TODAY'S TECHNOLOGY BEGETS TOMORROW'S MILITARY READINESS

by Lance A. Glasser

If our children and grandchildren have to go to war, as previous generations of Americans have done, will they face a lethal, high-tech battlespace more threatening than any of those that exist in today's international climate?

There is cause for optimism, but the outlook is uncertain. The world is filled with festering regional and ethnic conflicts, a vigorous drug trade, and flagrant abuses of human rights that testify to man's inhumanity to man. Tens of thousands of weapons of mass destruction are sequestered around the globe, and the international arms trade is brisk. The men and women of our armed forces are called into harm's way in many corners of the globe where snipers shoot at them from behind children and pregnant women. Today's military needs to be capable and ready even as our defense budget shrinks and as the rest of the world puts in place the lessons *they* learned from Desert Storm.

Yet, by historical perspectives, we live in relative peace. No credible enemy threatens the sovereignty of the United States. The cold war is over, and we are the victors. Like a great oak, the threat of the Soviet Union dominated our landscape, and with its collapse the level of threat to the United States dropped precipitously. But since that time, we have felt brambles draw our blood and seen seedlings that may yet grow to cast huge shadows on our children's future.

This is a time to be thankful, but not a time to relax. With about 1% of our national security budget, preparations are under way at the Advanced Research Projects Agency (ARPA), the principal research arm of the Department of Defense, to enable the United States to fight and win the conflicts of the future.

These will be fight-anywhere, fight-anytime wars, where "anywhere" and "anytime" will largely be defined by the enemy. The battlespace will be characterized by sudden and awesome lethality. The outcome will be determined in large part by the readiness of U.S. forces to engage the enemy.

Readiness, in this context, does not mean "ready when convenient"; more likely it means "ready when most inconvenient." It means ready today, tomorrow, and 20 years from now. The future will likely be more dangerous than the unusually peaceful present. The future threat will be unavoidably real and the need for response immediate.

As we demonstrated in the conflict in the Persian Gulf, war is controlled by information technology. To win the shooting war, we must first win the information war. Information superiority will separate the victors from the dead.

In response to this threat, ARPA's Electronic Systems Technology Office (ESTO) has embarked on a strategic thrust to achieve smaller, lighter, more mobile information systems. We focus on electronics because electronics accounts for 40 percent or more of the life-cycle cost of many weapons systems and is the stuff out of which military information systems are made, and we focus on mobility because mobility is fundamental to U.S. warfighting doctrine. Now is the time, when the threat is at a historic ebb, to focus our military research efforts on threats that lie beyond the horizon.

ESTO has launched a series of technology development efforts looking toward the future. These include sensors for enhanced situational awareness and targeting; displays to connect information sources with warfighters; packages and interconnections to enable electronic systems to be fielded in constrained shapes; low-power, wireless electronics to enhance mobility; signal processing techniques to make sense of data; and manufacturing and precision assembly processes to make weapon systems affordable.

As information technologies continue to become more capable, more compact, and more affordable, they will increasingly pervade forward-deployed and mobile military systems. These trends favor juxtaposing machine intelligence with interface systems that sense, source, display, and actuate. Information technology can only make a difference when it is coupled to the physical world and to people. ESTO is accelerating this process.

ESTO works on what is often referred to as "technology base development." This means that we develop the components and processes that are later composed into capable military systems in the "systems development" process. Technology base development plays a synergistic role in systems development. Today's military systems are not only more capable but also more complex and expensive. While some may debate the inevitability and wisdom of pursuing this course, the trend toward even greater complexity is seemingly inexorable. This trend, in turn, has had a tremendous impact on the practice and culture of systems design.

Developing a sophisticated, integrated product and process requires discipline and rigor. Many senior executives in the defense industry remember component technology development (what ESTO does) as being part of systems development. Those days are gone forever. Unless schedules and budgets are rigidly adhered to, the systems program will be canceled by corporate management or Federal senior acquisition executives. The immature technology approach and bootleg technology development projects of the past that once embellished systems efforts have been replaced by continuous process improvement, integrated product and process development, and total quality management. Although the systems engineering process works, it does not develop new component or module technologies. The risk equation and today's tight budgets do not allow it. The system risks to be managed involve complexity, interface compatibility, systems integration, global tradeoffs, and meeting the customer's needs. ESTO does what systems programs do not—develop the component technology base that will be required by the next generation of military systems designers. ESTO has launched a coordinated approach. Some representative programs are given below, together with examples of their potential contribution to the readiness and capability of U.S. forces.

MIMIC, MAFET, and HDMP programs on microwave and millimeter-wave integrated circuits and modules*: critical front-end components for radars, smart weapons, communications, and electronic warfare. A recent MIMIC upgrade to the guidance system of the Patriot Advanced Tactical Missile enabled the system to detect targets at twice the previous range.*

High-Definition Display Systems, including display technologies and head-mounted systems*: the core research and development component of the National Flat Panel Display Initiative, which ranges from data and computation to human understanding in time-constrained situations. High definition flat panel displays used for aircraft cockpits have demonstrated a mean time between failure 25 times greater than conventional CRT displays.*

Application-Specific Electronic Modules (ASEM), physical packaging, and multichip integration*: information technology for the rapid and affordable development and manufacturing of electronic modules and subsystems; technology for electronic packaging, including multichip and 3-D modules; mixed-signal modules; and module manufacturing. Multichip modules, such as the one planned for integration into the OH-58D Mast Mounted Site, operate at speeds in excess of 100 MHz and offer a tenfold reduction in size and 100x increase in reliability over conventional electronic packaging techniques.*

Rapid Prototyping of Application-Specific Signal Processors (RASSP)*: demonstration of the capability to rapidly specify, produce, and field affordable signal processors for use in DoD systems. RASSP allows product developers to "stay on the technology curve" by making incremental model-year upgrades in radars and other electronic systems. The payoff is near-continuous improvement in force readiness and capability.*

Low Power Electronics*: technology for low-energy signal processing. Advances in low power technologies will enable the development of portable electronic devices that will allow individual* *warfighters to communicate, navigate, target, and survive on the future battlefield.*

Microelectromechanical Systems (MEMS): *micro-sensors and microactuators. Using MEMS devices to monitor the components and fluids on H-46 helicopters in near-real time can reduce maintenance actions by over 30 percent resulting in a $60 million annual savings. Inserting MEMS inertial guidance devices in unguided artillery rounds will dramatically improve their accuracy, resulting in up to a tenfold reduction in ordnance required to destroy a point target, while reducing collateral damage and the risk of fratricide.*

In the United States there is historically not enough money for the military until it is almost too late. For this reason, and for the sake of the country's economic health (which greatly influences military capability), affordability is a key concern of the Department of Defense. Many of today's decisions on weapon system procurements are based on affordability.

A route toward affordability being pursued by ARPA is dual-use technology development (i.e., technology useful for both military and commercial applications). Dual-use can apply either to a product (e.g., an integrated circuit) or to a process (e.g., a computer-aided design methodology that can produce both military and commercial parts). Much of ESTO's electronics technology investments are dual-use. The essence of the argument in favor of dual-use is based on three factors:

Why *we invest is always for National Security.*

What *we invest in is always motivated by anticipated military need that will not be satisfied without action.*

How *we invest is based on affordability, i.e., creating the best value for the taxpayer; noting that the nation cannot afford two complete technology bases. When a dual-use strategy is applicable, it is usually the best bang for the buck.*

The result of our dual-use investment strategy is an integrated technology base that benefits the Department of Defense because larger product volumes lead to higher factory utilization, faster learning, and higher yields. This in turn leads to lower costs and an easier job of reliability assurance (through access to larger sample sizes). Higher yields also tend to produce a system with higher intrinsic reliability, potentially saving lives and decreasing the need for testing and screening.

ARPA has been in the dual-use technology business since its inception in 1958 in response to the launch of the Soviet Sputnik satellite the previous year. ARPA was, in effect, the first space agency, having laid the technological foundation for space exploration and exploitation (including the Apollo lunar landing) later exploited by NASA.

For ARPA, dual-use is not a theory but a 36-year record of success, including such technologies as packet switching for computer networks (originally implemented in the ARPAnet, which has evolved into today's Internet), artificial intelligence, computer graphics, gallium-arsenide integrated circuits (both analog and digital), parallel computing, distributed warfighting simulation, and many others, *all in use today by the U.S. military.*

ARPA has also done—and continues to do—military-specific research and development. The agency has a substantial list of successes in this area, too, including the first stealth aircraft, the "smart weapons" employed in the Persian Gulf War, and pioneering of the space-based ballistic missile defense concepts later embodied in the Strategic Defense Initiative. We also do military-specific technology base development, such as cryogenically cooled infrared focal plane arrays and accelerometers that can measure 100,000 G's inside the barrel of a canon.

ARPA has been the world's most successful government research and development organization of the last fifty years. Aligned to the future, we in ESTO are serving our military customer, creating a robust dual-use electronics technology base, and changing people's minds as to what is possible.

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