germany's Messerschmitt-Bolkow-Blohm (MBB) and France's Aerospatiale helicopter units, continues apace and will ultimately result in a single intra-European company responsible for up to 40 percent of the worldwide defense helicopter market (excluding the Soviet Union).

Two other European giants also recently announced market-specific merger plans. France's Thomson-CSF and Great Britain's GEC-Marconi jointly will produce radar systems under a new company, GEC Thomson Airborne Radar (GTAR). Based in Paris, GTAR's announced intentions include pursuit of a radar system for the post-European Fighter Aircraft (EFA) generation of European fighters. Although this may be true, the prospect is so far in the future that a much more likely near-term focus will be for the company to strengthen its existing radar businesses. The merger will provide both Thomson-CSF and GEC-Marconi with a greater ability to compete aggressively in the growing worldwide market for upgrades of the radar systems of older aircraft, including helicopters. U.S. defense companies with a solid history of defense exports to Europe are understandably scrambling to enter team arrangements with European companies to secure an inside position advantage in an increasingly constricted market environment.

The consolidation trend's origins largely stem from an organization called the Independent European Program Group (IEPG), which was formed in 1976 with the encouragement of Washington D.C. to strengthen European cooperation in NATO. In 1984, participating individuals were elevated to the Minister of Defense, and the organization began institutionalizing European defense cooperation by encouraging cross-national weapon programs and company mergers and agreeing on common operational defense requirements. Many of the ongoing cooperative European programs, listed in Table 1, emerged under the auspices of the IEPG.

The general downturn in European spending, particularly compared with U.S. budgets, and the increase in intra-European cooperation has greatly affected the U.S. defense trade advantage. According to the Pentagon, U.S. defense exports to Europe exceeded imports by a ratio of 8:1 in the late 1970s, but this ratio is now 2:1. Figure 1 illustrates how quickly, according to Defense Forecasts Inc., U.S. defense exports to Europe have fallen,

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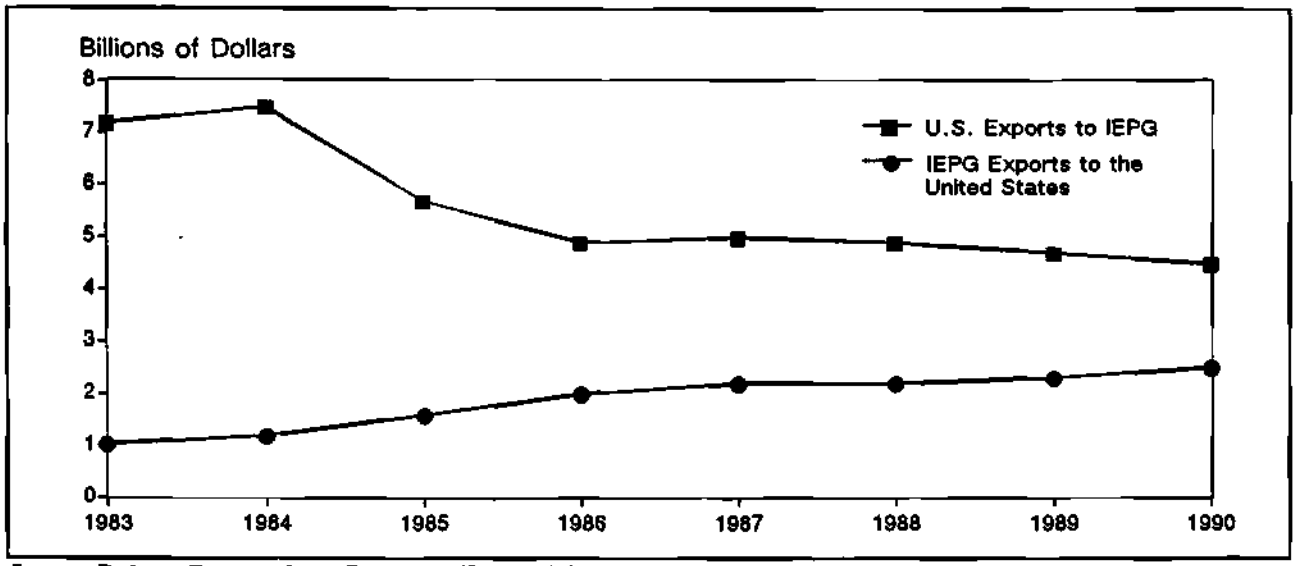
TABLE 1
Major European Cooperative Programs

System	Participating Countries	Primary Contractors
European Fighter Aircraft	Germany	Eurofighter Jagdflugzeug GmbH
	Italy	MBB
	Spain	Aeritalia
	United Kingdom	CASA
		British Aerospace
		Eurojet Turbo GmbH
		MTU
		Fiat
		ITP
		Rolls Royce
Tiger Attack Helicopter	France	Eurocopter GmbH
	Germany	Aerospatiale
		MBB
NH-90 Helicopter	France	Aerospatiale
	Germany	MBB
	Italy	Agusta
	Netherlands	Fokker
EH-101 Helicopter	Italy	Agusta
	United Kingdom	Westland
Brevel UAV	France	Eurodrone
	Germany	Matra
		MSG
Future Surface-to-Air Family of Missiles	France	Eurosam
	Italy	Aerospatiale
	Spain (LAMS)	Thomson-CSF
	United Kingdom (LAMS)	Selenia
		Ibermisil (LAMS)
		GEC Marconi (LAMS)
		British Aerospace (LAMS)
TriGAT Antitank Missile	France	Eurosam
	Germany	Aerospatiale
	United Kingdom	MBB
		British Aerospace
Multiple Launch Rocket System	France	Diehl GmbH
	Germany	Thomson-CSF
	Italy	Thorn-EMI
	United Kingdom	
Future Frigate	France	Contractors undetermined
	United Kingdom	
EUCLID	IEPG Members	Contractors undetermined

Source: Defense Forecasts Inc., Dataquest (June 1991)

FIGURE 1
U.S./IEPG Defense Trade



Source: Defense Forecast Inc., Dataquest (June 1991)

while European defense exports to the United States have expanded.

MAJOR PROGRAMS

The news, however, is not all gloomy. Several key European defense programs are proceeding, and each promises multimillion-dollar revenue to the producers of electronic systems, including some U.S. manufacturers. The five most important are described in the following paragraphs.

European Fighter Aircraft (EFA)

Although continually in doubt, the EFA program appears to have survived 1990, its most precarious year. After a shaky Germany gave reassurances to its partner nations of Italy, Spain, and the United Kingdom, completion of the development of Europe's most important military aircraft program finally seems assured.

Germany was the big question mark throughout the $11 billion developmental program. The costs of German reunification have stifled Bonn's economy and placed greater political pressures on the government to quickly reduce defense spending. Although it is unlikely that Germany will ultimately procure the originally intended 250 EFAs, the decision to complete development ensures that at least some EFAs will be manufactured.

Production of the single-seat multirole fighter is planned to begin in 1995. A total of 765 aircraft costing $36 billion is still planned, although Germany has now officially reduced its order for 160 aircraft. The United Kingdom plans to purchase 250, Italy 165, and Spain 100. Without third-party sales, it is unlikely that more than 500 EFAs will be produced through the year 2005, when production is slated to cease. The production schedule is likely to be stretched also.

The prime contractors for the program are British Aerospace with 33 percent share, MBB with 33 percent share, Aeritalia with 21 percent share, and CASA with 13 percent share. The engine for the system is also being developed through a cooperative effort involving the United Kingdom's Rolls Royce, France's Fiat, Germany's Motoreu u. Turbinen Union (MTU), and Spain's ITP.

It is estimated that nearly 60 percent of the total developmental costs associated with the EFA are related to its avionics and other electronic systems. Although many of the major contract awards are still to be let, several electronic programs are already under way.

Litton's German division, LITEF, was awarded an important avionic systems contract late last year. The contract calls for Litton to deliver 25 sets of inertial measurement units (IMU), two different avionic computers, and an interface processor unit (IPU). Litton has reportedly chosen to subcontract the IMUs to a second German-based Litton division, LTIF, and to a division of Cesel of

Spain. The computers are to be connected with fiber-optic cables to vital centers throughout the aircraft and will use ADA-based software. Litton has announced plans to subcontract the computers systems to Agusta, Computing Devices, Inisel, and Selenia. The IPUs, which will handle the digital fly-by-wire system, are made up of three interfaces. Two interfaces will use STANAG 3901 high-speed fiber-optic digital data buses, and the third will be linked a STANAG 3838 electronic data bus.

Other major electronics contractors working on the EFA include FIAR of Italy, Eltro of Germany, and Thorn-EMI of the United Kingdom. They are working on development of an infrared search-and-track system known as Pirate. GEC-Avionics, along with Teldix, Selenia, and Cesel, are developing the head-up display system under a $100-million contract. GEC-Avionics will also build the flight control computer under a $235 million developmental contract. In March, the weapon stations system, which allows communications from the cockpit to the weapon systems through a MIL-STD-1553 data bus, was awarded to a consortium made up of Alenia, Cesel, GEC-Avionics, and Teldix.

PAH-2 "Tiger" Eurocopter

The development of this system has resulted in the planned merger of MBB's and Aerospatiale's helicopter units. The helicopter, which will be produced in three versions, is designed to serve as the primary new combat helicopter for both France and Germany in the 1990s, much as the RAH-66 Comanche will serve the U.S. Army.

The first prototype has already emerged, with production slated to begin in 1997. Germany plans to procure 212 of an antitank PAH-2 version. France is counting on buying 75 armed escort variants, known as the HAP, and 140 antitank variants known as HAC-3GT. Total program costs are now estimated at close to $20 billion over program's lifetime.

The Tiger may not fare as well as the EFA, with supporters in both France and Germany growing increasingly weary as development costs have risen. Much appears to depend on whether the United Kingdom, which canceled its own Tonal antitank helicopter program last year, will choose the PAH-2 over the AH-64 Apache and A-129 Agusta. Toward this end, Eurocopter has begun to develop closer ties with Westland in the United Kingdom during the past year.

In 1990, the team of Crouzet, MBB, SFENA, and Teledix were awarded the PAH-2's avionics development contract, which is initially worth more than $100 million, and potentially worth nearly $1.3 billion. Crouzet is now in the process of developing the inertial navigation computer and sensors; Teldix will produce the CMA 2012 pulse-Doppler radar system.

Separately, Thomson-CSF has been awarded a contract to provide its Sherloc radar warning receiver to the PAH-2 development office, a contract potentially worth several hundreds of millions dollars.

Future Surface-to-Air Family of Missiles (FSAF)

Aerospatiale and Thomson-CSF have joined forces with Selenia to develop a family of four surface-to-air missiles that the team members hope will be capable of penetrating this U.S.-dominated market. The consortium, known as Eurosam, was joined by Great Britain and Spain in 1990 after the failure of NATO's Antiair Warfare System. Although the latter two nations participate directly in just one of FSAF's projects—the Local Area Missile System (LAMS)—they are involved in a variety of subcontracts for other types of missiles in the family.

Aerospatiale's Aster 15 missile is serving as the basis for a naval version of the FSAF (SAAM), which will have a range of 8 kilometers and enter service in about 1997. Currently, two versions are being designed, both of which will most likely be produced. The first will be equipped with the Arabel X-band radar by Thomson-CSF and used by France. The second will use the C-band phased-array system from Selenia and be procured by Italy. Both nations plan to use the missile as an alternative to the U.S. Sea Sparrow.

Aeropatiale's Aster 30 missile will serve as the model for the land-based surface-to-air missile (SAMP/T) as a longer-range shipborne surface-to-air missile (SAMP/N). The SAMP/T is being engineered as an alternative to the Raytheon-built HAWK and will have a range of up to 30 kilometers. This system will use Selenia's C-band phased-array radar.

The SAMP/N, with a designed range of 40 kilometers, is being developed to replace the U.S. Standard missile system and will use Thompson-CSF's Arabel X-band radar.

In 1990, Eurosam received $1.8 billion to cover the development costs associated with the SAAM, the SAMP/T, and the SAMP/N.

Finally, the LAMS, which is a derivative of the SAMP/N, is being pursued by all four governments as a third antiair missile system for naval

vessels. The two-year project definition stage is scheduled to conclude in February 1992. If a production decision is made, the Spanish consortium Ibermisil will provide the command-and-control systems, Thomson-CSF the long-range surveillance radar, GEC-Marconi the multifunction radar, and MARA the data computers.

Rafale Fighter Aircraft

Choosing to stay out of the EFA consortium, France has pursued its own next-generation multirole fighter, known as the Rafale. Development costs are estimated to be $6.5 billion. The production schedule, which is expected to begin in 1994, calls for a total of 336 aircraft at a cost of $16 billion.

The development of the Rafale is occurring under the auspices of Avion de Combat European (ACE) International, a consortium made up of Dassault-Breguet with 60 percent share, SNECMA with 20 percent share, Thomson-CSF with 10 percent share, and Electronique Serge Dassault (ESD) with 10 percent share.

Dassault is building the airframe and acting as the program's systems integrator and hopes to sell an additional 800 to 1,200 aircraft overseas. SNECMA is constructing its M88 engines for the program, and Thomson-CSF and Electronique Serge Dassault are developing the Spectra electronic countermeasures system. The Spectra system alone will reportedly be worth over $1.5 billion to the two companies. The main mission computer system is being developed by Sagem and ESD.

Although some reservations have been expressed by a few French government officials, the program appears to be solid. For France to drop the Rafale would be tantamount to France leaving the military aircraft business, an unlikely development.

The Advanced Short-Range Air-to-Air Missile (ASRAAM)

The original idea behind the ASRAAM was straightforward. The United States would develop a next-generation medium-range air-to-air missile, the AMRAAM, to replace the Sparrow, and the Europeans would develop a short-range missile to replace the AIM-9 Sidewinder. The United States would then procure the European's short-range system, with an expected production run of 60,000, and Europe would procure the medium-range missile.

For such a simple concept, ASRAAM has been fraught with difficulties and setbacks, beginning in 1989 when prime contractor British Aerospace's three European partners dropped out of the program. After this setback came technical difficulties and what many U.S. officials perceived as a lack of resolve by the United Kingdom to complete the program.

With these uncertainties looming and the U.S. manufacturer of the Sidewinder, Raytheon, anxious not to lose a solid long-standing market, the United States has begun to develop an upgraded short-range infrared-seeking missile known as the AIM-9R. Moreover, it was announced late last year that the ATF, the primary U.S. platform for the short-range missile in the next decade, would not accommodate the ASRAAM's design features, all but ending the United Kingdom's hopes of a 40,000-missile purchase by the United States of two-thirds of the planned total production.

Despite the gloomy prospects in the U.S. market, the British government decided in September 1990 to proceed with full-scale development of ASRAAM, but after declaring the original U.S./U.K. deal dead in May 1991, decided to revive the program.

Three teams plan to bid for the contract. The original prime, British Aerospace, will again offer its AIM-132 ASRAAM, which is equipped with a Hughes infrared seeker. GEC-Marconi and Matra will offer the MicASRAAM, which is a MICA missile built by Matra combined with a GEC-Marconi infrared seeker. Finally, Raytheon is rumored to be submitting a bid with yet another version of the Sidewinder, although its chances of winning are highly doubtful given the political circumstances surrounding the competition.

DATAQUEST CONCLUSIONS

The five programs highlighted in this newsletter alone represent prospective European defense spending in excess of $110 billion. They illustrate that despite the general downturn in European defense spending, significant opportunities continue to exist for well-placed electronics manufacturers. Likewise, many of the inclusive electronics systems are still being designed, providing opportunities for semiconductor design wins.

Barry Blechman
Gregory Sheppard

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Research *Bulletin*

MIL/AERO SEMICONDUCTOR MARKET SHARES REVIEWED

MAINTAINING IS GOOD

It is an understatement to say that 1990 was a tough year for suppliers to the military and aerospace electronics industries. Worldwide semiconductor shipments to these industries declined slightly from $2,858 million in 1989 to $2,846 million in 1990. The large, broad-line companies generally experienced a decline in shipments while focused medium-size and small companies picked up some market share. This is a pattern not unlike that of most other semiconductor markets.

Harris Remains on Top

Harris Semiconductor, with its product line ranging from discretes to complex cell-based ICs, remained the largest mil/aero semiconductor supplier, with 9.2 percent of worldwide shipments (see Table 1).

Harris also benefits from being the leading supplier of radiation-hardened semiconductors, which remains one of the areas of greatest demand because they are used in space, C3I, missiles, and a growing list of avionics applications. Motorola

TABLE 1
Estimated Worldwide Mil/Aero Semiconductor Shipments
(Millions of Dollars)

	1989	1990	1990 Market Share (%)
Harris	269	263	9.2
Motorola	185	191	6.7
National Semiconductor	183	175	6.1
Texas Instruments	182	154	5.4
AMD	138	124	4.4
GEC Plessey	111	120	4.2
Analog Devices	103	108	3.8
LSI Logic	91	100	3.5
SGS-Thomson/TMS	101	94	3.3
Intel	75	77	2.7
Others	1,420	1,440	50.6

Source: Dataquest (April 1991)

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remained in the number two position as it continues to capitalize on its strengths with discretes, its 68XXX MPU family, and its strong presence in the European market.

National Semiconductor, Texas Instruments (TI), and Advanced Micro Devices (AMD) all suffered principally from declines in their digital bipolar businesses. A common factor with these companies is the ongoing phaseout of portions of their older bipolar memory and standard logic businesses. National is focusing on the mixed-signal and advanced interface areas for the future. TI is emphasizing its DSP and specialized processor technology and joins AMD in focusing on high-density/performance PLDs. AMD, Intel, and TI each have entered or are planning to enter the Flash memory business.

GEC Plessey represents the combined forces of Marconi Electronic Devices and Plessey Semiconductor, which were merged as a result of the GEC-Siemens acquisition of Plessey. This company is the largest supplier to the European market with strengths in RF and mixed-signal technologies. Analog Devices continues to be the leading provider of data conversion products with growing presence in DSP.

LSI Logic continues to mine its vein of gate array design wins as it maintains a steady gain of market share. SGS-Thomson/Thomson-TMS suffered in part because of a steep decline in market SRAM prices and a slowing French market. Intel witnessed continued pervasion of its MCU and MPU families and is waiting to capitalize on its new offerings in avionic MPUs and datacom ICs.

DATAQUEST CONCLUSIONS

The tough market is forcing many suppliers to rethink their strategies and decide which lines they will continue to carry or introduce in military temperature versions. This might help supplier profitability, but it is hurting availability of mature and new products. Because of steep budget cuts, 1991 will most likely be a year of increased decisiveness regarding product line support.

Gregory Sheppard

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Research Newsletter

UPGRADE UPDATE: WAR OF PRIORITIES

THE BACKDROP

The fiscal 1992 and 1993 defense budgets submitted to Congress in February contain a wide range of weapon platform upgrades; many are in lieu of new program starts. As we predicted in August 1990, the Defense Technologies Strategy introduced last summer by former Under Secretary for Acquisition John Betti has been a catalytic force in causing substantial increases in the number and scope of programs to upgrade the capabilities of existing weapon systems. Furthermore, electronics and its elemental semiconductor and software technology will play key roles in these upgrade programs.

The strong trend toward upgrades over new starts has been reinforced by cancellation of several major new weapon programs, most notably the Lockheed P-7A next-generation antisubmarine aircraft and the General Dynamics/McDonnell Douglas advanced naval A-12 attack aircraft. Although these two program terminations will cut a total of nearly $33 billion through fiscal 1997, upgrade plans for operational platforms to fill the resulting deficiencies in U.S. military capability are already under way.

MAJOR PROGRAM UPGRADES

Patriot Missile

The success of the Patriot missile system during Operation Desert Storm has guaranteed Raytheon, the prime contractor, increased sales in both the United States and abroad. Apart from plans to replace the Patriots used during the conflict, the Patriot system is now planned for a number of upgrades.

Many of the original Patriots, known as the Patriot Anti-Missile Capability-1 (PAC-1), will be upgraded to the PAC-2 configuration. Although effective in the Middle East against the relatively slow-moving SCUDs, the PAC-1 missile was not originally designed to intercept missiles but rather was created as a point-defense antiaircraft weapon.

Army Secretary Michael P.W. Stone recently told Congress that the army's inventory objective for the Patriot missile is now 6,000, with half dedicated for air defense and half for defense against missiles. In approving a fiscal 1991 supplemental appropriation, Congress in March provided $312 million for various Patriot missile systems. Of that amount, $166 million will be used to procure an additional 283 missiles, some of which will be replacements for missiles fired during the war. An additional $114 million was appropriated to pay for the upgrading of systems from PAC-1 to PAC-2 and $32.2 million to investigate possible future upgrades. Of the $32.2 million approved, $16.7 million will be provided to develop remote launch capabilities, radar receiver enhancements, and navigational upgrades; $5.5 million will be for missile guidance enhancements; and $10 million will be to procure global positioning system (GPS) receivers for the PAC-2 enhancements.

PAC-2s will use the M818E2 dual-mode fuze and a new optimized antimissile warhead. Unlike the older fuze on PAC-1s, the M818E2 will produce two separate tracking beams. To provide the missile with a greater range, one tracking beam will be more focused, much narrower, and thus more powerful at longer distances, allowing intercepts much earlier than were possible with the PAC-1 system. The improved warhead carries heavier fragments for greater target destruction as well. The army has also announced that the new Patriot systems will use the AN/UYQ-61(v) Data Link Set produced by Whittaker Electronic Systems along with the CP-1932/UYK ruggedized

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microcomputer manufactured by KMS Advanced Products. Other subcontractors include Hazeltine, which designed the IFF integrator, and Martin Marietta, which designed the missile airframe and launcher.

TOMAHAWK CRUISE MISSILE

The Tomahawk missile program is dual-sourced between General Dynamics' Convair Division and McDonnell Douglas Missile Systems. Each year's split is usually announced in November, with 70 percent of the fiscal 1990 buy going to General Dynamics and 60 percent of the 400-missile fiscal 1991 buy going to McDonnell Douglas. The fiscal 1992 and 1993 requests are for 236 and 200 missiles, respectively. Additional quantities of Tomahawks, which saw extensive successful use in the Persian Gulf, will also be procured to bring inventories back to planned levels; Congress approved an additional 293 missiles at a total cost of $378 million in the fiscal 1991 supplemental appropriation.

Although the Tomahawk Block III upgrade was authorized several years ago, the improvements are just beginning to be produced and will likely be retrofitted in existing missile systems. The upgrade includes an improved guidance system and an increase in the missiles' range of 30 percent. The Block III systems incorporate GPS technology, an upgraded Digital Scene Matching Area Correlation (DSMAC-IIA), and an improved 402 turbo-engine for greater range. The DSMAC system is being dual-sourced between Loral and McDonnell Douglas; the program should run through 1996 or 1997.

The navy expects to procure 1,090 Block III Tomahawks over the next four years, with buys of 326 and 290 requested for fiscal 1992 and 1993, respectively; a total of 1,795 existing systems will be remanufactured to conform to Block III standards.

A-6E "Intruder" Attack Aircraft

The aging Grumman A-6E program received a breath of new life with the Pentagon's cancellation of the McDonnell Douglas/General Dynamics A-12 follow-on naval attack airplane.

The A-6E Systems Weapons Improvement Program (SWIP Block IA) was initiated in fiscal year 1990. This upgrade continues, along with a program to rewing 60 A-6Es in fiscal 1992 and 1993. The SWIP Block IA program will include a CP3X mission computer, which is an upgraded version of the IBM system and is being assembled by Cable Computer Technologies (CCT), and an integrated defensive avionics program, which is being directed by the navy at its China Lake, California, facility and is being competed for by Lockheed Sanders and a Raytheon/Hughes team. A GEC Avionics head-up display also will be added, along with a Litton ASN-139 carrier aircraft inertial navigation system II, a GPS system, and a CPU-140(x) signal data converter replacement. Grumman was given $26.6 million for the SWIP integration program in January and received an additional $17 million in March.

F-16 "Falcon" Fighter

With over 2,500 F-16s flying and nearly 4,000 more on order in 17 countries around the world, the Pentagon's decision to terminate the U.S. program after fiscal 1993 can only enhance the market for future Falcon upgrades. Moreover, the U.S. Government is likely to help General Dynamics' efforts to sell more F-16s overseas in order to keep the production line open in the event of a future contingency requiring more U.S. purchases.

The Mid-Life Upgrade (MLU) will affect 130 U.S. F-16A/Bs and 530 planes flown by Norway, Belgium, the Netherlands, and Denmark. This upgrade is designed to bring these older aircraft up to the F-16C/D standard. Although participation by some suppliers still has to be finalized, it is known that the MLU will add a GPS navigation link, an improved data modem that will allow pilots to receive ground target coordinates from controllers, the Martin Marietta LANTIRN targeting and navigation system, and the ability to be armed with AIM-120 AMRAAM missiles produced by Hughes and Raytheon.

Another upgrade program, known as the Operation Capability Upgrade (OCU), will increase the avionics and radar fire control capabilities of additional U.S. F-16A/B aircraft while expanding their computer capacity. The OCU upgrades are designed to enable these aircraft to play an air defense role. Radar improvements will allow detection and tracking of small targets beyond visual range as well as use of long-range Raytheon AIM-7 SPARROW and AIM-120 AMRAAM radar-homing air-to-air missiles.

Moreover, 350 Block 30 F-16 aircraft are slated to be reconfigured to an anti-armor role to

replace A-10 Warthog ground-attack aircraft. The new F/A-16s will receive forward-looking infrared sensors, Martin Marietta GPU-5/A Pave Penny laser target identification units, General Electric GAU-13 30mm Gatling gun pods, terrain-following systems, and the improved data modems.

F/A-18 "Hornet" Aircraft

With cancellation of the A-12, the navy has found itself in a position of requiring an interim aircraft to perform the carrier attack function until a replacement for the A-12, now called the A-X, can be introduced.

The two alternatives being considered are Grumman's F-14D or an upgraded version of McDonnell Douglas' F/A-18. Since Secretary Richard Cheney terminated the F-14D in the fiscal 1992 budget, it has been assumed that the navy has decided to proceed with upgrades to the F-18, but recent statements indicate that a final, definitive decision between the two is still several weeks away, giving Grumman some hope. Still, the likely choice is the F/A-18, which is already undergoing extensive upgrade planning.

Current navy plans call for the procurement of 228 new F/A-18C/D aircraft through fiscal 1998 as well as the development of an upgraded version, known as the F/A-18E/F, beginning this fiscal year. Production of the upgraded version is slated to begin in fiscal 1996.

The F/A-18E/F development program calls for $435 million in fiscal 1992 and another $1 billion in fiscal 1993. The "E" will be the single-seat version of the aircraft; it will have 25 percent larger wings, increased fuel and payload capability, and a thrust version of the General Electric F404 engine, which was to have been placed on-board the A-12. In addition, the cockpit reportedly will have a touch-sensitive screen, which was also under development for the McDonnell Douglas/General Dynamics A-12 program. Upgrades to the Litton ALR-67 radar warning receiver and the Hughes APG-73 radar are also planned. The entire upgrade program is scheduled to be evaluated by the Defense Review Board in December.

If the F/A-18E/F upgrade is chosen as the interim choice for the navy's primary attack aircraft, McDonnell Douglas may be able to salvage some of its investment in the A-12 program. Secretary Cheney is slated to make a final decision between the F-14 and F/A-18 upgrades the first week in May.

Tactical Army Combat Service Support Computer Systems

The army is continuing its stated commitment to upgrade its Tactical Army Combat Service Support Computer Systems. These transportable ruggedized microcomputers serve as the army's main battlefield light computer for processing personnel data, material management, and logistics information.

Unisys, which has produced over 10,000 of the B26 computers since 1984, received another $18.6 million contract in late January to upgrade 2,600 of the systems. The upgrades will be focused on the central processor, replacing the existing Intel 80186 with an Intel 80386 chip. Unisys will also replace the standard 80MB hard drive with a 400MB system and increase the RAM from 1MB to 4MB. Also, the 25MB tape-storage device will be replaced with tape capable of 150MB of storage.

"Copernicus" Naval Command and Control

For decades, the navy has worked with a mix of command and control systems, which has, at times, made it impossible for fleet commanders to communicate effectively with other naval assets. The navy is planning to overcome that limitation with a new program known as Copernicus.

The goal of the multiyear, multibillion-dollar effort is to improve the flow of computerized information to combat commanders. Some estimates place the current number of naval communications links at 33,000, all of which can send information over thousands of separate communications lines to tactical commanders. The problem is that the information flow arrives completely disorganized. Under the new plan, the navy will establish 8 worldwide computerized information networks and 14 tactical networks. Copernicus will integrate information gathered from myriad military assets including satellites, ASW forces, electronic intercepts and surveillance, and various surveillance sensors.

The plan is currently being implemented by the navy's new Space and Electronic Warfare branch. Although the complete upgrade plan will not be released until the end of May, it is reported that it will rely on standard computers designed by several civilian companies, such as the TAC-II system currently being delivered by C3 Incorporated.

E-3 "AWACS" Early Warning Aircraft

Many AWACS aircraft were used extensively and successfully during Operation Desert Storm. They provided detection, tracking, and identification of targets at stand-off ranges of up to 250 miles and coordinated many of the engagements between Iraqi and Allied air forces.

To enhance detection and tracking capabilities, upgrades are under way that potentially could result in over $1 billion in new contracts. One improvement program, known as the Block 30/35, will enhance target detection systems, sensors, and antijamming communications capabilities. The air force has selected Boeing as the prime contractor. Boeing will provide 5 development and 34 production model ship sets at a total cost of $650 million. In addition, Boeing and IBM were selected to upgrade the 18 aircraft currently assigned to NATO, a contract worth $700 million.

Under the agreement, the upgrades will include a Boeing Have Quick radio communications system, worth $230 million, and a Westinghouse radar. Other improvements will include a Rockwell GPS terminal and a computer memory upgrade to four-megaword IBM magnetic bubble memory using Hitachi 1MB bubble memory chips. IBM has also been selected to provide Pi CC-2E computers to control all aircraft systems. Control Data is providing the radar data processing system in cooperation with Westinghouse. Westinghouse has been contracted to write nearly 200,000 lines of Ada-based software. Boeing and Westinghouse are cooperating in the aircraft's main radar improvement program, which will build upon Westinghouse's AN/APY-2 system.

The fiscal 1992 air force budget request includes $51 million for E-3 modifications and $202 million in development funds; fiscal 1993 requests are for $85 million and $137 million, respectively.

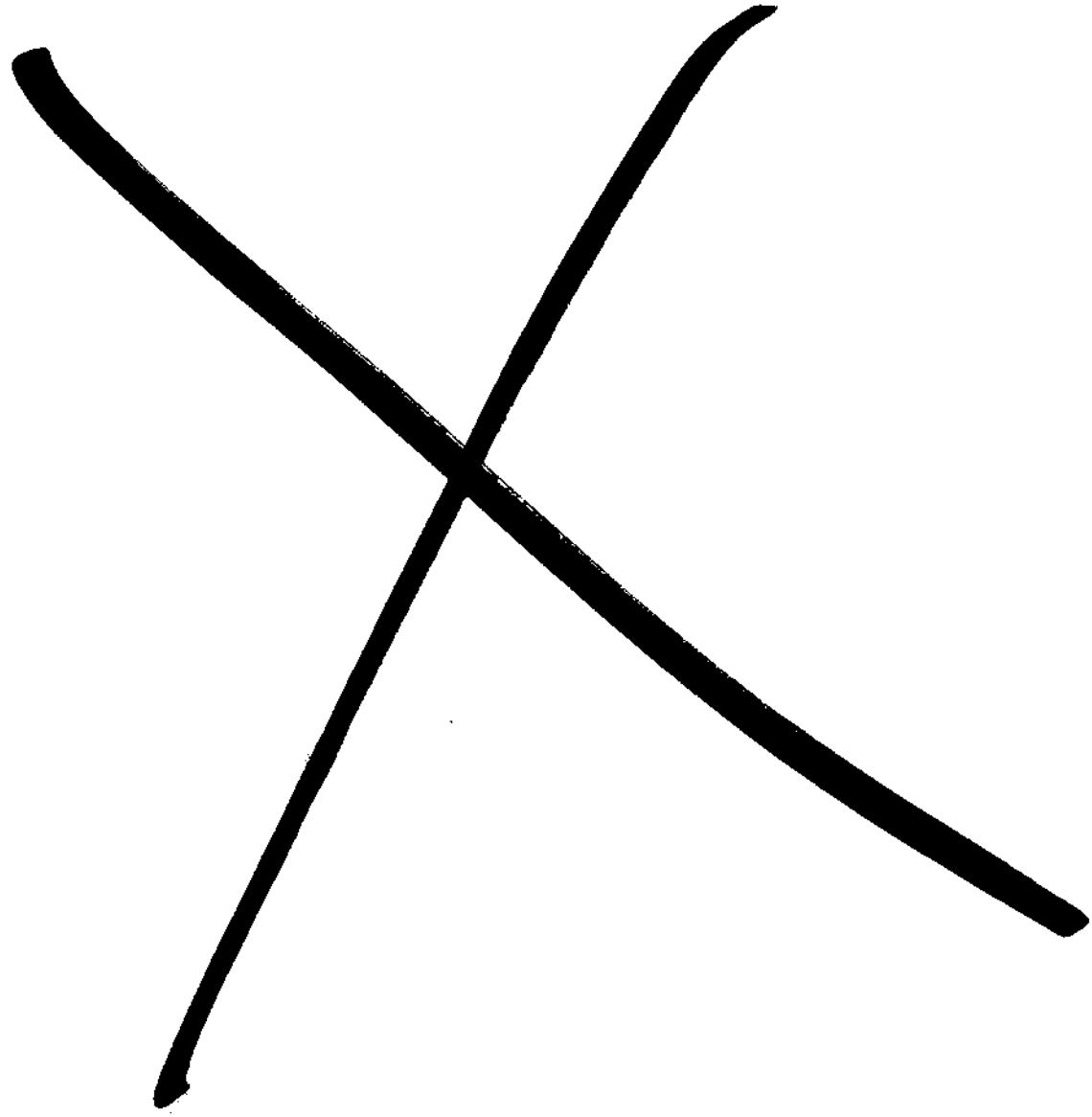
DATAQUEST CONCLUSIONS

Although upgrades will continue to be favored over new program starts through the mid-1990s, the simple fact that there are plans for program upgrades does not necessarily guarantee program funding. The difficult budgetary situation will continue to enforce tough decisions.

For example, Grumman's F-14D program, long viewed as a sure thing, was terminated by the Pentagon so abruptly that not only were funds zeroed in the fiscal 1992 budget proposal, but the navy ordered Grumman to stop work on modifications paid for with fiscal 1991 appropriations, leaving a reported 18 F-14As in various states of disassembly. Although Congress has reinstated fiscal 1991 funding in the Desert Storm supplemental bill, along with strong language ordering the navy to continue upgrading the aircraft as previously authorized, it is uncertain that Secretary Cheney will yield to congressional demands and fully reinstate the program. Grumman at one time had hoped to build 400 new F-14Ds and convert some 132 F-14As to the "D" configuration.

The F-14 upgrade termination clearly demonstrates the Pentagon's newfound commitment to upgrade only those systems that are necessary in light of the overall force restructuring. Other upgrade programs, although they may offer a significant expansion of current capabilities, will not proceed unless they are able to meet this essential litmus test. Therefore, Dataquest recommends caution when planning on upgrade-driven business.

Gregory Sheppard
Barry Blechman



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Research *Bulletin*

MILAERO TECH BRIEFS: 1991 USHERS IN A PLETHORA OF OFFERINGS

INTRODUCTION

The following publications were used as source material for this bulletin:

- PR—Press release
- M&A—*Military and Aerospace Electronics*
- EBN—*Electronic Buyers' News*

XICOR ENTERS 1Mb EEPROM FORAY

Joining a recently introduced 512K part, the new 1Mb version is expected to be available in MIL-STD-883 versions by April. It will be available in CDIP and CLCC versions, with 1,000-piece CDIP quantities priced at $423. (EBN, 2/25/91)

ALCOA OFFERS CERAMIC PACKAGING

Alcoa Electronic Packaging has invested $100 million in production facilities based in San Diego, California. It is producing prototypes of single and multichip packages in prototype quantities. To date, emphasis has been on pin grid arrays and other high pin-count packages. (EBN, 2/18/91)

MILITARY GALs FROM LATTICE

Lattice is offering MIL-STD-883 versions of its quarter-power CMOS GAL16V8A and GAL20V8A. Based on 0.9-micron electrically erasable technology, the 20ns versions typically draws 45mA of current. CERDIP versions of the GAL16V8A part in 100-unit quantities are priced at $12.38, and the GAL20V8A is priced at $38.40. (EBN, 2/11/91)

TEXAS INSTRUMENTS EXPANDS DSP LINE

TI introduced its SMJ320C30 in a MIL-STD-883 Class B version with execution speeds as fast as 70ns. Available in a 181-pin CPGA, the floating-point device also sports an optional Ada compiler. Quantities of 1,000 units are priced at $1,320. (EBN, 2/11/91)

HIGH-DENSITY SOS ASICs FROM GEC PLESSEY

GEC Plessey introduced its MA9000-A sea-of-gates family based on 1.5-micron silicon-on-sapphire technology. Available with 20,000 raw gates, the company claims that designs up to 16,000 gates have been delivered. The family offers 1M rad total dose, 10^{11} rads per second dose rate, and 10^{-11} errors per bit-day SEU immunity. Toggle rates up to 100 Mhz are possible. (PR, 1/29/91)

NONVOLATILE DRAMs FROM RAMTRON

Based on 3.0-micron silicon gate CMOS technology with integrated ferroelectric storage cells, Ramtron has introduced a 4K (512x8) version. Intended as an evaluation model for future higher-density offerings, the FRAM uses a single +5V power supply with 44mW maximum dynamic power dissipation. (PR, 1/29/91)

ADA 9X TARGETED AT INTEL PROCESSORS

The team of AETECH and PR Software is developing Ada support for the military versions of i386s. Also, Tartan Laboratories, along with TRW,

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

will develop Ada 9X real-time support for 80960MC 32-bit embedded RISC processors. Ada 9X will be the first major revision of the Ada language since its introduction in the 1980s. (PR, 1/22/91)

AMD SHIPS 2Mb EPROMs

Claiming to be the first on the market, AMD has availability of the 150ns parts in MIL-STD-883 versions, with plans for standard military drawing approval this quarter. AMD also plans to introduce a x16 version later in 1991. (PR, 11/12/90)

MICRON HAS VERY FAST 1Mb SRAMs

Soon to be compliant with MIL-STD-883, Micron Technology has 25ns versions available in x1, x4, and x8 configurations. The part also is described as low power, and JAN versions are being planned. (PR, 11/2/90)

MAXIM HAS FAST BiCMOS 12-BIT A/D CONVERTER

Maxim claims that the MAX174 only uses one-third the power of standard bipolar 574A converters while achieving 8µs conversion times. CDIP prices run $91.20 for quantities of 1,000. (M&A, 12/90)

ANALOG DEVICES OFFERS FOUR-CHANNEL A/D CONVERTER

Targeting motor controllers, adaptive filters, and phased-array applications, the company introduced what it claims is the first four-channel simultaneous sampling converter on the market. The AD7874 sports 12-bit resolution with 34µs conversion time. (M&A, 12/90)

AMD HAS FAST 1Mb FLASH MEMORY

Claiming 90ns speed, the Am28F010 Flash memory is compatible with Intel's 12V versions. MIL-STD-883 CDIP versions are available for $38.25 in quantities of 100. (M&A, 12/90)

CYPRESS INTRODUCES 15ns EPLDs

The erasable PLDC18G8-12 features eight programmable outputs and is targeted at the 20-pin PAL market. The device is supported by Cypress' PLD Tool Kit, as well as its ABEL and CUPL packages. (M&A, 1/91)

VITESSE HAS 200K-GATE GaAs ARRAYS

The VGFX200K sports a channelless architecture with utilization rates running between 50 and 70 percent. A 350K-gate version is slated for availability this spring. The parts are based on Vitesse's 0.6-micron H-GaAs III process. At 50 percent utilization, the 200K version dissipates 14 watts. Unloaded gate delays are 50ps. Available with 256 I/Os (ECL/TTL), 344-pin LCC packaging is available. (M&A, 1/91)

LORAL TO CLOSE MICROWAVE GROUP

Citing slowing demand for microwave components, Loral is closing its Narda-West facility in San Jose, California. The 200 employees affected may be transferred to other local Loral divisions. (EBN, 2/25/91)

Gregory Sheppard

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Research Newsletter

UNITED STATES DEFENSE BUDGET: PROGRAM HIGHLIGHTS

INTRODUCTION

The proposed FY1991 and 1992 budgets of the U.S. major electronics-intensive procurement programs have been announced. Table 1 presents a summary. This newsletter discusses some of the more notable program changes.

AIRCRAFT

The aerospace industry was hit hard by the new budget proposal. With fewer air wings to fill, the Pentagon announced cuts in many programs that just one year ago were believed to be safe.

TABLE 1
50 Major U.S. Procurement Programs
(Millions of Dollars)

	Authorized FY1991 Buy		Requested FY1992 Buy		Requested FY1993 Buy	
	No.	$	No.	$	No.	$
Aircraft:						
ATF	0	955	0	1,637	0	2,325
AH-64	0	91	0	145	0	153
CH-47	0	291	0	257	0	24
LH	0	340	0	550	0	617
OH-58D	0	39	0	209	0	95
UH-60L	48	105	60	508	60	428
AH-1W	8	93	12	145	12	142
AV-8B	24	555	0	10	0	11
CH/MH-53E	12	336	20	522	20	531
E-2C	6	466	6	539	6	542
F-14D	0	170	0	116	0	104
F/A-18	48	1,683	36	2,423	20	2,534
B-2	2	4,185	4	4,822	7	4,639
C-17	0	1,026	6	2,831	12	4,212
E-8A JSTARS	0	191	0	397	1	779
F-15	36	1,648	0	309	0	65
F-16	108	2,154	48	1,419	24	923

(Continued)

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TABLE 1 (Continued)
50 Major U.S. Procurement Programs
(Millions of Dollars)

	Authorized FY1991 Buy		Requested FY1992 Buy		Requested FY1993 Buy	
	No.	$	No.	$	No.	$
Ships:						
DDG-51	4	3,246	5	4,541	4	3,644
LHD-1	1	972	0	40	0	40
MHC-1	2	212	2	248	2	248
SSN-21	1	2,340	1	2,382	2	2,464
Trident	1	1,352	0	154	0	49
Missiles:						
AAWS-M	0	92	0	124	1,647	225
ATACMS	318	192	300	180	351	192
Hellfire	4,200	179	112	38	3,543	178
Patriot	817	759	0	140	0	66
TOW-2	10,946	211	10,000	281	9,440	245
AMRAAM	695	846	1,191	1,031	1,469	1,049
Harpoon	160	243	0	38	0	0
Standard	790	662	525	461	550	463
Tomahawk	400	710	236	500	200	417
Trident II	52	1,671	28	1,271	31	1,380
ACM	85	506	120	626	102	552
AGM-130	48	52	120	93	149	111
HARM	120	34	465	117	901	232
HAVE NAP	26	28	32	37	0	0
MX/Rail Garrison	12	918	0	458	0	106
SRAM-II	0	159	0	177	25	259
Mk-48 ADCAP	240	419	108	367	108	260
Space:						
FLTSATCOM	3	250	3	283	0	171
DMSP	1	216	2	162	0	55
DSCS	0	80	0	70	0	30
DSP	1	674	0	273	1	653
MILSTAR	0	956	0	1,404	0	1,536
NAVSTAR	0	282	0	397	0	420
NASP*	0	162	0	232	0	183
SDI	-	2,874	-	4,581	-	4,933
Vehicles:						
Bradley M-2	600	647	0	109	0	110
Abrams M-1	225	804	0	79	0	46
HMMWV	8,030	252	7,302	282	6,922	242

*DOD funding only
Source: U.S. Department of Defense

F-16

The General Dynamics Corporation F-16 Falcon took perhaps the largest hit, with the program now planned for termination after a final buy of 24 in fiscal 1993. This year's budget calls for the procurement of 48 F-16s in fiscal 1992 at a total cost of just over $1.4 billion, down from 180 units procured in fiscal 1989 at $3.2 billion. General Dynamics, however, has considerable orders from foreign sources to cushion the reduced U.S. buy.

F-15

The McDonnell Douglas Corporation F-15, which was slated for termination in last year's budget, will see a final buy of 36 aircraft in fiscal 1991 at a total program cost of $1.65 billion. This final buy will fulfill U.S. Air Force requirements.

A-12

Early in 1991 the Pentagon announced the termination of the A-12 attack aircraft being developed by McDonnell Douglas and General Dynamics. This termination decision was upheld in the most recent budget submission. Navy planners still want a new attack aircraft, and money will be allocated over the next several years both to seek an interim solution and design a new program. The new program has been designated the A-XX.

F-14

The final Grumman Corporation F-14 Tomcat purchase was completed in fiscal 1990. The planned remanufacture of older Tomcats to the "D" configuration will be terminated in the fiscal 1992 budget, resulting in an estimated savings of $1.4 billion. This decision was made despite cancellation of the A-12 because of the planned reduction in the aircraft carrier fleet. Money for on-board computer software upgrades and other system improvements continue, with a request for fiscal 1992 of $170 million.

ATF

According to Pentagon officials, the ATF remains on track, with a final decision to select between the competing contracting teams of Northrop Corporation/McDonnell Douglas and Lockheed Corporation/General Dynamics/Boeing Company still slated by April 30, and full-scale development to begin during fiscal 1992. The aircraft is slated to enter the air force inventory in the late 1990s.

LH

The U.S. Army's highest priority program, the Light Helicopter, will continue as an R&D program in fiscal 1992, with final bid proposals submitted in February. The LH will replace the army's fleet of OH-58 and AH-1 aircraft. The major contracting teams are McDonnell Douglas/Bell Textron and Boeing/Sikorsky. In all, 1,292 helicopters are to be procured between 1997 and 2005 for an average per-unit cost of $8.9 million.

B-2

Northrop's B-2 Stealth bomber, which last year was cut from a request of five to a congressionally allowable two, continues to be pushed by the air force. However, major adjustments have been made in delivery schedules as a result of Defense Secretary Cheney's Major Aircraft Review performed in May 1990. This year's request is for four aircraft at a total cost of $4.8 billion, to be followed by seven additional aircraft in fiscal 1993 at $4.6 billion.

C-17

This troubled Douglas Aircraft program is slated to begin procurement funding in fiscal 1992. The air force's requested funding last year for two aircraft was denied by the U.S. Congress. The air force is confident that the concerns expressed have been satisfactorily resolved and that the program is now ready to enter production. This year's request is for 6 aircraft at a total program cost of $2.83 billion, followed by a fiscal 1993 buy of 12 aircraft at a price of $4.2 billion. The air force has also decided to reduce the annual maximum buy from the originally planned peak production of 24 annually to 18.

F/A-18

The twin-engine Hornet aircraft manufactured by McDonnell Douglas will continue to be procured as a replacement for the aging F-4 and A-7 aircraft, although at diminishing annual rates in the

out years. The Pentagon has requested 36 aircraft for fiscal 1992, down from 48 last year, at a total cost of $2.4 billion and 20 aircraft in 1993 for $2.5 billion. Large increases in the R&D budget for this program, however, reflect the U.S. Navy's requirement to find an alternative for the A-12 program. It is believed that a variant of the F/A-18 is the leading candidate to serve as an interim solution to the navy's requirement.

SHIPS

The navy is continuing to downsize, aiming for a fleet of close to 450 ships, including 12 aircraft carriers, in the mid-1990s. Cutbacks in shipbuilding programs are the result.

DDG-51

The annual planned buy of the *Arleigh Burke*-class guided missile destroyer continues to be for five ships, as it was last year, when congress cut the navy request to four. The ships are being built by both Ingalls Shipbuilding and Bath Iron Works. There is a danger that if Congress decides to cut annual production any further, the dual-source production plan may be in jeopardy.

SSN-21

The Seawolf nuclear attack submarine request has also been slowed. The request will now be for one ship annually, at least through fiscal year 1996, when the navy will return to its original plan of alternating annual purchases of two and one. The lead ship was awarded to the Electric Boat Division of General Dynamics, although Newport News will compete for follow-on awards.

Trident

There will be no new procurements of the Electric Boat Division's Trident nuclear submarine; the program will stop with the 18 vessels already authorized. Lockheed's procurement of the Trident II D-5 missile continues, however, with $1.3 billion for 28 missiles requested in fiscal 1992 and $1.4 billion for 31 missiles in fiscal 1993.

MISSILES

Operation Desert Storm is giving a major boost to tactical missiles programs.

AMRAAM

Both the navy and the air force will continue building the Advanced Medium-Range Air-to-Air Missile, which is split between the Raytheon Company and Hughes Aircraft. A total buy of 695 missiles was authorized in fiscal 1991 for $846 million. This figure will increase greatly over the next two years if the Pentagon receives the amounts requested. For fiscal 1992 the combined requests stand at 1,191 missiles at a program cost of just over $1 billion. For fiscal 1993 the request will be for 1,469 missiles at close to $1.05 billion.

Tomahawk

The Tomahawk, produced by both General Dynamics and McDonnell Douglas, has reportedly performed well in Operation Desert Storm, with well over 250 having been launched at the time of the budget submission. Nevertheless, the navy continues its plan to phase out production of the missile, requesting 236 systems at a total program cost of $500 million in fiscal 1992. This request is much lower than both the 600 requested last year and the 400 Congress authorized and reflects the navy's belief before the war that there are adequate stocks of the system. The planned fiscal 1993 request will be for 200 missiles at a program cost of $417 million. There is a special "off budget" request for an additional 440 Tomahawks to replenish stocks used in the Gulf War.

AAWS-M

The Advanced Anti-Tank Weapon System-Medium program will continue development with a request for funding of $124 million in fiscal 1992. The missile, which will replace the Dragon system, is now slated to enter production in fiscal 1993, with a first buy of 1,647 systems now planned in 1993 for $225 million. This system, being developed by Martin Marietta Corporation and Texas Instruments Inc., is a high-priority program with the army and enjoys a great deal of congressional support.

SPACE

SDI

The chameleon-like Strategic Defense Initiative is being reoriented again, this time as a new concept called Global Protection Against Limited Strikes (GPALS). Bolstered by the belief that the

easing of tensions between the United States and the Soviet Union will continue, thus making it more difficult to justify an expensive system to defend against Soviet attacks, and by the success of the Patriot antitactical ballistic missile system in the Middle East, SDIO has chosen to refocus on a small system capable of defending against possible accidental launches and limited attacks in the near term.

This position is a change from last year's emphasis on the Brilliant Pebbles concept, and an even further cry from the original intention to field the elaborate and comprehensive systems envisioned in the initial Phase I SDI architecture. The 1992 request is 58 percent larger than the amount granted to the program by last year's congress and is unlikely to be met.

GPALS is a derivative of the Limited Protection System first promoted by Senator Sam Nunn in late 1989. The system will originally be almost one-half the size of the Phase I architecture proposed in the late 1980s, but will be capable of rapid expansion. The system is also designed to be highly mobile, allowing for its rapid deployment anywhere in the world.

Sensors for the program will be both ground- and space-based, and the interceptors, which will destroy incoming targets by kinetic energy, in principle will be based on the ground, in space, and even at sea. Interceptors in space will be designed to stop those incoming missiles with a range of between 600 and 800 kilometers. In fiscal 1991, $200 million was authorized to explore this concept. The Pentagon has requested a tripling of this amount for both fiscal 1992 and fiscal 1993.

The Theater and Anti-Tactical Ballistic Missile (ATBM) Defense element includes programs that have as their primary objective the development and deployment of rapidly relocatable ATBM defenses for U.S. forces deployed abroad. This program will focus on the integration of any GPALS system into this role, as well as the possible upgrading of existing weapons such as Raytheon's Patriot missile system. Israel's Arrow ATBM also will be funded in this category.

BSTS

Once the cornerstone of the SDI program, the Boost Phase Surveillance and Tracking System (BSTS) as originally envisioned is dead. After being transferred from the SDIO to the air force last year, the program met stiff competition from TRW's already functioning Defense Support Program (DSP) early warning satellite program. Although TRW will receive at least a short-term boost from the cancellation, including perhaps as much as $100 million in additional fiscal 1992 spending, the air force wants to "revisit" a program idea called the Advanced Warning System (AWS).

MILSTAR

The controversial MILSTAR program, originally designed to provide extremely reliable, high-frequency communication for U.S. nuclear and other military forces under extreme conditions, has been substantially restructured by the Pentagon after repeated expressions of concerns by the Congress and the cutting of over $750 million from the fiscal 1991 request. The restructured program, the first satellite of which is under construction by Lockheed, will move the program from the primary role of strategic communication to that of tactical. In addition, the program will be scaled back from the originally proposed 10 satellites to just 6, while associated ground stations will be scaled back from an originally planned 24 to just 9.

DATAQUEST CONCLUSIONS

The 1991 procurement accounts are taking the brunt of the budget cuts. However, 1992 and 1993 spending is expected to recover somewhat as advanced systems such as ATA are once again delayed, and "producible" and "modifiable" systems are given priority.

Besides the add-on business, this delay of advanced systems will bode well for those targeting upgrades to keep aging systems going.

Gregory Sheppard
Barry Blechman

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Research Newsletter

UNITED STATES DEFENSE BUDGET: CUTBACKS AND WAR IMPACT

OVERVIEW

War in the Middle East did not affect the fiscal 1992 and 1993 U.S. Department of Defense (DOD) budget requests made to the U.S. Congress on February 4. Adhering to the "top-line" figures set in last year's congressional/executive budget summit, the fiscal 1992 DOD budget request calls for a real decrease in overall defense spending of 1 percent below the amount approved for fiscal 1991. The figure, $278.3 billion in budget authority, also represents a 12 percent real decrease from the fiscal 1990 budget and is 24 percent lower than the fiscal 1985 budget, which marked the height of the Reagan-era military buildup. The five-year outlook calls for spending to decrease at an average of 3 percent annually in real terms.

Money needed to continue the war effort and replace stocks of expended materiel was included in a special "supplemental" request to Congress. A senior Pentagon spokesman explained that there was no assumption built into the fiscal 1992 and 1993 budgets for any Desert Shield or Desert Storm activities. An additional "off-budget" amount of $6.4 billion was requested to replace spent missiles and ordance. This request will be added to the $2.1 billion approved by Congress in a special action late last year for Desert Shield. All other costs associated with the operation are expected to be supplied by allied nations.

In order to achieve the budget figures demanded in the summit agreement, DOD officials were forced to make some hard choices, including a total of 81 program terminations and hundreds of programs stretch-outs and adjustments. The 81 program terminations alone will yield $11.9 billion in savings in fiscal 1992 and $90 billion through fiscal 1997. The budget also reflects optimistic expectations for the implementation of a treaty limiting conventional armed forces in Europe and the successful completion of a START treaty to limit nuclear weapons. Major program terminations, along with anticipated savings, are listed in Table 1.

DEFENSE SPENDING

For fiscal years 1991 through 1995 the new Pentagon request seeks a total of $113 billion less than was requested in President Bush's January 1990 budget submission. If the proposed top-line figures survive the budgetary process, DOD outlays as a percentage of the GNP are expected to fall to 3.6 percent, the lowest level since before World War II.

The fiscal 1992 and 1993 requests also reflect a radical departure from modern Pentagon planning, which had focused on requests for either marginal real increases or even rates of spending. As recently as April 1989, DOD planners were anticipating budgets with an average real increase of 1.2 percent a year through fiscal 1995. The fiscal 1992 request calls for an average real decline of just over 3 percent annually through 1995.

APPROPRIATIONS

Table 2 shows the DOD request broken down by category of appropriation. The investment accounts (procurement, RTD&E, and construction) will begin to recover from this year's debacle, but at very slow rates. In real terms, procurement spending is roughly one-half its peak in the mid-1980s. The one bright spot is R&D, for which real growth of 10 percent is planned during the next two years. The DOD is making a special effort to protect funding for the technology base, pegged at roughly $4.0 billion in each of the next two years. In announcing the budget, Defense Secretary Cheney stated that such funding will include an

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Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

TABLE 1
Major Program Terminations (FY1992-FY1993 Budget)
(Billions of Dollars)

	Savings	
	FY1992	FY1993-1997
Bradley Fighting Vehicle	0.7	1.7
Trident Submarine	1.4	2.8
LHD Amphibious Ship	-	2.1
P-7A Antisubmarine Warfare Aircraft	0.6	5.4
F-14D Remanufacture	1.4	13.4
Naval Advanced Tactical Fighter	0.1	2.0
A-12 Aircraft	2.7	19.5
Air Force Advanced Tactical Aircraft	-	0.8
F-16 Aircraft (End of FY93)	1.6	13.8
Peacekeeper Missiles	0.7	2.2
Mark XV Combat Identification System	0.1	0.2
BSTS Warning System	0.4	5.5
Tacit Rainbow Program	0.2	2.3

Source: U.S. Department of Defense

TABLE 2
FY1992/FY1993 DOD Budget
Budget Authority by Title
(Current Billions of Dollars)

	FY1990	FY1991	FY1992	FY1993
Military Personnel	78.9	79.0	78.0	77.5
Operations and Maintanance	88.3	86.0	86.5	84.7
Procurement	81.4	64.1	63.4	66.7
RDT&E	36.5	34.6	39.9	41.0
Military Construction	5.1	5.0	4.5	3.7
Family Housing	3.1	3.3	3.6	3.6
Other	-0.3	1.0	2.3	0.7
DOD Total	293.0	273.0	278.2	277.9

Source: U.S. Department of Defense

TABLE 3
Force Restructure

	FY1990	FY1995
Army Divisions	28 (18 active)	18 (12 active)
Aircraft Carriers	13	12
Carrier Air Wings	15 (13 active)	13 (11 active)
Battle Force Ships	545	451
Tactical Fighter Wings	36 (24 active)	26 (15 active)
Strategic Bombers	268	181

Source: U.S. Department of Defense

emphasis on high-performance computing and improved materials for electronics, gas turbine engines, and airframe components.

FORCE STRUCTURE

The great driver behind most of the budget reductions has been the Pentagon's effort to generate a significant force restructuring to take account of reduced global tensions, particularly between nations of NATO and the Warsaw Pact, while preserving a credible nuclear deterrent and the ability to project forces overseas for operations such as Desert Storm.

Pentagon officials are convinced that the force restructures, outlined in Table 3, will leave the U.S. military with enough equipment and troops to achieve any mission the president should wish to direct.

DATAQUEST CONCLUSIONS

The administration's declining budget assumes an ongoing relaxation of tensions with the Soviet Union, in spite of that country's recent crackdown in the Baltics. The Gulf War has yet to have a significant impact on electronics-intensive hardware procurement. Some DOD planners estimate that a war of greater than 60 days could create a need to replace previously over-inventoried systems left over from the Cold War. The administration, however, might take the opportunity to accelerate upgrades to these systems as well.

Gregory Sheppard
Barry Blechman

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Research Newsletter

MILITARY SEMICONDUCTOR PRICING: 1991 OUTLOOK

SUMMARY

In 1990, military grade pricing trended downward in many categories; but in general, the decline was not as steep as that of commercial pricing. Estimates for 1991 show continued significant downward military pricing trends in high-density SRAMs and 32-bit microcomponents, with a rising trend in standard logic.

TRENDS

Memory

The emergence of Standard Military Drawing (SMD) has helped create a multisourced situation for SRAM products, increasing the competition for certain categories. As a new generation of microprocessors based on 32-bit RISC (e.g., MIPS R3000) and running at 25 and 33 MHz are designed in, faster SRAM-based main memories are required to provide the needed 45ns and faster access times. This necessity has caused many SRAM suppliers to focus on the high-density (256K and 1Mb) high-speed (45ns to 25ns) arena, creating fierce competition (see Table 1 for pricing examples). An added source of supply has been the influx of SRAM suppliers using Japanese die, and many of these suppliers have either direct or tacit DESC-quality processing approval.

Military-specific (mil-spec) DRAMs do not seem to be following the steep commercial DRAM price trends. Although growing, the use of DRAMs in military systems is not as pervasive as that of SRAMs. Additionally, a large amount of commercial DRAMs are used in military systems as well.

EPROM pricing has stabilized, following normal life cycle trends. Dataquest estimates that aggressive declines will still occur in the sub-100ns EPROM products as competition intensifies, and the entrance of Flash memory may stimulate further erosion of the higher-density EPROMs. EEPROM has had some recent steep price declines, but during 1991 some leveling should occur as the somewhat limited supply base adjusts because of low profits. Demand for EEPROM is still growing steadily and is expected to increase for sub-100ns parts because of end-use needs.

The newest memory product, Flash, is just ramping up in the military market. Both the EPROM and EEPROM types of Flash product will be competitively priced to try to make a market entrance and displace some of the use for the regular EPROMs and EEPROMs. The price of the Flash EPROM (bulk erase) type is roughly one-half of the original EEPROM (sector erase) price.

Microcomponents

The 32-bit MPU market is leaning toward the RISC solution for many applications, with competition heating up between MIPS suppliers, Intel and others. MPUs based on MIL-STD-1750A remain price competitive because the part is multisourced. High-performance (>3 mips) and rad-hard 1750As are commanding much higher premiums. However, most of the CISC, DSP, and MCU architectures are expected to exhibit moderate price declines during the next few years (see Table 2).

ASICs

Gate Array and Cell-Based

Gate-array pricing is showing flat to slightly downward trends in the lower densities because of the established nature of production contracts. Some suppliers such as National and Harris are exiting the CMOS market, which helps keep pricing more buoyant. The higher densities show much

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TABLE 1
Estimated Military Memory Pricing
Military Specification: MIL-STD-883 Class B

	AAC* (%) 1990-1991	AAC (%) 1990-1993
SRAM		
Annual Volume: 10,000 Units		
16K, 4Kx4, 25ns	-20.9	-10.1
64K, 16Kx4, 35ns	-6.6	-6.8
64K, 8Kx8, 45ns	-7.9	-5.2
256K, 32Kx8, 70ns	-7.6	-9.2
256K, 256Kx1, 25ns	-28.2	-19.0
1Mb, 256Kx4, 45ns	-23.8	-17.2
DRAM		
Annual Volume: 10,000 Units		
64K, 64Kx1, 150ns	10.7	7.1
256K, 256Kx1, 150ns	-10.2	-6.6
1Mb, 1Mbx1, ≥100ns	-18.2	-20.6
EPROM		
Annual Volume: >1,000 to 5,000 Units		
128K, ≥150ns	-1.1	-1.3
256K, ≥150ns	-2.3	-2.0
1Mb, ≥150ns	-27.3	-21.6
EEPROM		
Annual Volume: >1,000 to 5,000 Units		
64K, ≥150ns	-7.3	-5.4
256K, ≥150ns	-16.2	-13.3
256K, 90ns	-28.3	-22.4
1Mb, ≥150ns	-31.6	-28.4
Flash Memory		
Annual Volume: 1,000 to 5,000 Units		
"EPROM," 12V, Bulk Erase		
1Mb, ≥150ns	-16.9	-18.9

*Average Annual Change
Source: Dataquest (February 1991)

more aggressive downward trends, especially those parts that are based on the newer 1.0-micron technology (see Table 3). Our survey shows that this year, cell-based ICs (CBICs) run at a premium to gate-array pricing, but during the next few years the production adder will grow smaller as CBICs gain in popularity.

Nonrecurring engineering (NRE) can run from a minimum to a maximum charge, depending on the level of design needed. The maximum NRE charge for turnkey service can run as much as 50 to 60 percent more than a minimum charge. In general, NREs in the lower densities seem to be trending upward, whereas higher-density NREs are trending aggressively downward as companies fight for new design starts.

ECL Gate Arrays

This market is fairly stable due to the fact that there are very few suppliers.

PLDs

In general, all forms of CMOS 24-pin devices are experiencing substantial price erosion because of competition caused by the entrance of numerous competitors. Dataquest anticipates that, during the next few years, the CMOS PLD market will see a waning number of participants. Pricing for 20- and 24-pin bipolar PLDs (excluding the newer high-speed—15ns and below—versions, which are still in their introductory decline phase) is expected to firm up during the next few years. As the single

TABLE 2
Estimated Military Microcomponent Pricing
Military Specification: MIL-STD-883 Class B
Annual Volume: 1,000 to 5,000 Units

	AAC* (%) 1990-1991	AAC (%) 1990-1993
16-Bit MPU		
68000-8	-11.8	-8.6
1750A	-17.4	-9.6
32-Bit MPU		
CISC >20-MHz	-19.4	-16.9
25-MHz R3000	-25.0	-26.3
Other 25-MHz RISC with FPU	-25.0	-23.4
DSP MPU		
DSP MPU (16-Bit Fixed Point)	-15.3	-10.0
MPR		
32-Bit FPU (First-Generation)	-8.0	-4.9
1553B Single-Chip Controller	-9.0	-9.1

*Average Annual Change
Source: Dataquest (February 1991)

TABLE 3
Estimated Military ASIC Pricing
Military Specification: MIL-STD-883 Class B

	AAC* (%) 1990-1991	AAC (%) 1990-1993
Gate Array/Cell Based		
Annual Volume: 100 to 500 Units		
1.5 Micron (1.3- to 1.7-Micron Drawn)		
5,000-9,999 Gates		
51- to 100-Pin CPGA	-5.9	-5.2
Average NRE	-19.9	-1.4
10,000-19,999 Gates		
51- to 100-Pin CPGA	-14.0	-9.0
101- to 200-Pin CPGA	-8.9	-7.5
Average NRE	-13.7	-2.7
20,000-49,999 Gates		
101- to 200-Pin CPGA	-9.5	-6.4
Average NRE	-15.2	-3.1

(Continued)

TABLE 3 (Continued)
Estimated Military ASIC Pricing
Military Specification: MIL-STD-883 Class B

	AAC* (%) 1990-1991	AAC (%) 1990-1993
1.0-Micron		
50,000-80,000 Gates		
201- to 300-Pin CPGA	-28.8	-11.4
Average NRE	-22.4	-11.4
Programmable Logic		
Annual Volume: 1,000 Units		
Bipolar		
Pin Count=20		
10-14.9ns	-11.7	-11.9
20-29.9ns	-5.0	-4.8
Pin Count=24 (except 22V10)		
10-14.9ns	-6.2	-4.3
20-29.9ns	-2.4	-2.4
22V10		
12-19.9ns	-11.0	-16.0
20-24.9ns	-14.3	-7.7
≥25ns	-2.3	-2.4
CMOS		
Pin Count=20		
15-19.9ns	-16.0	-16.6
25-30ns	0	0
Pin Count=24 (except 22V10)		
20-24.9ns	-12.6	-13.6
22V10		
20-24.9ns	-12.6	-13.6
25-29.9ns	-12.9	-11.2
≥30ns	-9.0	-9.6
Field-Programmable Gate Array		
Annual Volume: 1,000 Units		
CMOS 1.0- to 1.2-Micron (Drawn)		
Usable Gates		
>2,000	-15.9	-18.3
2,000 <4,000	-13.8	-14.8
4,000 <6,000	-23.7	-18.5

*Average Annual Change
Source: Dataquest (February 1991)

most popular segment, the 22V10 market (both CMOS and bipolar) is expected to see substantial price declines.

FPGAs

Because of the rapid acceptance of FPGAs, Dataquest expects to see new suppliers entering the market. Pricing should remain on a steep downward curve for the next few years as production ramps up and competitors enter the market.

Standard Logic

During the next few years, Dataquest foresees a trend of price firming in bipolar standard logic because the supply base has narrowed, particularly in JAN parts. Unit demand remains intact from continuation contracts that specify the use of standard logic. Additionally, replenishing of systems used in the Gulf War may also impact this trend. However, competition is still evident in the newer advanced CMOS products, which is reflected in the declining prices (see Table 4 for examples).

Analog and Discrete

Because of long product life cycles and the relative limited source nature of much of the analog business, prices are expected to remain generally firm. Erosion found in the JAN analog area has mostly subsided. Discrete pricing follows the same general trend as does analog. Discrete products are more "standardized" than analog ICs but are generally even more mature and thus have little motivation to move downward in price.

TABLE 4
Estimated Military Standard Logic Pricing
Annual Volume: 10,000 Units

	AAC* (%) 1990-1991	AAC (%) 1990-1993
54LS TTL		
54LS245 (Octal Noninverting Bus Transceiver)		
38510	7.0	7.2
883/SMD	5.5	5.5
54S TTL		
54S240 (Octal Inverting Buffer/Driver)		
38510	3.2	3.1
54F TTL		
54F373 (Octal D Transparent Latch)		
38510	-1.2	-0.7
883/SMD	-1.3	-0.9
54HC CMOS		
54HC245 (Dual D Flip-Flop)		
883/SMD	2.1	2.6
54AC/FCT		
54AC373/54FCT373 (Octal D Transparent Latch)		
38510	-13.8	-17.0
883/SMD	-19.6	-12.9

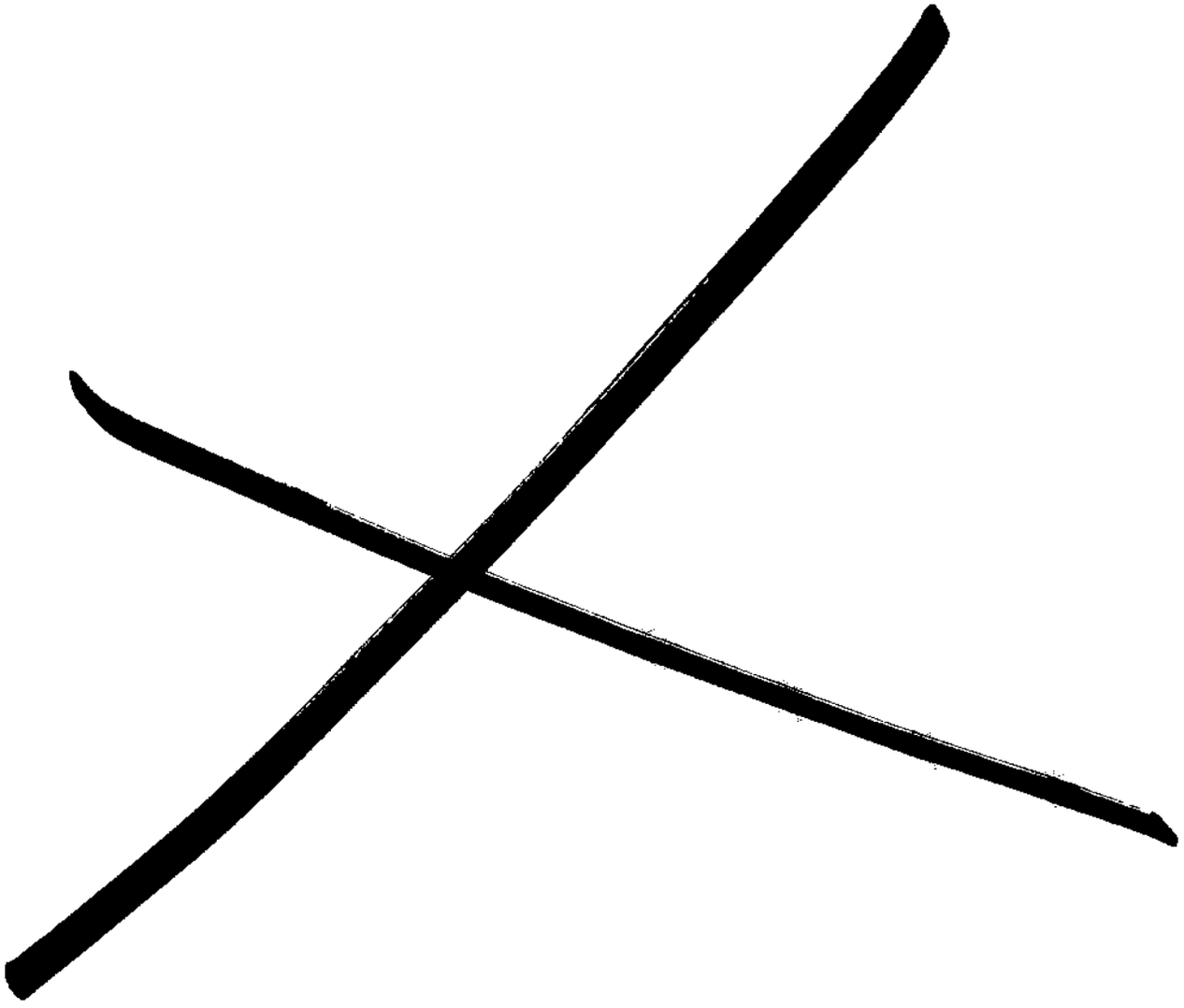
*Average Annual Change
Source: Dataquest (February 1991)

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest expects price declines to be less dramatic for military versions than for commercial versions of products such as SRAMs, most categories of ASICs, and complex microcomponents. The military SRAM arena should remain as price competitive as it has been in the past, even as the supplier base slims down. ASIC pricing is expected to remain buoyant due to its sole-sourced nature as well as a migration to higher-density designs. The firming of standard logic pricing, due partly to a reduced supply base, could in fact help alleviate a potential obsolescence problem in that area.

Dataquest recommends that pricing be tracked closely, especially in a turbulent 1991 environment.

Anna L. Cahill
Gregory Sheppard



1989/1990 MilAero Newsletter Index

The MilAero Newsletter Index is a quick reference guide to the MilAero 1989/1990 newsletters.

The newsletter's month and year follow each title listed in the index. Refer to the month tab to locate a specific newsletter.

This index is updated quarterly.

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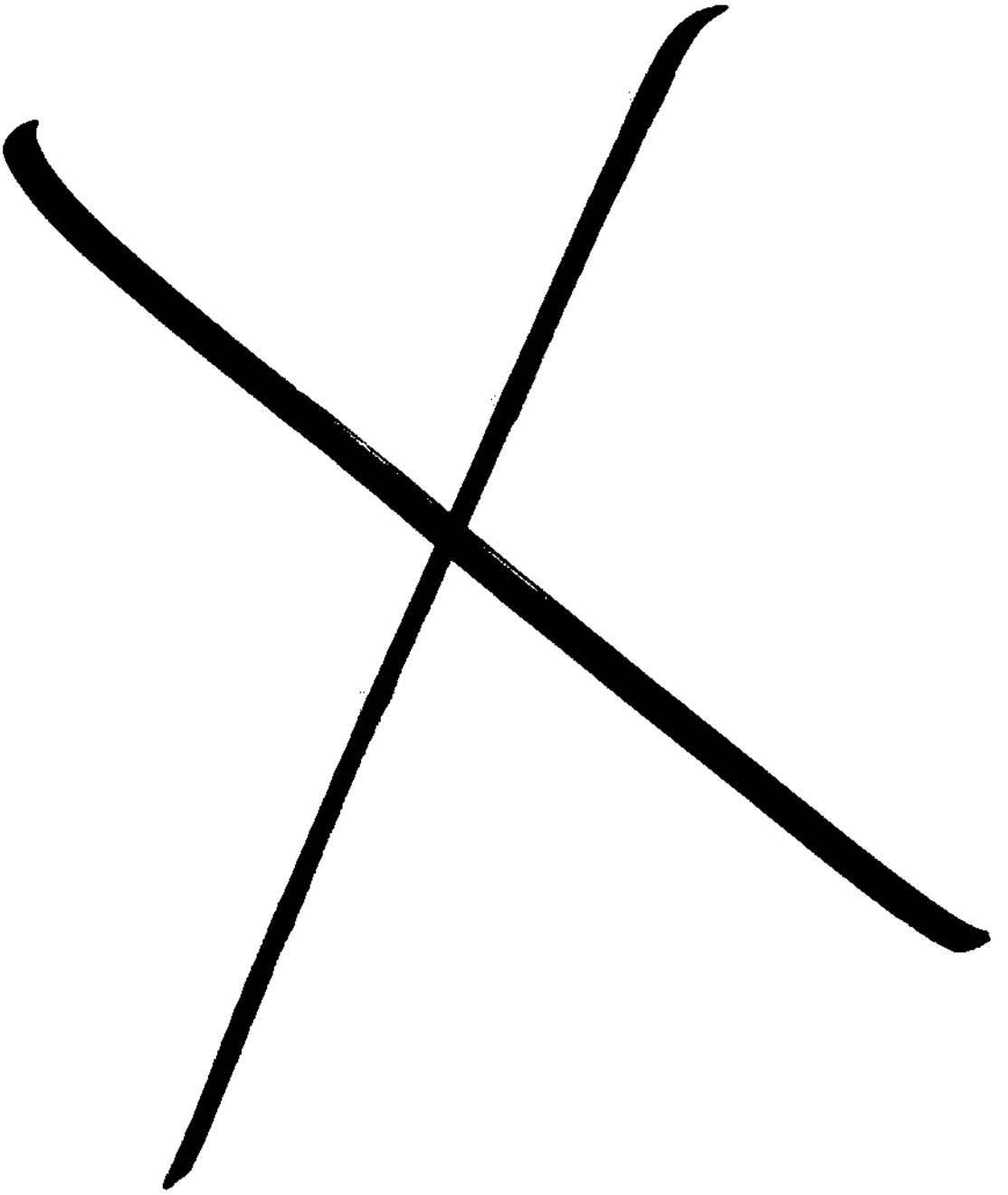
MilAero Update: Budget Cuts on the Horizon	March 1989-6
MilAero Update: Recent Electronic Contract Awards	March 1989-5
Strategic Defense Initiative Update	March 1989-4
Manufacturing: Low Volume, Military, and Efficient Too?	March 1989-3
MilAero Update: Superconductors, Foreign Ownership, Budget Proposal	February 1989-2
Unisys: Successful Merger, Bright Future	February 1989-1



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Research Newsletter

PACKAGING TECHNOLOGY: FROM AFTERTHOUGHT TO ENABLER

SUMMARY

Over the next decade, the demands of high-performance electronics systems will cause a dramatic shift in interconnect technology from the traditional dual in-line package (DIP) to advanced surface-mount technology (SMT) applications such as tape-automated bonding (TAB), flip-chip, and chip-on-board (COB). As the semiconductor industry approaches the 21st century, single-chip packaging solutions will increasingly give way to multichip modules (MCM) as the semiconductor industry enters an era of high-density interconnect (HDI).

During the next decade, the demands of the high-end ASIC business, particularly gate arrays, will have the biggest influence on the growth of SMT packaging. As we approach the year 2000, the technical workstation market, especially through its impact on microprocessor architectures, will play an increasingly important role in the advancement of MCM technology.

Given the necessary investments in developing an HDI infrastructure, the cost of penetrating a rapidly expanding packaging market will be enormous. As a result, industry participants that realize the critical performance factors necessary to high-performance system design will be forced to make investments in interconnect R&D similar to those made in semiconductor technology during the last decade. The high end of the data processing market of the 1990s could very well be dominated by the region that approaches the interconnect challenge in the most expedient fashion.

This newsletter looks at ASIC and reduced-instruction-set computer (RISC) trends as they affect worldwide packaging production over the next ten years. The analysis and data on which this newsletter is based are the result of an 18-month multiclient study conducted by Dataquest's Semiconductor Consulting Group, which culminated in the June 1990 publication of Dataquest's *VLSI Packaging Study*, a 400-page report on the future of the semiconductor packaging market.

FROM TH TO SMT: THE NEXT FIVE YEARS

Table 1 presents Dataquest's forecast for worldwide packaging production over the next five years, with a ten-year leap to the year 2000. The table describes the market as we believe it will act if the emerging interconnect technologies or their enhancements are not superseded by others. Although the traditional through-hole (TH) packages will maintain a sizable but declining share of the market, as shown in Table 1, SMT is expected to reach a 71 percent share of worldwide packaging production by 1994.

THE ASIC IMPACT

Over the next five years, Dataquest believes that the transformation of electronics industry designs from standard ICs to ASICs will be the most significant force in changing package interconnect. This is true not only because of the trend in higher-pin-count devices, but also because of the sheer pervasiveness of ASIC devices. Dataquest believes that from an $8.6 billion market in 1989, ASIC consumption will reach nearly $18.0 billion by 1994.

The largest segment of the worldwide ASIC market during this period will continue to be gate arrays, which will grow in revenue from just under $4 billion to almost $11 billion. Gate arrays will be the product area contributing most to both package proliferation and developments through the year 2000. The shift in gate array package production over the next decade from DIP, chip carrier, and PGA to SMT and MCM solutions is illustrated in Figures 1 and 2.

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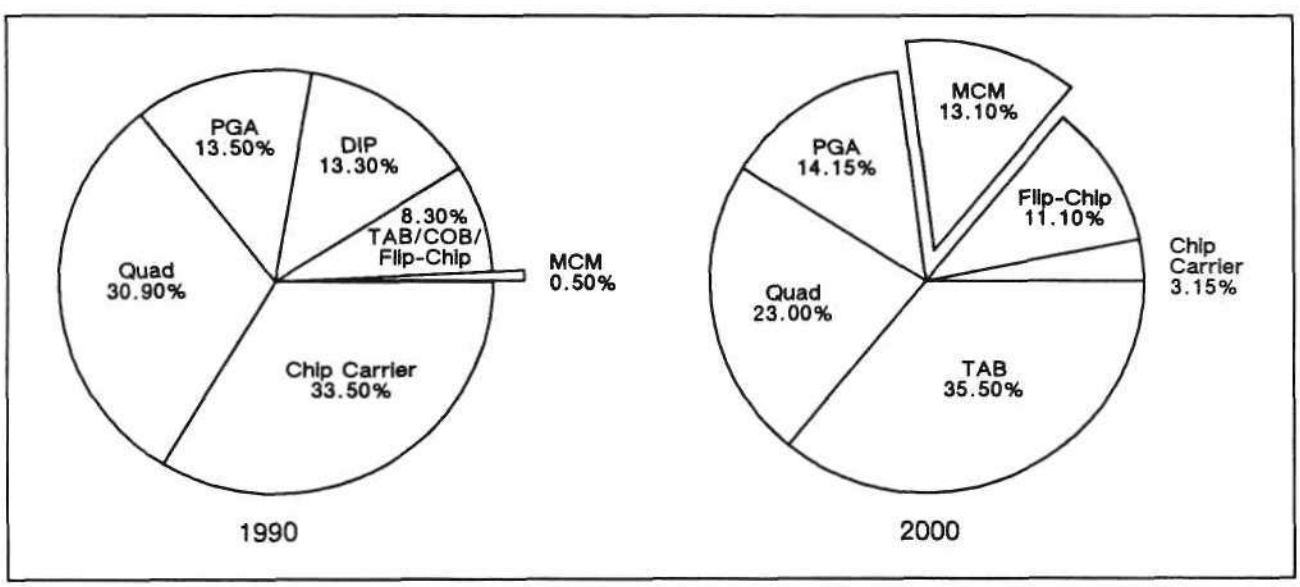
TABLE 1
Estimated Worldwide Package Production
(Millions of Units)

	1987	1988	1989	1990	1991	1992	1993	1994	2000
Plastic DIP	18,749	22,870	22,632	20,359	18,128	16,209	14,700	11,401	1,839
Ceramic DIP	3,479	3,958	3,583	3,251	3,206	3,039	2,922	2,621	1,327
QUAD	281	735	1,857	2,718	4,312	7,053	14,100	14,990	28,300
Ceramic Chip Carrier	138	191	246	270	302	405	431	387	160
Plastic Chip Carrier	203	332	425	466	623	809	899	804	341
SO	1,596	2,921	4,737	5,584	7,277	8,860	11,810	12,430	14,607
Ceramic PGA	49	137	181	256	410	641	807	862	482
Plastic PGA	11	34	85	147	248	554	770	904	587
TAB/COB/Flip-Chip	410	1,014	1,605	2,219	4,223	7,812	13,042	16,204	53,843
Total (Single Chip)	24,916	32,192	35,351	35,270	38,729	45,382	59,481	60,603	101,486
MCM (Units)	0	0	1	13	99	388	1,631	3,228	45,828

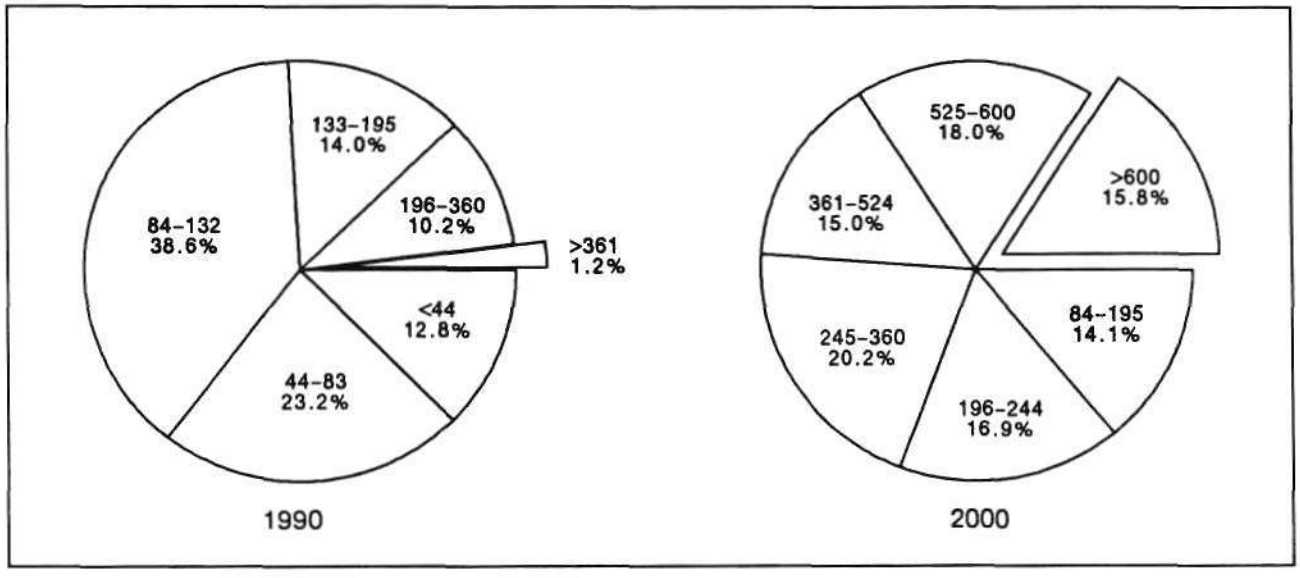
Note: MCM value = number of unit or chip demand.
Source: Dataquest (December 1990)

FIGURE 1
Estimated Worldwide Gate Array Package Production by Package Type
1990 versus 2000
(Percentage of Units)



Source: Dataquest (December 1990)

FIGURE 2
Estimated Worldwide Gate Array Package Production by Pin Count
1990 versus 2000
(Percentage of Units)



Source: Dataquest (December 1990)

THE WORKSTATION EXPLOSION

Although ASIC devices will be the technology driver for high-pin-count packages, the next generation of microprocessors (MPUs) will be the system performance drivers of MCM implementation—a trend owing to the continued growth of the technical workstation market. At a systems level, technical workstations are the electronic equipment products that will offer the greatest opportunity for change in process and packaging interconnect technology during the next decade.

According to Dataquest's Technical Computer Systems Industry Service (TCSIS), technical workstation industry revenue currently has a compound annual growth rate (CAGR) of 30.0 percent. In terms of architectural design, complex-instruction-set computing (CISC)-based workstations were the primary drivers of revenue growth in the technical workstation market of 1988. In the five years following 1988, however, TCSIS analysts expect RISC-based workstations to grow 57.5 percent in revenue and an impressive 89.9 percent in units. By 1993, as shown in Figure 3, RISC-based systems will account for 51.0 percent of workstation unit shipments, while CISC-based workstations will claim 49.0 percent.

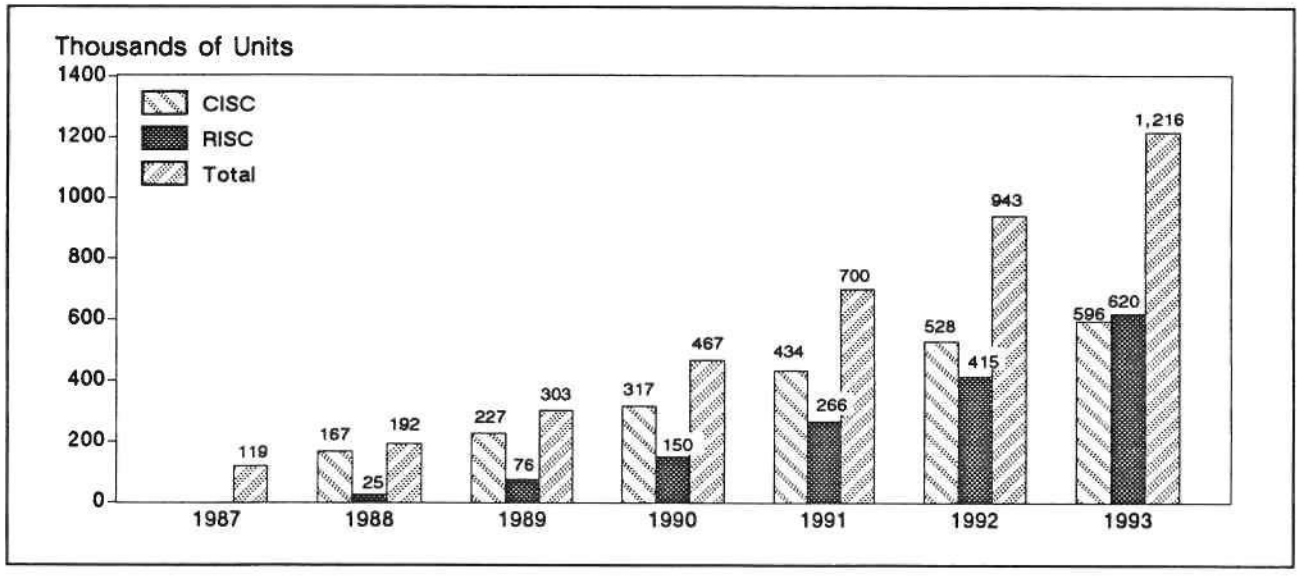
THE RISC IMPACT

Because most systems in the mid-1980s had relatively low, 10-MHz clock frequencies, interchip travel time was not a major concern of systems manufacturers. However, system clock frequencies currently are exceeding 30 MHz and are expected to reach 50 MHz by 1991 and 100 MHz by 1994—leaving only 20 and 10 nanosecond (ns) clock periods for calculation cycles. Currently available HDI technologies already have offered speed improvements of 15 percent or more at 50-MHz clock rates, with greater improvements at higher clock rates. HDI, just as much as developments in submicron manufacturing, will be critical to the continued improvement of high-performance MPUs.

HITCH YOUR WAGON TO A STAR

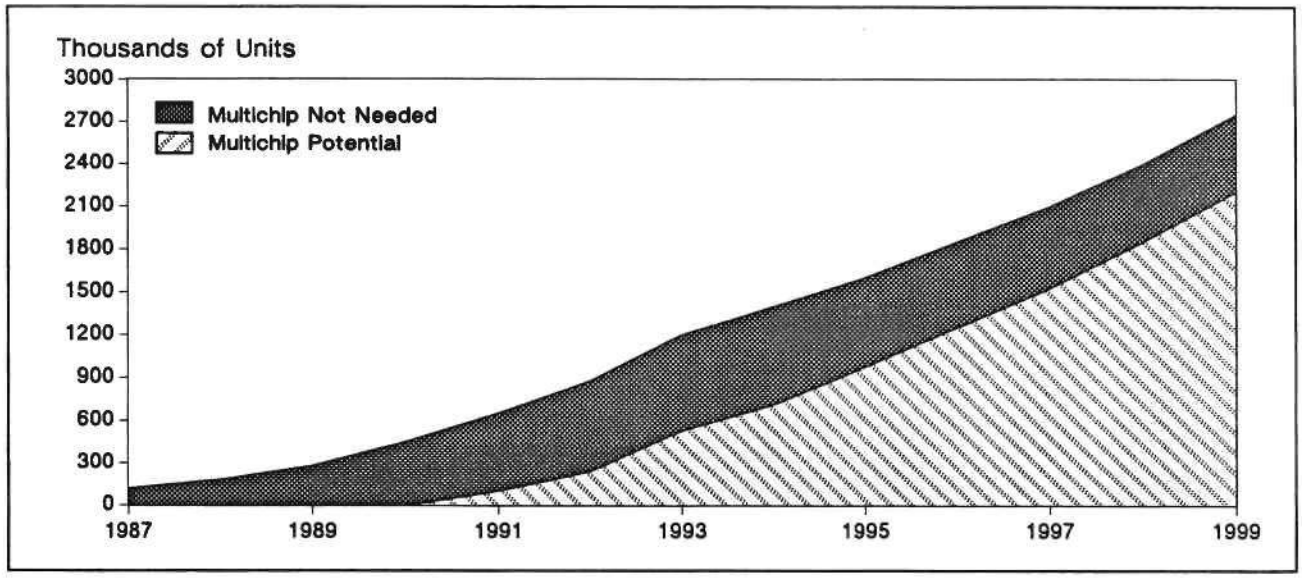
By the year 2000, workstations operating at 50 MHz and above will constitute 80 percent of the workstation market as measured in unit shipments. The increased penetration of RISC-based systems will in turn represent a tremendous opportunity for MCM producers. As illustrated in Figure 4, the number of workstations requiring MCM solutions will grow from approximately 70,000 units to over 2 million units during the next decade. This growth

FIGURE 3
Estimated Worldwide Technical Workstation Shipments
CISC versus RISC
1987-1993



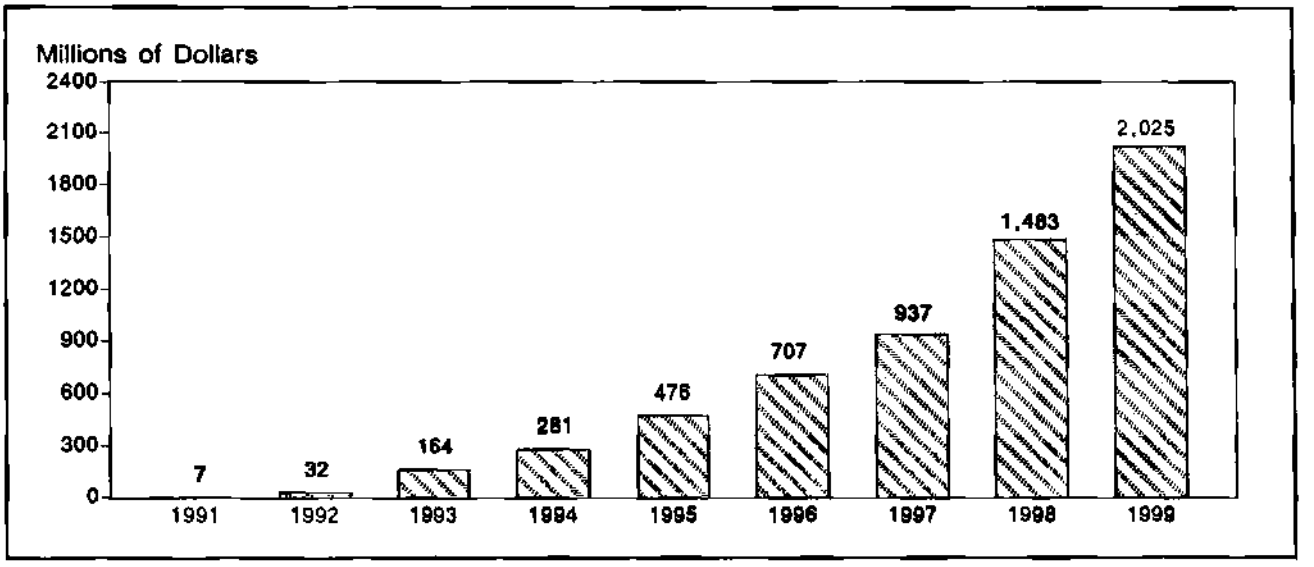
Source: Dataquest (December 1990)

FIGURE 4
Workstations Using Multichip Modules



Source: Dataquest (December 1990)

FIGURE 5
Multichip Module Revenue Potential in Workstations



Source: Dataquest (December 1990)

is significant not only in terms of numbers, but also because of its relationship to high-margin products. The MCM requirements of future workstations will create a market that could grow from only $7 million in 1991 to more than $2 billion by the turn of the century, as seen in Figure 5.

THE FUTURE LOOKS GREAT . . . BUT FOR WHOM?

The technical workstation market, and high-performance data processing and telecommunications applications in general, will offer numerous opportunities for SMT and HDI suppliers beyond those identified with MPU technology. As has been continually demonstrated in the electronics industry, new solutions create new problems that in turn engender new solutions. As RISC architectures answer the performance demands of next-generation technical workstations, increased CPU performance will in turn require new process and performance solutions in primary and secondary cache memory and the migration of main memory from fast SRAM/DRAM approaches to BiCMOS processes capable of operating in the 24 to 45ns range. Extended memory will, in turn, evolve from DRAM-based to solid disk-based technologies. The impact of all of these changes on memory, logic, and microcomponent package requirements will create high-growth markets for packaging technology.

The capital costs involved in making the transition to HDI will be huge, particularly given the priority that has historically been placed on process development in North American R&D spending. Increased emphasis on packaging solutions, however, is now a strategic necessity rather than a marketing afterthought. From its historic contributions to form-factor improvements in electronic systems to its more recent role in solving the pin-count challenges of increased logic integration, packaging is becoming an enabling technology in meeting the high-performance demands of 21st century data processing systems.

The interconnect requirements of the 1990s add yet another variable to the make-or-buy equation that worldwide systems companies must agonize over. Particularly in North America, systems companies must hope that their merchant IC suppliers not only keep pace in process and manufacturing technologies, but also find the resources to tackle the changes taking place in packaging. North American semiconductor suppliers have their work cut out for them: according to Dataquest's *VLSI Packaging Study*, MCM production by Japan and Europe will account for roughly 57 percent of units shipped worldwide in the year 2000.

Note: Contributors to the consulting study cited in this newsletter include Mary Olsson, Howard Bogert, and Mel Thomsen.

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Greg Sheppard
Michael J. Boss

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Research Newsletter

MILAERO TECH BRIEFS: MILITARY BUS ICs EMERGE

INTRODUCTION

The following publications were used as source material for this newsletter:

- PR—Press Release
- M&A Electronics—*Military & Aerospace Electronics*
- SIA—Semiconductor Industry Association

NEW MILITARY BUSES READY TO ROLL

In the past month, two significant semiconductor announcements were made in the military bus IC area. One is that National Semiconductor will have a PI bus transceiver (DS1776) available that complements Intel's PI bus controller IC. The BiCMOS transceiver IC, which is capable of an Icc of 37mA, is expected to be MIL-STD-883-qualified by the first quarter of 1991. A 100-piece quantity will be priced at $40. It complements an existing part from Signetics, the 54F776. PI bus is the mandated backplane bus for Joint Integrated Avionics Working Group (JIAWG) projects such as the ATF fighter and LH helicopter. Avionics upgrade programs, as well as the ARINC commercial airliner backplane bus standard, are considering adopting either the 16- or 32-bit wide PI bus for all future projects. (PR, 11/90) The second announcement was a joint announcement by Philips Components-Signetics and Texas Instruments for a codevelopment/alternate-source agreement for Futurebus+ ICs (transceivers, controllers, and datapath ICs). The two companies join National Semiconductor, which has announced plans for a Futurebus+ chip set. Futurebus+ (aka IEEE P896.1) has been chosen by the U.S. Navy as its future mission-critical computer bus. The bus is capable of 32 through 256 bits of width and up to 3.2 GBps in data transfer. VME and Multibus II modules can work together with Futurebus+ modules in the same system. (PR, 10/90)

Dataquest Analysis

Dataquest believes that both PI bus and Futurebus+ present a significant opportunity to semiconductor companies and OEM module manufacturers. Because they are open standards, they encourage private, nondevelopmental item (NDI) development by multiple board manufacturers. This is a key point because the Department of Defense (DOD) will not tolerate any further proliferation of custom government R&D funded bus structures.

PI bus ICs (controllers and transceivers) have a potential market of $15 million per year by the late 1990s, assuming an average number of modules per aircraft and an average aircraft build/retrofit rate. Futurebus+ still is awaiting final specification of its protocol functions, which is expected early in 1991. Given its compatibility with existing VME and Multibus II designs, its success as a high-performance bus upgrade for U.S. Navy shipboard computing (e.g., UYK 43/44) seems assured. Given that the navy has more than 500 ships with several hundred modules per ship, the navy shipboard computing market alone for Futurebus+ ICs could run $10 million a year by the year 2000.

BAR RAISED FROM $100,000 TO $500,000 FOR SF1411

Congress has passed legislation increasing the threshold from $100,000 to $500,000 for DOD contracts that require SF1411 cost justification. May 2, 1991, is the proposed effective date when

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the new set of Defense Federal Acquisition Regulations (DFARs) should be completed, stating guidelines on how to implement and administer this shift. Implementation is contingent upon completion of the DFAR guidelines written by DOD's procurement policy staff. A "sunset" provision has been implemented, allowing for the possibility of defaulting back to the $100,000 level after five years if the $500,000 level is not successful. (SIA, 11/90)

DARPA SELECTS CONTRACTORS FOR MULTICHIP MODULE PACKAGING

Multichip modules are essential for future defense applications because they shrink the distance between the chips, reducing bottlenecking and increasing operating speed of the electronic system. DARPA has selected two teams to enter into contract negotiations for the High-Density High-Speed Electronic Packaging Program. The first is Texas Instruments of Dallas, Texas, which is teamed with General Electric of Schenectady, New York. The second is E-Systems of Dallas, Texas, which is teamed with nCHIP of San Jose, California (foundry service); National Semiconductor of Santa Clara, California; Cypress Semiconductor of San Jose; Multichip Technology of San Jose; General Dynamics of Arlington, Virginia; and Fairchild Defense of Germantown, Maryland. Each team will receive $10 million funding for a three-year contract. (PR, 10/90)

PERFORMANCE INTRODUCES MULTICHIP MODULE

Performance Semiconductor claims to have the industry's first multichip module with MIPS R3000 architecture, the Performance Integrated Multichip Module (PIMM), to create a fully functional CPU, FPA, 32KB instruction cache, 32KB data cache, and PACEWRAP R3100A system bus interface chip. The module is in a single 144-lead VLSI quad flatpack for military applications and will operate at system clock rates of 25, 33, and 40 MHz. Performance states that the devices will be available in the first quarter of 1991. (PR, 11/90)

EDI OFFERS FAST DRAM AT 70ns

Electronic Designs Inc. (EDI) of Hopkinton, Massachusetts, introduced a 1Mb CMOS DRAM that complies with MIL-STD-883C. EDI claims to have the fastest DRAM currently available in either a 256Kx4 or a 1Mbx1 organization. Pricing for DIP starts at $240 for quantities of 100. (PR, 8/90)

SEEQ'S HIGH-DENSITY EEPROM

SEEQ claims that its 1Mb electrically erasable programmable read-only memory (EEPROM), with an access speed of 120ns, is the fastest device in its class. SEEQ is focusing the EEPROM toward memory and data storage applications in flight data recorders, fire control radar, and missile systems. (M&A Electronics, 8/90)

CATALYST UV-EPROMs: HIGH SPEED, LOW CURRENT

Available with access times of 70, 90, and 120ns, Catalyst Semiconductor introduced a MIL-STD-883C high-speed CMOS EPROM. The company plans to replace the slow EPROM and SRAM combinations with single high-speed EPROMs. Packaged in 28-pin DIPs, 100-piece quantities for the 120ns parts begin at $36.98, going up to $88.77 for the 70ns part. (M&A Electronics, 8/90)

NATIONAL RECEIVES JAN CLASS B FOR FACT

National Semiconductor has received MIL-M-38510 approval on three of its Fairchild Advanced CMOS Technology (FACT) logic family products. It claims to be the first manufacturer of advanced CMOS logic products to offer ACMOS Class B products. These devices are the first 3 (quad 2-input NAND gate, triple 3-input NAND gate, and dual 4-input NAND gate) of 20 functions targeted for the 1990 JAN Class B segment. The JAN Class B FACT logic functions are offered in ceramic DIP (CERDIP) and flatpack packaging, with leadless chip carrier (LCC) availability target for late 1990. Pricing for each device in quantities of 100 is $5.90 for CDIP and $8.90 for flatpack. In addition to JAN Class B, National anticipates that FACT logic will acquire Class S qualification by the end of 1990. (PR, 9/90)

AVANTEK INC. OFFERS SILICON MMICs

Three new silicon microwave integrated circuit (MMIC) low-noise amplifiers are being offered

in unpackaged form for hybrid applications. The highest-frequency version, the INA-03100 at 1.5 GHz, is intended for use in cellular radios, in Global Positioning System (GPS), and as an IF amplifier in microwave communications and high-speed fiber optics. The two lower-frequency versions (INA-01100 and 02100) are useful for IF amplifiers in instruments, cellular, and spread-spectrum radio. Pricing for the INA devices ranges from $3.90 to $4.90 in quantities of 100. (M&A Electronics, 8/90)

AMD SHIPPING 12ns PALs

AMD claims to be shipping the fastest military-qualified 22V10, which is now in production. The PAL 22V10-12 is available in 24-pin CERDIPs, flatpack packages, and 28-pin LCC packages. Unit prices are $57.90 for the CERDIP and $104.25 for the flatpack and LCC packaging in 100-piece quantities. (PR, 10/90)

HARRIS CLEARED TO EXPORT HIGH-REL AND RAD-HARD DEVICES

Since the Berlin Wall fell, the U.S. State Department has been reevaluating export controls. Harris now is cleared to export high-reliability (hi-rel) and radiation-hardened (rad-hard) ICs to 13 European suppliers for civilian space programs such as the European space shuttle, Eureca, and a series of satellite programs. (M&A Electronics, 9/90)

Anna L. Cahill
Gregory Sheppard

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Research Newsletter

POSITIONING FOR THE UPGRADE DECADE—THE VIEW FROM GOMAC

OVERVIEW

As most of the plans for new defense platforms (aircraft, missiles, ships, etc.) are being either cut or delayed, increasing emphasis is being placed on keeping existing platforms effective. Effectiveness means that the system is reliable, maintainable, and able to perform its chartered mission. As the life cycles of the systems and their semiconductors become even further separated, the ongoing effectiveness of these systems is being challenged as parts obsolescence becomes a factor. The Government Microelectronic Application Conference (GOMAC) and the Diminishing Manufacturing Sources (DMS) conferences held in November highlighted the assorted trade-offs with maintaining and upgrading older platforms as parts obsolescence becomes worse.

THE IMPACT OF DISCONTINUED PARTS

In spite of cutbacks in defense spending, thousands of ships, tens of thousands of aircraft and tracked vehicles, and hundreds of thousands of missiles and communications equipment will continue to be employed for many years. The B-52 bomber, for example, is slated to last through the year 2030, with its electronics updated every 10 or 15 years.

Aside from reliability and maintainability (R&M) and obsolescence reasons, system upgrades are driven by the need for improved resolution in sensing systems, higher signal-processing throughput, and the need for more embedded processing and memory capacity. Table 1 briefly outlines the different opportunities for electronics and semiconductor companies presented by upgrades and the need to minimize the impact of discontinued parts.

SOLUTIONS, SOLUTIONS

As noted in Table 1, the approaches to solving discontinued parts problems are many and vary greatly depending on factors such as the ongoing availability of the part (e.g., available from an aftermarket manufacturer or in inventory from a last-time buy), commonality across many systems, and available funds/contract mechanisms.

Last-time buys and the inventorying of semiconductors works well in some cases but falters

TABLE 1
Upgrade/Discontinued Part Impact Avoidance Trade-Offs

Solution	NRE Cost	Logistics Cost	Main Advantage/Disadvantage
Life Cycle Extension	0-$50K	$10K-$20K	Same technology/inventory guess
IC Redesign	$25K-$50K	$20K-$200K	Focused spending/part incompatibility
Board/Hybrid Redesign	$5K-$100K	$120K-$400K	Avoids other phaseout problems/logistics costs
System Redesign	>$100K	$500K	Adds new capability/high costs

K = Thousand
Source: Dataquest (November 1990)

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when there are no complete systems bills of materials and well-understood unit requirements. DESC in the United States, which is responsible for coordinating many common parts needs across programs, often has a problem with stocking either too much or too little inventory. Many companies such as Westinghouse maintain computerized databases of bills of materials of systems on which they worked so that they can easily offer upgrade service later in the systems' life cycles.

Many examples of IC redesign were presented at the conferences; all principally use ASIC technology. Honeywell discussed its bipolar arrays with both analog (40V) and digital (RTL, DTL, TTL) emulation capabilities. Using its RepliCAD CAD tools and library, Honeywell claimed that it could reverse-engineer older parts and have working silicon within two weeks. Another part-emulation example was presented by David Sarnoff Labs, which can provide replacement parts with BiCMOS gate arrays in a program called GEM.

Board redesign can be desirable when more than one IC on a board is subject to phaseout in the near future. Coupled with the desire to improve reliability (e.g., convert to CMOS VLSI to reduce power and pin count), testability (e.g., JTAG capability), and design documentation in VHDL, merchant solutions ranging from FPGAs and gate arrays to complied cells are being liberally employed. The Sacramento Air Logistics Center discussed its success with its Microelectronics Technology Support Program (MTSP) and with providing redesigned computer boards for the F-111 program. Its program manages a cadre of system and silicon contractors/subcontractors with a total pooled (across many US Air Force programs) funding cap of $650 million. The program also focuses on the documentation, training, software, and testing impacts of installing the new hardware.

System redesign usually is considered only when design changes are substantial and substantial funding exists. Usually, major systems such as airborne radar, targeting and navigation, or electronic warfare are the subject of major upgrades.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Although overall defense spending is being cut, reductions are mainly occurring for new platforms. An increasing share of world defense spending is being targeted at electronically intensive system upgrades to extend the operational lives of aging systems. With discontinued parts hastening the need, these upgrades will provide one of the best ongoing opportunities for electronics and semiconductor companies. Almost all forms of technology—ranging from CMOS, BiCMOS, and bipolar to GaAs—will be needed in ASIC, MPU, memory, and analog functions.

Dataquest recommends that semiconductor and electronics OEMs align themselves in psuedo-vertically integrated teams to capture upgrade business. The OEMs know how to market to government customers, and chip companies possess the advanced CAD software, design libraries, packaging technology, testing capabilities, and mass manufacturing know-how.

Gregory Sheppard

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Research Newsletter

1991 DEFENSE BUDGET: PLATFORMS CUT DEEPLY

OVERVIEW

In a process that included an unprecedented number of transformations and budget revisions, beginning with Secretary Richard Cheney's defense request to legislators in January, Congress finally reached agreement on the fiscal 1991 defense budget in the waning hours of a thrice-extended legislative session.

After months of wrangling over budgetary levels and the scope of specific programs, overall spending limits, the fiscal implications of operation Desert Shield, and threats of Presidential veto, the budget emerged from the two houses in much the same form it had assumed before the Iraqi invasion of Kuwait.

The fiscal 1991 Department of Defense (DOD) budget marks the sixth consecutive year of real decline. This year's budget includes a cut of over $20 billion from President Bush's original defense request (see Table 1). Still, most of the critical issues that slowed the process this year, such as the debate over program terminations and long-term force planning, were dodged in the final defense bill, leaving the new Congress to fight many of the same battles again next year.

Of the cuts that were made, most came from large weapon programs originally planned and authorized during the unprecedented defense buildup of the early Reagan years. Big-ticket items such as Northrop's B-2 stealth bomber suffered considerably, as did the formerly "black" A-12 navy fighter (see Table 2). The hardest hit, however, was the Strategic Defense Initiative (SDI). President Bush had sought a total of $4.7 billion for the troubled program, which emerged from the process with a new direction and only $2.9 billion. This amount is still more than the $2.3 billion the House sought to authorize.

TABLE 1
Fiscal 1991 Defense Authorization
(Billions of Dollars)

		1991				
	1990	Request	House Action	Senate Action	Conference Report	Percent Change 1990-1991
Military Personnel	78.5	79.1	78.2	78.2	78.2	(0.4)
O&E	86.8	90.1	83.8	85.9	85.5	(1.5)
Procurement	82.6	79.0	63.8	67.4	67.2	(18.6)
R&D	36.8	38.1	35.7	36.5	36.1	(1.9)
Military Construction	5.3	5.7	4.9	5.2	5.3	0
Other	1.4	5.9	5.4	5.2	5.2	371.0
Subtotal	291.4	297.3	271.8	278.5	276.8	(5.0)
DOE Military	9.7	11.0	11.0	11.1	11.0	13.4
Total Defense	301.1	308.3	282.8	289.5	287.8	(4.4)

Note: Columns may not add to totals shown because of rounding.
Source: US Government

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TABLE 2
Major Systems
(Millions of Dollars)

	Admin. Request Quantity/Budget	House Action Quantity/Budget	Senate Action Quantity/Budget	Conference Approval Quantity/Budget
B-2	5/2,496	0/0	2/1,989	2,349
Northrop	710	0	767	0
SDI	4,692	2,300	3,680	2,890
DDG-51	5/3,566	4/3,218	5/3,536	4/3,218
Ingalls/Bath Iron	4	4	4	4
SSN-21	2/2,343	1/1,457	0/150	1/1,457
General Dynamics	1,139	649	0	649
F-16 C/D	150/2,357	108/1,987	108/1,925	108/1,857
General Dynamics				
F/A-18	66/1,894	84/2,290	42/1,310	48/1,525
McDonnell Douglas	151	192	96	110
C-17	6/1,705	2/350	0/300	2/400
Douglas Aircraft	204	204	0	60
F-15	36/1,700	36/1,474	36/1,700	36/1,544
McDonnell Douglas	0	100	100	100
A-12	8/1,306	0/456	0/104	0/55
McDonnell Douglas/General Dynamics	290	0	0	555
Trident II (D-5)	52/1,344	42/1,444	52/1,344	52/1,344
Lockheed	193	193	193	193
ATF	964	964	870	964
Northrop/McDonnell Douglas				
Lockheed/General Dynamics				
AMRAAM	1,250/893	0/0	450/463	450/463
GM/Hughes				
Trident Submarine	1/1,245	1/1,146	1/1,245	1/1,146
General Dynamics	143	0	0	0
Patriot	817/883	817/791	817/791	817/791
Raytheon				
F-14	12/780	12/790	12/781	12/781
Grumman	126	126	126	126
M-1	225/747	225/698	225/807	225/747
General Dynamics	0	0	0	150
Tomahawk	600/809	400/659	400/663	400/659
General Dynamics				
McDonnell Douglas				
Bradley	600/657	300/430	600/657	300/430
FMC Corporation	31	19	31	19
AV-8B Harrier	24/457	24/457	24/440	24/440
McDonnell Douglas				
Adv. Cruise Missile	100/356	100/366	100/366	100/366
General Dynamics/McDonnell Douglas	107	64	107	107
UH-60 Blackhawk	72/272	72/272	48/116	48/116
Sikorsky	197	197	197	127
E-2C	6/351	6/351	6/397	6/397
Grumman	38	38	38	38
CH-53E	23/377	25	0	0
Sikorsky	58	0	35	35

Source: US Government
Note: All second lines represent funds granted for advanced procurement.

HIGHLIGHTS

B-2 Bomber

Perhaps the most controversial and certainly the least understood decision involved Northrop's B-2 bomber. Northrop, plagued by numerous ongoing investigations, found little landing room for the B-2 on Capitol Hill and settled for trying simply to hold on to the 15 aircraft that previously had been authorized. This setback is a major one for the company, which less than a year ago was counting on constructing 132 of the bat-winged bombers.

The House, led by Congressman Les Aspin (Democrat-Wisconsin), sought to stop the program completely after the fifteenth bomber. The Senate sought to preserve funding for two new planes in fiscal 1991. What emerged was an "everyone wins" agreement that will grant the air force enough funds to go ahead with two more aircraft, but without specifically stating that the funds can be used for this purpose. This agreement allows House members to say that they did not authorize any bombers and Senate members to say that new bomber construction is implicit in the funding levels. In all likelihood, the new aircraft will not be authorized, because House members are threatening legal action if they are, and cost overruns on the original 15 will consume the funds anyway. In short, the B-2 dodged a bullet that will most assuredly be fired again next year.

Strategic Defense Initiative

Former President Reagan's "Star Wars" initiative was another of the programs to catch heavy flak from Capitol Hill. Apart from a reduction of nearly $1.8 billion from the administration's request of $4.7 billion, legislation mandates a redirection of many ongoing SDI projects.

This year's defense bill eliminates the five program elements that have dominated SDI since its inception in 1984 and creates five new funding categories: Phase I Defenses; Limited Protection Systems, Theater, and ATBM Defenses; Follow-On Systems; and Research and Support Activities. This plan is Congress' attempt to push the administration away from the grandiose three-phase program that had guided budget requests in the past and direct DOD planning toward more near-term possibilities, such as a limited protection system.

A-12 Aircraft

Another program to have its wings clipped was the once super-secret A-12 navy fighter, developed jointly by McDonnell Douglas and General Dynamics. As part of Secretary Cheney's Major Aircraft Review, the administration requested funding for eight planes at a cost of over $1.3 billion. During the course of the budget debate, however, the program emerged from the shadows and significant difficulties began to surface, including a serious weight problem and nearly a year delay in the overall program.

The House responded by recommending zero production or advanced procurement funding in 1991. The Senate viewed the program with even less favor, zeroing all funding authorization except $104 million for spare parts as part of the navy's overall spare parts funding. In conference, however, cooler heads prevailed, and $38 million was preserved for the production option (although no planes were authorized), with $555 million authorized for advanced procurement. This program is likely to be scrutinized carefully by both the Pentagon and Congress during the next year.

MILSTAR

The fiscal 1991 defense budget will require the Pentagon to reign in its expansive plans for MILSTAR, DOD's plan for secure satellite communications into the 21st century. Nearly $6 billion already has been sunk into MILSTAR's development. Now the original plan to launch at least eight jam-resistant, survivable satellites, along with numerous ground communications terminals, appears to be in jeopardy.

The Senate zeroed the program because of excessive costs, while the House scaled the program back to $770 million. The conference bill emerged with MILSTAR intact, but with only one-half of the administration's $1.2 billion request. In addition, Congress directed the DOD to consider adopting a less costly alternative.

Lockheed, which, along with such ground terminal contractors as Magnavox, Raytheon, and Rockwell, is constructing the first satellite, is likely to sustain the most cuts as the DOD is forced to reevaluate the program throughout the year.

Electronic Warfare Consolidation

Frustrated by the military services' "go it alone" approach to procuring electronic warfare equipment, Congress mandated the establishment of a consolidated electronic warfare program under the under secretary of defense for acquisition and allocated $162 million in funding.

The frustration felt by Congress grew largely out of the air force's decision last year to drop out of the air force/navy common Airborne Self Protection Jammer (ASPJ) program, being developed by ITT and Westinghouse, and instead to pursue two separate programs: Northrop's ALQ-135 jammer for the F-15 and Raytheon's ALQ-184 jammer for the F-16. This move by the air force flew in the face of repeated congressional direction to move toward common systems. In addition, the price tag associated with three separate systems was a whopping $463 million for fiscal 1991 alone.

Along with recognition that $187 million existed in unobligated funding authority, Congress earmarked $60 million for the ASPJ, $39 million for the ALQ-184, and nothing for the ALQ-135. Congress further directed the under secretary to establish a comprehensive, service-wide plan to "eliminate redundancy, maximize commonality, and meet essential operational requirements at the resource levels likely to be available with projected future budgets." After this plan is established, Congress directed the under secretary to terminate all programs that are no longer needed.

Such direct language will surely heat up the competition between the three systems in what may very well evolve into a winner-take-all showdown.

Impact of Desert Shield

The budget was little affected by the Iraqi invasion of Kuwait, with authorizers allocating $174 million in funds for operation Desert Shield as a separate line item outside normal defense programs. These funds will be expended largely on operation and maintenance costs associated with the stationing of forces in Saudi Arabia.

However, several new and significant military sales to the region have bolstered more than a few companies. In the first sale, announced in August just after the invasion, the Saudis received 24 additional McDonnell Douglas F-15s, 200 General Dynamics Stinger missiles, and 150 M60 tanks. The total package was about $2.3 billion.

A second sale, now under way, is worth an estimated $7.5 billion and will include seven Lockheed KC-130 aerial tankers, 150 General Dynamics Abrams M-1 tanks, 200 FMC Bradley fighting vehicles, 150 Hughes TOW II missile launchers with 1,750 TOW IIA missiles, 155 Hellfire missiles, 6 Raytheon Patriot missile systems, 8 Sikorsky UH-60 Blackhawks, and 12 McDonnell Douglas AH-64 Apache attack helicopters.

Additional sales to Israel will follow to compensate for this new equipment moving to Saudi Arabia.

Dataquest Conclusions

In short, 1990 was not the make-or-break year for defense programs that many expected. Congress preferred to chip along the edges rather than to cancel systems outright, and the old-fashioned "horse trading" that has dominated conference meetings between the Senate and the House for so long, once again prevailed.

The real battle can be expected next year. A preview will be delivered in January with Secretary Cheney's submission of the administration's fiscal 1992 defense request. With so little time, it is likely that the January submission will mirror the fiscal 1991 request to a large extent, particularly because the highly touted internal defense reviews have yielded few fundamental changes.

The new Congress, however, is not likely to look favorably upon such a submission. With breathing room between elections, combined with a deteriorating economic situation, many programs are likely to be squeezed much harder next year and old debates surrounding such big-ticket systems as the B-2, MILSTAR, and the A-12 should start all over again—but this time, perhaps with some nasty surprises.

The implications of the budget moves for the defense electronics and semiconductor industries remains much the same as last year. Opportunities in new platforms keep stretching on the time horizon, while the business of upgrading equipment remains the principal near-term opportunity.

Barry Blechman
Gregory Sheppard

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Research Newsletter

QML: DELAYS CAUSING ANXIETY

SUMMARY

Timely industry acceptance of the qualified manufacturing line (QML) approach to mil-spec semiconductor quality assurance is in jeopardy because the US Congress and the Department of Defense (DOD) have cut the funds needed to get the QML program off the ground. The funds are needed for approval audits of semiconductor companies so that the companies can commence participation in the QML program. To date, the necessary funding in the Defense Logistics Agency budget has been directed elsewhere, and 1991 funds have yet to be identified clearly in the budget. After garnering a high degree of interest from many merchant semiconductor companies, the DOD has created a situation of frustration with a quality assurance concept that many companies believe is the best way for them to remain viable mil-spec suppliers.

QML DEFINED

QML (aka MIL-I-38535) is a quality assurance and design specification for semiconductors used in DOD and, potentially, NASA and some non-US built NATO systems. The program technically is being driven from the Rome Air Development Center (RADC) and is being implemented and monitored by the Defense Electronic Supply Center (DESC).

QML currently is described as an alternative to the traditional qualified parts list (QPL) or JAN program (aka MIL-M-38510). QML's approach to quality is to ensure that the elements of design and manufacturing are of the necessary specification, rather than to just test specifications at various places in the manufacturing process, as JAN entails. The fundamental tenet of QML is the employment of a closed loop system known as statical process control (SPC), which utilizes ongoing monitoring of the incoming raw materials, the wafer fabrication, and the packaging process to identify and control deviations from specifications. Furthermore, the design libraries and CAD tools are separately approved in QML. The overall management of quality control is in the hands of a company team known as the Technical Review Board (TRB).

Two classes of QML currently are being considered: class Q for nonspace applications and class B for space use that includes special end-of-line testing. The ultimate intention of QML visionaries is have one class usable for all applications. However, the space design community approaches system designs conservatively and is not expected to change its desires for additional testing anytime soon.

Like JAN, all QML product must be manufactured in the United States or at specifically approved international sites. There is a movement afoot within the SIA Government Procurement Committee to recommend the integration of JAN with QML so that JAN products eventually can be reclassified as QML products and overhead cost savings can accrue.

QML SCHEDULE

Perhaps the essential ingredient for QML, as applied to semiconductors, is to create a situation where a critical mass of suppliers and OEMs believe that the program can meet their long-term needs. The principal need being addressed by the suppliers' adoption of QML is cost reduction through reduced part qualification overhead, synergy and a greatly improved commercial quality assurance process, and enhanced revenue through earlier acceptance of new products.

Table 1 is a listing of suppliers scheduled to participate in the QML program. Intel's initial key QML product is the 80386; AT&T's is the WE DSP32C digital signal processor MPU. The intent

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TABLE 1
QML Schedule

Company Name	Status
AT&T	Approved November 1989
Intel	Approved March 1990
IBM	Scheduled September 1990
Harris	Delayed
Honeywell	Scheduled August 1990
LSI Logic	Delayed
National Semiconductor	Delayed
Texas Instruments	Delayed
UTMC	Qualified Observer
VLSI Technology	Delayed

Source: Department of Defense

is to use complex, high-profile parts to thoroughly test the entire quality control mechanism. The standard evaluation circuits (SECs) are mostly SRAMs, a standard high-volume part.

QML Sweet and Sour

The acceptance of QML by the merchant industry is not universal. A lot of the uncertainty has to do with investment and economy of scale. Table 2 presents an overview of the demographics surrounding the acceptance of QML. Large companies and the principal ASIC companies stand to benefit the most from QML and thus are firmly behind it. Based on economies of scale and the long-term benefit from more closely coordinated commercial and military lines, they can justify the $500,000 to $1 million investment in the qualification process and statistical process control techniques (if needed).

Medium-size and small companies might not have enough business to justify the investment. Factors that will help swing medium-size and small companies to QML include the potential conversion of existing JAN lines and the potential approval of offshore assembly and test.

Impact on Obsolescence

Along with VHDL for capturing design data, QML promises to alleviate some of the problems caused by sunset technology. In particular, QML will help accelerate the early introduction of new semiconductor technology into the system life cycle, thus potentially adding as much as two to three years of technology (e.g., 2.0-micron double-metal CMOS) availability before the technology is phased out. QML should help greatly with the documentation and characterization of processes and products. The lack of documentation and characterization data is one of the most plaguing problems with older standard logic families.

QML AS A MARKET

QML as a specification is addressing the user needs that JAN is not covering today, primarily smaller-volume, VLSI/ULSI, application-specific, limited-source ICs. The JAN program was set up to

TABLE 2
QML Perception

	QML Acceptance
Best	Top ten companies market
	Large ASIC companies
	Captive operations
Neutral	Medium-size companies
	Companies not on QPL
Negative	Small companies
	Medium/small companies on QPL
	Fabless companies

Source: Dataquest (October 1990)

address the issue of standard specifications for industry standard semiconductors and has not been able to deal effectively with, in particular, user-definable products that rapidly are becoming the largest single IC category in the mil/aero semiconductor market.

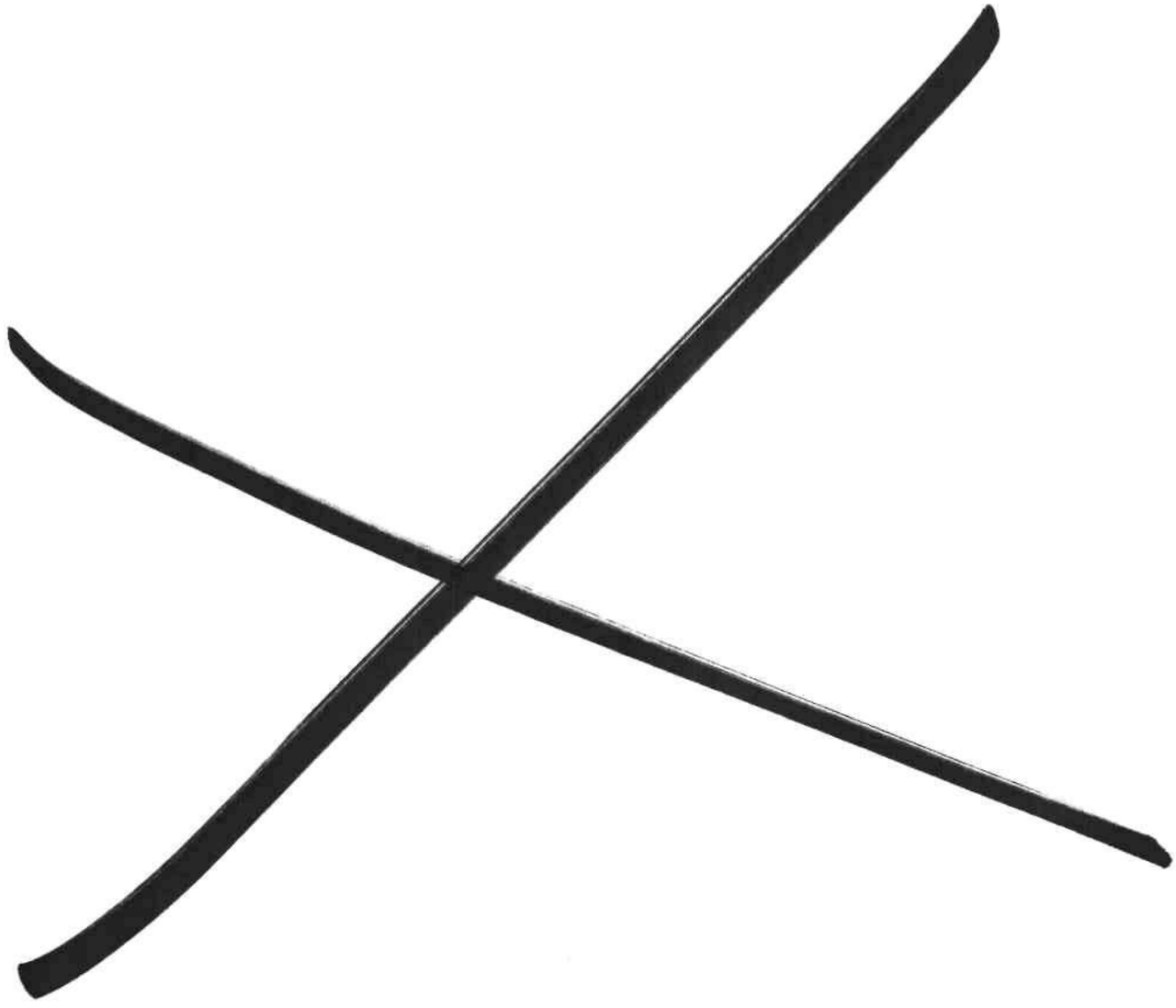
Gate arrays, cell-based ICs, custom ICs, 32-bit MPUs, and complex MPRs collectively represent 30 percent of the North American mil/aero market (only a small percentage of QML will apply to Europe) in 1990. These are the prime product areas to be addressed by QML. The majority of the ASIC business, for example, is done on a source control drawing (SCD) basis, and QML would help standardize and reduce sourcing overhead. Should QML reach critical mass from both the supplier and OEM standpoints in or near 1992 or 1993, QML products could be a $100 million market by 1995 and $225 million by 1998.

DATAQUEST RECOMMENDATIONS AND CONCLUSIONS

Dataquest recommends that suppliers that stand to benefit from QML be patient. Too many factors are pulling for QML not to succeed, including long-term DOD-DLA commitments to reducing costs and improving quality, and supplier desires to streamline operations and the costs of serving the mil/aero market.

As for OEMs, they perhaps need more warming up to the program and its potential benefits. More communication from the DOD and suppliers will help melt the mind-set barriers. A partial list of benefits to OEMs includes design cycle acceleration, reduced qualification/SCD overhead, and a broader, more competitive supplier base.

Greg Sheppard



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Research Newsletter

NONVOLATILE MIL/AERO MEMORY: NEW TECHNOLOGY FILLS MARKET NEEDS

SUMMARY

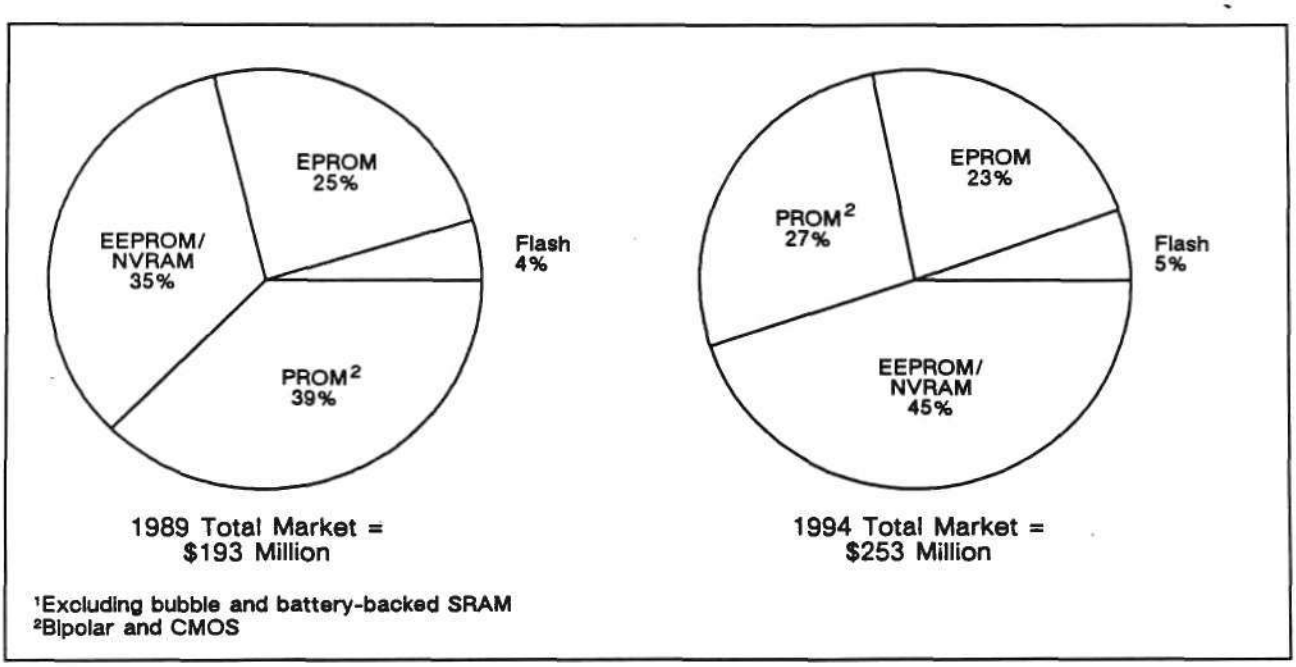
In spite of its name, nonvolatile semiconductor memory is indeed a volatile area in which military and space system designers keep demanding ideal technology. In short, the system designers want a nonvolatile technology that is in-circuit reprogrammable, dense, fast, and durable to radiation and millions of read/write operations.

The EEPROM is the principal workhorse for today's mil/aero applications. EPROMs follow (see Figure 1). Flash, a new technology blending the features of both EPROM and EEPROM, is emerging to serve the price/performance wedge in between the two. The mainstream mil-grade versions of EPROMs and EEPROMs have been under severe price pressure for the past year, but unit demand remains strong. Our surveys show that the price erosion is easing as suppliers react to the situation and position themselves so that they can develop areas of the market such as high-speed and Flash memory.

TECHNOLOGY CHOICES

Over the past two years, several new variations of nonvolatile memory technology have been introduced. Many of these technologies represent a blending of EPROMs, EEPROMs, and SRAMs to fill a spectrum of user needs for speed (read, write,

FIGURE 1
Mil/Aero Nonvolatile Memory Demand[1], North America and Western Europe



Source: Dataquest (September 1990)

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and erase), density, compatibility (e.g., voltages), in-circuit programmability, durability, and radiation tolerance.

EPROM technology is rapidly converting over to CMOS, particularly as the 1Mb parts are introduced. Sub-100ns and 16-bit-wide versions are being introduced to address the higher-access throughputs of the new 16- and 32-bit processors used in conjunction with them. Military EPROMs as fast as 70ns (256K) are available from companies such as ATMEL, WaferScale Integration, and Catalyst. Megabit densities are available from EPROM market leaders Intel and AMD.

CMOS PROMs are available now with accesses as fast as 25ns (16K) and 45ns (64K). Cypress, ATMEL, and WaferScale Integration are the principal suppliers of CMOS PROMs. BiCMOS PROM versions should appear on the market soon, driving the speed/density curve out further.

Pure EEPROM technology is continuing to improve in density and speed. Megabit densities are available, and access times as fast as 70ns (256K) are available. Because the technology is solidly entrenched into most mil/aero systems, Dataquest expects investment in EEPROM technology to remain strong as suppliers take users to new levels of density and read/write/erase speeds. The leading suppliers of mil-grade EEPROMs are Xicor, SEEQ, ATMEL, and Microchip. Harris is making its presence known in this market by offering space versions up to 256Kb in density with 300K rads total dose capability.

Flash memory is drawing much attention; it promises the advantages of EE technology at EPROM prices (eventually). With 512Kb parts available now, 1Mb versions are now entering the market. Some offerings are targeted at EPROMs with 12-volt programming voltages and bulk erase, and some allow 5-volt programming and byte-wise write ability, more like EEPROMs. Flash memories (the EPROM-oriented varieties) currently cost two to three times more than EPROMs and about one-half that of EEPROMs. Flash military prices are expected to settle down to near parity with EPROM prices three to four years from now. The major players in mil-grade Flash memory currently are SEEQ, Intel, ATMEL, and Catalyst.

Nonvolatile SRAMs (NVRAMs) blend the nonvolatility of EEPROMs and the fast access times of SRAMs. NVRAM access times as fast as 35ns are available. The bulk of available densities are at the 4Kb and below level. Joining Xicor as the principal supplier of NVRAMs are Simtek and Catalyst. Simtek is planning to release a 64Kb version later this year.

Pushed in part by the perception that existing solid-state technologies are not durable or rad-hard enough for tactical and strategic applications, the US agency DARPA is funding research in ferroelectric RAMs, or FERRAMs. FERRAMs employ the use of a ferroelectric material such as lead-zirconate-titanate (PZT) in the dielectric of the memory capacitor, which stays polarized in a 1 or 0 state when written to. Current technology employs a two-transistor, two-capacitor cell. Future technology (for 4Mb densities) will employ only one of each element. FERRAMs are very difficult to manufacture, but a substantial amount of money is being applied to make the technology more manufacturable and durable. FERRAMs are available in densities up to 16Kb, and access times as fast as 100ns are possible for the smaller densities. Ramtron is the most visible supplier, with a product in user hands. DARPA is working with several companies, including National/Krysalis, Westinghouse, Raytheon, and McDonnell Douglas to further the technology.

Another infant technology gaining some visibility is magnetoresistive RAM, or MRAM. In effect, the technology is magnetic memory on an IC. It employs a nickel-iron permalloy as its active material. Research into MRAM technology is being funded by the SDIO through Honeywell and its spin-off start-up, Nonvolatile Electronics.

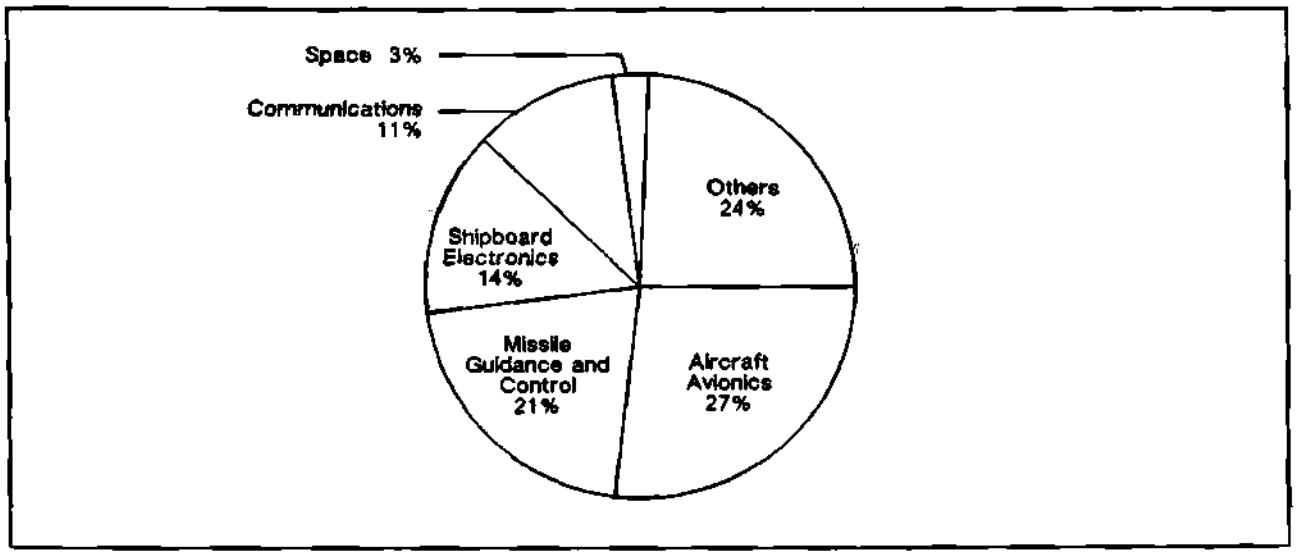
Expanding Applications

There are two primary classes of nonvolatile memories: in-circuit erasable/writable and non-in-circuit changeable versions. Figure 2 shows the size of principal application areas in mil/aero systems on a dollar basis.

PROMs (bipolar and CMOS) and EPROMs represent the bulk of nonerasable products used in mil/aero systems. They are used as control code memories and fixed data storage in most situations where a microprocessor, microcontroller, or DSP chip set is employed. The bulk of applications for EPROMs remain at 256Kb densities or below, with 1Mb densities entering the customer evaluation stage.

PROMs are used most often in fast (sub-70ns) applications. PROM applications requiring sub-45ns access times can employ the bipolar versions from leading companies such as AMD, National, Signetics, Raytheon, and Fujitsu. CMOS versions as fast as 25ns are available from Cypress.

FIGURE 2
Mil/Aero Nonvolatile Applications (Dollar Basis—1989)



Source: Dataquest (September 1990)

TABLE 1
Key Mil/Aero In-Circuit Programmable Uses

Application	Typical Array Size
Mission computer main memory	8-36MB
Avionic SEM-E modules	1-4MB
Digital map database	4-64MB
Aircraft data/mission recorders	4-300MB
Radar warning receivers	48-96KB
ECM/ECCM units	48-96KB
Unmanned aerial/underwater control/mission memory	256K-4MB
Tactical missile control	16-256KB
Shipboard standard computer main memory	1-4MB
Satellite control and mission memory	1-64MB
Space launch vehicle control	256K-4MB

Source: Dataquest (September 1990)

In-circuit programmable technologies include EEPROMs, NVRAMs, and Flash memory. These memories are used for updatable main memories, shadow memories, data/status buffers, and modifiable control codes and lookup tables. Some specific applications are listed in Table 1.

Upgrade Applications

Dataquest estimates that as much as 50 percent of future nonvolatile memory use will come from the replacement or functional improvement of existing board or module designs. This replacement is being driven by the preferential budget treatment

electronic upgrades of existing platforms receive over building new platforms.

Examples of replacement applications include migration to CMOS from NMOS for EPROMs and bipolar to CMOS for PROMs. These applications are characterized by a desire to minimize the expense required for board redesign, the desire to take advantage of power reductions, or to avoid part obsolescence. Functional improvement applications include the movement to in-circuit programmability as offered by EEPROM and Flash technology and the migration to faster and higher-density parts involving some board redesign. Another class of functional improvements includes the displacement of main memory and electromechanical mass storage (such as in-flight data recorders) with fast (70ns or faster) nonvolatile technology that does not need battery backup.

DATAQUEST CONCLUSIONS

In the quest for the perfect nonvolatile IC memory for military and space applications, semiconductor companies, government technology planners, and system designers will continue to push the market into more application-specific niches. The niches will continue to be shaped by factors such as in-circuit reprogrammability, speed, density, durability, radiation tolerance, and compatibility with existing board designs. This last factor is paramount, given the budget constraints on many programs.

Based on this scenario, Dataquest believes that the mil/aero nonvolatile memory supply base for the new technologies such as Flash will continue to fragment into a spectrum of alternatives, each with two to three suppliers. This situation should continue until de facto standards are more clearly established, primarily by the commercial marketplace.

In the meantime, we expect the commodity areas of EPROMs and EEPROMs to remain under price pressure until suppliers become less aggressive about booking business. Because of strong demand from upgrade applications, we expect the unit growth to remain positive for commodity parts. The newer products such as high-speed (sub-100ns) EPROMs, 1MB EEPROMs, and Flash should find attractive, moderate, ramp-up growth over the next two to three years.

Gregory Sheppard

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Research Newsletter

UPGRADES TO BE FAVORED OVER NEW STARTS

SUMMARY

Congress will soon agree on drastic cuts in President Bush's proposed fiscal 1991 defense budget. Many of the cuts will be taken by canceling procurement of numerous advanced weapons and platforms developed during the Reagan Administration's large defense build-up during the early and mid-1980s.

Although nearly every large program will be stretched, production funding for advanced platforms with a high degree of concurrency between development and production will sustain disproportionate cuts in relation to other programs. In the current environment, programs such as the Advanced Tactical Fighter, the Light Helicopter, the B-2 bomber, and the Block III Main Battle Tank cannot stay on track.

Even the Department of Defense (DOD), long the most vocal advocate of new program starts, is backing away from pursuing the type of highly advanced next-generation platforms that dominated Pentagon thinking in the 1980s. These cutbacks, however, affect primary manufacturers of airframes, missiles, ships, and vehicles. Defense electronics will be relatively spared, because prolonging the lifetimes of existing platforms will require the upgrading of these systems with more advanced electronic subsystems. Table 1 lists some of the most troubled systems.

UPGRADE STRATEGY

The new Defense Technology Strategy, recently endorsed by the Assistant Secretary for

TABLE 1
Troubled Programs and Upgrade Alternatives

Program	Contractor	Upgrade Option	Contractor
Advanced Tactical Fighter	General Dynamics/Lockheed McDonnell Douglas/Northrop	F-15XX	McDonnell Douglas
P-7A Aircraft	Lockheed	P-3	Lockheed
LH Helicopter	Bell/Textron/McDonnell Douglas Boeing Vertol/Sikorsky	AH-64 AHIP	McDonnell Douglas Bell Textron
Block III Tank	General Dynamics	M-1	General Dynamics
A-12 Aircraft	McDonnell Douglas General Dynamics	A-6	Grumman
B-2 Bomber	Northrop	AGM-129	General Dynamics McDonnell Doug
Boost Surveillance and Tracking System	Grumman Lockheed	DSP	TRW

Source: Defense Forecasts

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Acquisition, John Betti, calls for military services to redirect their energies away from new program starts and toward continued upgrades of existing systems over the next 20 years. Although the document reportedly calls for steady spending (approximately $6 billion per year) on long-lead research and development (R&D), emphasis will shift toward upgrading computing and sensing technologies that can be integrated into existing platforms. Perhaps the initial manifestation of this trend has already been witnessed in the US Navy's decision to cancel production of the P-7A long-range antisubmarine aircraft, but to continue funding development of the Update IV avionics suite that was to have served both the P-7A and newer P-3Cs.

This "new thinking" in the Pentagon, coupled with severe fiscal pressures faced on Capitol Hill, will most assuredly have a dramatic impact on many weapon systems that were considered solid just a few years ago.

PROGRAMS

Advanced Tactical Fighter (ATF)

The need to procure the Advanced Tactical Fighter (ATF), prototypes of which are currently being tested by the competing teams of General Dynamics/Lockheed and McDonnell Douglas/Northrop, was endorsed in Secretary of Defense Dick Cheney's Major Aircraft Review, although the program was slipped two years.

It recently came to light, however, that the ATF was examined independent of new data on possible upgrades of McDonnell Douglas' F-15, the air force's current top-of-the-line fighter. This discovery led the Senate Armed Services Committee to authorize $100 million to be used to preserve F-15 upgrade options and to study production of the so-called F-15XX configuration. At the same time, the committee stripped monies for full-scale ATF development, assuring program slippage beyond Cheney's two-year delay.

Although the ATF may not survive congressional cuts, many of the avionics and propulsion systems designed for use in the ATF will continue. The Services seem committed to pursuing integrated avionics programs, based on the Air Force's Pave Pillar, which are designed to produce avionics packages useful in a wide range of platforms. The next-generation package is known as the integrated electronic warfare suite (INEWS) and estimated to account for nearly 25 percent of the ATF's total production costs. Two teams are developing such an advanced avionic package: TRW/Westinghouse for the Northrop/McDonnell Douglas prototype and Sanders/General Electric for the Lockheed/General Dynamics version. The team of Westinghouse/Texas Instruments is producing the main radar systems for both prototypes. All three teams can expect continued funding of their programs independent of any decisions on the future of the ATF.

If a decision were made to go ahead with the F-15XX, it has already been determined that the engines designed for the ATF, being completed between Pratt and Whitney and General Electric, will be used. The upgraded F-15 also would make use of the advanced INEWS and the integrated communications, navigation, and identification system (ICNIA).

With a planned total cost of $33 billion to deliver 750 F-15XX aircraft (less than one-half the estimated cost of the ATF) and a start-up period scheduled for just four years, this option may be the favorite of many lawmakers and civilian budget officials.

P-7A Antisubmarine Aircraft

The navy's decision in late July to cancel production of Lockheed's troubled P-7A antisubmarine aircraft, after an investment of over $200 million, probably shocked the nearly 250 Lockheed subcontractors scattered over 30 states, but many will soon find continued sales with a possible decision to upgrade older P-3 aircraft.

One vital electronic component is sure to survive the cancellation of the P-7 airframe. Two hundred Update IV avionics suites have already been slated to be fitted on both existing P- 3Cs and new P-7As during the next six years. The navy now will likely go ahead with expanding upgrades of the P-3s, although perhaps at a slower rate. In addition, there is likely to be considerable foreign interest in the avionics package because many nations currently are flying the P-3, including the United Kingdom, Italy, Norway, Germany, and Japan.

Boeing, the prime contractor for Upgrade IV, has experienced many software-related problems, while AT&T, the contractor for the AN/UYS-2 Enhanced Modular Signal Processor (EMSP)—a key component—is nearly two years behind schedule. Still, the upgrade promises vast improvements over the current system. Other corporations well

placed in this system are Motorola, with its 68000 series microprocessors and Honeywell, which produces the VHISC chips.

Current domestic production plans for the P-3C call for just six more of the aircraft to be produced—three for Pakistan and three for Canada. Any decision to keep the P-3 production line open will have to be made before the last plane rolls out in September 1991.

Light Helicopter (LH)

The army's ambitious and highly prized Light Helicopter program is also in trouble. In accordance with the congressional desire to "fly before you buy," funds will likely be withheld for full-scale development until the first prototypes are thoroughly tested.

Bell Helicopter Textron and McDonnell Douglas are competing for the system against Boeing Vertol and Sikorsky. When the two teams entered the competition, they had hoped for a total domestic buy of 4,100 helicopters. Even if the program survives, the total planned buy is now down to less than 1,900.

Although the LH airframe is suffering considerably in the current political environment, the subcontractors for both teams can expect continued development of many of their advanced avionics systems. There is increasing interest in reviving programs to upgrade existing AH-64 and OH-58D helicopters by integrating many systems currently under development.

The primary subcontractors for Boeing Vertol/Sikorsky include Boeing, the avionics system integrator; Harris, for the super-high-speed data bus; IBM, with a VHSIC-based processor; TRW, for electronic self-defense; and Westinghouse, for VHSIC-based computers and millimeter wave radar. Major subcontractors for the McDonnell Douglas/Bell Helicopter Textron team include AT&T for signal processing hardware: Northrop for the electronic defense package, Eaton for the EW suite, and General Electric/Honeywell for integrated flight control systems.

M-1 Main Battle Tank

Congress has long been critical of the army's armored systems modernization program, which places an emphasis on next-generation, or Block III, main battle tank construction at the expense of upgrading the highly sophisticated M-1 already in the field.

Criticism increased this year with the army's recommendation to cancel the current-generation M-1A2 "Abrams" main battle tank, produced by General Dynamics, after a total production run of just over 60 tanks. Even with Saudi Arabia's recently announced decision to procure 315 tanks, it is unlikely that the tank plants at Lima, Ohio and Detroit, Michigan can survive without significant additional foreign sales. Because these plants are the only two tank production lines left in the United States, such a decision would eliminate all US tank manufacturing capability for the foreseeable future.

At the same time, the army is requesting R&D funds to explore a new generation of heavy tanks that many believe will not be needed given the prospective international environment. Congress therefore is likely to demand that the army drop Block III planning and concentrate on upgrading the electronics and munitions of the original Block I Abrams. Such upgrades, it is estimated, could improve M-1 efficiency by as much as 250 percent and cost significantly less than the construction of an entirely new tank.

This decision would likely benefit many of the current Abrams subcontractors such as Hughes Electro-Optical and Data Systems Group, which produces the laser range finders and thermal receiver units; General Motors and Allison, which produce heavy transmissions; and Honeywell, which produces the advanced munitions for the M-1 program.

A-12 Attack Aircraft

Troubles in the McDonnell Douglas and General Dynamics A-12 Navy attack aircraft have prompted both the navy and congress to reassess their options, including the possible upgrading of existing Grumman A-6 planes.

The A-12 program was originally planned as the navy's next-generation medium-attack aircraft to be placed on 15 carriers. A planned buy of 858 aircraft was reduced to 620 planes in Secretary Cheney's Major Aircraft Review in light of plans to reduce the number of carrier task force groups. A recent Congressional Research Service study, moreover, suggests that the total buy could be reduced by several hundred more.

The A-12, which until recently was an entirely "black" program, has accumulated nearly $500 million in cost overruns and is considerably behind schedule. These problems have led to renewed interest in an old Grumman proposal for an A-6G configuration. Although not openly endorsing the idea of a return to the Grumman proposal, the Senate Armed Services Committee did add $85 million to the navy's $84 million request to accelerate upgrades on existing A-6 aircraft.

Both the congress and the DOD publicly continue to support for the A-12, but if the program continues to incur delays and overruns, it may quickly become politically untenable.

B-2 Stealth Bomber

Northrop's much troubled B-2 program is likely to limp through this year with continued production funding despite the strongest move yet on Capitol Hill to kill the program after construction of the 15 aircraft already approved. There is little question, however, that without a dramatic change in US-Soviet relations the program will never produce the 75 aircraft that survived Secretary Cheney's Major Aircraft Review. Other means of enhancing the bomber element of the US strategic triad being discussed include accelerating development of the highly classified AGM-129 advanced cruise missile, designed to be placed on existing B-1B and B-52G bombers. Incorporating stealth capabilities, the missile is nearing completion of development and has the advantage of being capable of operating from existing platforms. General Dynamics is the prime contractor, with McDonnell Douglas serving as the second source. After two flight tests by McDonnell Douglas and four by General Dynamics, the air force is expected to award production contracts. The two companies are scheduled to enter head-to-head competition for the missile as early as 1993.

Any shift away from the B-2 program will further hurt Northrop Corporations future earnings and could have a near fatal impact on the company if combined with either a cancellation of the ATF or the selection of the General Dynamics/Lockheed team. The news does not get much better for Northrop as the company recently has been the focus of highly charged weapons fraud cases. Some congressmen in key committees have gone so far as to push for a ban on all Pentagon dealings with the company.

Boost-Phase Surveillance and Tracking (BSTS)

This system, long the cornerstone of the original Phase I architecture for the Strategic Defense Initiative (SDI), has had several setbacks in the last year. These setbacks are raising questions as to whether the program will ever be deployed. Lockheed, whose major subcontractors include Hughes, IBM, SAIC, and TRW, is competing for the program against Grumman, whose major subcontractors include GE/RCA, GTE, Honeywell, Litton/Itek, McDonnell Douglas, Raytheon, Rockwell, and Sparta.

The first setback to the program came with the introduction of the Brilliant Pebbles concept; each Pebble was said to be capable of carrying its own missile launch detection and tracking system. In Congressional testimony, officials from Strategic Defense Initiative Office (SDIO) stated that the development and deployment of Brilliant Pebbles would mean that the BSTS system, as originally envisioned, would not be necessary.

In what many viewed as a second setback for the program, the SDIO requested that beginning the program be moved over to air force control in fiscal year 1991. The air force, which has long favored its well-established Defense Support Program (DSP) of early missile warning satellites, built by TRW and first launched in 1971, has proven to be a less vocal advocate of the BSTS.

It is unlikely that the BSTS system will be allowed to enter production before detailed studies are conducted comparing cost and performance between the proposed system and possible DSP upgrades. The possibility of such upgrades must be seen as encouraging for TRW and its subcontractors, which include IBM, for the software, and Aerojet Electrosystems for the infrared telescope and sensor subsystems.

DATAQUEST CONCLUSIONS

Dataquest believes that two overall themes will guide congressional spending on new platforms over the next decade. The first will be a desire to fully exploit existing weapon platforms through computer, sensing, communication, and ammunition upgrades at steady and cost-effective rates of production. The second theme will dictate that if new platforms are approved, the concurrent development and production schedules that dominated planning in of the 1980s will not be tolerated.

Congress will increasingly insist on a fly-before-you-buy system of procurement.

The implications of these themes for semiconductor vendors are likewise twofold. Upgrades typically will incorporate new electronic features, and these features will employ large amounts of ASICs, ASSPs, microprocessors, memories, MMICs, and precision analog functions. The other impact is that the physical silicon or GaAs implementation will become more transparent to the system design as pressure is applied to use accurate design tools and simulations to capture chip designs and reimplement them over several process generations.

Gregory Sheppard
Barry Blechman

Dataquest
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Research Newsletter

MILAERO TECH BRIEFS: JULY 1990

This newsletter provides a useful consolidation of events, announcements, and general news in the military/aerospace semiconductor field. The following publications were used as source material for this newsletter:

- PR—Press Release
- EBN—*Electronic Buyers News*
- M&A Electronics—Military & Aerospace Electronics

PMI EXPANDS JAN SPACE OFFERING

PMI expanded its already strong presence in the linear space market by achieving Class S QPL approval on 12 parts. In what took eight months for approval turnaround, a variety of key operational amplifiers, A/D and D/A, and comparators are now available. (EBN, 6/4/90)

SALEM PLANS RAM ENTRY

Salem, a division of Microsemi Corporation, based in Beverly, Massachussets, plans to follow the lead of Electronic Designs and others by offering an 883C memory product based on die from Japanese companies. Products mentioned include 128Kx8 70ns SRAMs, 80ns 1Mb DRAMs, and two video RAMs. Hitachi, Mitsubishi, NEC, and Sony were mentioned as die sources. (EBN, 5/7/90)

TI OFFERS FAST PLDs

Texas Instruments (TI) has announced the availability of several 10ns devices compliant to MIL-STD-883C Class B. The versions are 16L8, and 16R8, 6, 4, and 100-piece DIP sales price was noted to be $15.16 and surface-mount versions are $21.45. (EBN, 7/7/90)

SILICON GENERAL EXPANDS DIODE ARRAY OFFERING

Based on a newly developed SOI process for better diode isolation, Silicon General joins National Semiconductor on the QPL for the 1N6100 and 1N6101. Volume pricing was noted to be $20.25 each. (EBN, 7/9/90).

PARADIGM OFFERS FAST SRAMs

Paradigm Technologies of San Jose, California, has announced availability of a 25ns 128Kx8 CMOS SRAM targeted at RISC MPU applications. The product, which is fabricated on Paradigm's own 0.8-micron CMOS process, will be available in military versions in the near future. (M&A Electronics, 7/90)

HEWLETT-PACKARD UNVEILS MMIC SWITCH

The Microwave Semiconductor division of Hewlett-Packard has introduced a family of broadbandwidth, low-power switches targeted at electronic warfare and communications applications. With bandwidths up to 6 GHz, the GaAs-based devices are constructed with a molecular-beam epitaxy technique and with titanium-platinum-gold metallization. Military temperature versions are available for $38 in samples of 100. (M&A Electronics)

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LSI LOGIC ENTERS ERROR CORRECTION ARENA

Capable of speeds up to 40 MHz, LSI Logic's new error correction IC, the L64710, fills out a growing list of standard products from the company. Capable of handling data streams as fast as 320 Mbps, the parts are well suited for high-speed data communication links. Done in 0.7-micron CMOS and available with 68-pin ceramic PGAs, the 40-MHz version is priced at $473 in 100-piece quantities. (M&A Electronics, 6/90)

SIPEX OFFERS SPEEDY SAMPLE AND HOLDS

Sipex of Billerica, Massachusetts, is offering a 16-bit, high-speed sample-and-hold amplifier. Capable of 250ns acquisition times, the hybrid device is available in MIL-STD-883C versions for $289 in 100-piece quantities. (M&A Electronics, 6/90)

ANALOG DEVICES HAS DAC/FIFO COMBO

Constructed with BiCMOS, the 12-bit DAC and FIFO combination IC helps MPUs save time by allowing eight outputs to be clocked simultaneously. The AD7848 sports a 42ns minimum-write pulse width and is available in a 40-pin LCC. (M&A Electronics, 6/90)

VLSI TECHNOLOGY INTRODUCES FIFOs

Pursuing a fast-growing FIFO market, VLSI has introduced 2K, 1K, and 512x9 versions. Based on 1-micron CMOS technology, the devices are capable of up to 20ns access times. Ceramic-packaged military versions are expected in the third quarter of this year. (PR, 6/90)

UTMC OFFERS RAD-HARD MPUs AND SRAMs

UTMC is offering its 12-MHz, 6-mips, UT1750AR microprocessor with megarad capability. The 144-PGA part is available on the company's RAD-SPEC program for $1,318 in 100-piece quantities. The company also has announced the availability of two 8Kx8 55ns CMOS SRAMs with SEU immunity exceeding 1.0 E-10 errors/bit-day. Available in 28-pin DIPs and flatpacks, the level H versions of the SRAMs are priced at $1,185 in 100-piece quantities. (PR, 6/90)

Gregory Sheppard

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Research Newsletter

POWER TRANSISTORS: MARKET STRENGTH IN AN ERA OF INTEGRATION

SUMMARY

The control of power for lighting, motors, and other electrical equipment still is the domain of discrete power devices. Less than 22 percent of the semiconductor power control market by revenue is supplied by power ICs. The demand for high currents and high voltages is still best and most cost-effectively met by power discrete transistors and power thyristors. Although many find the power discrete marketplace less exciting than that of other semiconductors, it represents a keystone for the growth of embedded control and application-specific smart power ICs. It has demonstrated a growth rate consistent with that of ICs and a continued offering of new products and technologies to answer the needs of the marketplace.

POWER CONTROL MARKET

The total power control semiconductor market (which excludes power diodes) is divided into three main product types—power transistors and thyristors, which comprise the discrete side and power ICs, which are considered to be part of the analog IC category. Table 1 lists the revenue and growth rates associated with each of these constituent product types.

Power ICs, with a 22 percent market share, still have considerable room for growth. Smart power, the combination of logic and power transistors on an IC, supplies less than 8 percent of the total power control semiconductor market.

Definition of Power

Power semiconductors are defined as discrete devices or ICs that can control one or more amps of current, dissipate one or more watts of power, or are capable of operating with voltages exceeding 100 volts. In the discrete area, transistors that do not meet these criteria are designated as small-signal transistors.

Power Transistors

As a dominant part of the power control market and with a continued strong growth rate, power transistors are expected to retain their dominant position in power control throughout the upcoming decade. The power transistor market

TABLE 1
Total Power Control Device Market

	1989 Revenue ($ Millions)	1989-1994 Forecast CAGR
Power Transistors	2,278	11.9%
Thyristors	594	6.4%
Power Integrated Circuits	785	13.9%
Total Power Control Semiconductors	3,657	11.4%

Source: Dataquest (August 1990)

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grew at a compound annual growth rate (CAGR) of 12.9 percent in the five-year period from 1984 to 1989. Power transistors have shown a strong growth trend in recent years as automotive electronics, motor controllers, switching power supplies, and other electronic controls have multiplied.

Dataquest expects power transistors to grow by an 11.9 percent CAGR from 1989 through 1994. These figures represent a continued strong growth rate, although the slow growth of 1989 to 1990 lowered the CAGR somewhat. Figure 1 shows power transistor revenue for the past five years (1984 to 1989) as well as the forecast revenue for the next five-year period (1990 to 1994).

Bipolar versus MOSFET Transistors

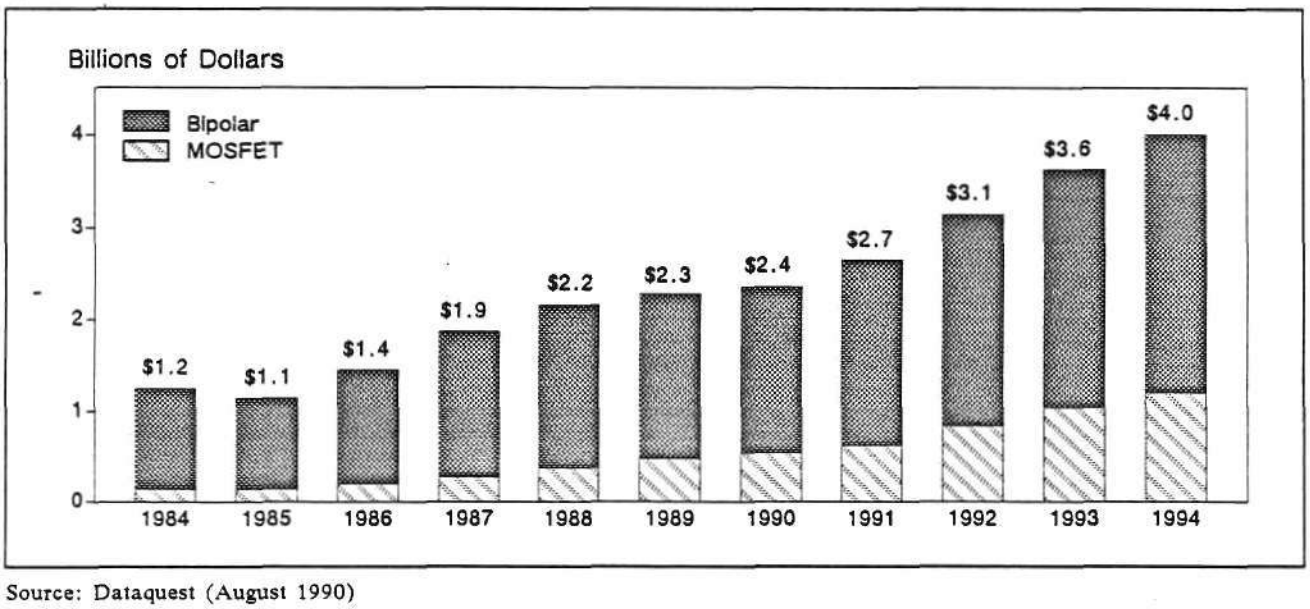
Although they have been touted as bipolar killers for more than a decade, MOSFET power devices are only now making a dent in the bipolar market with a 20 percent share in 1989. Significant price reductions, coupled with new and improved product offerings within the past few years, have helped increase the applications and usage of these products.

Why the trend toward power MOSFETs? Because of their shorter rise and fall times, power MOSFETs can switch substantially faster than bipolar power transistors, resulting in higher efficiency and lower power dissipation in switching applications. However, not all applications need high switching speeds. In some cases, the high switching speed of the MOSFET can create destructive voltages when driving inductive loads (dI/dt) that were not present in a bipolar implementation. Additional advantages of power MOSFETs are high-input impedance and gain and a simple interface with standard logic circuits. However, the bipolar power transistor is still the preferred technology for high-voltage, high-current applications because of its low ON-state saturation voltage, which is significantly lower than the ON resistance of MOSFETs. The problem is that power MOSFETs have an ON resistance (R_{ON}) that increases geometrically (to the 2.6th power) with the voltage rating.

The more recently introduced insulated gate bipolar transistor (IGBT) offers a solution to this ON resistance dilemma for MOSFETs. The IGBT combines the high-impedance input characteristics of the MOS transistor with the low-saturation voltage of the bipolar transistor. The bipolar action in the current path of the IGBT offers a low-resistance path, even with a high-voltage capability. Although IGBTs are slower than their MOSFET counterparts, they interface just as readily with MOS logic while reducing the power loss and dissipation problems that the high ON resistance would normally cause. Because of this capability, IGBTs are helping expand the market for MOSFET devices.

IGBTs are also called COMFETs (COnductivity Modulated FETs), MBTs (MOS-Bipolar Transistors), or GEMFETs. Dataquest classifies IGBTs within the general MOSFET category.

FIGURE 1
Power Transistor Revenue History and Forecast



Source: Dataquest (August 1990)

The difference between bipolar and MOS power transistors is summarized in Table 2. This table emphasizes the mixed bipolar/MOS performance characteristics of IGBTs.

Smart Power Transistors

Some power MOSFETs are offered with an additional control terminal that provides a "sense" output to monitor the current through the device. This current sensing allows the control electronics to compensate for inductance and monitor current overloads and provides a smart power system with improved features and performance.

POWER TRANSISTOR FORECAST AND HISTORY

Table 3 shows the five-year revenue history and forecast for both bipolar and MOS power transistors. The MOSFET segment of the power transistor market is growing rapidly and is expected to account for 30.0 percent of total power transistor revenue by 1994, as shown in Table 4. Power MOSFET revenue is expected to grow at a 20.3 percent CAGR from 1989 through 1994. In contrast, bipolar power transistors should grow at only a 9.2 percent CAGR during the same time frame. Figure 1 illustrates these different growth trends.

POWER TRANSISTOR MARKET SHARE

Dataquest estimates that the top ten worldwide suppliers of power transistors accounted for 68.7 percent of the $2.28 billion market in 1989. The estimated top 20 suppliers are shown in Table 5.

Many of these companies are involved in both bipolar and MOSFET power transistors to various degrees. Table 6 shows the estimated market share ranking for the top ten MOSFET power transistor suppliers, and Table 7 shows a similar listing for bipolar power transistor suppliers.

MOSFET Prices Dive

MOSFET average selling prices (ASPs) declined dramatically during the past year. As these power devices move out of the realm of niche products into a more mainstream power position, the pressure on selling price increases. In addition to this normal ASP decline as MOSFETs compete for bipolar sockets, the slow 1989 market caused many vendors to cut prices rapidly. International Rectifier (IR) and Samsung, in particular, made strong moves to gain market share.

Two casualties of this pricing battle have been IR and Siliconix. IR essentially mortgaged the company for power MOSFET business and has been in tight financial straits for the past three

TABLE 2
Performance Comparison: Bipolar versus MOS Power Transistors

Feature	Bipolar	MOSFET	IGBT
Control Parameter	Current	Voltage	Voltage
Switching Speed	Low-Medium	Fast	Low
Speed Temperature Sensitivity	High	Low	High
ON Resistance	Low	High	Low
Ruggedness	High	Moderate	Moderate
Input Impedance	Low	High	High
Interface to Logic	Complex	Simple	Simple
Thermal Runaway	Yes	No	Yes
Can Parallel Devices	No	Yes	No
ESD Sensitivity	None	Some	Some

Source: Dataquest (August 1990)

years. A major competitor, Siliconix, which also invested heavily in a 6-inch fab for power MOSFET production, has been reeling from its losses of the past year and recently filed for Chapter 11 protection from its creditors (including IR royalty payments). Siliconix raised prices on its power MOSFET line, which will further reduce its participation in this market. A recent settlement between Siliconix and IR regarding patent infringement resulted in a $12 million payment by Siliconix to IR over a two-year period.

Figure 2 illustrates the ASP decline for MOSFETs over the past five years. Mature bipolar devices, on the other hand, actually have shown ASP increases over this same period. Although MOSFETs may not reach price parity with bipolar devices any time soon, prices are expected to continue declining over the next five years.

TABLE 3
Worldwide Power Transistor Revenue (Millions of Dollars)

			1984-1989 Actuals				CAGR
	1984	1985	1986	1987	1988	1989	1984-1989
Bipolar	1,095	993	1,246	1,598	1,778	1,801	10.5%
MOSFET	145	143	196	273	375	477	26.9%
Total	1,240	1,136	1,442	1,871	2,158	2,278	12.9%
Annual Growth		(9.2%)	26.9%	29.8%	15.3%	5.5%	

			1989-1994 Forecast				CAGR
	1989	1990	1991	1992	1993	1994	1989-1994
Bipolar	1,801	1,820	2,025	2,300	2,585	2,800	9.2%
MOSFET	477	540	675	840	1,040	1,200	20.3%
Total	2,278	2,360	2,700	3,140	3,625	4,000	11.9%
Annual Growth		3.6%	14.4%	16.3%	15.4%	10.3%	

Source: Dataquest (August 1990)

TABLE 4
Worldwide Power Transistor Revenue (Percentage of Total by Type)

			1984-1989 Actuals			
	1984	1985	1986	1987	1988	1989
Bipolar	88.3%	87.4%	86.4%	85.4%	82.4%	79.1%
MOSFET	11.7%	12.6%	13.6%	14.6%	17.6%	20.9%

			1989-1994 Forecast			
	1989	1990	1991	1992	1993	1994
Bipolar	79.1%	77.1%	75.0%	73.2%	71.3%	70.0%
MOSFET	20.9%	22.9%	25.0%	26.8%	28.7%	30.0%

Source: Dataquest (August 1990)

DATAQUEST CONCLUSIONS

Electronic power control, whether for complex systems or simple electronics, embedded or accessible, is growing strongly and carrying both ICs and discrete devices with it. IC solutions to power control applications are limited in their capabilities and require significant cost trade-offs. Because of this, the discrete power transistor market continues to grow at a rate only slightly below that of the IC marketplace. This strong growth, coupled with the issues of MOS/bipolar competition, the proper partitioning/positioning of ICs and power discretes, and a continuing stream of technology developments, brings to the discrete market the same dynamics more commonly seen in the IC arena.

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Gary Grandbois

TABLE 5
Estimated 1989 Market Share for Power Transistors

Rank	Company	Percent Share	Revenue (Millions of Dollars)
1	Toshiba	13.3%	302
2	Motorola	13.0	297
3	NEC	8.3	190
4	SGS-Thomson	7.0	160
5	Hitachi	5.5	125
6	Mitsubishi	4.8	110
7	Philips	4.6	105
8	Matsushita	4.5	102
9	Sanyo	4.2	96
10	Harris	3.4	78
11	Fuji Electric	3.4	78
12	Sanken	2.8	63
13	International Rectifier	2.7	62
14	Siemens	2.5	58
15	KEC	2.2	49
16	Texas Instruments	2.0	45
17	Samsung	1.9	44
18	Siliconix	1.4	32
19	Rohm	1.3	30
20	Shindengen Electric	1.2	28
	Others	10.0	224
	Total	100.0%	2,278

Source: Dataquest (August 1990)

TABLE 6
Estimated Top Ten Suppliers of Power MOSFETs Ranked by Revenue

Rank	Company
1	Motorola
2	International Rectifier
3	SGS-Thomson
4	Toshiba
5	Siliconix
6	NEC
7	Samsung
8	Harris
9	Fuji Electric
10	Hitachi
Total MOSFET Revenue	$477 million

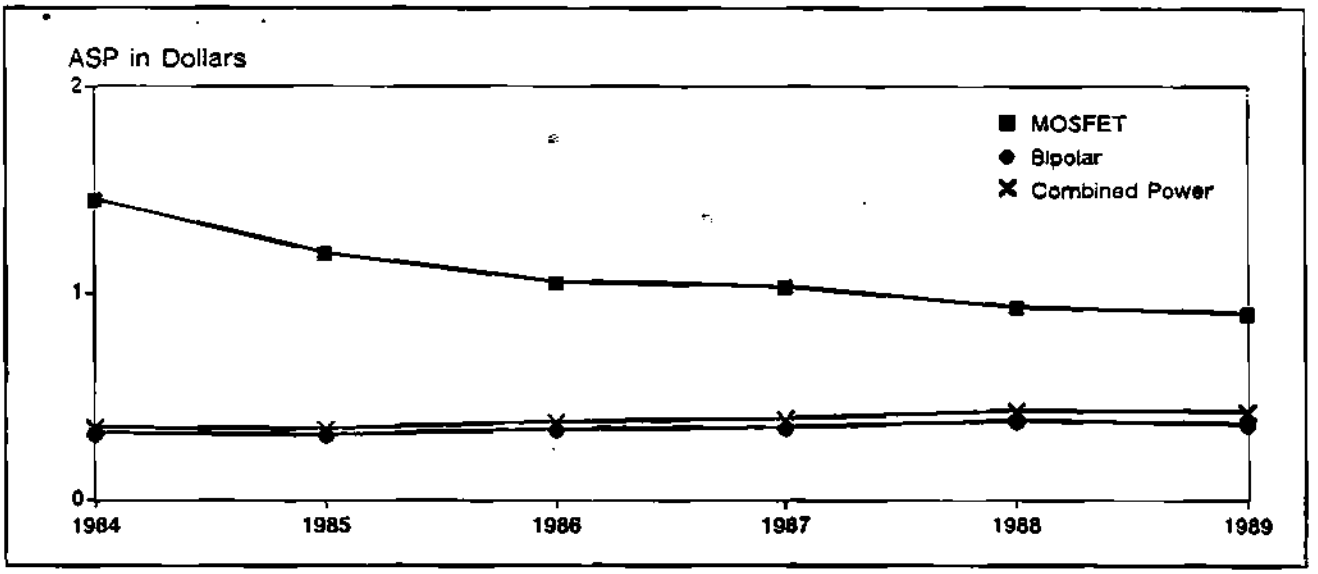
Source: Dataquest (August 1990)

TABLE 7
Estimated Top Ten Suppliers of Bipolar Power Transistors Ranked by Revenue

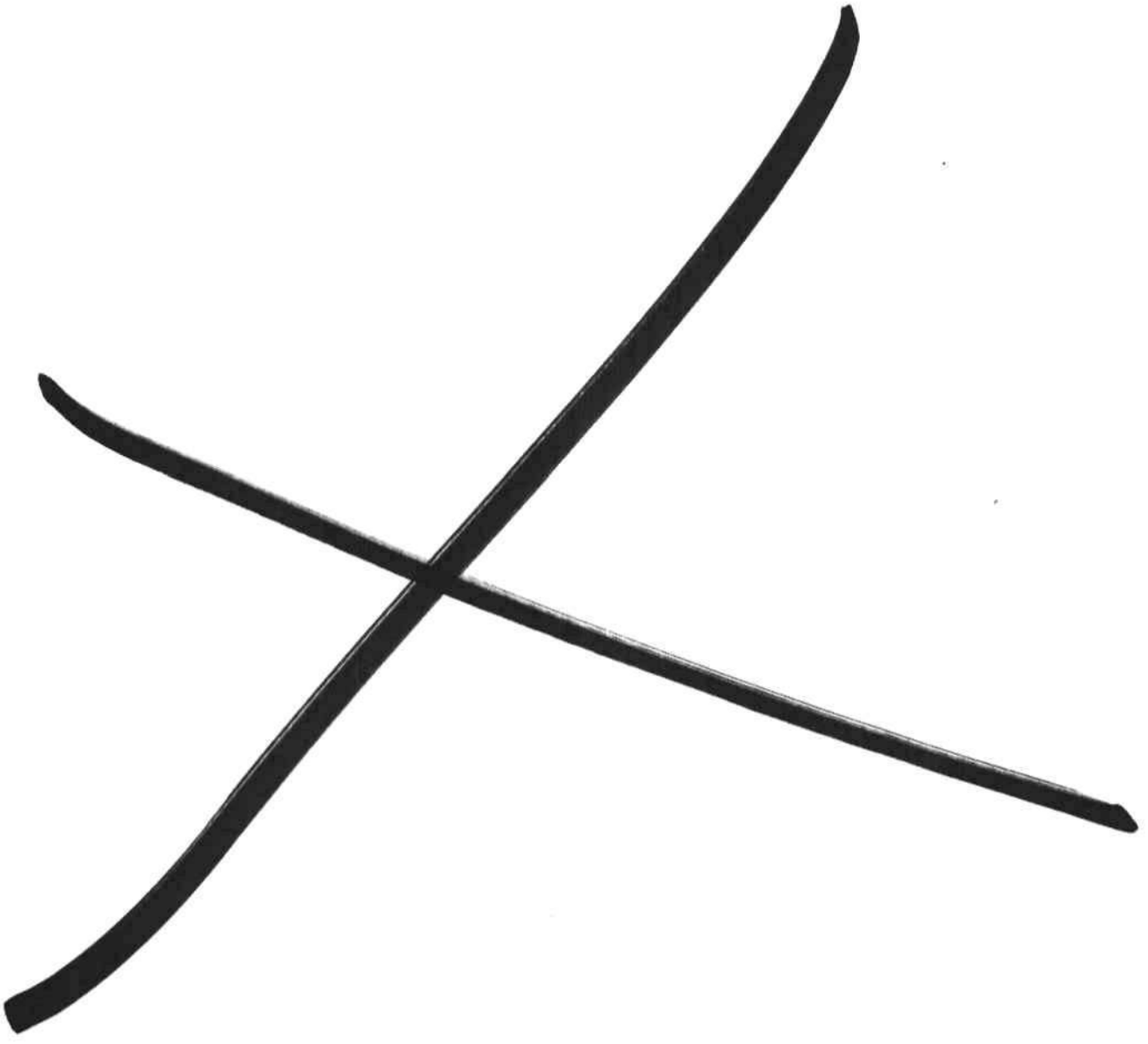
Rank	Company
1	Toshiba
2	Motorola
3	NEC
4	Hitachi
5	SGS-Thomson
6	Mitsubishi
7	Philips
8	Matsushita
9	Sanyo
10	Sanken
Total Bipolar Revenue	$1,801 million

Source: Dataquest (August 1990)

FIGURE 2
Power Transistor ASP Trend



Source: WSTS, Dataquest (August 1990)



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Research Newsletter

THE CHANGING EUROPEAN DEFENSE MARKET

OVERVIEW

The threat of a major conventional war in Europe, which for over 40 years drove the Western nations to spend large sums on defense and to maintain a rapid pace of weapons development, has evaporated. It has been less than a year since the breach of the Berlin Wall, but the impact on NATO's defense plans has come quickly as popular pressures have mounted rapidly throughout the NATO Alliance to reduce defense spending. The trend is to decrease force levels, even before arms control agreements are completed, meaning fewer hardware purchases and an easing of the urgency previously attached to modernizing existing weapons.

NATO's Defense Planning Committee met in Brussels, Belgium, in June and asked General John Galvin, commander of NATO's military forces, to devise target force reduction goals. Although forces will remain level in 1990, planners in most nations are beginning to schedule troop and equipment reductions, both in anticipation of the Conventional Forces in Europe (CFE) treaty and in order to accommodate reduced defense budgets. NATO's defense ministers are hopeful that such anticipatory planning will avoid sudden unilateral efforts that could bite even more deeply. Even so, declining defense budgets will mean major restructuring of European defense programs and companies.

NATO DEFENSE SPENDING

Together, the Western European nations spend roughly one-third the amount on defense that the US spends alone (see Table 1). So far, the defense budgets of most NATO nations have remained relatively stable (see Table 2); the real crunch will be felt in the next two or three years. Prospective changes in key European defense budgets are highlighted in the following paragraphs.

Great Britain

The United Kingdom's defense budget for fiscal year 1990-1991 is planned for $34.60 billion, a 2.9 percent increase from the 1989-1990 budget.

TABLE 1
Total 1988 Defense Spending and Percentage of NATO Total

Country	Billons of Dollars	Percentage of NATO
Belgium	4.1	0.9
Canada	10.0	2.2
Denmark	2.3	0.5
France	36.1	7.8
West Germany	35.1	7.6
Greece	3.4	0.7
Italy	20.4	4.4
Luxembourg	0.9	0
The Netherlands	6.7	1.5
Portugal	1.4	0.3
Spain	7.2	1.6
Turkey	2.7	0.6
United Kingdom	34.7	7.5
United States	293.1	63.7
Non-US NATO Total	165.0	34.0
Total NATO	458.1	100.0

Source: Defense Forecasts

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TABLE 2
Annual Percentage Change in Defense Spending by NATO Countries—1987-1989 (Excludes Inflation)

Country	1987	1988	1989*
Belgium	1.6	(3.5)	0.7
Canada	2.2	1.1	(3.1)
Denmark	2.3	2.9	(2.0)
France	3.1	(0.6)	0.7
West Germany	0	(1.0)	0.6
Greece	1.7	6.5	(7.5)
Italy	5.8	4.5	1.9
Luxembourg	13.4	15.2	(3.1)
The Netherlands	1.7	(0.2)	1.4
Norway	9.7	(3.6)	8.2
Portugal	1.3	9.4	(9.0)
Spain	12.6	(7.3)	1.8
Turkey	(1.3)	3.4	3.0
United Kingdom	(2.1)	(4.3)	3.3
United States	(0.3)	(1.5)	0.2
Non-US NATO Total Average Growth Rates	1.8	(0.9)	1.1
NATO Total Average Growth Rates	0.4	(1.3)	0.5

*Estimated
Source: Defense Forecasts

With a 6.5 percent annual inflation rate expected in Great Britain, the planned budget represents a 3.6 percent reduction in real spending power. The 1991-1992 British defense budget is planned to reverse this decline, rising $1.85 billion to $35.44 billion, a real increase of 0.6 percent. Even this marginal growth is not likely to hold, however, as the British treasury is pressing the Ministry of Defence (MOD) to cut an additional $1.60 billion from the 1991-1992 request. If the Thatcher government should fall, the cut would be much larger.

The programs most likely to suffer are the Challenger tank program, the European fighter program, and the Trident submarine. The proposed cuts may also endanger the EH-101 helicopter, a program with participation by West Germany and Italy.

The Netherlands

The Dutch government announced cuts of F5.5 billion from the planned 1990 defense budget, meaning essentially, no real growth. The cuts in the Dutch budget come largely from a decision not to replace General Dynamics' F16 aircraft lost through attrition and a decision to forego the purchase of upgrade equipment for the electronic warfare suites on-board the remaining F16s. The Dutch government also decided to cancel the planned purchase of four Raytheon Patriot surface-to-air missile systems.

West Germany

According to the West German Defense Minister, Gerhard Stoltenberg, the Bundeswehr will

reduce its total strength from 1.34 million to 950,000 active and reserve soldiers. When the CFE agreement is implemented, the Bundeswehr plans an additional cutback in active-duty personnel.

Given prospective demands on the West German economy from the integration of East Germany, further cuts in Bonn's defense expenditures are almost certain. Any substantial reduction, therefore, most surely will affect the FRG's participation in the European Fighter Aircraft (EFA).

Turkey

Among the NATO allies, Turkey stands as the sole exception to the growing trend toward smaller defense budgets. Ankara appears firm in pursuing its ten-year, $10 billion modernization plan. As part of this drive, the Turkish Armed Forces intend to acquire a fleet of armored infantry combat vehicles; serious consideration is being given to a derivation of FMC's Bradley. The Turkish government also has contracted to purchase $325 million worth of Loral's ALQ-178 electronic warfare suites for 160 F16s that are being assembled in Turkish Aerospace Industries (TAI).

PROGRAM COOPERATION

A diminished feasibility for many multinational cooperating programs has accompanied waning popular support for large defense expenditures. Such international and intercorporate alliances, both transatlantic and intra-European, were all the rage in the mid-1980s. Although there were some successes, the bulk of large ventures have failed. There are many reasons for the failures in these programs ranging from a shortage of government funds or the inability of different national armed forces to agree on performance requirements to changes in hardware procurement schedules and conflicts among the teamed companies.

The most notable failures include the NATO frigate and the Modular Standoff Weapon System (MSOW). Other programs in dire jeopardy are the EFA, the Anglo-Italian EH-101 multirole helicopter, the Anglo-French-German TriGAT antitank weapon, and the ASRAAM air-to-air missile.

The NATO Frigate Replacement

This program began with eight nations: Canada, West Germany, France, the Netherlands, Spain, Italy, the United Kingdom, and the United States. Originally pursued as the standard NATO Alliance frigate, the project promised eventual sales of $30 billion to a consortium of over 50 companies known as the International Schiffs-Studien GmbH, based in Hamburg, West Germany.

After nearly eight years in development, the new warship was already a year behind schedule and plagued with technical problems and national disagreements. Britain, in a move that shocked the other countries, announced its withdrawal, a move emulated quickly by France and Italy. West Germany already had pulled out after investing over $10.5 million, leaving the future of the proposed frigate in doubt.

The Modular Standoff Weapon System (MSOW)

This sophisticated air-to-surface missile program was begun in 1986 with France, Canada, Spain, Italy, West Germany, the United States, and the United Kingdom as partners. In 1988, both Canada and France abandoned the program, the former due to fiscal constraints, the latter to pursue an independent program. France has since set out to lure European partners away from the MSOW and toward the Apache missile being developed by the Matra Corporation.

The MSOW program also has suffered repeated technical setbacks, leading both the United States and Britain, each with a 22 percent stake in the project, to withdraw. Nearly $400 million already had been invested for project definition and preliminary research carried out by Rockwell International Missile Systems of the United States, CASA of Spain, Messerschmitt-Boelkom-Blohm GmbH (MBB) of West Germany, British Aerospace (BAe) of the United Kingdom, and Casmu of Italy.

The remaining partners—Spain, Italy, and West Germany—may continue the project, but they will be hard pressed to find a viable market in the face of competition from the Apache and a number of US programs.

European Fighter Aircraft (EFA)

The EFA is the largest cooperative program ever attempted. The program is run by Aeritalia of Italy, BAe of the United Kingdom, CASA of Spain, and MBB of West Germany, which is teamed with Dornier of France.

The total acquisition cost of the EFA is expected to exceed $46 billion for the development and production of 765 aircraft through the year 2005. Britain had planned to buy 250. That number still appears firm, although Dennis Healey, the Defense Minister in the last Labour government, recently called on the United Kingdom to withdraw from the program.

It is more likely that West Germany will rescind its plan buy 250 aircraft. Both the opposition Social Democratic Party and the Free Democrats, Chancellor Kohl's current coalition partner, already have publicly advocated Germany's withdrawal. If financial pressures continue to mount, as it appears likely, Chancellor Kohl may decide to withdraw from the program, which would almost certainly lead to its termination.

Although it is likely that West Germany will complete contractual agreements through the development stage, Daimler-Benz, the German conglomerate that owns MBB, has requested that the German government arrange for alternative employment in the civilian sector for those working on the EFA in the event of a German withdrawal.

The EH-101 Multirole Helicopter

Developed by Westland of England and Agusta of Italy, this program has been racked with delays, overruns, and technical setbacks. The UK MOD, for example, recently revised its estimate of development costs upward from £835 million to £1.1 billion. The helicopter was designed originally to serve both antisubmarine needs and army troop transport needs. Delivery was to begin in 1991, but current plans indicate that full production will not start until after 1994, and there are still no firm orders for the system. In addition, the EH-101 was recently rumored to be on an internal British MOD hit list of possible program cuts in the wake of lower defense budgets and the narrowing of new program starts.

The TriGAT Antimissile Program

This third-generation antitank weapon is another system reported to be on the British internal hit list. Previously considered relatively stable, the missile is being developed by Euromissile Dynamics Group, a Paris-based venture that includes British Aerospace, Aerospatiale of Italy, and MBB of West Germany. This $1.3 billion development program was to produce two prototype missiles—one man-fired, the other launched from helicopters.

Belgium, the Netherlands, and Spain joined the program and agreed to contribute 5 percent of the development costs as late as mid-1989. Even so, the reduction in East/West tensions and the prospective drastic reduction in Soviet armored vehicles as a result of the CFE treaty make TriGAT a very expensive missile. It may have a difficult time finding buyers when production models are scheduled to reach the markets in the mid- to late 1990s.

The Advanced Short-Range Air-to-Air Missile (ASRAAM)

This program was originally conceived in a cross-Atlantic agreement that provided for the United States to design a medium-range system and for the Europeans to design a short-range missile to replace the aging Sidewinder, produced by Ford Aerospace of the United States. It has been plagued with difficulties since its inception.

British Aerospace had the lead on the ASRAAM, with Bodenseewerk Geratetechnik of West Germany as the other main ally. Other companies involved included Garret of Canada and Raufoss Ammunisjonsfabrikker of Norway. The Federal Republic of Germany withdrew from the program last year, leaving BAe searching for other partners and trying to breathe new life into the failing £1 billion program.

The British Ministry of Defence is fully supportive of the effort to continue work on the ASRAAM, but a further complication has arisen as a result of an agreement between GEC and Marconi. Their agreement was to compete for the short-range market with a new system based on their seeker system for the MICA missile produced by Matra and Dassault of France. US purchases are also in doubt, with many on this side of the Atlantic pressing for a new version of the Sidewinder.

The ASRAAM is officially still on track, although it is now years behind schedule. The odds on it ever entering production must be considered long, however, and growing steadily longer.

CORPORATE COOPERATION

Although many cooperative efforts based on singular weapon programs seem to be failing, a new trend is developing toward corporate alliances

on a broader scale. Strategic alliances are not new in Europe; however, their number in recent months has swelled dramatically, leaving many US defense manufacturers, whose history of alliance-building has been restricted through relatively tough antitrust legislation, flat-footed. Still, US companies are flocking to European shores in search of well-established European markets with niche markets.

The biggest and most successful partnership began in 1974 with the joint venture of General Electric and Snecma of France to produce midsize commercial jet engines for Airbus and Boeing jumbo jets. According to published reports, last year's sales amounted to nearly $11 billion.

Since that springboard convergence, other US companies have connected with overseas companies. Recently, for example, Boeing teamed with Mitsubishi Heavy Industries, Fuji Heavy Industries, and Kawasaki Heavy Industries for portions of Boeing's next-generation jumbo jet. Germany's Daimler also has recently signed with United Technologies' Pratt & Whitney to exchange senior engineers to study each other's programs. Insiders believe that this exchange could eventually lead to large-scale cooperation.

Nevertheless, European companies lead the pace on defense industrial cooperation. In the past few weeks, for example, two pairs of European companies announced plans to form new antisubmarine warfare (ASW) business conglomerates. First, GEC of Britain announced the friendly acquisition of Marconi Underwater Systems to strengthen its competitive position in sonar and underwater weapons. This merger stunned many watchers, but it served as simply the opening act to an announcement by Britain's Ferranti Computer Systems that it was merging with Thomson-CSF's Sintra sonar subsidiary of France. This merger creates Europe's largest sonar manufacturer and places the new company in an excellent position to fill an expanding ASW market.

Even when looking abroad for corporate partners, not all European companies are looking West for technology support. In a bold move, Mitsubishi of Japan and Daimler-Benz of Germany have signed an agreement to cooperate in several areas. Although this venture is directed toward civilian sectors, there is little question that dual-use technologies will have clear implications for the defense sector and that these companies could be well placed to gain in the new international defense market.

There are dangers in such wide-ranging cooperative agreements, as Daimler-Benz recently found out when an old ally, General Electric, filed suit in federal district court. GE feared that, under the new cooperative agreement between Daimler-Benz and GE's US rival Pratt & Whitney, many of GE's trade secrets, shared under a previous alliance with Daimler-Benz, would be compromised. In a recent out-of-court settlement, prompted by the issuance of a restraining order, Daimler-Benz agreed to pay an unspecified amount in damages to GE and to destroy technical documents obtained during the previous joint venture.

DATAQUEST CONCLUSIONS

In Dataquest's opinion, there can be little doubt that the downward trend in European and American defense spending will continue to force defense-dependent corporations into global strategic alliances in an effort to secure future sales and protect production lines. Two schools of thought are developing among US policymakers on the trend. The first seeks to insulate US industry in order to ensure a domestic industrial base capable of fulfilling US defense contracts and competing overseas without the concern of technology flight. This school urges even tighter laws to restrict US companies from teaming up with foreign companies. The second school increasingly views cooperative defense ventures as just another inevitable part of the web locking Western governments and institutions into a stable and interdependent world order. We anticipate that this school will dominate US policy, leading to greater US government help in lessening current US restrictions on cooperative international defense, R&D, and production.

Gregory Sheppard
Barry Blechman

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Research Newsletter

RAD-HARD SEMICONDUCTORS: MARKET AND SUPPLY BASE ASSESSMENT

OVERVIEW

The demand for radiation-hardened (rad-hard) semiconductor products initially was driven by applications for space platforms, launch systems, and strategic missiles. This market is collectively known as the strategic rad-hard market. Dataquest defines rad-hard as technology that is functionally tolerant of 10^5 rads (Si) or greater for total dose. A more restrictive definition of strategic rad-hard is technology that exceeds 10^6 rads (Si).

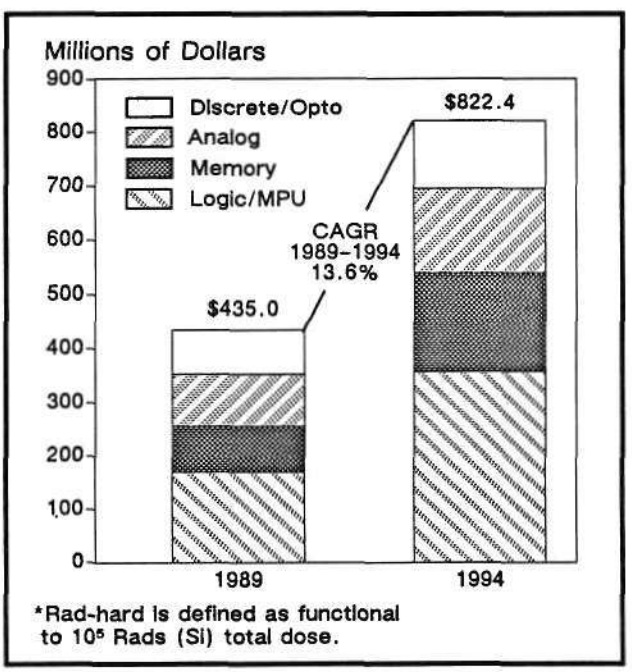
As we enter the 1990s, a new market is emerging for tactical applications such as avionics and new strategic applications such as C^3I. Tactical levels typically are defined as being between 5×10^3 and 10^5 rads. Products that are specified for these applications also are known to be rad-tolerant and typically are commercial versions of bulk substrates that have been characterized as tolerant. Future demand for products is being segmented even further by increased tolerance to dose-rate effects and single-event upset (for memories).

PRODUCT DEMAND

As shown in Figure 1, the combined North American and Western Europe demand (as specified by OEMs) for rad-hard products is estimated to have a 13.6 percent growth rate through 1994. This figure is more than double the growth rate for overall semiconductor consumption in the military/aerospace market. Growth will be driven principally by system immunity requirements moving to the chip level and the relative faster growth of space systems. The digital MOS (principally CMOS) categories should grow the most as conservatively designed space systems are upgraded with ASICs, 16- and 32-bit MPUs, large arrays of SRAMs, and nonvolatile memory products such as EEPROMs. It generally takes three to five years for new technologies to catch on with space system designers because of their conservative desire to use ultrareliable technologies. Further details on this forecast can be found in the "Radiation Tolerance" section of the MilAero database binder.

The metal-gate 4000 series CMOS standard logic family is finding continued demand in space applications, but it is slowly being displaced by ASICs and newer CMOS and BiCMOS logic families. The 16-bit MIL-STD-1750A architecture, followed by the Intel 80C86-80386 family, currently are proving to be the most widely used rad-hard microprocessor families. The 64K SRAM products

FIGURE 1
Rad-Hard Mil/Aero Semiconductor Demand*
North America and Western Europe



Source: Dataquest (June 1990)

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in bulk and SOS/SOI are the current shipment leaders, with 256K densities gaining design wins. After achieving design credibility for reliability, 64K and 256K EEPROMs have emerged as the products of choice for nonvolatile storage requirements.

Most ASIC use on spacecraft and rad-hard applications remains full custom or modified cell based. This fact is due to the uniqueness of rad-hard designs and processes for each application. Although bipolar is used heavily today, bulk CMOS and BiCMOS and CMOS-SOS/SOI are rapidly gaining acceptance among designers.

Dataquest further estimates that the demand for rad-hard semiconductors will grow faster for 1-Meg rad capability. We expect this category, which constitutes an estimated 25 percent of all rad-hard demand in 1989, to exceed 50 percent demand by 1995, assuming that BSTS and other SDI elements are constructed as well as the Freedom space station and its multinational elements. Although not captured in this analysis, Dataquest estimates that the tactical or rad-tolerant product requirements (5×10^3 to 10^5 rads (Si)) are at least equal in size to what we have defined as the rad-hard market. The tactical product area also is growing faster than the average as more tactical equipment designs employ semiconductors with at least some radiation-resistant specifications.

RAD-HARD APPLICATIONS

There probably are as many different kinds of applications of rad-hard semiconductors as there are different programs. Deep space, low earth orbit, missile electronics, and aircraft electronics all have different missions and are subject to various forms of radiation-induced problems. Table 1 lists important ongoing and emerging space programs that are candidates for using rad-hard technology.

TECHNOLOGY DEVELOPMENTS

There are as many approaches to obtaining radiation hardness as there are different companies claiming to serve the market. Aside from system level designs using techniques such as shielding, radiation hardness can be achieved by varying circuit design techniques, process modifications, and the use of special substrates such as silicon-on-sapphire (SOS) or silicon-on-insulator (SOI). In addition, many of the modern commercial processes are inherently immune to some radiation effects.

In the United States, the Strategic Defense Initiative Organization (SDIO) and the Defense Nuclear Agency are coordinating much of the research on rad-hard technology. The 1990 SDIO research plan, which is budgeted for $29 million, calls for further development of bulk, SOS, and SOI approaches to 256K and 1Mb SRAMs. Much interest is focused on evaluating single-event upset (SEU) immunity with leading-edge product offerings exceeding 10^{-10} errors/bit-day. Nonvolatile memory and data conversion IC rad-hard characteristics also are being evaluated.

The rad-hard SRAM area has become very competitive—companies such as AT&T, IBM, Harris, Honeywell, Marconi, TI, and UTMC are competing for design wins. The technologies range from bulk and SOS to SOI (SIMOX). Many of the 256K offerings have 35ns access times, even the SOS versions. Both x8 and x1 versions are in demand as space memory arrays become deeper and jump to dozens of megabytes.

The Rome Air Development Center (RADC)-sponsored RH32 program is seeking to develop a rad-hard 32-bit RISC MPU for use in SDIO applications. Honeywell and IBM are developing the Advanced Spaceborne Computer Module with $70 million contracts. This module will use RH32 MPUs. Honeywell and TRW each have $8 million contracts to develop the RH32 over the next two years. The MPU is required to operate at 20 mips after exposure, address 4GB of memory, and stay reliable for ten years in orbit.

Companies such as Analog Devices, Harris, Marconi, National Semiconductor, and Precision Monolithics are the leading suppliers of rad-hard analog products. The processes range from extra passivation processing to special dielectric isolation (DI) processes to GaAs. Rad-hard MOSFETs are gaining a reputation of reliability for space applications.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Today, much of demand for rad-hard products is transparent to the chip supplier as a myriad of third parties, government agencies, and OEMs conduct their own testing and product characterization and do not involve the supplier. In this situation, a supplier modifying the process could unknowingly destroy the special recipe for radiation-effect immunity. Dataquest believes that this method of

TABLE 1
Representative Space Programs

Program	Agency	Company
Lightsat	USAF/DARPA	TRW/Defense Systems
Pegasus	DARPA	Orbital Sciences
BSTS	SDIO	Lockheed/Grumman (study)
DSP	USAF	TRW
DMSP	USAF	GE/RCA
MILSTAR	DOD	Lockheed, TRW
Intelligence	DOD	Multiple
Shuttle-C	NASA	Rockwell
Brilliant Pebbles	SDIO	TBD
Space Station	NASA/ESA/NASDA	Multiple
NASP	NASA	TBD
Launchers	USAF/ESA/NASA	General Dynamics, McDonnell Douglas, Martin-Marietta, Ariane
Communications		GE, Hughes, Ford, Matra, MBB, Mitsubishi, Motorola
Earth Observation		International multiple
Helios	European MODs	Multiple
Hermes	ESA	Multiple
Saenger	ESA/W. Germany	MBB
Topex	CNES	Fairchild/TRW
Research	ISAS	Mitsubishi, NEC
Experimental		Israel Aircraft Industries

TBD = To be determined
Source: Dataquest (June 1990)

doing business will change, and semiconductor suppliers will become a more integral part of the design process.

The strategic and tactical rad-hard market should prove to be attractive to willing suppliers. However, there are caveats for new entrants: be prepared to adopt more defensible barriers such as guaranteed electrical specifications (e.g., Harris' RHAP), off-the-shelf marketing (e.g., UTMC's-RAD-SPEC), and available rad-hard CAD libraries. Furthermore, we believe that the burden of responsibility for rad-hard quality assurance will move from the OEM to the semiconductor supplier for these reasons. Because of the investment challenge this situation presents, we expect the rad-hard supply base to consolidate into two or three strong suppliers in each category.

Dataquest anticipates that by the mid-1990s, OEM users of rad-hard components can benefit from more uniform quality standards and product offerings from a smaller but more capable supply base.

Gregory Sheppard

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Research Newsletter

MILITARY SEMICONDUCTOR DEMAND UPDATE: SLOW WITH POCKET OPPORTUNITIES

OVERVIEW

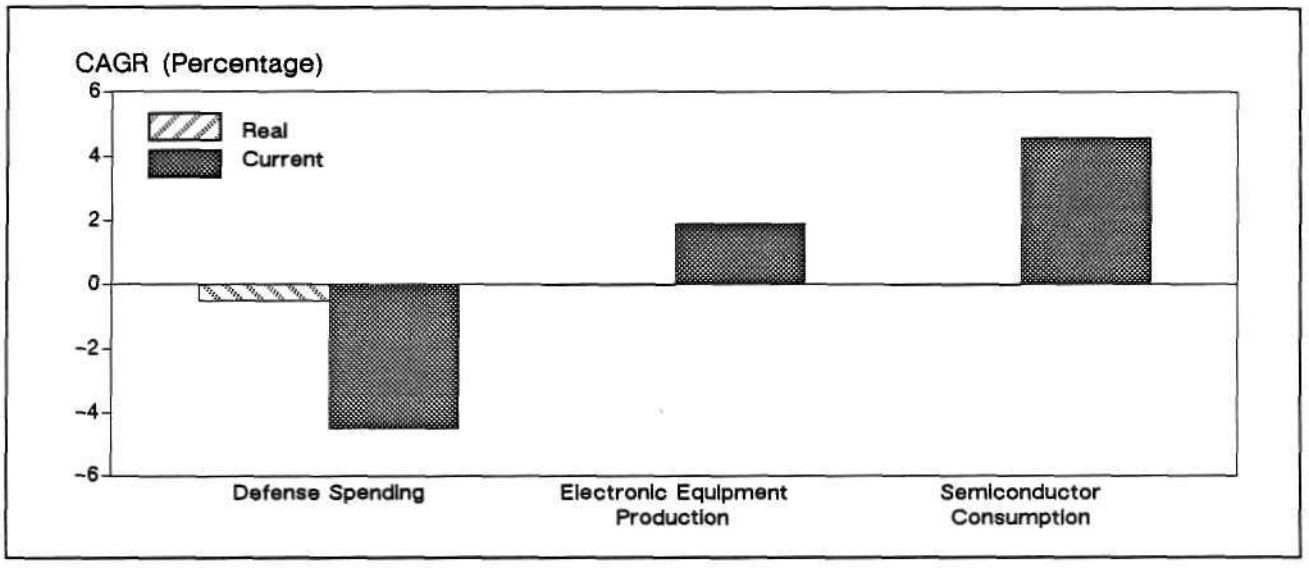
As noted in Figure 1, Dataquest expects defense spending, with inflation included, to remain fairly flat during the forecast period and with inflation factored out, to decline 4.5 percent. Within this spending environment, we expect military electronics production to continue growing at 1.9 percent, and the semiconductors consumed by that electronics segment to grow by 4.6 percent.

SPENDING ASSUMPTIONS

A disproportionate percentage of the near-term spending cuts are expected to fall on personnel and operations for the European theater. This situation is in response to the dramatic political changes in Eastern Europe. The European countries have started to propose spending cuts, averaging within the 2 to 3 percent range, and US spending cuts should be within the 5 percent range. Delay of the Conventional Forces in Europe (CFE) treaty between NATO and the Warsaw Pact is tempering the phasing of the cuts in the number of troops and electronics platforms.

Many of the emerging big-ticket electronics-intensive programs (e.g., the ATF fighter) and joint European programs (e.g., the EFA fighter) are going to be delayed from production because of the combination of national fiscal pressures and diminishing political will to field new equipment on an aggressive time schedule. Additionally, ongoing programs to support the European theater, such as the M-1 tank and the F-15 fighter, are going to be phased out of production.

FIGURE 1
Worldwide Military Electronics and Semiconductor Outlook (1989-1994)



Source: Dataquest (June 1990)

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However, to counter this downward impact on electronics demand, almost all of the existing platforms (aircraft, ships, tanks, missiles) have or will have electronics upgrade programs to prolong their usefulness. These upgrades provide a low-cost way to avoid the impact of key system component obsolescence and to increase capability while addressing the issues of improved reliability, reduced maintenance, and downtime.

SEMICONDUCTOR OUTLOOK

Dataquest's 2.8 percent growth forecast for 1990 worldwide military semiconductor consumption reflects a year of uncertainty from the OEM buyers' standpoint but one of continued basic demand as many production programs keep on churning. As depicted in Table 1, we expect overall growth to improve as the political uncertainty becomes stabilized and decisions are made about which programs to emphasize.

It is clear that digital MOS is displacing digital bipolar but not as fast as originally thought. Many of the new programs employing CMOS technology are stretching out, and many of the older programs employing the mature JAN products are being prolonged because of add-on contracts. The exception to this situation is CMOS memory ICs because they are being used in great numbers today. Growth of CMOS memory will begin to slow somewhat as this highly competitive area is affected by declining prices.

The analog category will experience slow growth this year because of historically low pricing but will gather steam as the supply base thins and new technologies such as BiCMOS and MMICs become more of a factor. MilAero subscribers can refer to the database notebook for a detailed forecast by product area and geographic area.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

In spite of all the talk about drastic defense spending cuts in an era of a warming cold war, we believe that a significant opportunity remains for semiconductor suppliers in this market. Although companies positioned in the traditional commodity products are getting some near-term reprieves in add-on-derived orders, the long term clearly will be dominated by the following:

- CMOS ASICs (FPGAs, gate arrays, cell-based)
- MPUs (16-bit MCUs, 32-bit MPUs, DSPs, communications ICs)
- Volatile and nonvolatile memories
- Precision analog
- MMICs

TABLE 1
Estimated Worldwide Military Semiconductor Consumption (Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994	CAGR 1989-1994
Total Semiconductor	2,258.3	2,284.1	2,347.4	2,425.0	2,540.7	2,690.9	2,865.5	4.6%
IC	1,778.4	1,827.4	1,888.9	1,957.3	2,058.5	2,192.0	2,348.8	5.1%
Digital Bipolar	481.0	462.1	437.7	401.8	369.2	340.2	314.0	(7.4%)
Memory	83.4	75.5	66.7	58.8	52.0	46.9	42.8	(10.8%)
Logic	397.6	386.6	371.0	343.0	317.2	293.3	271.2	(6.8%)
Digital MOS	837.7	921.6	1,006.3	1,100.4	1,213.6	1,344.6	1,490.1	10.1%
Memory	315.8	358.4	391.6	426.7	469.0	519.0	575.9	10.0%
Microcomponent	196.4	209.6	227.4	249.3	276.3	306.2	338.6	10.1%
Logic	325.5	353.6	387.3	424.4	468.4	519.4	575.7	10.2%
Analog	459.7	443.7	445.0	455.0	475.7	507.3	544.7	4.2%
Discrete	393.9	376.4	378.9	386.0	395.1	405.7	416.5	2.0%
Optoelectronic	86.0	80.3	79.6	81.7	87.1	93.2	100.2	4.5%

Source: Dataquest (June 1990)

These categories, on average, will grow at least twice the overall rate.

Although these categories might look attractive to participate in, keep in mind that this market is slow to absorb most new products in production quantities. But companies that are committed to this market in the long term and manage to synergize and economize their commercial and military operations should find this market to be attractive throughout the 1990s.

Gregory Sheppard

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Research Newsletter

REVISED FEDERAL PRICING REGULATIONS ARE READY FOR PUBLIC COMMENTS PRIOR TO ENACTMENT

SUMMARY

Proposed revisions to the Federal Acquisition Regulation (FAR), which will affect electronic equipment and semiconductor pricing procedures, have cleared the defense and civilian regulatory councils and legal review, and clearance for public comment is expected soon. The revision includes the following changes:

- A preference is made for price analysis over certified cost or pricing data for nondevelopmental items (NDI), i.e., defense products developed at private expense.
- Exemptions for new and discontinued products are available.
- A new alternate procedure, which is based on catalog pricing, permits exemptions of up to $1 million per order by self-certification as to the lowest price offered.
- The catalog exemption allows adding government sales placed under competition and by GSA schedules to units of commercial sales in determining commerciality.
- The buyer's authority to grant exemptions that do not strictly meet all criteria is raised to $1 million and, with approval, to $10 million.
- Controversial audit and price reduction clauses are added in the release for public comment.

This newsletter discusses information included in the current and revised FAR 16.804-3 and related legislation, examines the revised FAR in terms of its impact on the semiconductor industry, and presents Dataquest's conclusions and recommendations.

REVISED PRICING REGULATIONS

Preference for Nondevelopmental Items

Many commercially oriented companies do not submit certified cost or pricing data and consequently are prohibited from selling privately developed commercial and modified commercial products to the DOD and other federal agencies. Exemptions allowed under law could not be obtained by these companies because of excessive buyer demands for cost data and overly restrictive buyer interpretations of federal regulations granting exemptions. The revised regulations are intended to remove this "impediment to the maximum practicable acquisition of NDI" for defense and other federal acquisitions.

Adding Certain Government Sales to Commercial Sales

The catalog price exemption previously excluded all government sales in determining substantial sales to the general public. The revision permits government sales awarded by competition and by GSA supply schedules to count as "commercial sales at published discounts."

Granting Exemptions That Do Not Strictly Comply

The authority of buyers to grant individual and class exemptions on claims that do not strictly comply with the regulations and policy guidelines has been raised to $1 million; with supervisory concurrence, it is raised to $10 million. The buyer

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must determine, by price analysis, that the price(s) exempted is fair and reasonable and must document the findings.

Exemption for New and Discontinued Products

The current and revised regulations provide that price exemptions and fairness of prices may be determined by established prices or by prices "based on" established prices of products with "substantial sales to the general public." New and discontinued NDI often do not conform to this "commerciality" test. The revised regulations provide broad buyer discretion to grant exemption if the buyer is convinced that the price is reasonable by use of the price analysis alone.

A New Alternate Procedure

The revisions to FAR 15.804-3 provide for an "alternate procedure" up to a $1 million threshold that permits exemption for "highly commercial companies" without submission of price data.

Controversial Audit and Price Reduction Clauses

Previously, pricing data provided for catalog or market price exemptions were certified by the supplier as to accuracy of the data, that no prior claim had been denied in the past two years, and that the contractor would grant access to records for up to three years, in order to permit authorized government representatives to verify the claim. The revision attaches to catalog price claims post-award audit and price reduction provisions, such as are currently required for submissions of certified cost data. Prices based on competition or market price are expressly exempt from the added audit and price-reduction provisions.

The SF411 Burden on the Semiconductor Industry

Suppliers of military/space grade integrated circuits (ICs) have universally complained of the "SF1411 burden." Most suppliers of military/space grade ICs do not have the highly specialized cost accounting, factual data collection and disclosure, and cost-estimating systems and specialized personnel required to supply certified cost or pricing data without unacceptable risks of noncompliance and the associated severe penalties. For broad-based suppliers, the cost of such capabilities ranges in millions of dollars and serves no useful purpose for their commercial business. The significance of negotiated federal sales to such suppliers is relatively small, and the cost/benefit ratio does not favor broad-based supplier selling based on SF1411 submissions of certified cost data.

For niche and small suppliers of military/space grade versions of their product, federal business may be significant. However, the cost/benefit ratio may be even less attractive from an absolute cost point of view and may be simply prohibitive.

A large problem exists for suppliers of military/space grade ICs in that there is no practical way to comply with the cost accounting, disclosure, and cost-estimating rules of the SF1411. IC companies are organized for high volume/low unit cost production through highly automated and highly integrated operations. The SF1411 pricing method demands the capture and recording of product cost to support the cost/price proposed. In the IC manufacturing environment, the capture of the unique and significant added cost that low-volume military/space grade naturally entails is beyond the state of the art of practical cost accounting efficiency.

As learned in the aerospace industry, physically and financially segregated facilities and operations are required to achieve the cost accountability demanded by Cost Accounting Standards (CAS) and FAR 31, Cost Principles. It is ludicrous to suppose that a $500 million IC fabrication plant be dedicated to military/space production by each of the many competing companies. It is equally irrational to dedicate multimillion-dollar test facilities to such a purpose. The unit cost of military/space ICs consequently would be prohibitive beyond measure. The incredible unit cost reduction curve of military/space grade ICs is achieved by the very minimum of physical/financial segregation and is achievable by no other means. No practicable means exist for an IC manufacturer to comply with SF1411 requirements without either generating cost to account for cost or risking noncompliance and the severe penalties that follow. It is understandable why many companies choose not to risk it.

The exemptions granted to military/space grade suppliers have in the past been few and far between despite the fact that most military/space grade products, services, and processes are privately developed, qualified, and offered for sale to

many buyers, constituting a "commercial marketplace."

Too often in the past, the strict interpretation of FAR 15.804-3 has been that a military/space grade microcircuit cannot be eligible for exemption because the product is manufactured to a military, space, or federal specification. Since FAR 15.804-3 excludes "government end-use sales" from the definition of commercial products, government and industry buyers alike previously concluded that they were prohibited, by public law, from granting an exemption on a product produced to a military/space/federal specification. These strict interpretations led to the excess use of SF1411s that GAO and DOD Procurement officials, industry, and Congress complained about.

THE BASED-ON TECHNIQUE OF EXEMPTION

In fact, the existing regulations do provide for exemptions for government end-use products. These provisions are reflected in FAR 15.804-3(b)(3), 3(c)(6), and 3(c)(7), under what is known as the "based-on" technique of exemptions. The public laws and regulations state that an exemption or waiver from the SF1411 or SF1412 requirements may be granted wherein a proposed price is based on competition based on an established catalog price of a "same or similar" commercial product, or based on an established market price of a "same or similar" commercial product. The Armed Services Pricing Manual, Volume 2, affirms this interpretation of the present FAR 15.804-3. FAR 15.804-3 permits "price analysis without resort to cost analysis" to be used to determine reasonableness of the price of a military/space grade IC by comparison of prices to same or similar commercial product prices. All military/space grade products are derivatives of commercial products.

MILITARY/SPACE GRADE ICS ARE MODIFIED COMMERCIAL PRODUCTS

All products acquired by the DOD and other federal agencies are categorically "government-use products." Even food products can be rightfully called "government end-use" products versus "commercial products," within the meaning of FAR 15.804-37.

FAR 11.001 specifies that a "commercial-type product" is a commercial product. Such a modified product is defined by FAR 11.001 as a commercial product "manufactured to peculiar federal standards."

The Preference for NDI statute and the fiscal year 1990 Defense Authorization Act legislate a preference for privately developed products available in "a commercial marketplace" be used to the maximum extent practicable. Almost all military/space grade ICs are manufactured to peculiar federal requirements, are privately developed and qualified, and are made available in a commercial marketplace to hundreds of buyers that are free to choose between same or similar competing products sold at current market prices. Therefore, military/space grade ICs are commercial products.

REVISED FAR 15.804-3 EXEMPTS MODIFIED COMMERCIAL PRODUCTS

As in the prior regulations, the "based-on technique" for exempting government end-use products is preserved.

The major change is that exemptions "based-on" catalog or market prices are limited to commercial and modified commercial products. The implication is that all other government end-use products may be subject to either special SF1412 exemption by the buyer or the requirement for submission of an SF1411 prior to award.

PUBLIC LAW/REGULATIONS PROHIBIT USE OF SF1411S

The fiscal year 1990 Defense Authorization Act prohibits the requirement for certified cost or pricing data for sales that fall under the revised regulations. Only the Secretary of Defense may require an SF1411 and only after price analysis is exhausted and the Secretary determines that certified cost or pricing data are required as a last resort.

This act reverses the presumption and burden of proof under the Truth in Negotiations Act, whereby submission of certified cost or pricing data are mandatory prior to award of a negotiated contract expected to exceed $100,000, unless the offeror can sustain a burden of proof of right to exemption.

Under the revised legislation and the revised FAR 15.804-3, a claim of exemption of a commercial or modified commercial sale or a sale based on competition must be processed by price analysis.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Sellers of privately developed military/space grade semiconductors should insist on their rights to claim exemption. Buyers should avoid requests for SF1411s and rely on price analysis, as is expressly permitted under existing and revised law and regulations.

Pressing a supplier for cost or pricing data when in fact the supplier is not in position to comply, even if the seller is willing to certify, ultimately has bad consequences for both buyers and sellers.

Competitive suppliers of "same or similar" commercial and modified commercial products exist in every family of semiconductors, almost without exception. In these cases, the revised legislation and regulations wisely require the use of price analysis and prohibit cost analysis.

Greg Sheppard
Richard Kelly

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Research Newsletter

MILAERO TECH BRIEFS: APRIL 1990

This newsletter provides a useful consolidation of events, announcements, and general news in the military/aerospace semiconductor field. The following publications were used as source material for the newsletter:

- PR—Press Release
- EBN—*Electronic Buyers News*

MICRON OFFERS MILITARY VERSION 1MB DRAMS

Micron Technology has announced that it is the first supplier to receive a JAN part 2 qualification of a 1Mb DRAM. The device is available in speeds from 150 to 80ns. Available packaging is 18-pin DIP, 20-pin LCC, and flatpacks. (PR 3/90)

INTEL TO MARKET PI BUS IC

Intel will be manufacturing and marketing the PI bus interface unit IC developed by IBM. The PI bus standard is mandated on all future U.S. military avionics programs. Designed in a 1-micron CMOS ASIC library, the IC is available in a 164-pin ceramic quad flatpack. (PR 4/90)

SPT HAS 16-BIT DAC

Signal Processing Technologies (SPT), formerly the DSP group at Honeywell, has announced availability of a monolithic 16-bit DAC with 150ns settling time. The 32-pin IC is available for $55 (commercial spec) in 100-piece quantities. A military version is expected in the second quarter of 1990. (PR 2/90)

UTMC HAS STANDARD RAD-HARD PRODUCTS

United Technologies Microelectronics Center (UTMC) has announced its Rad-Spec program, which features "standardized" pricing and delivery of its line of rad-hard products. The program offers products standardized to the JAN rad-hard specs M, D, R, and H. The company's CMOS gate arrays, 1553 communication ICs, 1750A MPUs, SRAMs, and DSP ICs are included in the program. (PR 2/90)

SIEMENS HAS JAN DISPLAY

Now available for the JAN QPL is the MDL2416C Intelligent LED Display. The TTL-CMOS-compatible device joins logic and display capability on the same IC. Pricing is $70 in 1,000-piece quantities. (PR 4/90)

SGS-THOMSON ANNOUNCES U.S. MILITARY ROLE

SGS-Thomson has announced that it will consolidate various Inmos operations into its military unit based in Carrollton, Texas. In addition to the substantial SRAM capability, the company will manufacture the 32-bit Transputer RISC MPU at the facility. Plans are to produce CMOS 256K and 1Mb military DRAMs also. (EBN 4/90)

DARPA INVESTS IN GAZELLE

The Defense Advanced Research Projects Agency (DARPA), an R&D arm of the U.S. Department of Defense, announced its equity investment of $4 million in Gazelle Microcircuits. The company manufactures GaAs PLDs and communication circuits. As part of a $50 million

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investment fund, this investment is believed to be targeted at helping create a supply base for GaAs technology. (PR 4/90)

UTMC OFFERS MONOLITHIC 1553 TRANSCEIVER

Addressing the 1553 hybrid transceiver market, UTMC is offering SMD versions of the popular military standard communications interface. Single-channel DIP versions of the bipolar-based product are available for $158 in 100-piece quantities. (PR 4/90)

Gregory Sheppard

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Research Newsletter

OPPORTUNITIES REMAIN IN THE STRATEGIC DEFENSE INITIATIVE

OVERVIEW

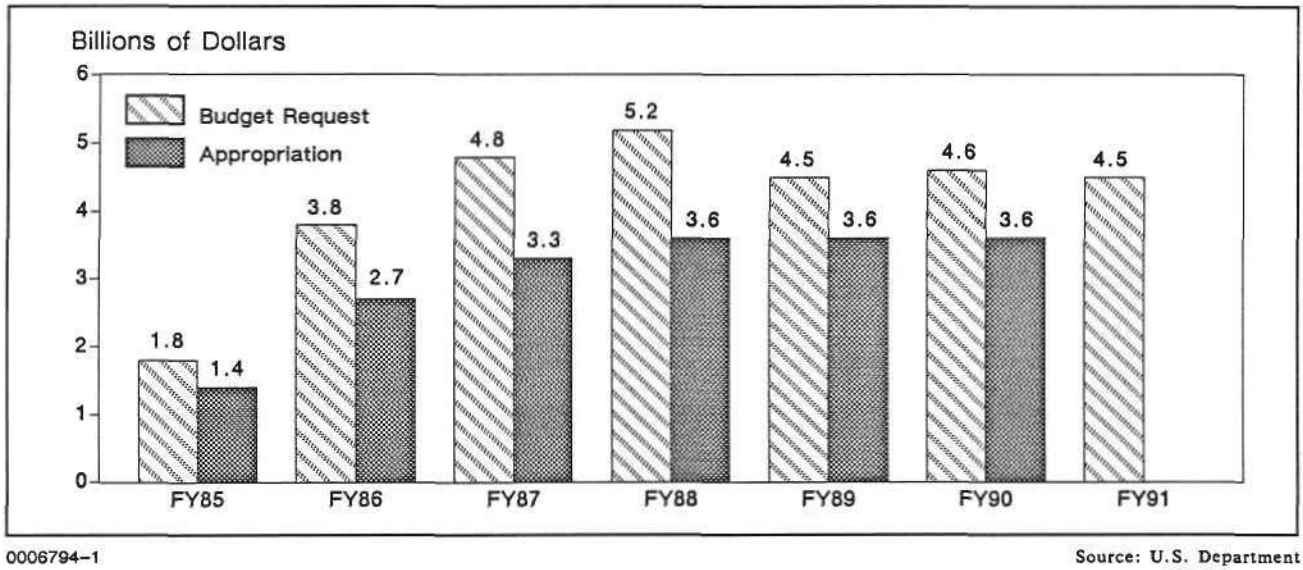
President George Bush is proving to be a stronger advocate of the Strategic Defense Initiative (SDI) than most observers had expected. Following through on campaign promises, the president's fiscal 1991 budget request would substantially increase the program's funding. Although lower by some $2.1 billion than the original request of the Strategic Defense Initiative Office (SDIO), the fiscal 1991 proposed budget is 22 percent higher than the $3.6 billion granted by Congress for fiscal 1990 (see Figure 1).

In proposing a $4.66 billion dollar budget, including funds for relevant Department of Energy programs, the president is striving to promote two tracks of the SDI program. The first track, calling for rapid development of a Phase I system including space-based weapons for a deployment decision by the end of 1992, is receiving added emphasis at the expense of the second track—research and development of follow-on systems incorporating more advanced technologies.

The biggest winners in the Bush administration's request are weapons depending on kinetic energy, such as Brilliant Pebbles; space-based sensors; and ground-based weapons that would be consistent with an overall shift in focus to an accidental-launch protection system.

Given the changing world political environment and increased domestic budgetary pressures, however, it is unlikely that Congress will go along with such an approach. Congress has cut the administration's SDI request by about $1 billion in each of the past five years (see Figure 1). This year will prove no exception, with the final appropriation unlikely to exceed $3.5 billion. Even so, some component programs—including Brilliant Pebbles and sensor technology—are likely to grow substantially.

FIGURE 1
Strategic Defense Initiative Funding



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Source: U.S. Department of Defense

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

THE OPPORTUNITIES

The Phase I Systems

In late 1986, the Reagan administration decided to work toward a deployable strategic system in the "near term." This decision led to the focusing of financial resources and technical expertise on so-called "Phase I" programs, with a deployment target set for the mid-1990s. The top participants in SDI contracts in 1989 were Boeing and Lockheed (see Table 1).

The design architecture of the Phase I system was approved by the Defense Acquisition Board in 1988. It included five main components: Boost Surveillance Tracking System (BSTS), Space Surveillance and Tracking System (SSTS), Ground-Based Surveillance and Tracking System (GSTS), Space-Based Interceptors (SBI), and Battle Management (C3/BM). Together, these systems

TABLE 1
Top SDI Contractors as of January 1990 (Millions of Dollars)

Company Standing					
1989	1990		Prime Awards	Subcontracts	Total
1	1	Boeing	1,098.9	50.4	1,149.3
2	2	Lockheed	956.9	160.1	1,117.0
4	3	TRW	553.1	240.6	793.7
3	4	Rockwell	416.7	344.6	761.3
6	5	McDonnell Douglas	683.7	54.4	738.1
5	6	Hughes	207.0	419.1	626.1
7	7	Teledyne Brown	419.9	2.4	422.3
8	8	M.I.T.	303.5	0.2	303.7
13	9	Martin Marietta	285.6	3.0	288.6
10	10	Aerojet	113.2	172.6	285.8
11	11	Grumman	215.0	33.0	248.0
9	12	Raytheon	206.7	35.5	242.2
12	13	LTV	197.2	23.6	220.8
21	14	SAI	90.3	96.6	186.9
14	15	Los Alamos	180.6	0.7	181.3
16	16	Nichols	153.2	25.4	178.6
15	17	Lawrence Livermore	169.2	0.2	169.4
25	18	BDM	121.0	10.4	131.4
18	19	GRC	127.0	0.2	127.2
20	20	AVCO	121.0	0	121.0
17	21	Colsa	120.7	0.1	120.8
19	22	Westinghouse	72.8	40.6	113.4
22	23	Ball	82.5	18.9	101.4
23	24	APL	90.5	0	90.5
24	25	Kaman	81.5	0.3	81.8

Source: U.S. Department of Defense
Dataquest
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would make up a defensive shield with only limited capabilities but which, once deployed, could be updated and expanded to incorporate more advanced technologies. The overall Phase I program has moved in spasms, as technological development in some areas has excelled, while in others it has failed to meet expectations.

This year's budget clearly shows a new direction for strategic defense, with emphasis shifting away from the space-based interceptor and toward the Livermore Laboratory's Brilliant Pebbles concept, as well as toward an accidental-launch protection system depending heavily on a small number of ground-based interceptors that would be compliant with the antiballistic missile (ABM) treaty instead of a more extensive system that would break the agreement.

Brilliant Pebbles

Pressed for a deployment decision by 1992 or 1993, the administration has asked for increased funding for the newest shining star in the Star Wars concept—the series of small, lightweight, space-based weapons known as Brilliant Pebbles. Given a 300 percent increase in funding in fiscal 1990, the program is slated to receive $329 million in fiscal 1991. This increase would be more than 250 percent compared with last year's figure of $129 million.

Each of the planned 4,600 "pebbles" would be independent, incorporating its own target acquisition sensors, rocket engines and thrusters, and warhead—all run by a superminicomputer with the power of a CRAY I, yet packaged in a system about 1 meter long and weighing less that 45 kilograms. Brilliant Pebbles would thus replace, at least through the beginning of the 21st century, the original Phase I concept of space-based interceptors deployed in clusters in battle satellites and wedded to the more complex battle management provided by a combination of SSTS, BSTS, and C3/BM systems. To reflect this shift, SDIO is requesting less than one-half the amount sought last year for the SBI program being developed by Rockwell (subcontractors include Aerodyne, Aerojet, Calspan, Honeywell, Mission Research, Space Vector, and Teledyne Brown) and Martin Marietta (subcontractors include Acurex, Ford Aerospace, General Electric, Kaman Science, Litton, LTV, McDonnell Douglas, Photon Research, and Rockwell). The two SBI contracting teams, however, are in a good position to capitalize on their knowledge in the competition for Brilliant Pebbles contracts.

Early this year, SDIO announced plans to award up to six contracts worth from $1 million to $2 million each for eight-month conceptual studies of Brilliant Pebbles. In an effort to encourage new ideas, SDIO will accept concepts that differ from the Lawrence Livermore conception, if the postulated price of the system is lower without a loss of projected capabilities. Following the completion of these studies, SDIO expects to select two contractor teams for three-year follow-on contracts. SDIO then hopes to promote dual-source full-scale production, beginning after 1992. Noting the importance of this program to the credibility of the overall SDIO program, the organization has chosen to manage the development of the system itself, rather than give the responsibility to outside contractors.

Given the political weight now behind the Brilliant Pebbles concept and the fact that its development is still in the conceptual stage, most of the fiscal 1991 request is likely to be approved by Congress. The boom will fall next year, however, when funds for the two development contracts are to be requested, unless more solid evidence of the concept's performance emerges.

Surveillance and Tracking Systems

The BSTS and SSTS programs also will go ahead in fiscal 1991, as they are desirable to provide reliable warning of missile attacks independent of the architecture of any strategic defense system. The most stable of the Phase I systems, these two programs are intended to replace the current Space Early Warning Systems and some 30 ground tracking stations. The BSTS system, being developed by Lockheed Missiles and Space and Grumman Aerospace, reportedly will be composed of up to six satellites along with three spares, each with 23 sensors. These satellites would provide an independent source of information to Brilliant Pebbles and replace TRW's Defense Support Program satellites. Using infrared technology, the BSTS would detect the exhaust plumes of hostile ballistic missiles in their boost phase. Apart from work on radiation-hardened, high-density circuits, BSTS contractors also are pursuing promising infrared detectors using focal plane arrays. To date, the most promising technologies use mercury cadmium telluride, as it is extremely sensitive and naturally radiation resistant. The administration has requested $265 million to keep this program on track.

At the midpoint of a missile's flight, the BSTS would hand off responsibility to the SSTS, composed of some 18 satellites placed approximately 1,250 miles above the Earth. Utilizing passive long-wave infrared sensors, this system would have the additional responsibility of delineating between real warheads and the decoys that are also likely to be released. The prime contractors for this system are TRW and Lockheed Missiles and Space. The fiscal 1991 budget calls for $195 million over the $60 million requested last year.

An additional radar system, known as the Ground-Based Surveillance and Tracking System (GSTS), was recommended in a study by M.I.T.'s Lincoln Laboratories to complement the space-based systems. This system is currently under development by Honeywell, McDonnell Douglas, Sparta, and TRW. The army, which is administering the program, is expected to award either Rockwell or Hughes a contract in early July to join the other companies in a $330 million program to build a demonstrator of a long-wave infrared sensor for the pop-up version of the GSTS. Only $40 million was appropriated last year, but this year SDIO has requested $150 million to pursue the program more aggressively. Although some of the technology looks promising, it is unlikely that SDIO will convince Congress to grant so large an increase.

Accidental-Launch Protection System (ALPS)

First promoted by Senator Sam Nunn nearly two years ago, the concept of deploying a ground-based system of high-velocity rockets to protect the United States from accidental or unauthorized launches of small numbers of missiles is receiving increased attention within the Defense Department. The plan originally called for the use of 100 Exoatmospheric Reentry Interceptor System (ERIS) nonnuclear missiles, the maximum allowed under the provisions of the ABM Treaty, to be produced by Lockheed and placed in Grand Forks, North Dakota. The first ERIS test flight is scheduled for this summer. These missiles would be called upon to destroy attacks consisting of up to 50 warheads, fired either by accident or from a "rogue" platform operating outside official government sanctions. With the continuing proliferation of missile programs in the third world, this program is being closely examined.

The most recent plan calls for 70 ERIS missiles to be joined by 30 High Endoatmospheric Defense Interceptor (HEDI) terminal defense missiles produced by McDonnell Douglas. The HEDI missiles are currently undergoing testing, with emphasis on their nitrogen-cooled sensors.

The ALPS has much political support, so long as it stays in development. However, it remains to be seen what will happen if procurement funding is requested, particularly if a site near Washington is chosen.

Directed-Energy Weapons (DEWs)

The big loser in the foreseeable future for strategic defense is the very system that first captured President Reagan's imagination and eventually gave birth to SDI. Known as the X-ray laser and touted as the ultimate weapon by Dr. Edward Teller, the system promised, with a single brilliant flash of a space-based nuclear weapon releasing 100,000 radioactive beams of light across the heavens, to engulf and destroy every incoming nuclear missile. That promise has proven to be infeasible, and, for the first time in the program's history, the administration is asking for less money this year than Congress appropriated last year.

Some laser programs are proceeding, however. The ground-based free electron laser, which to date has received more than $500 million with another $500 million slated over the next five years, has been a boon to both Boeing and Los Alamos National Laboratory, which last year were awarded a contract potentially worth $500 million to develop the system. Subcontractors to the Boeing/Los Alamos team include Maxwell Laboratories, Rocketdyne, Spectra, Thomson-CSF, and United Technologies Optical Systems. Another contract for the system probably will be awarded to Boeing in July.

Chemical laser programs, now mostly grouped under the direction of the Alpha chemical laser program run by TRW, also are slated for a substantial funding increase from the $117 million appropriated last year; $211 million is requested for fiscal 1991. This request will be in considerable trouble on Capitol Hill.

Another type of DEW system is neutral particle beams, which destroy their targets by penetrating deep inside to disrupt internal operations. Although the project is still in early development, preliminary tests indicate that electrical systems are highly susceptible to disruption by particle beams. This program is slated for an increase to $165 million over last year's $116 million.

National Test Bed

Reductions in SDI's prospective funding profile add importance to devices and procedures necessary for test and evaluation. Funding in this area can be expected to continue, although at a slower rate. The SDI National Test Bed, to be constructed at Falcon Air Force Base in Colorado Springs, Colorado, is the most important component. The facility will serve as the nerve center for all future testing of strategic defense systems by integrating command and control systems and other SDI test and simulation facilities. Martin-Marietta Information and Communications Systems was awarded a five-year $569 million contract in 1988 to design, install, and operate the National Test Bed facility. The SDIO has requested $140 million for fiscal 1990 against last year's appropriation of $125 million.

The test bed will allow testing and evaluation of strategic defense concepts, architectures, and hardware through simulations. In short, the facility will allow system-wide testing before construction—a potential cost saver that is supported by many on Capitol Hill. Cray supercomputers will generate the simulations.

ALLIED PARTICIPATION

SDIO's original program push to garner non-U.S. partners will continue to taper off. There was much excitement in the European defense industry when SDI contracts were first opened to non-U.S. companies in 1985. Since that time, however, little more than 200 contracts have been awarded overseas, amounting to just $375 million.

Foreign companies have found the cumbersome Pentagon procurement process too difficult to penetrate. In addition, support for international industrial cooperation in the SDI is not strong on Capitol Hill, as members continue to be vocal about their demand that allied governments share in the costs of the program and not simply its benefits.

Nearly $185 million, or roughly one-half of all allied contracts, has gone to Israel. Although Israel has received 16 contracts overall, the bulk of the money has been for the Israeli Aircraft Industries' Arrow Missile Defense Program, which is continuing.

Although a handful of contracts will be let through SDIO's Multinational Programs Directorate, most foreign companies will continue to find U.S. requirements and restrictions too forbidding to commit large resources. Likewise, as pressure to reduce programs increases, foreign companies will be very likely targets for cuts.

OUTLOOK AND DATAQUEST CONCLUSIONS

Dataquest believes that the SDI program will continue to receive a level of funding that will allow pursuit of most of its research and development programs. Congress is less likely to appropriate the full amounts requested for those systems nearing deployment decisions in an effort to postpone the political debate that would most assuredly accompany such a decision. The issue will not really be drawn for two years, however, thereby delaying until then any large-scale orders for production electronics and semiconductors.

Domestic budgetary pressure combined with the developments in Eastern Europe will most likely bring the overall program down below $3.5 billion in fiscal 1991. We expect the biggest cuts to be suffered by DEW programs, SDIO operational expenses, and programs in the Systems Analysis & Battle Management Program.

Major contractors, however, especially those that have diversified through subcontracts—particularly Boeing, Lockheed, and Martin Marietta—will continue to benefit from the SDI program. Additional winners will be those companies associated with systems designed to protect against accidental launch—particularly Lockheed and McDonnell Douglas. ALPS could very likely become the highest-priority SDI element for deployment in this century.

Gregory Sheppard

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Research Newsletter

BUSINESS OPPORTUNITIES IN JAPANESE AEROSPACE

INTRODUCTION

On April 3, 1990, U.S. and Japanese government trade negotiators announced the signing of an accord, which could create opportunities for U.S. and other nations' aerospace firms to bid on Japanese satellite projects. The satellites affected by this accord include Japanese government projects, CS-4, communications, and weather satellites, which previously had been barred from non-Japanese bidding. The satellite agreement follows similar accords for expanding sales of American-made telecommunications equipment in the Japanese market and removing restrictions on the sales of U.S.-made supercomputers to Japanese universities and other government sectors.

This newsletter discusses government and private-sector satellite projects in Japan. The new opportunities this accord creates for semiconductor manufacturers are presented. Information about what organizations to contact concerning these and other aerospace opportunities also is provide herein.

JAPANESE SATELLITE PROJECTS

Background

The Japanese aerospace agencies consist of two major companies: Institute of Space and Astronautical Science (ISAS) and the National Space Development Agency (NASDA), which develops all Japan's commercial satellites and launch vehicles. Government funding for the overall Japanese space program was $1.1 billion (¥140 billion) in 1988 and is projected to grow to $2.4 billion (¥300 billion) by 1999. These agencies have been responsible for launching an average of one satellite per year since 1970 and have plans to increase the number of launches to four annually.

Using the only available comparison statistics, which date back to 1986, the Japanese space budget was ¥117 billion ($700.6 million), compared with the U.S. space budget of ¥1,192 billion ($7,137.7 million). Table 1 lists the Japanese historical satellite launches, as well as scheduled future launches.

As a precursor to the new U.S. and Japanese accord, the Japanese negotiating delegation announced in late March that the Japanese government would scrap its plans to develop the highly controversial CS-4 satellite. The United States had claimed that the CS-4 satellite could not be totally a research and development (R&D) effort, as the Japanese claimed, because Nippon Telegraph and Telephone (NTT) was funding 75 percent of the development costs. The United States claimed that this huge investment by NTT qualified the CS-4 to be classified as a commercial, not a research, effort.

The CS-4 now will be broken out into two separate projects. The first will be a completely research-oriented satellite, the Experimental Data Relay Tracking Satellite (EDRTS), which will be wholly funded by NASDA. The earliest the EDRTS is expected to be launched is 1995 at an estimated cost of ¥65 billion ($406 million). The major leading Japanese satellite developers (Mitsubishi Electric, NEC, and Toshiba) are expected to continue their involvement in this project.

The second project will be a commercial communications satellite, which will be open to international competition such as the United States' Hughes Aircraft, General Electric, and Ford Aerospace. Because of the pressure, NTT, the original financial supporter, could pull out of this portion of the CS-4 project. If NTT does pull out, the door would open up even wider for foreign bids.

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TABLE 1
Japanese Satellites Launched

Satellite	Launch	Main Contractor	Comments
		Historical Launches	
GMS	Jul. 1977	NEC	N/A
CS	Dec. 1977	Mitsubishi	N/A
BS	Apr. 1978	Toshiba	N/A
GMS-2	Aug. 1981	NEC	N/A
CS-2	Feb. 1983	Mitsubishi	N/A
BS-2	Jan. 1984	Toshiba	N/A
GMS-3	Aug. 1984	NEC	N/A
CS-3	Feb. 1988	Mitsubishi	N/A
GMS-4	Nov. 1989	NEC	N/A
Muses-A	Jan. 1990	ISAS	Moon Probe
		Future Launches	
Geotail	1991	N/A	Geophysical research
Solar-A	1991	ISAS-sponsored	Solar observer
BS-3B	1991	NEC/GE	Sister to BS-3A
ERS-1	1991	NEC/Mitsubishi	Aperture radar
HESP-1	1992	ISAS-sponsored	Solar physics
ETS-6	1992	Mitsubishi	Engineering test, H-2
H-2	1993	N/A	Space flyer unit
Astro-D	1993	ISAS	X-ray observer, M-3S-2
GMS-5	1994	NEC/Hughes	H-2, weather satellite
ADEOS	1994	N/A	Earth observation
BS-3a	Mid-1990	NEC/GE	Color TV—3 channels
H-2	Mid-1990	N/A	Venus probe
JEM	Mid-1990	NASDA	Space station module
H-2	Mid-1990	Mitsubishi	Hope, spaceplane

N/A = Not Available
CS = Communications satellite
BS = Broadcasting satellite
GMS = Geostationary metrological satellite

Source: Japan Science and Technology Agency, 1988 Statistics
Dataquest
April 1990

What It Means for Semiconductor Companies

Dataquest estimates that each satellite contains $40 million worth of electronic equipment and each launch system contains $12 million. Of this figure, 3.8 percent of both the satellite contents and launch equipment are semiconductors. Each launch will require a little less than $2 million worth of semiconductors, bringing the cost of the expected four Japanese launches a year almost up to $8 million. This figure, of course, does not include the ground equipment required to monitor all satellite activities.

Semiconductor suppliers with contracts and/or close relationships with U.S. or European aerospace companies that are already well aligned with Japanese firms active in the commercial satellite business clearly are in a key position for additional sales opportunities. Firms that specialize

in radiation-hardened (rad-hard) semiconductor technologies would have a particularly strong advantage with aerospace firms. The top 10 semiconductor suppliers to the military (including aerospace) are listed in Table 2. Dataquest estimates that the military/aerospace worldwide semiconductor market in 1989 was $2,268 million.

Companies to Contact

The semiconductor suppliers in Table 2 clearly are in an advantageous position. But with the opportunity to supply semiconductors to the newly opened Japanese satellite market, suppliers need to know the appropriate party to contact in order to make their efforts worthwhile. Dataquest recommends that companies interested in following up on this subject contact any of the following organizations:

- American Electronics Association, Santa Clara, California
- British Aerospace, London, England
- Department of Commerce, Aerospace Policy and Analysis, Washington, D.C.
- Electronic Industry Association, Tokyo, Japan
- European Space Agency, Paris, France
- International Semiconductor Cooperation Center (INSEC), Tokyo, Japan
- Japan External Trade Organization, New York, New York, and Tokyo, Japan
- Matra Espace, Paris, France
- Semiconductor Industry Association, Cupertino, California

TABLE 2
Top 10 Semiconductor Suppliers Worldwide Military/Aerospace Applications

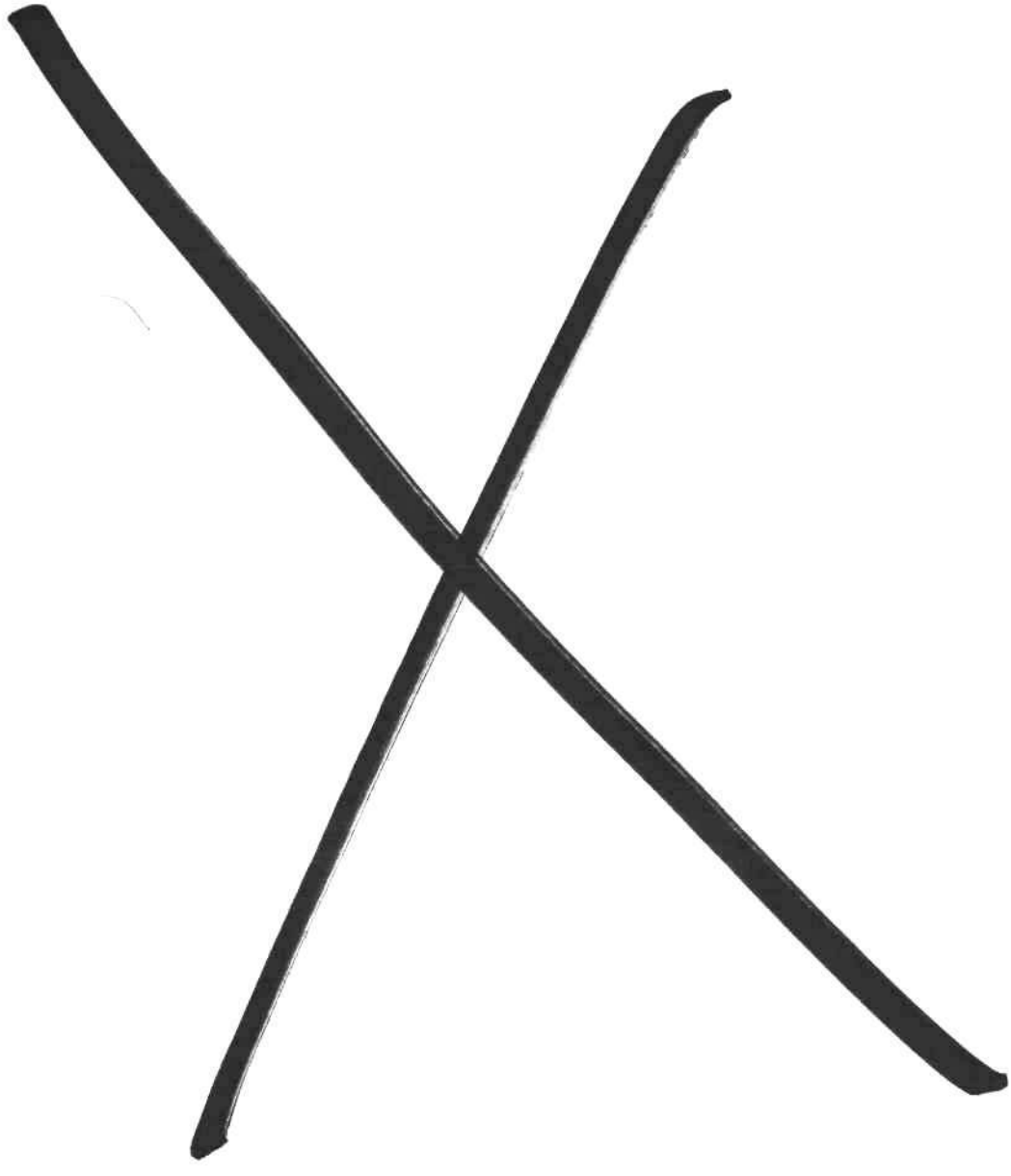
Rank	Company
1	Harris
2	Texas Instruments
3	Motorola
4	National Semiconductor
5	Advanced Micro Devices
6	LSI Logic
7	SGS-Thomson
8	Philips
9	Intel
10	Mitsubishi

Source: Dataquest
April 1990

DATAQUEST CONCLUSIONS

Dataquest believes that more accords involving the satellite market will be made, especially because the deadline for these talks is June 19, 1990. Another approaching deadline is that of the U.S.-Japan Semiconductor Trade Arrangement, which is scheduled to expire in July 1991. The U.S. government may propose a renewal to the five-year trade agreement because of pressure from semiconductor manufacturers that want either to renegotiate to bring the market share level up to the 20 percent goal or designate Japan as an unfair trader. (Dataquest estimates that the United States had 9.7 percent of the Japanese market in 1988.) Japanese officials, however, have responded through a trade journal that they would reject a renewal proposal.

Greg Sheppard
Ione Ishii



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Research Newsletter

ASICs: TECHNOLOGY OF CHOICE FOR MIL/AERO USERS

SUMMARY

ASICs are solidifying their position as a technology of choice for future defense and aerospace needs. With upgrade/update programs driving near-term usage, Dataquest expects ASICs to be the fastest-growing general semiconductor category for mil/aero applications as the worldwide market reaches an estimated $927 million by 1994. The design start activity is expected to level as the market absorbs the current designs and average design complexities climb toward subsystem levels. Nonrecurring engineering (NRE) constitutes an estimated 35 percent of the gate array and cell-based IC markets. The principal issues for users will be supply base management, design tool and library investment, and testability.

MARKET OVERVIEW

As shown in Figure 1, CMOS gate arrays represent the largest segment of ASIC usage. This segment's size is a result of the proliferation of design tools from companies such as LSI Logic early in the defense build-up period during the mid-1980s. Because of the long lives of most military and aerospace programs, we expect CMOS gate arrays to remain the largest segment throughout the early 1990s. Principal gate array usage to date has been dominated by system upgrades for functionality or reliability and for avoiding the impact of sunset standard logic families.

Cell-based ICs are growing in popularity and their use for mil/aero applications is expected to rival that of gate arrays by the mid-1990s. Cell-based technology is being used increasingly to displace what was once the domain of full-custom ICs, as users can construct signal-processing and embedded-control ICs to fit specific program needs. SCS is a leading provider of compilation tools for mil/aero use cell development, partly because of its participation in the VHSIC program. Harris and VLSI Technology are leading providers of cell products. Cells are popular because they allow the optimized mixing of various semiconductor functions such as control, memory, and data conversion on the same IC, and each cell is separately characterized for military and space specifications.

Dataquest expects mixed analog and digital technologies to have greater market presence as design tools and mixed-signal testers become more mature and user friendly. Companies such as Harris, National Semiconductor, and Plessey lead a list of firms offering mixed-signal manufacturing and design support. For high-performance applications in computing and bit manipulation, GaAs and ECL technology will have substantial design preference. Joining the ECL suppliers that include AMCC, Motorola, and National are GigaBit Logic and Vitesse, which have GaAs technology. BiCMOS is expected to address the situations in which density, power, and performance are simultaneously critical. AMCC, LSI Logic, National, and Texas Instruments are part of a growing list of military-specific BiCMOS ASIC firms.

Market Drivers

Figure 2 illustrates the total logic gate content in average configurations of sample mil/aero systems. These systems range from portable satellite communication sets to surface ships and submarines with their extensive C^3I and sensor systems.

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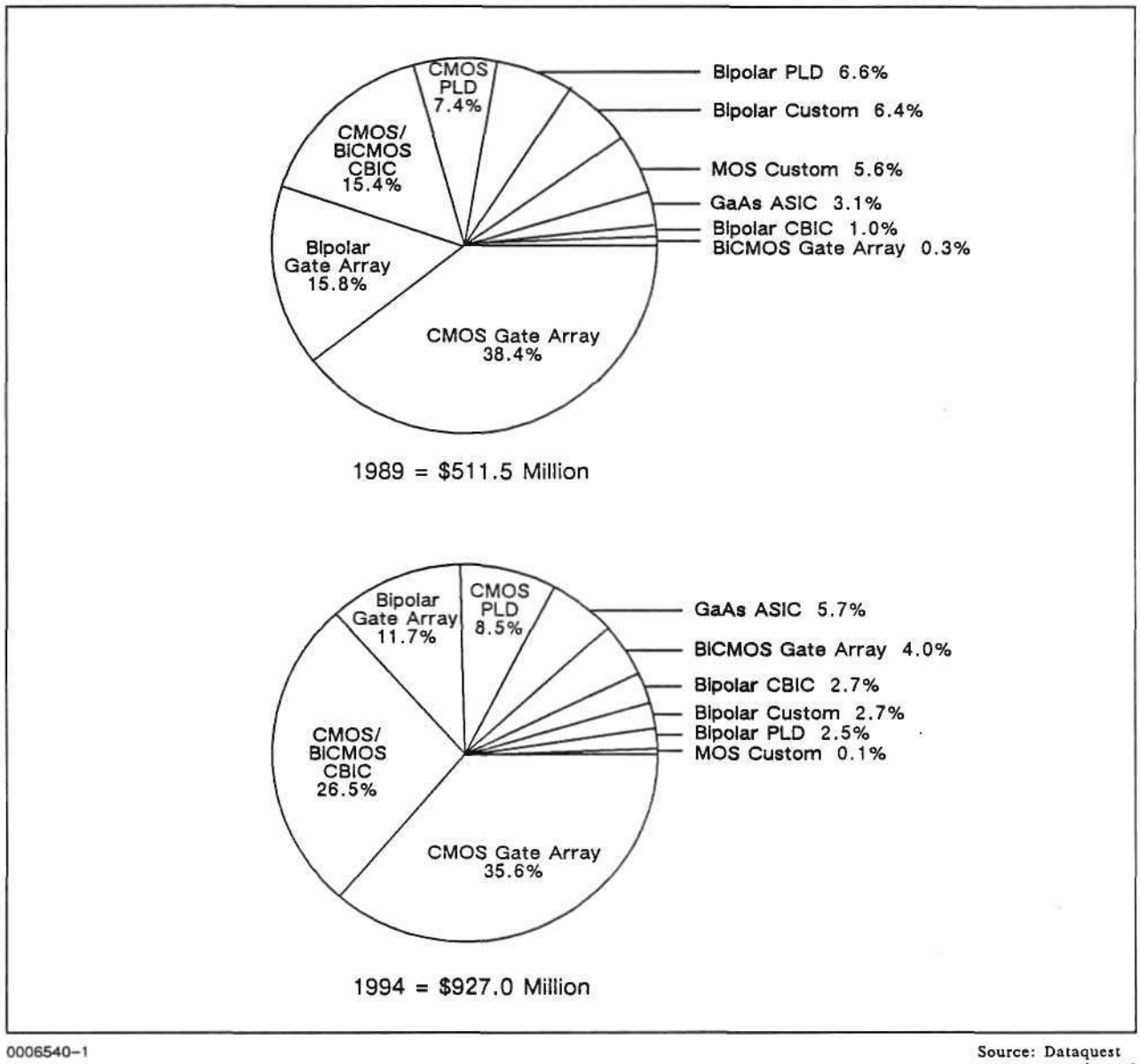
FIGURE 1
Mil/Aero ASIC Market



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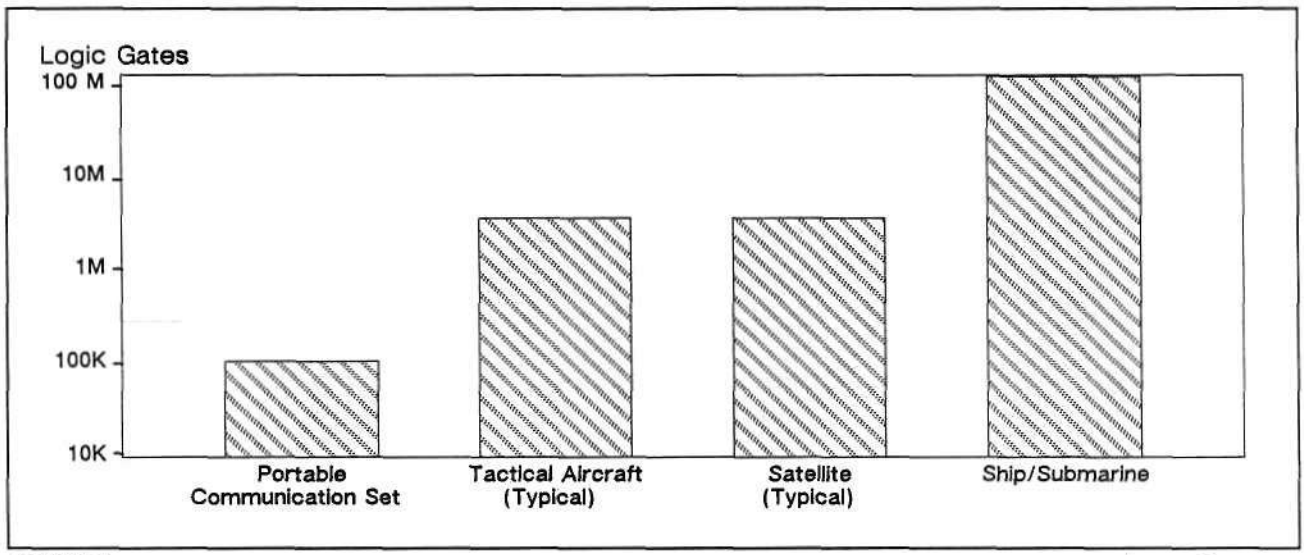
Source: Dataquest
March 1990

FIGURE 2
Mil/Aero Logic Usage



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Source: Dataquest March 1990

ASICs' use in mil/aero systems is accelerating for several reasons including the following:

- IC replacement for reliability and maintainability (R&M) including reduction of total board space and lead count, power-consumption reduction, implementation with surface-mount components, and improved testability
- Replacement of standard logic or linear devices to avoid obsolescence
- Improved functionality or the addition of extra capabilities such as programmability and higher frequencies
- Relatively easy prototype development with PLD/FPGAs
- Alignment of design documentation with ASICs that have new mandatory documentation standards such as VHDL and the Computer-Aided Logistics System (CALS)
- Use for the wide range of new start, recomputed, or major redesign programs
- The general match between a highly customized need (each program having distinct requirements) and a customized but economic technology solution

As gate densities approach subsystem levels and core functions and linear elements become available, ASICs are increasingly being used in signal processing, functional applications such as communication ICs, and embedded control applications.

Key Programs

Table 1 lists examples of ASIC use in mil/aero applications along with sample programs.

ASIC TECHNOLOGY TRENDS

Process

The key trends in ASIC process technology continue to be the diminishing feature sizes; the evolving triple and quadruple metal layering; the emergence of BiCMOS, high-density ECL, and GaAs; and, for military applications, the refinement of specialized high-temperature and radiation-hardened (rad-hard) processes. The mixing of array and cell technology on the same IC is being introduced by several companies. The employment of direct-write e-beam technology for quick-turn prototype and small production runs is proving to be an acceptable alternative for the mil/aero market. The service offered by ES^2/US^2 exemplifies this approach.

TABLE 1
ASIC-Intensive Programs

Equipment Type	Sample Programs	Companies
General Purpose Computer	UYK, nondevelopmental	Unisys, CDC, Raytheon
Aircraft Computers	Common modules	Unisys, Texas Instruments, Thomson, Hughes
Space Computing	Modules, SDI, launchers	Honeywell, IBM, Matra
Communication Transceivers	SINCGARS, MSE, GPS	GTE, Thomson, General Dynamics, Rockwell, GEC
Warning Receivers	ALQ, AAR series	Loral, Litton
Electronic Countermeasures	ALQ, decoys	Sanders, Raytheon, Westinghouse
Weapon Guidance and Control	AAWS, smart munitions	Hughes, Raytheon, Thomson
Electro-Optic	Vision, targeting, EW	Texas Instruments, Martin Marietta
Unmanned Vehicles	Air and underwater	McDonnell Douglas, IAI
Radar	ATA, ATF, EFA	Westinghouse, Hughes, Texas Instruments, GEC
Sonar	New subs., antisubs.	GE, IBM, Sintra, Magnavox
Simulators	Aircraft, ship	CAE, GE, Hughes, Thomson
Logic Emulation	MTSP	Honeywell, Hughes

Source: Dataquest
March 1990

New process CMOS technologies for the 1990s typically have feature sizes of 0.8 micron with total densities exceeding 200,000 gates. New BiCMOS processes are capable of exceeding 100,000 gates with 400ps gate delays and have the flexibility of ECL or TTL I/O levels. ECL processes have announced capabilities of 100,000 gates and 50ps gate delays but are currently produced with 30,000 gates and 150ps capabilities. GaAs densities are exceeding 15,000 and 70ps delays using 1.0-micron E/D MESFET technology. The capability exists to scale GaAs processes down to 0.25 micron and achieve 50,000 gate densities.

A state-of-the-art analog or mixed-signal process is characterized by additional features such as, but not limited to, the f_t of the transistors, bandwidth of the op amps, resolution of the data converters, and power-handling capabilities. The transistor f_t ranges from greater than 100 GHz for experimental GaAs to 6.5 GHz for bipolar. Op amp bandwidths up to several hundred MHz are possible, as are 12-bit data converters. Several 40-volt capabilities are possible for power-handling functions.

Computer-Aided Design (CAD)

The independent leading companies in overall electronic design automation are Cadence and Mentor Graphics followed by Daisy/Cadnetix and Valid Logic Systems. The most notable trend for these companies is embodied in the success Cadence has attained by marketing its Framework product. Portable to industry standard workstations, the Framework product provides value with a common, integrated user interface and database shared by many application tools. The Framework definition has a chance to become an industry software interface standard.

Perhaps the major stumbling block to date for CAD is analog and mixed-mode simulation and layout. In addition to the CAD firms mentioned, EEsof, Intergraph, and View Logic are notable suppliers of mixed-mode tools. Analog simulation generally is achieved with a variety of the SPICE simulation language. However, once a few hundred transistors are exceeded in the design, the SPICE simulation becomes very compute intensive, and accelerators and even high-speed computers are needed.

The problem with mixed-mode simulation has been that the analog and digital portions are typically done separately and then "glued" together. The Analogy Saber and SCS Lsim products are both examples of simulators that handle feedback between the digital and analog portions of a design. Because layout and routing of analog and mixed-signal ASICs remains a semi-automated process, most ASIC vendors in this technology provide this service. Standard automation of the physical design still appears to be a few years away.

Programmable Logic and FPGAs

A new entrant into the ASIC arena is the field-programmable gate array (FPGA), which Dataquest tracks as a subsegment of programmable logic devices (PLDs). Dataquest estimates that FPGAs will account for 30 percent of all mil/aero CMOS PLD usage by 1994. Mil/aero users are finding that CMOS FPGAs offer the general advantages of PLDs with low NRE charges and fast-turn prototypes but in the the 3,000 to 9,000 density range. Actel and Xilinx and their partners are the principal suppliers of military temperature FPGAs.

Bipolar PLDs are still in demand in the programs in which they are entrenched but have been under severe price pressure. Traditional bipolar suppliers such as AMD and Texas Instruments are joining firms such as Altera and Cypress in the 22V10, EPLD, and EEPLD market.

Technology trends in PLDs include the emergence of high-speed ECL and GaAs versions capable of 3ns propagation delays and the introduction of high-density 5,000 to 9,000 CMOS FPGAs. Leading-edge TTL technology is at 5ns delays (7.5ns for 22V10 versions).

Libraries

As new systems require more high-performance, embedded-control, and digital signal processing features, we expect MPU/MCU core-anchored libraries to find increasing popularity. The ability to customize and to reduce space and pin count will be highly desirable in military and aerospace designs, and core-based designs are well suited to that purpose. New designs will be using MPU cores such as MIL-STD-1750A, 68000, and 80C51, and peripherals such as MIL-STD-1553B.

Mil/aero system designers are enjoying using DSP ASIC building block libraries of multipliers, multiplier/accumulators, and other functions to implement signal-processing solutions. Analog cells are finding their way onto more designs in such forms as data conversion and filters. SCS' GENESIL compiler design system is very popular in the military ASIC community, partly because of its participation in the VHSIC program.

We expect continued new library development for rad-hard features. Because of special design, layout, and even different process considerations, rad-hard libraries are often built separately. SCS' GDT system has been used to develop rad-hard designs.

Testability

During 1989, much interest was generated by the proposed IEEE 1149.1 (IC-level boundary scan) and IEEE 1149.X (backplane) testability standards. The 1149.1 (JTAG) standard is based principally on elements of both the European-developed Joint Test Action Group (JTAG) and the VHSIC ETM standards. The principal motivation for 1149.1 was to develop a way to do detail board-level testing without using board-of-nails testing, a process that is very complex to accomplish with new high-density, surface-mount packaging.

Implementing 1149.1 involves placing a boundary scan circuitry on each IC on a given board and adding four control pins. Testing on the board of nails will be governed by a separate controller IC. Implementing 1149.1 adds additional die area and pin count to each IC, depending on the circuit size and design partitioning. The advantage of using 1149.1 is the overall cost saving by allowing thorough board testing and early detection of defective components and manufacturing errors.

Texas Instruments has introduced its SCOPE design library, which incorporates 1149.1 features. LSI Logic and VLSI Technology also have announced support for 1149.1 in their libraries.

Testers

ASIC device testers can cost from $500,000 to $2 million. State-of-the-art test rates are as much as 200 MHz (Tektronix), but the average rate is approximately 80 MHz. Test accuracy can reach 250ps; however, average accuracy is around 800ps. These figures leave many of the BiCMOS, ECL, and GaAs ASICs untestable. Many testers can handle up to 512 pins if other features are traded off.

Eagle, LTX, Schlumberger, STS, and Teradyne have mixed-signal testers for addressing that particular technology.

Packaging

The principal developments in ASIC packaging involve surface mounting and increasing density, reliability, speeds, and power-handling capabilities.

Partly due to the reliability thermal mismatch problem between leadless ceramic chip carriers (LCCCs) and the printed circuit board, ceramic quad flatpacks are emerging as the ASIC package of choice along with PGAs in the greater-than-68-pin range. TAB technology for improved bond reliability is also winning favor in the mil/aero marketplace.

Rad Hard

Dataquest expects rad-hard applications to grow substantially as a percentage of overall demand. We estimate that as many as 40 percent of all design starts have some implicit or explicit rad-tolerance specification. We further expect the bulk of the growth to be for products with specifications between 10^3 and 10^4 rads, and for specifications greater than 10^6 rads. Demand for space or single-event upset (SEU) sensitive applications will be driven by the proliferation of NASA, ESA, and military C^3I programs, which are flourishing in spite of defense spending cutbacks. Leading rad-hard ASIC suppliers include Harris, Marconi, and LSI Logic.

Impact of QML

The implementation of the qualified manufacturers' list (QML) per MIL-I-38535, now in beta site development, should help lower barriers for introducing new ASIC technology. It should help standardize communication among vendors, users, and government supervisors concerning new technology and ongoing quality and reliability issues associated with semicustom designs. For ASICs, the QML approach is expected to accelerate expanded use of ASICs into other applications.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

For semiconductor marketers, ASICs are a significant bastion of growth in a tough military/aerospace market. The market is likely to be driven in the short term by upgrading and the fear of obsolescence. In the long term, complex systems on a chip incorporating familiar core architectures, peripherals, and signal-processing features should drive the market. Dataquest expects new design start activity to flatten as the number of new programs decline and average design complexity surges. ASIC companies need to continue investing in design libraries and tools such as mixed-signal and digital signal processing that lend themselves to mil/aero uses.

The implications for ASIC users are centered on technology and supply-base management. Dataquest makes the following recommendations for semiconductor users:

- Keep the number of vendor design systems to a minimum, but greater than one per technology
- Centrally coordinate overall design libraries to avoid duplication and to deepen relationships with deserving suppliers
- Continually monitor user acceptance of developments in mixed-signal tool availability and testing capability
- Consider a move to ASICs early to avoid a worsening obsolescence problem with many of the traditional standard logic families

Gregory Sheppard

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Research Newsletter

GLOBAL REGIONAL PRICING STRATEGY BRINGS KEY ADVANTAGES TO SEMICONDUCTOR USERS AND SUPPLIERS

At Dataquest's Semiconductor Users and Applications Group conference (held in San Francisco, California, on February 12 and 13), the authors of this newsletter spoke on strategic and tactical IC pricing trends. This newsletter highlights Dataquest's key strategic recommendations, with special emphasis on the advantages of a global regional pricing strategy. For example, Dataquest expects the 4:1 unit/price crossover from the 1Mbx1 DRAM to the 4Mbx1 device (100ns versions) to occur in North America during the first quarter of 1991. For DRAM users and suppliers, a global regional strategy emphasizes insight into the factors—including government mandates—that will affect the timing of this critical crossover in different world regions.

STRATEGIC RECOMMENDATIONS

Dataquest analysts made the following five pricing strategy recommendations during the conference:

- Semiconductor users and suppliers must learn to *jointly manage* higher IC prices for enhanced system value.
- Users, *in alliance* with suppliers, must manage competitiveness despite single-sourced IC products.
- Users should develop component pricing and procurement strategies based on *system cost* impact analysis.
- Suppliers and users must manage world *regional pricing differentials*.
- Suppliers and users should *stay close* to each others' manufacturing activities and production plans.

This newsletter shows how management of global regional price trends helps suppliers and users control rising IC prices.

RISING IC PRICES?

Figure 1 shows a surprising component price trend: the weighted average IC price has increased since the mid-1980s and Dataquest predicts that it will climb even higher in the 1990s.

What is the fundamental reason for higher average IC prices? The integration of functions, or system capability, onto the average IC has been happening so rapidly that the IC system integration process has slowed IC unit shipment growth relative to dollar growth.

The trend of rising IC prices underscores the first strategic recommendation: users and suppliers must learn to jointly manage IC supply, demand, and pricing in order to increase system value, especially as users employ more single-sourced ICs in systems. With many aspects of semiconductor technology really becoming systems-on-a-chip, both OEMs and semiconductor suppliers need to approach pricing on a system value basis. This strategy rings most true for products such as ASICs, 32-bit microprocessors, and application-specific standard products (ASSPs), in which price comparisons often are not possible because of the uniqueness or single-source nature of the product.

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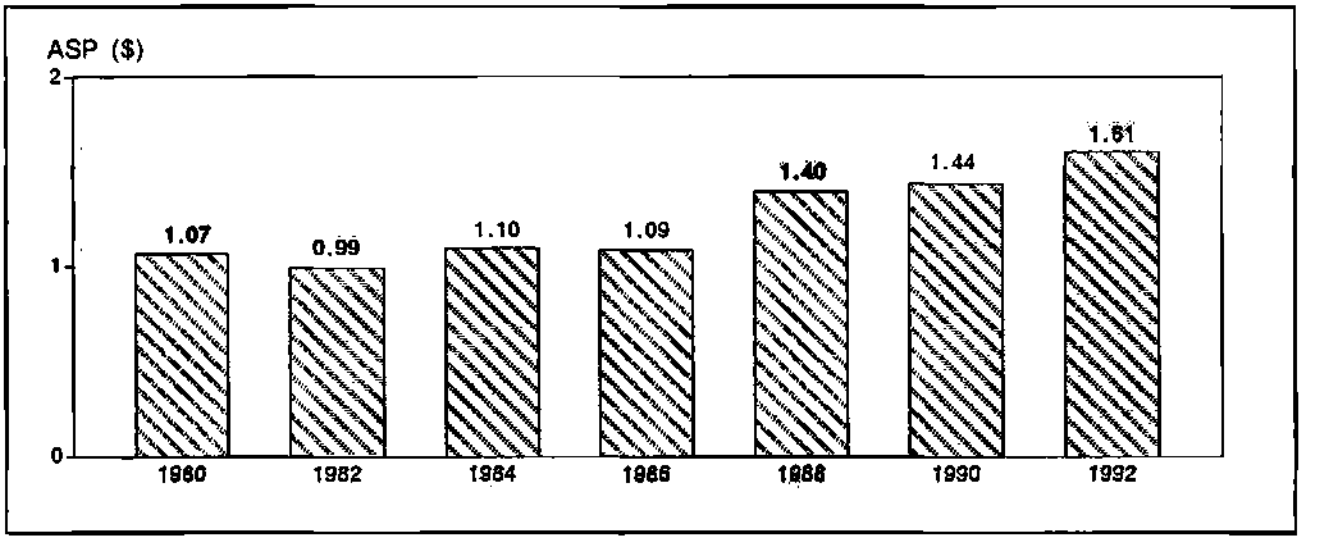
FIGURE 1
Overall Average
IC Selling Price Is Up



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Source: Dataquest
March 1990

GLOBAL REGIONAL SOURCING AND SUPPLY STRATEGIES

The challenge of managing higher IC prices connects directly with the next element of the pricing equation—strategic management of *global regional trends* in IC prices. For example, suppliers must manage world regional pricing differences in order to assess and respond to their competitive strengths and weaknesses in the world regions. Users must learn to manage a search for world regional differences in IC pricing that can mean significantly lower total system costs and higher system profit margins.

WORLD REGIONAL PRICE TRENDS

Figure 2 uses information from the on-line *DQ Monday* service to illustrate world regional price differences as of February 12, 1990, for three critical products: the 1Mbx1 DRAM 100ns, the 32Kx8 SRAM 100ns, and the 16-MHz 80386SX. The U.S. price serves as the base, and Figure 2 shows the pricing difference—the percentage greater or less than the U.S. base price. The product mix includes two multisourced devices (DRAMs and SRAMs) and a sole-sourced part (the 80386SX). Pricing in Europe and South Korea has moved sharply since the mid-February conference, which reinforces the need for users and suppliers to monitor global regional trends constantly.

Figure 2 shows that as of February 12, users that source the 1Mbx1 DRAM in Japan pay 12 percent *more* than users that source in the United States. By contrast, buyers of the 32Kx8 slow SRAM pay 13 percent *less* in Japan than in the United States. Users that procure the 80386SX microprocessor in Japan pay almost 20 percent more than buyers that source in the United States.

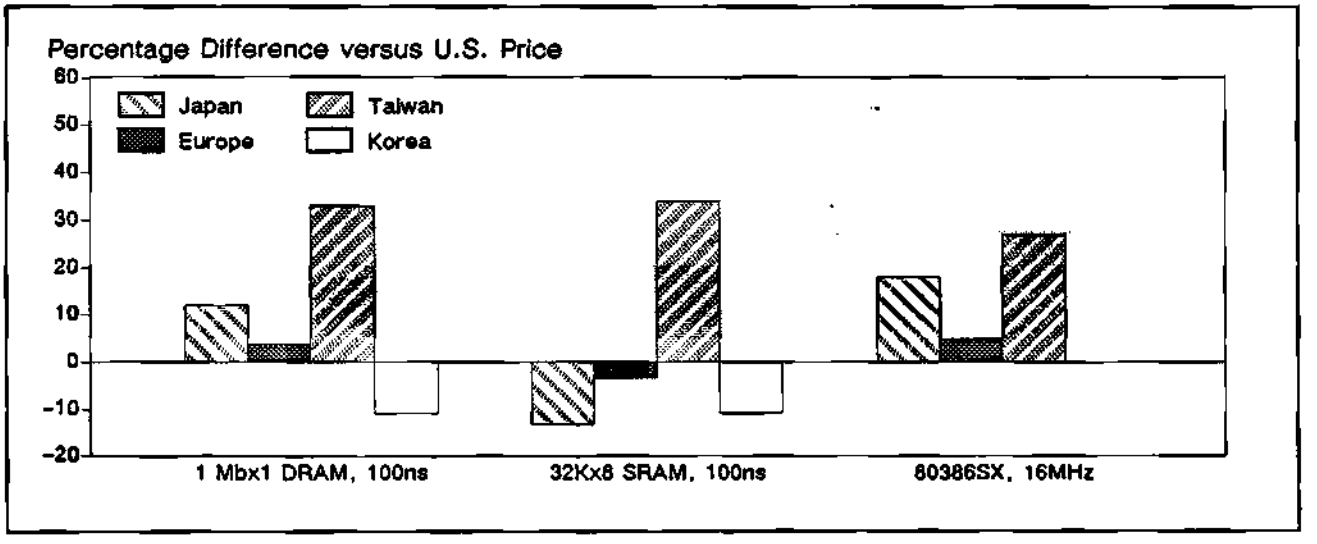
Users that buy memory products in Europe pay prices that are in the same range as U.S. prices, but buyers that source the 16-MHz 80386 microprocessor in Europe pay 5 percent more than in the United States.

Buyers that procure in South Korea—which typically are members of a vertically integrated firm—pay prices that are 10 to 11 percent lower than U.S. prices for the memory products specified above. In contrast, users that source in Taiwan—which typically are *not* part of vertically integrated enterprises—pay much higher prices across the board.

FACTORS BEHIND GLOBAL REGIONAL PRICING VARIATIONS

Two main factors lie behind global pricing variations: the strength of regional system-application markets and the home region of major IC suppliers. For example, the United States is a strong application market for workstations and

FIGURE 2
Price Trends by World Region Compared with U.S. Price (as of February 12, 1990)



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Source: Dataquest March 1990

PCs, both of which are DRAM-intensive systems, so users that source DRAMs in the United States now enjoy favorable pricing. Regarding the home regions of major suppliers, Japan is a world leader in production of slow SRAMs and ROMs, so buyers that source in Japan currently pay less for those devices.

DRAMs

Dataquest notes that in the case of DRAMs, the United States' strength in DRAM-intensive applications means competitive DRAM pricing in the United States *despite* Japan's world leadership in DRAM production. DRAM pricing was higher in United States than in Japan during the supply crunch of 1987 and 1988. The presence today of a global network of DRAM suppliers (European, South Korean, and U.S. suppliers as well as Japanese firms), which competes for strong U.S. demand, has kept DRAM pricing lower in the United States than most regions. Wild card DRAM suppliers such as Samsung of South Korea and Siemens of West Germany, impede trends toward formation of supplier cartels.

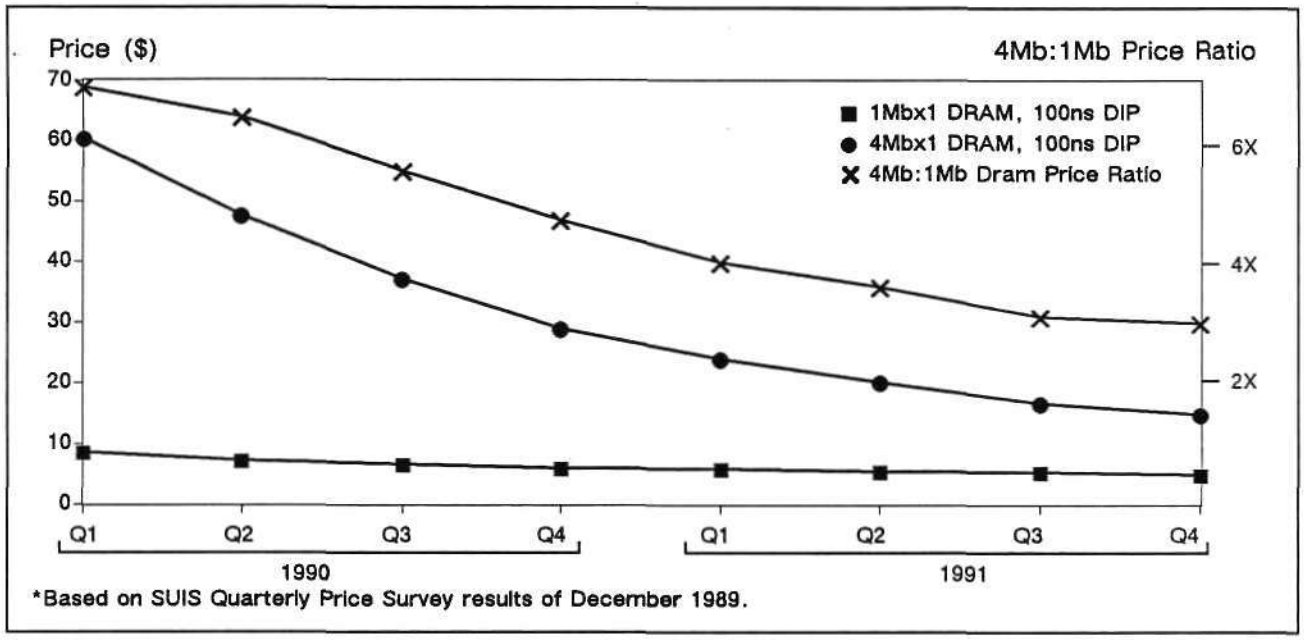
Looking to the future, Japan might emerge as a strong application market for high-definition television (HDTV), a DRAM-intensive system for the mid-1990s and beyond. That prospective reality, combined with Japan's likely continuing strength in DRAM technology, *could* translate over the long term into a distinct pricing advantage for users that source DRAMs in Japan.

THE 1Mb-TO-4Mb DRAM PRICE CROSSOVER BY WORLD REGION

Global regional differences, particularly in DRAM pricing, mean immediate challenges and opportunities for semiconductor suppliers and users. Users that track world pricing trends will discover large pricing differences that can lower system costs. For suppliers, accurately forecasting world regional DRAM demand and operating fabs to support this demand means risky but potentially lucrative business.

For DRAM users and suppliers, a central issue now is the timing of the 4:1 unit/price crossover from the 1Mb DRAM to the 4Mb product. As presented at the conference, Figure 3 shows North America megabit-density DRAM price trends by quarter for 1990 and 1991. The top line of this figure is read along with the *right axis* to show the 4Mbx1:1Mbx1 DRAM unit/price ratios during this period. For North America, Figure 3 forecasts the 4:1 unit/price crossover from 1Mb DRAMs to 4Mb DRAMs to occur during the first quarter of 1991.

FIGURE 3
North American
Megabit-Density DRAM Price Trends*



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Source: Dataquest
March 1990

After the speech, a member of the audience asked how North America's fair market value (FMV) system and Europe's floor reference pricing system would affect the crossover scenario. First, the effect of FMVs on North American DRAM pricing was considered in the crossover projection shown in Figure 3. Dataquest still expects the crossover in North America to occur during the first quarter of 1991.

Second, European DRAM pricing controls to date are *delaying* the crossover in Europe. The pricing mandate currently means 1Mb DRAM price declines in Europe because the reference price sits *below* the market price—with users demanding the lower reference price in current negotiations. The effect of European government controls on 1Mb DRAM pricing can not be fully assessed at this time, but Dataquest expects the megabit-density DRAM unit/price crossover in Europe to occur during early 1991 at the earliest.

Third, in Japan, first-tier suppliers of 4Mb DRAMs plan to move users to the 4Mb device by the end of this year; however, suppliers are backing down from this goal. Recent cutbacks in 1Mb DRAM production by suppliers in Japan signal some price stabilization for the 1Mb device. The elusive issue of the internal transfer price for DRAMs within vertically integrated firms will play a major role in the crossover in this region. *If* leading-edge suppliers of 4Mb DRAMs in Japan reach all of their goals on yield rates, design wins, and production ramp up, users that source in Japan might cross over later this year or during early 1991.

Finally, the continuing drop in 1Mb DRAM pricing in South Korea signals a crossover after other world regions—during the second or third quarter of 1991.

DATAQUEST CONCLUSIONS

At the conference, Dataquest recommended that semiconductor users and suppliers learn to jointly manage rising IC prices toward the goal of enhanced system value. To meet that objective, we make an allied recommendation: suppliers and users must actively track and manage world *regional IC pricing differentials.*

For DRAM users and suppliers, a global regional pricing strategy links a host of factors—such as the home region of suppliers, the strength of regional application markets, government controls, internal-transfer pricing—that will affect the

timing of the critical megabit-DRAM crossover in different world regions. The effects of U.S., Japanese, and European government controls on the crossover scenario are as follows:

- The effect of FMVs on North American DRAM pricing were considered in the crossover projected for the first quarter of 1991.
- European pricing controls as currently proposed are starting to extend the crossover in Europe, which should occur *after* the North American regional crossover.
- First-tier suppliers of 4Mb DRAMs in Japan now appear to be retreating from their prior goal of crossing users over from the 1Mb device to the 4Mb product by the end of this year. The DRAM transfer price within vertically integrated firms plays a special role in Japan's crossover, which is likely to happen during early 1991.
- In other world regions, the crossover should occur by mid-1991.

Ronald Bohn
Gregory Sheppard

Dataquest
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The Dun & Bradstreet Corporation

Research Newsletter

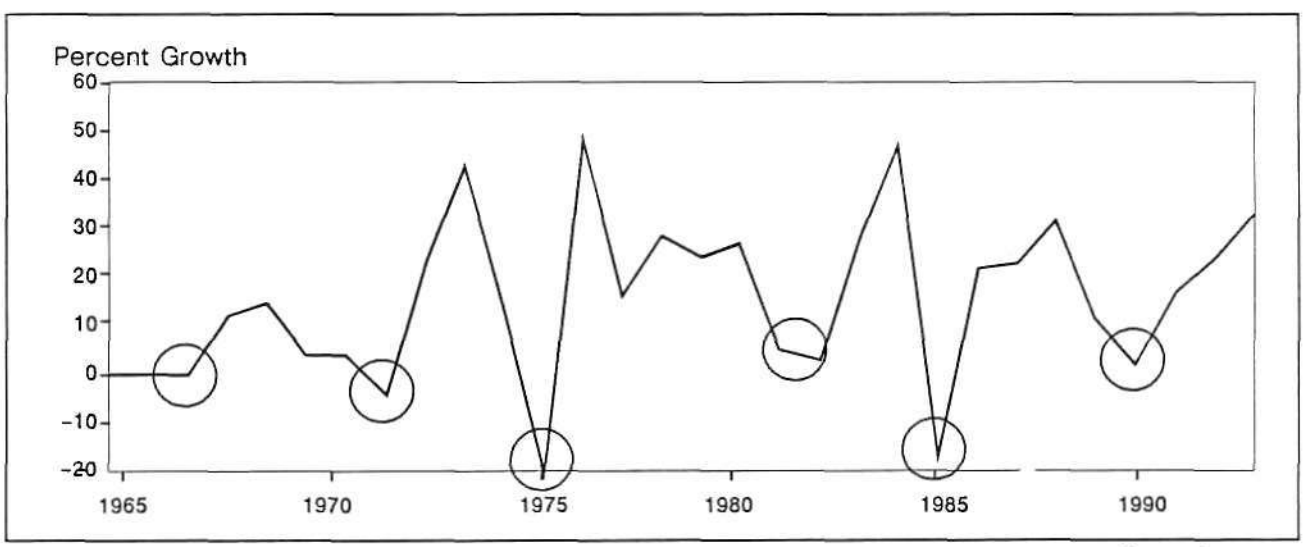
TRUE OR FALSE: USER-SUPPLIER RELATIONSHIPS TO CHANGE IN THE 1990s?

Strategic partnering was proposed in the early 1980s to describe how semiconductor customers and suppliers should conduct business with each other. But when the industry had a severe downturn in 1985, suppliers scrambled after every deal, and prices fell through the floor. When the industry finally had a mild boom in 1988, buyers chased after every available part, DRAM shortages developed, and spot-market lead times and prices went through the roof. Then in 1989, DRAMs became plentiful again and prices fell to record lows.

Is *strategic partnering* the solution to reducing the wild swings (see Figure 1) that have occurred in the semiconductor industry during the past 25 years? Buyers and sellers had a chance to find out at Dataquest's annual conference for semiconductor users and suppliers, held again this year in San Francisco, California. The more than 180 attendees to the two-day February conference included buyers (45 percent), sellers (40 percent), and persons from government agencies, investment firms, and the trade press (15 percent). Eleven of the top 15 North American users (e.g., those that purchased more than $7 billion of semiconductors in 1989) were represented, along with delegates from 13 of the top 15 worldwide semiconductor suppliers.

This newsletter summarizes the conference by discussing the changes affecting the semiconductor

FIGURE 1
Estimated Worldwide Semiconductor Industry Revenue
(Would Closer User-Supplier Relationships Reduce the Swings?)



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industry today, ways in which Dataquest clients can seize opportunities while hedging the downside, industry forecasts for the 1990s, and Dataquest's second annual "Semiconductor Supplier of the Year" award.

CHANGES AFFECTING THE INDUSTRY TODAY

The worldwide electronics industry continues to evolve, and developments in microelectronics show no signs of slowing down. Regions and technology are the two major areas of change affecting the industry today.

Regions

A supplier with headquarters located in one world region must deal effectively with customers located in different world regions. "(Having) resident experts in foreign countries is the key to success," explained Linn Nelson, executive vice president and cofounder of Barnel International. "To be global means to act local," echoed Kevin McGarity, senior vice president and manager of worldwide marketing for Texas Instruments' Semiconductor Group.

Distributors will either decline or prosper in the 1990s as the electronics industry becomes more global in scope. It all depends on whether or not distribution channels can adapt to changing needs such as VLSI/ULSI and customer-specific products. "Distribution must skate to where the puck will be," urged Charles Clough, president and chief executive officer of Wyle Laboratories, "if U.S. distributors are to increase the competitiveness of American equipment manufacturers and maximize the marketing efficiency of American semiconductor manufacturers."

What should a U.S. or Asian semiconductor supplier do to be competitive in the European Community? "Learn how to communicate," replied Jean-Pierre Melia, member of the board of Fiat Semelco and purchasing director of its Magneti Marelli France division. True buyer-supplier partnerships are important for risk sharing, forecasting, and long-term commitment, with technical cooperation preserving mutual interest during booms and crises. "The European electronics industry *believes* in 1992, European industry *is* restructuring now, and new opportunities *exist* beyond 1992," predicted London-based Jim Eastlake, senior industry analyst for Dataquest's European Semiconductor Industry Service.

Technology

The high R&D food chain of specification through design is collapsing as semiconductor companies focus on implementing systems with application-specific standard products (ASSPs). "System and semiconductor companies are coming together," stated John Rizzo, vice president of marketing for Momenta Corporation.

During 1989, 1Mb DRAMs went from shortages in the first half, to oversupply and multitier pricing in the third quarter, to production cutbacks and severe price erosion in the fourth quarter. The 4Mb DRAM is expected to have an unusually difficult market introduction in 1990. "The rules for memory ICs have not changed; each cycle is just different," concluded Fred Jones, associate director of Dataquest's Semiconductor Industry Service and manager of the Memory segment.

ASICs are integrated circuits that are dedicated to a single user. One type of ASIC, the MOS gate array, will have an increase in usage of 25 percent between 1984 and 1994. "ASICs allow a shorter time to market for a greater total product revenue," reported Jerry Banks, senior industry analyst for Dataquest's Semiconductor Industry Service. Mixed-mode ASICs, which combine both digital and analog circuits on the same IC, allow a reduction in the number of ICs in the equipment and reduce the problems of interconnection between ICs while optimizing circuit operation. "Users must learn about mixed-signal ASICs and suppliers must learn to specialize in markets and applications for this segment of ASICs to maximize its potential," advised Gary Grandbois, senior industry analyst for Dataquest's Semiconductor Industry Service.

SEIZING OPPORTUNITIES WHILE HEDGING THE DOWNSIDE

Change brings uncertainty, which creates risk. The industry can hedge risk by specializing in a segment of the electronics manufacturing cycle, forming closer user-supplier relationships, and exploring the possibility of a futures market for key electronic components.

Specializing

Greater product complexity and new market and product needs have led to specialized markets and products, which in turn have led to innovations such as fabless semiconductor companies.

Executives now have a greater choice in organizing an enterprise to serve a market, and customers benefit from the better service. "Semiconductor companies in 1990 are based on either technology, specialized products and technology, or design," summarized Michael Canning, vice president of manufacturing for fabless Cirrus Logic.

Relationships

What's in store for the 1990s is the sharing of problems to develop joint solutions users and suppliers need to form partnerships for R&D, applications, design, process, and applications success. "Do what the customer wants when he wants it done," recommended Charles Thompson, senior vice president and director of world marketing for Motorola's Semiconductor Products Sector.

Japanese semiconductor companies assimilate the local culture and business practices when they form a subsidiary in a foreign country because their customers demand it. "U.S. equipment manufacturers want to be treated the same all over the world and at the same time treated as a Japanese equipment manufacturer would be treated in Japan," revealed Robert Brown, senior vice president of semiconductor operations for Toshiba America Electronic Components. "Global service issues include early access to new technology, technical assistance, logistic support, local manufacturing, flexibility, and quality products."

The automotive industry is sometimes cited as a role model for the electronics industry because of close relationships between the users and suppliers of automotive assemblies. "Improved supplier responsiveness is (a) win/win (situation)," proclaimed Gene Richter, executive director of corporate procurement for Hewlett-Packard. Mr. Richter's newness to data processing electronics—he has been in this field for 18 months—enables him to evaluate the issues of the day with the objective eye of an outsider. Based on more than a decade of experience in the industrial and automotive sectors (with Black and Decker and Ford Motor Company), he challenged suppliers to pay more attention to fundamentals (e.g., planning, communicating, measuring, and follow-up) and to upgrade sales organizations (e.g., more resources, more training, more clout, and more global in scope).

Users today expect minimal inventory, guaranteed lead times, and a reduced vendor base. Sole-sourced components, however, still make users nervous unless they have formed a mutually dependent partnership with a supplier. A supplier, in turn, can use this opportunity to provide a total cost and value analysis for the user. To keep sole-source suppliers honest, Frank Gill, senior vice president of sales for Intel, reminded the audience that "a socket may be sole-sourced, but the electronic function is not."

Multichip modules are packages with two or more VLSI die, which make it possible to build higher-performance systems. Many technical and business challenges still face this new but promising idea. "Relationships between single IC suppliers, system houses, and strong package suppliers are required," recommended Dr. William Steingrandt, director of product development and marketing for Alcoa Electronic Packaging.

Futures

DRAM price volatility, coupled with its commodity nature, suggests futures as a familiar risk-management tool for modern business. "A DRAM is a small sliver of highly refined sand," explained Hoon Won, chief executive officer of Memory Clearing Corporation, "and can be traded like any other commodity." If the DRAM futures market does become a reality in upcoming months, it would be regulated by the Commodity Futures Trading Commission.

INDUSTRY FORECASTS FOR THE 1990s

Every year at this conference, Dataquest forecasts markets, applications, and prices for the upcoming year and the next five years. Dataquest and The Dun & Bradstreet Corporation presented these latest forecasts.

Markets

The U.S. economy is going global in the 1990s because of structural changes taking place in the international economy. "Real GNP for the U.S. economy is expected to grow only 2.4 percent in 1990 and 3.4 percent in 1991," summarized Joseph Duncan, vice president, corporate economist, and chief statistician for The Dun & Bradstreet Corporation.

The U.S. equipment industry is healthy with an orders-to-shipments ratio at parity or greater and an equipment inventory that is being well managed. "Worldwide electronic equipment production is expected to grow 5.4 percent in 1990, 7.3 percent

in 1991, and 8.6 percent in 1992," predicted Terrance Birkholz, research analyst for Dataquest's Semiconductor User and Applications Group.

Although equipment production increases each year at a steady 5 to 10 percent, semiconductor production swings between negative 20 and positive 50 percent (see Figure 1). "The semiconductor industry pauses every five years to catch its breath," concluded Hal Feeney, group vice president and director of Dataquest's Components Group. The industry is projected to grow at a compound annual growth rate (CAGR) of 18 percent between 1990 and 1994 (see Figure 2).

In every region of the world, offshore semiconductor manufacturers are becoming local producers. "The next five years will continue the trends of new sources and regions. There will be adequate capacity," predicted George Burns, industry analyst for Dataquest's Semiconductor Equipment and Materials Service. Because of the effects of trade policies and subsidies, however, the possibility of overcapacity in 1995 looms on the horizon.

Costs, not availability, are the overall key issues among users this year. "Top user issues in 1990 include on-time delivery, pricing, and cost control," summarized Mark Giudici, product manager and senior industry analyst for Dataquest's Semiconductor User and Applications Group. Overall, respondents to Dataquest's annual purchasing survey plan to have a 9.6 percent semiconductor purchasing growth in 1990, with medium-size semiconductor companies the most optimistic about growth. However, "survey respondents expect 1990 growth to be at almost half that of 1989," reported Carolyn Doles, industry analyst for Dataquest's Central Research Group, which supports the Components Group.

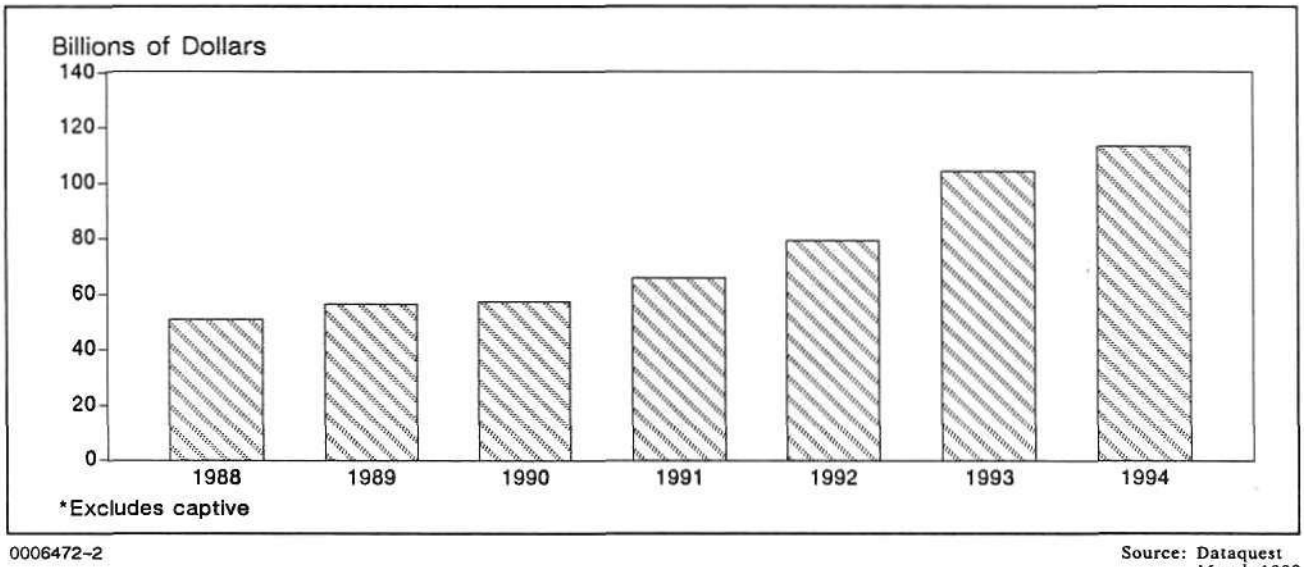
Applications

Multimedia PCs are expected to have a major impact on semiconductor demand by 1994. Between now and then, however, semiconductor companies have to keep their lines filled with wafers if they want to remain in business. "Market drivers for 1990 include 386-based PCs, workstations, rigid drives, LANs, laser printers, and facsimile machines," explained Kevin Landis, industry analyst for Dataquest's Semiconductor User and Applications Group.

Prices

The sticker shock of higher-priced, sole-sourced ICs is mitigated by high value. "Develop pricing and procurement strategies based on the system cost impact and keep close to manufacturers' activities and production plans," advised Greg Sheppard, senior industry analyst in Dataquest's Semiconductor User and Applications Group. Microprocessor, memory, and ASIC prices are expected to continue to decline in 1990 and 1991. (The estimated worldwide 1Mb DRAM

FIGURE 2
Worldwide Semiconductor Industry Revenue Forecast*



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Source: Dataquest
March 1990

pricing for 1987 to 1990 by quarter is presented in Figure 3.) "The crossover from 1Mb DRAMs to 4Mb DRAMs is expected to occur as early as the fourth quarter of 1990," predicted Ron Bohn, industry analyst for Dataquest's Semiconductor User and Applications Group.

SEMICONDUCTOR SUPPLIER OF THE YEAR AWARD

For the second consecutive year, Motorola's Semiconductor Products Sector was the recipient of Dataquest's annual "Semiconductor Supplier of the Year" award. Charles Thompson, senior vice president and director of marketing for Motorola's Semiconductor Products Sector, accepted the award from Gene Norrett, corporate vice president and general manager of Dataquest's Technology Information Division and Hal Feeney, group vice president and director of Dataquest's Components Group (see Figure 4).

The award is based on an annual Dataquest survey of more than 800 procurement site personnel representing the top 200 U.S. electronics companies that use semiconductors. Those surveyed were asked to rate semiconductor suppliers in the following five areas: quality, on-time delivery, pricing, technical support, and customer service. Motorola received the highest overall rating, with Texas Instruments ranking second, National Semiconductor third, Hamilton-Avnet fourth, and Intel fifth.

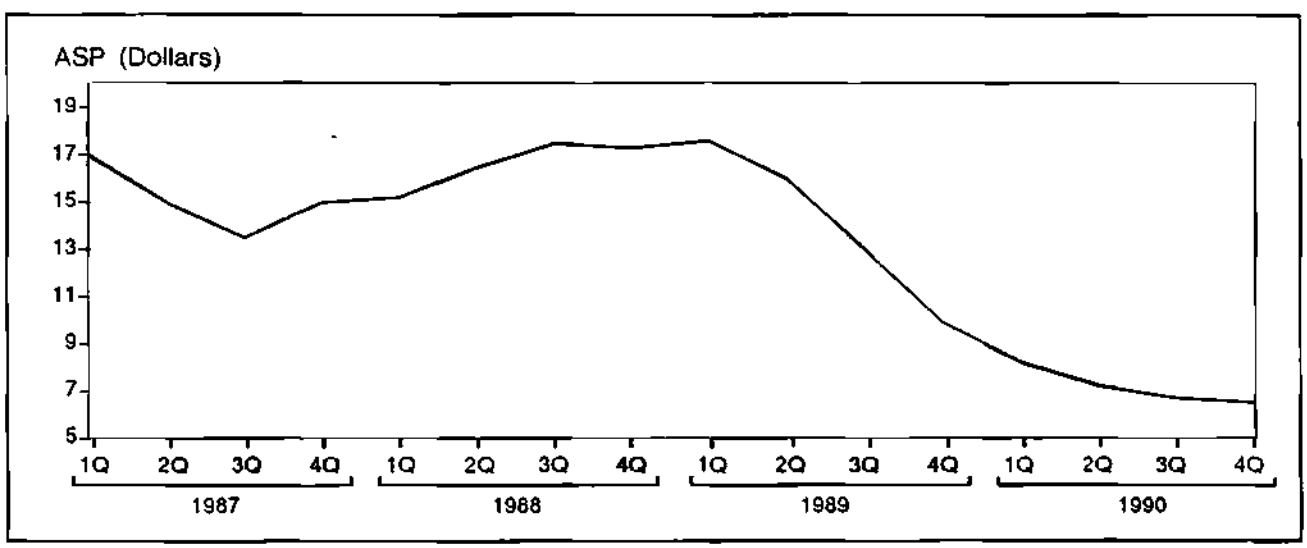
DATAQUEST ANALYSIS

Conclusions

Dataquest concludes that user-supplier relationships will indeed change for the better in the 1990s. We believe that the adversary attitudes of users and suppliers helped cause the wild swings experienced by the industry in the past 25 years (see Figure 1). Practices reflecting such attitudes as "they got us last time, so we'll get them this time" must give way to partnerlike cooperation because the fates of users and suppliers are becoming more tightly linked than ever before.

The conference did provide a forum to discuss changes that currently are under way in world regions and semiconductor technology, as well as how these changes are likely to affect users and suppliers. For example, the stakes in microelectronics are rising, with state-of-the-art fabs expected to cost as much as $1 billion by the year 2000. No supplier would ever make such an investment without first establishing that markets exist for the production, because the cost of an error is just too great—that is why users must share their technology and purchasing needs with suppliers. Likewise, no user would ever jeopardize its equipment business by depending on components that are inappropriate or unavailable for its needs—that is why suppliers must share their technology and capacity plans with users.

FIGURE 3
Estimated Worldwide 1Mb DRAM Pricing Quarterly: 1987-1990



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Source: Dataquest March 1990

FIGURE 4
Second Annual Semiconductor Supplier of the Year Award (left to right) Gene Norrett, Charles Thompson, Hal Feeney

0006472-4

Source: Dataquest March 1990

Recommendations

Dataquest recommends that clients watch component market developments closely if they want to stay ahead. For that purpose, Dataquest publishes monthly reports such as the following:

- *Market Watch*—A bulletin released after the SIA book-to-bill *Flash Report* to give deeper insight into the monthly trends in the semiconductor market and an analysis of what is expected during the following six months
- *OEM Monthly*—To provide insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions
- *Procurement Pulse*—An update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers
- *SAMonitor*—An update that closely monitors changes in key electronic equipment markets

We also recommend that field and factory personnel have a basic understanding of electronics since this technology has become pervasive. For example, if a company has people who define CMOS (pronounced "SEA-moss") as green plants that grow on rocks at the beach rather than a semiconductor technology that offers high density and low power consumption, that company may consider implementing a training course at its facility.

Roger Steciak

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Research Newsletter

1990 SEMICONDUCTOR USER SURVEY FOCUS CHANGES FROM AVAILABILITY TO SUPPLIER PERFORMANCE

SUMMARY

Results of the Fifth Annual Dataquest Semiconductor User Survey were presented at Dataquest's Semiconductor User and Applications Conference held in San Francisco, California, on February 12 and 13. The three key findings were as follows:

- Respondents expect to increase their 1990 semiconductor purchases by 9.6 percent.
- Medium-size semiconductor users are the most optimistic about growth opportunities in 1990.
- The top three issues are on-time delivery, price, and cost control.

This newsletter summarizes the presentation and highlights the key findings of this survey.

METHODOLOGY

As in the past, Dataquest used the *Electronic Business* Top 200 company listings as a basis for the survey. We removed the sample companies that made or distributed semiconductors or software to ensure that we dealt with potential semiconductor users. This reduction brought our sample down to 188 companies. From this base, we surveyed by telephone 882 procurement sites of these companies and received 324 responses (37 percent). As seen in Figure 1, the majority (53.7 percent) of the respondents were from the Pacific and Northeast regions because of the larger concentration of technology manufacturing in those areas.

Table 1 shows the total respondent breakdown by application segment.

The military/areospace segment had the highest percentage in terms of response, partly because of the higher average selling prices (ASPs) relative to commercially priced semiconductors. The purchasing power of the 1989 sample represented 26.4 percent of total U.S. merchant shipments and is forecast to rise to 28.8 percent of the U.S. total in 1990.

SEMICONDUCTOR USER OUTLOOK

User Expectations

More than one-half (51.5 percent) of the respondents expect to have higher system sales in 1990. This figure, combined with 33.6 percent of those expecting flat sales, adds to a healthy total of 85.1 percent of the respondents that expect steady-to-increased sales this year. Mirroring this optimism in system sales, the respondents expect to purchase 9.6 percent more semiconductors in 1990 than in 1989. Relative to the past forecasts, this less-than-10 percent increase is historically conservative. Compared with semiconductor supplier forecasts that we have seen, this is an optimistic forecast in an otherwise flat market. Since the survey was taken, many large system companies have announced lower growth expectations, but our monthly survey data to date still show steady growth outlooks from the purchasing managers and mixed outlooks from the supplier community.

The brightest outlook for procurement growth is coming from midsize data processing and military/aerospace companies. The data processing respondents foresee higher growth opportunities in the high-end PC/workstation market and positive growth in the high-density storage and add-on memory board sectors of the industry. Countering common wisdom, midsize military/aerospace companies expect to see higher-than-average purchases

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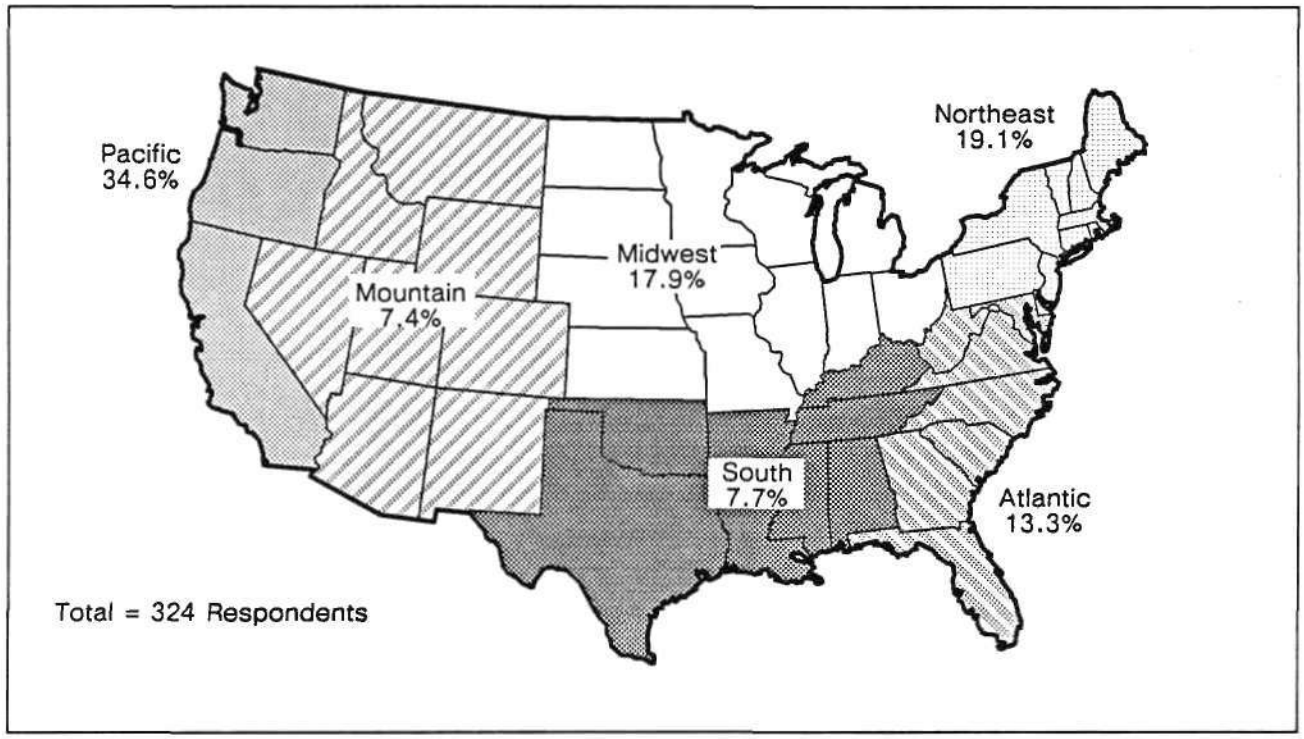
FIGURE 1
Procurement Survey Audience



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Source: Dataquest
March 1990

TABLE 1
1989 Survey Respondents' Purchasing Dollars

Military/Aerospace	35.6%
Industrial	23.9
Communications	17.9
Data Processing	12.8
Consumer	8.1
Transportation	1.7
Total	100.0%

Source: Dataquest
March 1990

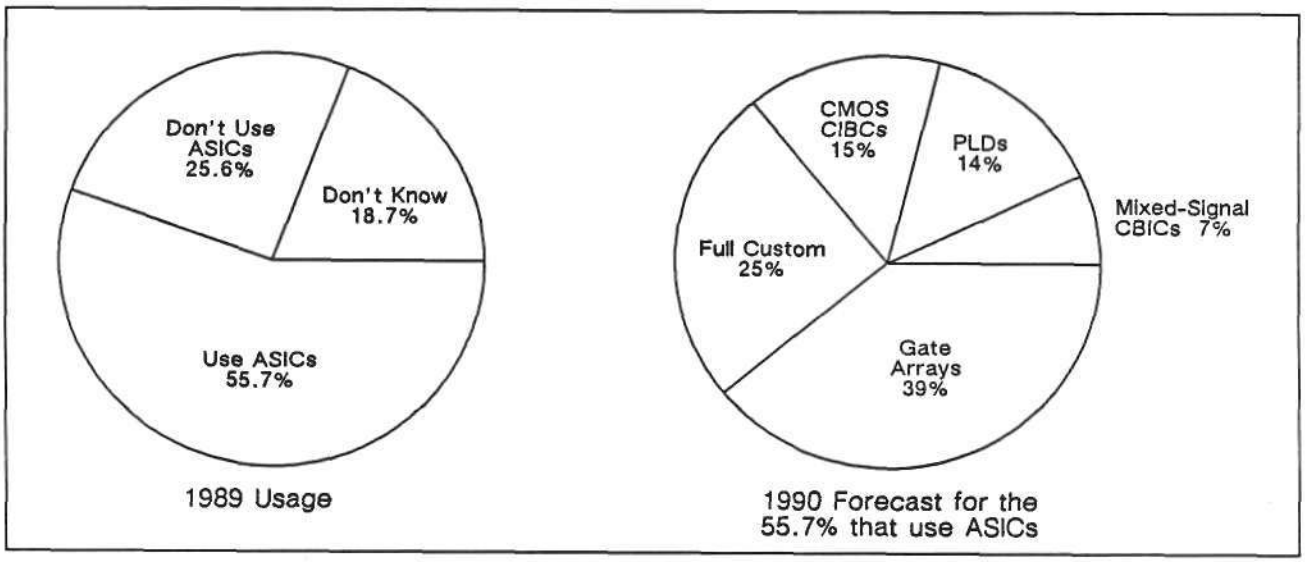
this year due to the clear status of many key programs. Last year, these programs had uncertain futures because of budget cuts. The programs that remain are comparatively secure and will receive a higher portion of funding than in 1989. More than one-half (55.7 percent) of the respondents used ASIC devices last year. A potentially larger marketing opportunity still remains for ASIC suppliers because 44.3 percent of the respondents either don't know if they use ASICs or simply don't use them at this time. The 1989 expenditure and forecast for 1990 are shown in Figure 2.

User Plans

The U.S. supply base for this year's respondents gained market share in 1989 at the expense of Japanese suppliers as a result of the improved availability of DRAMs relative to 1988. The 17.4 percent Japanese market share for the sample now reflects pre-1988 levels of market support. The trend toward manufacturing sites to offshore locations has abated, and 84.5 percent of the respondents plan not to move at all. Those that have facilities overseas now are beginning to use them to supply the local markets in addition to their traditional use as a source of low-cost production.

Last year's plans to reduce inventory levels have occurred, as seen in Figure 3. More than three-fourths (81 percent) of the respondents plan on either reducing or stabilizing their inventory levels this year. The respondent-targeted inventory

FIGURE 2
ASIC Usage



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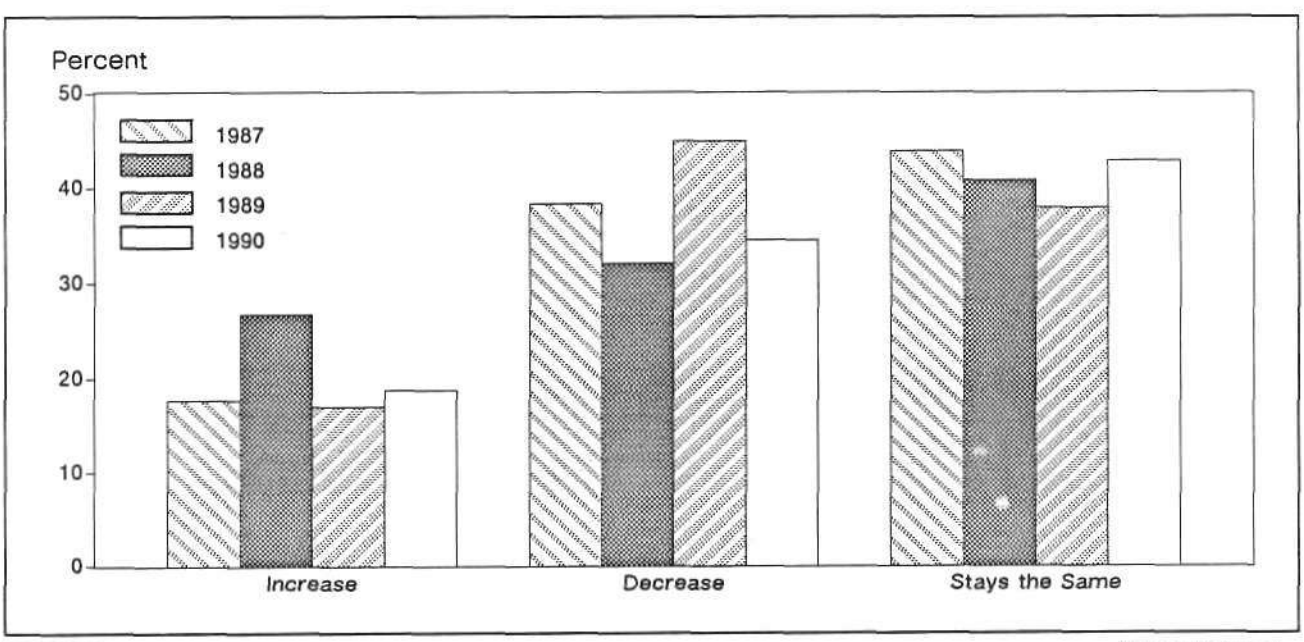
Source: Dataquest
March 1990

FIGURE 3
Expected Change in Target Inventory Levels
(Percent of Total Respondents)



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Source: Dataquest
March 1990

level averaged out to 47 days. This relatively high target level is partly due to the inclusion of the military inventory requirement to have, on average, 180 days of inventory on hand. Our monthly survey reflects a target level for February of 19 days, which is more representative of the overall commercial market.

Top User Issues—The Focus Now Is on Supplier Performance

The biggest change in this year's survey was noting the shift of key issues away from product-related to supplier-related problems (see Table 2). For instance, the fifth-ranked problem for both 1988 and 1989 was memory. This year, memory availability was not even ranked as a top 20 issue! Focus has shifted to how well a given supplier performs on its commitments in terms of delivery, price, and meeting forecast needs. The number three issue, cost control, is the subtheme this year with all of the issues revolving around it. All semiconductor suppliers should take note that now, more than ever, meeting customer needs will be *the* determining factor in supplier loyalty this year. As mentioned in the Dataquest newsletter entitled "True or False: User-Supplier Relationships to Change in the 1990s," that chronicled the conference, Motorola again won the Semiconductor Supplier of the Year Award as voted by this year's respondents. In the buyers' eyes, Motorola met these needs by being perceived as the best in overall delivery, price, quality, technical support, and customer service. Next year's winner would be wise to address this new list of issues.

DATAQUEST CONCLUSIONS

This year's survey confirmed many trends that Dataquest had previously noted and also provided new insights as to what the user community is planning for 1990. The relatively conservative procurement estimates for this year reflect the uncertain outlook for system sales, yet most of the respondents were optimistic about the end markets at the time of the survey. Current surveys still show a steady undercurrent of semiconductor sales that is keeping low growth forecasts on track. It is important to note that the most growth in semiconductor procurement will be coming from

TABLE 2
User Issues

1990 Ranking		1989 Ranking	1988 Ranking
1	On-time delivery	3	3
2	Pricing	2	2
3	Cost control	7	4
4	Availability	1	1
5	JIT/inventory control	6	9
6	Quality/reliability	4	6
7	New products/obsolescence	8	8
8	Reducing vendor base	—	7
9	Forecasting	—	—
10	Government regulation	—	—

Source: Dataquest
March 1990

midsize companies, primarily in the data processing and military/aerospace industries. These two markets have the largest potential for higher sales for the following reasons:

- New products in the workstation and high-end PC markets as well as for more powerful peripherals
- Completed military budget cuts, resulting in steady procurement plans for surviving programs

Dataquest believes that the overall change of theme from availability issues to supplier performance underlines the efforts to reduce overall costs from every angle. Those companies that excel in supporting their customers will differentiate themselves and grow accordingly.

Mark Giudici
Carolyn Doles

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Research Newsletter

FISCAL 1991 DEFENSE BUDGET PLACED BEFORE CONGRESS

OVERVIEW

The U.S. Department of Defense (DOD) requested $295.1 billion in budget authority for fiscal 1991, a real decline of 2 percent from fiscal 1990 levels. The trend line for outyear budgets also calls for 2 percent real decreases per year through 1995 (see Table 1). The DOD requested $292.1 billion in budget outlays as well, which, although lower in real terms than last year's spending, would contribute only $3.6 billion to the $74.0 billion in deficit reductions required by the Gramm-Rudman-Hollings amendment. This fact suggests that Congress may demand larger cuts in defense spending as it reviews the budget during the next eight months.

Features of the proposed budget include the recommended termination of 20 weapon programs, a cut in active-duty personnel to bring force levels roughly equal to 1980 numbers, and an increased commitment by the DOD to drug interdiction to $1.2 billion. Other force structure changes include the demobilization of two army divisions, two battleships, and five submarines, as well as other minor cuts in forces. Domestic and foreign base closures also have been proposed and are estimated to save less than $100 million in fiscal 1991.

There are few surprises in the budget as the DOD mounts an effort to establish a holding pattern in major decisions until events in Eastern Europe crystallize. This approach will not be received warmly on Capitol Hill, however, where members already are complaining that the cuts are not nearly enough and do not reflect either the reality of pressing needs to reduce the deficit nor the happy circumstance of disarray in the USSR.

On the bright side, there is support both on the Hill and in the Pentagon to emphasize technologically superior systems and upgrades. This support bodes well for the electronics industry, as most strategic and conventional high-technology systems will stay on track (see Table 2). Such systems include Lockheed's P-7A Long Range Air ASW Aircraft, the LHX scout helicopter with Bell Textron and McDonnell Douglas teaming against Boeing Vertrol and Sikorsky, the Submarine Combat System, McDonnell Douglas/General Dynamics' A-12 attack plane, and Grumman's JSTARS radar. The National Aerospace plane is slated for $158 million in DOD funding to complement similar funding levels from NASA. The budget also proposes funding levels similar to last year's for

TABLE 1
DOD Budget Authority and Outlays: Fiscal 1990-1991 (Billions of Dollars)

Plan	1990	1991	1992	1993	1994
April 1989					
Proposed Authority	295.6	317.5	332.4	351.0	369.4
January 1990					
Proposed Authority	291.4	295.1	300.0	304.4	308.0
Amount of Change	(4.2)	(22.4)	(32.4)	(46.6)	(61.4)
January 1990					
Proposed Outlays	286.8	292.1	296.9	299.0	302.2

Source: Department of Defense

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Sematech, the Balanced Technology Initiative, and NATO research and development. The level of commitment to RDT&E is further illustrated by the fact that it is one of the least affected areas among the proposed cuts, with a projected real decline of only 1 percent.

TABLE 2
Programs with Large Electronics Content—35 (Millions of Dollars)

System	FY 1989	FY 1990	FY 1991
AH-64 Attack Helicopter—McDonnell Douglas	1,078	1,602	165
E-2C Hawkeye—Grumman	398	379	449
F/A-18 Hornet—McDonnell Douglas	2,516	2,064	2,123
SH-60F CV ASW Helicopter—Sikorsky	373	107	288
P-7A Long Range ASW Aircraft—Lockheed	64	198	255
C-17 Airlifter—Douglas Aircraft	2,014	2,319	2,717
F-15 Eagle—McDonnell Douglas	1,555	1,535	1,845
F-16 Falcon—General Dynamics	3,199	322	2,973
B-2 Bomber—Northrop	5,308	4,302	5,536
Patriot air defense missile system—Raytheon	870	984	909
AMRAAM missile—Hughes/Raytheon	848	814	1,342
HARM missile—Texas Instruments	535	396	385
Standard missile—General Dynamics/Raytheon	670	464	659
Tomahawk cruise missile—General Dynamics/ McDonnell Douglas	753	628	863
Trident II (D-5) missile—Lockheed	2,450	1,662	1,746
MX Peacekeeper missile—Boeing	1,266	1,724	2,836
SRAM II missile—Boeing	191	226	183
Advanced Cruise Missile*	97	368	541
DDG-51 Guided Missile Destroyer—Bath Iron Works/Ingalls Shipyard	2,837	3,501	3,681
SINCGARS—ITT/General Dynamics	249	114	313
Army Data Distribution System (ADDS)*	96	19	44
High Mobility Multipurpose Wheeled Vehicle (HMMWV)—LTV	153	218	252
Mobile Subscriber Equipment (MSE)—GTE	1,030	979	28
Fleet Satellite Communications*	190	329	263
Defense Meteorological Satellite Program (DMSP)—RCA	209	164	198
Defense Satellite Communications System (DSCS)—General Electric	86	73	80
NAVSTAR Global Positioning System— General Dynamics/Rockwell	121	81	251

(Continued)

TABLE 2 (Continued)
Programs with Large Electronics Content—35 (Millions of Dollars)

System	FY 1989	FY 1990	FY 1991
Over-the-Horizon Backscatter Radar*	201	220	255
Space Boosters—Martin Marietta	802	681	472
Unmanned Aerial Vehicles (UAVs)*	90	111	104
LHX Light Armed Scout Helicopter— McDonnell Douglas/Bell Textron Boeing/Sikorsky	177	274	465
Advanced Air-to-Air missile (AAAM)*	30	70	84
Advanced Tactical Fighter (ATF)— Northrop/McDonnell Douglas Lockheed/General Dynamics/Boeing	675	1,046	1,047
Advanced Launch System*	0	86	60
Strategic Defense Initiative (SDI)*	3,710	3,582	4,471
National Aerospace Plan (NASP)*	228	193	158

*Either multiple contractors are involved or the production contract has not been awarded. Source: Department of Defense

HIGHLIGHTS

Program Terminations

Secretary of Defense Richard Cheney stated that he preferred to terminate programs that were not immediately critical to national security rather than absorb the costs associated with long stretch-outs. While the 20 programs proposed for termination (see Table 3) are a start, it is likely that Congress will push Mr. Cheney even further, seeking to terminate or cut back severely such costly programs as Northrop's B-2 bomber, Douglas' C-17 airlifter, the Midgetman, and the mobile MX missiles. The cancellation of the Airborne Self-Protection Jammer (ASPJ), produced by ITT and Westinghouse, clearly signals to the defense industry that the DOD will first target those programs that make themselves conspicuous by failing to meet either cost, time, or performance specifications.

Strategic Programs

The DOD recommended delaying the planned guidance upgrade for the Minuteman II pending the outcome of ongoing arms control talks. However, the Pentagon plans to fund the rail garrison MX at $2.8 billion for the construction of 12 systems, as well as $202 million for continued development of the Midgetman single-warhead missile. In addition, the budget calls for the construction of 52 Trident II (D-5) missiles at $1.75 billion, the building of one Trident submarine at $1.45 billion, and five B-2 bombers at $5.54 billion. The Pentagon has requested $4.60 billion, which is $0.90 billion more than last year, for the Strategic Defense Initiative (SDI). The MX, Midgetman, B-2, and SDI programs are expected to receive substantial cuts and stretch-outs.

Research and Development

RDT&E held its own and is likely to remain virtually intact through the expected budget battles on Capitol Hill. It is even possible that the Hill will mandate additions in this area, as happened last year. Members are increasingly concerned about maintaining the United States' technical superiority in the face of increasingly sophisticated midpower threats. Much will depend on the Critical Technologies Plan, the Pentagon's blueprint for pursuing specific projects, which will be delivered to the Armed Services Committees by mid-March.

TABLE 3
Proposed Program Terminations in Fiscal Year 1991

System	Savings in Millions FY 1991	FY 1992-1994
V-22 Osprey—Bell Textron	(1,395)	6,468
F-14 D fighter aircraft—Grumman	(469)	1,991
Army Helicopter Improvement Program (AHIP)—Bell Helicopter	(328)	1,400
Phoenix missile—Hughes/Raytheon	(333)	614
M-88A2 Improved Recovery Vehicle—BMY	(90)	309
F-15E fighter aircraft—McDonnell Douglas	(+303)	3,317
Apache Helicopter—McDonnell Douglas	682	2,528
M-1 tank—General Dynamics	1,086	6,249
Maverick missile—Hughes/Raytheon	367	743
Air Force Airborne Self Protection Jammer (ASPJ)—ITT, Westinghouse	264	1,199
Combined Effects Munitions*	142	399
Sea Lance missile—Boeing	156	975
Non-Line of Sight Missile (FOG-M)—Boeing/Hughes	131	1,202
Advanced Short Range Air-to-Air missile (ASRAAM)*	7	46
Follow-on to F-4G Wild Weasel*	12	176
Air Base Survivability*	19	130
CHAPARRAL missile—Ford/Hughes	26	157
MK 19 grenade launcher*	20	130
OV-1D aircraft mod program*	37	120
Autonomous Precision Guided Munition*	27	114

*Either multiple contractors are involved or the production contract has not been awarded.
Note: Numbers in parentheses in FY 1991 column denote that the program was terminated in fiscal 1990 budget.
Source: Department of Defense

Arms Control

Perhaps the most unusual element of the defense budget is the fact that the proposed 2 percent annual real declines are dependent on rapid conclusion of a treaty on Conventional Forces in Europe, a quick follow-on agreement to further reduce manpower and hardware levels, and the successful negotiation of the START treaty on strategic forces. In essence, planners are holding the DOD's budget hostage to arms control negotiations with the Soviets. If the agreements now under negotiation are not reached, then even the minimal cuts suggested by the Pentagon will evaporate. Congress will not go along with this posture, as it expected *more* cuts even *without* taking into account arms control agreements, given the evident disarray in the Warsaw Pact.

Greg Sheppard
Barry Bleckman

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Research Newsletter

MILAERO TECH BRIEFS: JANUARY 1990

This bimonthly newsletter provides a useful consolidation of events, announcements, and general news in the military/aerospace semiconductor field. The following publications were used as source material for this newsletter:

PR—Press Release
EBN—*Electronic Buyers News*

AT&T GRANTED FIRST QML CERTIFICATION

In December, the Defense Electronic Supply Center (DESC) awarded AT&T Microelectronics of Allentown, Pennsylvania, the first industry-qualified manufacturer list (QML) certification. Its design, fabrication (1.4-micron CMOS), assembly, and test facilities were collectively certified to meet the new MIL-I-38535 standard for QML suppliers. (EBN, 12/25/89)

XICOR JOINS QPL RANKS

Xicor announced that it received DESC certification of its CMOS and NMOS wafer operations. The company is targeting June 1990 for the qualified parts list (QPL) I listing of its X28C256, 32Kx8 full-featured CMOS EEPROM. (EBN, 12/25/89)

TRW AND MOTOROLA ANNOUNCE SUPERCHIP

As part of the VHSIC Phase II effort, these companies announced the development of the CPUAX. Fabricated at Motorola's Austin, Texas, facility on a 0.5-micron CMOS process, the central processing unit IC has 4 million devices with a performance capability of 200 million floating-point operations per second. (PR, 1/3/90)

UTMC HAS JAN GATE ARRAYS

UTMC announced the QPL I qualification of its 1.5-micron CMOS gate array family. There are four density grades up to 11K gates with average gate delays of 0.65ns. Software support is included with the company's Highland VAX-based design system. (PR, 1/3/90)

INTEL OFFERS MEGABIT FLASH

Guaranteed for a minimum of 10,000 read/write cycles, the 1Mb CMOS flash memory device is based on Intel's proprietary 1-micron EPROM tunnel oxide technology. The M8F010 is organized x8 and has an access time as low as 200ns. Erase time is five seconds, and programming time is two seconds. The average selling price (ASP) is $350 for 100-unit quantities of this 883 Class B-qualified device. (PR, 12/14/89)

INTEL ANNOUNCES BUS IC AND ASIC CAPABILITIES

The M82389 is a message-passing coprocessor for controlling the Multibus II parallel system bus. Available in February 1990, the 883 Class B version can operate up to 40 MBps. The company also announced a $2.4 million contract with IBM to develop a three-chip CMOS cell-based IC chip set for avionics applications. The company also announced the availability of an 80C51 military cell library as well as a plan to have 16-bit MPU cores later in 1990. (PR, 9/11/89)

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HARRIS UNVEILS 16-BIT MICROCONTROLLER

Optimized for real-time control in embedded applications, the RTX-2000 features a stack and multiple bus architecture. The processor is programmable in FORTH high-level language. The device's performance can reach 8 mips, making it suitable for imaging and other digital signal processing (DSP) applications. (EBN, 12/25/89)

EDI AND SHARP SET UP SRAM TEAM

EDI will work with Sharp to help create high-reliability 1Mb SRAMs based on Sharp's 0.8-micron CMOS technology. They will develop both latched and separate I/O 256Kx4 and 128Kx8 versions. Access times will be in the 25 to 35ns range. EDI had previously announced the availability of 128Kx8 70 and 150ns versions available to 883 Class B processing. (PR, 10/25/89)

NATIONAL EXPANDS LOGIC OFFERINGS

National Semiconductor's advanced CMOS logic family, FACT, has been JAN Class B and Class S certified by DESC. The company also has launched the FACT Quiet Series for designers that are concerned about the ground bounce noise problem. For its TTL FAST family, the company also announced the availability of versions resistant to 4,000 volts of electrostatic discharge (ESD), addressing the requirement in MIL-M-38510, Rev M. (PR, 10/89)

ACTEL OFFERS FPGAs

Actel has introduced two 883 Class B field-programmable gate arrays (FPGAs). Available in 1 and 2K gate densities and sporting radiation-resistant characteristics, the prices run $224 and $386, respectively, in 100-piece lots. (EBN, 12/25/89)

Gregory Sheppard

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Research Newsletter

MODULAR AVIONICS: HIGH-LEVERAGE OPPORTUNITY

SUMMARY

The next generation of tactical aircraft for the U.S. Army (LHX Helicopter), Navy (Advanced Tactical Aircraft—ATA or A-12), and Air Force (Advanced Tactical Fighter—ATF) will feature congressionally mandated, general-purpose, modular avionic building blocks. With as many as 3,800 of these aircraft to be procured during the next 15 years, a $45.0 billion avionic equipment market and a $1.8 billion semiconductor market will be highly affected by contract outcomes and the decisions of standards bodies.

THE OPPORTUNITY

The overall opportunity for electronics OEMs and semiconductor companies is shown in Table 1. On a weighted average, these new aircraft are estimated to cost $21 million each, and each one will comprise 60 percent electronics. Each aircraft, on a weighted average basis, will use an estimated 4,000 integrated circuits worth $460,000.

THE TECHNOLOGY

In an effort to reduce redundant development of avionic subsystems such as electronic warfare and integrated communications, the U.S. Congress mandated that certain new aircraft programs will need to coordinate technology requirements. To this end, the Joint Integrated Avionics Working Group (JIAWG) was created of armed service and industry representatives to coordinate and standardize duplicative efforts.

The principal output of JIAWG regarding hardware was the creation of a common and modular avionics architecture that could be configured to any aircraft. Known as the Advanced Avionics Architecture, it prescribes a bus-oriented approach using various combinations of modules (i.e., data processor and memory) to achieve the different avionic needs of the ATF, ATA, and LHX. The current version of this architecture is known as the Common Avionic Baseline III (CAB III).

The existing types of common data processing modules include the MIL-STD-1750A processor, bulk memory (volatile and nonvolatile),

TABLE 1
U.S. Common Avionics Opportunities Quantified

Aircraft	Aircraft Procured	Unit Cost ($M)	Electronic Value/Unit ($M)	Total Electronic TAM ($B)	Total Semiconductor TAM ($M)
ATA (A-12)	450	$45.0	$25	$11.3	$ 450
ATF	1,300	$35.0	$19	24.8	986
LHX	2,096	$ 7.5	$ 4	8.4	340
Total	3,846	$21.0	$12	$44.5	$1,776

Source: Dataquest
January 1990

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MIL-STD-1553B and high-speed data bus modules, and a power supply module. Hughes, IBM, Texas Instruments, and Unisys are the principal contractors competing to supply these common modules.

PROGRAM STATUS

The following paragraphs briefly describe the principal programs that compose the demand for common avionic electronic modules.

ATA—A-12

The prime contracting team is McDonnell Douglas and General Dynamics operating under a $4.4 billion development contract. This replacement for the A-6 carrier-based attack craft is scheduled to start full-scale development late in 1990 with first deliveries scheduled for 1997. Allied-Signal and IBM are working on the core mission and air data computer systems.

ATF—YF-22/YF-23

This program has two contractor teams, Lockheed/General Dynamic/Boeing and Northrop/McDonnell Douglas, vying for a full-scale development contract that will be awarded by July 1991. The ATF is intended to replace the F-15 as the principal U.S. fighter. Hughes, Texas Instruments, and Unisys are the principal digital module subcontractors to these teams.

LHX

Full-scale development of either the McDonnell Douglas/Bell Textron or Boeing/Sikorsky UTC version is slated to begin in early 1991. The LHX is slated to replace the AH-1, OH-58, and OH-6 helicopters. IBM, Hamilton Standard, Texas Instruments/Hughes, and Unisys are listed among the principal module suppliers.

INEWS/ICNIA

Integrated Electronic Warfare System (INEWS) and Integrated Communication, Navigation, and Identification Avionics (ICNIA) are common electronic systems being developed for eventual application to all three aircraft. Joint development funding for these programs is averaging $32 million annually. These programs will use the fruits of the GaAs-based technology from the MIMIC program to achieve high functional densities, frequencies, and reliability levels. Sanders/GE and TRW/Westinghouse are principal developers of INEWS. Kearfott-Astronautics and TRW/Collins are the principals behind ICNIA.

STANDARDS AND CHIP OPPORTUNITIES

In order to implement these programs, both VHSIC and MMIC class technology will be employed. In addition to the 16-bit MIL-STD-1750A MPUs (3 to 5 mips), a need exists for 32-bit MPUs (5 to 10 mips) to anchor the central data processors for mission management and flight control. For this purpose, JIAWG selected the MIPS Computer System and Intel 80960 instruction set architectures (ISAs) as the twin versions of the common avionics 32-bit processor (CAP-32). Further narrowing of the standard to one ISA is possible pending the award of the ATF and LHX full-scale development contracts.

Table 2 summarizes semiconductor opportunities presented by the JIAWG-controlled avionic programs.

The JIAWG architecture requires at least one PI bus controller IC per module. Emerging from the VHSIC program, PI bus has the ability to operate up to 32 bits wide and at 25 MHz. Honeywell, IBM, Texas Instruments, and Unisys have announced some implementation of PI bus ICs. To support the need for built-in testing, these new avionic modules will be able to accommodate sophisticated self-test through on-board test circuitry built into each IC and through a test controller IC. The current leader in test standards is JTAG, or IEEE 1149.1.

The high-speed bus can be implemented using the fiber-optic medium. The three most popular media being coordinated by committees of the Society of Automotive Engineers (SAE), which helps the JIAWG decide many avionic standards, are the 1-Mbps MIL-STD-1773, the 100-Mbaud AS4074.1 Linear Token-Ring Bus, and the 100-Mbaud AS4074.2 High-Speed Ring Bus. For sensor-to-processor links, a 1-Gbps parallel bus also is under consideration.

The aircraft stores (dispensable items) data communication interface standard, MIL-STD-1760, is also a monolithic IC opportunity. A fiber-optic version of that standard also is under consideration by the SAE.

TABLE 2
Avionic Semiconductor Needs

Technology	Principal Application
CMOS/BiCMOS Gate Arrays and Cell-Based ICs	MPR logic, DSP, PI & TM bus MCU/1750A core, 1553B
16-bit MPU/MCU (1750A, etc.)	Assorted aircraft embedded control functions
32-bit MPU/MPR	Mission and flight computers
DSP ICs	Assorted embedded control, filters, FFTs
Digital GaAs	Sensor, EW picosecond preprocessing
Graphic ICs	Flight displays (CRT, color LCD), HUDs
Data Conversion	Fly-by-wire/light controls, sensors
PI/TM/JTAG/1553B/1760/High-Speed Bus	Bus control ICs
Bipolar/BiCMOS/DMOS Power	Motor/actuator control, radar, EW
MMIC	Amplifiers, mixers for transmit/receive modules, EW, ICNIA
SRAM	1Mb densities for main computers
Nonvolatile	1Mb-density EEPROM, Flash memory for embedded control

Source: Dataquest
January 1990

The SEM-E (6-inch by 6-inch) module standard has emerged as the preferred technique for physically implementing the modules. The modules are dual sided and accommodate surface-mount components.

JIAWG has selected Ada as the standard high-level software language for its avionic programs. With upgrades in progress for improved real-time features, Ada is slated to handle embedded applications.

DATAQUEST RECOMMENDATIONS AND CONCLUSIONS

The opportunity presented by common avionics is high leverage and high stakes. Dataquest believes that semiconductor companies would be wise to capture design-ins on both teams of the ATF and LHX projects to help assure success later. The initial ATA design is mostly complete with non-JIAWG hardware, but it will most likely be upgraded with JIAWG-standard hardware as it enters full-scale development.

Some hardware changes will most likely affect the ATF and LHX after the full-scale development contract is awarded; therefore, ongoing tracking of the implementation of these programs is advised. Patience and persistence should be the order of the day for all with vested interests in these programs, as they will most likely be delayed as the defense budget is trimmed further.

Gregory Sheppard

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Research Newsletter

USE OF LEADLESS CERAMIC CHIP CARRIERS TO SLOW

INTRODUCTION

The use of surface-mount technology in military systems has, in general, improved their long-term reliability. Almost all packaged components used in the past involved leaded components, mostly of the ceramic dual-in-line type. As surface-mount technology came into use, the leadless component, specifically the leadless ceramic chip carrier (LCCC), was introduced as an alternative. It offered advantages in packaging density, handling, performance, and automation during both assembly and test processes. These advantages were not without compromise, however. Differences in the coefficient of thermal expansion between the LCCC and the printed circuit board substrate material on which it is mounted caused problems that affected the long-term reliability of the system. The LCCC did not possess the strain-accommodating capability inherent in leaded devices. Many proposals have been made to solve this reliability problem without compromising density and performance advantages. Dataquest discusses the industry status of the LCCC package in this newsletter.

THE LCCC PACKAGE AND SOLDER FATIGUE

The LCCC package contains no leads. Instead, it consists of tiny metallized contacts (node-pads) spaced over the ceramic body, which are on 50-mil pitch. Attachment of the LCCC to the printed circuit board (PCB) is made with the use of solder (generally 63 percent Sn/37 percent Pb) reflowed either by the vapor phase or infrared process.

Before thermal fatigue testing, the soldering of the LCCC package to the PCB indicates no cracking or voids. However, as the number of cycles for thermal testing from -55 to +100°C accumulate, the tendency for solder joint cracking begins to occur. The cracking is particularly evident when organic substrates, such as epoxy or polyimide, are used.

Industry research has found that three definitive stages of LCCC solder joint degradation occurs. The first phase is the stress mark, the second is the stress crack, and the third degradation phase is electrically open cracks.

Further studies have shown that the strain produced by the mismatch in coefficient of thermal expansion (CTE) among the three assembly materials (LCCC, PCB, and tin/lead solder) during thermal cycling increases the coarse hardening of the microstructure in the solder. The strain promotes the tendency toward crack formation in the lead-rich region. It is this coarse microstructure that represents the highest strain area in the solder joint. Thus, the cracks are most likely to occur either at the point farthest from the fillet surface (i.e., beneath the LCCC) or at the corner of the package and proceed toward the front edge of the LCCC. As thermal cycling is continued, the crack then proceeds upward to the solder fillet surface and completes the solder joint failure.

LIMITS ON THE LCCC PACKAGE

When LCCCs were first used in surface-mount applications, the terminal count was relatively low, in the 16- to 32-pin range. The package size was comparably smaller, causing only minimal stress cracks to occur during temperature cycling. However, with the advent of VLSI came higher lead counts and correspondingly larger LCCC packages with greater than 32 leads. It is in these packages that the stress problems magnify themselves and solder joint reliability is questioned.

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Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

POSSIBLE SOLUTIONS TO THE EXPANSION PROBLEM

Studies by AT&T and others have taken place recently to examine the major process variables and their effect on solder joint integrity, specifically in terms of joint strength and thermal fatigue life. The investigations have focused on many areas including solder composition, solder grain size, voids, fillet formation, and packaging design. After evaluating these factors in relation to the thermal fatigue life of the LCCC solder joints, it has been determined that a leaded interface between the LCCC and the PCB is needed to control the thermal expansion mismatches. This packaging design approach also has been found to provide an acceptable level of reliability for military avionics.

Various types of lead/component interfaces have been evaluated and are shown in Figure 1. All of the lead types offer varying degrees of stress relief in addition to compatibility with existing surface-mount assembly processes. However, a study by Control Data has shown that the S-shaped compliant lead has the lowest stress on the joint and provides for the optimal soldering solution. These S-shaped spring clips are soldered to the pads of the LCCC and are designed to interface with the PCB without decreasing the packaging density of the electronic assembly. The lead is 0.070 inches high, 0.018 inches wide, and 0.005 inches thick, is made from beryllium copper, and plated with tin/lead solder. The S-lead is attached to the LCCC via vapor phase reflow and is then attached to the PCB using a second reflow process. The resulting board assembly passes the 1,000-cycle requirement of thermal stress from -55 to +100°C.

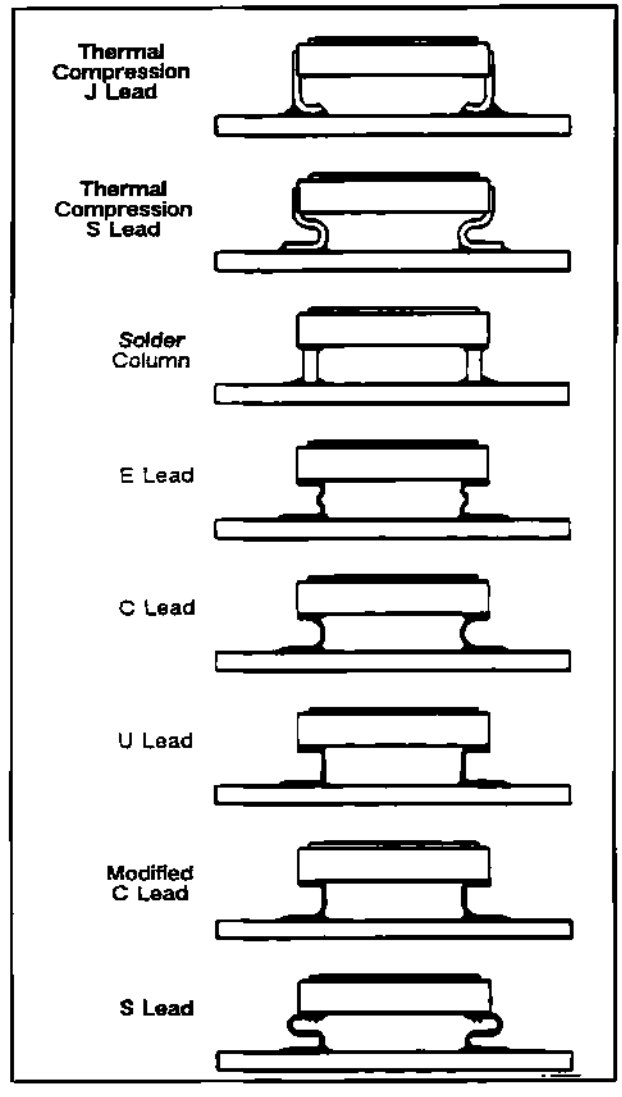
Research by AT&T, IBM, and others also has concluded that leaded packages offer greater reliability over the LCCC. Leaded ceramic chip carriers (LDCC) with a J-bend lead form survive the thermal cycle test with only slight solder joint degradation. Gull-wing leaded chip carriers of 172 leads and higher that have been soldered to a substrate also survived similar tests with no failures.

DATAQUEST SUMMARY AND RECOMMENDATIONS

A leaded package results in far greater thermal cycle reliability than a leadless package of similar size. It is interesting to note that small components such as chip capacitors and resistors withstand the effects of thermal cycling, thus adding credence to the larger package-more solder joint cracks theory.

Estimated use of LCCCs during upcoming years is shown in Table 1. The estimated trend shows a slower growth rate. Increasing lead counts and mounting reliability pressures will necessitate the use of leaded components. In addition, as military packaging for VLSI progresses to multichip modules, the need for the packaging of individual low lead count die will decrease, thus reducing the demand for LCCCs. As this decrease occurs, semiconductor companies and material suppliers are likely to place a lower priority on supporting the LCCC package.

FIGURE 1
Types of Compliant Leads Evaluated



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Source: Dataquest January 1990

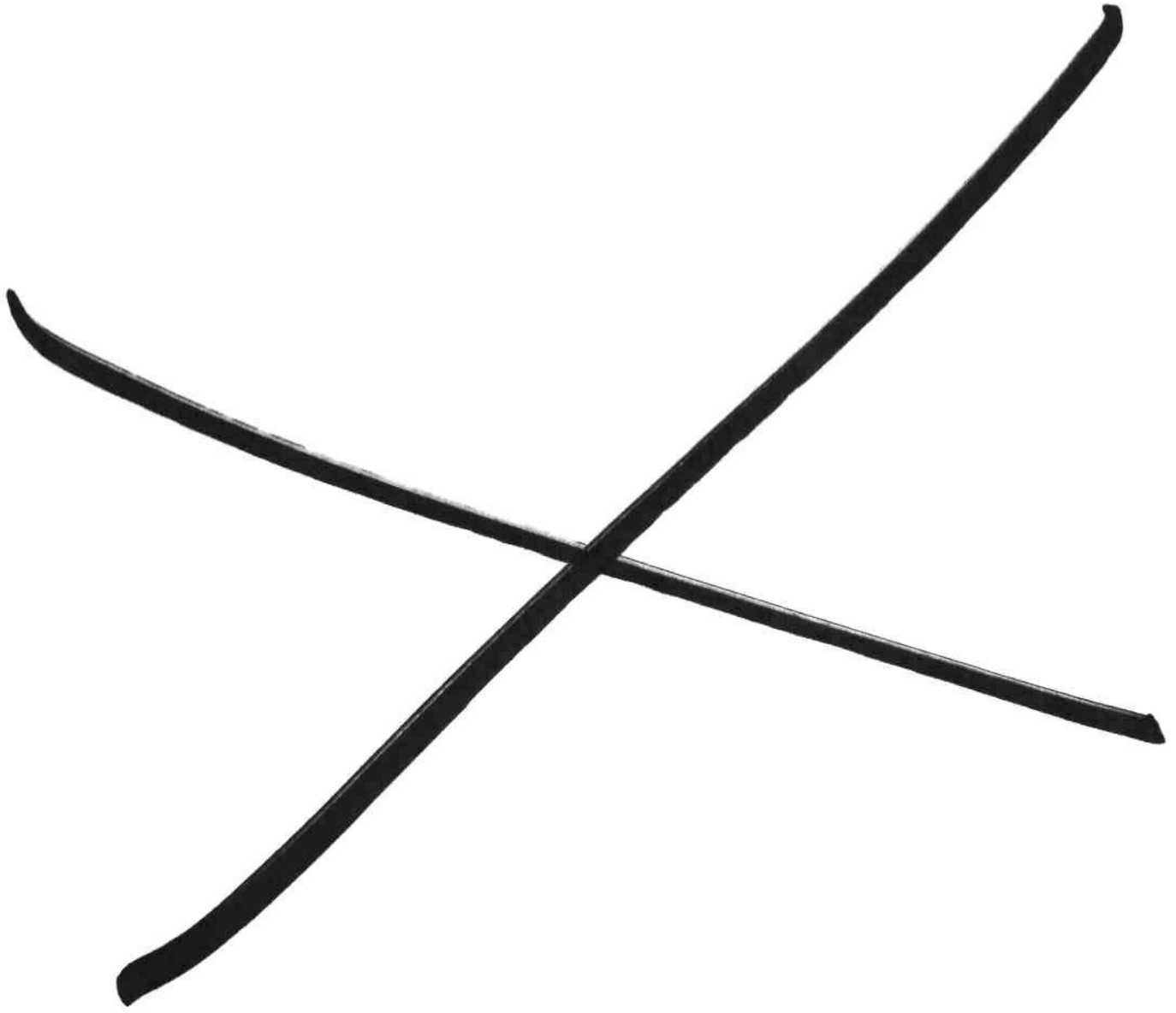
TABLE 1
Projected Usage of Ceramic Chip Carriers in North America (Millions of Units)

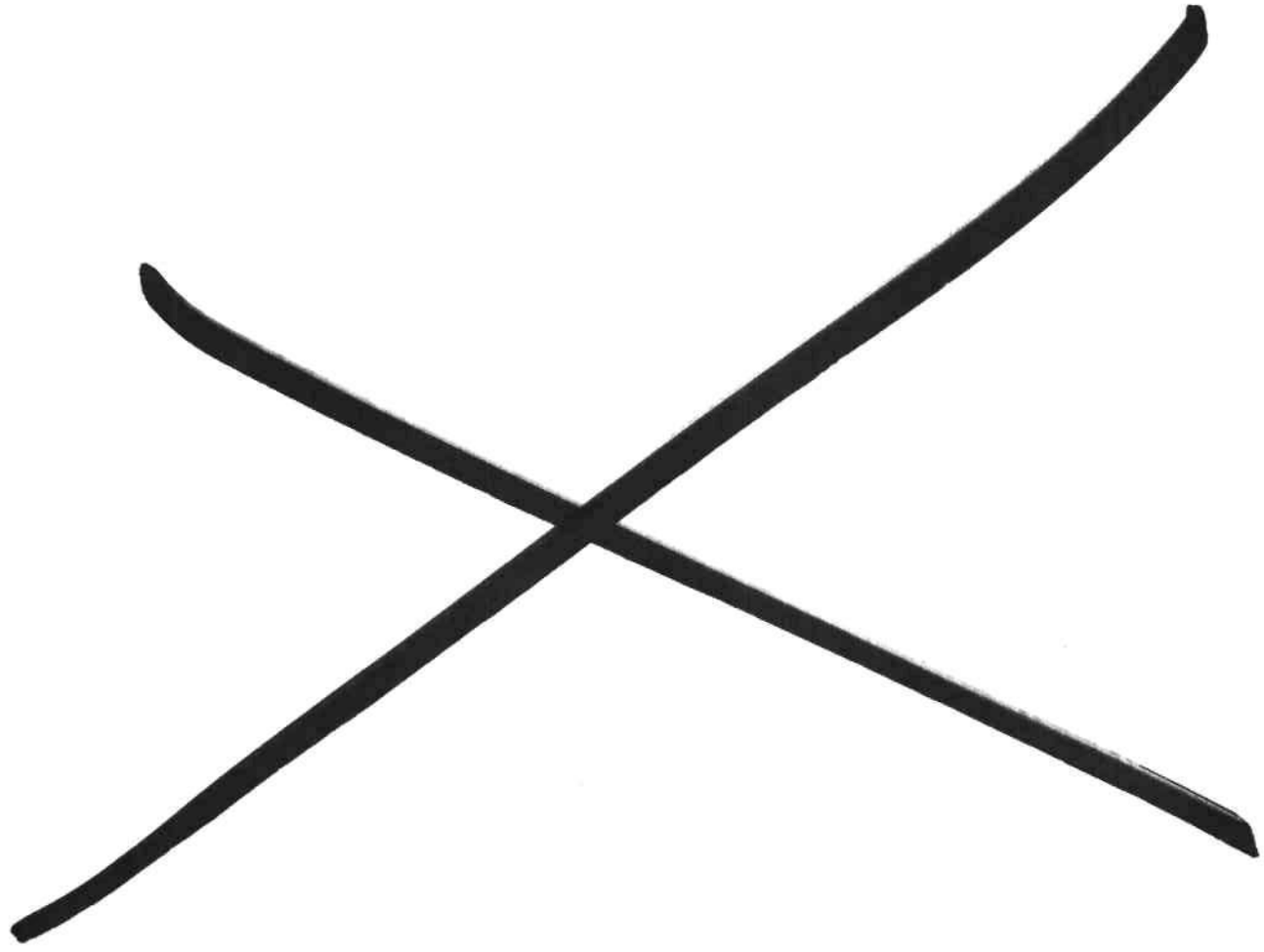
	1988	1989	1990	1991	1992
Leaded—LDCC (50-mil pitch-J bend)	165.0	212.5	221.8	256.7	368.0
Leadless—LCCC (50-mil pitch)	55.0	63.5	66.2	68.3	92.0
Leaded—Ceramic quad flat pack (<50-mil pitch-gull wing)	27.1	60.0	74.1	133.5	246.2
Total	247.1	336.0	362.1	458.5	706.2

Source: Dataquest January 1990

Dataquest recommends that serious consideration be given when specifying the LCCC for new designs and systems, especially when using higher lead count ASIC and microprocessor parts. Sourcing, die size, I/O needs, and reliability will continue to be the major determining factors for the use of LCCC packages. These factors should be kept in mind, because some semiconductor manufacturers have stopped development of new packages based on the leadless ceramic format.

Jim Walker
Greg Sheppard





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Research Newsletter

DEFENSE AUTHORIZATION BILL CLEARS CONGRESS

SUMMARY

The $305.5 billion fiscal 1990 defense budget, which emerged after nearly two months of vitriolic House and Senate conference meetings, represents the fifth straight annual real decline in defense spending.

On November 22, Congress completed final action on the bill but maintained a Gramm-Rudman-Hollings legislation-mandated provision for automatic cuts that will be in effect through the first week of February 1990. The effect is that each spending program will be cut back by a theoretical 1.2 percent from the 1990 budget level. The Department of Defense (DOD), however, will have considerable leeway in determining final disposition of the 1.2 percent cut.

TO CUT OR NOT TO CUT

Although the approved budget authority matches the dollar amount agreed upon at last April's Executive/Legislative budget conference, its content differs sharply from many administration requests (see Tables 1 and 2). For starters, the administration had recommended cancellation of 10 major military systems, including the V-22 Tilt Rotor Aircraft being developed by Textron Bell Helicopter and Boeing Vertol and the Grumman F-14D fighter. The Senate accepted the requests, but the House voted to terminate only two programs, the LANTIRN and the HEMTT 10-ton truck. What emerged from Conference was the cancellation of six programs outright, the continuation of two programs for one year, and a delay in

TABLE 1
Budget Authority Changes Made to Meet Outlay Target
(Billions of Dollars)

Title	Request	Change	Conference
Military Personnel	$ 79.2	(0.5)	78.8
Operation and Maintenance	90.2	(3.8)	86.4
Procurement	78.8	5.7	84.4
Research and Development	39.6	(1.4)	38.2
Military Construction	8.1	(0.2)	7.8
Department of Energy	9.4	0.3	9.7
Drug Interdiction	N/A	0.5	0.5
Other	0.3	(0.3)	0
Total	$305.3		305.5

N/A = Not Applicable
Note: Columns may not add to totals shown because of rounding.

Source: U.S. Congress

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TABLE 2
Major Weapon Systems 1990 Budget
(Billions of Dollars)

	Bush Request	Conference Report
Strategic Defense Initiative	4.9	3.8
B-2 Bomber Northrop, et al.	4.7	4.3
DDG-51 Destroyer Bath Iron Works/Ingalls	3.6	3.5
F-16 Falcon General Dynamics	3.4	3.4
C-17 Cargo Aircraft Douglas Aircraft/Pratt-Whitney	2.9	2.3
F/A-18 Hornet McDonnell Douglas	2.5	2.2
Trident II Missiles Lockheed Missiles and Space	2.0	1.7
M-1 Tank General Dynamics	2.0	2.0
MX and Midgetman Boeing, Martin-Marietta, et al.	2.0	1.9
F-15C/D/E Eagle McDonnell Douglas	1.7	1.7
Trident Submarine General Dynamics	1.3	1.1
Advanced Tactical Fighter	1.1	1.0
SSN-21 Attack Submarine General Dynamics Elec. Boat Div.	1.0	1.0
F-14D Tomcat—Grumman Corp.	1.0	1.8
Patriot Missile—Raytheon	1.0	1.0
AH-64 Apache Attack Helicopter McDonnell Douglas	1.0	0.9
Mobile Subscriber Equipment GTE	1.0	0.9
AMRAAM Missile General Motors/Hughes	1.0	0.8
SSN-688 Nuclear Submarine General Dynamics/Newport News	0.8	0.8
Space Boosters Martin Marietta/McDonnell Douglas	0.7	0.7

(Continued)

TABLE 2 (Continued)
Major Weapon Systems 1990 Budget
(Billions of Dollars)

	Bush Request	Conference Report
CV-SLEP Carrier Service Program Philadelphia Shipyard	0.7	0.7
Bradley Fighting Vehicle FMC Corp.	0.7	0.6
Tomahawk Missile General Dynamics/McDonnell Douglas	0.6	0.6
AV-8B Harrier McDonnell Douglas	0.6	0.6
E-2C Hawkeye Grumman Corp.	0.6	0.4

Source: U.S. Department of Defense

the termination decision for another year for the remaining two programs.

Several major strategic programs were hit hard. SDI took a nearly $1 billion cut from the administration's amended request, or $279 million less than last year's appropriation, which is the first real decline in SDI spending since the program began. The Conference committee also cut $150 million from the administration's requests for the Midgetman and MX missiles. The B-2, while escaping the Draconian measures proposed in the original House language, was slapped with a 9 percent cut and limited to a fiscal 1990 procurement of two planes and long-lead items for five aircraft in fiscal 1991, with the committee including language that prevents obligation of funds until six conditions are met by the administration.

The closest thing to a winner in this year's budget was research and development. For example, the House won the fight in favor of going ahead with the National Aerospace Plane. Likewise, real growth was given to overall science and technology programs, which portends renewed interest in longer-term technological innovation.

HIGHLIGHTS

Program Terminations

Had the conferees adhered to the administration's requests to cancel all 10 proposed weapon systems, they would have saved more than $3 billion in fiscal 1990 and $16 billion during the course of the Five-Year Defense Program. The six programs that were terminated in accordance with Secretary Cheney's request were the HEMTT 10-ton truck, LANTIRN, the SSN-688 (after fiscal 1990), the M-88 tank recoverer, the AH-64 helicopter (after fiscal 1991), and the F-15E fighter.

In an effort to ease the impact on affected companies and workers, the committee decided to extend production runs for both the F-14 and the AHIP helicopter. The conferees agreed to construct 18 more F-14D aircraft, 6 more than even the House had proposed. Grumman, however, will be required to agree that no more Tomcats will be produced; no one on Capitol Hill wants to see another intensive lobbying campaign. The AHIP line also will be terminated after a final production run of 36 units at a cost of $195 million.

Both the V-22 tilt-rotor aircraft, which was given $225 million in R&D funds, and the Raytheon/Hughes Phoenix missile were given "stays of execution" in that any decision on termination was postponed until next year.

Strategic Forces and Nuclear Deterrence

The Strategic Defense Initiative suffered considerably at the hands of the committee. It was reduced to $3.6 billion for DOD and $200 million for DOE; the administration had requested $4.6 billion overall. The committee also extended the two-year-old Congressional prohibition on tests of systems that could violate the ABM treaty.

ICBM modernization saw many trades between the House and Senate leadership. Although leaning toward the Senate spending proposal, the conference accepted House language that caps all MX deployment at 50, regardless of basing mode. The committee's decision to allow the administration to carve up the $1.85 billion between the MX and Midgetman programs will test, in practical terms, the administration's commitment to a mobile system.

Northrop's B-2 bomber still is in trouble despite the approval to fund the production of two aircraft in fiscal 1990. The committee insisted on language that would prevent a repeat of the B-1 fiasco, where multiple problem areas were discovered only after production. The committee language has institutionalized the "fly before you buy" doctrine.

Research and Development

The National Aerospace Plane (NASP) survived the administration's attempts to reduce spending greatly and transfer the entire program to NASA. Because of strong House support, the committee kept DOD in the program and authorized up to $225 million for continued development.

The committee's obligation to high technology again was demonstrated in its decision to authorize $3.51 billion—$220 million over the administration request—for defense science and technology-base programs. This level represents a growth in real terms of 2 percent, with another increase of 2 percent slated for fiscal 1991.

DATAQUEST CONCLUSIONS

If a bright spot can be found in this year's defense package, it is in Congress' continued pressure to force the administration toward spending on long-term technologies.

In real terms, little more is being spent on the DOD's technology base in 1989 than in 1965. In fact, as the House Committee stated, the ratio of research to development spending is now approximately 12 to 1, whereas 24 years ago it was 5 or 6 to 1.

The failure of DOD planners to fund research adequately for the technologies necessary to meet the demands of the 21st century has increasingly angered Congress, which responded this year by mandating several critical technology programs. Likewise, Congress expressed its disappointment with the DOD's effort to produce the mandated *Defense Critical Technologies Plan*. Congress therefore directed the White House to present a *National Critical Technologies Report*, which will then be used for a more comprehensive and detailed plan for fiscal 1991.

In overall funding levels, defense science and technology programs were increased by 2 percent in real terms, bringing them to $3.51 billion. The commitment also was made to up next year's level to $3.77 billion, another 2 percent in real growth.

Among the more notable increases was additional funding for the Defense Advanced Research Projects Agency (DARPA). These additional funds will be used for DARPA's X-ray lithography program, which will receive $40 million; $25 million for the gallium arsenide program; $20 million for the high-resolution display program; and $12 million for artificial neural network research. The government's Semiconductor Manufacturing Technology (Sematech) program received $100 million, and an additional $30 million was added to the defense industrial preparedness programs.

Perhaps the most exciting prospects to emerge from the committee report are several initiatives designed to increase the use of commercial products and technologies and develop a single, uniform regulation for source selection. The former proposal will establish a three-year demonstration program to increase the use of commercial technologies within the defense industry.

All of these changes bode well for industries, both defense and commercial, that are working on cutting-edge technologies. A clear trend is developing, at least on Capitol Hill, to maintain and, if possible, exploit and expand the U.S.'s technological envelope. The action of this year's Conference committee makes clear the legislative commitment to push America's defense establishment and industry toward the next century.

Greg Sheppard
Barry Blechman

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Research Newsletter

GOMAC 1989: JTAG, MIMIC, VHDL EMERGE WHILE DMS LOOMS

SUMMARY

The theme of this year's Government Microelectronics Application Conference (GOMAC) was leveraging emerging technology. The theme was motivated by the ever-increasing need for economically acquired technology in the face of Department of Defense (DOD) spending cuts. The conference had its usual excellent coverage of application papers and support technology developments. Of special interest was coverage of the emerging VHSIC Hardware Description Language (VHDL) design standard, the emerging Joint Test Action Group (JTAG) or IEEE 1149.1 test standard, and early reports from the Microwave/Millimeter Wave Monolithic IC (MIMIC) program. The VHDL and 1149.1 standards both have a chance of becoming broadly accepted commercial standards as well, and their refinement and acceptance warrant close tracking. The session on discontinued parts, which Dataquest cochaired, further addressed solutions to the intractable diminishing manufacturing sources (DMS) problem with microcircuits.

VHDL

Several papers were presented on VHDL CAD tools, application of those tools, and simulation procedures and models. It was pointed out that the standard will be mandated on new IC designs used by the DOD. Additionally, several software companies at the conference demonstrated design systems and simulators. The large amount of attention focused on VHDL at GOMAC underscores its chance for success in addressing the diminishing sources problem; however, the issue of developing standard device simulation models still looms.

One paper from the Institute for Technology Development addressed the device model issue as it described the successful use of a new set of model design guidelines developed by the EIA subcommittee on model standards. Those guidelines addressed the current problem of model accuracy and standardization across different simulator libraries.

It was noted that an EIA subcommittee is working on an analog version of VHDL for possible inclusion in IEEE 1076 specification by 1992.

JTAG-DERIVED TEST STANDARD

Much interest was shown in the proposed IEEE 1149.1 (IC-level boundary scan) and IEEE 1149.X (backplane) testing standards. The proposed standard 1149.1 is based on elements of both the European-developed Joint Test Action Group (JTAG) and VHSIC ETM standards. The principal motivation for 1149.1 was to develop a way to do detailed board-level testing without using board-of-nails testing, a process that is very complex to accomplish with high-density, surface-mount packaging.

Implementing 1149.1 involves placing boundary scan circuitry and adding four control pins on each IC on a given board. Testing on the board then is governed by a separate controller IC. Implementing 1149.1 adds additional die area and pin count to each IC and could add from 10 to 50 percent to the cost of each IC, depending on the circuit size and design partitioning. The advantage of using 1149.1 is the overall cost saving by allowing thorough board testing and early detection of design and manufacturing errors.

Texas Instruments presented several papers on the subject, including detailing its SCOPE design approach as applied to an ASIC design. Texas Instruments also is introducing a line of BiCMOS octals that utilize JTAG.

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Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

MIMIC

With the MIMIC program halfway through its Phase 1 schedule, several papers were presented by the various program team members. At this stage of the program, TRW and ITT reported that they both were on schedule with the development of their share of 21 Phase 1 brassboards. TRW highlighted its progress on heterojunction bipolar transistor technology (HBT), which is unique compared with the FET approaches of the other teams.

A government spokesperson described the program as being approximately halfway to its targets of integration level and cost per function. The cost target for the program includes reducing the cost of solid-state radar transmit/receive modules to $500 from the current estimate of $5,000. Much of the remaining development for this technology has to do with mass production issues including adequate substrate quality, controllable processing (for QML), CAD tools, automatic testing, and packaging.

DIMINISHING MANUFACTURING SOURCES (DMS)

Two DOD papers were presented on the issue of diminishing manufacturing sources (DMS). One paper by Peter Holbrook of the Pentagon addressed the charter of a multiservice committee known as Diminishing Manufacturing Source and Material Shortage (DMSMS) Ad Hoc Working Group. The group is responsible for evaluating the currently disjointed and underfunded DMS efforts that are under way in each service and providing an action plan to address the issue Pentagon-wide. The paper cited the fact that 40,000 DOD-used microcircuit designs are subject to obsolescence in the next two to five years and that the ultimate cost for alleviating the problem could be $2.9 billion. Mr. Holbrook indicated that the group's full report is due in January 1990.

Another DOD paper was given by Theodore Glum of the Air Force Sacramento Air Logistics Center, about the Microelectronics Technology Support Program (MTSP). With multiple contract awards due this month, the $650 million program will consolidate diverse discontinued parts needs across the air force and manage a cadre of qualified suppliers of ASIC emulation, CAD library, and aftermarket technology. The advantages of this program are its multiple funding sources and balanced approach to the problem of obsolescence.

DATAQUEST RECOMMENDATIONS

Although the conference was replete with rich presentations on advanced technology and research applicable to defense electronics, the merchant semiconductor industry was noticeably lacking in representation. Of the approximately 150 papers presented, only 24 were authored or coauthored by a representative of a merchant semiconductor company, and the majority of those were by only one company—Texas Instruments.

Because an estimated 90 percent of the semiconductor supply to government applications is from merchant suppliers, their lack of greater presence is surprising. It is further surprising because the top policymakers in the Pentagon are pushing for greater use of economically efficient, nondevelopmental item (NDI) semiconductor technology as supplied by merchant companies. Granted, the conference also addresses technology needs not currently met by the other 10 percent of the merchant industry, but that should not prevent more merchants from participating.

Greg Sheppard

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Research Newsletter

SENATE BILL S.1352 DIRECTS DOD TO COMMERCIALIZE PROCUREMENT

SUMMARY

Senate Bill S.1352 (DOD Appropriations Act for fiscal years 1990 and 1991) directs the U.S. Department of Defense (DOD) to do the following:

- Limit the clauses required for inclusion in contracts and subcontracts for commercial products to statutory only
- Develop a special inspection clause for commercial products
- Prescribe new regulations limiting the requirement for certified cost or pricing data in contracts for commercial products
- Enhance training for procurement and acquisition personnel in the acquisition of commercial products and NDI
- Assign a focal point in each command for the acquisition of commercial products and nondevelopmental items (NDIs)

This newsletter discusses information included in Senate Committee Report 101-81 on Senate Bill S.1352, examines the bill in terms of its impact on the semiconductor industry, and presents Dataquest's conclusions and recommendations.

SENATE BILL S.1352

Contract Clauses

According to the report, "the elimination and modification of unnecessary and burdensome clauses is one of the most effective means of encouraging the acquisition of commercial products."

Inspection

The report stated that the DOD should take advantage of other approaches to quality assurance. These other approaches included placing more reliance on commercial warranties and rewarding contractors with proven records of performance.

Cost or Pricing Data

Section 822(d) of the bill directs the Secretary of Defense to issue regulations ensuring that a contractor has to submit cost or pricing data in commercial or competitive procurement only if the agency head believes that data is necessary to determine whether or not the contract price is reasonable. This exception is to be applied only where there is no adequate alternative basis to requesting certified cost or pricing data. Such alternatives would include situations where the price is determined to be fair and reasonable based on adequate price competition, price analysis, market research, a review of prices for the same or similar commercial products or services, or similar techniques.

Simplified Procedure Test Program

Section 824 of S.1352 directs the Secretary of Defense to conduct acquisitions using simplified procedures for procurement of commercial products. The bill directs the test program to begin within 270 days of the enactment of the bill and covers a three-year period.

The "Preference for NDI" statute was enacted by the U.S. Congress in 1987 to implement the Packard Commission recommendation that when acquiring defense systems the DOD

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maximize the use of commercial products and previously developed noncommercial products in designing such systems. The objective was that billions of dollars in research and development and inventory carrying costs could be saved through private development and production of items for the defense market. In Senate Bill S.1352, the Armed Services Committee is highly critical of the DOD's slow pace in establishing a preference for privately developed commercial components.

CERTIFIED COST ON PRICING DATA

Because all military- and space-grade ICs are privately developed and produced for the defense/space markets, it would appear that a Mil-Spec IC may be defined as a commercial product within the following:

- The intent of Congress to encourage the maximum use of privately developed products
- Section 822(h), wherein a commercial product definition includes "any modified version of a product or component of any product that is or has been sold in substantial quantities to the general public"

Senate Committee Report 101-81 expresses concern for industry complaints that regulations interpreting exceptions to the requirements for certified cost or pricing data "create a rigid test of commerciality, which in many cases creates an impediment to the purchase of commercial products."

DOD Procurement assured the committee that the problem could be resolved without changes in the Truth-In-Negotiations Act (i.e., the regulations could be revised). The committee directed the Secretary of Defense to "issue regulations ensuring that a contractor is required to submit cost or pricing data in commercial or competitive procurements only if the head of the agency determines that data is necessary to determine whether the contract price is reasonable. The committee directs that this exception only be applied where there is no adequate alternative basis to requesting certified cost or pricing data. Alternatives to requesting cost or pricing data include, but are not limited to, situations where the price is fair and reasonable based on adequate price competition, a price analysis, market research, a review of prices for same or similar commercial products or services, or other similar techniques."

The proposed revisions to the cost and pricing regulations were sent by DOD Procurement to the Defense Acquisition Regulations (DAR) Council in June 1989. These revisions are to FAR 15.804-3, which prescribes the exceptions to requiring certified cost or pricing data, i.e., SF1411 cost proposals otherwise required under FAR 15.804-2 and the Truth-In-Negotiations Act. A careful reading of the proposed revisions to FAR 15.804-3, however, reveals that the solution to the strictures of using these exceptions for nondevelopmental items does very little to resolve the military IC suppliers' problems with the strict interpretation of FAR 15.804-3.

THE SF1411 PROBLEM

The problem with the SF1411 is at least threefold. Consider the following:

- IC prices have little or no basis in cost; they are set by the market.
- Cost as defined by the SF1411 is determined by the supplier's cost-accounting system.
- In defining cost, 19 items of cost are "disallowed."
- Thus, prices determined by such disallowing and by the SF1411 rarely will be consistent with market prices.

Table 1 illustrates the problem for the IC supplier.

A cost-based product price, as required by the SF1411, that is consistent with verifiable cost accounting data is an *average* unit cost approach by product. An average cost-based price never will match the market price by product. The semiconductor industry prices to market; therefore, the SF1411 always will produce an artificial price created by the limitations of cost accounting and *not* by the interactions of supply versus demand and free market forces. Forcing the SF1411 on commercially oriented, market-driven industries simply makes no sense. Only accountants and lawyers will benefit.

The Senate Bill S.1352, the Preference for NDI statute, and the Federal Acquisition Regulations and FAR 11.001 recognize that the definition of a commercial product includes a modified commercial product produced to "peculiar federal requirements." Military- and space-grade ICs are produced from modifications to commercial designs and processes to meet federal requirements.

TABLE 1
Generic IC Supplier Product P&L

Product	Sales	Unit Sales Price	-	Unit Standard Cost	=	Unit Gross Margin	Percentage of Price
A	1 ea	$100	-	$20	=	$80	80%
B	1 ea	80	-	20	=	60	75%
C	1 ea	60	-	20	=	40	67%
Total	3	$240	-	$60	=	$180	75%
Actuals	1 ea	$240	-	$65	=	$175	73%

Source: Government Contract Associates
Dataquest
November 1989

Then why is it that mil-spec/space-grade products have not been recognized as commercial products? The only regulatory constraint is that FAR 15.804-3 excludes from sales to the general public those sales that are for "government end use." Traditionally, buyers interpret products that are manufactured to military/space specifications as being for government end use. Therefore, they are not commercial items and not eligible for exemption.

The revised FAR 15.804-3 regulations, as before, do little to alter the buyer's perception that privately developed items produced to federal peculiar requirements are not commercial items.

If a generic commercial product and its privately developed military counterpart are determined by the buyer to be not "sufficiently similar" or not "substantially the same," the claim of exemption may fail, even if several manufacturers produce the same or a similar product at established prices.

Senate Bill S.1352 establishes a major new policy that stresses the maximum use of privately developed products as the major aspect of DOD procurement reforms. The initial changes in pricing regulations by DOD Procurement indicate that it does not yet understand the SF1411 problem for commercially oriented companies that privately develop products for the federal government and sell at market prices and not at published discounts. If DOD Procurement understood the problem, it would make available a market price exemption alternative to the SF1411, and privately developed items for the defense market would be defined as commercial products.

DATAQUEST CONCLUSIONS

Impact on OEMs

Dataquest believes that an entirely new form of federal contracting and subcontracting will emerge for sales of "commercial" and "modified commercial" products. It will be a hybrid between the Uniform Commercial Code (UCC) and federal statutory law, in the area of general provisions and administration. Major retraining of contracting and subcontracting personnel will be required. Contract clause changes are four years away; however, dramatic pricing changes will emerge in the next three to six months.

Impact on Component Suppliers

Commercially oriented, market-driven companies will have greatly expanded commercial pricing alternatives to the SF1411. Federal contract subcontract structure will not be greatly altered. However, commercial subcontract clauses will be more UCC and commercial practice by industry groups. There will be less flowdown from federal primes. Subcontract price alternatives will be expanded, although market pricing alternatives will be hardly changed. Much retraining of defense contracting personnel will be needed.

DATAQUEST RECOMMENDATIONS

Dataquest recommends that original equipment manufacturers be sure their prime contracting

and subcontracting personnel are kept informed as this scenario unfolds. OEMs should not expect *major* contracting changes for three or four years, unless they are selected for a test program. However, they should budget now for training of pricing and subcontract audit personnel, beginning in the spring of 1990.

Our recommendations for component suppliers are the same as for OEMs, except that their alternatives for market pricing are still greatly limited. However, an initiative is under way with DOD Procurement to make a market pricing alternative available to companies that privately develop, produce, and distribute standard products produced to peculiar federal requirements. The initiative recommends that such "modified commercial products" be classified as commercial products and thus fall within the Senate Bill S.1352 prohibitions against use of SF1411 and the new commercial contracting rules.

Dataquest strongly recommends that all contractors and subcontractors support the Senate Bill S.1352 program for commercialization of federal procurement practices. We suggest that you contact your Senate and House representatives and industry associations immediately. The Senate and House Armed Services Committees are in conference on this issue now.

Greg Sheppard
Richard Kelly

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Research Newsletter

EUROPEAN DEFENSE ELECTRONICS: 1992 AND BEYOND

SUMMARY

Given the general relaxation of military tensions, progress in arms talks, and tightening fiscal constraints, Western European governments are focusing defense resources increasingly on quantitatively smaller but qualitatively more capable forces. This trend emphasizes procurement of electronics and, therefore, semiconductors for new weapon systems, modernization and upgrading of existing systems, and the development of force multipliers such as improved command, control, communications, and intelligence (C3I) systems.

THE MARKET

The determination of the members of the European Community (EC) to integrate Western European markets in 1992 may pose a significant new challenge to non-European defense electronics companies that are seeking contracts abroad. European officials deny any protectionist intent, yet there is considerable concern that outside businesses may be subject to protectionist barriers in various forms—for example, import quotas or local content requirements. Although defense items ostensibly are to be excluded from EC regulations, members have pushed for tariffs on dual-use technologies because of their civilian applications. Because the majority of U.S. defense exports to EC nations are system components, such tariffs could have significant impact on the trade relationship.

The year 1992 will be less a market watershed than a continuation of an ongoing process of integration in Europe. Taking a cue from the success of other pan-European ventures such as Ariane-Space and Airbus industries, the Independent European Program Group (IEPG) has sought to develop a European-wide defense procurement system. European avionics and electronics industries are currently undergoing major restructuring that will probably result in more concentrated groupings in areas such as flight controls, optical systems, and sensors. The GEC/Siemens takeover of Plessey is the most recent example of this concentration. The real effect of the 1992 phenomenon will be the more effective competition from rationalized European industries made possible by integrated economies.

One continuing area of dispute for U.S. and European companies is technology security. European and U.S. government views on the export of high-technology items always have differed, with the United States favoring tighter restraints and political controls over transfers. U.S. restrictions on technology transfers to third-world countries will continue to dampen American exports. Moreover, the relationship between the regulations of the 17-member Coordinating Committee on Multilateral Export Controls (COCOM) regarding restricted technologies and trade relationships involving EC members that are not part of COCOM is not clear.

MARKET OUTLOOK

The outlook for defense spending in the major European countries is not much different than that in the United States. Fiscal and political pressures in every nation are leading to real declines in defense expenditure or, at best, level budgets in real terms. Popular support for defense spending is eroding rapidly in many European states; the erosion is being fed by continuing improvements in East/West relations, increasing environmental concerns, and tighter budgetary constraints overall. Rapid progress in the Vienna talks on conventional forces in Europe could produce an arms-control agreement by the middle of the next decade that will require NATO governments to reduce their ground and air forces by up to 20 percent in some weapons categories.

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These factors threaten the initiation of new development programs as well as the continuation of several high-profile procurement programs that already are under way. As a result, many European governments are looking for means to upgrade existing systems with new electronics rather than procure new weapons. Belgium's decision in May 1989 to reduce defense spending is a case in point, as it dashed previous hopes for Belgian purchases of the European Fighter Aircraft (EFA), the French Rafale, or the Agile Falcon F-16 planned to be developed by the United States and certain European countries.

Traditionally, a strong component of European-produced defense electronics has been exports to the Middle East; however, demand for systems has slowed substantially as the war between Iran and Iraq has subsided and oil-based economies struggle with continuing lower prices of that commodity.

Figures 1 and 2 present Dataquest's forecast of military electronics production and derived semiconductor consumption. We expect electronic equipment production to grow 3.3 percent in 1990 and accompanying semiconductor consumption to grow 5.6 percent.

MAJOR PROGRAMS

Figure 3 presents the estimated total development and production spending and the accompanying electronics content of some of the important, electronics-intensive, Western European defense programs.

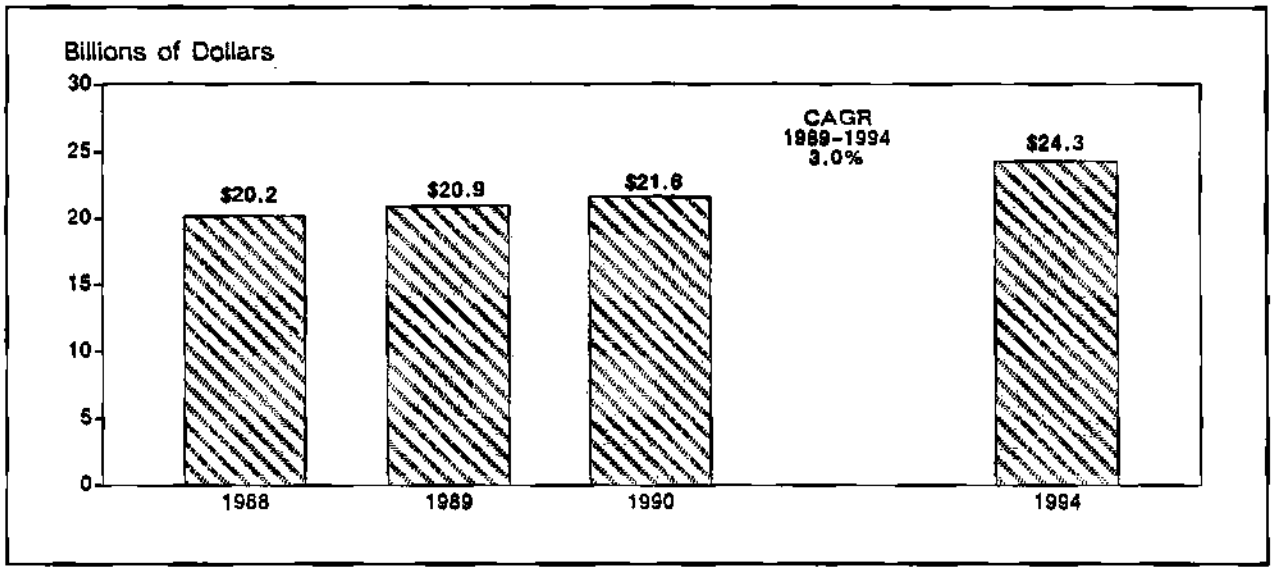
Rafale Aircraft

France dropped out of the EFA program in 1986 to pursue its own new fighter aircraft, the Rafale. Among other things, the Rafale will be armed with an antiradar missile and laser-guided missiles, as well as the MICA and Magic 2 air-to-air missiles. The Rafale also will incorporate terrain-avoidance capability with track-while-scan radar and simultaneous ground attack/air defense scan modes.

A joint company, Avion de Combat European (ACE) International, has been established by the four primary Rafale contractors—Dassault-Breguet (60 percent), SNECMA (20 percent), Thomson-CSF (10 percent), and Electronique Serge Dassault (ESD) (10 percent). Dassault-Breguet will build the airframe, and SNECMA will manufacture the M88 engine for the Rafale. The first prototype is expected to fly in 1991, and full-scale production is scheduled for 1994.

The radar will be based on Thomson's RBG (formerly RDX) multimode phased array radar. Thomson-CSF, with 66 percent of the work, will concentrate on the antenna and air-to-air operating modes; ESD will be responsible for ECCM and air-to-ground operating modes. The $318 million

FIGURE 1
European Military Electronic Equipment Production



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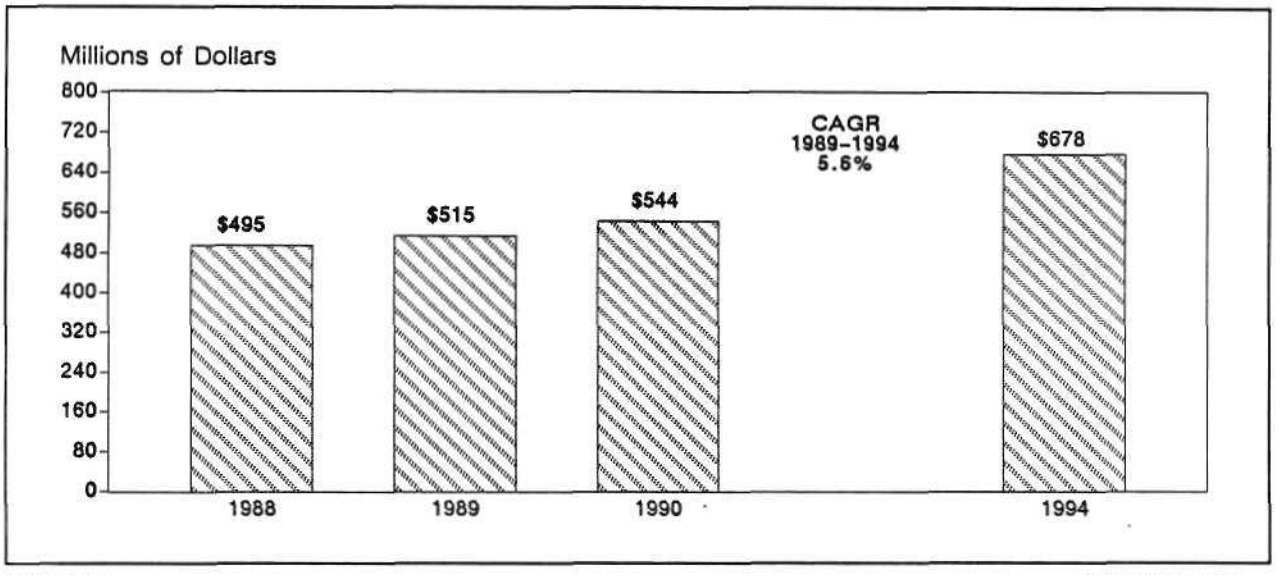
Source: Dataquest
October 1989

FIGURE 2
European Military Semiconductor Consumption



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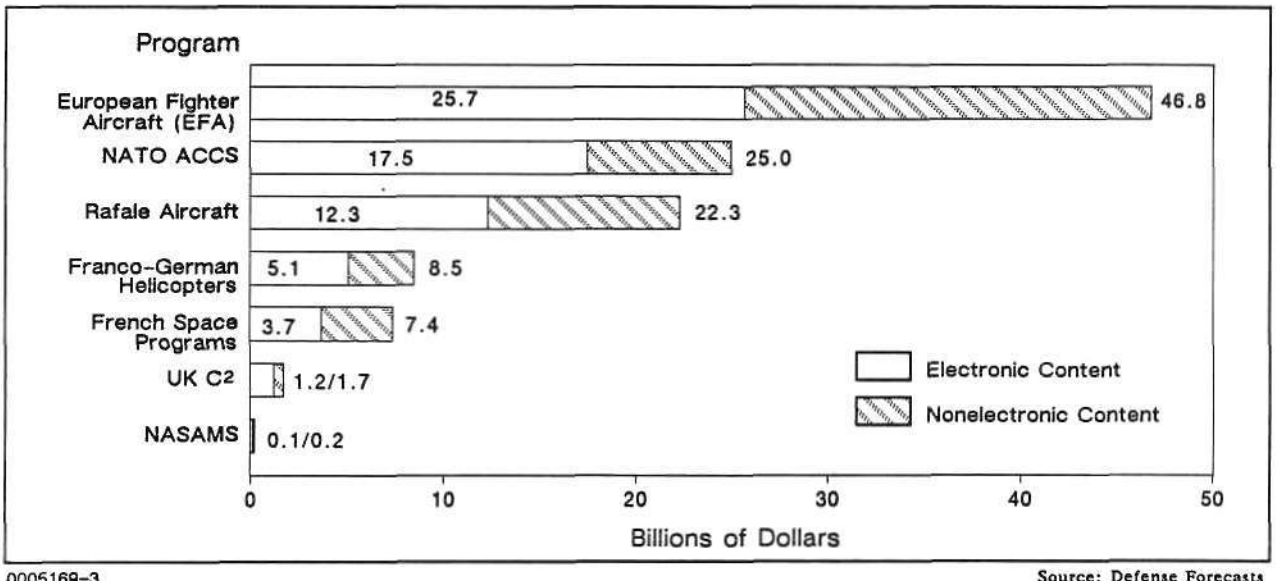
Source: Dataquest
October 1989

FIGURE 3
Important European Military Program Spending



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Source: Defense Forecasts
Dataquest
October 1989

radar contract, which eventually could total approximately $1.6 billion, was awarded to Thomson and ESD in April 1989.

Space Programs

France has an active space program and will be expanding its military satellite program. In December 1988, Minister of Defense Jean-Pierre Chevenement revealed a 15-year military space program that would increase funding as well as European cooperative efforts. The plan calls for spending approximately $7.4 billion to add a radar-based reconnaissance satellite, a ground-based space surveillance system, and an electronic intelligence satellite to existing programs.

France is expected to contribute approximately $1.1 billion between 1987 and 1991 to two satellite programs developed jointly with Italy and Spain. The programs are the Helios military observation satellite and the Syracuse Communications Systems satellite. Another major program is the Telecom (I, II, and III) satellite.

Command and Control Systems

The Improved U.K. Air Defense Ground Environment C2 System (IUKADGE/ICCS) program is approximately five years behind schedule and $200 million over budget. Designed to link air- and ground-based radars and command centers for air defense of the United Kingdom, the largest obstacle for the IUKADGE has been software. Contractors have been using a mix of COBOL, FORTRAN, and RTL 2 programming languages. The total program cost is estimated to be approximately $1.7 billion; the prime contractor is UKADGE Systems Ltd., a consortium comprised of Hughes Aircraft, Marconi, and Plessey. More than 80 percent of the IUKADGE program is funded by NATO.

Norwegian Advanced Surface-to-Air Missile System (NASAMS)

The NASAMS will adapt the Hughes AIM-20 AMRAAM for surface-to-air use as part of the Norwegian southern air defense system upgrade. Beginning in 1991 or 1992, Norway hopes to replace Nike missile batteries with two full batteries of NASAMS. The six-year program will include a total of 18 launchers with 118 AMRAAM missiles; the three-phase contract is valued at $215 million.

The NASAMS fire unit will consist of a Hughes TPQ-36A 3-D low-altitude surveillance radar, a fire distribution center manufactured by Norsh Forrsvarsteknologi A/S (NFT) of Norway and three missile launcher subunits each with six missiles; a battery will consist of three fire units.

HKV, a joint venture of Hughes Aircraft and NFT, was awarded $13 million in early 1989 for a Phase I demonstration and evaluation of this surface-to-air application of the AMRAAM.

JOINT EUROPEAN PROGRAMS

European Fighter Aircraft (EFA)

The EFA is being developed jointly by the United Kingdom, West Germany, Italy, and Spain. A multirole fighter, the EFA will feature, among other things, fly-by-wire controls, stealth characteristics, composite materials, look-down-shoot-down radar, terrain-following capability, and multiple target acquisition systems.

Development work on the aircraft has been divided among the four members of the Eurofighter consortium, according to the proportion of planes each country plans to buy: British Aerospace, 33 percent; Messerschmitt-Boelkow-Blohm (MBB) of West Germany, 33 percent; Aeritalia of Italy 21 percent; and CASA of Spain, 13 percent. A four-country agreement was signed in May 1988 that authorized full-scale development of the EFA, with contracts signed in early 1989 for close to $8 billion. Production is scheduled to begin in 1995, with initial deployment in 1996, but this schedule is not likely to be met. The program calls for 765 aircraft to be produced through 2005, although more may be added later to accommodate foreign sales. Development costs for the EFA are estimated at $10.8 billion, with procurement costing another $36.0 billion.

Electronics manufacturers will be the main beneficiaries of the EFA program, as avionics systems are expected to account for at least one-half, and perhaps as much as 65 percent, of the total cost. Although most electronic subsystems still are in early conceptual stages, a four-country consortium has been formed to bid on design and production of the EFA's digital fly-by-wire flight control system: Aeritalia, Bodenseewerk Geratetechnik (West Germany), GEC Avionics (United Kingdom), and Inisel (Spain). A group led by FIAR of Italy also was formed to develop the infrared search and track system for the EFA. Other members of the group include Eltro of West Germany and Thorn-EMI of the United Kingdom.

Of the EFA's components, its multimode pulse-Doppler radar system requires the longest lead time in development and paces the development of other items. Two multinational industry teams—one led by Ferranti Defense Systems (United Kingdom) and the other by AEG (West Germany) and Marconi Defense Systems (United Kingdom), are bidding fiercely for the contract. Ferranti's proposal, the ECR-90, is based on radars developed for Sweden's JAS-39 Gripen program and in service with the United Kingdom's Royal Navy Harriers. The ECR-90 will use a high-power signal processor that incorporates Ericsson's 32-bit D80A chip. AEG's proposal, the MSD 2000, is based on Hughes' APG-65 radar.

The radar selection already is one year overdue and, accordingly, the delivery of the first 12 flyable preproduction radar units has slipped to November 1991. The entire radar program is expected to be worth approximately $1.8 billion. Work on radar development and production eventually will be divided among the four EFA participating countries using the same ratio as for the overall program.

PAH-2/HAC-3GT/HAP Franco-German Helicopter

France and West Germany are working together to develop and produce a new combat helicopter that will be fielded in the late 1990s. The constant dollar cost of the program is projected at $8.5 billion. Two versions of the helicopter are to be produced: one for antitank missions and one for escort and fire support.

Of the real procurement costs, $1.3 billion is earmarked for mission equipment packages, including navigation aids, observation equipment, weapon sights, fire control gear, and a mast-mounted avionics package. The main contractor for the mission equipment packages will be SOFRADIR, a French concern owned jointly by Thomson-CSF, SAT, and CEA Industries. French and West German subcontractors will be involved. In January 1989, three teams made bids for the avionics and mission management contracts, which are valued at more than $100 million: ESD and Litef of West Germany; Societe Francaise d'Instruments de Mesure (SFIM) and Bodenseewerk Geratetechnik; and a team made up of Crouzet (France), SFENA (France), Teldix (Bosch) (West Germany), and MBB's Dynamics Division (West Germany).

France and West Germany also will jointly develop infrared charge-coupled device (IRCCD) technology for the helicopter's optronic systems. The main contractor for the helicopter program as a whole is Eurocopter, a consortium of Aerospatiale (France) and MBB.

NATO Air Command and Control System (ACCS)

When deployed in the year 2000 (at the earliest), Dataquest believes that ACCS will integrate, process, and relay NATO air-defense tracking and targeting information, providing an automated command and control system to support all European air operations. We also expect data to be gathered into mobile, ground-based automated data processing systems and then channeled into a Combined Air Operations Center for dissemination. The ACCS consists of eight elements: AFATDS, ASAS, FAADC2I, CSSCS, MCS, MSE, and SINCGARS. ACCS funding should double from $4 billion in fiscal 1988 to $8 billion by fiscal 1992. ACCS will replace the existing NATO Air Defense Ground Environment system. Work is expected to begin in 1991 and last 18 years. France has indicated that it may participate.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Because of slowing growth of local defense spending and export markets, Western European defense electronics production growth is expected to remain in the 3 percent range. However, a selected set of modernization and upgrade opportunities remain for electronic OEMs and their semiconductor suppliers.

In the spirit of 1992, defense program spending and risk are being shared increasingly among countries. Additionally, Dataquest believes that the consolidation of defense electronics OEMs is not over. The implication for semiconductor suppliers is that extensive local presence will be needed in multiple countries for each program in order to obtain and retain design wins. As OEMs continue consolidating, they will begin enjoying the benefits of economy of scale, including more purchasing leverage.

Greg Sheppard
Barry Blechman

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Research Newsletter

MILAERO TECH BRIEFS: SEPTEMBER 1989

This bimonthly newsletter provides a useful consolidation of events, announcements, and general news in the military/aerospace semiconductor field. The following publications were used as source material for this newsletter:

Press Release	PR
Electronic Engineering Times	EET
Electronic News	EN
Electronic Buyers News	EBN

DESC HAS ELECTRONIC BULLETIN BOARD

The Defense Electronics Supply Center (DESC) in Dayton, Ohio, has an electronic bulletin board that will make available information such as the QPL and SMD lists, qualification status/schedule, and messaging to DESC personnel. The phone number for information is: (513) 296-6046.

SIMTEK AND PLESSEY TEAM UP

A business arrangement has been announced whereby Plessey will provide manufacturing and marketing capabilities and Simtek (Colorado Springs, Colorado) will provide nonvolatile memory technology. Simtek products include 256K EEPROMs with 70ns access time and a 64K nonvolatile SRAM with integrated EEPROM cell and an access time of 35ns. Plessey plans to incorporate these technologies into their FPGA product line. (EBN, 7/24/89)

SARATOGA OFFERS FAST 16K SRAMs

Targeted at cache, graphics, and writable control-store applications, Saratoga Semiconductor has introduced a 12ns BiCMOS SRAM based on its 1-micron SABiC 4.0 process. It is currently available in SOG, SOJ, and CERDIP and in x8 and x4 configurations. (EBN, 7/24/89)

LEACH SECOND-SOURCES TELEDYNE'S RELAYS

The Controls Product Division of Leach Corporation has an agreement to exchange technical information with Teledyne Relay for the manufacture of military-grade, solid-state relays. The agreement allows Leach to market Teledyne's current 1- to 10-amp relays and all future versions. Solid-state relays are targeted at the electromechanical relay market. (EBN, 7/24/89)

DESC CREATES JAN CLASS S TEST UNIT

The DESC has approved establishment of a quality-assurance facility for JAN Class S microcircuits. It will provide standardized auditing, training, and physical destructive testing (PDA) capabilities not previously available to the Department of Defense and NASA contractors. (EBN, 7/24/89)

IXYS TO ACQUIRE ASEA BROWN BOVERI UNIT

In a move to solidify its position in the power semiconductor business, Ixys of San Jose, California, has announced plans to acquire ASEA Brown Boveri's Power Semiconductor Group. The Brown Boveri units make power modules, thyristors, and ultrafast rectifiers. The projected 1989 revenue for the combined unit is more than $50 million. (EBN, 9/11/89)

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SGS-THOMSON TO ACQUIRE MICROWAVE SEMICONDUCTOR

A letter of intent for acquisition has been signed between SGS-Thomson and Siemens, the parent of Microwave Semiconductor Corporation (MSC) of Somerset, New Jersey. Having dropped out of the GaAs business last year, MSC still produces silicon products. (EBN, 9/11/89)

GRUMMAN TO FOLD TACHONICS

Unable to find a buyer for its Tachonics Corporation merchant GaAs unit, which produces GaAs MMICs, Grumman Corporation has decided to close down operations after current contracts are completed. Grumman's Electronic Systems Division will continue to design GaAs products for the company's space and defense needs. (EN, 8/28/89)

FEI TO MARKET TRW MMICS

FEI Microwave Incorporated and TRW's Electronics and Technology Division have agreed to let FEI market and distribute TRW's millimeter/microwave ICs (MMICs). More than 30 MMIC parts will be ready to market by mid-1990, including those developed by the TRW team, as part of the Department of Defense MMIC program. TRW has a pilot line currently, and it also has established Texas Instruments as a second-source MMIC foundry. (PR, 8/29/89)

INTEL ANNOUNCES 1M EPROM, FAST 64KX8 SRAM

Available to Mil-Std-883C Class B processing, there are three versions of the CMOS 128Kx8 part available in a 32-pin CDIP—150ns, 200ns, and 250ns. Introductory 100-piece prices range from $405 for the fastest to $293 for the slowest.

The CMOS 64Kx8 SRAM is compliant with Mil-Std-883C Class B and has access times ranging from 25ns to 70ns. Pricing is $75 for 100-unit quantities. (PR, August 1989)

MARCONI ELECTRONIC DEVICES AND CTI MERGE

A new operation formed by the merger of Circuit Technology Incorporated (CTI) and Marconi Electronic Devices will be known as Marconi Circuit Technology Incorporated. This unit will manage all U.S. operations including manufacturing and marketing of Marconi Electronic Devices products produced in the United Kingdom. (DE, June 1989)

LOGIC DEVICES ATTACKS FAST 16K SRAM MARKET

Logic Devices, Incorporated, of Sunnyvale, California, has entered volume production on x1, x4, and x8 versions of CMOS SRAMs with access times at 12ns, 15ns, and 20ns, respectively. AT&T will be a principal source of wafers used for the Mil-Std-883C Class B product. Logic Devices also makes CMOS DSP component products. (EN, 7/3/89)

MICRODIE SAMPLES 1-MEGABIT DRAMs

Based on designs by Mosaid, and reportedly silicon from Samsung, Microdie of Torrance, California, is sampling 256K and 1-Mb DRAMs manufactured to Mil-Specs. Speculation is that the product may be produced in Spain in the future. (EN, 7/17/89)

SCORPION TO MAKE AMD PMOS

Scorpion Semiconductor of San Jose, California, announced that it has acquired the rights to Advanced Micro Devices' (AMD's) silicon gate PMOS technology. The full line of PMOS FIFOs and shift registers, as well as mask sets and inventory, was transferred to Scorpion. (EET, 8/14/89)

RAMTRON BREAKS GROUND

Ramtron of Colorado Springs, Colorado, has announced plans to build a 68,000-square-foot R&D facility. A specialist in ferroelectric RAM or FERRAM technology, Ramtron currently procures wafers from non-U.S. sources. (EET, 8/14/89)

MICROSEMI GETS DESC APPROVALS

Microsemi in Broomfield, Colorado, has received approval from DESC for a family of D0-5 rectifiers. Complying to JAN, JANTX, and JANTXV are 1N1186R, 1N1188(R), 1N1190(R), 1N3766(R), and 1N3768(R). (EN, 7/17/89)

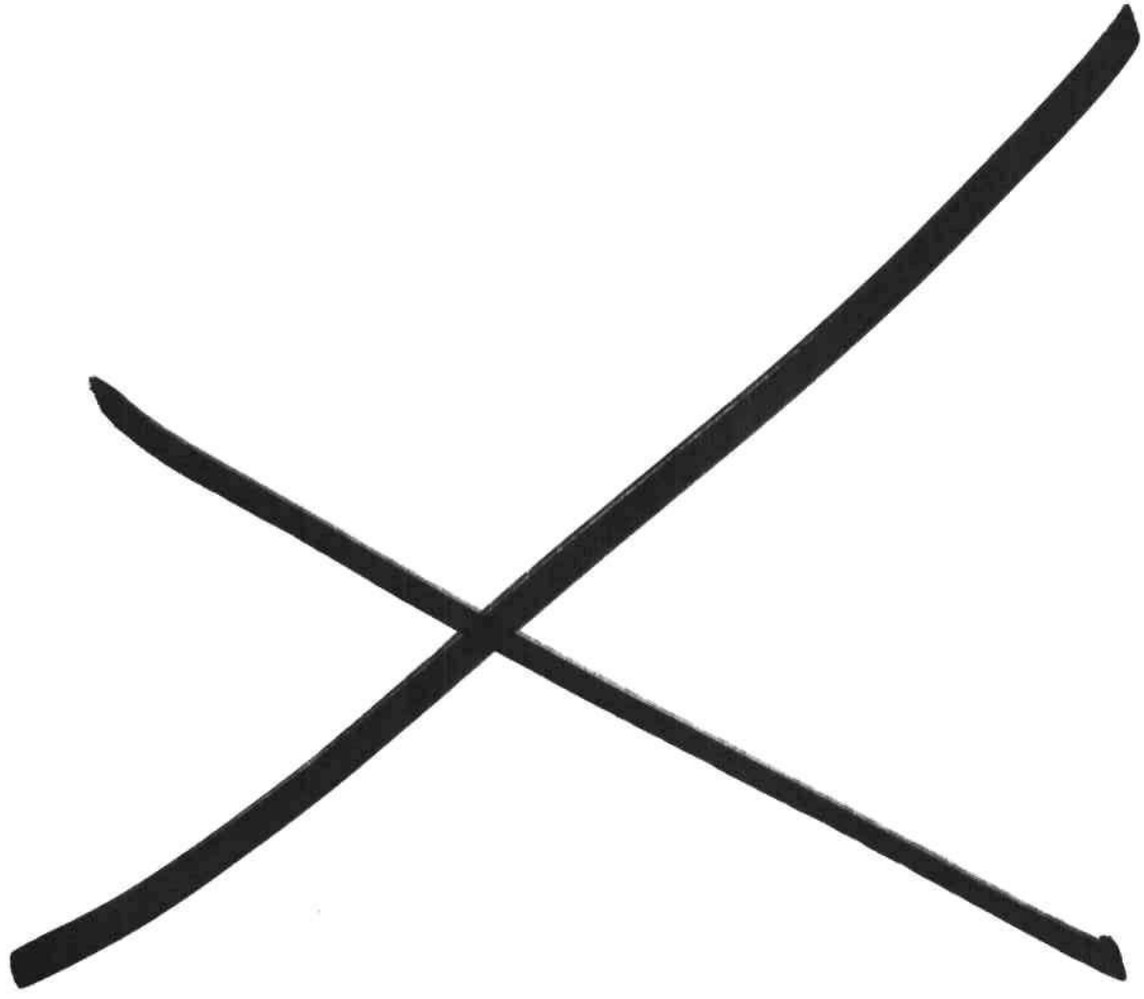
SIGNETICS ANNOUNCES LOGIC SEQUENCER

Signetics has announced availability of a military version of its programmable logic sequencer, the PLUS405. The military version operates at 30 MHz, features a dual clock, and is volume priced at $26.90 in CDIP. (EN, 7/17/89)

TRIQUINT OFFERS CLASS S GaAs/MLC PACKAGING

Triquint Semiconductor has announced DESC approval of GaAs wafers and die processed to Mil-Std-883C Class S. These products complement Triquint's current offering of packaged Class B products. Additionally, the company announced availability of several multilayer ceramic (MLC) packages, including digital versions that can operate up to 2.5 GHz and support 196 pins and a MMIC package that can operate up to 12 GHz. In quantities of 1,000, the price of the 196-pin digital package is $74 and the MMIC package is priced at $18. The company also does custom-MLC package designs. (EN, 7/17/89)

Greg Sheppard



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Research Newsletter

MILITARY/AEROSPACE SEMICONDUCTOR DEMAND: A MIXED BAG

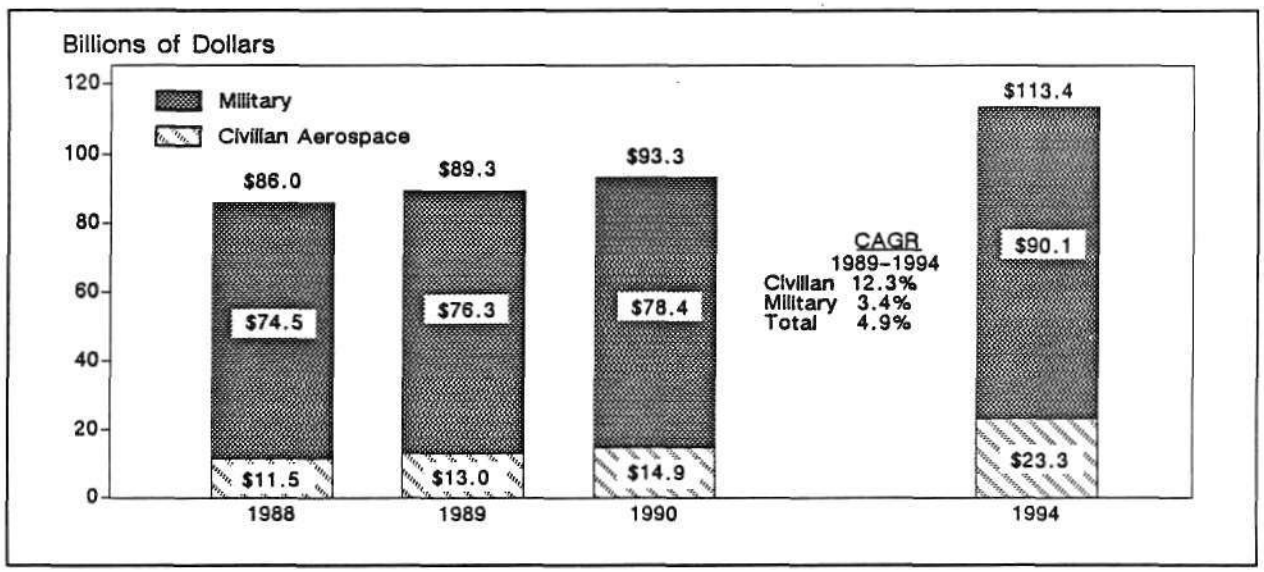
SUMMARY

Slackening worldwide spending on national defense will continue to moderate the need for electronics and semiconductors in the military/aerospace (mil/aero) sector. However, near-term opportunities will continue to proliferate in selected areas of defense such as avionic upgrades, spaceborne applications, and antisubmarine warfare (ASW). The civil aerospace sector is entering a boom period as aircraft order backlogs reach record highs and world air traffic control systems are upgraded. Dataquest expects overall military and civil aerospace electronic production to grow 4.5 percent in 1990, in turn driving a semiconductor growth of 6.6 percent (see Figures 1 and 2). We expect the North American share of the mil/aero semiconductor market to decline to 69 percent in 1994, as the Japan and Rest of World (ROW) regions expand to 8 percent (see Figure 3).

ENVIRONMENT

In general, worldwide expenditure on military equipment has reached a plateau and will most likely recede given the current state of political opinion. With NATO and the USSR striking a reduction agreement in intermediate-range nuclear missiles and talks opening on reducing conventional forces in Europe, much of the political desire to maintain aggressive modernization plans has

FIGURE 1
Worldwide Military/Aerospace Electronic Equipment Production Forecast



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Source: Dataquest
September 1989

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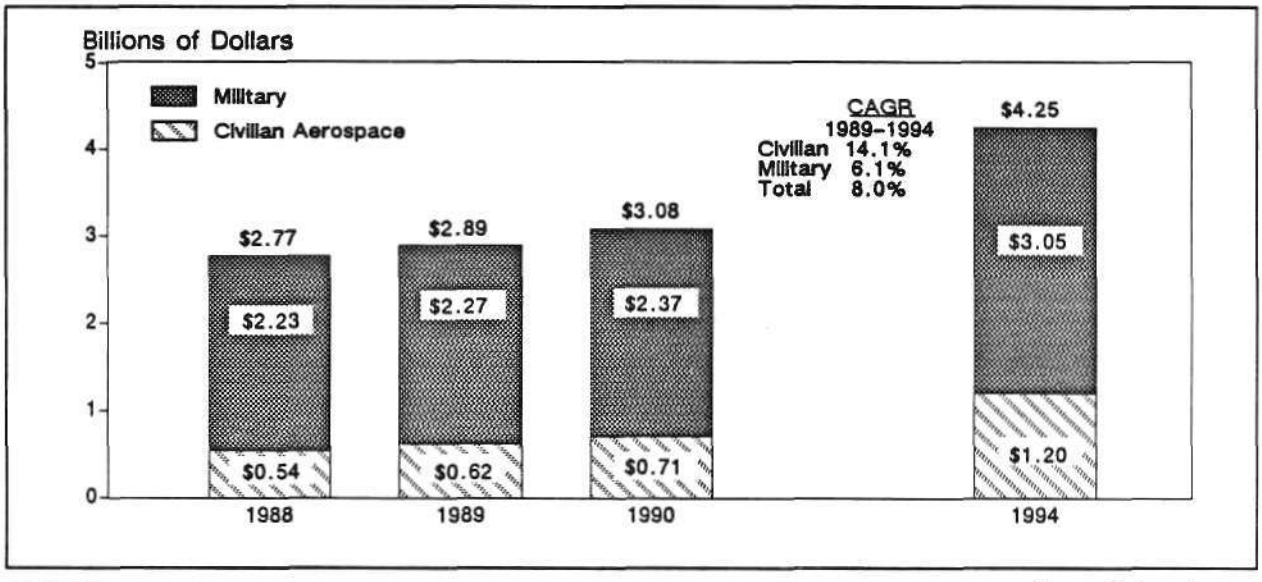
FIGURE 2
Worldwide Military/Aerospace Semiconductor Forecast



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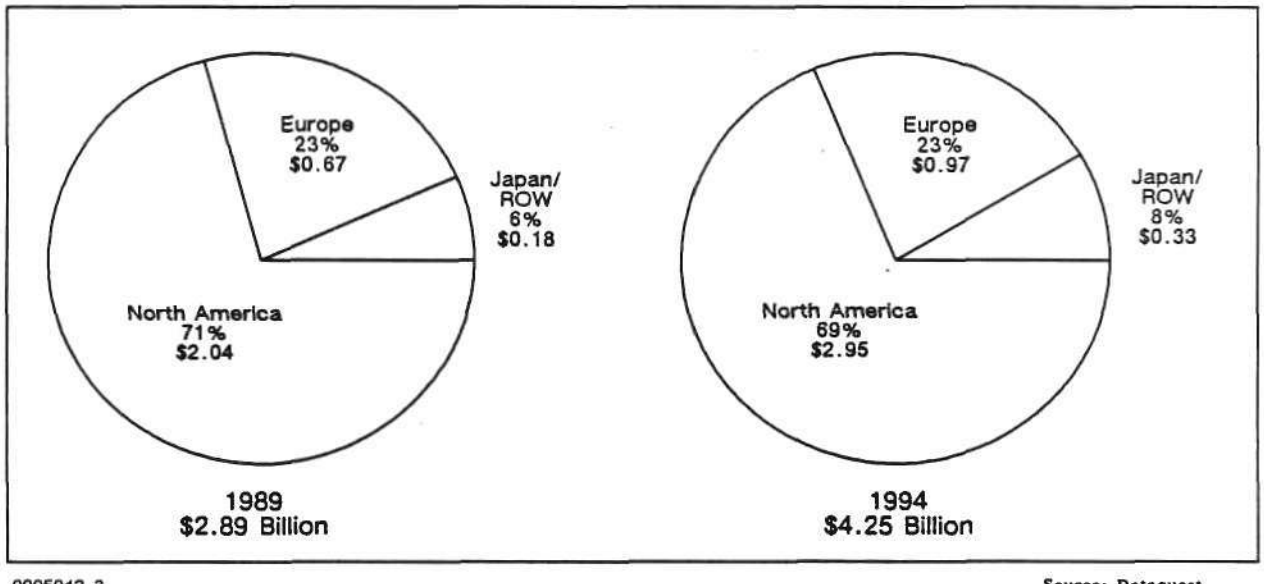
Source: Dataquest
September 1989

FIGURE 3
Geographic Split of Mil/Aero Semiconductor Consumption



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Source: Dataquest
September 1989

eroded. Additionally, cooling tensions between Iran and Iraq, in Afghanistan, and in Africa have slowed third-world demand for equipment.

The U.S. government is bound by the Gramm-Rudman guidelines to reduce its budget, and defense is the prime target for cuts. With desire

for a unified Europe running at a postwar high and also to check spending, European governments are considering substantial defense cuts as well. The net result is that defense spending will at best be flat in real terms during the next five years.

GROWTH APPLICATIONS

Many military systems applications are forecast to continue substantial growth. In addition, Dataquest believes that the entire civil aerospace electronics sector is poised for a large growth surge. Applications that present attractive opportunities include the following:

- Commercial airliners—Employ thousands of semiconductors for digital fly-by-wire control, navigation/communication (nav/comm) systems, and advanced two-person cockpits
- Surging passenger miles and aircraft numbers—Forcing almost every area of the world to upgrade decades-old air traffic control radars, signal processors, displays, and landing systems
- Expanding NASA, European Space Agency (ESA), and Japanese space programs—Space station Freedom to be the international centerpiece
- Unmanned aerial and underwater vehicles—Perceived as more desirable electronics-intensive alternatives to risking lives
- Aircraft upgrade programs—Upgrade programs including improved-capability radar systems, E-O targeting systems, warning and countermeasure units, and nav/comm systems should continue for existing aircraft such as the F-14, -15, -16, -18, -111, B-1, and the Toronado
- Missile guidance and control—Planned upgrades for almost all missiles in production to improve guidance accuracy and reliability
- Space applications—Need for nuclear treaty verification systems, next-generation intelligence and communication (E-O and transponder payloads), and advanced launchers
- Smart weapons—Electronics-intensive torpedoes, shells, and mines
- Embedded NDI computing—Use of off-the-shelf computers and peripherals continuing to expand as use is further encouraged

MARKET DRIVERS

In an environment where defense spending is flat, how does semiconductor demand keep growing at a 5 to 7 percent rate? The principal answer is that continuing penetration of electronics and semiconductors into aircraft, spacecraft, ground vehicles, and shipboard systems expands their functionality, making them more reliable and easier to test and maintain and reducing their size, weight, and power requirements.

Figure 4 presents Dataquest's estimates of how semiconductors will be employed in the 1990s in mil/aero applications. The R&D phase represents the period of time when system designs are developed. Computer-based simulation will be used heavily at this time, and key architectural decisions such as microprocessor architectures will be made. During R&D, many ASIC NRE designs are developed and sample quantity levels of chips are procured. New aircraft programs such as the ATF, ATA, and EFA are examples of programs currently in this phase.

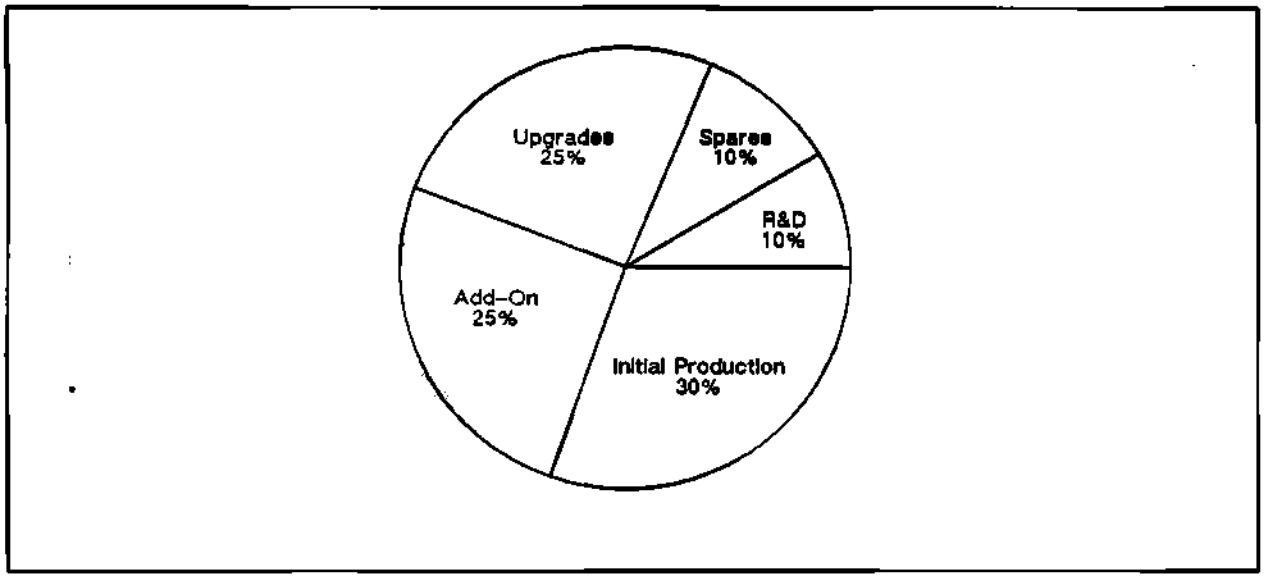
Once the design is completed and the program is funded for initial production, the system design is baselined or frozen and final chip-sourcing decisions are made. The Trident II missile and MILSTAR programs are good examples of programs in this phase. The add-on phase is similar to the initial production phase, except that second sources for both the chips and the systems themselves are potentially developed. The AMRAAM missile program exemplifies this phase as Raytheon became a second source to Hughes Aircraft after the design was completed. The upgrade phase changes meaning when chip-sourcing decisions are opened up again because system designers often redesign part of the system to either correct a problem, take advantage of new technology, update obsolescence, or compensate for unavailable components.

SEMICONDUCTOR MARKETS

What's Hot

Figure 5 presents what Dataquest expects to be lucrative semiconductor product areas in mil/aero applications for the North American and Western European marketplaces.

FIGURE 4
Semiconductor Usage by Type of Military Program



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Source: Dataquest
September 1989

In addition, the following products and technologies should emerge in the 1990s as significant displacers of current technologies:

- High-speed bus upgrade of 1553B
- Fiber-optic MUX ICs
- 32-bit DSP MPUs
- Super high performance and precision amplifiers
- GaAs MMIC ASICs
- Power/motor control ASICs
- Specialty memories (cache, dual ports, video RAMs)
- Ferroelectric memories
- Flash memories
- Optronic chip interconnect
- High-density multichip module packaging
- Automated mixed-signal design, simulation, and test generation
- Sensitive, large IR imaging arrays

Logical Logic

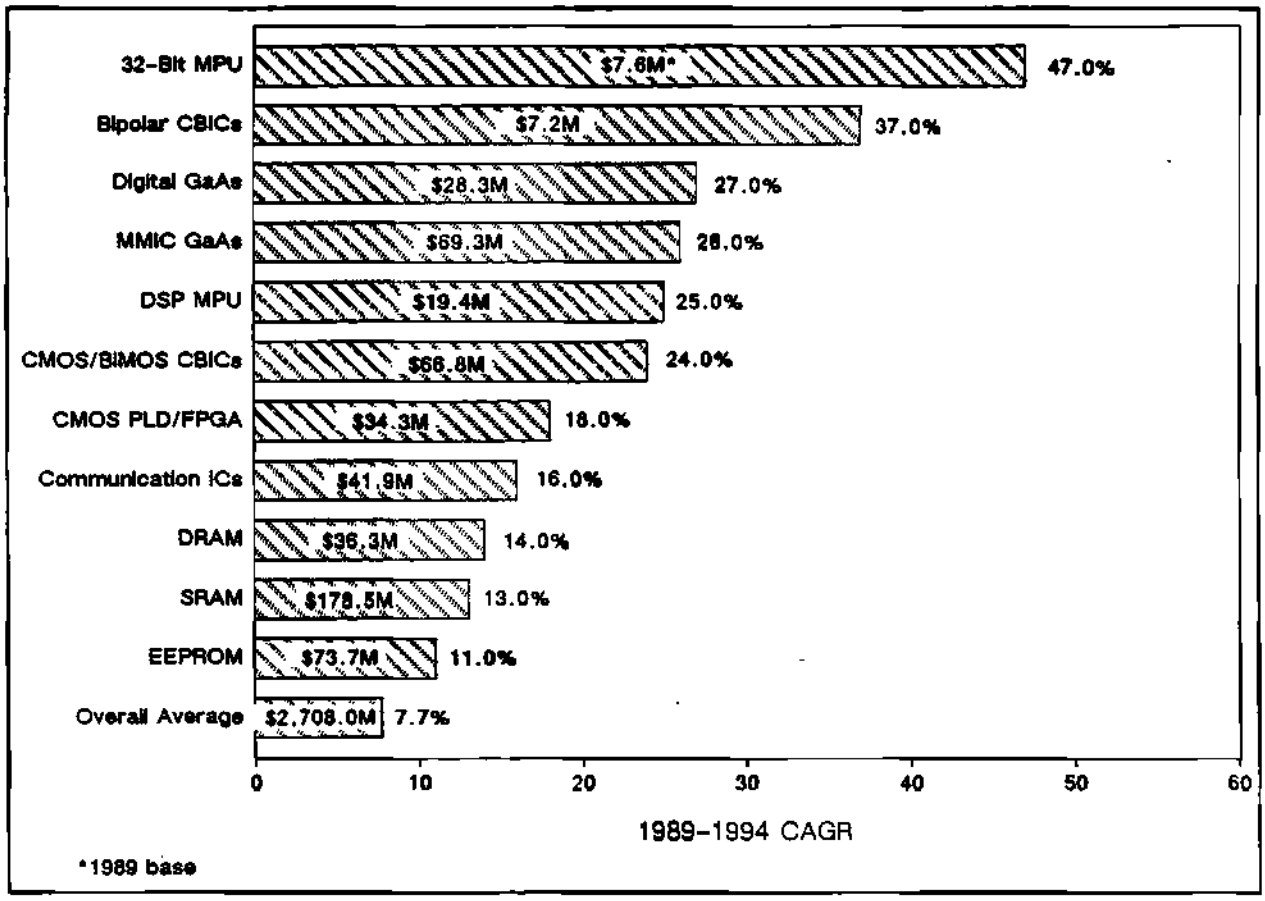
All forms of cell-based IC, including bipolar, CMOS, and BiCMOS digital and mixed-signal varieties, should experience good growth during the next few years as they seriously compete with gate arrays for the greater-than-10,000 gate designs. A key swing factor in this market will be the vendor support of the VHDL design language standard and its application to device simulation models.

In the 5,000 to 10,000 range, CMOS PLDs and field programmable gate arrays (FPGAs) should capture the interest of many system designers because of their high densities, improved design tools, and ease of use. Much of the growth of ASICs will continue at the expense of bipolar standard logic. Most of the bipolar logic families rapidly are approaching the obsolescence phase of their life cycles.

Standard VLSI

Currently, 8-bit MCUs such as the 8051 and 16-bit MPUs such as the 68000 and 1750A dominate mil/aero applications. As in commercial applications, the 32-bit MPUs, 16-bit MCUs, and DSP

FIGURE 5
High-Growth Mil/Aero Semiconductor Products (North America and Europe Markets)



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Source: Dataquest
September 1989

MPUs will capture a sizable share of new and upgrade sockets as the 1990s unfold. However, because of longer system lifetimes and a desire not to rewrite installed software, Dataquest believes that the current designs will be difficult to displace rapidly. DSP MPUs have been in the market development phase for some time but now are starting to ship to programs that are going into production. Analog Devices, Motorola, and Texas Instruments are the key players in military applications. The 1553B communication ICs now are shipping into almost every electronics platform.

Memories

Overall, mil/aero systems are becoming more memory intensive in order to serve expanded digital embedded control. Therefore, SRAMs and EEPROMs in particular are serving growing volatile and nonvolatile needs. In both cases, we expect the 256K density levels to become the dominant density during the next two years. DRAMs also are finding many uses in applications such as decoys, countermeasures, and sonobuoys.

Analog and Discrete

For front-end applications in systems such as radar, electronic warfare, and missile guidance, Dataquest expects GaAs MMICs to emerge as a significant market through the early 1990s to displace hybrid/discrete versions. Further demand for higher precision and performance amplifiers, 12- and 16-bit data converters, and specialized motor/

actuator control ICs also is expected. MOSFETs should continue their applications growth across the board.

Rad-Hard Needed but Opinions Differ

There is no doubt that rad-hard requirements are expanding and a growth potential of twice the current overall rate exists. In particular, tactical applications in avionics should continue expanding. However, there is substantial confusion in the market over testing, the guaranty of operation, and functional versus parametric performance specifications. Many organizations are working on standards for this area, and we expect the market to become more defined when those are in place.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

We believe that many opportunities remain in the military semiconductor business, and certainly the entire civilian aerospace sector presents many application opportunities. With defense budgets being cut and procurement practices in turbulence, semiconductor companies and OEM users need to remain patient.

In the United States, the introduction of the qualified manufacturers list (QML) approach to certify a supplier's capability and the standard military drawing (SMD) most likely will help leverage commercial technology more easily into mil/aero applications. This situation will be beneficial to all parties, as it helps make the hi-rel business easier to serve and preserves a broad and deep supply base.

In Europe, the emerging support and strength of CECC specifications for components, as nurtured by the upcoming 1992 phenomenon, will most likely require extensive local presence in order to serve the market well. It would behoove companies to monitor these situations closely and to position themselves accordingly.

Greg Sheppard

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Research *Newsletter*

MilAero Code: Newsletters: July–September
1989–10
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MILAERO TECH BRIEFS: JULY 1989

This bimonthly newsletter provides a useful consolidation of events, announcements, and general news in the military/aerospace semiconductor field. The following publications were used as source material for this newsletter:

PR – Press release
EN – Electronic News
EBN – Electronic Buyers News
AW – Aviation Week and Space Technology

ZILOG EARNS JAN CERTIFICATION

Zilog announced certification of its MOD II CMOS process manufacturing line in Nampa, Idaho. This facility will fabricate, assemble, and test CMOS products. Scheduled for release during the fourth quarter of 1989, the CMOS Z80 CPU will be Zilog's first JAN–certified CMOS product. (PR, April 1989)

XILINX INTRODUCES FPGAs

Targeting the fast–growing field programmable gate array (FPGA) market, Xilinx has announced availability of MIL–STD–883 Class B 1,800– and 2,000–gate FPGAs. With plans to release versions that have as many as 9,000 gates, the higher–density versions could prove to be viable alternatives to factory–programmed ASICs. (PR, March 1989)

THOMSON–CSF EMBRACES 88000

Thomson–CSF of France, one of the world's largest defense electronic companies, has announced that it will adopt the Motorola 88000 RISC microprocessor family for its defense electronics systems. Furthermore, Thomson–TMS, Thomson's military and space

semiconductor subsidiary, will be an alternate source for the 88100 CPU and 88200 cache and memory management units, as well as future militarized versions of the 88000 family. (PR, May 1989)

NATIONAL ENTERS FCT MARKET

National Semiconductor has extended its broad coverage of the standard logic market to the high-drive FCT segment with the June introduction of six MIL-STD-883 Class B octal parts. Another eight are expected to be introduced by July 1989. With typical electro static discharge tolerance exceeding 10kV, these parts are available with Level S and radiation-tolerant processing. (PR, June 1989)

BROOKTREE OFFERS MILITARY DACs

Brooktree of San Diego is marking its entry into the MIL-STD-883 market with a large range of DAC products targeted at graphics/imaging applications. Introductory products include a 30-MHz triple 8-bit DAC in a 40-pin CDIP; a 50-MHz single 8-bit DAC in a 24-pin side-brazed DIP; and two RAMDACs, including a 125-MHz version with a 256x24 color lookup table with triple 8-bit video DACs packaged in an 84-pin ceramic PGA. (EBN, May 15, 1989)

INTEL RELEASES FLASH DEVICE

Intel is offering a 256K flash nonvolatile memory device qualified to MIL-STD-883 that is suitable for applications requiring periodic updating, such as threat tables and navigation systems. That version can be reprogrammed a minimum of 100 cycles, and a newer 1Mb military version is undergoing qualifications with a minimum 10,000 cycle capability. (AW, June 19, 1989)

ATMEL TO PURCHASE HONEYWELL OPERATIONS

Atmel of San Jose, California, a $60 million nonvolatile memory manufacturer, has announced its plan to purchase Honeywell's Solid State Electronic Division in Colorado Springs, Colorado. The facility currently has approximately 1,000 employees and produces bipolar and CMOS ASICs, as well as sensors. The 250,000-square-foot facility contains 3- and 4-inch lines and a 38510 certified, Class 10, 6-inch CMOS line capable of submicron processes. (EN, June 12, 1989)

PMI OFFERS HIGH PRECISION OP AMP

The OP-177 has an offset voltage of only 10uV at room temperature and 20uV maximum over the full military temperature range. This fact, coupled with a voltage drift of 0.1uV/degree Celsius, eliminates the need for external trimming and increases system accuracy over temperature. Military grades are priced at $9 for 100-piece quantities. (PR, May 1989)

UTMC ENTERS RAD-HARD SRAM MARKET

United Technologies Microelectronics Center is offering an 8Kx8 SRAM to complement its rad-hard gate array offerings. The product is based on a proprietary CMOS design that has low-temperature processing to enhance the total dose hardness properties. Single-event upset (SEU) critical versions in 1,000-piece quantities are priced at $1,037 each, and SEU tolerant versions are $246 each. (EBN, June 19, 1989)

ALLIED-SIGNAL IS MERCHANT

Previously functioning only as a captive supplier, Allied-Signal Microelectronics Center in Columbia, Maryland, clearly has positioned itself as a merchant semiconductor company. The company has a 60,000-square-foot Class 1 wafer fab with a capability of 1.2-micron CMOS processes. The company's products include 40 and 50 MHz MIL-STD-1750A MPUs, MIL-STD-1553 interface ICs, digital cell-based ICs, and a 64K silicon-on-insulator (SOI) SRAM. (EN, 6/12/89)

AVANTEK PRODUCES X-BAND MODULES

Avantek has developed and put into production a 5W solid-state power amplifier module that operates in the X-band (9.2 to 10.2 GHz). Having produced 2,300 of these modules for phased array radar applications, the company anticipates the price of a module to be $100 to $200 in quantities of 500,000 within five years. (AW, May 22, 1989)

Greg Sheppard

NEW DIRECTORY OF DATAQUEST PUBLICATIONS

A new directory describing 30 Dataquest Research Publications is now available from Dataquest's Direct Marketing Group. The directory includes information on the following:

- Monthly newsletters on global semiconductor, information systems, and office equipment markets
- SpecCheck specification guides for hundreds of facsimile machines, copiers, personal computers, and printers
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THE ASIC PACKAGE PROLIFERATION

SUMMARY

Surface–mount technology is now mainstream. Dataquest believes that surface–mount devices (SMDs) will continue to grow at a pace that exceeds traditional packaging and assembly techniques. As ASICs continue to grow in usage, many new surface–mount package families will be developed. This will cause multiple package choices for the same IC, resulting in difficulties for design engineers, assembly engineers, and purchasing agents (i.e., nonstandard packages for second–sourcing). It could make it more costly for semiconductor manufacturers to compete.

This newsletter will discuss the packages currently being used or under development for ASICs. It will also review the issues and choices pertaining to standards involved in ASIC packaging.

INDUSTRY ANALYSIS

Dataquest expects the worldwide integrated circuit package market to grow at a 10 percent compound annual growth rate (CAGR) from 1987 to 1992. We expect surface–mount devices to continue to show the greatest gain. They are expected to grow from the current level of 20 percent (year–end 1988) to almost one–half of all IC packages (48.4 percent) by 1992. These statistics are shown in Tables 1a and 1b.

The forecast shows the fastest growth area to be the quad flat package (76.3 percent CAGR). This is directly related to the worldwide increase in ASIC production.

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

Table 1a

Estimated Worldwide Shipments by Package Type (Millions of Units)

Package	1987	1988	1989	1990	1991	1992	CAGR 1987-1992
Plastic DIP	23,194	26,282	25,292	21,741	21,103	20,625	(2.4%)
CERDIP	3,346	3,738	3,274	2,778	2,783	2,727	(4.2%)
Ceramic DIP	270	277	250	231	225	203	(5.9%)
Quad/Ceramic and Plastic	284	805	1,357	1,640	2,785	4,833	76.3%
Ceramic Chip Carrier	207	315	374	383	430	562	22.1%
Plastic Chip Carrier	508	1,024	1,412	1,513	1,987	2,792	40.6%
SO	3,092	4,954	6,202	7,167	9,396	12,881	33.0%
PGA/Ceramic and Plastic	234	614	983	1,118	1,583	2,339	58.5%
Other (TAB/COB/ FCHIP)	470	860	1,224	1,480	2,249	3,817	52.0%
Others	479	657	684	596	612	608	4.9%
Total	32,084	39,526	41,051	38,647	43,153	51,386	9.9%
Total of SMT	4,561	7,958	10,569	12,183	16,847	24,885	40.4%
Percent of SMT	14.2%	20.1%	25.7%	31.5%	39.0%	48.4%	

Table 1b

Estimated Worldwide Shipments by Package Type (Percent)

Package	1987	1988	1989	1990	1991	1992
Plastic DIP	72.3%	66.5%	61.6%	56.3%	48.9%	40.1%
CERDIP	10.4	9.5	8.0	7.2	6.5	5.3
Ceramic DIP	0.8	0.7	0.6	0.6	0.5	0.4
Quad/Ceramic and Plastic	0.8	2.0	3.3	4.2	6.5	9.4
Ceramic Chip Carrier	0.7	0.8	0.9	1.0	1.0	1.1
Plastic Chip Carrier	1.6	2.6	3.4	3.9	4.6	5.4
SO	9.6	12.5	15.1	18.6	21.8	25.1
PGA/Ceramic and Plastic	0.7	1.6	2.4	2.9	3.7	4.6
Other (TAB/COB/ FCHIP)	1.4	2.2	3.0	3.8	5.2	7.4
Others	1.4	1.6	1.7	1.5	1.4	1.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Percentages may not add to 100.0% because of rounding.

Source: Dataquest
June 1989

PACKAGE TYPES

Quad Flat Packs—Old and New

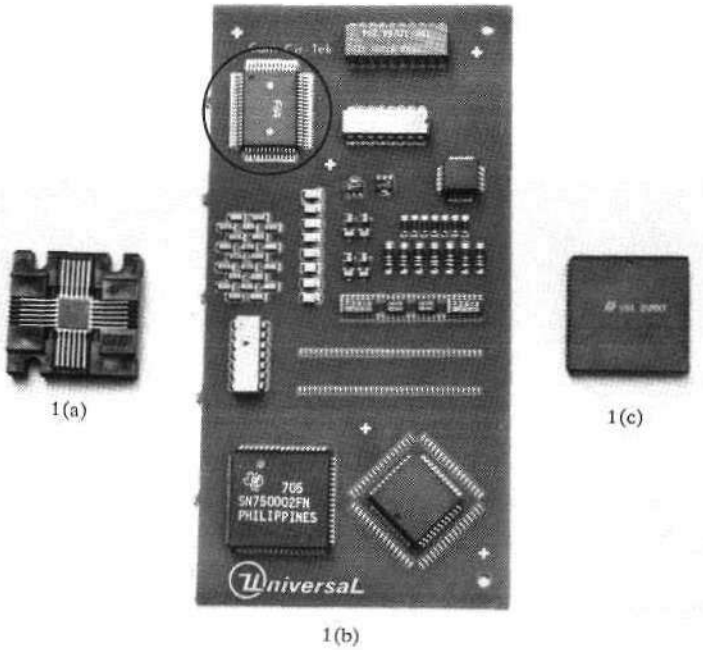
The true, original flat package is not new. Based on 50–mil lead spacing and ceramic technology, it has been and still is used primarily in military applications. The quads are mostly flat, retangular packages with bodies constructed of alumina or beryllia, with glass–to–metal seals. The long leads are splayed out away from the package body on all sides, in a gull–wing–style lead form. Lead counts generally range from 12 to 28 leads. Figure 1(a) shows a photograph of a ceramic quad flat package.

As commercial development of surface mount became prevalent in the early 1980s, the Electronic Industries Association of Japan (EIAJ) began to develop its own plastic versions of the quad flat package. These packages were based on the premise of keeping package body sizes the same and varying the lead pitch, thus increasing lead count density. Pitches of 1.0mm (39.4 mils), 0.8mm (31.5 mils), and 0.65mm (25.6 mils) form standards that define packages from 20 to 240 leads, depending upon body size. This package is also called the quad flat pack (QFP), as seen in Figure 1(b).

Expanding on this, the U.S. manufacturers agreed that placing leads on all four sides of a package was beneficial. But bending the leads underneath the package would increase density even further, and it also could be compatible with the ceramic leadless chip carrier board footprint. Thus the J–bend plastic leaded chip carrier (PLCC) was developed, with lead counts ranging from 18 to 100 leads on 50–mil center lead spacing (see Figure 1(c)).

Figure 1

Ceramic Quad Flat Package



1(a) 1(b) 1(c)

0004254-1

Source: Dataquest
June 1989

However, the PLCC on 50-mil spacing did not address the increasing demand of ASIC products for higher lead counts (more than 100 pins). So, the United States through the Joint Electronics Device Engineering Council (JEDEC) developed the plastic quad flat package (PQFP) for this requirement. It uses the same plastic body sizes as the PLCC, but has leads on 25-mil centers and a molded "bumper" protruding from each corner for lead protection during handling. Lead counts for this package family range from 44 to 244 leads, and the gull wing is the preferred lead form (see Figure 2).

Figure 2

Plastic Quad Flat Package

0004254-2

Source: Dataquest
June 1989

Finer Pitch Packages

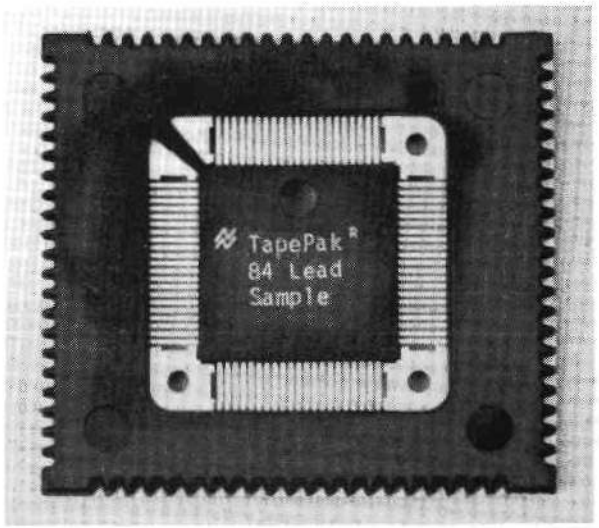
With the consumer market driving for smaller, less costly electronic gadgets and the ASIC market needing higher lead count packages, the Japanese have developed yet another package family: The shrink quad flat package (sometimes called the very small quad flat package (VQFP)). In some ways, this family is an extension of the EIAJ quad flat package (QFP). It also uses standard body sizes, but the package is one-half the thickness, and the lead pitches are reduced to 0.5mm (19.7 mils), 0.4mm (15.7 mils), and 0.3mm (11.8 mils). Lead counts range from 32 to 520 leads.

Besides those mentioned, two more surface-mount package families have recently been introduced into the market for ASIC packaging. One is TapePak developed by National Semiconductor; the other is the TQFP, a TAB quad flat pack developed by LSI Logic.

TapePak uses TAB (tape automated bonding) tape as the lead frame that is attached directly to the die. No wire bonding is used. This die–on–tape combination is then molded in plastic so that an outside ring is formed apart from the inside encapsulated die. This outside ring provides for lead protection and test capabilities. The package body is excised from the carrier ring by the pick–and–place machine and is subsequently attached to the printed circuit board. Like the Japanese quad flat pack, the TapePak family uses standard body sizes with lead counts from 40 to more than 460 leads on 20–, 15–, and 10–mil pitch. This package is shown in Figure 3.

Figure 3

TapePak



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Source: Dataquest
June 1989

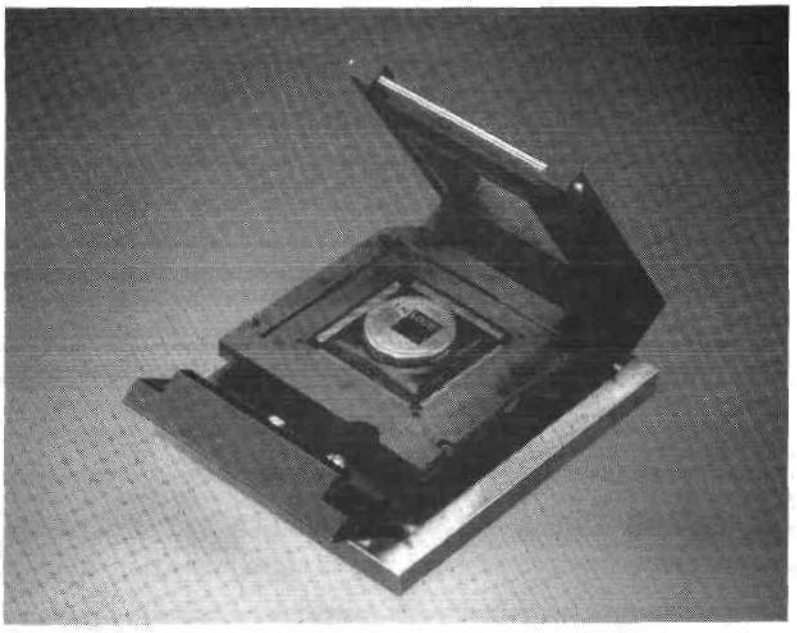
The TQFP is similar to TapePak, except for the following:

- It uses wire bonding for lead counts up to 300 and TAB from 300 to 524 leads.
- The die is encapsulated, using a liquid epoxy "blob."
- A two–piece plastic disposable slide carrier is used for lead protection and test.
- Pin counts range from 164 to 524 leads.

A picture of the TQFP is shown in Figure 4.

Figure 4

TAB Quad Flat Pack



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Source: Dataquest
June 1989

Higher Lead Counts and the No-Package Package

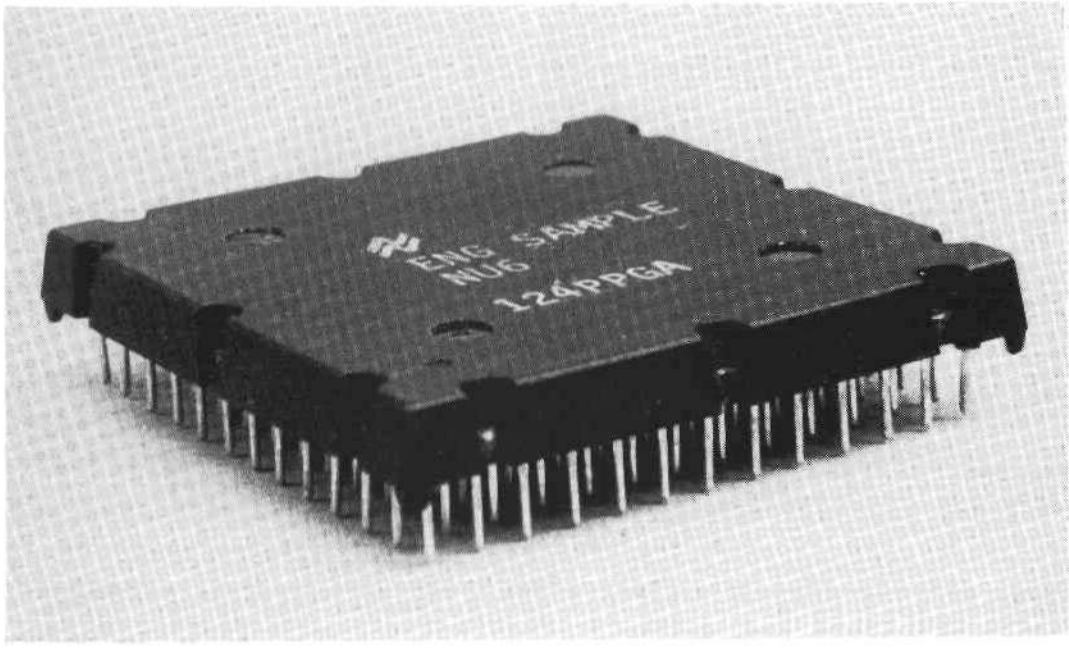
Another packaging solution to ASICs is the pin grid array. Although not assembled to the board using surface-mount technology, it does provide high-density capability to 1,000 leads and beyond. Rows of pins on 100-mil spacing (and more recently 50 mil) are arranged in a grid format to form the PGA (see Figure 5). It is available in both ceramic and plastic and is capable of dissipating more heat than most surface-mount packages.

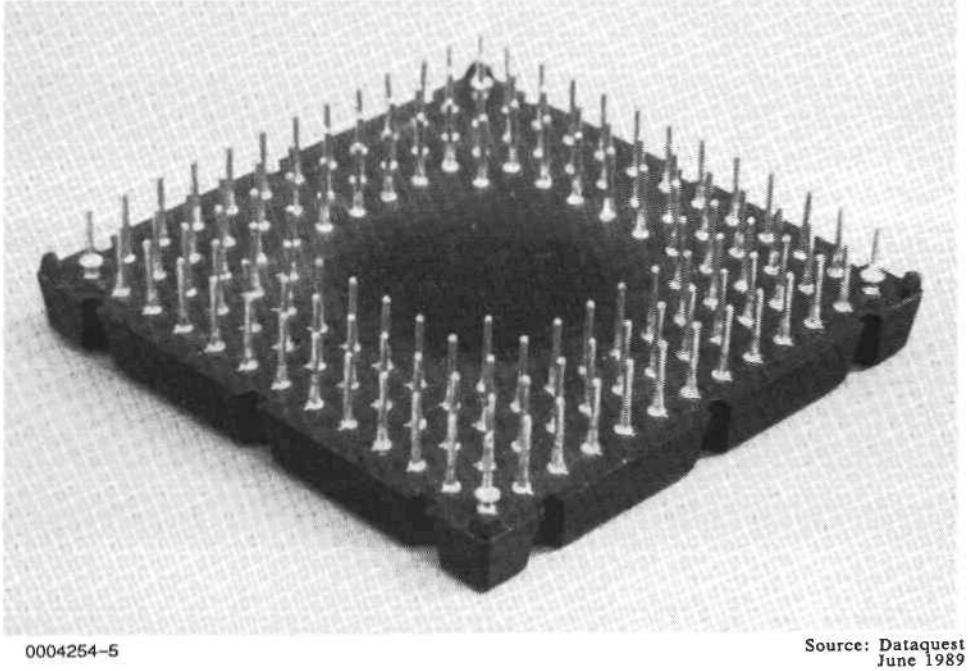
There is one more approach to ASIC packaging that does not really use a package in the traditional sense. Chip-on-board (COB) technology enables the bare die to be attached directly to the printed circuit board. The die is attached to the board via an adhesive (usually epoxy) and wire-bonded directly to the pads or traces on the PCB. After bonding, the die is usually coated with a blob of plastic material to provide for mechanical and environmental protection.

Variations of the COB approach include TAB-on-board (TOB). Component leads are etched on single-layer or multilayer copper/copper-polyimide tape. The tape is etched to form patterns that correspond to the die pad layout. These patterned leads then make the connection between the die and the printed circuit board. Whereas wire-bonded COB is done on a chip-by-chip basis, TOB can be done via an automated, reel-to-reel process. The die-on-tape can then be attached to the board and encapsulated, as in the COB process. An example of TOB is Siemens' Micropak. A basic flow of the TOB process is shown in Figure 6.

Figure 5

Rows of Pins Forming the PGA





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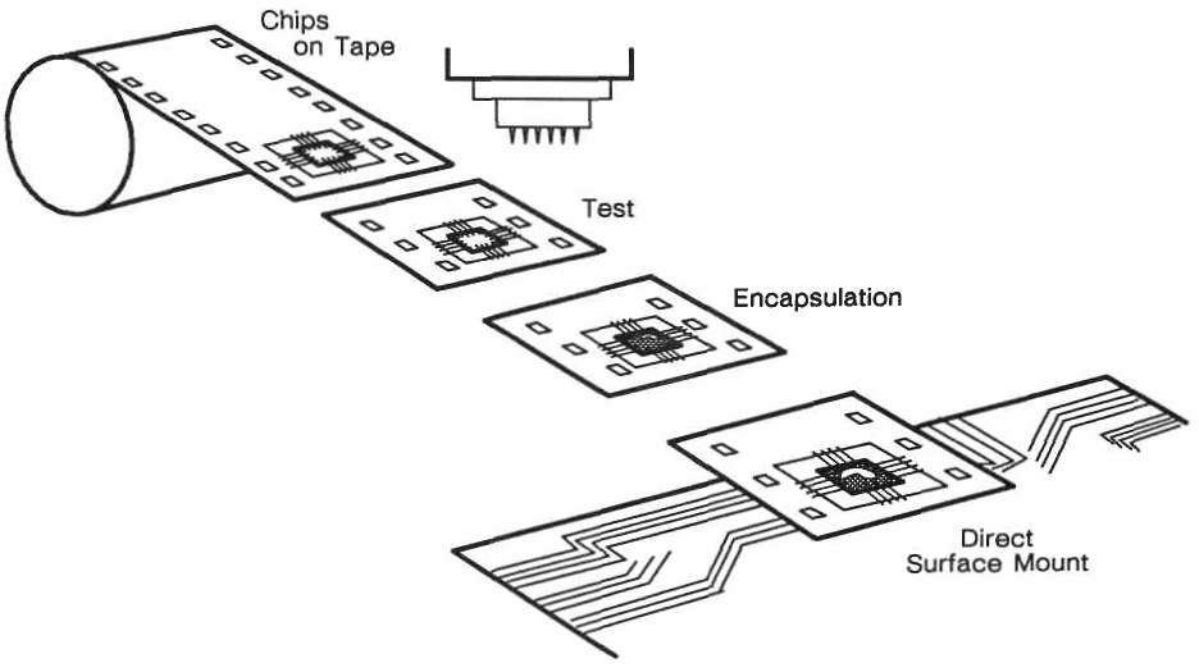
Source: Dataquest
June 1989

Figure 6

TOB Process (Basic Flow)



0004254-6

Source: MESA Technology

Finally, flip chip is one other assembly process that can be used in ASIC packaging. This process was developed by IBM in the late 1960s and is known as C-4, for controlled-collapse chip connection. It is basically a process in which the chip is designed for facedown reflow soldering. The bond pads are bumped with solder while in wafer form. Passivation (silicon nitride) is added, and the wafer is tested via the solder bumps. After testing, the dice are placed facedown, or flipped, on the ceramic substrate, and the assembly is heated in a furnace to reflow the solder. The surface tension of the solder aligns the dice properly to the substrate. This is the maximum use of interconnect density, as no lead frame, wires, or tape are used.

A DESIGNER'S NIGHTMARE

What package should an ASIC design engineer choose? Assuming that it is an ASIC requiring 68 leads, the following choices can be made if a plastic package is desired:

- 68-lead PLCC (JEDEC)
- 68-lead PQFP (JEDEC)
- 68-lead QFP (EIAJ)
- 68-lead VQFP (EIAJ)
- 68-lead TapePak (JEDEC)
- 68-lead PPGA (JEDEC)
- 68-lead COB (No standard)
- 68-lead TOB (EIA/IPC/ASTM)
- 68-lead Micropak (Europe/DIN)

The following section discusses the above listing in more detail. Table 2 lists some common specifications for each package.

Table 2

68-Lead Package Options*

	Lead Pitch	Lead Width	Package Size	Package Height
PLCC	0.050"	0.028"	0.950" sq.	0.180"
PQFP	0.025"	0.012"	0.550" sq.	0.102"
QFP	0.0256"	0.0118"	0.394" x 0.551"	0.100"
VQFP	0.0118"	0.004"	0.197" x 0.276"	0.050"
TapePak	0.020"	0.010"	0.505" sq.	0.072"
PPGA	0.100"	0.018"	1.14" sq.	0.180"
COB	0.008"	0.0014"	0.378" sq.	0.032"
TOB	0.020"	0.010"	0.378" sq.	0.032"
Micropak	0.0197"	0.009"	0.386" sq.	0.025"

*See Appendix A attached to this newsletter.

Source: Dataquest
June 1989

One can readily see that little, if any, compatibility exists among the various packaging styles, except possibly COB versus TOB. This means that designing with an ASIC from supplier A in PQFP (JEDEC) may not be compatible with the ASIC from supplier B in QFP (EIAJ), even if the silicon function is the same. The possible result is a sole-source supplier based primarily on package offering, not silicon.

STANDARDS ACTIVITY

There has been criticism of industry organizations for their lack of leadership in setting surface-mount standards. Some is justified, as it is difficult to get everyone to agree on one of anything, whether it be process, part, or package. There are major differences between the U.S. and Japanese styles of packages. Work needs to continue to bring commonality to this area.

Package standardization is proceeding within the United States at a faster rate as surface mount becomes a proven technology. To address industry awareness and the need for areas of standardization in surface-mount technology, representatives from EIA, IPC, JEDEC, and ASTM have joined together to form the Surface Mount Council. In January 1989, they issued a document entitled "Survey Report: Surface-Mount Standards, Requirements, and Issues."

This report surveyed responses regarding the awareness and usage of 14 typical standards currently available to the industry. In the case of integrated circuit components, the survey found that only 61 percent of the respondents used all or part of the EIA JEP-95 specification (JEDEC Registered and Standard Outlines for Semiconductor Devices). Eighteen percent were aware of this standard but did not choose to use it, and 16 percent were not aware of the standard. Highlights from this report related to component standards are shown in Table 3.

Table 3

Surface-Mount Component Standards

	Use Standard	Use Part of Standard	Do Not Use	Unaware of Standard
EIA RS 481A--Taping of SM Components for Automatic Placement	30.6%	18.8%	17.6%	20.0%
EIA PDP 100--Mechanical Outline for Registered and Standard Electronic Parts	14.1%	29.4%	16.5%	27.1%
EIA JEP 95-JEDEC--Registered and Standard Outlines for Semiconductor Devices	24.7%	36.5%	17.6%	16.5%
EIA JESD 11--Chip Carrier Pinouts for CMOS 4000HC and HCT Circuits	9.4%	17.6%	16.5%	44.7%

Source: EIA/IPC Surface Mount Council

In addition, many organizations worldwide have established committees to discuss issues related to surface-mount technology. A list of these is shown as follows:

- ACPI (Automated Component Placement and Insertion Group)—c/o AMP, 1000 AMP Drive, Harrisburg, PA 17112
- ANSI (American National Standards Institute)—1430 Broadway, New York, NY 10018
- ASTM (American Society of Testing and Materials)—1916 Race Street, Philadelphia, PA 19103
- BSI (British Standards Institute)—2 Park Street, London, W1A 12BS, United Kingdom
- CSA (Canadian Standards Association)—178 Rexsdale Boulevard, Rexsdale, Ontario, Canada
- DOD (U.S. Department of Defense, Naval Publications Center)—5801 Tabor Road, Philadelphia, PA 19120
- EIA (Electronic Industries Association)—2001 Eye Street N.W., Washington, D.C. 20006
- EIAJ (Electronic Industries Association of Japan)—250 West 34th Street, New York, NY 10119
- EMPF (Electronics Manufacturing Productivity Facility)—1417 North Norma Street, Ridgecrest, CA 93555
- IEC (International Electrotechnical Commission)—3 Rue de Varembe, 1211 Geneva 20, Switzerland
- IEPS (International Electronic Packaging Society)—114 North Hale Street, Wheaton, IL 60187
- IPC (The Institute for Interconnecting and Packaging Electronic Circuits)—7380 N. Lincoln Ave. Lincolnwood, IL 60646
- ISHM-I/SMT (International Society of Hybrid, and Microelectronics, Interconnect and SMT Division)—Box 2698, Reston, VA 22090
- SEMI (Semiconductor Equipment and Materials—International)—805 E. Middlefield Road, Mountain View, CA 94043
- SMART (Surface-Mount and Related Technologies Group)—3 Lattimore Rd., Wheathampstead, Herts AL4 8QF, United Kingdom
- SMC (Surface-Mount Club)—British Overseas Trade Board, 1 Victoria St., London SW1H 0ET

- SMC (Surface-Mount Council—Joint ASTM/IPC/EIA/JEDEC Committee)—c/o IPC, 7380 Lincolnwood Ave., Lincolnwood, IL 60646
- SMEMA (Surface-Mount Equipment Manufacturers Association)—71 West St., Medfield, MA 02052
- SMTA (Surface-Mount Technology Association)—5200 Wilson Road, Suite 107, Edina, MN 55424
- STACK (Standard Computer Komoponenten GmbH)—5775 Wayzata Blvd #700, Minneapolis, MN 55416
- VRCI (Variable Resistive Component Institute)—c/o Bourns, Inc., 1200 Columbia Avenue, Riverside, CA 92507

DATAQUEST CONCLUSIONS

We believe that package proliferation will continue as the ASIC market develops. Many new packaging schemes will arise to meet the speed, thermal, and density requirements needed. Custom and semicustom packaging, including multichip modules using COB and TOB, will become more prevalent. Procurement of semiconductor integrated circuits will depend upon package needs and functions in addition to the basic electrical parameters of the chip. As a result, purchasers will need to specify even more details when ordering.

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Mark Giudici

Appendix A

Package Standards

PLCC	JEDEC Publication 95, MO-047AA-AH
PQFP	JEDEC Publication 95, MS-069
QFP	EIAJ Specification IC-74-4, 1986
VQPF	EIAJ Specification IC-74-4-I, 1988
TapePak	JEDEC Publication 95, MO-071
TQFP	JEDEC Publication 95, under consideration
PGA	JEDEC Publication 95, MO-083
COB	Standards not available. Use TOB guidelines.
TOB	JEDEC UO-017 and Surface Mount Council--IPC/EIA/ASTM Publication SMC-TR-001, Guideline Introduction to Tape Automated Bonding Fine Pitch Technology
Micropak	Based on DIN 15851

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Research *Newsletter*

MilAero Code: Newsletters: July–September
1989–8
0004193

MILITARY SEMICONDUCTOR PRICING TRENDS

SUMMARY

In 1989, pricing of military–specification (mil–spec) semiconductor products is expected to be relatively stable. Dataquest expects continued erosion of the maturing bipolar standard logic families, as alternatives such as ASICs and CMOS replacements affect this market. Standard analog product pricing is expected to remain relatively firm at historically low levels for the next two years; pricing of discrete products also is expected to remain relatively firm during the forecast period.

Microcomponents and ASICs are expected to continue fetching the highest premiums over commercial–grade functions. Fast SRAMs are still priced at six to eight times more than their commercial plastic equivalents, but substantial competitive pressure during the next few years will drive prices down at a faster rate than in previous years.

TRENDS

Standard Logic

Price erosion in the most used logic family, low–power Schottky (LS), should continue in the near term, but should stabilize and even begin an upward trend in the long term as the supply base shrinks. Intense competition is expected to continue driving down pricing for Fairchild Advanced Schottky TTL (FAST) in both the JAN and 883C versions. Advanced low–power Schottky (ALS), Schottky (S), and high–speed CMOS (HCMOS) pricing is expected to remain firm through early 1990. Pricing for the various AC/ACT/FCT families is expected to continue moving down aggressively as competition becomes more intense. Intense competition is expected as a result of standard military drawing (SMD) and qualified parts list (QPL) catalogs filling out and of a reduction in the premium over bipolar versions. Relative pricing of selected standard logic families is shown in Figure 1.

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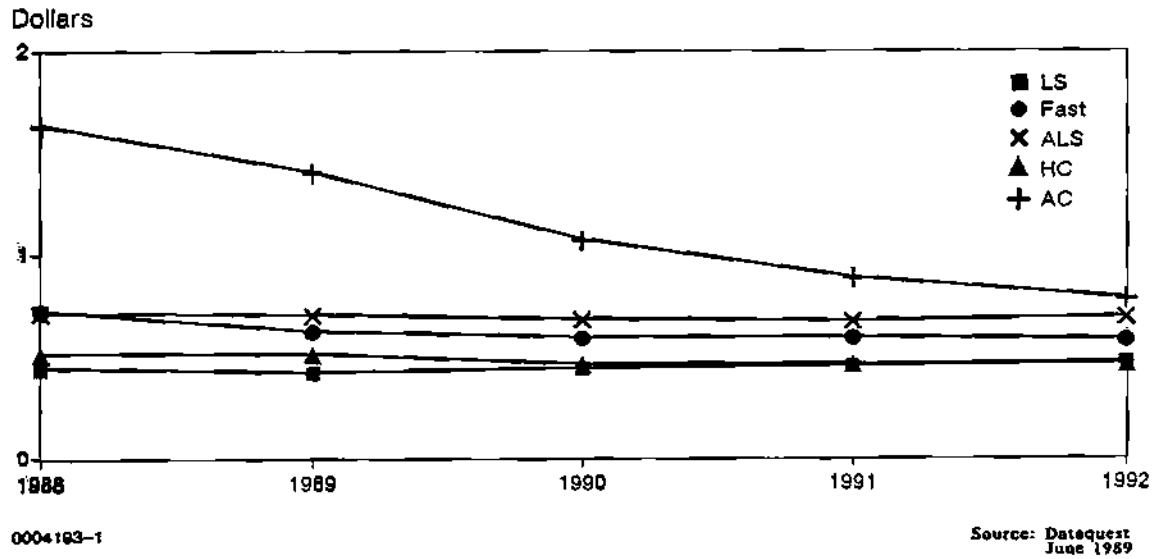
Figure 1

Military Standard Logic Price Trends
(5400—883C Class B)



Microcomponent

Prices of 16-bit MPUs are expected to drop an average of 15 percent in 1989 and 1990. Prices of older versions will not decline as rapidly, but competition is expected to drive down pricing for the newer versions of the 68XXX, 80XXX, and MIL-STD-1750A families. Prices for the newer 16-bit versions of these products are in the $300 to $500 range.

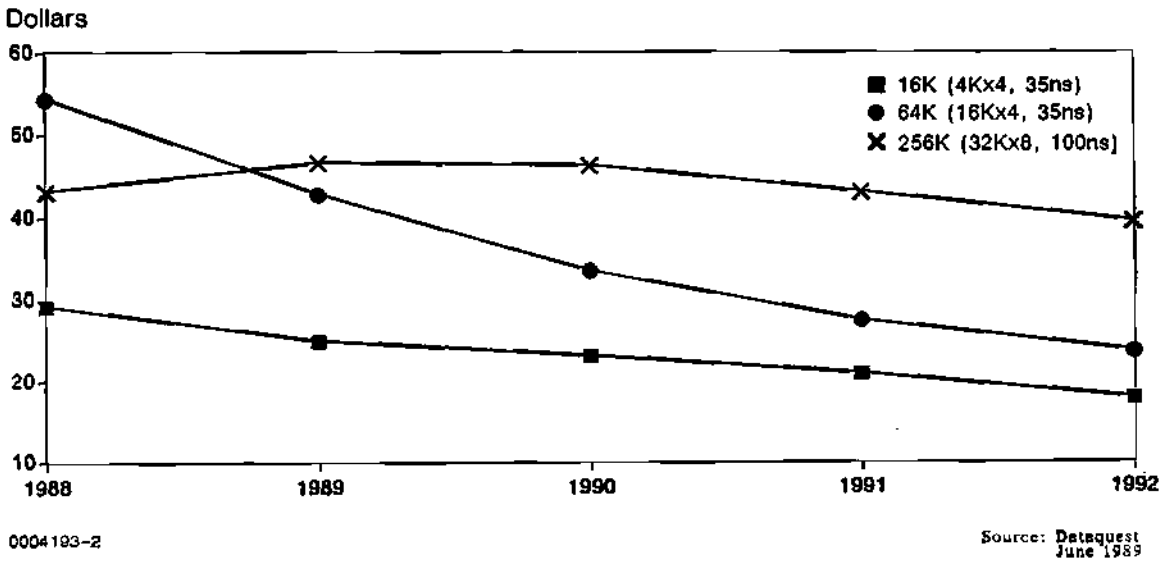
The 32-bit MPUs generally are in the design-in phase; thus, prices remain relatively buoyant at $500 for slower versions and $1,000 for 25-MHz versions. In the early 1990s, large, high-volume avionics programs are expected to help drive down 32-bit MPU prices to the $500 range. We expect 8-bit MCU pricing, such as for the 8051 family, to decline 8 to 12 percent during the next two years.

Memory

Increasingly aggressive competition is expected to continue pushing down 64K fast SRAM prices approximately 20 percent per year during the next two years (see Figure 2). The fast SRAM category has attracted several suppliers, as it remains a profitable, high-growth niche in the mil-spec market. Pricing for slow SRAMs, such as the 32K x 8 256K, 100ns version, is expected to remain buoyant through 1989. This is because most of the slow SRAM supply comes from resource-limited DRAM production lines.

Figure 2

Military SRAM Price Trends
(883C Class B)



Pricing for 64K EPROMs is expected to remain firm as these products enter their sunset phase, while prices for 256Ks should drop 10 percent a year for the next two years under competitive pressure. EEPROMs are in strong demand; however, competitive pressures also are strong and have kept 883C 64K prices in the $25 range and have put 256Ks on a 20 percent per year decline.

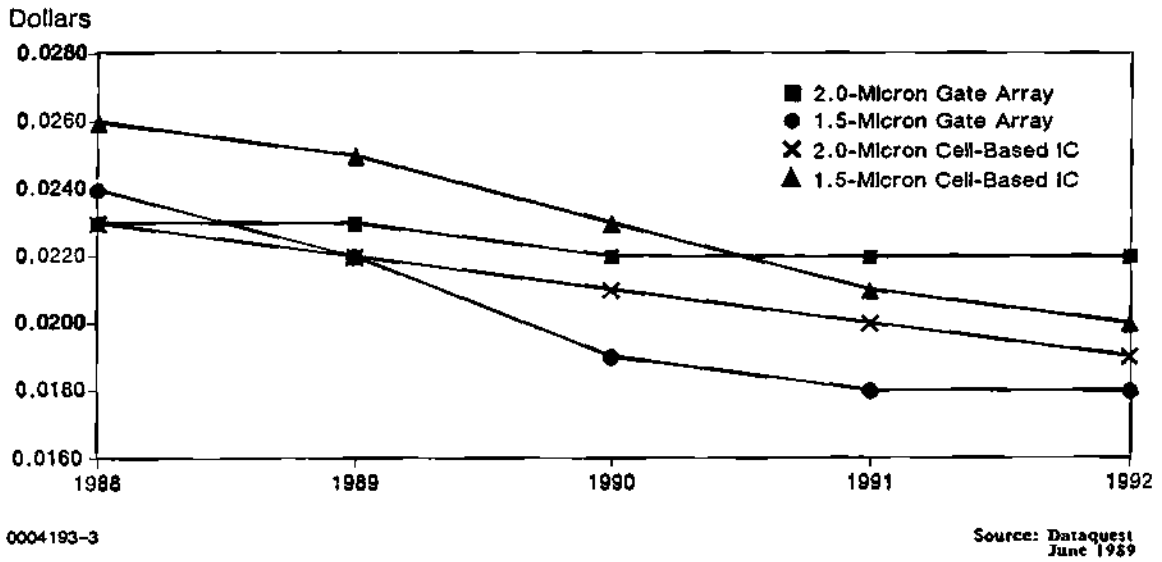
ASIC

CMOS gate arrays are fetching 10 to 15 times the price of commercial versions, with per-gate pricing in the $0.022 range. The lack of mature pricing and procurement practices will maintain the relatively high premium for gate arrays. The 5,000- to 10,000-gate CMOS gate arrays will experience a mild decline on the order of 5 percent per year through 1990 as they enter mainstream production (see Figure 3). The 1.5-micron class cell-based CMOS ICs are expected to continue fetching a 10 percent premium over 1.5-micron gate arrays of similar density.

Prices of smaller TTL PLDs should continue declining 7 to 10 percent per year during the next two years. The higher-density 22- and 24-pin varieties are expected to remain under severe competitive pressure, and they will decline at a 12 to 15 percent rate during the next two years.

Figure 3

Military ASIC Price Trends
(Average Source Control Drawing—5K–10K Gates CMOS)



Analog

Generally, prices for industry-standard mature amplifiers, comparators, voltage regulators, interface ICs, switches, timers, and data conversion ICs are expected to decline by 3 to 5 percent per year through 1991. This reflects the easing of mil-spec (JAN and 883C) demand and some buildup of inventory.

Areas retaining substantial price premiums include 12-bit data conversion products, precision and high-performance amplifiers, and GaAs-based MMIC standard products.

Discrete

Besides MOSFETs, which are moving down the learning curve, fed by expanding demand and competition, prices for standard diodes and transistors should remain firm. GaAs FET and diode prices also should remain firm as a result of stabilization of the microwave markets for electronic warfare and communication following a period of oversupply and depressed demand.

Other Notable Trends

Generally, when radiation tolerance is called out in a specification to a chip vendor, the premium can be 10 to 12 times the base 883C Class B price if the requirements are for unique design and manufacturing. Surface-mount packaging can run from 10 percent more on mature small lead count packages to 40 percent more on new VLSI ICs.

DATAQUEST CONCLUSIONS

Price movements of semiconductor products during the next two to three years should play favorably for cost-conscious military/aerospace electronics OEMs. For semiconductor vendors, the next two to three years should represent a period of relative price predictability versus the disorderly price declines of 1987 and 1988.

Dataquest expects commodity 883C and JAN products, such as bipolar logic, TTL PLDs, and standard analog functions, to decline somewhat further or to remain at historically low levels. The relative sole-source situation of CMOS gate arrays and cell-based ICs should keep prices elevated into the early 1990s. SRAMs and EEPROMs will continue price declines under increasing competitive pressure. Commodity microcomponents, such as 16-bit MPUs, will continue a predictable decline in pricing as they follow their commercial learning curves.

Greg Sheppard

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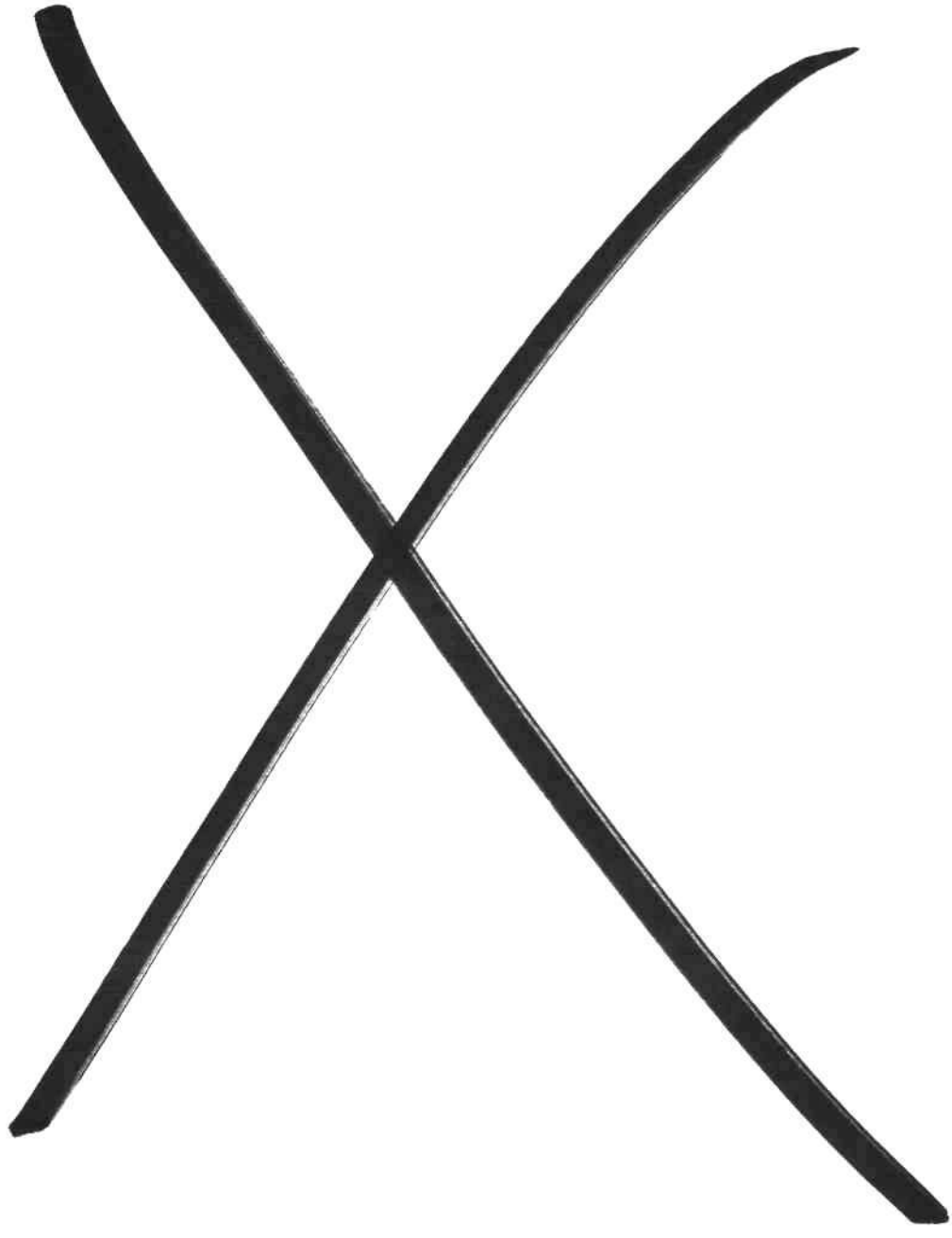

Dataquest
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Research Newsletter

MilAero Code: Newsletters: April–June
1989–7
0003735

IMPROVEMENTS IN QUALITY: DOD–STD–2000

INTRODUCTION

A new government soldering standard is now in effect; it is intended to provide a single set of soldering requirements for all services and to reduce conflict and confusion in the production of electronic assemblies. The objective is to force contractors to solder right the first time. Dataquest believes that this will improve productivity, thus resulting in fewer defects, improved reliability, shorter manufacturing cycle time, and lower unit cost.

This newsletter will explain the progress made and the work needed in the strategic standards arena.

WHAT IS DOD–STD–2000?

DOD–STD–2000 (now MIL–STD–2000, released as of January 1989) is the result of many years of effort to establish a single, uniform soldering standard for use by the Department of Defense (DOD). It is actually a combination of documents made up of DOD–STD–2000–1 through DOD–STD–2000–4, culminating an eight–year joint effort by industry and government organizations.

DOD–STD–2000–1 is officially entitled "Soldering Technology, High Quality/High Reliability." It contains requirements for process control of soldering. Specific requirements include the following:

- Training issues for instructors, process control engineers, operators, and inspectors
- Equipment issues for solder machines, soldering irons, solder pots, wire strippers, and hand tools
- Component issues, including solderability testing and stockroom control

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- Facilities issues, including electro static discharge (ESD), humidity, and general environmental controls

- Process controls such as cleanliness testing, inspection, and rework procedures

Section 2, or DOD-STD-2000-2, entitled "Part and Component Mounting for High Quality/High Reliability Soldered Electrical and Electronic Assemblies," includes criteria for design considerations. Specific items covered are the following:

- Lead bending

- Component placement

- PWB design

- Associated MIL-STD-275 items

Section 3, entitled "Criteria for High Quality/High Reliability Soldering Technology," contains a pictorial representation of workmanship acceptance standards in photographs and drawing format. These criteria include examples of preferred connections, acceptable connections, and nonacceptable connections.

These first three sections are designed to be used together for applications where process-controlled soldering is required. The fourth part, DOD-STD-2000-4, is a standalone document for special circumstances. This section may apply to instances where the above requirements are not necessary or are not economically feasible or cost-effective. It is based upon MIL-STD-454.

IS SURFACE-MOUNT TECHNOLOGY INCLUDED?

Surface-mount technology (SMT) is not addressed completely in DOD-STD-2000. Chip resistors, capacitors, and the older ceramic flat packs are included in the soldering criteria, but LCC and LDCC packages, both gull-wing and J-bend, are not covered. Neither are pin grid arrays. Furthermore, high-density packaging for surface mount is not discussed in any detail. In most cases, then, DOD-STD-2000 does not apply to surface-mount technology, and exception to the specification must be taken. It should be noted that work is being done to develop surface-mount requirements for incorporation into MIL-STD-2000. This joint team effort should be ready sometime in the summer of 1989.

IMPLEMENTATION OF DOD-STD-2000

The navy has issued Specification Change Notice 4, which basically inactivates WS-6536 for new designs and states the equivalence and acceptability of MIL-STD-2000. The navy also has modified its internal policy to make MIL-STD-2000 the standard navy requirement specification for soldered electronic assemblies.

The army has issued guidelines for implementation of MIL-STD-2000 on all new contracts and on existing cost-effective contracts.

Many benefits will result from the adoption and use of DOD-STD-2000. These benefits include the following:

- A decrease in manufacturing costs caused by poor solder connections—Tighter process controls will reduce defect levels, thus eliminating the labor costs associated with touch-up and inspection.
- A reduction in cycle time for soldering operations—Doing it right the first time will eliminate rework and reinspection time.
- An increase in awareness and development of soldering technology—Operators will become proficient at soldering, thus reducing the likelihood of making a mistake.
- An improvement in company image and profits—Implementation of the specifications will increase process knowledge and facilitate informed discussion of problem areas between the supplier and the customer.

IS IT ENOUGH?

DOD-STD-2000 is based on visual criteria and inspection methods, translating to the definition of what constitutes a highly reliable solder joint: the outward appearance of solder volume. This definition does not address all the issues necessary for today's emphasis on product reliability, however. Surface-mount assemblies require a new set of inspection criteria, different from the criteria for through-hole technology. SMT joints must now be inspected for both mechanical and thermal integrity along with the conventional electrical concerns.

Efforts to address these issues and redefine the visual criteria into performance parameters have begun. The challenge is to include sufficient flexibility to accommodate hardware and applications not yet designed. The immediate plan is to integrate 3-D laser imaging, infrared laser thermal inspection, X-ray inspection, and 3-D finite element computer modeling into a system. This will detect the presence of manufacturing defects and correlate the individual and cumulative effect that each has on field performance prior to actual implementation.

DATAQUEST ANALYSIS

Dataquest sees the DOD-STD-2000 standard as a leap forward in the development of process controls for improving the quality and reliability of electronic assemblies for government applications. The present set of criteria contained within the specification pertains to 100 percent visual inspection of the solder joint appearance, rather than to a defect classification that is based on the in-situ performance of the solder. Developments are under way to provide quantitative measurement analysis using nondestructive test methods.

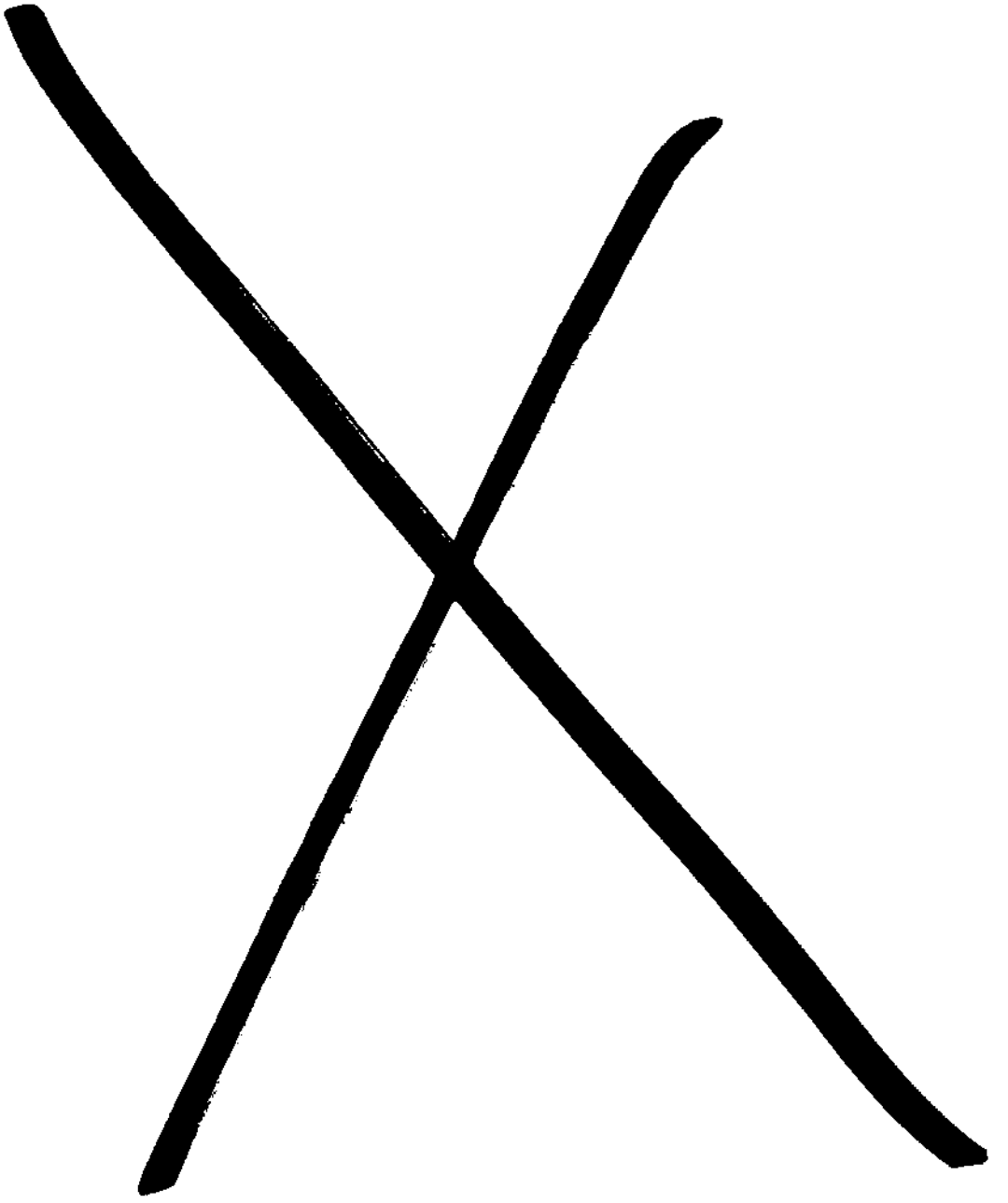
Greg Sheppard
Jim Walker

Dataquest

Conference Schedule

1989

Semiconductor User/ Semiconductor Application Markets	February 27–28	Le Meridien Hotel San Francisco, California
Japanese Components	April 20–21	Tokyo Bay Hilton International Tokyo, Japan
Computer Storage	April 26–28	The Doubletree Hotel Santa Clara, California
Document Processing	May 16–18	Monterey Sheraton Hotel Monterey, California
Copiers	May 16–17	
Printers	May 16–17	
Electronic Publishing	May 18	
Imaging Supplies	May 18	
Color	May 18	
SEMICON/West Seminar	May 24	The Dunfey Hotel San Mateo, California
Telecommunications	June 5–7	Silverado Country Club Napa, California
European Components	June 7–9	Park Hilton Munich, West Germany
Asian Semiconductor and Electronics Technology Seminar	June 28	Radisson Hotel San Jose, California
Financial Services	August 22–23	The Doubletree Hotel Santa Clara, California
Technical Computing and Applications	September 11–13	The Doubletree Hotel Santa Clara, California
European Copying and Duplicating	September 18–19	Majestic Hotel Cannes, France
Western European Printer	September 20–22	Majestic Hotel Cannes, France
Taiwan Conference	September 25–26	Grand Hotel Taipei, Taiwan
Distributed Processing	September 26–28	The Doubletree Hotel Santa Clara, California
SIA/Dataquest Joint Conference	September 27	Santa Clara Marriott Santa Clara, California
Information Systems	October 2–6	Tokyo American Club Tokyo, Japan
Semiconductor	October 16–18	Monterey Sheraton Hotel Monterey, California
Asian Semiconductor and Electronics Technology	November 2–3	Kunlun Hotel Beijing, China
European Telecommunications	November 8–10	Grand Hotel Paris, France
European Personal Computer	December 6–8	Athens, Greece



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Research Newsletter

MilAero Code: Newsletters: January–March
1989–6
0003453

MILAERO UPDATE: BUDGET CUTS ON THE HORIZON

The Bush administration has revised Ronald Reagan's fiscal 1990–1994 defense budget proposals downward. In place of Reagan's two percent annual real growth, President Bush has proposed to freeze the defense budget in real terms in fiscal 1990, have it increase by one percent per year in fiscal 1991 and 1992, and resume the two percent growth path beyond that. The new course requires a $6 billion cut in budget authority in fiscal 1990, a $10 billion cut in fiscal 1991, and a $50 billion cut over the full five–year period. The impact on actual spending will depend on how the reductions are apportioned.

The prolonged conflict over the nomination of Senator John Tower and the subsequent approval of Dick Chaney to be Secretary of Defense delayed the apportionment of reductions to specific weapon programs or forces. Acting Defense Secretary, William Taft, IV, gave the military services the responsibility of recommending how to absorb the reductions with only limited guidance. The overall amount was divided among the services, with the army, air force, and navy instructed to identify programs worth $1.8 billion, $2.0 billion, and $2.3 billion, respectively, in fiscal 1990. Their only direction, apparently, was to spare the Strategic Defense Initiative and "to look at" force structure, meaning to consider cutting forces rather than slowing modernization programs.

This process within the Pentagon is only the first step in this year's budget cuts, however. In view of the continuing debate concerning overall budgetary priorities and the possibility of automatic Gramm–Rudman cuts in all departments' budgets, Congress would appear to hold the whip hand. Congress' review of the defense budget has been delayed by the prolonged Tower controversy and will not be completed until late summer. There will be early signals of where the congressional knife may fall, however, the first being the annual Congressional Budget Office (CBO) report on options for cutting the budget. This year's report lists 31 options; the 16 pertaining to research and procurement programs are summarized in Table 1. The remaining options suggest either reductions in force levels or changes to support procedures that could save money. While none of these options have legislative standing, their inclusion in the report suggests possible congressional interest.

The modernization options can be divided into two parts: those that would cancel programs all together, and those that would slow, but not terminate procurement or research programs. The former group primarily includes programs that are near their end in any event, such as the SSN–88 class submarine; thus, the savings are relatively

small. The two exceptions are the rail-mobile M-X missile and the Marines' V-22 "Osprey" helicopter. The former is a real possibility for cancellation, given the skepticism in the House of Representatives regarding it. The Osprey, however, is probably a secure program, since it is one of the Marines' highest priorities, and they usually seem to get their way with Congress.

The more likely congressional course is to slow down programs, and each of the options listed in the table must be considered a definite possibility. The reduction in the SDI program may be almost a certainty, in fact, as well as the slowdown in the National Aerospace Plane, both of which lost their chief sponsor when President Reagan retired to California. A slowdown in the B-2 bomber also seems likely. Unofficially, the five-year budgetary saving from a B-2 slowdown would reach between $20 billion and $30 billion. An adjustment in the army air defense program might be the fourth most likely possibility.

If program slowdowns become the norm, especially on new programs, then electronics OEMs and semiconductor suppliers will have to expect and prepare for the hard reality of extended, low-level production runs.

Gregory Sheppard
Barry Blechman

Table 1

CBO Options for Cutting the Defense Budget
(Billions of Dollars)

Option	Budget Savings FY '90	Savings FY '90-'94	Outlay Savings FY '90	Savings FY '90-'94
I. Terminations				
F-15 Fighters	1.7	7.2	0.2	5.1
Trident Missile Refits	0.1	1.3	*	0.9
Binary Munitions	0.1	1.0	*	0.6
Phoenix Missiles	0.4	1.0	*	0.9
OH-58 Helicopter Refits	0.3	1.7	0.1	1.2
SSN-688 Submarines	1.5	1.5	0.1	1.1
Rail-Mobile MX Missiles	1.2	5.8	0.5	4.8
V-22 Helicopters	1.6	10.2	0.2	6.3
II. Slowdowns				
C-17 Airlift Aircraft	-	4.8	-	1.9
F-16 Fighters	0.6	4.2	*	2.4
DDG-51 Frigates	1.4	7.3	0.1	2.9
Army Air Defense Systems	0.4	1.8	*	1.0
B-2 Bombers	C L A S S I F I E D			
Delay All New Starts	1.2	6.4	0.3	3.8
National Aerospace Plane	0.1	0.7	0.1	0.6
Strategic Defense Initiative	1.7	17.6	0.9	14.0

*Less than $50 billion

Source: Congressional Budget Office

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Research *Newsletter*

MilAero Code: Newsletters: January–March
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MILAERO UPDATE: RECENT ELECTRONIC CONTRACT AWARDS

This Research Newsletter discusses several recent contract awards of significance in the United States for work in the electronics area. It is important for semiconductor companies to understand these programs and to take proactive steps to get their components designed early or to get established as a second source.

ADVANCED ANTITANK WEAPON SYSTEM—MEDIUM (AAWS–M)

The team of Texas Instruments and Martin Marietta will be awarded in April an army demonstration/validation (dem/val) competition for full–scale development of the AAWS–M, a one–man portable, fire–and–forget weapon intended to replace the Dragon antitank missile. The competition included two other teams: Hughes/Honeywell and Ford Aerospace/General Dynamics.

This contract will provide funding for a 36–month, full–scale development program. Texas Instruments, which developed the dem/val weapon, will produce 90 percent of the AAWS–M in low–rate production. The two contractors will then compete for late production lots. The army's current call is for procurement of 5,000 launchers and 58,000 missiles, plus 16,000 missiles to be procured for the marines. However, a Martin Marietta spokesperson estimated the potential demand for the AAWS–M to be on the level of 100,000 missiles in the United States and 70,000 abroad.

The TI/MM weapon employs a staring focal plane array long wavelength infrared (LWIR) sensor as its seeker. The seeker is 64 x 64 elements in size and can be expanded. In contrast to shorter–wavelength sensors, which are limited to edge and centroid tracking of targets, with the LWIR seeker it may be possible to track specific features of target. A Texas Instruments spokesperson noted that TI's seeker offers enough target definition to attack a specific aim point and, eventually, to recognize targets autonomously. TI is proposing a derivative of the same seeker for the army's Advanced Antitank Missile System—Heavy (AAMS–H), a potential replacement for the TOW missile. The technology also could be used as the basis of a fire–and–forget "Hellfire" antitank missile for the AH–64 Apache and LHX helicopters.

ADVANCED RADAR WARNING RECEIVER (ARWR)

The air force announced on December 20, 1988, that the Loral Systems Manufacturing Company of Hauppauge, New York, had been awarded a $20.4 million fixed-price contract for the production of the first 19 Advanced Radar Warning Receivers for F-16C/D and RF-4C aircraft. Loral will produce 673 units, with spares and warranties, in a program worth $210.3 million and spanning fiscal years 1989 through 1992. Deliveries are scheduled to begin in June 1991. The ARWR, eventually to be used on more than 1,400 U.S. tactical fighters, also has a large potential market overseas.

Loral's ALR-56M won the competition over Litton's ALR-74. Both systems were capable of meeting the Air Force Aeronautical Systems Division's requirements, but the Loral system, at $200,000 excluding spares and test equipment, was the less expensive. Litton has protested the award to the GAO's General Counsel's Procurement Law Control Group, asking that the air force cancel the award and either give it to Litton or recompete it. Litton charges that Loral's Systems Manufacturing Company, as a new company, does not meet the responsibility requirement in the acquisition regulations. Fewer than 5 percent of such protests are successful.

AIR-TO-AIR COVERT SENSOR TECHNOLOGY (AACSENT)

Honeywell's Electro-Optics Division was awarded a contract to support work by the Air Force Avionics Laboratory in AACSENT research. The air force will fund 72 percent of the $4.7 million three-year effort, and Honeywell will provide the remainder. Honeywell's bid beat General Electric, Martin Marietta, Northrop, and Texas Instruments.

The air force's AACSENT program is an effort to improve significantly the potential benefits of electro-optic technology in target and threat sensing for air-to-air combat. The program is laying the groundwork for sensor suites to equip combat aircraft after the year 2000; these aircraft are expected to face threats from opponents increasingly more stealthy and less heat emitting. Attention will be focused on passive means of detecting and on identifying targets positively at long range and in bad weather.

A Honeywell official states that many of the components for advanced sensors are available now, and much of the program's work will be to predict which component technologies can be built up affordably. Reportedly, one of the most promising technologies is staring focal plane arrays. According to Honeywell, the LWIR in an 8- to 10-micron wavelength range is just starting to emerge. This technology may also have applications in sensors for space-based interceptors.

MK XV IDENTIFICATION FRIEND OR FOE (IFF)

Allied-Signal's Bendix Communication Division received a $161.9 million contract in February 1989 for the full-scale development of the MK XV IFF, the first phase of an expected $700 million project to include development, testing by the air force and Bendix, and integration of the equipment into various types of aircraft. Production of the equipment—perhaps 3,200 interrogators and 12,700 transponders—is expected to cost $2.8 billion. The other competitor for the award by the Air Force Aeronautical Systems Division was Texas Instruments' Defense Systems and Electronics Group of Plano, Texas.

The MK XV IFF will employ an automatic question-and-answer format in which aircraft, ships, or air bases would be equipped with interrogator systems and friendly aircraft equipped with a transponder system to reply. The system will also provide air traffic control capabilities.

SINGLE-SOURCE PROCESSOR, SIGINT (SSP-S)

Ford Aerospace and Communication's Western Development Laboratories Division was awarded a $13.1 million army contract to develop an intelligence processing system that will allow command elements to integrate and analyze vast amounts of intelligence data from multiple sources. The system will employ two communications vans and a Digital Equipment Corporation VAX/8350 with data links to 20 remote analysis workstations. The Ford system is designed to be compatible with the army's existing secure tactical computer system.

SUBMARINE INTERNAL COMMAND AND CONTROL SYSTEM

The Defense Advanced Research Projects Agency (DARPA) awarded four $500,000 contracts in November 1988 for demonstration of submarine command and control prototypes in May 1989. The industry teams are led by the DuPont Corporation with Martin Marietta's Aeronautical and Naval Systems; General Electric's Advanced Technology Laboratories; Lockheed's Georgia Operation, Marietta; and McDonnell Douglas. The prototype contracts are part of DARPA's $100 million effort to apply high technologies for improving U.S. submarine capabilities.

Gregory Sheppard
Barry Blechman

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STRATEGIC DEFENSE INITIATIVE UPDATE

OVERVIEW

The Reagan Administration's final defense budget proposed a 46 percent increase in funding for the Strategic Defense Initiative (SDI) and planned to begin the first full–scale development work on elements of Phase I of the defense system. As a result of the pressures of the federal deficit, the budgetary priorities of the Democrat–controlled Congress, and the president's refusal to consider a tax increase, however, the Reagan SDI request will undergo a significant scaling back and will experience little, if any, real growth in fiscal year 1990.

The FY 1990 budget proposes more than $5.9 billion for the strategic defense programs of the U.S. Department of Defense (DOD) and the U.S. Department of Energy (DOE), which would represent 46.2 percent growth over FY 1989 funding of approximately $4 billion. The budget request provides for further growth of 18 percent for FY 1991, bringing the SDI budget to nearly $7 billion. Overall, appropriations for SDI would increase more than 72 percent between FY 1989 and FY 1991. In contrast, once SDI funds are removed, the remaining military research, development, test, and evaluation budget would face flat growth during FY 1990 and a decline in real terms in 1991.

Significantly, the FY 1990 request calls for the first contracts to be awarded for full–scale development of systems that would become part of the planned SDI Phase I architecture.

BSTS FAVORED

The Reagan budget proposes a significant increase in funding for the Boost Surveillance and Tracking System (BSTS)—an orbiting surveillance system employing infrared sensor technology to detect and track missiles in the boost phase of their trajectories. The BSTS would have dual applications. For SDI, it would provide detection of missile launches, acquisition and tracking of boosters and post–boost vehicles, and kill assessment. Generally, however, the BSTS also could serve as a more survivable and more capable replacement for Defense Satellite Program satellites now

used for early warning. The FY 1990 budget requests a 40 percent increase in funding for BSTS development from $235 million in FY 1989 to $330 million in FY 1990 (see Table 1). BSTS funds would continue to grow to $427 million in FY 1991. The U.S. Air Force and the Strategic Defense Initiative Organization (SDIO) plan to spend at least $8 billion eventually for the development and deployment of BSTS. Contracts have been awarded to the Grumman Corporation of Bethpage, New York, and the Lockheed Corporation of Sunnyvale, California, which will compete for the full-scale development award in fiscal 1990. The Lockheed program employs a scanning sensor that is being developed by Hughes Aircraft, while Grumman is looking toward a staring sensor.

Table 1

SDIO FY '89 Allocation and FY '90 and FY '91 Requests
(Millions of Dollars)

	FY '88 Actual	FY '89 APPN	FY '90 Request	FY '91 Request
Surveillance, Acquisition, Tracking, and Kill Assessment (SATKA) Projects	934.5	1,100.7	1,281.0	1,436.0
Directed Energy Projects	934.3	819.8	1,116.9	1,322.9
Kinetic Energy Projects	773.2	773.1	1,346.5	1,534.6
Systems Analysis and Battle Management Projects	461.5	506.5	780.9	975.6
Survivability, Lethality, and Key Tech Projects	429.6	406.3	776.8	947.6
Sensors and CC/SOIF	959.7	1,137.7	1,600.7	1,995.3
BSTS devel.	173.9	235.0	329.5	427.0
Midcourse sensor devel.	37.7	107.9	163.8	314.8
Initial Interceptors and Other KE concepts	560.8	635.6	1,100.7	1,221.9
Space-based interceptor	165.0	116.0	346.3	380.4
Advanced Concepts	845.8	703.8	1,130.6	1,359.7
CL Tech.	64.8	67.6	297.6	439.3
Key Technologies	566.6	541.9	1,010.4	1,206.7

Source: Strategic Defense Initiative Organization

OTHER SDI ELEMENTS

Other sensor systems relevant to the Phase I architecture receive a similar increase in the FY 1990 funding request. Overall, the sensor and CC/SOIF budget request calls for a 41 percent increase in FY 1990 and a further 25 percent increase in funding for FY 1991 (see Table 1). Development of midcourse sensors is allocated an increase of almost 200 percent for FY 1990–1991, while funds for development of terminal sensors also would nearly double in FY 1990. Increased funding for sensor development will be reflected in further demand for high–density, radiation–hardened circuits for signal data processing; mass–produced and long–wavelength infrared (LWIR) sensors for focal–plan arrays; optical technologies such as large, lightweight, high–quality mirrors for sensor optics; cooling technologies such as cryocooling; radars; and software.

Development and validation work for the Ground–Based Surveillance and Tracking System have been awarded to McDonnell Douglas Aeronautics. The prime contractor for the development of the Ground–Based Radar is Raytheon, and the sensor to be used in the upcoming Airborne Optical Adjunct experiment was developed by Hughes.

Kinetic energy (KE) weapons, the key element of the Phase I strategic defense system, also received a large boost in requested funding. Relevant technologies and the development of initial interceptors and other KE concepts are requested to increase by 73 percent, from $635 million in FY 1989 to $1.1 billion in FY 1990. In particular, SDIO requests almost a 200 percent increase in funding, to $346 million, for the development of space–based interceptors between FY 1989 and FY 1990. Technology supporting KE programs includes low–cost miniature sensors, seekers, data processors, inertial reference units, weapon platform fire control sensors, and other missile electronics.

The prime contractor for the space–based interceptor program is Martin Marietta, with subcontracts to Honeywell's Electro–optics Division and LTV's Missile Division for development of sensors and advanced electronic subsystems, respectively. The ground–based Exoatmospheric Reentry–Vehicle Interceptor system is by Lockheed, with seeker development by Texas Instruments. The High–Endoatmospheric Defense Interceptor system, also a ground–based option for Phase I deployment, has McDonnell Douglas as its prime contractor, with the Hughes Missile System Group developing the IR homing seeker and on–board data processor and Aerojet working on the propulsion and sapphire window cooling systems.

Proposed SDI spending on advanced concepts and technologies would increase in real terms, but in general, it would not increase on anywhere near the same scale. One exception is technology work on chemical lasers (CLs). The SDIO request calls for a 550 percent increase in funding for CL technology over the FY 1990–1991 period, from $67.5 million in FY 1989 to $439 million in FY 1991. The SDI Test Bed was awarded to Martin Marietta, with subcontracts to Carnegie–Mellon University, Computer Technology Associates, Ferranti (UK), Hughes, IBM, Nichols Research, Ralph M. Parsons Co., Singer–Link, and Tracor Applied Science.

DATAQUEST CONCLUSIONS

Many of these programs and the overall SDI budget almost certainly will be cut significantly before the FY 1990 budget passes into law. The defense budget is likely to experience zero, or perhaps even negative, real growth in FY 1990. Moreover, with President Reagan's departure and a general consensus on the need for modernization of offensive strategic forces, as well as the military services' determination to protect conventional military forces, SDI lacks a strong sponsor in the budget process; therefore, it will be quite vulnerable.

Representative Les Aspin, chairman of the House Armed Services Committee, has stated that he expects the funding debate to range around a floor of $4.0 billion for SDI, and perhaps an eventual agreement on a level of $4.3 billion, a modest increase of 6 percent from current funding levels. Such modest growth, according to Senator John Warner, ranking Republican on the Senate Armed Services Committee and an SDI supporter, would be a victory for SDI. In the longer term, Representative Aspin projects that SDI spending might approach the nominal target of $19 billion set by the Reagan Administration for the year 2000, but it will face continuing downside pressures through the mid–1990s. In particular, Representative Aspin argues that ICBM mobility, Trident submarine and missile procurement, and the B–2 bomber are higher priorities than SDI in the midterm. Other voices in Congress are calling for even greater cuts in the SDI budget.

Beyond the debate on levels of funding for SDI over the next two years, a serious dispute is likely to develop over the direction and priorities of the program. Specifically, the Congress can be expected to oppose SDIO's priority on development of systems for a Phase I deployment. Funding for the development of space–based interceptors, for example, will almost certainly be scaled back. Congress is likely to prefer a research strategy that gives priority to the development of advanced technologies that would not be available for deployment until the next century but promise far greater capabilities, instead of sinking considerable sums into systems that would be available more quickly but would be limited in capabilities. Of those Phase I systems slated for major increases in FY 1990–1991, only the BSTS is likely to be funded with relatively small cuts, because of the early warning capabilities that it would provide even in a non–SDI environment.

The conclusion that can be drawn for electronics OEMs and semiconductor companies is that SDI will present only a limited near–term opportunity as the BSTS is most likely implemented. However, the other key SDI systems appear to remain long–term opportunities with an expanding time horizon.

Gregory Sheppard
Barry Blechman

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MANUFACTURING: LOW VOLUME, MILITARY, AND EFFICIENT TOO?

Texas Instruments recently won a $112 million award from the United States Air Force for a five-year contract with the Microelectronics Manufacturing Science and Technology (MMST) program. The program is a cooperative effort by the Air Force Wright Aeronautical Laboratory's Manufacturing Technology Directorate and Electronic Technology Laboratory and the Defense Advanced Research Project Agency (DARPA).

Under the contract, Texas Instruments will develop the equipment and systems for cost-effective manufacturing of low-volume military integrated circuits, microwave devices, and sensors. The program will include the development of advanced processes, process equipment (such as dry chemical cleaning systems), process sensors, process control expert systems, and an integrated factory control system that can be scaled and adapted to a variety of fabrication facilities. These elements will be integrated into a pilot fabrication facility that will feature sub-0.5-micron line geometries, more than 1,000 designs per year with 800 wafers per month throughput, and a minimum cycle time of less than three days.

Texas Instruments hopes to push the state of the art in computer-integrated manufacturing (CIM) by research in processing and in-situ sensors, VHDL-compatible simulation, modeling, symbolic computing, and artificial intelligence computer-integrated processing.

Techniques and equipment developed under this program will be equally applicable to silicon, gallium arsenide, and mercury-cadmium-telluride-based process technologies.

To achieve maximum flexibility for minimum lot sizes, Texas Instruments is planning to replace traditional batch processing equipment with single-wafer processing systems. Diffusion furnaces, for example, might be replaced by single-wafer equipment. With single-wafer processing systems, equipment footprints will shrink dramatically—the entire manufacturing facility might take up no more than 2,500 square feet and cost just a fraction of what conventional facilities cost.

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

Dataquest notes that this program has some broad implications. If Texas Instruments and the Air Force are successful at achieving the technical goals of this project, it could help solve crucial technology sourcing problems for future and ongoing defense programs. Because of the typically small order quantities, unique technologies (e.g., radiation hardening), and long life cycles of military semiconductor requirements, it has been difficult for the Department of Defense to secure a cost-effective, stable supply of ICs and sensors. The resulting fabrication technology from this project could be used to lower the overhead of operating a small-volume fabrication operation, thus preserving and even enhancing the supply base of companies that serve the military market.

Additionally, a recent report by the Japanese Technology Evaluation Program points out that Japanese semiconductor manufacturers are ahead of their U.S. counterparts in the implementation of CIM, especially for volume production such as that used for DRAMs. The authors of the report point out that experience in implementation of CIM in volume production could be transferred to nonvolume production such as that used for ASICs, and thus represent a strategic threat to the U.S. semiconductor industry in an area where it has traditionally been in the lead. However, techniques developed for low-volume military manufacturing in the MMST program are applicable to nonmilitary low volume production, and therefore, we believe, will help the U.S. industry maintain its leadership position in low-volume, flexible manufacturing.

Much has been said and written about the need for the U.S. industry and government to work together to keep the U.S. competitive in an increasingly competitive world. Dataquest believes that programs such as MMST's could be part of a successful strategy by government and industry to keep the U.S. semiconductor industry competitive on the world's shop floors.

Greg Sheppard
George Burns

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MILAERO UPDATE: SUPERCONDUCTORS, FOREIGN OWNERSHIP, BUDGET PROPOSAL

MARKET FOCUS: GREATER EMPHASIS TO BE PLACED ON MILITARY APPLICATIONS OF SUPERCONDUCTORS

Recent discoveries of materials that can conduct electricity with no resistance, and thus no loss of power, at relatively high temperatures promise revolutionary improvements in the performance of many types of electronic systems. Weapons and other types of military equipment are possible applications of these superconductors. Recognizing this potential, the Defense Science Board recently proposed an accelerated five-year program of superconductor research and development that would triple the Defense Department's spending on superconductors by the year 1992 (see Table 1). The proposed program stresses early development of engineering test models of sensors, weapons, and naval propulsion systems. Fitting well with the new administration's likely emphasis on advanced technologies to offset the impact of smaller U.S. Armed Forces (see accompanying section on Reagan budget), the proposal seems assured of funding near the proposed levels. Spending of approximately $250 million per year can be anticipated in the early 1990s.

Possible military applications of superconductors have intrigued defense specialists for years; the new availability of high-temperature superconducting (HTS) materials will turn these speculations into reality. The following potential applications include some of the highest priorities on the defense research and development (R&D) agenda:

- Infrared sensors
- Microwave and millimeter wave (MMW) devices
- Magnetic sensors
- Electrical machinery
- Launchers
- Digital signal and data processing

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

Table 1

Suggested Department of Defense Superconductivity Funding (Millions of Dollars)

	Program	1988	1989	1990	1991	1992	1993
6.1	Basic Research Including Theory	$17	$ 20	$ 20	$ 25	$ 25	$ 30
6.2	Applied Research on Processing of New Materials, Manufacturing Sciences, Cryogenics, and High-Strength Composites	22	50	60	70	70	75
6.3	Engineering Demonstrations of Electronics Applications of New Materials (e.g., Magnetic Sensor, IR Sensor, and Microwave Antenna)	13	10	20	30	40	50
6.3	Engineering Demonstrations of High-Power Applications of New Materials	0	0	0	0	10	20
6.3	Early Exploitation of High-Power Engineering Test Models Using LTS (e.g., Quench Gun, MHD Torpedo for Quiet Propulsion)	22	30	50	70	80	70
6.3	Early Exploitation of Electronics Engineering Test Models Using LTS (e.g., Digital-Signal Processing, Squids, Millimeter-Wave Sensors)	5	10	10	20	20	15
	Total	$79	$120	$160	$215	$245	$260

Source: Report of the Defense Science Board Taskforce on Military Systems Applications of Superconductors (October 1988)

Infrared Sensors

The use of superconductors will reduce the power required to cool signal-processing and data-extraction subsystems, making large space-based focal plane arrays with great sensitivity and range more feasible. Such devices will be used for a variety of surveillance and targeting missions, including potential applications in space-based missile and air-defense systems.

Microwave and Millimeter-Wave (MMW) Devices

The use of superconductors can reduce receiver noise and, thus, increase the potential range, reduce power requirements, and/or reduce the necessary size and weight of antenna for microwave and MMW space-communications systems. Superconductors may also make space-based MMW imaging arrays feasible by providing all-weather capabilities as well as an ability to penetrate clouds and smoke.

Magnetic Sensors

Magnetometers and gradiometers using low-temperature superconductors are already available commercially and are being evaluated by the navy for mine-detection systems and antisubmarine sensors.

Electrical Machinery

High-power applications of superconductors can result in a substantial weight savings in DC motors, leading to more efficient and flexible ship-propulsion systems, very quiet drives for submarines, and very lightweight, powerful motors for torpedoes and other maritime applications.

Launchers

The marriage of superconductors with the electromagnetic mass accelerator concept promises to make launchers capable of hurling projectiles at extremely rapid velocities a practical possibility. Potential applications include rail guns, including such weapons for space-based missile defenses, and hypersonic antitank projectiles capable of penetrating the most advanced defensive armor.

Digital Signal and Data Processing

The Defense Science Board was cautious in describing the potential applications of superconductors for data processing systems. It noted that insofar as low-temperature superconductors (LTS) can provide more than a tenfold increase in processing speed over conventional GaAs of the same complexity, with lower power dissipation, computers could realize significant performance benefits through the application of LTS technology. With existing technologies, however, the decrease in power requirements is offset partially by the power required to maintain the low temperatures. The use of HTS may override this difficulty, but it would require the development of a completely new type of device. The board stated that HTS materials may be more compatible with semiconductor materials, thus enabling hybrid approaches to be taken.

PROGRAM AND CONTRACTOR NEWS: BACKLASH BUILDS AGAINST FOREIGN OWNERSHIP OF DEFENSE-RELATED INDUSTRIES

An accelerating pace of acquisitions of highly visible U.S. defense contractors and high-technology companies in defense-related industries by foreign investors is creating a backlash in Congress and the Executive Branch. Only a last-minute arrangement between the U.S. government and Huels AG of West Germany prevented President George Bush from vetoing the proposed sale of Monsanto's electronic materials division, the last independent U.S. producer of 8-inch silicon wafers, to the German chemical company. The new administration is likely to prevent or slow similar transactions in the future.

The trend in foreign acquisitions of publicly owned U.S. companies can be seen in Table 2, which summarizes information filed with the Securities and Exchange Commission. The data show that the number of foreign acquisitions began to rise substantially in 1984. By 1986 and 1987, there were 300 such actions each year; the data for the first two quarters of 1988 suggest that there were more than 400 foreign acquisitions in the past year. Between 10 and 20 percent of these acquisitions pertain to companies that either sell now to the Pentagon, directly or indirectly, or sell products that are likely to be of interest to the armed services in the future. Of these defense-relevant companies, approximately one-fourth to one-half are engaged in high-technology research and development.

Table 2

Number of Foreign Acquisitions of U.S. Companies (1981-1988)

Year	Total Number	Defense-Relevant	Materials	Basic Manufacturing	High Technology
1988*	192	37	11	15	11
1987	310	41	12	19	10
1986	306	43	5	14	24
1985	195	43	13	12	18
1984	178	21	1	4	16
1983	105	11	0	5	6
1982	214	27	4	10	13
1981	261	40	3	23	14

*First two quarters only

Source: Mergers and Acquisitions Magazine

There are, of course, many advantages to foreign investment in the U.S. defense industrial base, including the infusion of new capital, the preservation of manufacturing capabilities that might otherwise have to close, and even net inflow of technology to the United States. Still, the trend disturbs Americans on an emotional level, which is then reflected in the Congress, and raises certain specific problems when target companies are engaged in highly classified activities or produce unique products essential for military needs.

Certain specific acquisitions highlighted these problems during the past year. Three components of the Singer Company, a defense electronics firm, were sold to foreign interests during 1988, including the Link Simulation and Training System Division, the company that is developing the simulator for the B–2 Advanced Technology Bomber. Another sensitive acquisition was Plessey's purchase of Sippican Inc., a major builder of antisubmarine and communications systems. The prices paid for these companies far exceeded the American investment community's expectations. This demonstrated the investors' willingness to accept a lower return on investment than potential American buyers, or it indicated that they are prepared to pay this premium to gain access to advanced technologies and new markets.

During the Reagan Administration, which was dominated by a "free–traders" doctrine, the U.S. government almost never intervened to limit these acquisitions. The interagency Committee on Foreign Investment in the United States (CFIUS), which is chaired by the Treasury Department, has never ruled against a prospective acquisition, having considered 29 during the course of its eight–year lifetime. The infamous prospective Fujitsu acquisition of Fairchild Semiconductor from Schlumberger in 1986 might have been the first government turndown, but the offer was withdrawn in the face of unofficial pressures.

In the Monsanto case, when the CFIUS met to consider the proposed sale, the Commerce and Defense Departments raised strenuous objections. As required in last year's Trade Reform Act, the issue was then passed to President Bush, who was required to act by February 6. The new administration is less doctrinaire about free trade (and free capital flows) than its predecessor, however, and most observers expected the first negative ruling on a proposed foreign takeover.

The agreement seems to bear out that prediction. In a letter dated January 23, Huels' chairman C.H. Krauch assured Treasury Secretary Nicholas Brady that Monsanto's research and manufacturing facilities will remain in the United States and that Huels will invest $50 million to expand those capabilities; Monsanto's advanced production technologies would not be transferred overseas for at least five years; and Huels would honor Monsanto's arrangements with Sematech, including the agreement not to enter into similar consortia.

These pledges assuage American concerns, and the deal will go through. Still, the backlash is building. The Senate Armed Services Committee, for example, plans to hold hearings on foreign takeovers in the defense industry during the coming months. All told, it appears likely that the new administration will be a great deal tougher on prospective foreign investment in high–technology U.S. defense industries.

BUDGET ANALYSIS: OUTGOING ADMINISTRATION'S PROPOSED BUDGETS FOR FISCAL YEARS 1990 AND 1991 LEAVE DIFFICULT CHOICES FOR CONGRESS AND PRESIDENT BUSH

In one of his last official acts, President Ronald Reagan proposed an overall fiscal plan, a five-year defense program (fiscal years 1990 through 1994), and specific defense budgets for fiscal years 1990 and 1991 that raise more issues than they solve. This forces the Congress and the new administration to make difficult decisions during the coming year. The new program, which envisions a 2 percent annual growth over the rate of inflation between fiscal 1989 and 1994, places its greatest emphasis on continued research and development of advanced weapon systems. This suggests budgetary demands over the next few years that will be difficult to meet without corresponding reductions in force levels, further stretching of existing procurement programs, or additional cuts in purchases of politically less visible goods such as munitions, communications gear, and various support equipment.

Under President Reagan's request, the Defense Department's appropriations would rise from $290 billion in the current fiscal year to $306 billion in fiscal 1990 and $321 billion in fiscal 1991. Actual outlays would rise more slowly, reaching only $305 billion in fiscal 1991, reflecting the proposed budget's concentration on new program starts and research and development. The result is a serious problem for those concerned with the federal deficit, as it would renew growth of the Defense Department's unexpended balances, creating fiscal problems in future years.

In keeping with the outgoing administration's emphasis on acquiring new weapons, procurement accounts are requested to increase by 16 percent over the two-year period, reversing the trend toward substantial reductions that took place during the past four years; procurement budgets dropped 31 percent between fiscal 1985 and 1989. Among the procurement accounts gaining the most ground are those for air force aircraft and missiles, which are slated to increase by 32 and 45 percent, respectively, over the two years, and navy aircraft, which is requested to increase by 22 percent (see Table 3). Most of these increases are to be used for so-called "black" or classified programs, including the air force's B-2 bomber and advanced cruise missile and the navy's A-12 aircraft; all three of these are expected to enter full-scale production during the period. All totaled, classified programs account for approximately 20 percent of defense procurement in the proposed fiscal 1990 budget and are expected to continue to rise.

In the research and development accounts, the biggest winner is the Strategic Defense Initiative (SDI), for which $5.7 billion is requested for Department of Defense (DOD) research in fiscal 1990, and nearly $7.0 billion is requested in fiscal 1991; the Defense Department received only $4.1 billion for the SDI in fiscal 1989. Other research programs that fared well in President Reagan's last budget include programs to develop new air defense systems; new antisatellite programs, including one envisioning the use of a directed energy weapon system; and most of the previously proposed programs to develop advanced conventional weapons. Programs that did not fare well include the Midgetman ICBM and two navy antisubmarine programs (low-cost sonobuoys and the Ariadne sensor network), which have been terminated, and the air force's Advanced Tactical Fighter, which was delayed by one year. The production rates of a number of aircraft, missile, ship, and weapon programs were diminished as well, stretching out previously planned expenditures for these systems. The Defense Department's advanced research programs of special interest to the semiconductor industry, including the Microwave/Millimeter Wave Monolithic Integrated Circuits (MIMIC) program, were continued as previously planned.

Table 3

Department of Defense Procurement Accounts
Fiscal Years 1989 and 1991
(Millions of Dollars)

Account	1989	1991	Percent Change
Department of the Army			
Aircraft	2,872	3,268	18%
Missiles	2,592	2,908	17%
Weapons and Tracked Vehicles	2,820	3,002	6%
Ammunition	2,005	1,542	(30%)
Other Items	4,660	4,282	(9%)
Department of the Army			
Aircraft	9,314	11,369	22%
Weapons	6,093	6,333	4%
Shipbuilding	9,882	9,765	(1%)
Other Items	4,736	5,724	21%
Marine Corps Procurement	1,292	1,415	9%
Department of the Air Force			
Aircraft	15,620	20,628	32%
Missiles	7,120	10,372	46%
Other Items	8,154	9,256	14%
Defensewide	2,535	1,795	(29%)

Source: Department of Defense, Procurement Programs (P-1) for Fiscal Years 1990 and 1991 (January 9, 1989)

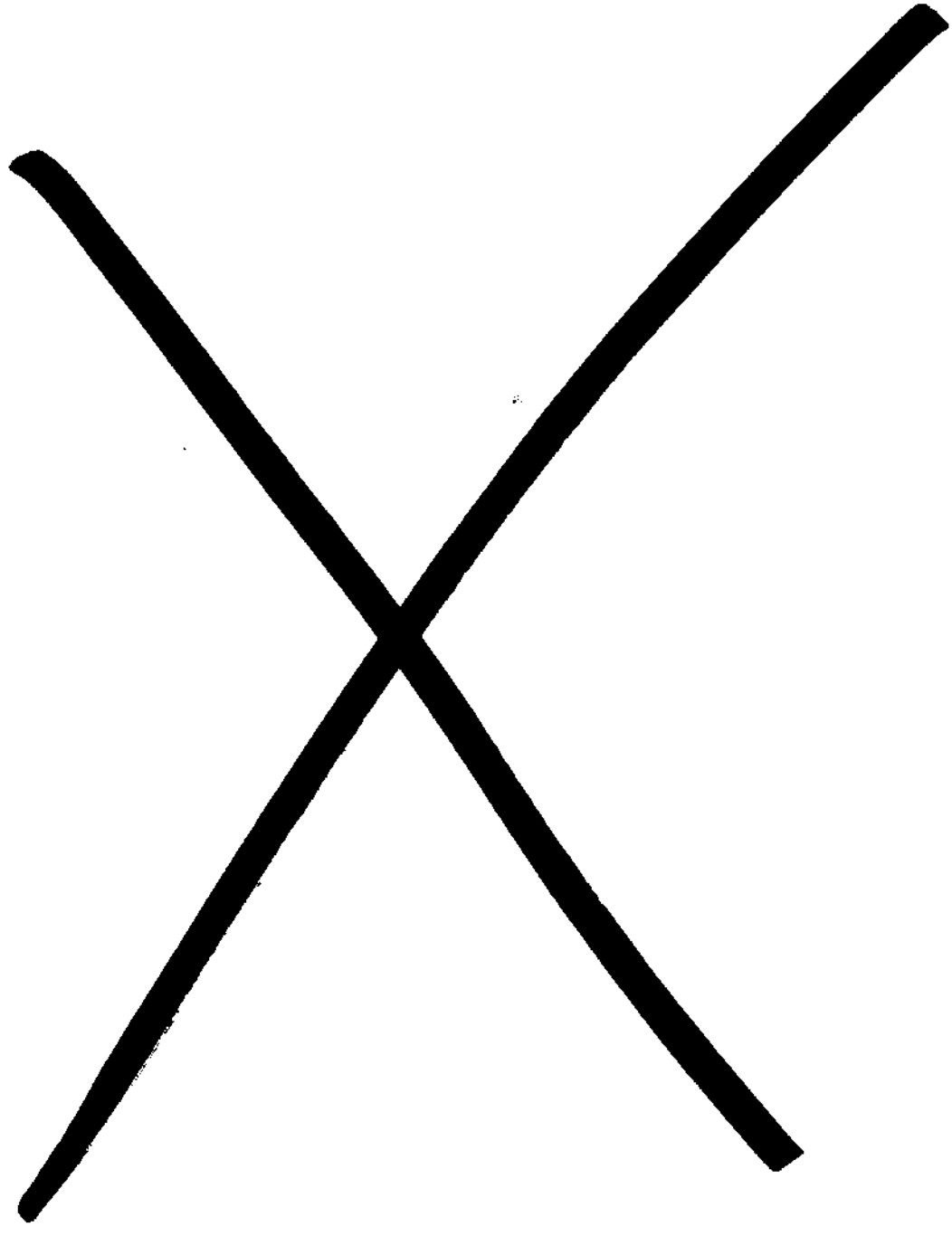
Virtually all observers expect Congress to make major changes in the Reagan defense program. The overall fiscal plan proposes substantial cuts in domestic programs in order to finance the growth in defense, without raising revenue, while meeting the deficit reduction targets mandated in the Gramm-Rudman-Hollings legislation. Many of these cuts have been proposed before and were rejected by the legislature. In addition, there are questions concerning some of the economic assumptions that went into the president's deficit projections, with the upshot that further cuts in spending may be necessary even without a shift in priorities.

At an absolute minimum, it is expected that defense will be held to zero real growth, requiring cuts from the proposed budgets of approximately $6 billion in fiscal 1990 and $13 billion in fiscal 1991. Many observers believe, however, that even larger reductions may be in store for the DOD unless President Bush changes his position on revenue increases. Likely candidates for reductions include the Strategic Defense Initiative and the Air Defense Initiative, each of which is unlikely to exceed current

funding levels; the rail-mobile basing mode for the M-X ICBM, which could be cancelled or at least held to a low funding level; and the B-2 Advanced Technology Bomber, production of which could be delayed for another year or two.

Reductions in force levels may also be mandated over the next few years, including the early retirement of two navy carrier battle groups, the demobilization of additional air force tactical wings, and the demobilization of up to three army divisions. Any reductions in forces, of course, will reduce pressures on procurement and research accounts. It is certain that cuts will be made in defense. However, the allocation of reductions and the depth of the cuts will become clear only over the next four months.

Greg Sheppard
Barry Blechman



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UNISYS: SUCCESSFUL MERGER, BRIGHT FUTURE

COMPANY OVERVIEW

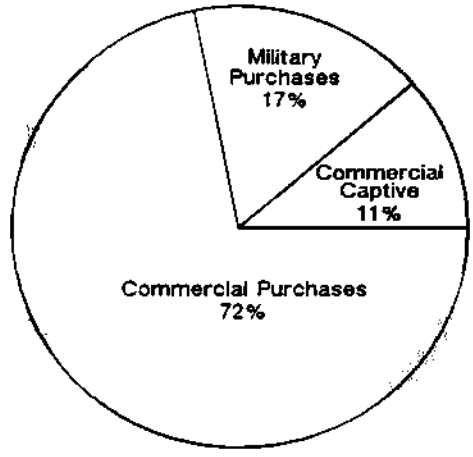
Unisys, formed in 1986 by the merger of Sperry and Burroughs, is a fine example of the power of synergy. Unisys' total revenue in 1988 was $9.9 billion, an increase of 3.0 percent from 1987; earnings were $218 million, roughly flat from year to year. The company manufactures computers ranging from networked workstations through mainframes and is a major supplier of defense electronics including embedded computers, radar control, and navigation systems. The compatibility of product lines, organizational skills, and an ongoing focus on cost control have helped this merger to be uniquely successful as it enters its third year. Although the company is not without challenges still from global and focused competition, it already has hurdled many of the financial problems encountered by joined operations.

Cost savings accrued from the structural changes made since the merger are being transformed into opportunities for long-term growth through research and development (R&D), with a budget that increased by 20 percent in 1988. In fiscal year 1987, Unisys ranked fifth among electronics vendors in R&D expenditures, having invested $597 million in R&D.

One of the important reasons behind the company's success at managing its cost structure is an emphasis on cost-effective sourcing of materials—in particular, semiconductors. Total semiconductor use at Unisys in 1988 is estimated at $360 million, with $40 million in commercial grade produced captively (see Figure 1).

Figure 1

Unisys Semiconductor Use



$360 Million

0003037-1

Source: Dataquest February 1989

COMPANY DIRECTIONS

Unisys expects to double its revenue to $20 billion by the early 1990s. Internal expansion and acquisitions in selected high-growth areas are paving the way for Unisys' growth. In 1988, Unisys acquired Timeplex and Convergent Inc. and entered into a joint venture with Mitsui & Co. to form Nihon Unisys Ltd. (NUL). Timeplex now forms the core of Unisys Networks, uniting all communications engineering and placing Unisys at the forefront of industry-standard networks that provide whole business solutions. Convergent will provide Unisys with strategically important engineering, development, and marketing expertise and will be an anchor for a $2 billion distributed systems business that includes Unisys' UNIX systems, BTOS workstations, and personal computers. NUL will increase opportunities for Unisys in one of the fastest-growing computer markets in the world; NUL is Japan's fifth-largest computer company.

Unisys plans to be the leader in opening and unifying mixed-system environments, and the company expects to revolutionize the practical use of information technology. A new Unisys "solutions environment" will permit use of software across multiple system families. Drawing on its expertise in fourth-generation languages and artificial intelligence, Unisys intends to streamline the entire process for creating applications software.

After a decade of investment in the development of common module technology, Unisys continues to play its key role of developing modularly designed avionic information-processing systems for the future. Unisys has significantly expanded its role in developing navigation, radar, and communications systems as well as electronic warfare systems by securing significant contracts in 1987.

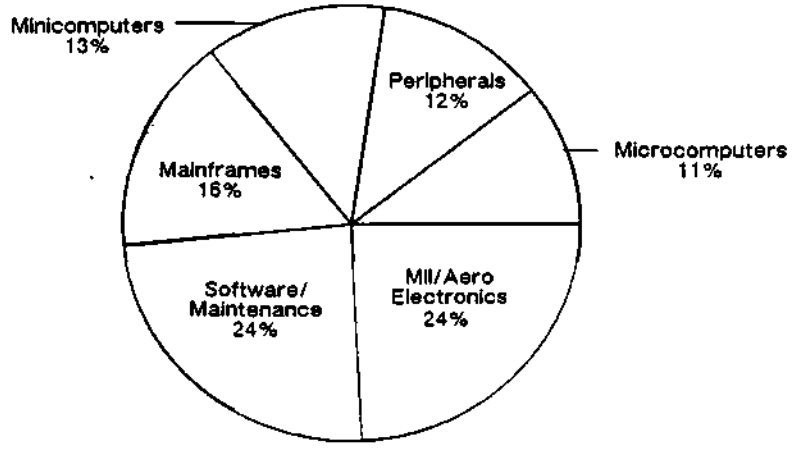
The company is gearing its focus toward entering into larger network projects and improving and upgrading its mainframe and workstation offerings including architectural continuity, connectable open systems, embedded computing systems for military and aerospace, intelligent workstations, and fourth-generation languages.

PRODUCT LINE

Unisys' product portfolio is divided into two main segments: Commercial Information Systems (75 percent of total revenue) and Defense Systems (25 percent of total revenue). Percentage of revenue by product line can be seen in Figure 2.

Figure 2

Unisys Revenue by Product Line



$9.7 Billion

0003037-2

Source: Dataquest
February 1989

Commercial Information Systems

The Commercial Information Systems group focuses on the following five business areas:

- Industrial and Commercial
- Financial
- Public Sector
- Communications and Airlines
- Federal Information Systems

In 1987, Unisys made a significant move toward providing the total business solution. The company expanded its BTOS II family of networked workstations and introduced Cluster Share, through which IBM-compatible PCs can be readily integrated into a BTOS network. The company also introduced the Unisys PW^2 Family, the first Personal Workstation to run all three of the popular industry-standard operating environments: MS-DOS, OS/2, and UNIX.

The company also entered into an important arrangement with AT&T in 1988. This arrangement will allow Unisys to play a strategically valuable role in enhancing the functionality of the UNIX operating system environment for the rapidly growing commercial market.

Unisys reaffirmed its commitment to the mainframe base with a series of significant introductions and announcements in 1988. The company introduced the B38 workstation based on the INTEL 80386. It extended both the high and low ends of the A Series, providing it with one of the widest performance spectrums in the industry. Unisys also extended the 110 and 2200/200 systems and the V Series, and made the first deliveries of the new System 80 Models 10 and 20.

Defense Systems

The Defense Systems group provides defense electronics through these five major lines:

- Shipboard and Ground Systems
- Systems Development
- Communication Systems
- System Support
- Computer Systems

The following paragraphs describe some of Unisys' key military and aerospace programs.

Government Agency Contracts

Unisys is instrumental in the FAA's air traffic control automation and modernization program and supplies all of the FAA's terminal automation systems. Culminating a 10-year cooperative effort by four government agencies, NEXRAD (Next Generation Weather Radar) is now entering production under a $450 million, multiyear contract. By the mid-1990s, 175 NEXRAD systems will be installed for commercial use and in military sites worldwide.

Navy Contracts

The navy accounts for a major percentage of Unisys' defense revenue. In 1988, Unisys won the latest sole-source contract for the AN/AYK-14(V) navy airborne computer. Under this contract, Unisys will provide 65 16-bit computers with options for 365 more units. Unisys is also an alternate supplier for the Aegis combat system. The system will be used aboard more than 50 guided-missile cruisers and destroyers. In April

of 1988, a Unisys/Westinghouse team won a $10 million qualification contract leading to becoming second-source producers for the Aegis SPY-1D electronic radar. Unisys, a leading supplier of shipborne computers, is replacing the navy's old, small, general-purpose computers with embedded computer system families—the UYK43 and UYK44. Unisys also has won a $280 million contract to supply microcomputers throughout the U.S. Department of Defense.

Other major navy contracts awarded in 1988 include a $509 million contract in March for the initial production of navigation systems for D-5 Trident II missile-firing submarines and a $101 million award to provide MK 99 fire-control systems for which Unisys is a second-source supplier. In 1988, installation of the first navigation system on the Trident submarine, the USS Tennessee, was completed and integration tests started.

Air Force Contracts

Unisys is also a contractor on major air force programs. Selected to develop the YF-23 advanced tactical fighter (ATF) avionics processor, Unisys is at the leading edge of new technologies for the future generation of military aircraft. The company has expanded its role in advanced modular avionics and very high speed integrated circuit (VHSIC) central computers for U.S. combat aircraft during the last year. The Unisys Common Module family that includes various standard modules currently consists of 16-bit 1750 MPU modules; 32-bit MPU modules planned; communication modules (1553B, high-speed, dual-speed); and memory (EEPROM, CMOS) and power modules.

The air force also selected Unisys to be one of two major suppliers to the air force's rapid-deployment, high-capacity voice communications project: the AN/TRC-170 Troposcatter Digital Microwave Communication System.

Unisys is developing a third-generation airborne battlefield command and control center (ABCCC3) in a capsule for specially modified Air Force EC-130s to provide contingency command control for forward areas of the battlefield. The center serves as an airborne extension of several ground-based control agencies.

Foreign Government Contracts

Unisys is working on several contracts for foreign governments. At the end of 1987, the Royal Thai Air Defense System (RTADS) which Unisys is designing, integrating and installing, was more than half complete. Unisys is also working on a nearly $1.1 billion contract covering electronic combat systems for six Canadian frigates assigned to Unisys Canadian subsidiary-Paramax Electronics Inc.; the initial contract was extended by $1 billion to supply systems for six more frigates.

DIVISIONS/SUBSIDIARIES

Table 1 presents a summary of Unisys' commercial and defense divisions and subsidiaries. This list represents a combination of Sperry and Burroughs units minus the divisions sold to Honeywell.

Table 1

Unisys Divisions and Subsidiaries

Location	Equipment
Unisys Corporation Detroit, MI (Parent Company)	
Commercial Systems Group	
Foundation Computer Systems Cary, NC	Utility software
GRAFTEK, Inc. Boulder, CO	Peripherals, computer services, engineering/ technical software
Memorex Santa Clara, CA	Peripherals, accessories, components
Pasadena Plant Pasadena, CA	Computers
Sperry Corp. Saint Paul, MN	Electronics services, computers, peripherals, AI software
Timeplex, Inc. Woodcliff Lake, NJ	Utility software, data communications equipment
Unisys Knowledge Systems Organization Paoli, PA	Artificial intelligence
Defense Systems Group	
Communication Systems Group Salt Lake City, UT	Telecommunications, intelligence, data communications, computers
Computer Systems Division Eagan, MN	Information processing systems, militarized computer products and displays
Shipboard & Ground Systems Group Great Neck, NY	Sonar equipment, EW communication systems, sonar countermeasures equipment, ground defense radar systems, shipboard navigation equipment, shipboard radar equipment
System Development Group Camarillo, CA	Command and control, custom services microcomputers
System Support Group McLean, VA	Technical services, facilities management, integrated systems
Semiconductor Facilities	
Unisys Components Group Rancho Bernardo, CA	ASICs

Source: Various Industrial Sources

SEMICONDUCTOR PROCUREMENT

The impact of Unisys' new leverage after the merger was felt directly in purchasing. Greater volume allowed Unisys to renegotiate supplier contracts, significantly reducing procurement costs. It also created a critical mass to successfully execute vendor quality–improvement programs. In 1987, Unisys cut 21 percent off its purchasing bill. Suppliers' rosters were dramatically cut also; for instance, the number of connector suppliers was reduced from 88 to 20.

The purchasing operation is done through central procurement units as well as through the divisions themselves. The Materials Management Center (MMC) in Pueblo, Colorado, is in charge of semiconductor procurement for the Computer Systems Division units in Pueblo and in Saint Paul, Minnesota, as well as for the Shipboard and Ground Systems Group in Clearwater, Florida. The Communication Systems Division in Salt Lake City, Utah, and the Shipboard and Ground Systems Group in Great Neck, New York, do their own purchasing. Central procurement for commercial semiconductors is done by the Component Engineering and Procurement Organization (CEPO) in San Diego, California. CEPO is responsible for supplier qualification, component engineering, quality verification, contracts, and executing procurement.

Figure 3 shows a percentage breakout of semiconductor purchases. In–house capabilities, recently consolidated into the Rancho Bernardo, California, facility, supply an estimated 11 percent of commercial semiconductor use. This facility produces primarily gate arrays and cell–based ICs. These products are manufactured both on bipolar process technology as supplied by Motorola and on CMOS from Intel. Along with internal CAD and packaging technology, the purpose of this captive capability is to produce volume proprietary logic ICs as well as quick–turn engineering prototypes. Standard products are almost entirely purchased directly from outside vendors.

Military semiconductor purchases accounted for approximately 19 percent or $60 million of total external purchases. All of the military semiconductor sourcing is done externally, both directly and with distributors.

After the merger, Unisys reorganized its purchasing operations, creating the following seven procurement task forces:

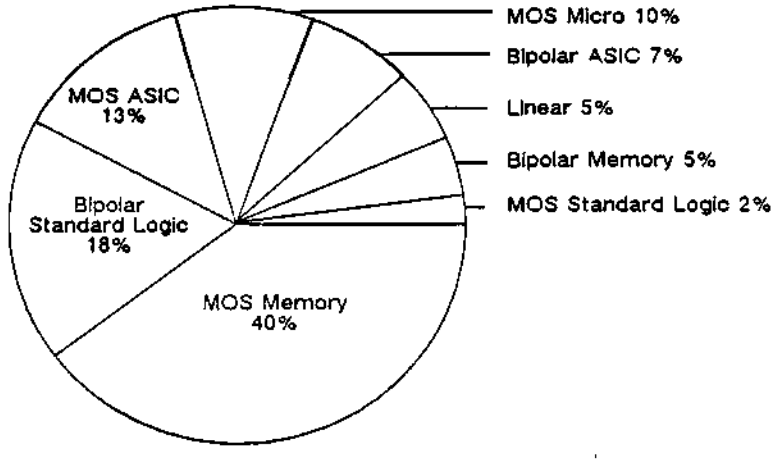
- Electronics
- OEM
- Foreign
- Mechanical
- Semiconductor
- MRO
- Government

These task forces are responsible for determining corporate needs, setting price targets, and conducting negotiations. Four of the task forces deal primarily with electronics. The semiconductor group coordinates contracts for both defense and commercial divisions; the OEM group coordinates personal computers and small systems; the electronic group coordinates all passive devices, connectors, electromechanicals, and printed circuit boards; and the international procurement group executes purchases with offshore suppliers mostly in the Far East. Offshore suppliers, account for roughly $350 million annually—mostly for systems, peripherals, and components. The role these offshore suppliers play is increasing as they represent a growing portion of Unisys' purchases.

Strategic programs that facilitate and improve operations efficiency are also being set in place. Currently Unisys has certification, just-in-time (JIT), and electronic data interchange (EDI) programs with selected component vendors.

Figure 3

Unisys Semiconductor Purchases
1988



$360 Million

0003037-3

Source: Dataquest February 1989

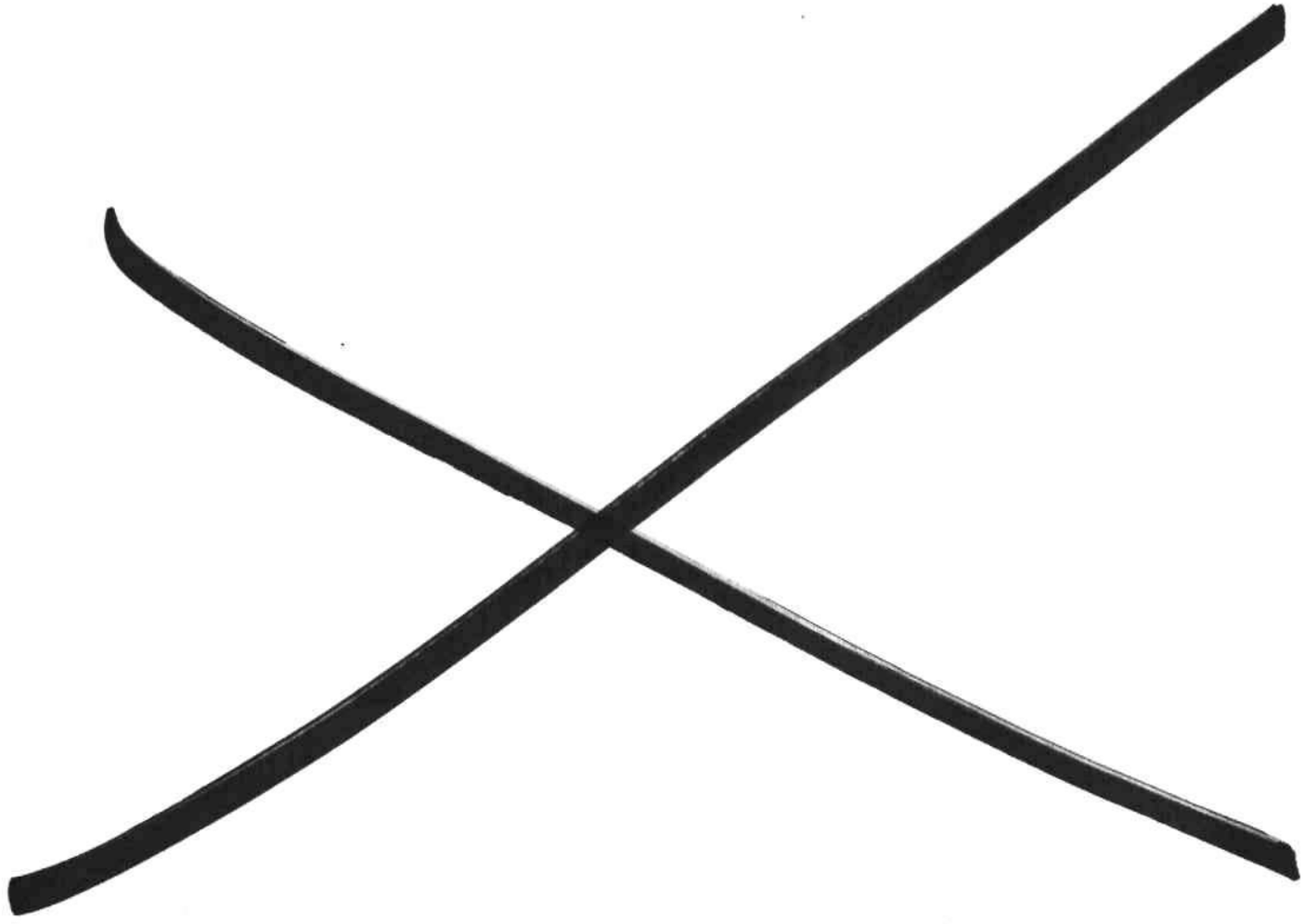
DATAQUEST CONCLUSIONS

Compatibility, leverage, and cost control are perhaps the best terms to describe the success of the Unisys merger. Similar yet somewhat complementary product lines and corporate organizations have helped Unisys in achieving leverage in both the markets it serves and the purchases it makes. Although 1988 was a relatively flat year for revenue and earnings growth, the company is faring much better than most mergers and probably much better than either Burroughs or Sperry could have alone.

Unisys has been able to maintain a high level of R&D investment principally because of aggressive cost control and economies of scale achieved during the past two years. By applying the principle of centralized leveraged contracting and working closely together with its suppliers and internal engineering organizations, the component procurement groups at Unisys have contributed greatly toward maintaining cost control.

Unisys' ability to increase R&D efforts because of reduced overall costs is a key competitive advantage, putting the company in an enviable position of decoupling its new product-development funding from moderate swings in revenue. This could prove to be an advantage in both the commercial computer market, where many economists are predicting a downturn in 1990, and in the defense electronics market, where funding is flat and efficiencies will be mandated.

Greg Sheppard
Najoo Wadia



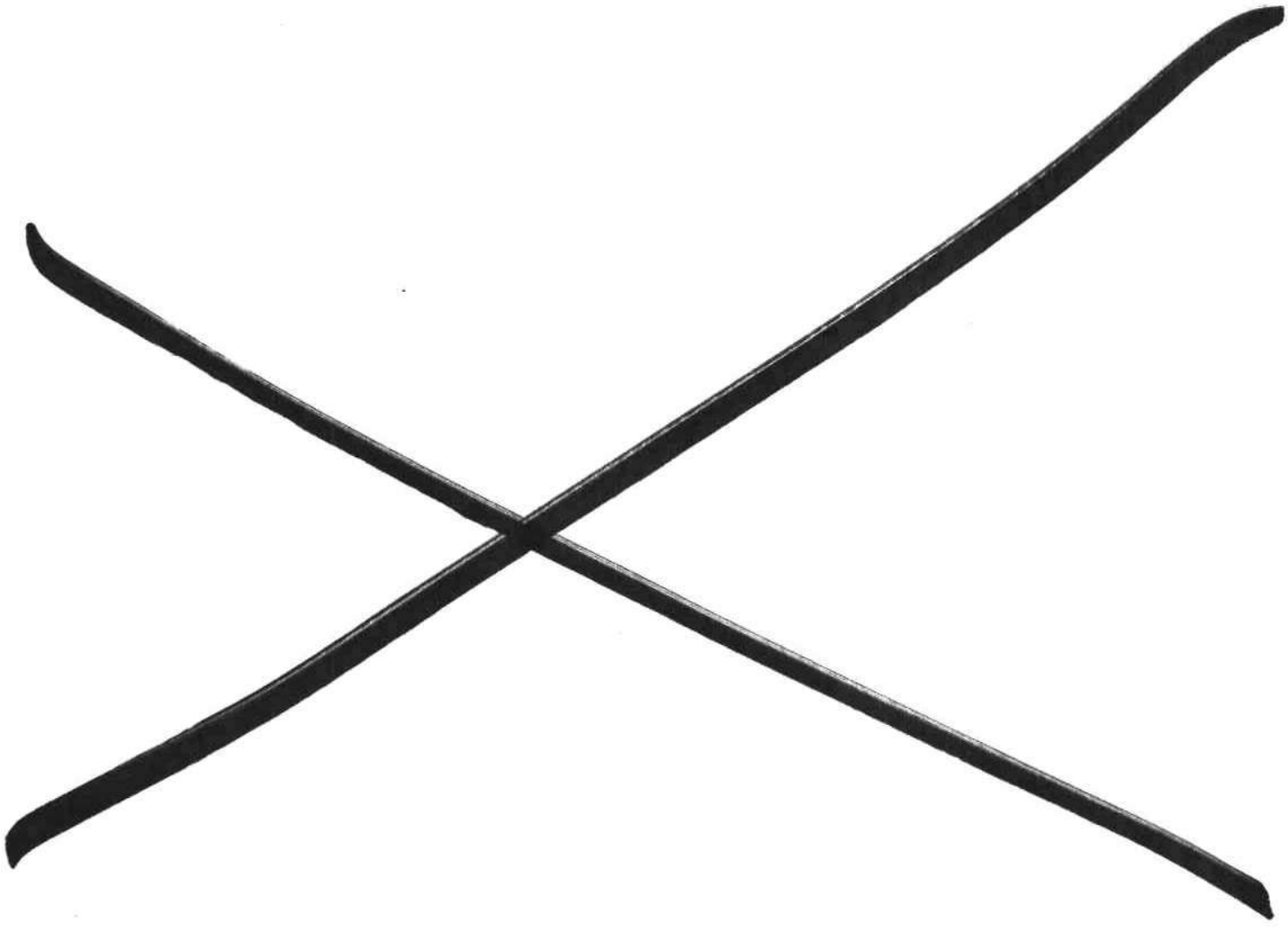
1988 MilAero Newsletter Index

The enclosed MILAERO Newsletter Index is a quick reference guide to the MILAERO 1988 newsletters. It is structured as follows:

- Titles are organized by both subject and company.
  - The first part is a company list, e.g., LSI Logic.
  - The second part is a subject list, e.g., Memory.
- The newsletter month and year follow each title listing in the index. Refer to the month tab to locate a specific newsletter.

This index is updated quarterly.

1988 MilAero Newsletter Index



Dataquest
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Research *Newsletter*

MilAero Code: 1988–1989 Newsletters: November 1988–3
0001839

RECOMPETITION: A WAY OF LIFE

OVERVIEW

In spite of controversial public benefits, the U.S. government is continuing with a policy of dividing up the production contract pie on many of the large defense programs. Following guidelines laid down by congressional acts and Department of Defense directives, DOD management must recompete or second–source certain programs to gain further efficiencies in technology utilization, unit pricing, quality, schedule, and industrial base expansion.

The impact of this continuing policy direction is risk for some and opportunity for others. Risk comes for contractors and their suppliers who participate in the RTD&E phase of a program and stand the chance of losing their investment of time and money if the production phase of that program is shared or given to another team. On the other hand, recompetition creates opportunities for other OEMs and their suppliers.

BACKGROUND

An overview of the recompetition situation was presented at the annual EIA ten–year forecast meeting. Presented at this meeting was an analysis of the status, directions, and programs affected by recompetition or second–sourcing.

The principal motivation for recompetition has come from the implementation of several overlapping congressional acts and DOD directives (see Table 1). The driving force for these policies is a desire to obtain the best technology for defense systems while keeping a cap on costs. Costs are broadly defined to include the direct cost of manufacturing, the cost of schedule slippage, and the cost of quality. The other objective of these policies is to broaden the industrial base through involvement of a larger set of companies.

Table 1

Recompetition Policy Guidelines

Event	Result
1981 Defense Acquisition Improvement Program	Increased competition in the acquisition process
1982 DOD Directive 5000.1 (Updated in 1987)	Policies that govern the procurement of defense programs
1983 DOD Directive 5000.2 (Updated in 1987)	For major systems; defines the procedures to be used and the structure of DSARC
1984 DOD Appropriations Act, Section 797, P.L. 98-212	Concentrates on production contracts; SECDEF must justify sole source award or provide a plan for dual sourcing
1984 Competition in Contracting Act (CICA)	Established competition as the norm and sole source as the exception
1986 Defense Acquisition Improvement Act	Acquisition strategy due to SASC and HASC prior to beginning FSD on any major program; must consider multiple sources

Source: EIA

Although there are recompetition advocates in each of the services, the how-and-when decision is usually made by the individual program managers. According to the EIA, the following list of criteria are typically used for determining which programs could be recompeted:

- Congressional interest
- Priority program
- Large quantities
- Small proportion of nonrecurring costs
- Relatively flat rate and economic learning curves
- Adequate technical data packages

The types of recompetition are listed in Table 2. An analysis of past recompetitions indicates that there is no predominant method and that the circumstances of each particular program dictate the method chosen.

Table 2

Recompetition Forms

Form	Characteristics
Form, Fit, Function (F3)	Design commonality not required; must meet operational requirements
Technical Data Package (TDP)	Developers data package provided to second-source by customer
Leader-Follower (L-F)	Second-source needs developer's help to produce the end item
Licensing (L)	Developer grants limited data rights to second-source for royalty fees
Teaming (T)	Teams formed prior to FSD; each builds specific parts and they trade technology
Leader-Leader (L-L)	Two contractors chosen as primes through the FSD phase

Source: EIA

THE CONTROVERSY

The true long-term benefit to the U.S. government from recompetition is a controversial subject. The controversy lies in the valid measurement of the past success of recompetition. Several government audits claim that recompetition has achieved its economic objectives and should be continued. However, some people believe that the audits were superficial and did not take into account such factors as learning-curve losses and the time value of money. In spite of the disagreement, several defense contractors are in poor financial health, and recompetition is one of many factors contributing to the wave of merger and acquisition activity.

RECOMPETITORS

Some companies have proven to be very successful at pursuing and securing follower or second-source contracts. Some companies actually prefer to be a second-source, thus avoiding the risks of pioneering the engineering development. Nevertheless, second-source companies must be very competitive, especially with manufacturing efficiency, subassembly and component procurement, and quality control. Some of the more notable second-source companies are Raytheon (on the AMRAAM, Maverick, and Stinger missiles), Rockwell (on several communications programs), and Unisys (for AEGIS electronics).

POTENTIAL RECOMPETITIONS

Tables 3 through 5 present a set of programs that could be potentially recompeted over the next few years. Indicated are the program name, the sponsoring government agency, the current prime contractor, and an estimate of when the recompetition activity could occur.

Table 3

Potential Air Force Recompetitions

Program	Sponsor	Prime	Method	Schedule
MSOW/AIWS	Armament Division	TBD	L-F	1995+
Tacit Rainbow	ASD	Northrop	L-F/Dual Source	1989
Sensor-Fused Weapon	Armament Division	AVCO	TBD	1991
ASRAAM	International MOU	TBD-NATO Consortium	Dual Source	1995
Long-Range Cruise Missile	Armament Division	TBD	L-F	1995+
Have Quick IIA	ESD	Magnavox	TDP	1989
GPS User Equipment	USAF/USN/USA	Various	TDP/F^3	1990+
MK-XV IFF	USAF/USN/USA	TBD (Raytheon/Bendix) (TI/E-System/ Teledyne/Hazeltine)	TBD	1988
AGM-130A Standoff Weapon	Armament Division	Rockwell	TDP	TBD
SRAM II	ASD	Boeing	F^3	1992
DAACM	Armament Division		Subcontract Dual Sources	
NDS Satellite Payload Boxes	ASD Space Division	Rockwell	TBD (F^3 or TDP)	1991
AN/ALR-74 RWR	ASD Wright-Patterson	Litton	TDP	1990
AN/ALR-56C RWR	ASD Wright-Patterson	Loral	L-F	1989
MX Ordnance Initiation Set	Ballistic Missile Office	Thiokol/Lockheed	Dual Source	1989
MX Third Generation Gyro	Ballistic Missile Office	Honeywell/Northrop	Dual Source	1989

TBD = To Be Determined

Source: EIA

Table 4

Potential Army Recompetitions

Program	Sponsor	Prime	Method	Schedule
FOG-M	MICOM	TBD (Hughes/Boeing) (Ford/GD) (TI/Martin)	Prime-Teaming Subcontract L-F	1993/1994
AAWS-M	MICOM	TBD (Ford/GD) (Hughes/Honeywell) (TI/Martin)	Prime-Teaming Subcontract L-F	1990 1995
AAWS-H	MICOM	TBD	TBD	TBD
TOW 2	MICOM	Hughes	Dual Source	1992
Patriot	MICOM	Raytheon	TBD	1993+
MLRS	MICOM	LTV	Subcontract L-F	TBD
IFTE	CECOM	Grumman	L-F	1989
MSE	CECOM	GTE/Thomson	L-F	1992
EPLRS	CECOM	Hughes	TBD	1990
Tactical Automatic Switcher System	CECOM	GTE		
ADV Quick Look	ERADCOM	UTL	TBD	TBD
AFTADS	CECOM	Magnavox	TBD	TBD
FAAD C^2I	CECOM	TRW	Winner-Take-All	1989
Follow-On to Lance	MICOM	TBD	TBD	1995
RPV/UAV	Joint Program Office	TBD	TBD	TBD
LHX	AVSCOM	TBD (Boeing/Sikorsky) (MDC/Bell)	Dual Source	1991
ATACMS	MICOM	LTV	Subcontract L-F	1990

TBD = To Be Determined

Source: EIA

Table 5

Potential Navy/Marine Recompetitions

Program	Sponsor	Prime	Method	Schedule
Sea Lance	NAVSEA	Boeing	L-F/Dual Source	1990
AAAM	NAVAIR	TBD (Hughes/Raytheon) (GD/Westinghouse)	Prime-Teaming Subcontract L-F	TBD
AIWS/MSOW	NAVAIR	TBD	L-F/Dual Source	1995+
Harpoon/SLAM	NAVAIR	McDonnell Douglas	L-F	TBD
RAM	NAVAIR	General Dynamics	Dual Source	TBD
Dragon III	USMC	McDonnell Douglas	Dual Source	TBD
Excalibur	NAVSEA/NAVAIR	TBD	L-F	TBD
HARM Low-Cost Seeker	NAVAIR	Ford	L-F	1992
F-14A Remanufacture	NAVAIR	Grumman	L-F	1990
MK-10616 Transducer	NAVSEA	BF Goodrich	TDP	1988
AN/ASW-27C Data Link System	NAVSEA	Harris	TDP	1989
Airborne Instrumentation System	NAVAIR	Kollsman/Cubic	TDP	1989
AN/TYQ-23	SPAWAR	Litton	Subcontracts L-F	Ongoing
WPU-5/B Rocket Motor	NAVAIR	Aerojet	TDP	1989
TALD	NAVAIR	Brunswick	L-F	1989
A-6E SDLM/Rewing/ Block Upgrade	NAVAIR	Grumman	TDP	1990
ID-1791 A/A and ARV-48A Attitude Indicators	NAVAIR	Jet Electronics Technology, Inc.	F^3	1989
AN/AQS-XX ALFS	NAVAIR	TBD	L-F	1989
V-22 Osprey	NAVAIR	Bell/Boeing	Teaming	1991/1992

(Continued)

Table 5 (Continued)

Potential Navy/Marine Recompetitions

Program	Sponsor	Prime	Method	Schedule
Big Eye Bomb	Joint Program	Marquardt	TDP	1993
ASPJ High-Voltage Power Supply	NAVAIR	ITT	F^3	1989
AN/APS-137(V) Radar	NAVAIR	TI	L-F	1990
AN/UYS-2 EMSP	NAVSEA	AT&T	L-F	1990/1991
AN/AYK-10A Upgrade	NAVAIR	Unisys	TDP	1990

TBD = To Be Determined

Source: EIA

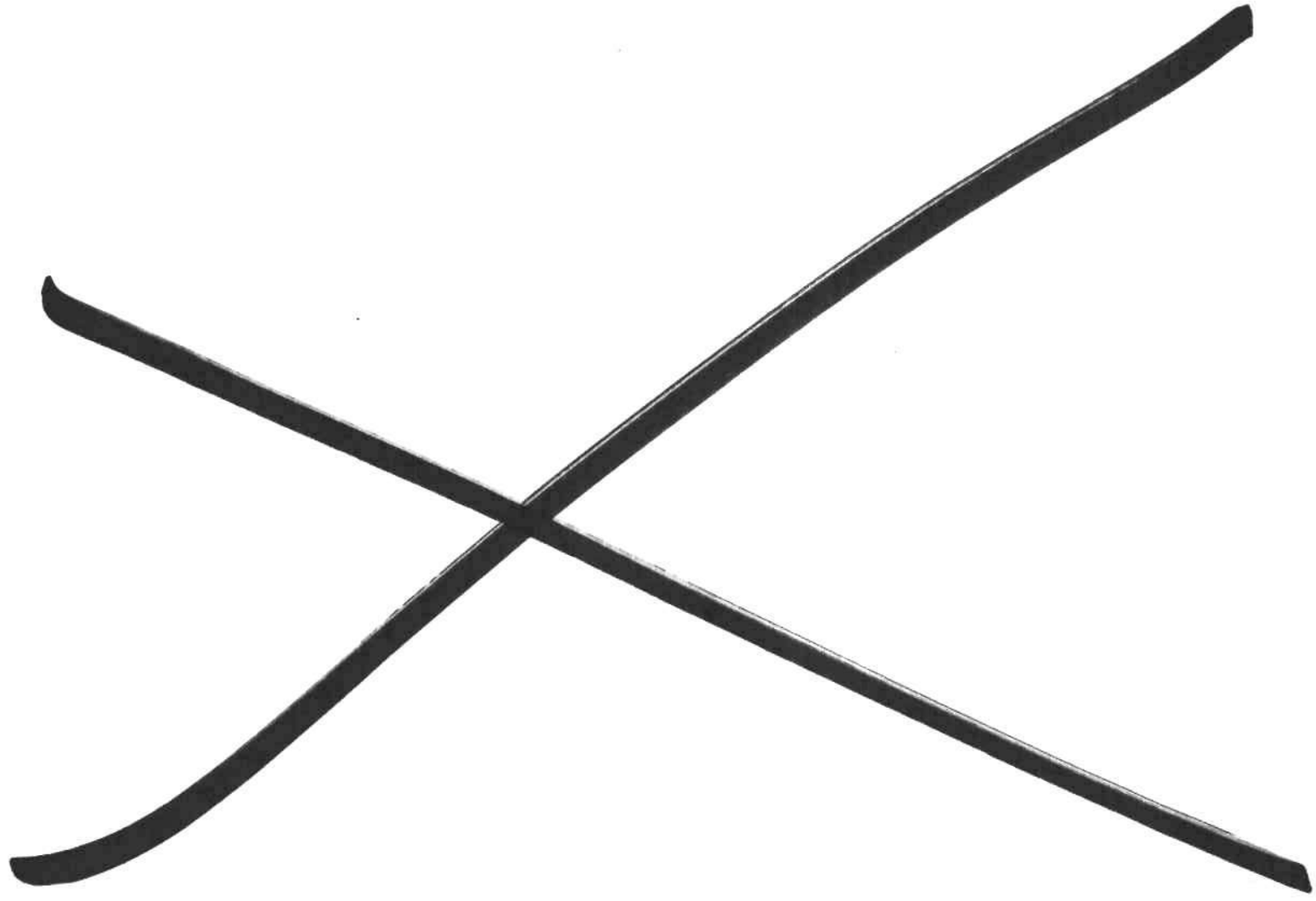
DATAQUEST CONCLUSIONS

In spite of arguments against the merits of recompetition, Dataquest believes that recompetition is here to stay for some time. We believe that Congress will continue to exert pressure on DOD administrators to recompete various high-visibility programs.

The bottom-line impact for OEM contractors is multifold. OEM manufacturers need to continue improving their efficiency in applying technology and developing cost-effective manufacturing and procurement systems. They also need to continue active management practices to streamline their operations and to integrate the functions of engineering, manufacturing, and procurement. The companies that do not adjust will eventually lose out in the race for the large production contracts.

The impact on the subassembly and component suppliers will be very similar as the same requirements are passed on to them. Zero defects, just-in-time delivery, and electronic data interchange (EDI) are some of the demands that will be placed on suppliers. Additionally, suppliers will need the capability to follow opportunities as they migrate to second-source OEMs.

Greg Sheppard



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Research Newsletter

MilAero Code: 1988–1989 Newsletters: July–September
1988–02
0000870

MILITARY ELECTRONICS MARKET: OPPORTUNITY IN TRANSITION

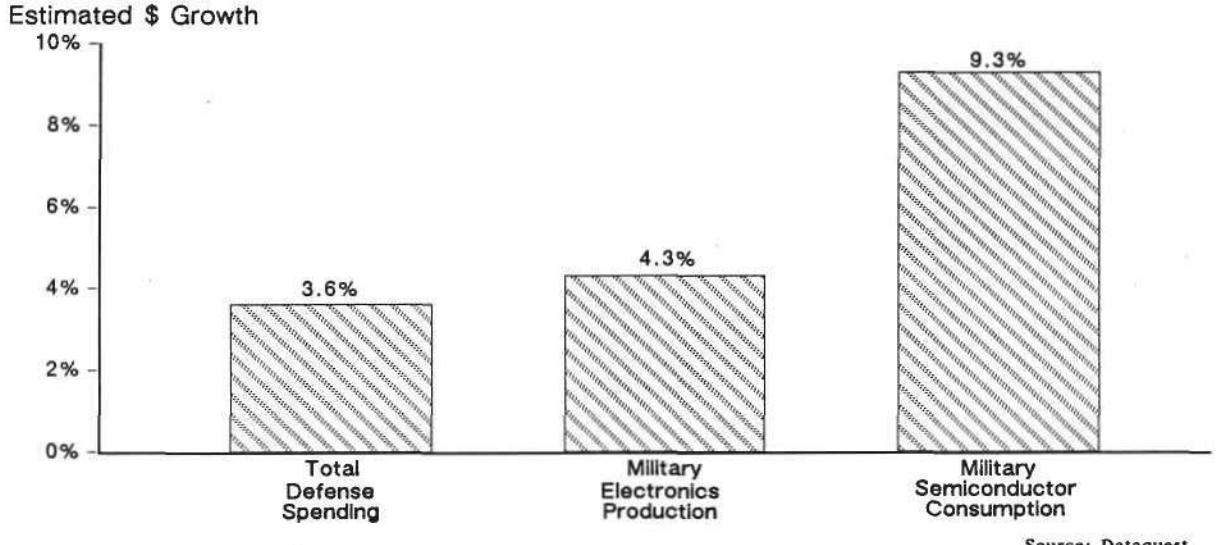
SUMMARY

There is little doubt that worldwide military spending is flattening as the U.S. defense budget, which dominates about 50 percent of worldwide spending (excluding the Warsaw Pact countries), declines and levels out. But there is also little doubt that the electronic and semiconductor content of new military systems, as well as related upgrade programs, is increasing and should continue to increase well into the next century, providing a lucrative opportunity for well–positioned suppliers.

Figure 1 summarizes the interrelated projected growth rates for worldwide total military spending, military electronics production, and military semiconductor consumption. For the period 1988 through 1994, military electronic equipment production is expected to grow at a 4.3 percent compound annual growth rate (CAGR) while semiconductor consumption for that equipment will grow at a 9.3 percent CAGR. Electronics is expected to be heavily relied upon as a productivity multiplier to counter the effects of leveled budgets. The United States and NATO are expected to continue using sophisticated electronics to even effectively the balance of power with Warsaw Pact countries.

Figure 1

Estimated Worldwide Military Electronics Growth Elements 1988–1994 CAGR



Source: Dataquest August 1988

EQUIPMENT OPPORTUNITIES

Macro Trends

For the next five to ten years the complexion of military electronics spending is going to change. A large percentage of spending during the Reagan administration was for new, sophisticated platforms (ships, submarines, aircraft, etc.) and weapon systems. Most of these systems utilized electronics as a means of achieving flexibility and effectiveness. What appears to be the political reality of the future, however, is less concentrated spending on the big ticket systems and more on enhancement of what is currently in production. We therefore believe that many of the large RTD&E programs, including Strategic Defense Initiative (SDI), the Advanced Tactical Aircraft (ATA), and the Advanced Tactical Fighter (ATF), will be stretched out into the mid-1990s.

Another major shift in electronics consumption will mirror developments in nuclear weapon treaties. As treaties like Intermediate Nuclear Forces (INF) take effect, conventional systems are expected to be emphasized with additional funding. Specific areas of emphasis, as outlined by the Balanced Technology Initiative and NATO, are:

- Smart weapons
- Reconnaissance, Surveillance, and Target Acquisition/Battle Management C3I (RSTA/BM)
- High-power microwave technology
- Armor/anti-armor technology
- Stealth and antistealth systems
- Satellite treaty verification systems

System Forecast

Table 1 presents the worldwide forecast for military electronic equipment production; some of the forecast highlights are discussed in the text that follows.

Table 1

Worldwide Military Electronic Equipment Production Forecast
(Millions of Dollars)

	1987 (Actual)	1988	1989	1992	1994	CAGR 1988-1994
Radar	$10,671	$11,034	$11,124	$12,402	$ 13,316	3.2%
Sonar	3,682	3,766	3,791	4,283	4,631	3.5%
Missile and Weapon	9,640	10,115	10,360	12,418	13,937	5.5%
Space	6,922	7,041	7,066	8,421	9,418	5.0%
Navigation	2,184	2,272	2,315	2,671	2,941	4.4%
Communication	7,170	7,562	7,801	9,160	10,095	4.9%
Electronic Welfare	5,173	5,461	5,604	6,609	7,292	4.9%
Reconnaissance	3,515	3,689	3,789	4,412	4,862	4.7%
Aircraft Systems	6,851	7,140	7,267	8,528	9,489	4.9%
Computer Systems	7,548	7,873	8,053	9,588	10,710	5.3%
Simulation and Training	973	1,029	1,062	1,299	1,474	6.2%
Miscellaneous Equipment	14,346	14,897	15,134	16,588	17,516	2.7%
Total Military	$78,676	$81,878	$83,366	$96,379	$105,681	4.3%

Source: Dataquest
August 1988

Radar Systems

Radar systems comprise the largest single category of equipment. Their presence is ubiquitous as they are utilized in many situations, including air traffic control, air and space defense, and instrumentation. Their market is affected heavily by the number of platforms built, especially aircraft and missile platforms. Some of the key programs driving the radar forecast are the F-16, ATF, ATA, EFA, B-2 aircraft, implementation of the Joint Surveillance Target Attack Radar System (JSTARS) systems, the Patriot air defense system, and upgrades of the Ballistic Missile Early Warning Systems (BMEWS) and of the Distant Early Warning line (DEW).

Sonar Systems

The sonar systems forecast reflects a slowing number of new ships and submarines, but continued healthy funding for antisubmarine warfare (ASW) and upgrades.

Missile and Weapon Systems

Missile and weapon systems will be influenced by two primary factors: increased desire for better guidance and control, and a reduced need for strategic missiles. Some of the larger missile programs include the Trident II, AMRAAM, and Patriot.

Space Systems

Space systems will continue to be prioritized for communications, meteorology, surveillance, and intelligence needs. SDI, the single largest program, is expected to continue in the R&D phase until the mid-1990s.

Navigation Systems

Navigation system production will continue to be affected by the implementation of the Global Positioning System (GPS) as well as aircraft production levels.

Communications Systems

Communications systems, such as the Single-Channel Ground and Airborne Radio (SINCGARS) and the Mobile Subscriber Equipment (MSE), will continue to be implemented over the next three to five years.

Electronic Warfare Systems

Electronic warfare systems will continue to be used in helping defend aircraft and ships from missile attack. The Integrated Electronic Warfare System (INEWS) exemplifies one large program targeted for use on the ATF, ATA, and B-2 bomber.

Reconnaissance Systems

Reconnaissance systems will continue to be emphasized as the ears and eyes for intelligence information. The Advanced Tactical Air Reconnaissance System (ATARS) is one new system that will replace film-based sensors with optoelectronics.

Aircraft Systems

Aircraft systems include aircraft-specific controls and instrumentation as well as integrated systems like the Integrated Communications, Navigation, and Identification Avionics (ICNIA). Both upgrades and new aircraft production will affect growth for this category.

Computer Systems

Computer systems include both commercial and militarized general-purpose systems. Their use in RTD&E and administration is very mature; however, their embedded applications are growing rapidly.

Simulation and Training Equipment

Simulation and training equipment will continue to find ready demand as the need to educate new pilots, commanders, equipment operators, and technicians continues to expand.

Miscellaneous Equipment

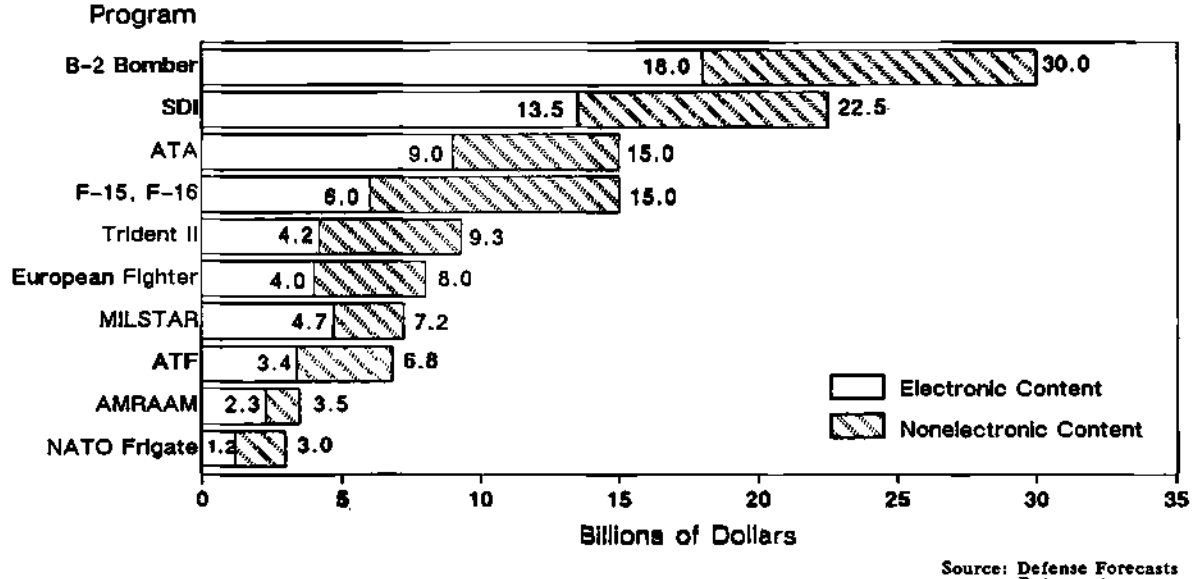
Miscellaneous equipment comprises a mixture of unidentified hardware for operations and maintenance purposes, and highly classified programs.

Important Programs

Ten of the most important military system programs are identified in Figure 2. The largest of those identified is the B-2 Advanced Technology "Stealth" Bomber, with cumulative spending from 1990 through 1994 estimated at $30.0 billion. The electronics content of the spending on this program is estimated at $18.0 billion. Additionally, Dataquest estimates that the program will consume an estimated $610 million worth of semiconductors over the same time period.

Figure 2

Ten Important Military Programs
Spending Forecast
1990–1994



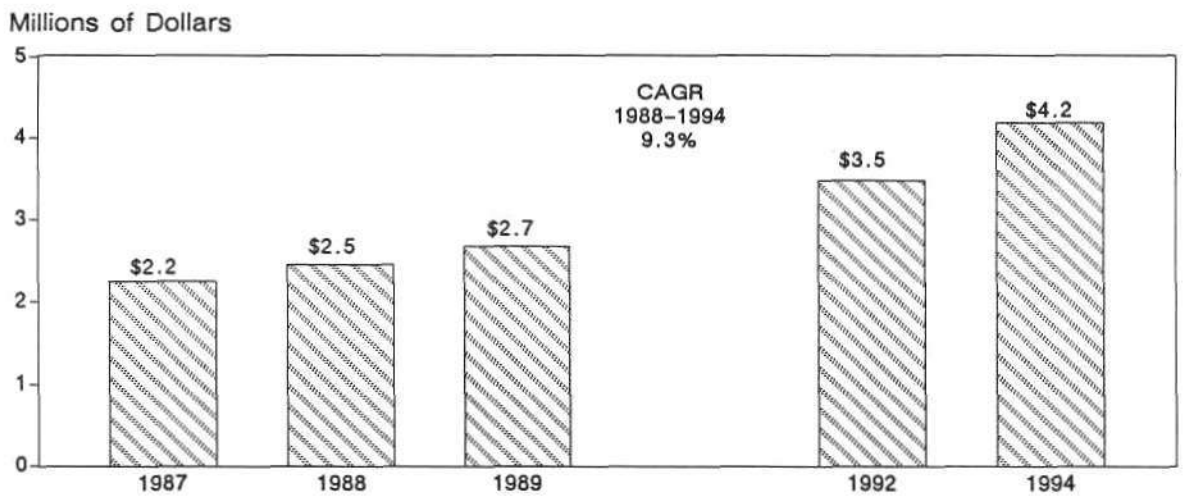
Source: Defense Forecasts
Dataquest
August 1988

CHIP VALUE

The worldwide military semiconductor market was estimated at $2.2 billion for 1987. It is expected to grow 9.1 percent in 1988 and at a 9.3 percent CAGR from 1988 through 1994, as shown in Figure 3. Slowing outlays, program audits, oversupply, and excess inventory all occurred during 1987, making it a depressed year for military semiconductor shipments. The result of all this activity was a collapse in prices, especially in the commodity standard logic and linear categories, where prices dropped 25 percent or more. In 1988 we have been witnessing a moderate recovery as some of the inventory is burned off, some of the part-time suppliers have exited, and prices generally have stabilized. In 1989, we expect more of the same moderation as macro-perturbations from budget declines sort themselves out.

Figure 3

Estimated Worldwide Military Semiconductor Market



Source: Dataquest
August 1988

All forms of MOS are expected to dominate future military applications, as they dominate in commercial applications (see Table 2). CMOS has much design-in presence in space and missile systems. However, CMOS is experiencing a much broader demand as most of the new military applications fall under increasingly ambitious size and power constraints. Military systems are also expected to better utilize VLSI-era products such as 16- and 32-bit MPUs, sophisticated peripheral chip sets, and high-density SRAMs, EPROMs, EEPROMs, and increasingly, DRAMs. ASICs, especially CMOS gate arrays and bipolar programmable logic, have already been discovered as the convenient route to customized, integrated solutions. For high-performance needs, the new generation of high-density, lower-power bipolar gate arrays are expected to win designer approval for 1990s systems.

Table 2

Worldwide Military Semiconductor Consumption Forecast
(Millions of Dollars)

	1987 (Actual)	1988	1989	1992	1994	CAGR 1988-1994
IC	1,833.8	2,011.1	2,210.4	2,931.7	3,579.3	10.1%
Bipolar Digital	607.7	614.8	624.7	687.8	738.6	3.1%
Memory	113.2	107.6	104.4	97.6	89.5	(3.0%)
Logic	494.5	507.2	520.4	590.1	694.0	4.2%
MOS Digital	782.6	914.3	1,065.9	1,580.4	2,048.6	14.4%
Memory	264.6	302.4	347.8	514.3	650.1	13.6%
Microcomponent	190.0	224.9	266.1	423.0	584.3	17.2%
Logic	328.0	387.0	452.0	643.1	814.2	13.2%
Analog	443.5	482.0	519.8	663.5	792.1	8.6%
Discrete	330.3	352.5	372.7	430.2	483.8	5.4%
Optoelectronic	82.3	87.5	90.6	108.8	123.9	6.0%
Total Semiconductor	2,246.3	2,451.2	2,673.6	3,470.7	4,187.0	9.3%

Source: Dataquest
August 1988

Some other high-growth product areas will include GaAs ICs, which will displace hybrid discrete front-end systems with an integrated, intelligent capability to address the changing world of secure communication, accurate radar, and counterpoint electronic warfare. Intelligent power is expected to continue penetrating systems, as concepts like fly-by-wire (electronic rather than mechanical or hydraulic controls) for aircraft begin to be implemented.

We expect improvements in the semiconductor acquisition system to help accelerate acceptance of many of these new products. One important acquisition system improvement will be the creation of a qualified manufacturers list (QML), which qualifies a manufacturer's ability to produce high-quality products without requiring the extensive documentation and testing for each part built to a military specification.

DATAQUEST ANALYSIS

Opportunities will continue in military electronics and semiconductors, but the opportunities are going to be more selective as the worldwide industry adjusts to a slowdown in defense spending. Perhaps our most important recommendation is to remain vigilant and flexible. From the perspective of an electronics OEM or a technology supplier to those OEMs, it will be increasingly important to remain aware of which military programs are viewed by policy makers as absolutely required and which are not. Gone are the days when all military programs are fully funded.

Greg Sheppard

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DEPARTMENT OF DEFENSE (DOD) PROCUREMENT SCANDAL

SUMMARY

On Tuesday, June 14, a two–year, top secret investigation of fraud and bribery in the military contracting process—dubbed "Operation Ill Wind"—was brought dramatically to the public's attention, as agents from the FBI and the Naval Investigative Service combed the offices of current and former Pentagon officials, defense contractors, and their consultants, searching 38 locations nationwide. The investigation has placed as many as 85 contracts, worth tens of billions of dollars, under scrutiny, in what Senator John Warner (R–Va.), ranking Republican on the Senate Armed Services Committee, called "the most serious case (of corruption) in the history of the Department of Defense." The primary long–term implication of this scandal will be eventual, increased controls by the U.S. government on contractors. This comes at a time when the government was considering easing controls. Short–term implications include fines and suspensions for the companies involved and possible rebidding on involved contracts. To date, there has been no major impact on semiconductor buying plans by military OEMs.

Investigation Background and Details

The investigations center on three types of wrongdoing. One, defense "consultants" obtained information from Pentagon personnel on the bids submitted by a contractor's competitors, often in return for bribes of various sorts, and then sold that information to the contractor for much more than they paid. Two, DOD procurement officials were induced to change weapon system specifications to skew contract competitions toward certain contractors. Three, the contractors themselves engaged in collusive bidding, in which one contractor would agree not to underbid another in exchange for promises of lucrative subcontracting.

The activities of the implicated consultants, some of whom are former DOD officials, have received particular attention, with Melvyn Paisley, former assistant secretary of the navy for research, engineering, and systems (until March 1987), and his associate, William Galvin, two of the most frequently mentioned figures.

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

To date, a total of 42 search warrants has been served around the country; an additional 275 subpoenas for documents and testimony have been issued. The contents of the warrants and the affidavits used to obtain them have, by and large, remained under court seal; however, accounts of the investigation were sketchy (a small number of warrants and affidavits provided most of the available specifics). Federal investigators have indicated that affidavits still under seal include more explosive material about larger companies and bigger contracts.

According to press reports, more than 50 consultants, perhaps two dozen DOD officials, and as many as 20 defense contractors are under scrutiny. It is important to note, however, that no company or individual has yet been charged with wrongdoing; indeed, some of the contractors that have been named may not be targets of the investigation, but rather, were searched for information regarding implicated consultants. It may not be clear exactly who is under investigation until indictments are handed out, which is not expected before November or December.

Individuals or companies implicated in this probe could face stiff penalties, including fines, cancellation of contracts, and possible suspension or disbarment from participation in defense contracting. Further, the DOD has already indicated, both in word and deed, that it will not wait for indictments or convictions before taking "appropriate" actions regarding tainted contracts. Six Pentagon officials, including five whose offices were searched on June 14, were quickly reassigned to positions not involving procurement. One was later suspended, as were two consultants and an employee of Varian Continental Electronics. Also, payments were halted for a while on nine contracts listed below. All contracts with four companies—Emhart Corporation, Hazeltine Corporation, Litton Industries, and Norden Defense Systems (a subsidiary of United Technologies)—are being reviewed.

PROGRAMS AND COMPANIES

On Friday, July 2, the DOD announced a freeze on new contracting and payments (later unfrozen) related to the following programs (approximate contract values are given in parentheses):

- The Anti-Submarine Warfare Operations Center is a system of 20 shore-based command and control centers ($712 million). TRW is the prime contractor, with perhaps 100 subcontractors.
- The Digital Communications Terminal, a device used with military radios ($150 million), was built by the Data Systems Division of Litton Industries.
- The Advanced Tactical Air Command Center (ATACC) is a mobile marine corps air support and air defense facility ($118 million) that is currently in the bidding stage.
- The Tactical Environmental Support System, a shipboard and shore-based computer data base system ($58 million) is supplied by Lockheed Corporation.

- The Fiber-Optic Cable System connects digital switches and radio equipment ($51 million); the contractor is Bell Atlantic.
- The MRC-139 digital wideband radio set ($49 million) was built by Canadian Marconi Company, a subsidiary of GE (Canada).
- The UYQ-21 ASW is an aviation electronics display ($38 million).
- Bancroft tactical high-frequency, single-channel radios ($30 million) were supplied by Gould.
- Very-low-frequency and low-frequency communications equipment was also affected by the DOD's action ($6.5 million).

Table 1 lists the companies that have been searched or subpoenaed in connection with the defense procurement probe (specific divisions are indicated where possible).

Table 1

Companies Having Been Searched or Subpoenaed in Connection with DOD Probe

Company	Location
Armtec, Inc.	Palatka, Florida (subcontractor to Unisys)
Cubic Corporation	San Diego, California, plant
Electronic Data Systems Corporation	Computer services unit of General Motors (subpoenaed)
Executive Resource Associates	Arlington, Virginia, consulting firm
Gould, Inc.	El Monte, California (subpoenas served at headquarters and at Navcom Systems Division)
Hazeltine Corporation	Greenlawn, New York, and Arlington, Virginia (a subsidiary of Emerson Electronic)
Hercules, Inc.	Headquarters of Aerospace Products Group, Wilmington, Delaware (subpoenaed)
Litton Industries	Litton Data Systems, Van Nuys, California
Loral Corporation	Loral Electronic Systems (Yonkers, New York) and Loral Defense Systems (Akron, Ohio)
LTV Corporation	Missiles and Electronics Group, Dallas, Texas (subpoenaed)

(Continued)

Table 1 (Continued)

Companies Having Been Searched or Subpoenaed
in Connection with DOD Probe

Company	Location
Martin Marietta	Baltimore, Maryland (subpoenaed)
McDonnell Douglas	McDonnell Aircraft Group, St. Louis, Missouri
Northrop Corporation	Ventura Division, Newbury Park, California
Teledyne, Inc.	Teledyne Electronics Division, Newbury Park, California
Unisys Corporation	Shipboard and Ground Systems Division (Great Neck, New York) and Computer Systems Division (Eagan, Minnesota)
United Technologies	Pratt & Whitney's Washington, D.C., office and Norden Systems' plants at Bridgeport, East Norwalk, and Trumbull, Connecticut
Varian Associates, Inc.	Varian Continental Electronics, Dallas, Texas
Whittaker Command and Control Systems	Farmington, Arizona
Zubier Enterprises	Harrisburg, Pennsylvania

Source: Dataquest
August 1988

Systems or Programs Implicated in Warrants or Press Reports

Aegis Shipborne Air Defense System

Press accounts have noted a sudden change that took place in 1986 in the navy's plans for second-sourcing the Aegis, directed by Melvyn Paisley. These changes had the effect of giving Unisys (then Sperry) the entire second-source contract.

Advanced Tactical Aircraft

Court papers accuse Paisley of seeking to steer the ATA program toward McDonnell Douglas. He became a consultant to McDonnell Douglas soon after leaving the navy in March 1987.

Engines for the F/A-18 and V-22 Tiltrotor Aircraft

Warrants served at Pratt & Whitney accuse the company of obtaining information about rival bids, helping it win second-source contracts for the F404 (F/A-18) and the T406 (V-22) engines.

F/A-18 Foreign Sales

Warrants served at McDonnell Aircraft allege that the company obtained various types of inside information on sales to Switzerland, South Korea, and Taiwan.

Unmanned Vehicles

Investigators searching Northrop Corporation's Ventura Division were said to be seeking documents and information regarding Northrop's NV-144 unmanned vehicle, a contender in the navy's midrange Remotely Piloted Vehicle (RPV) program, and the Tacit Rainbow tactical missile, for which Northrop is the prime contactor.

Identification Friend-or-Foe (IFF) Equipment

According to a search warrant, documents were sought pertaining to two components of the navy's IFF system. Teledyne Electronics is the prime contractor for one.

DATAQUEST ANALYSIS

The following paragraphs describe the likely longer-run implications of the procurement scandal.

Prosecution

Prosecution of the indicted individuals and companies is sure to continue into the next decade. The contracting atmosphere will accordingly be tense, perhaps slowing the already Byzantine procurement process. If any regulations are imposed on the use of "consultants," they may impede both illicit and licit flows of information between the Pentagon and defense contractors, complicating procurement further.

Contract System Changes

Secretary of Defense Frank Carlucci recently announced that contractors will have to guarantee they did not obtain their contracts illegally, or they will face stiff penalties. He also mandated a single best-and-final cycle on all future contracts.

Continued Reliance on Competitive Contracting

The greater reliance on competitive contracting and other procedures that made the defense industry less profitable were beginning to generate political opposition in recent years. However, the procurement scandal will almost certainly undercut any support for a regression of competitive contracting. The pressure to place more of the burden of R&D costs, as well as cost overruns, on defense contractors will be given further political impetus as well.

Better Management and Control of the Pentagon

The procurement scandal will of course generate pressure for more effective management both within and of the Pentagon. This pressure will likely be felt most acutely in the so–called "Black" programs, those so sensitive that their costs and schedules are well–guarded secrets. The fact that two prominent Black programs, the Advanced Tactical Aircraft and the Tacit Rainbow missile, have already been implicated may lead legislators, as well as senior DOD officials, to seek more control over these types of programs and to limit their number.

Any new administration will feel compelled to take some sort of dramatic action to demonstrate that it is in control of weapons procurement. Though no specific action can be predicted at this juncture, any steps taken are sure to have a significant impact on the defense industry and its environs.

Barry Blechman
Gregory L. Sheppard