AY 97 COMPENDIUM
ARMY AFTER NEXT PROJECT

Yves J. Fontaine

Paul T. Hengst

Barbara A. Jezior

William T. Lasher

Gary J. Motsek

Arthur J. Sosa

Billy E. Wells, Jr.

Edited by

Douglas V. Johnson II

April 6, 1998

*****

*****

Comments pertaining to this report are invited and should be forwarded to: Director, Strategic Studies Institute, U.S. Army War College, 122 Forbes Ave., Carlisle, PA 17013-5244. Copies of this report may be obtained from the Publications and Production Office by calling commercial (717) 245-4133, DSN 242-4133, FAX (717) 245-3820, or via the Internet at rummelr@carlisle-emh2. army.mil

*****

Selected 1993, 1994, and all later Strategic Studies Institute (SSI) monographs are available on the Strategic Studies Institute Homepage for electronic dissemination. SSI's Homepage address is: http://carlisle-www.army.mil/usassi/welcome.htm

CONTENTS

TABLE AND FIGURES

FOREWORD

This compendium of student papers is the first in an annual series generated by the U.S. Army War College Special Program, the Army After Next Seminar. This seminar is a continuing research effort involving students, staff, and faculty that attempts to wrestle with the nature of military power 30 years into the future. This is a difficult task with no known "Right" or "Wrong" markers. Michael Howard, in his seminal article, "Military Science in an Age of Peace," tells us that the task of the professional soldier in time of peace is to try to figure out the future in such a fashion that, when it arrives, he won't be so far wrong as to be unable to take corrective action quickly.

These student papers are largely focused on present problems which must be solved before movement toward the future can make much progress. If they are not dramatically futuristic in approach, they are nevertheless set against a future backdrop which is still in the process of being defined. The broader Army After Next program, led by the U.S. Army Training and Doctrine Comand, is an experiment, an examination of what could be. The Army War College seeks to play its part through this contribution and by educating those officers who will field, staff, and command our future Army.

RICHARD H. WITHERSPOON
Colonel, U.S. Army
Director, Strategic Studies Institute

PREFACE

This collection of essays reflects the state of future thinking by selected students of the U.S. Army War College Class of '97. Before summarizing the papers contained herein, it is informative to recap student papers for the entire class. There were a number of surprises. This year saw a deep interest in Reserve Component (RC) contributions to National Security, Information Operations broadly defined, Logistics, and the full range of "Not-War" situations. Of 300-odd papers, 20 were focused on Logistics, 26 on Information Operations, 17 on RC issues, and 15 on "Not-War" issues. In addition, there were 14 focused on aspects of the Future Army not specifically included within these other categories. However, when we use the Future Army as a primary category, the number of papers jumps somewhat to around 50, depending upon how rigorously one defines "Future Army." This compendium reflects this focus of interest.

It is essential that the reader understand the general qualifications of our authors. Most of these authors are Army officers with about 22 years of commissioned service. They are practical men and women despite their broad educational backgrounds. Most hold a master's degree in some discipline, but have had little opportunity to theorize and mature their thinking about great political issues—their job has always been to prevent problems or solve them when things go awry. Consequently, this volume contains no treatises on international relations nor analyses of macro-trends in global relationships. Perhaps that is a fault of the curriculum, but the nation does not pay officers to think those thoughts; by a wonderful quirk of logic, it chooses to elect others to do that.

The idea of a "Military After Next" seems first to have surfaced in an article published in the *Washington Quarterly* in 1993 by Paul Bracken. Within a year, U.S.

Army Chief of Staff General Dennis J. Reimer commissioned Headquarters, Training and Doctrine Command (TRADOC), to begin an exploratory program to investigate the possible shape and behavior of the Army in the 2025 time frame. Almost simultaneously, the Strategic Studies Institute (SSI) of the U.S. Army War College (USAWC) sought and obtained approval to put together a Special Program (actually an extended Advanced Course) entitled "The Army After Next," as a parallel experiment with full academic freedom to read, think, and debate the breadth and depth of the plausible. Twelve students were selected for the program from a group of 30 volunteers. Some of their papers are included in this volume; but other students worked similar issues on their own initiative, and the lead paper in this compendium is one of those.

The structure of this compendium is as follows: Lieutenant Colonel Wells' paper is a wide-ranging, impassioned presentation of the future of infantry. Branch parochialism aside, it serves as a thought-provoking baseline by which the other papers should be evaluated, for, in the end, real war is about infantry. Wells' presentation leads logically to the Land Warrior program which Ms. Barbara Jezior, as the second author, explains in depth, treating the combat soldier as a whole system.

Ms. Jezior, who was invited to stay on at USAWC for a year and teach, describes the course of developments in soldier systems. Late in the academic year the Army After Next (AAN) Seminar took up issues of operations and tactics, using Ms. Jezior's paper as a springboard. If the Army chooses to pursue the Land Warrior system, it will give the individual soldier significantly greater influence on the battlefield. But in combination with other similarly equipped soldiers and support measures, the Land Warrior system promises a quantum leap in battle effectiveness. After extended debate, the AAN Seminar more or less agreed that the basic unit of Land Warriors ought to be a "squad" of about seven persons, two teams of three and a leader. Note how this contrasts with Wells' argument for a somewhat larger group. The next level of aggregation, however, was thought to be about four such "squads." Whether this unit would be a company or platoon was not considered relevant; what was more important was the amount of ground such a unit could control. When augmented by Unmanned Aerial Vehicles (UAV) and advanced antitank weapons, one "squad," in the Seminar's estimation, could control the entire Gettysburg battlefield (vice the 165,000 men who strove there in 1863), and that a group of four of these squads could control the entire battle area, about a 15-by-15-mile square. Next year the Seminar will spend more time considering how the Land Warrior system would work in urban combat, and what force levels would be required there—more, we suspect.

Ms. Jezior describes the current state of Land Warrior system development and outlines some of the more visionary things being considered. In its current state of development, Land Warrior allows its user to "see" and engage around corners, to see and engage in most conditions of visual obscurity, to maintain significant situational awareness of the immediate operational area, and to communicate laterally and vertically in a semi-automatic mode. Not yet, but soon, his battledress will be chemical agent resistant with automatic alarm and prophylactic mechanisms, and, later, biological agent resistant. Biomedical function monitoring is part of the suit, and biomedical enhancements will be incorporated once adequately tested. The list grows as time and money increase, but therein lies one of the major limiters. Such battle suits will not be cheap, and their cost may prove the primary limiting factor.

Lieutenant Colonel Arthur Sosa, an Army aviator with a deep interest in UAVs, provides a good look at their background and development. He does not address the overt connections between these systems and the soldier, but the reader will make those connections readily. The application of UAVs to each level of war will prove a significant capability enhancer. At the "squad" level, it is well within the plausible to think of the following scenario. One Land Warrior is alerted by UAV reconnaissance to some suspicious activity three miles to his west. Reaching into his backpack quiver of micro UAVs, he programs one for "Search-human/military material," and launches it toward the hot spot. The nearly silent, negligible cross-section sensor darts out to scan the area, detects human movement, reports the result of an Identification Friend or Foe (IFF) inquiry and awaits further instructions. Those instructions could include return to launch point, mark target, or kamikaze. If the object is a hard target requiring an Enhanced Fiber Optic Guided Missile (EFOGM) or other fire strike, the UAV may remain long enough to do post-strike battle damage assessment (BDA). In short, the UAV has the capacity to expand the soldiers' control of the battlefield in the same exponential fashion as the armed helicopter. In fact, mainstream Army thinking, at least as represented by USAWC students, reveals very limited conceptions of what UAVs already have done, much less how much they can do. The limitation of this technology appears to be principally human. Humans must eat, sleep, and have some social interaction, especially in stressful situations.

Because the soldier will always find employment in a wide range of circumstance, the next piece is by a logistician, Lieutenant Colonel Yves J. Fontaine, who addresses the persistent shortcomings in the soldier's support system in a variety of recent operations. He reviews the logistics shortcomings of recent operations in order to describe the challenge of creating a needed revolution in logistics operations. His descriptions of the logistical problems within these successful operations demonstrate the potential for significant improvements, many of which are possible in the near future. One can see in the management concepts Fontaine describes pathways toward implementation of the broader concepts in Colonel Gary Motsek's paper that follows. Fontaine's hard-nosed analysis concludes:

> Nevertheless, the level of technology available today (and probably in 2025) does not significantly change the way we do business as logisticians. Current technology allows us to improve . . . to process faster . . . [It] does not mean the U.S. Army can decrease the logistics tail.

This may be Fontaine's most important conclusion. Unless radically new systems are developed that require little logistics support, all improvements in logistics systems will continue to be at the margin.

Colonel Gary J. Motsek also addresses logistics. In his monograph titled, "Logistic Support to the Army After Next Warfighters," he argues that the time for change in logistics operations is now. Leaning upon the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* as a starting point, Colonel Motsek argues that major changes in logistics management are already underway, but that further change is essential. He points out that we do not know the exact dimensions of the Army After Next force, but we do know it will be a smaller, faster moving force, both strategically and tactically. We may reasonably assume it will be well-equipped with information technology that significantly improves all facets of situational awareness. His interest, of course, is focused on how that awareness will translate into near-immediate response to logistics needs in a very fluid environment. He goes on to caution that only so much change is possible as long as the current weapons system mix obtains. A 70-ton M1 tank has requirements that cannot be met by anything less than large quantities of fuel, ammunition, and heavyweight component transporters. Colonel Motsek carefully points out that the Army After Next is likely to be responsible as executive agent for many items of supply for the other services, as is today's Army. Part of his solution to is to reorganize the logistics world to establish a national level logistics provider. This concept capitalizes on the idea of centralized management and decentralized execution. All logistics stocks are centrally managed, as are Transportation Command's (TRANSCOM) assets, today. Commander-in-Chief TRANSCOM (CINCTRANS) "is the single Department of Defense point of focus to contract and leverage civilian transportation resources" as well as military lift assets. He concludes that there will be funding obstacles in modernizing the force that will likely necessitate the ability to support several generations of force structure; that the tactical transportation challenge will likewise impose an expense in the development of the force; and that the idea of a Commander-in-Chief Logistics (CINCLOG) needs considerable development.

Whatever the strategic situation, whatever the combat mode, the soldier will be utterly dependent upon information technology. Lieutenant Colonel Paul T. Hengst presents an overview of some of the technical aspects, focusing on the Intelligent Information Grid (I2G) upon which the AAN will be dependent. This I2G will form "a single grid so powerful and intelligent that it will be able to provide common situational awareness to friendly forces, real-time intelligence on enemy forces and fire control." In order to establish this tool, which functions as the central nervous system for military forces, two major improvements must occur:

- Technology. Artificial intelligence must become a reality for management functions within the grid, multi-level security is a must, and database technology management must become more responsive.

- Management. The I2G will operate off of commercial systems with all that entails; the funding stream to maintain competitive position within the commercial structure must be maintained; and DoD must establish a central management organization to focus resources according to development priorities so as to acquire the most effective systems when needed, and to reduce training and interoperability problems.

Finally, Lieutenant Colonel William T. Lasher discusses information management systems and some of the existing issues and proposed resolutions thereto. His basic point is that, until we commit fully to developing a system of systems in information, we will confront unnecessary obstacles to the kind of information flow a really revolutionized military requires.

There were 6-10 other papers that might have been included, and segments of 12 or so others that addressed future military matters, but space constrained selection. What is reassuring is the high percentage of largely future-focused studies, what is discouraging, although understandable in the program's first year, is the general inability to push thinking out into the timeframe of our sons' and daughters' military careers. Nonetheless, this compendium represents a good first effort to grapple with the long range future in a program that we expect to see mature over the next decade at least.

DOUGLAS V. JOHNSON II
Army After Next Project Coordinator
Strategic Studies Institute

CHAPTER 1

THE FUTURE OF INFANTRY: MANEUVER IN THE 21st CENTURY

Billy E. Wells, Jr.

[Editor's Note: This paper ranges widely and passionately over the entire realm of infantry, but it does so in light of the most recent warfighting experiments and advances in infantry related technologies. As noted in the text, several of the following papers are directly related to the author's arguments. Where these arguments are duplicative, I have opted to direct the reader to the broader following articles. While not entirely focused upon Army After Next, this paper lays the base case from which any geopolitical situation requiring the use of military force must begin. It is comprehensive in its address of technology, training, education, and leader development. Other papers address the required elements of command and control, and sustainment. DVJ]

INTRODUCTION

The thesis of this paper is that highly mobile infantry forces combined with increasingly lethal artillery and aviation will be the dominant land combat force of the future. This will occur as the geopolitical environment evolves a new set of conditions requiring capabilities traditionally associated with infantry. At the same time, domestic requirements will continue to shape the direction of national strategy and force structure, focusing on lighter, more economical dual use technologies and forces. As technological developments create the requirement and the capability for a dispersed and expanded battlefield, mobility requirements will expand the roles of aviation due to its speed and of artillery due to its range. Infantry, by merging dismounted mobility with aviation and providing targeting information to artillery even in close terrain, will be the key to full spectrum dominance. How the infantry force is selected, organized, trained, employed, and supported will require significant changes in order to meet the challenges of future conflict.

THE ROLE OF INFANTRY

Throughout history the infantry has remained the most flexible arm because it can fight in so many ways and places. No other component of the ground force can perform the wide range of infantry missions. Aviation cannot occupy and hold terrain and cannot operate continuously. Armor is partly deaf and blind, increasingly restricted by terrain, difficult to conceal, vulnerable to an expanding variety of weapons, impossible to deploy rapidly, and difficult to sustain. Artillery, although increasing its capabilities, is incapable of engaging small fleeting targets at close range without endangering friendly personnel. Like armor, artillery is of limited use in certain environments and of little value in most military operations other than war.

The basic combat mission of the infantry is unlikely to change in the long term. Infantry will continue to "close with the enemy by means of fire and maneuver to defeat or capture him, or to repel his assault by fire, close combat, and counterattack." In order to accomplish this mission, infantry performs six critical tasks: find, fix, finish, disrupt, protect, and control. Although these tasks may be accomplished alone, they are usually done in concert with the other arms and services.

Infantry has always played an important role in gaining contact with the enemy. Traditionally an aspect of battle dominated by cavalry, this critical function is essentially an infantry task in close terrain and at the low end of the spectrum of conflict. Even in open terrain, infantry may be the force of choice due to its low signature, if it can be placed in proper position with good communications.

Despite the expanded capability of current and projected sensors, close terrain (or poor visibility) still restricts their use. While there are developmental programs targeted at foliage penetration, they are not likely to solve the visibility problem for urban terrain or to be able to distinguish combatants from noncombatants.[1]

Once found, the enemy is usually fixed to facilitate his destruction. The requirement to fix enemy forces is as old as warfare. Fixing allows "time dominance" of the enemy. When an enemy force is fixed, it loses flexibility and initiative and leaves itself vulnerable to the massing of destructive effects. Infantry is not the only force capable of fixing; however, it is the most capable one, especially when combined with other arms. The requirement to fix diminishes in importance proportionally with real time situational awareness and response capability. Even with perfect situational awareness, however, fixing the enemy facilitates the massing of effects.

Infantry forces are required to finish the battle however it may be fought. Other forces are incapable of clearing the terrain required to consolidate victory and have difficulty in capturing enemy personnel. The implication that infantry must always come to grips with the enemy to finish him is misleading. While close combat is the essential infantry task, weapons developments clearly indicate that in certain conditions infantry will fight at extended ranges. The meaning of closing with the enemy must be modified to include long range engagements and "fire fights" along with its traditional implication of bayonet and rifle butt.

Disruption is traditionally a light force function, whether cavalry or infantry, and multiplies the effect of combat power by creating vulnerabilities and destroying enemy synchronization. In essence, disruption magnifies the friction of war for the enemy. Infantry, by virtue of its exceptional mobility and low signature, acts as an excellent disrupter. Infantry has increasing potential to expand this role with aviation support.

Protection of valuable resources remains a critical infantry task across the spectrum of conflict. Fire support and air defense commanders habitually request infantry security forces to reduce their vulnerability to ground attack. From fortress troops to fire bases in Vietnam to aviation forward operating bases in Operation DESERT STORM, infantry support has been critical to protecting valuable assets. Even mobile armored forces require infantry for security. Today's crew-served systems do not possess the personnel depth to maintain constant 24-hour security and must have infantry for close-in protection and early warning, especially in close terrain or bad weather. This requirement is expanding as the battlefield becomes more non-linear.

Control of populations and critical terrain is an infantry intensive and essential function either in combat or in increasingly prevalent operations other than war. The closer the terrain and the larger the population, the greater the requirement for infantry.

As requirements for infantry increase, solutions must be found to meet the future challenges of full spectrum dominance. In some cases, technology can actually expand the individual soldier's battlespace. In others, such as close terrain and population control, technology can certainly make the individual soldier more effective, but it cannot reduce the personnel requirement for the foreseeable future. A review of current and future infantry systems and their capabilities will reveal some striking future possibilities.

TECHNOLOGICAL DEVELOPMENTS

Incredibly, the infantry appears to be gaining the most from changes in technology and emerging global trends. An examination of research and development efforts clearly indicates it to be one of the most rapidly advancing forces in terms of lethality, mobility, and information capability. Technological innovations and mobility combinations with other arms are revolutionizing the future infantry battlefield.

Antitank Weapons.

Infantry antitank weapons represent some of the most dramatic advances in capability across the force. The ability of individual infantry soldiers and small crews to destroy armor beyond tank gun range is dramatically changing the combat power equation. Four air transportable systems, Javelin, Follow on to TOW Missile (FOTT), Line of Sight Antitank (LOSAT), and the Enhanced Fiber Optic Guided Missile (EFOGM), are dramatically changing the open field advantage in favor of the easily concealed and increasingly lethal infantryman.

The Javelin began fielding in 1996 as part the Force XXI Army Warfighting Experiment (AWE). Representing a tremendous leap ahead capability for the infantryman compared to the M47 Dragon, the Javelin has an integrated day-and-night sight. Passive infrared fire control with a lock-on before launch provides a "fire and forget" capability. Either top attack or direct fire modes may be selected for defilade targets. With a 2000+ meter range and a soft launch capability for firing from enclosures, Javelin represents a powerful new antitank capability for the rifle platoon.[2]

The TOW weapon system is receiving various missile and target acquisition upgrades as well. The FOTT missile is designed to reach about six kilometers with a lock-on before launch and "fire and forget" capability similar to the Javelin. Capable of defeating known and expected future threat armor, it will also be capable of overcoming predicted threat countermeasures as well. The improved target acquisition system for TOW with second generation Forward Looking Infrared (FLIR) and laser range finder enhance the crew's capability to acquire targets and to compensate for incorrect range determination.[3]

The most deadly direct fire antitank weapon system under development is the LOSAT which takes advantage of kinetic missile technology to fire a 170-pound, 112-inch-long "telephone pole" at 5000 feet per second through an armored vehicle. With a range beyond TOW and a capability to engage multiple targets, this system represents a decided advantage against any known or predicted future tank and antitank missile countermeasure system. Originally designed for mounting on the now defunct armored gun system chassis, it can be mounted on the heavy version of the High Mobility Multi-purpose Wheeled Vehicle (HMMWV), giving it an air assault/air mobile capability.

The EFOGM is designed to destroy tanks and rotary wing aircraft defiladed by terrain out to 15 kilometers. This system is HMMWV mounted as well. Like LOSAT, its two-man crew and vehicle are air assault capable. Target acquisition is FLIR with Global Positioning System (GPS) inertial measurement for accurate target location, allowing the system to serve as a reconnaissance asset while en route to its own target. With six missiles carried ready to fire and 12 systems planned for a brigade sized maneuver force, EFOGM will give small, agile light forces a decided advantage over slower armored units. By using terrain obstacles to impede movement and obstruct line of sight, the lighter force completely deprives the heavy force of its capability to locate and engage it.[5]

Directed Energy.

Directed energy weapons go beyond the current capabilities of kinetic and chemical energy capabilities to defeat armor. Directed energy uses lasers or high power microwave systems to disrupt enemy electronics and fire control optics in an asymmetrical attack. The weapon strikes at the speed of light at ranges far beyond current or projected tank main guns. Operating in a scan mode, an invisible laser searches the battlefield for optics. In a manner similar to the way radar reflects back to its source and identifies a target location, the laser detects optics ranging from binoculars to tank fire control equipment. In the attack mode, it can disrupt these same systems by transmitting a high energy beam which glazes optics and destroys FLIR systems.

Because it requires only electrical energy to operate, logistical requirements are essentially limited to sustainment of the weapons platform. This could be anything from an infantry fighting vehicle to the individual soldier. While there are ethical issues associated with the attack aspects of this system (it can cause blindness), its target acquisition role is worthy on its own merits. It can provide precise target locations for both direct fire and indirect systems. When employed in the attack mode, it eliminates the requirement for expensive precision guided munitions altogether. In the detection mode during Operation Other Than War (OOTW), directed energy can identify surveillance efforts by insurgents and is effective in locating snipers.[6]

Directed energy is not a drawing board item. Two Bradley mounted Stingray directed energy systems were built in 1991 and deployed to DESERT STORM (results, if any, remain classified). Two other systems, the Outrider, a HMMWV mounted version of Stingray for light forces, and the Target Location and Observation System (TLOS) were also planned by the Army; however, the Outrider project was canceled.[7]

Scheduled for fielding in 1998 with three systems per rifle platoon, the TLOS could revolutionize the battlefield. TLOS is an M-16 mounted device that detects fire control systems, both optical and FLIR, by using a laser scanner to search the battlefield. Weighing 6.5 pounds, the system can detect at ranges of 2500 meters during the day and 3000 meters at night. The final, lighter weight version will have digital integration and GPS and will compute range to target. This system can also destroy optics, though current systems have had this capability removed.[8]

The impact of such a weapon in the hands of an individual infantry soldier would be enormous. The fire control system of any armored vehicle or aircraft within sight could be destroyed. Constraints have been placed on this capability by the Department of Defense, however. As mentioned above, there are ethical issues surrounding the use of such a weapon, as it can blind people. Since similar ethically-driven restraints on the crossbow and gunpowder were not successful, we can expect similar systems to appear in other countries as an effective asymmetrical and cheap counter to our technological advantage in the air and on the ground.

Nonlethal Weapons.

Microwave sound weapons range from lethal to nonlethal. In the nonlethal mode, these weapons create imbalance and disorientation through effects on the inner ear and can incapacitate individuals. But with sufficient power, they can cause the internal organs to resonate, producing death. They can cause sensitive materiel subsystems such as electronics to overheat and melt. Modern vehicle ignition systems, fire control electronics, and communications networks are all vulnerable to this type of attack. Ultralow frequency devices can be directional and tunable, and can penetrate buildings and vehicles as well, providing great potential for use in urban terrain. Many of these weapons are already under development, and the challenges of power requirements are rapidly being surmounted. For example, the Russians have already developed a 10 hertz sonic baseball-size device that can be tuned for lethal or nonlethal effects[9]. The U.S. Army is developing systems as well and has been working on a tunable crew served acoustic weapon.[10]

Nonlethal weapons are a response to the changing requirements and nature of conflict around the globe. Peacekeeping missions and humanitarian assistance are now frequent occurrences, and combat is more likely to occur in an urban setting where the presence of innocent civilians is likely to demand a reduction in collateral damage. Insurgencies pose another demand for nonlethal technology. The guerrilla's traditional technique of inciting the government to use overwhelming force, thereby alienating the population, is now at risk. In the future terrorists will find it much more difficult to hide behind human shields, and radical or fanatic groups may be deprived of their much sought after martyrdom, all because of our use of nonlethal weapons.

Current nonlethal developments are targeted at performing a wide range of tasks in a civilian intensive environment where damage must be limited. In built-up areas, buildings and rooms may be seized with minimal damage through the employment of sedative agents or electric, acoustic, or pyrotechnic stun weapons. Crowds may be controlled through the use of blunt impact or malodorous munitions. Individuals may be marked with invisible marking rounds fired (along with many of the other mentioned devices) from the Objective Individual Combat Weapon (OICW) 20mm grenade launcher. Individuals may be secured for apprehension by entanglements or sticky foams and effective barriers created with nonlethal acoustics. Various devices may be employed for seizing or controlling vehicle access as well. Engine kill acoustical or directed energy devices or aerosols as well as antitraction materials can create barriers or assist in the apprehension of those attempting to flee.[11]

First deployed to Somalia to assist in the withdrawal of U.S. forces, where limited use was made of sticky foam, nonlethals have since been deployed to Haiti and Bosnia, and can be expected to remain on the scene for the foreseeable future. For the first time, the ground commander has the option of a graduated response across the spectrum from lethal to nonlethal, depending on the situation. This is not without some complicating factors; for example, rules of engagement are likely to become more complex. Finally, nonlethal technology could lower the psychological threshold of war, making it a more palatable instrument of policy. A palpable threat of death has utility. Regardless of potential shortcomings and complications, nonlethal weapons provide infantry a flexibility of response previously missing from the inventory.[12]

Mortars.

A dispersed battlefield may in some cases limit field artillery's efficiency in attacking certain targets, which may have a high priority for engaged units. While this represents no change from current requirements, the infantry's traditional weapon to fill the gap, the mortar, is undergoing a quiet revolution. With a range of 7,200 meters (vice the 5,700 meter range of the Russian equivalent), the 120 mm mortar currently being fielded, along with future composite mortars which can be fired from a HMMWV, will provide the American infantryman a significant advantage.[13]

More important than the mortars are the associated fire control capabilities and ammunition. Scheduled for fielding in 2001, the XM95 Mortar Fire Control System (MFCS) completely integrates the mortar platoon into the Advanced Field Artillery Tactical Data System (AFATDS). For the first time, mortars will be digitally linked to the fire support planning system. Essentially a conversion of the Multiple Launch Rocket System (MLRS) positioning and guidance system, MFCS reduces mortar setup times from eight minutes to one. The crew does not have to dismount to lay in the mortar due to imbedded Global Positioning System (GPS), which also reduces the Circle Error Probable (CEP) from 230 meters to 60 meters. Overall, the system provides an autonomous single weapon system capability functionally equivalent to Paladin.[14]

Enhanced fire control married with precision guided mortar munitions (PGMM) represents a deadly combination. Employing an infrared sensor, the PGMM operates in a man-in-the-loop mode for laser target designation or in an autonomous mode where it automatically seeks the largest infrared source in a 500 square meter area (expandable to 1000 meters). With a range of 15 kilometers, the round is capable of precision engagement of armor, bunkers, or other high value targets.[15]

Infantry Fighting Vehicles.

Infantry forces traditionally exploit any mobility advantage they can obtain. This has remained true from mounted archers to 18th century dragoons, and extends to the present day armored infantry fighting vehicle. Today the American infantryman has available to him the finest infantry fighting vehicle in the world, the Bradley. Scheduled for fielding in the year 2000, the next version of the Bradley, the M2A3, will feature second generation FLIR and squad vision displays; will be completely digitized; and will be capable of internetting with the other members of the combined arms team. With enhanced situational awareness, battlefield combat identification capability, and better armor, the M2A3 represents an extremely survivable and effective vehicle.[16]

However, by 2010 the initial production Bradleys will be almost 28 years old. Given the rapidly accelerating technological advances, continued upgrading may not be cost effective. A new vehicle designed to meet the 2010-2015 threat and capable of autonomous dispersed battlefield operations is required. To meet this need, the United States Army Infantry School has developed the requirements document for the Future Infantry Vehicle (FIV).

Designed for greater mobility, the FIV will weigh no more than 25 tons, be transportable by C-130 or airdropped from the C-17 or C-5. Capable of high dash speeds and rapid acceleration, the vehicle would employ advanced propulsion systems (possibly an electric drive) and be fuel efficient relative to current systems. The vehicle will be designed to automatically provide digital fuel and ammunition status to logisticians, thus eliminating voluminous reports, enhancing anticipatory logistics, and increasing optempo.

Addressing a critical mobility shortfall in the current Bradley, the FIV will be amphibious capable with 5 minutes preparation. Some unique capabilities such as an autopilot and formation capability are being examined, along with robotic control by the dismounted squad.[17]

Although considerably lighter than the Bradley, the FIV will be more survivable. Anticipated as a turretless design, the system will employ composite armor, saving weight, and, through low observable technology, provide a significantly reduced visual, radar, acoustic, and infrared signature. Current design criteria specify 30mm or better frontal protection and defense against top attack munitions, employing false target generation/jamming or conceivably the Phalanx shotgun type close defense weapon. Stand off mine detection and destruction technologies are to be incorporated, providing the vehicle an in-stride breach capability. For the first time an environmental control and overpressure system designed to protect the infantry soldiers from chemical attack will be incorporated as well. For offensive employment the FIV will feature a new on-board multispectral smoke system designed to defeat thermal sights. Like the Bradley, add-on armor will be available.[18]

The FIV concept represents a significant increase in flexibility by employing both lethal and nonlethal weapons. With acquisition and weapon ranges out to 8000 meters, the system will probably employ a lethal gun (perhaps electromagnetic), fire and forget missile, and laser mix. The system must defeat troops in the open or in trenches (implying microfuzed munitions), destroy threat tanks beyond main gun range while the FIV is in total defilade or moving, and be capable of defeating both rotary and fixed wing aircraft. Advanced target acquisition will allow for multiple simultaneous tracking and precision engagement similar to that of LOSAT. Nonlethal systems are employed for close in self defense, especially in OOTW situations. Finally, the FIV capability to carry an entire Land Warrior squad of 9-12 soldiers represents the greatest increase in lethality over the Bradley, which severely restricts squad size.[19]

Employing a wide variety of integrated electronic sensors, the digitized system will identify threats beyond maximum engagement range and provide warning of threat optical, laser, and radar acquisition and thermal indication of munitions launch, direction, and velocity. The FIV must be capable of employing unmanned aerial and ground sensors, NBC alarms, jammers, and perhaps weapons. Built-in test and training systems, including the ability to download digital mapping and imagery directly from space based or aviation platforms, complete a wide range of digital capabilities. Digitization, however, will not be limited to the vehicle alone.[20]

The Digitized Soldier.

As a result of current research and development programs, the lethality, survivability, and sensor potential of the infantry soldier is increasing rapidly (see Chapter 2, Ms. Jezior's study).

IMPLICATIONS FOR THE FUTURE

Force Structure.

The development of force structure to meet competing requirements must exploit the inherent capabilities of infantry to create a robust and flexible armed force capable of executing its assigned mission at minimal cost.

The generally lightweight nature of much dual use technology is applicable to the infantry soldier in particular. This allows infantry to be rapidly and constantly modernized at relatively low cost. Other systems are more costly due to special production requirements. Large, low density, high dollar systems with long production lead times are even less cost effective. Light ground combat units offer a greater return for the modernization investment. This is not to say that other forces are unnecessary. They are valuable, but they are less easily modernized and less flexible across the spectrum of conflict.

Organizational Requirements.

Historically, revolutions in military affairs have coincided with multiple transformations in mobility, lethality, and information capability. These, combined with timely adaptation of tactical or operational systems, result in greatly enhanced capability to dominate time and space. The most dramatic example of this is probably the blitzkrieg, combining the mobility of the tank, the ability to transmit information via vehicle mounted radio, and the concept of close air support into an operational system designed to disrupt rather than attack enemy defenses directly. Achieving such a dramatic transformation today, given the accelerated pace of technological change, poses a great challenge. Strategic, operational, and tactical victory will belong to the side that can develop organizations with a superior combination of mobility, firepower, and information capability at each level.

The Decentralization of Arms. Today we are witness to a merging of the levels of war from tactical to strategic. Levels of intensity are merging as well, and, as they do, many roles and missions are changing and being consolidated. Aviation is assuming the traditional role of cavalry based on its mobility and information gathering capability. Artillery is rapidly developing the ability to fix through precision munitions and, along with aviation, is rapidly becoming the biggest tank killer on the battlefield. Armor, no longer in sole possession of a mobility advantage, now seems better adapted for the role of a fixing force rather than exploitation. The infantry has become one of the best disrupters on the battlefield, a traditional artillery role. By virtue of its unique capability to combine foot mobility with that of the armored vehicle and aircraft, it remains the most versatile of arms, capable of all its traditional roles as well.

These changes demand revisions to organizational structure. Units capable of rapid concentration to attack and speedy dispersal to avoid destruction are neither large nor rigidly designed. The approach, then, is to combine differential capabilities in the same unit at the lowest possible echelon, as evident in the trend toward combined arms and joint organization at lower echelons.

High optempo units will require organic mobility assets. Units cannot wait for transportation on a dispersed battlefield. Originally, armored personnel carriers were fielded as a division or regimental asset, but later were made organic to squads. It is conceivable that the assault helicopter may one day follow this same path.

Dispersion, mobility, and vast improvements in precision fire control and communications argue for a decentralization of artillery as well. We have reached the state where individual artillery vehicles can receive and process a fire mission on the move, and execute it in 1 minute. This capability for dispersed yet responsive artillery operations is unique to the U.S. Army and provides the best possible defense against counterbattery fire.

In the dispersion of expanded battlespace, reconnaissance efforts are directly affected by a geometrically expanding security zone. Aerial reconnaissance is required at brigade level. Vehicular mounted ground cavalry cannot cope with shifting requirements of a nonlinear battlefield unless they are air transportable. A combination of UAVs, rotary wing aviation, and ground cavalry with vehicles which can be slung under assault helicopters provides the most rational response to this challenge.

The logic of dispersed operations argues for versatility across the spectrum of conflict rather than the limited specialization envisioned by some. Individuals may possess a particular expertise, but units must be flexible, not specialized. The balance of versatility and specialization must be struck at the lowest possible echelon in order to achieve flexibility.

Currently that level is the brigade as a fixed (though not by Table of Organization and Equipment [TOE]) organization with multiple arms assigned in battalion strength and supporting units attached for field operations. Assigned combat arms units are subsequently task organized at battalion task force and company team level. The dispersed battlefield may force a lower level of permanent assignment, retaining combat support and combat service support units at brigade level and forming more permanent task forces at lower echelons. This concept has been promoted for some years by armor proponents while the infantry community has steadfastly resisted it. The time to reconsider may be here.

The Heavy Infantry Force. Heavy mechanized land forces have lost the mobility differential they were created to provide. The sheer bulk and weight of current combat vehicles limits strategic, operational, and tactical mobility.

Light Infantry Forces. Designed for the low end of the spectrum of conflict, today's light forces are strategically mobile and require minimum sustainment.

Current light forces will achieve substantial advances in effectiveness through digitization. Situational awareness has always been critical to light infantry. Lacking the capability to extricate itself from danger through superior mobility or to defend itself with massive firepower available to heavier forces, light infantry commanders have excelled at detailed planning and preparation for tactical operations. The absolute requirement to get it right the first time or lose a significant number of lives in the process has created a culture of deliberate, methodical operations. Conversely, this same cultural aspect has slowed the tempo of light force operations to a crawl, even when merged with the powerful mobility advantage of an air assault task force. Digitization and greatly improved situational awareness should increase the tempo of light operations considerably.

Lack of organic tactical, and to a lesser extent operational, mobility will still restrict the scope of light force operations. Maneuver by muscle quickly exhausts the light infantry soldier. To overcome these shortfalls, tactical mobility must be reintroduced to the light division structure through the introduction of either ground or aviation lift capability.

Air assault is the only organizational concept which retains the full capability of light infantry while providing the tactical and operational mobility required of the modern battlefield. From Algeria and Vietnam to the Falklands and DESERT STORM, the merger of infantry foot mobility and the speed and obstacle crossing capability of the helicopter have proven to be a potent combination. In close terrain the attack helicopter served as a direct fire support weapon for the infantry, while the infantry found enemy targets for servicing by indirect fire support units. In open terrain the infantry served to secure and support attack helicopter operations.

Today's aviation allocation to light divisions is inadequate for the fast-paced operations of the future. Battlefield agility must be enhanced if tomorrow's force is to truly achieve full spectrum dominance. Small highly mobile organizations with exceptional long range nonjammable communications and rapid cross country speed (both operational and tactical) can dominate a wide variety of tactical situations. Future force structures should provide aviation at increasingly lower echelons, eventually replacing the air assault concept with one of air maneuver.

The Infantry Squad. The squad will remain the building block of infantry units. The traditional parameters that have limited squad size are expanding. Previously, dispersion of the squad was restricted by the range of voice communications. Individual soldier radios and GPS along with soldier computers, which can provide automatic location updates, increase the command and control capability of the squad leader, and the situation awareness of his subordinates. Individual soldiers may find themselves dispersed 50 to 150 meters or even more, depending on terrain conditions.

With individual combat weapon ranges of 1000 meters, squad level antiarmor capability with Javelin of 2000 meters, and the digitized ability to call and have precision guided indirect fire on the way in 60 seconds out to a range of 7,200 meters, the squad can dominate the same terrain as yesterday's rifle platoon. Squad firepower is no longer dependent simply on the number of riflemen.

These changes dictate the requirement for a new squad study. The last study, the Infantry Rifle Unit Study (IRUS), was conducted in 1969. Employing various combinations from zero fire teams to three, and numbers of soldiers from seven to sixteen, this study reached several important conclusions. First, for ease of control two fire teams, each with leaders, was the best organization for the infantry squad. Second, each squad should have an organic machine gun for additional firepower. Finally, squads of eleven and thirteen men consistently outperformed smaller organizations, especially in close terrain situations where smaller organizations rapidly became ineffective due to attrition and compartmentalization. These results confirmed earlier testing in 1956 and 1961.[21]

The rationale for the current nine-man squad of the U.S. Army leaves much to be desired. The 1946 Infantry Conference at Fort Benning, Georgia, provides the only semblance of justification for this organization. This conference examined, among other issues, possible revisions of the World War II 12-man rifle squad. Attendees operated on two key assumptions. First, the squad should consist of only as many soldiers as a single leader could control; and, second, it would not engage in separate fire and maneuver as mutually supporting teams, but operate as a single unit within the context of platoon fire and maneuver.[22]

Conference members determined that the number of soldiers to execute this concept was about eight plus the squad leader. Additionally, based on wartime experience, it was concluded that the squad should be capable of absorbing 25 percent casualties and still remain functional. Subsequent studies of wartime operations have determined that separate team employment in supporting fire and maneuver is impossible once squad size drops to seven men. Hence a nine-man organization has little hope of executing current squad level fire and maneuver doctrine.[23]

The ultimate adoption of the current nine-man squad has no basis in warfighting theory. When the Army decided to adopt the Army of Excellence and create new light divisions, it came up short in personnel strength. This shortfall was made up in part by the reduction of nonmechanized squads from eleven to nine men. Similarly, the mechanized infantry squad was constrained based on the carrying capacity of the Bradley vehicle, not infantry combat requirements. Given peacetime manning and wartime attrition, effective training and combat operations appear to be at risk with this organization, especially when the need for dispersion is considered.[24]

Intuitively, it seems that the infantry squad needs to increase in size, given technological advances and the nature of the future battlefield. However, such a decision needs to be made on the basis of scientific analysis, not opinion.

Leadership.

New organizations and tactics will require even better leadership at lower echelons. Dispersed and independent operations of small units will require the caliber of leadership and reliability normally expected of the officer corps. This will further enhance the already strong role and prestige of the noncommisioned officer (NCO) in the American Army. However, increased technical aspects of military operations will make it more difficult than ever to retain quality noncommisioned officers, especially in an era of a strong economy. This will demand an increase of benefits commensurate with enhanced responsibilities.

Soldiers are affected by leadership, machines are not. Even today there exists a disparity between grade and pay versus leadership requirements and responsibility. In a military institution where all specialties are technical, a more balanced approach between benefits and responsibility is necessary. The current rifle squad costs the government as much as a high performance aircraft over an equivalent life cycle and requires much more skill to lead under the turbulence of peacetime conditions, not to mention the stress of close combat.

The tradition of an officer requirement as pilot for a single aircraft as compared with a senior noncommisioned officer to command a single combat vehicle must be reexamined. An actual comparison of risk, responsibility, and pay would be embarrassing to the officer, especially considering that information technology and robotics are rapidly eroding the requirement for manned aerial platforms. Traditional approaches based on elitism are no longer relevant.

Because of increased span of control, the future noncommisioned officer corps could be smaller, allowing more flexibility for better pay and enhanced privileges and benefits. The gap in rewards between those who lead people and those who only control machines must be closed, especially if both must possess considerable technical competence as well.

While the NCOs will become the specialists, the officer corps will require more generalists capable of commanding combined arms units. This represents a refutation of many futuristic visions of increased specialization. With increased skill expected in the employment of all arms at a lower grade, merger of branches may be necessary at field grade into a maneuver specialty rather than the current combat arms system. Retention of skill identifiers would assist in providing the proper mix of experience in combined arms battalions by alternating specialties in the command group. This simply represents tacit acknowledgment at a lower echelon of what occurs today in heavy brigades, where the second in command is from a different branch than that of the brigade commander.

The increased span of control derived from better situational awareness raises several associated issues. With increased span of control at each echelon and fewer echelons in the hierarchy, the leader-to-follower ratio is obviously diminished. This creates a flatter pyramid for upward mobility in both the officer and NCO corps, introducing the associated issues of opportunity for promotion and increased pay. This may require shorter careers and a revision of the military retirement system.

At the same time, a short career must be made attractive through enhanced pay and benefits such as education, retraining, and separation options. Another option could be an expansion of officer candidate opportunities in lieu of other commissioning programs. One of the traditional reasons for maintaining a separate officer and NCO structure has been the time required to advance through the ranks. With fewer echelons and an increasingly higher standard for NCOs, a merger of the leadership structure is conceivable, though highly controversial.

A final issue concerns the development of daring and resourceful leaders. Dispersion and greater span of control have the potential to result in reduced personal contact with soldiers. It becomes more difficult and less necessary to "troop the line" for an actual look at the situation. One of the principal dangers of overreliance on information technology is that it has the potential to distance the chain of command from the fighting soldier, whose respect for leaders is based not only on their competence, but their willingness to share the hardship of the battlefield.

The Infantry Soldier.

The word "warrior" is the most frequently abused label in the current military lexicon. Most, if not all, who wear a uniform view themselves as warriors. In reality there are very few who qualify.

A warrior is one who places himself at great risk to engage in direct combat with the enemy. Generally speaking, where the casualties may be found, there also will the warriors be found. This criterion eliminates a significant majority of the nation's military structure and, indeed, large parts of the Army. It is not difficult to argue that, as a group, the infantryman represents the most numerous warrior element in the armed forces. Always at the greatest personal risk and with the least protection, he offers battle to his enemies on an individual, personal, and sustained basis.

Even within this group, the warrior ethic is not all-inclusive. S. L. A. Marshall was one of the first American military writers to recognize that relatively few infantrymen actually fired their weapon in battle. By his research, only 15-30 percent of World War II combat infantry soldiers actually fired their weapon in an engagement. This contention was verified in postwar articles by infantry unit commanders who stated that in any given engagement, you could count on certain soldiers to aggressively engage the enemy. Others, who were willing to share the danger, did not necessarily fight. Asked to repeat his study in Korea, Marshall found the average up to 50 percent.[25]

Although Marshall's findings have been hotly debated for years, numerous other scientific studies of the Korean War determined that there were certain characteristics of fighters and nonfighters, which could be easily identified in advance. Significant among the factors required of the fighter were a higher order of intelligence, combined with leadership ability, outdoor orientation, emotional stability, and a sense of humor. All factors were clearly identifiable through personality tests, which could be administered prior to selection for a military specialty.[26]

This research has significant implications for the future infantry force. The high-tech land warrior of the future requires a greater degree of resilience than his predecessors. Stress on highly mobile units is likely to be increased due to their more frequent employment in combat. With increased dispersion, the requirement for self-imposed discipline becomes higher, and a greater premium will be placed on self-reliance, initiative, and the ability to operate for extended periods alone or in small groups. All soldiers on the future battlefield must be predisposed to fire their weapon.

This argues for psychologically and physically stronger infantry soldiers possessing the best physical, mental, and moral traits the nation can offer. Infantry soldiers cannot be drawn from lower quality recruits. To achieve the goal of "every man a fighter" requires psychological screening and conditioning. This same method is applied today to the selection of special operations personnel, who must consistently operate in an environment similar to the future dispersed battlefield.

Two other criteria must eventually be applied in selecting the individual infantry soldier. First, there must be age limits for enlistment into an infantry specialty. Infantry is a young man's game. With age comes loss of the physical ability required to operate at platoon level. Second, from the standpoint of maximizing military effectiveness, the individual combat soldier should be single. There are a host of reasons for this. The higher operational tempo of a smaller force structure could be better managed with less soldier stress and therefore better focus during extended training or deployments. Psychological tests of fighters and nonfighters from the Korean War show a direct correlation between nonfighters and combat soldiers with dependents.[27] This is not a politically correct observation, but it is true. Soldiers with conflicting loyalties between commitment to the squad and responsibility for providing for dependents are less likely to expose themselves.

In a small military, those who endure the harshest service should be offered the most compensation. A *gratis* educational scholarship program combined with thorough screening would have the advantage of attracting more of the desired candidates for infantry as well as providing sufficient motivation to leave the service short of traditional retirement. Interestingly enough, the best trained and disciplined light infantry represented by the Ranger Regiment already experience this as a natural process. Most Ranger first termers leave the service for college, having saved the required amount of matching funds to complete a degree.

The only nonlinear wars that we have fought in the past have been counterinsurgencies. These conflicts have always been infantry intensive. The requirement for infantry on the dispersed nonlinear battlefield of the future will be no less. In fact, demands for infantry protection of combat support and combat service support units during division level warfighter exercises always exceed capability. The increasing probability of urban operations magnifies this requirement for more infantry.

If infantry is the most employed and most capable of arms, it also the most frequently expended. Casualty statistics for infantry have remained relatively constant. While overall casualties have been reduced significantly, those from the infantry have remained around 80 percent of the total.[28] While dispersion, new tactics, and better individual body armor and stealth technology may reduce these figures, we can still expect the infantry force to sustain the bulk of casualties in future war. In fact, casualty losses by branch provide a clear indication of the depth required to sustain lengthy combat operations. By some calculations, there is insufficient infantry strength today, active and reserve, to repeat a successful defense of South Korea.[29]

Infantry shortages in close terrain combat have historically led to cannibalization of other units to provide the required ground strength. This occurred in World Wars I and II and in Korea. Operations in Somalia, Haiti, and Bosnia have highlighted the substantial shortages of infantry strength in heavy units deployed to these regions; nondeploying units were stripped of infantry to fill positions in participating organizations. This is not surprising as the current mechanized infantry platoon has only two nine-man squads, representing two-thirds of its light component and only one-half of previous wartime organizations. Similar shortfalls in forces of the former Soviet Union in Afghanistan and Chechnya dramatically highlight the risks of infantry-poor units in combat.

This problem will be magnified on the future battlefield. Mobile units are more frequently engaged, resulting in more casualties over time. Although their casualties per engagement may be fewer based on their ability to choose and strike the enemy's weak spots, the cumulative effect may be greater. At the same time, the human "machine" requires time to recover from the stress of combat. A medical analysis of infantry units in Korea under various combat conditions from light to heavy provided a clear indication of the time required to regain full human combat potential. The more intense the combat, the longer the recovery time required.[30]

This finding implies serious consequences for attempting to do more with less in infantry close combat. No other arm bears the psychological and physical burden of the infantry soldier. Men are not machines, and they must be sustained differently or they will eventually fail. Aside from reduced combat effectiveness, the results of repeated commitment to combat without recovery time include a greater propensity to commit atrocities, a serious political consideration given the global information environment of future war.

Current Army infantry strength represents only 11.4 percent of the active component and 10.4 percent of the reserves.[31] This is an amazing situation, given the wartime and OOTW requirements for infantry. In a long war or two major regional contingencies, especially where reconstitution of units is mandated, this manning practice will create significant problems. The increase in required technological competence degrades the ability to mass produce combat infantry soldiers. A larger infantry component is required to meet the challenges of future conflicts. This does not entail an increase in force structure. Manpower savings in crew reductions due to automation and a reduction in clerical and enlisted staff requirements must be reinvested in infantry strength.

Training.

Training represents the single greatest challenge to the future infantry force. The infantry soldier must be trained to operate in small groups or as individuals for extended periods. While initial quality selection will help, the new recruit must be conditioned for the additional stress of new forms of combat. This requires a more demanding basic and advanced individual training program than is currently employed. The internalization of soldier values must become a goal of training as well. Only the crucible of a combined selection and conditioning process can provide the product required for decentralized operations.

Overall, essential technical training for the digitized soldier will require a longer training program than that currently employed. As a result of dispersion, the individual soldier may be required to obtain additional skills such as conducting indirect fire and performing selected engineer tasks. Close combat skills cannot be neglected and must remain the core of individual training. In addition, the training base must turn out a fully as opposed to a partially trained soldier. Units will have their hands full responding to sustainment training for an increased number of tasks and adapting training programs to rapid changes in doctrine, tactics, techniques, and procedures. They will not have the time to complete the soldier's individual training.

Accelerated technological change will outdate many techniques and procedures within a relatively short time. Lack of a monolithic enemy with a set doctrine, as in the Cold War, complicates matters as well. While doctrine and tactics can be developed within 1-2 years to keep up with these changes, internalization of new doctrine is much more difficult. Incremental modernization of the force will create its own challenges. Requirements for top-to-bottom retraining of units in the field will demand innovative solutions. Distance learning provides one alternative for rapidly disseminating new doctrine. This will require changes to institutional structure and some adaptations of the battle focused training approach.

One way to increase quality and decrease training time is to standardize squad and dismounted platoon doctrine and standard operating procedures across the force and to focus on basics. While infantry forces possess a common mission with associated tasks required for successful employment, they may be deployed strategically, operationally, or tactically by a variety of means. Care must be taken to distinguish between means of delivery, which can vary, and means of employment, which can be standardized.

A false theory of specialization by means of delivery undermines the essential character of infantry, which is defined by its role on the battlefield. The impact of this myopic concept is a general dilution of emphasis on basic infantry tasks and increased emphasis on tasks associated with getting to the place of employment. In a training resource constrained environment, this specialization concept is dysfunctional, siphoning away time and resources from the main effort, teaching infantry combat doctrine.

Contemporary unit experiments have benefited from Army level training and doctrine development resources applied to individual units of brigade size or lower. While these experiments shed little light on how to structure the modernizing institutional army, they can provide some valuable insights to the changing battlefield and the expanding role of infantry.

Recent Experimentation Results.

Recent simulation results culminating in the Force XXI Army Warfighting Experiment (AWE) at the National Training Center confirm the potential of infantry as the dominant future battle force. Lethality of the dismounted infantryman has been demonstrated to be dramatically increased through improvements in weaponry and night vision equipment. For example, Dismounted Battlespace Battle Lab (DBBL) experiments, including Warrior Focus and Night Eagle, used various night vision enhancements with impressive results. In one M16 qualification firing experiment employing night vision goggles with laser aiming lights, total hits were almost the same for night as for daylight. Standing position hits were even better at night.[32] During the Warrior Focus exercise at the Joint Readiness Training Center, experimental units equipped with upgraded night vision equipment scored more hits on nighttime live fire exercises than the previous ten rotational units and suffered far fewer casualties.[33]

Recent Force XXI AWE results provide indications of a similar lethality increase against armor. The Javelin antiarmor missile, currently replacing the M-47 Dragon, devastated any operating force (OPFOR) that dared come within range. Unlike many of the other AWE initiatives, light infantry employment of this weapon was considered by all observers an absolute success. Innovative tactics such as ferrying light antiarmor teams around the battlefield in UH-60 Blackhawk helicopters to block OPFOR movement provide a clear indication of the future capabilities of infantry married to aviation.[34]

This same combined infantry/aviation capability and its enormous battlefield impact was employed in the Prairie Warrior 96 AWE at Fort Leavenworth, Kansas. This experiment provided for a "Mobile Strike Force" concept of digitized units. Two brigades of the force were standard mechanized and armored heavy units equipped with the best computerized command and control systems under development, along with direct feeds of intelligence collection assets into the brigade tactical operation centers. The third brigade was a light motorized infantry unit with an armored gun system battalion and a variety of new weapons, including 120mm mortar precision guided munitions and HMMWV mounted EFOGM and LOSAT.

This light brigade was not resourced with the same level of intelligence and communications support provided the heavy brigades. Task organized with the aviation brigade for additional mobility, this unit destroyed more enemy than either of the other two organizations and suffered considerably fewer casualties. Imaginative tactics employed the aviation for operational and tactical mobility, the HMMWV for tactical mobility and rapid closure to targets from landing zones outside enemy low level air defense coverage, and the infantry to find and fix the enemy forces for precision attack.[35]

Similar division level experiments by the TRADOC Analysis Center (TRAC) showed comparable results. Regardless of division design employed, the greatest killers in the open terrain fight were consistently attack aviation, precision rocket artillery with brilliant antitank munitions, and infantry. Tank engagements were minimal in their contribution (less than 10 percent of enemy combat vehicle kills) due to limited mobility compared to other assets.[36] Aside from employment in combat, infantry proved its utility as a security force in the seizure of terrain required to facilitate helicopter and artillery mobility, and as an aid to disrupting and targeting enemy forces.

The DBBL is currently focused on an advanced concepts technology demonstration labeled the Rapid Force Projection Initiative (RFPI). The RFPI hypothesis proposes that hunters employing advanced sensor technology and digitally linked to precision stand-off killers such as EFOGM, High Mobility Artillery Rocket System (HIMARS), and automated howitzers firing Sense and Destroy Armor (SADARM) munitions can tremendously increase rapid deployment force survivability and lethality. Experimentation is far from complete; however, initial computer simulations have shown a clear increase in effectiveness. In one scenario, an airborne brigade using conventional tactics and weapons was defeated by an attacking motorized rifle regiment. When the same scenario was run with the airborne brigade using the RFPI concept and equipment, the threat regiment was defeated before it ever came close to the airhead.[37]

Army After Next wargames have taken mobility and strategic deployability requirements to a new level. Since future combat units must be more deployable while still maintaining lethality, this experiment employed several lightweight brigade sized organizations with organic strategic/self-deployment capability in a scenario involving multiple major regional contingencies. The principal success of this approach was the demonstrated ability to rapidly execute deployment to multiple regional contingencies in different theaters. Execution of the concept was made feasible only by a dramatic reduction of present day requirements for ammunition and fuel and through close association of ground units with their strategic lift.[38] When considered together with other results, AAN experimentation clearly points to the future contribution of infantry within the context of national military strategy, operational art, and tactical doctrine.

The Future Contribution of Infantry.

The ground force mission is to take the struggle to the heart of the conflict, where it directly affects the opponent's will. By seizing the critical points necessary to bring a struggle to its conclusion, ground forces create a permanent presence that cannot be ignored. Air power alone is incapable of this decisive act except as a means of delivery and support for airborne/mobile troops. Neither is naval power able to execute decisive operations on its own, except in a limited way and only then through the introduction of a ground force such as naval infantry.

In operations across the spectrum of conflict, the close combat soldier is the final arbiter of victory or defeat. Technological advancements are rapidly increasing the capabilities differential between the infantry soldier and his potential opponents to the point of returning infantry dominance to the battlefield.

The first phase of change has already begun. Fielding of expanded night vision capability to every soldier is scheduled to begin this year. This fielding includes thermal sights for individual weapons that can see through smoke and fog for the first time. This one change will dramatically tilt the balance of infantry combat power in favor of the American soldier. The second major change is occurring relative to the infantryman and his open battlefield nemesis, the tank. As the latest National Training Center rotation clearly showed, infantry equipped with Javelin are deadly to armored forces. These new capabilities will begin the change to a tactical doctrine that provides for a wider variety of infantry employment in a more expanded battlespace.

The second phase of change will accompany the rise of the Longbow equipped helicopter as the premier tank killer of the future. Full fielding, beginning in 1998, will further increase helicopter survivability, denying direct fire counterengagement. The effect will be similar to the artillery revolution brought on by combining ballistics with the field telephone. Possessing superior mobility and firepower, and with the capability of terrain protection en lieu of armor, the attack helicopter will dominate open terrain battle. At this point the artillery-infantry-aviation combined arms team begins to emerge more clearly as the heir to mobile warfare. This evolution will accelerate with further artillery and infantry developments.

By the year 2000, automated artillery and mortar fire control will be digitally linked to the individual soldier *via* the Land Warrior system, initiating the third phase (see Chapter 2). This coincides with the fielding of the rapidly deployable and highly mobile HIMARS rocket system capable of firing the Army Tactical Missle System (ATACMS) with brilliant antitank submunitions out to a 300 kilometer range.[39] To cover this geometrically expanded battlefield with 24-hour all-weather surveillance will require a dedicated infantry-aviation team employing lightweight vehicles that can be lifted into position. By this time, the requirements of an expanded battlespace will relegate units still having large logistical requirements to the status of third world armies.

The final phase of foreseeable change will coincide with the obsolescence of the current family of systems beginning about 2005. By this time, the Army has planned to begin fielding of its first robotic systems,[40] and Future Infantry Vehicle development should be nearing completion, providing enhanced mobility, lethality, and protection for the infantry soldier. Infantry cross spectrum dominance in a variety of environments will be improved by the introduction of planned individual and crew served weapons in 2006. The rapidly deploying ground soldier's ability to destroy armor will have reached a new level with the introduction of LOSAT and EFOGM systems mounted on light vehicles.

Artillery systems will complete the evolution required to rapidly destroy massed armor with the fielding of the BAT P3I brilliant antitank munition in 2005 along with fully automated artillery represented by the Crusader. These developments coincide with the fielding in 2006 of Commanche, which, when combined with lightweight infantry and artillery systems, will have transformed the combined arms team into an agile, dynamic, and lethally deployable force capable of true cross spectrum dominance.[41]

CONCLUSION

Smaller forces need not be less lethal. A carefully crafted force incorporating new weapons capabilities and information technologies can be more deployable, more lethal, and more versatile than existing structures. This will require innovation in design, and perhaps significant changes in tactics and doctrine as well. Requirements for dispersion on the open battlefield will demand increases in mobility for all forces. At the same time, the more likely close terrain fight will demand an increase in high quality infantry offset by decreases in crew and clerical requirements allowed by automation.

Traditional roles and relationships may be dramatically altered as capabilities brought on by technological change are incorporated into the force. Regardless of change, basic principles of force design will drive us toward a balanced combined arms team structure where the capabilities and limitations of all arms, old and new, are mixed in a balanced fashion to minimize weaknesses and maximize the threat to our enemies. This union of capabilities, all strategically mobile from the continental United States and rapidly redeployable from one theater to another, meets the requirements of *Joint Vision 2010* and will set the stage for transition to the Army After Next.

ENDNOTES - CHAPTER 1

1. Commandant, United States Army Infantry School briefing, "State of the Infantry," May 1996.

2. *Ibid*.

3. *Ibid*.

4. *Ibid*.

5. Ronald V. Hite and Gilbert F. Decker, *Weapon Systems, United States Army 1997,* Washington, DC: U.S. Government Printing Office, 1997, p. 240.

6. Commandant, USAIS.

7. *Ibid*.

8. Directorate of Combat Developments, *Infantry Programs and Projects*, Fort Benning, GA: United States Army Infantry Center, 1996, p. D-1.

9. Joseph W. Cook, David P. Fiely, and Maura T. McGowen, "Nonlethal Weapons: Technologies, Legalities, and Potential Policies," *Air Chronicles,* Maxwell Air Force Base, AL: Air University, 1996, p. 9 (http://www.cdsar.af.mil/mcgowen.html, June 5, 1996).

10. Gerald J. Iafrate, *Advanced Concepts and Technology II*, Alexandria, VA: U.S. Army Research Office, 1995, p. 9.

11. Dismounted Battlespace Battle Lab (DBBL), *Army Nonlethal Requirements Briefing*, June 10, 1996.

12. Cook, *et al*., p. 11.

13. Directorate of Combat Developments, p. C-2.

14. *Ibid., C-5.*

15. Commandant, USAIS.

16. Directorate of Combat Developments, p. E-2.

17. Directorate of Combat Developments, *Mission Need Statement for Future Infantry Vehicle (FIV),* November 30, 1995, p. 8.

18. *Ibid.,* p. 2.

19. *Ibid.,* p. 4-7.

20. *Ibid.,* p. 8.

21. Stephen E. Hughes, "The Evolution of the U.S. Army Infantry Squad: Where Do We Go From Here? Determining the Optimum Infantry Squad Organization for the Future," Thesis, Fort

Leavenworth, KS: U.S. Army Command and General Staff College, School of Advanced Military Studies, 1994, p. 18.

22. *Ibid.,* p. 6.

23. *Ibid.,* p. 14.

24. *Ibid.,* p. 21.

25. Peter Watson, *War on the Mind, The Military Uses and Abuses of Psychology,* New York: Basic Books, 1978, p. 45.

26. Robert L. Egbert, Victor B. Cline, and Tor Meeland, *The Characteristics of Fighters and Non-Fighters*, Fort Ord, CA: Army Field Forces Human Research Unit No. 2, 1954, p. 9.

27. Watson, p. 49.

28. Department of the Army, *Staff Officer's Field Manual Organizational, Technical, and Logistical Planning Factors, Volume 2,* Field Manual 101-10-1/2, Washington, DC: U.S. Department of the Army, October 7, 1987, pp. 4-11.

29. Mike Jacobson, "Whither the Infantry, Does the US Army Have the Soldiers to Fight a Second Korean War?" Draft manuscript, Fort Benning, GA, undated, pp. 18-19.

30. S. W. Davis and J. G. Taylor, *Stress in Infantry Combat*, Chevy Chase, MD: The Johns Hopkins University Press, 1954, p. 3.

31. Office of Infantry Proponency, United States Army Infantry School briefing, "Infantry Update," May 1996.

32. Commandant, USAIS.

33. Dismounted Battlespace Battle Lab briefing, "Warrior Focus Advanced Warfighting Experiment," November 1995.

34. Sean D. Naylor, "The Javelin Missile: A Lethal Ace Up the Sleeve," *Army Times,* April 28, 1997, p. 14.

35. Personal observations of author acting as an Infantry School observer.

36. TRADOC Analysis Command briefing, "Force XXI Division Design Analysis," March 1996.

37. Dismounted Battlespace Battle Lab briefing, "Rapid Force Projection Initiative Concept," April 1996.

38. Sean D. Naylor, "What the Future Holds . . .," *Army Times,* March 17, 1997, p. 20.

39. Hite and Decker, pp. 155, 161.

40. Directorate of Combat Developments, p. D-9.

41. Hite and Decker, pp. 109, 157.

CHAPTER 2

THE REVOLUTIONIZED WARFIGHTER CIRCA 2025

Barbara A. Jezior

[Editor's Note: Ms. Jezior's study extends that of Colonel Wells, speculating on advanced soldier technologies in a systematic way which has not been done before. Ms. Jezior's future scenario provides a backdrop for these technologies, several of which are on the very edge of thinking. This study attempts to look beyond the systems Colonel Wells addresses, most of which are in existence today, whether fielded or not. DVJ]

INTRODUCTION

A Plausible Scenario.

At the end of the 20th century the military decisionmakers made some very astute choices. They realized a land force would still be needed in 2025, but also knew the politics and budget realities of the day meant a small force was all they could realistically plan for. They reasoned that, if it had to be small, it had to be elite. Simultaneously, the technological advances in command, control, communications, computers, and intelligence (C^4I) of the time were forcing radical changes in warfighting doctrine. This future force would be fighting a war of maneuver, not attrition, and one of the critical elements in dominating maneuver could be a revolutionized warfighter. Since the warfighter would continue to be the common denominator of the spectrum of conflict, they saw no risk in a full-bore investment that would equip the warfighter with every tool possible that could tip the battlefield balance in his or her favor. That foresight 25 years ago resulted in today's *revolutionized warfighter who is the sine qua non for military success across the globe, and who has proven the wisdom of the earlier investment many times over.*

The 2025 warfighter bears little resemblance to that of the late 20th century. He and his team members are multi-skilled, smart, and more "in charge" than their predecessors.[1] Radically new technologies have also served to make him and her the soul of stealth and prowess on the battlefield.They have an arsenal of cutting edge technologies to select from.

One battlefield option is the encapsulated, climate-controlled fighting suit with power enhancements, sophisticated weapons and sensors, a communication and guidance package, and active (chameleon-like) camouflage. The power and strength component augment the warfighter's own body strength by supporting all body parts associated with load carrying. The suit provides situational awareness, operational information, and tactical guidance along with small-unit medical, logistic, and intelligence data.[2]

Another option is a lightweight battle dress uniform that is flexible and body conforming. It improves performance by concentrating vital body heat and blood flow within muscular tissues. It, too, has the sensors and C^4I capabilities of the first suit described. The compression materials incorporate biological and physical sensors that monitor blood pressure, pulse, body temperature, penetration (from projectiles), blood loss, and other vital signs. It provides friend or foe identification. All the sensors are linked and centralized as appropriate.[3] The warfighter also has cotton-weight ballistic protection and lightweight chemical-biological (CB) gear comprised of a fabric that breathes like regular clothing when no CB agents are present.

He can also augment his human powers with skinpatch pharmaceuticals tailored specifically for him as the need arises. For example, he can control his fears, and generate greater powers of concentration and physical strength.

He has three-dimensional representation of the battlefield on his arm- or head-mounted display. He can take virtual trips to other parts of the battlefield to see the action from other vantage points. He has extended sensory powers that are continuing to evolve. Not only can he see everything in human visual range, to include what is obscured by terrain or structures, he will also be able to hear and see beyond human range and see the enemy before the enemy sees him. If by any chance the enemy should see and target him first, he has the inner comfort of knowing that the sensors embedded in his clothing would alert the medical world of his exact whereabouts and the seriousness of his wounds.

He can connect to the entire information infrastructure with a tiny system that has filtered incoming data to offset information overload. He gets what he wants when he needs it. His computer system is interactive and has both video and voice functions. Best of all, it is so user friendly that no training was required. It is completely integrated with his other equipment.

The combination of his innate capabilities with radically improved communications and situational awareness has resulted in flattening the traditional military hierarchy. His team is very small and flexible, its size and structure mission dependent. Both his lateral and hierarchical relationships are a source of support and strength.[4] *He has a level of understanding that far surpasses his level of authority. Every kind of information is his to receive, understand, and assess.*

His weapons are far more lethal and precise. These, combined with the support of the precision indirect fires he knows he can depend on, give him immediate target kill. The indirect fires will be on time and on target; there is no more mistaking friend for foe. Immediate target kill has terrific *psychological impacts—a positive one on him, and a negative one on the enemy.*

Back to 1997.

Whatever the future brings, many investigators believe a small strategic land force will be a requirement. This force must deploy swiftly, deter or halt aggression, and secure any area vital to U.S. interests. Investigators also predict a shift from large armies fighting attrition warfare to small dispersed units fighting maneuver warfare.[5]

Technological advances in the C^4I arena and the correlative changes in doctrine, training, and leadership also point to that small, elite force comprised of multi-functional soldiers or integrated combat arms formations.[6] Either case demands the multi-skilled, highly mobile, and independent warfighter, linked to other platforms, who may be fighting more often in cities and suburbs than on open hills.[7] This future warfighter will also probably face the outlaw tactics of nonstate actors who have no compunctions against using chemical/biological (CB) weapons.

These future warfighters must achieve dominance in maneuver to gain battlefield control and to increase their probability of survival. Enjoying a technical revolution in soldier capabilities, they will seek distributed and cooperative engagement at the lowest levels.[8] The small elite force of the future simply must be as lethal and high-powered as possible, down to the very last warfighter. As the first Army After Next war game indicated, "The *sine qua non* of ground forces in the future is smart, high-quality soldiers who can operate at a very, very fast tempo and in a very sophisticated way."[9]

TECHNOLOGICAL STEPPING STONES TO THE WARFIGHTER SYSTEM

What technologies are on the horizon that can meet the materiel needs of such a revolutionized force? This paper discusses a few of those technologies relevant to the dismounted "Warfighter System," those pertaining to any item the dismounted warfighter wears, carries, and consumes in a tactical environment. These technologies will improve one or more of the warfighter's lethality, survivability, C^4I, mobility, and sustainability.

Only recently has the Army decided to take a systems approach to managing soldier programs, the same approach it takes to managing major weapons systems. This means the myriad of soldier programs now enjoy centralized oversight as the "Warrior System," rather than having each commodity developed in a stovepiped, piecemeal fashion. This allows for a fiscally balanced and prioritized soldier "platform" that makes these programs more visible and better able to compete for funding. It also means better and better-integrated equipment.

Land Warrior Program.

A revolutionized warfighter will be the result of an evolutionary process, since no one program will develop a whole new set of technologies to replace all warfighter components at once. The Land Warrior program managers have taken a systems approach to developing technologies that will result in dramatically new and improved capabilities for the dismounted soldier. There is definitely room for improvement, especially in those areas pertaining to information technology.[10]

By the year 2000, we will begin to see Land Warrior modular fighting systems designed for close combat situations.[11] The basic components are a helmet mounted display, an improved image intensification (I^2) modular weapon, improved protective clothing to include improved modular body armor, a computer and radio set-up, and special software for battlefield communications.

The helmet-mounted computer display is linked directly to the M16 or M4 weapon, which can incorporate other types of weapons and sights. The weapon's thermal sight allows target engagement in daytime, nighttime, around corners, or out of a foxhole without exposing its bearer. The computer-based global positioning system (GPS) and radios are mounted on the soldier's back. Digital orders can be transmitted down the chain of command, and, if a soldier sees something worth reporting, he can also send a digital report through his computer.

The thermal weapons sight, which can see through obscurants like smoke, also makes it possible to transmit a digital still video picture of a battlefield object. The system's modularity means the soldier can "mix and match" the various components, depending on mission needs. This ensemble is already in prototype and has been demonstrated.

The Land Warrior system will give battalion tactical operations centers better control of the battlespace and the pace of operations. Unit leaders will know where their soldiers are and be able to meet their logistical needs very quickly.

Military Operations in Urban Terrain (MOUT).

Urban warfare is predicted to be a large part of the military future and is a tough challenge in many ways. It usually involves high military and civilian casualties. Today, the capabilities for conducting urban operations are no different than they were in Vietnam, as fighting in the Balkans is demonstrating.[12] Urban operations have traditionally been characterized by difficult command and control (C2), high military and civilian casualty rates, and large numbers of soldiers.[13]

What urban fighting requires is light, mobile combatants who are in tune with their immediate environment (situational awareness), and who have links to outside platforms, such as sensors and fires. They also need flexible, responsive logistical support. While soldiers fighting in the open have many similar requirements, urban infrastructure and the constant risk of civilian involvement impose unique conditions.[14]

There is a joint program underway which will meet many of the requirements for urban fighting, constituting a major intermediary step toward the revolutionized warfighter(urban or otherwise). This MOUT Advanced Concepts Technology Demonstration (ACTD) will demonstrate new concepts in 2000, and the resulting materiel should go into full scale development and fielding within 3-5 years thereafter. The individual projects that make up this umbrella program are:[15]

Force XXI Land Warrior. Adds sophistication to the Land Warrior system previously discussed, such as further advanced individual communications, situational awareness, location, and small arms body armor.

Small Unit Operations. Communications/geo-location, sensors, and situational awareness technologies will be integrated in other battle platforms allowing enhanced C^4I, and sensor to shooter linkages with precise indirect weapons.

- *Objective Individual Combat Weapons.* Precision individual weapon, employing either point munitions or airbursting munitions for attacking targets in defilade. Fire control will be wirelessly linked to C^4I networks for indirect viewing of targets (on a helmet mounted display) and precise handover of targets to indirect fire weapons systems.

- *Combat Identification.* Knowing friend from foe will be accomplished by embedded soldier-to-soldier laser interrogation and radio frequency response enabled by sensors and C^4I.

- *Counter-sniper*. The ability to detect sources of direct fire.

- *Non-lethal weapons*. Non-lethal technologies are being pursued that will incapacitate, distract, or seize individuals, stop vehicles, control crowds, deny areas, and disarm or neutralize equipment.

- *Multi-purpose Individual Munition*. A shoulder-fired weapon that can defeat light armor and targets in masonry structures.

With the successful outcome to this ACTD, the warfighter will be able to move information around the battlefield as needed. Everything from firepower to supplies can be delivered when and where needed. A warfighter's probability of survival is also greatly increased with the cutting-edge laser, armor, reduced signature, and other technologies. He will also obtain a real psychological edge, especially from his much improved situational awareness.

The 2005-2025 Technologies.

The years following the MOUT ACTD will see breakthrough technologies as well as improvements to MOUT technologies that will ultimately comprise the revolutionized Warfighter System.

This section describes some of those potentialities, but it is by no means a complete list. Many of the future technologies have widespread application; very few are peculiar to the military. A few "blue sky" or "stretch" technologies (not considered achievable by *circa* 2025) will also be outlined here, along with a few that do not fall into the Warfighter System definition. They are included because of the enormous impact they could have on the individual warfighter.

Some of the 2005-2025 potential technologies may not hit their targeted time table for a number of reasons. It is reasonable to assume those technologies coming to fruition after 2005 may still offer the best to be had at 2025. The best that can be done is to put forth possibilities with the caveat that unexpected technological breakthroughs are sure to occur, and the military will be watching for them and responding to them.

The taxonomy for the promising Warfighter System technologies is warfighter capabilities. The most appropriate category for a given technology may be arguable, but that illustrates the synergy that can be gained by looking at the warrior as a system. For instance, improving the warrior's lethality is going to affect his survivability, just as improving his mobility may also improve his survivability.

Survivability. "Smart" materials will give new meaning to the words "stealth and survivability" and will have tremendous payoffs. One example is a chameleon-like uniform material that renders the warfighter virtually invisible. Another is a ballistic material based on spider silk. This ballistic material will be, inch-for-inch, stronger than steel, but lighter than cotton, and will offer comfort and mobility along with survivability.

Chemical-biological protection from smart materials technology is also emerging. One possible technology is molecular imprinting. In this case, a polymer membrane "traps" threatening molecules when they match the imprints of noxious substances. The other is a gated membrane technology. A material embedded with this technology will breathe like regular clothing until a CB agent is detected, and then the membrane will close off. With either technology, the bulk of the current CB protective suit bulk will be a thing of the past, much improving the warfighter's comfort and mobility.[16]

Sensor technology will also play a large role in survivability. Embedded in clothing or other gear, sensors not only will be able to detect CB agents, they could also cancel the effects of body temperature, obscuring battlefield signature. They will also be able to monitor the location of the wearer and the enemy, and provide other battlefield intelligence. The notion is to link all this information.

A key sensor for improving survival is a bioanalysis system which will electronically relate real-time warrior body status (e.g., vital signs, penetration from projectiles, blood loss) to a central monitoring site.[18]

One form of medical CB protection could be a reactive vaccine (administered after exposure) which would stop the damage by attacking and neutralizing the agent or by repairing the actual damage.[19]

Warfighters should be able to grow new organs from their own tissue thanks to advances in human genome mapping, and a stretch will be replacement limbs fabricated of artificial tissues.[20] While those two technologies fall outside the Warrior System definition, they merit mention because of their implications for the rear-area medical support available to the warfighter.

Sustainability. There will be considerable improvements in rations by 2025. For instance, food should be more concentrated and lighter, and there could be a transdermal (through-the-skin) nutritional system.[21] This system would be comprised of time-released nutriceutical substances tailored to the individual's needs, which would go directly into his system through patches or lotions. The transdermal system will not truly substitute for food, but it will meet nutritional needs when food is not available.[22]

Bioprocessing will eventually revolutionize logistics and lighten the warfighter's load. He will be able to create food, water, and ammunition components from substances locally available. The warfighter will no longer have to carry those items, or at least not as many of them. Bioprocessing does not fall into the strict Soldier System definition, but would alter the warfighter's life on the battlefield.

The generation of sustainment items will probably not become a reality in the 2025 timeframe, except for the water. It is possible that by 2025 an individual water purifier will be able to filter heavy metals, the only substances it cannot filter today. The warfighter could then carry a small purifier or packet of chemicals instead of carrying water in those areas where water is available.

Command, Control, Communications, Computers, and Intelligence (C^4I). This area is rife with possibilities. A single chip embedded in a warrior's clothing may be a whole miniature satellite communication system comprised of micromechanical devices that could be controlled by voice, gesture, or thought.[23] Sensors will allow a warfighter to "see" through any weather, foliage, and other obscurants, as well as detect CB agents.[24] One distinct possibility for a CB sensor may come through micro-electro-mechanical-system (MEMS) technology. MEMS could replace cumbersome $17,000 laboratory spectrometers, which determine chemical composition of substances, with a $20 device that the warfighter could hand carry.[25] Biosensors may someday detect the presence, and maybe even the status, of enemy soldiers by detecting smells and other signatures. This capability is a stretch, but "breakthroughs by 2020 would be possible if enough resources are applied."[26]

Pharmaceutical enhancements could contribute to the warfighter's sense of control in battlefield situations. These pharmaceuticals could target specific areas of the brain and increase or extend cognitive, psychological, and physiological functions. The warfighter's memory could improve along with his attention span. He could suffer less fear and stress, and be more alert. He could be physically stronger and sleep better. He could deal with information overload and make better decisions. A stretch in performance enhancers would be those that combat fatigue and hunger.[27] Another stretch technology would be man-machine interfaces allowing the warfighter to control equipment from afar with his or her mind. While this speculation might evoke a chuckle, it is not as blue sky as it seems. Several automobile manufacturers are now trying to develop headrests that pick up signals from the driver's mind to control automotive functions.[28]

Advances in the traditional computing technologies will continue. Computer systems will become much more user friendly, and will be smaller and lighter. Voice activation will be commonplace. Information overload will also be tackled with "smart agent" computer applications. However, a whole new computing technology, biocomputing, will bring unprecedented changes. Biocomputing is predicated on DNA-based storage and has widespread military applications. A DNA chunk the size of a sugar cube could hold 10 petabytes (10 million billion) of data. The individual soldier could have a small computer with billions of bytes of information, with everything from a complete language dictionary, to topographically accurate maps, to guides to the local flora and fauna if he is forced to live off the land.[29]

There are several other possible biotechnology applications to future complex integrated C^4I systems. For example, sensors could be linked with biocomputers which warfighters could instruct by consciously altering their brain waves or by voice pattern signals, putting warfighters in a position to communicate more effectively with their machines.[30]

Lethality. While MOUT ACTD weapons technologies will presumably offer lethal and non-lethal contributions to the future warfighter, the development of precision indirect fires is required because of the greater lethality they offer. The indirect fire technologies do not fall into the definition of Warfighter System, but they have a profound impact on the battlefield. The warfighter would have less weaponry and ammunition to carry, lightening his load and improving his chances for single shot kills—a real psychological *coup*.

Anti-materiel weapons also have promise. They will feature agents that react in such a way to destroy the intended target, such as rubber-eating microbes, or microbes that consume silicon, electronics, or Kevlar.

Genetically-designed weapons that are based on DNA of a target, such as the genetic sequence of an enemy leader, or those that are targeted on a bodily function such as sight or motor ability, may eventually be pursued. While these are ethically arguable and run counter to the Biological Weapons Convention, research will be needed to counter such weapons should enemy forces possess them.[31]

Mobility. New or improved airdrop technologies will allow for high tempo insertion of small units at many different locations, providing an edge in maneuver. There will be no time delays associated with personnel and equipment link-up. These technologies will also allow soft landings and a concomitant reduction in damage and injuries.[32]

CONCLUSIONS

The future warfighter will be part of an elite joint force which represents an expensive investment not easily replaced. The economics involved in the training and sustainment of such a force dictate that these warriors have the cutting-edge warfighting tools and technologies. The Warfighter System will be a vital prerequisite to dominating maneuver and will also allow the military to meet urban warfare challenges. Since the dismounted warfighter has been, and will continue to be, the common denominator in the spectrum of conflict, it is an investment choice that can be made with utmost confidence.

Like traditional major acquisition programs, the Warrior System program must be steadily funded and centrally managed. Programmatic oversight should reside at the highest organizational levels. Unlike traditional programs, the Warfighter System poses unique considerations for doctrinal, psychological, personnel, training, and technological spheres. As such, it needs special organizational structures and procedures.

An overarching systems approach is required that can fuse all the Warfighter System's aspects—materiel and otherwise. The system's designers must carve out a long-range program showing a balanced approach and defined priorities. This will instill confidence in program success at the highest military levels and in Congress, thus enhancing prospects for adequate funding.

ENDNOTES - CHAPTER 2

1. Office of the Secretary of Defense, *Tactics and Technology for 21st Century Military Superiority: Final Report*, Vol 1, Washington: Defense Science Board, October 1996, pp. 11-5 - 11-13; Douglas A. MacGregor, *Breaking the Phalanx: A New Design for Landpower in the 21st Century*, Westport, CT: Praeger Publications, 1997, pp. 1-19.

2. Philip Brandler, Acting Technical Director, Natick Research, Development and Engineering Center, "The Army After Next (AAN)," memorandum for Commander, U.S. Training and Doctrine Command, ATTN: ATCG-S (Dr. Paul Berenson), Fort Monroe, VA, July 2, 1996, para. 2d.

3. *Ibid*., para. 2c.

4. *Tactics and Technology*, p. V-12.

5. *Ibid.*, pp. II-3—II-9.

6. MacGregor, pp. 59-93.

7. *Tactics and* Technology, pp. III-17—III-20.

8. A. Fenner Milton, "Soldier Systems: The Path to the Army After Next," Briefing of Major General Robert Scales, Washington: Office of the Deputy Assistant Secretary for Research and Technology, February 19, 1997, unnumbered page.

9. Sean D. Naylor, "What the Future Holds . . . ," *Army Times*, March 17, 1997, p. 22.

10. *Tactics and Technology*, p. II-9.

11. "Infantry System Turns Soldier Into High-Tech Urban Warrior," *National Defense*, Vol. LXXXI, April 1997, p. 24.

12. *Tactics and Technology*, p. III-17.

13. *Ibid*.

14. *Ibid*., p. III-20.

15. Brandler, para. 2a.

16. *Ibid*., para. 2g.

17. Steven Kenney, *et al*., *Biotechnology Workshop 2020, May 29-30, 1996: Summary Report*, SAIC Document No. 96-6963 &SAC, McLean, VA: Science Applications International Corporation, undated, p. 29 (hereafter SAIC).

18. Brandler, para. 2c.

19. SAIC, Tab H, p. 3.

20. Joseph A. Engelbrecht, Jr., *et.* al., "Alternate Futures for 2025: Security Planning to Avoid Surprise," Research paper presented at Air Force 2025, p. 153; Robert Langer and Joseph Vacanti, "Artificial Organs," *Scientific American*, September 1995, Vol. 273, No. 3, p. 131.

21. Kenny, *et al*., p. 22.

22. Brandler, para. 2j.

23. Engelbrecht, *et al.,* p. 181.

24. *Tactics and Technology*, p. V-21.

25. John Markoff, "New Wave in High Tech: Tiny Motors and Sensors," *New York Times*, January 27, 1997, p. 1.

26. Kenny, *et al*., p. 28.

27. *Ibid*., p. 36.

28. *Biotechnology Workshop 2020: Readings*, Tab H, p. 12.

29. *Ibid*., Tab H, pp. 8-9.

30. Kenny, *et al*., p. 29.

31. *Biotechnology Workshop 2020: Readings,* Tab H, p. 3.

32. Brandler, para. 2b.

CHAPTER 3

UNMANNED AERIAL VEHICLES: PROMISES AND POTENTIAL

Arthur J. Sosa

> All the business of war, and indeed all the business of life, is to endeavor to find out what you don't know by what you do know; that's what I call guessing what was at the other side of the hill.
>
> Duke of Wellington[1]

INTRODUCTION

The concept of Unmanned Aerial Vehicles (UAVs) began with the appearance of target drones in the 1940s. Shortly thereafter, a veil of secrecy fell over UAV research, and their operational capabilities were developed covertly. Nearly 50 years later, during Operation DESERT STORM, UAVs came to the attention of the general public through extensive war reporting, highlighted by reports of Iraqi soldiers with arms held high, attempting to surrender to a circling UAV. The Gulf War became the latest proving ground to evaluate UAV capabilities in combat and their potential role on the modern battlefield.

My experiences as an Army Attack Helicopter Company Commander and Combat Aviation Battalion Commander have taught me the value of aerial weapons platforms on the battlefield as a combat multiplier. The success of Operation DESERT STORM was made possible through the unique synergy of men and machines in cohesive units. The operation also underscored the vulnerabilities of the human and the machine in that equation. Machines can fail, but more often it is a human operator exceeding personal limitations that becomes responsible for turning aircraft into scrap metal. High stress mission conditions, fatigue, poor weather, and reliance on night vision devices increase pilot workload and risk. These factors create pilot errors which are responsible for the majority of aircraft accidents.

It still takes less time to build a combat aircraft than to recruit, train, and qualify the pilots who will fly it in combat. Encounters with enemy air defense systems, enemy air assets, and enemy small arms fire are predictable, potent threats when U.S. forces deploy into a hostile theater of war. What high risk roles can be performed by unmanned aircraft? Which must be performed by manned aircraft regardless of risk?

In this information age, emerging electronic and aviation design technologies are melding in UAVs. These factors in combination increase mission capability while enhancing aircraft and human survivability. For purposes of this paper, I shall restrict my remarks to unmanned systems except in those circumstances where a comparison to manned systems would be helpful for clarification.

A BRIEF HISTORY OF UNMANNED FLIGHT

Unmanned aircraft may appear as a novel concept to some outside the military community. This is hardly startling, considering that the early use of unmanned aircraft was subject to security classification. A civilian resident of Carlisle, Pennsylvania, working at the War College overheard several of my colleagues discussing their research papers. At a quiet moment he turned and asked me, “What are you researching?” “Unmanned Aerial Vehicles," I replied. This immediately drew a puzzled look, and then my acquaintance said, “Oh yeah! My son has one of those. He flies it at a big field outside of town.”

The potential of UAVs can be better understood through the events that led to their development. The rapid progress and growth of the UAV program open our imagination to further possibilities for improving current capabilities and exploring new military applications for the future defense.

The protection of American citizens is one of the stated vital interests of the United States. An American hostage or prisoner held by an enemy creates political leverage for that enemy to exact concessions from the United States. This was clearly demonstrated by the downing of a U-2 spy plane and capture of pilot Francis Gary Powers by the Soviets in 1960. The incident occurred only a few years after President Dwight D. Eisenhower had proposed mutual aerial surveillance or "Open Skies" to ease tensions between the Soviet Union and the United States. When overflight privileges were denied by Soviet Premier Nikita Khrushchev, President Eisenhower covertly authorized overflights of the Soviet Union to maintain surveillance of the growing Russian military. Embarrassed by the incident, President Eisenhower was compelled to make a public statement announcing terminatation of U-2 flights over the Soviet Union.

Two months after the Powers shootdown, a similar incident occurred. The Soviets downed an American RB-47 aircraft over the Barents Sea between Norway and Russia, 50 miles from Soviet territory. Two of the crew members survived and were taken prisoner. However, three American lives were lost, and further embarrassment for the United States ensued. These incidents forced the United States to explore alternatives to its manned reconnaissance program. Intelligence analysts believed the growth of Soviet military power demanded a surveillance capability to provide critical reaction time for U.S. forces if needed. Aerial reconnaissance was the best means to satisfy this requirement, but further risk of American pilots was not acceptable. Initial feasibility studies of UAVs grew out of this realization.

"Red Wagon" was the code name for the first flight demonstration of target drone aircraft modified for reconnaissance use. The highly classified project began in July 1960, shortly after Powers' U-2 was shot down. The drone was developed by the Ryan Company, a manufacturer of target drone aircraft. It was advertised as

> a ground controlled target flying at near sonic speed and at altitudes in excess of 60,000 ft. It was to be flying for more than six hours while being engaged by surface to air missiles in an Air Force Training program against high flying enemy aircraft.[2]

This cover story was intended to disguise the true purpose of the tests.

Meanwhile, U.S. policy with respect to UAVs continued to develop. A report from Dr. Harold Brown, Director of Defense Research and Engineering in 1961, summarized the issues and requirements of aerial reconnaissance programs:

> The suspension of overflights (by U.S. over Russia) and peripheral operations by U-2 aircraft is political in nature and has deprived the United States of its most effective aerial intelligence collection capability.
>
> The fact that Sino-Soviet Bloc capabilities, both offensive and defensive, are dynamic and aggressive, dictates that an almost constant surveillance be maintained to insure maximum US combat effectiveness. This requires high resolution (1 foot) photographic coverage of selected areas and of specific targets within these areas.
>
> Based on the preceding remarks, the following criteria are proposed for use in the selection of any future vehicle that will be used for overflights:
>
> *Unmanned*. For political, diplomatic and public acceptability.
>
> *Operate independent of foreign and U.S. overseas bases.* Not dependent on a third country for support and/or policy. It could be recovered over international waters.
>
> *Lead Time*. Recommend that the study phase of a drone program be undertaken immediately.[3]

Clearly, a need exists for accurate aerial-photo intelligence data without the political liability of a dead or captured aviator. However, budget battles for modernization and research funding continued to impede

UAV progress. At this time, the Soviets were supplying missiles to Cuba. In October 1962, Major Rudolph Anderson was killed when his U-2 was hit by a surface-to-air missile (SAM) over Cuba. At that time, only two UAVs were mission capable. The Cuban missile crisis in 1962 prompted additional funding for reconnaissance.

The earliest combat use of UAVs occurred in Vietnam. Twenty-eight different configurations of UAVs flew from 1962 through 1975, involving over 3,435 operational sorties. The missions flown by the Vietnam War UAVs included both day and night photo reconnaissance missions, photo missions over the Hanoi Hilton prisoner of war camp, and other battle damage assessment (BDA) photos of Hanoi from 2,000-3,000 feet.[4] However, there were also alternative special purpose UAV payloads used during the Vietnam War. For example, several 147NA/NC UAVs were maintained on standby for possible pre-strike electronic countermeasures (ECM) chaff-dispensing missions. An undetermined number of UAVs were used for electronic intelligence or electronic countermeasures missions. Over 29 UAVs, called "bullshit bombers," were launched to drop leaflets. The appendix also offers several examples of unmanned systems serving as decoy aircraft.[5]

In Vietnam, off-the-shelf-technology was successfully adapted to enhance aerial reconnaissance capabilities. This field experience is a proof of concept for UAVs, creatively demonstrating a potential for expanding their missions. The UAV project engineers evaluated many advanced technology concepts, which included:

- Prototype low observable (Stealth) designs to reduce radar signature.[6]

- Radar altimeter low altitude control system to hug terrain.[7]

- Integration of LORAN for position accuracy within 200 feet.[8]

- Unmanned flight to 65,000 feet at nearly the speed of sound.[9]

- UAV suppression of enemy air defenses (air to surface missile).[10]

- UAV bomber (1964) with a 250-pound bomb.[11]

The second and third order effects of the UAV program could have surfaced in the 1960s by spin-off research developments, but the doctrine and the culture were slow to adapt to the potential opportunities offered. In the Air Force, advocacy for unmanned systems was seen as a vote against manned aircraft, tantamount to career suicide for senior aviators.

How did manned systems and unmanned systems compare? It is reducing risk and the related cost in human lives that is really at the center of the issue. William Helmich, Ryan Company's Program Manager for their Air-to-Surface Missile Project, offered one prophetic opinion:

> The drone runs about one-tenth the cost of a (1970 vintage) manned jet fighter, which carries one or two pilots each. And, everyone wanted to cut down on the number of guests in the Hanoi Hilton, and this (Ryan 234 armed UAV prototype) is one way to do it.[12]

U.S. UNMANNED AERIAL VEHICLES TODAY

Unlike during the Vietnam era, the current UAV Program is a joint service program with participation by all services. The Defense Airborne Reconnaissance Office (DARO) manages the Defense Airborne Reconnaissance Program (DARP) and is a focal point for all airborne reconnaissance matters.[13]

The Joint Requirements Oversight Council (JROC) sets priorities for the Department of Defense (DoD) by allocating funds to key projects. Tactical UAV (TUAV) is the number one UAV program priority. TUAVs are represented by two distinct systems called Pioneer and Outrider. The second and third priority projects, respectively, are the Predator and High Altitude Endurance UAVs.[14] These separate and unique UAV projects are the core of the DARP. Each UAV system has the potential of being tasked to perform a variety of missions with each individual service component.[15]

The TUAV will eventually support Army battalions, brigades, and light divisions as well as deployed Navy units. The TUAV mission is to provide near real-time, reconnaissance, surveillance, and target acquisition (RSTA) and BDA.[16] Currently both the Pioneer and Hunter UAV systems are filling this role. An Advanced Concept Technology Demonstration (ACTD) design called Outrider is being evaluated as a replacement for Pioneer and Hunter. Outrider's operating range is over 200 kilometers, nearly twice the range of the previous systems. It is more easily deployable than the earlier systems, requiring only a single C-130. Both Hunter and Pioneer would require multiple C-130 or C-141 sorties. Each of these TUAV systems uses a Global Positioning System (GPS) for navigation and cruises at approximately 90 knots air speed (90 nautical miles/hour).[17]

The Predator is the Medium Altitude Endurance or Tier II UAV. This system was a ACTD and is now in production. It has a mission range of over 500 nautical miles, approximately five times that of the TUAVs. Predator has 20 hours fuel endurance, cruising at 70 knots. Satellite communication (SATCOM) allows near real-time transmission of reconnaissance and target acquisition data from over the horizon, beyond electronic line of sight. This system is the first to incorporate a de-icing capability, essential for flight operations in cold weather. The Air Force's 11th Reconnaissance Squadron at Nellis Air Force Base, Nevada, formed in August 1995 was the first UAV unit equipped with Predator. The Predator system is called

Tier II because of features that surpass the capabilities of its UAV predecessors.

The Global Hawk is a Tier II+ UAV. This is a conventional high altitude endurance system currently in testing and development, with a first flight planned for March 1997.[18] Its aft-mounted jet engine distinguishes it from the other UAV propeller driven systems. The jet engine allows Global Hawk to fly over 345 knots, almost four times the airspeed of previous systems, and to attain a range of 3,000 nautical miles. This Teledyne Ryan built UAV resembles a U-2 in size and shape. Its transcontinental flight capability could replicate the Francis Gary Powers' U-2 flight easily, and, arguably, since it is unmanned, do so without the same potential political liabilities. The payload is similar to that of the other systems which use electro-optical/infrared and synthetic aperture radar. These sensor systems provide day-night and all-weather imagery capability. Survivability is achieved by its high altitude stand-off and its self-defense measures. The phrase "global" is well suited to this UAV; with its strategic range, Global Hawk is self-deployable worldwide.

DarkStar is the Low Observable High Altitude Endurance or Tier III(-) UAV. In this context, Low Observable means stealth capable. The Darkstar is the only U.S. produced UAV with true stealth design. Owing to its stealth focus, DarkStar will not achieve the same overall flight performance as the Global Hawk, but should attain over 250 knots airspeed for more than 8 hours endurance, reaching altitudes over 45,000 feet. The payload capacity, although not fully described in the open literature, appears to be less than Global Hawk as well. The DarkStar sensor payload includes either an electro-optical or synthetic aperture radar, not both systems like Global Hawk.[19]

> DarkStar trades air vehicle performance and payload capacity for survivability against highly defended air defenses by minimized radar return. This UAV is still in the developmental

and test flight stage with production scheduled to begin in the year 2000.[20]

Larry Lynn, Director of Defense Advanced Research Projects, states that "DarkStar will demonstrate a warfighting capability that the United States has not had since the early days of the SR-71 Blackbird and the U-2 Spyplane."[21]

Each modern UAV system possesses unique flight characteristics and capabilities to support the Joint Task Force Commander on the modern battlefield. Joint command and control of these assets require rapid facilitation of in-flight handoffs of mission aircraft and seamless sharing of data. To accomplish this, DARO is developing two types of UAV ground control systems. Two distinct types of ground control links will support the Tactical and the High Altitude Endurance UAVs, respectively. The Tactical Control System (TCS) is designed for TUAVs supporting the close battle without going beyond the horizon. The Common Ground Segment for the relatively autonomous high altitude endurance UAVs provides high data exchange rates and multi-payload functionality for significantly more complex missions beyond the horizon.[22]

The nature of UAV missions is directly influenced by the threat environment, distance to the area of interest, and the payload components required. The fiscal year 1997 UAV systems and payloads demonstrate significant improvements over Vietnam era reconnaissance pilotless vehicles (RPV). These improvements cut UAV size and weight, upgraded electronics to smaller high efficiency integrated circuits, and achieved real-time data sharing *via* SATCOM data linkages. UAVs provide responsive coverage of large geographic areas of responsibility, quicker than possible by repositioning reconnaissance satellites. This advantage in responsiveness is critical to many JTF Commander intelligence requirements. In an effort to expand the UAV flight mission, the DARO program managers are looking to the most promising technologies for new applications

THE POTENTIAL IN UAV MISSION PAYLOADS

Several new UAVs are in development and testing. These systems represent significant product improvements over the Ryan platforms used during Vietnam. Let us now examine the potential that technology offers for alternative payloads and expanded UAV roles and missions.

On January 16, 1996, Dr. Paul Kaminski, the Under Secretary of Defense for Acquisition and Technology, identified primary enabling technologies and architectural concepts that are vital to achieve battlefield dominance. One or more of these technologies are relevant to all high technology military systems. Several of the following technologies will be applied to UAV system development:

- Advanced processing;
- Automatic target processing;
- A common grid;
- Distributed and open architectures;
- Sequential application of off board collectors;
- Data compression;
- Very large, dynamic, object-oriented data bases;
- Data storage;
- Data dissemination; and,
- Planning analysis tools.

Battlefield dominance thus relies heavily on automated information processes or information dominance. Predictably, information requirements of battlefield commanders will vary in terms of quantity, quality, and timeliness, according to their role in the close, deep, or theater fight. UAV systems will require an advanced C^4I (Command, Control, Communication, Computers, and Intelligence) infrastructure for collection, processing, and dissemination to meet the unique needs of commanders at all levels.

UAVs are critically dependent on computer data processing, data compression, storage, and high speed data transmission for navigation and flight profile. The UAV mission equipment will also need a high speed data dissemination capability to feed the C^4I infrastructure and serve its subscribers. Fortunately, the technology sectors that engineer multimedia microchip capacity, computer processing, and high speed data modems produce significant improvements with regularity in the private sector. Private sector automation technology directly supports some UAV development programs, thus reducing costs. New directions in UAV missions have been well described by Rear Admiral Barton Strong, Program Executive Officer, Cruise Missile and Joint Unmanned Vehicles Office:

> In developing effective and affordable UAVs and ground control systems we need to prepare for both core and specific UAV missions. The core missions include day or night reconnaissance, surveillance and target acquisition (RSTA); combat assessment (CA); and battlespace management. As new payloads become available, more specific UAV taskings will evolve to include adjusting indirect fire; close air support; deception operations; search and rescue (SAR) and mine detection. Our list of potential "real time or near real time" UAV missions is growing.[23]

A clear indication of the program managers' intent to explore the potential of UAVs for missions beyond the historical aerial reconnaissance mission is reflected in the fact that the DARO approved 16 proof-of-principle demonstrations of UAV payloads, which are described in Table 1.

Demonstration Payload	Potential Mission Application
Meteorological Sensor	Systemic atmospheric readings
Radiac Sensor	Plot suspected NBC contamination
Light-weight Standoff Chemical Detector	Detect and plot toxic agents
Light-Weight Communications (COMINT) payload	Find/identify ground communications emitters
Acoustic Wave Chemical Detector	Detect/plot low level chemical agents
Hyperspectral Sensor	Detect hidden/difficult targets
Coastal Reconnaissance and Analysis	Detect mines (day/limited visibility)
Tactical Remote Sensor System	BLOS* ground sensor data relay
Communications Relay	BLOS communications relay for ground forces
Electronic Intelligence Payload	Locate/identify enemy ground forces
Radar Jammer Payload	Jam enemy ground radars
Light-weight COMINT Payload	Find/identify ground communications emitters
Communications Jammer Payload	Jam both radios and data links
Tactical Meteorological System	Weather from remote/denied areas
*Beyond Line of Sight	

Table 1.

UAV Joint Program Office Payload Projects.[24]

The goal of each payload project as shown in Table 1 is to provide battlefield commanders with additional means to achieve battlefield dominance. As of this writing, results of these proof-of-principle demonstrations are unavailable. However, some initial information has been released, for example, the Defense Advanced Research Project Agency (DARPA) reported promising results on feasibility tests using ultra-wide band radar (UWB) to detect buried mines. However, according to the report, mine-detecting radar operating from a UAV at altitude will require a significantly higher power supply than used in ground tests. Furthermore, precise location of small mines is difficult with UAVs, even with dual GPSs.[25] Additional testing is planned.

A report in the *Journal of Electronic Defense* described tests of four different payloads installed in a UAV for electronic warfare potential. One payload performed precision direction finding using high frequency (HF), very high frequency (VHF), and ultra high frequency (UHF) bands. A second payload autonomously recognized and jammed "enemy" VHF and UHF transmission. A third payload tested radar electronic warfare, and the fourth payload was a tactical radar jammer to counter pulse, pulse-doppler, and continuous-wave radar threats. All payloads performed well in the initial concept tests. It is now up to the services to analyze the data and then decide whether they will develop programs for UAV electronic warfare payloads.[26]

The concept of armed or lethal UAV systems is also being tested. One defense publication reported that a UAV-flown laser targeting system successfully guided anti-armor missiles to four out of five targets.[27] In another report, General Charles Krulak, Commandant of the Marine Corps, announced that the Marine Corps was assessing the development of UAV bombers in recent tests conducted at Aberdeen Proving Grounds.[28] The concept of using UAVs for a weapons delivery platform originated in 1953 and was tested in 1964, using two 250-pound bombs from a Ryan Firebee RPV.[29] There is a variety of possible armed UAV prototypes.

The first launch of an air-to-ground weapon—a Maverick missile—from a UAV was made on December 14, 1971.[30] The UAV, a Teledyne Ryan BGM-34, was recovered after firing, confirming the proof-of-principle. This project was originally designed to assist Israel in maintaining a balance of power with Egypt by providing a low cost weapon system to counter the Russian SAM and AAA batteries in Egypt.[31] Anti-radar "harassment drones and decoys have a major role in efforts by the Israeli Air force to defeat hostile air defenses."[32] *ARMADA* magazine reports that six nations presently have attack UAVs.[33] In addition to Israel, these nations include Iran, Israel, Germany, France, South Africa, and the United States.

As can be seen in Figure 1, many nations are coming to realize that UAVs provide cruise missile capability at a fraction of the cost. A hostile UAV carrying a lethal payload could reach the United States from a number of locations. Consider the domestic and international impact associated with chemical or biological agents dispensed by UAV. Suddenly, terrorists could have an accurate, long-range delivery means for weapons of mass destruction (WMD). Non-proliferation of UAV technology is clearly a national security issue for the United States.

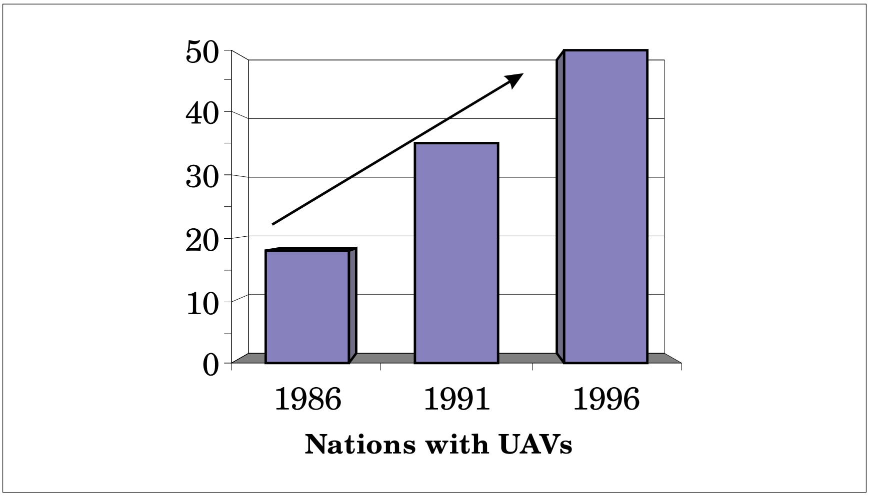


Figure 1.
Proliferation of UAVs.[34]

The Missile Technology Control Regime (MTCR) is a voluntary agreement to prevent the proliferation of missiles capable of nuclear delivery, which covers cruise missiles and related technologies.[35] The MTCR specifically prohibits the "export of unmanned aerial vehicle systems (including cruise missile systems, target drones, and reconnaissance drones) capable of delivering at least a 500 kilogram payload to a range of 300 kilometers."[36] The MTCR was first established in 1987 and now has 25 countries participating.

The United States is a charter member of the MTCR and has taken a strong stand in support of weapons control agreements including armed UAVs. The following statement appeared in the *1995 UAV Annual Report:*

> We will continue to monitor advances in the arms control arena and ensure treaty compliance. In addition, to preclude any future misunderstanding about UAVs as weapon platforms, the DARO has made it clear that it has no plans to develop or test armed reconnaissance UAVs.

Clearly there has been a major reversal in U.S. policy in the last 2 years; concept tests of armed UAVs are now allowed. Oddly, there is no mention of this significant change in policy in the *1996 UAV Annual Report*.

The UAV program addresses the airworthiness of each system and the opportunities this technology offers to commanders at every level. Emerging technologies as buttressed by over 40 years of experience with UAVs have led to a family of uniquely capable air vehicles that allows U.S. forces to dominate the battlefield without incurring unnecessary risks to aircrew members. However, the proliferation of UAV technology is tantamount to handing a cruise missile to a hostile nation as a delivery means for WMD. We have come far in those 40 years, but did we come far enough? Let us consider what the future applications for UAVs could and should be.

RECOMMENDATIONS FOR THE FUTURE

Three primary recommendations emerge from this review of UAVs. First, we should increase the commitment on the part of all services, especially the Air Force, to maximize UAV capabilities. Second, we should research UAV fighter aircraft. Third, the United States should monitor international efforts for development and sale of UAVs and related technology.

As to service commitment on behalf of UAVs, I do not advocate a UAV program as a substitute for airpower. There can be no replacement for tactical or strategic lift capability. UAVs are ill suited for lift purposes. UAVs are better suited for aerial reconnaissance, communications relay, electronic warfare, and radar jamming missions. Nonetheless, UAV systems should have achieved greater integration into the military overall and into the Air Force in particular.

Considering this nation's over 40 years experience with UAVs, it is amazing that there is only one Air Force UAV unit in existence. Furthermore, several of the payload concept tests mentioned earlier merely repeat similar tests conducted during the 1960s and early 1970s. Microchip and miniaturized on-board computers are providing the UAV with a virtual cockpit capability. This virtual cockpit and alternative payloads will make new UAVs even more functional as aviation assets than in the past. Richard T. Wagaman, former President of the Association of Unmanned Vehicle Systems, tells us that:

> UAVs are being used for more functions every day. The military UAV missions are obvious and have been addressed many times. The non-military government and commercial unmanned aircraft functions will yield a yearly market exceeding one billion U.S. dollars by the turn of the century. [and] will likely exceed $2 billion by 2005—just 10 short years away.[38]

It would be a telling indictment if the private sector realizes the enormous potential of UAVs before the military. A spark is needed. It is time for a new generation of Hap Arnold's or Billy Mitchell's to lead a cultural revolution to further the unmanned revolution in military affairs.

The second recommendation deals with the U.S. need to research a UAV fighter concept. This concept offers some economy compared to manned systems—an alternative to large numbers of high technology manned fighter aircraft. A small number of UAV fighters could serve in the first wave of a high risk theater campaign to whittle down enemy air defenses. This would effectively preserve manned systems for later lower-risk missions. The question of whether to rely on threat-based or capability-based weapons systems to support U.S. national security strategy becomes irrelevant if UAVs can do both cost efficiently. Consider the potential benefits of a UAV fighter in terms of cost avoidance (benefits 1-5) and operational capabilities (benefits 7-9; benefit 6 applies to both):

1. No ejection seat/no oxygen system (low cost/less weight);

2. A virtual cockpit: no flight controls or pilot safety systems;

3. No ergonomic studies of cockpit design (low cost);

4. Potentially less time & cost to replace a combat UAV than replace a combat fighter and pilot;

5. If feasible, convert current aircraft to UAV for testing;

6. Reduce fratricide: real-time/gun camera slow-motion and stop-action imagery, thus improving target identification;

7. Fly by wire (F-16 type) control system would connect through on-board computer to ground control system;

8. Extremely high g-maneuvers (exceeding human capacity); and,

9. Precise close air support: combine gun camera targeting with laser guided munitions.

An ironic but significant justification for unmanned fighters (in lieu of manned versions) is to increase the aircraft's capability by removing the human constraint. Pilots generally cannot sustain more than 6-7 Gs. In a tight turn, a fighter aircraft can easily develop G-forces that will cause pilots to lose consciousness. UAVs are already capable of exceeding 8 Gs, sufficient to outmaneuver manned systems in aerial combat. In 1971, this air-to-air concept was tested informally in mock dog fights, pitting an unarmed UAV against veteran Navy pilots in two F-4s with Sparrow and Sidewinder missiles. The UAV repeatedly outmaneuvered the F-4s and was not hit.[39] This capability may be as significant as stealth in aircraft survivability, providing the best countermeasure against enemy UAVs.

The final recommendation deals with monitoring international development and sale of UAV technology. This will become increasingly difficult if Mr. Wagaman's assessment for the growth potential of the nonmilitary market for UAVs proves correct. He claims that the annual nonmilitary UAV market will double to $2 billion. For example, UAVs may be used for dusting crops, highway traffic surveillance, counterdrug operations, border surveillance, and nuclear power plant or chemical plant discharge monitoring. In each of these examples, a common operational theme emerges. Extended, monotonous, and high-risk hazardous operations entail technologies that make UAVs attractive to civilian as well as military application. The UAV is clearly a dual use technology, ultimately capable of crop dusting farms as well as delivering biological toxins and nerve agents to the battlefield. The United States must be prepared for a two-fold challenge:

- Prevent rogue nations from gaining a delivery means for weapons of mass destruction, and

- Devise countermeasures for highly maneuverable, stealthy enemy UAV aircraft.

CONCLUSION

The United States DoD must maintain a balanced military capability to protect national interests and project power. This must be done without eroding the national economy or vital domestic interests. UAV systems offer a unique opportunity for a true revolution in military affairs and a cost-effective alternative to a large manned aircraft fleet.

ENDNOTES - CHAPTER 3

1. As quoted in Jay M. Shafritz, *Words on War*, New York: Simon & Schuster, 1990, p. 208.

2. William Wagner, "Lightning Bugs and Other Reconnaissance Drones," Fallbrook, CA: *Armed Forces Journal* and Aero Publishers, 1982, p. 17.

3. *Ibid.,* p. 19.

4. *Ibid.,* p. 202.

5. *Ibid.,* p. 99.

6. Bill Sweetman,"The Invisible Men," *Air & Space Smithsonian*, April/May 1997, p. 19.

7. William Wagner, p. 175.

8. *Ibid.,* p. 194.

9. *Ibid.,* p. 166.

10. *Ibid.,* p. 182.

11. *Ibid.,* p. 174.

12. *Ibid.,* p. 185.

13. Defense Airborne Reconnaissance Office, *UAV Annual Report, FY 1996*, November 6, 1996, p. 1.

14. *Ibid.*

15. *Ibid.,* p. 31.

16. *Ibid.,* p. 14.

17. *Ibid.,* p. 31.

18. *Ibid.*, p. 20.

19. *UAV Annual Report, FY 1996,* p. 31.

20. *Ibid.,* p. 22.

21. *Ibid*.

22. *Ibid*., p. 24.

23. Rear Admiral Barton Strong, *Statement before Subcommittee on Airland Force of the Senate Armed forces Services Committee*, March 29, 1996.

24. *UAV Annual Report, FY 1996,* p. 39.

25. Bruce D. Nordwall, "Ultra-Wideband Radar Detects Buried Mines," *Aviation Week & Space Technology*, March 31, 1997, p. 63.

26. Z. Lum, "Demo Done, UAV EW Payload Players Await Report," *Journal of Electronic Defense*, Vol. 20, January 1997, p. 27.

27. Pat Cooper, "New Battlefield Tasks Eyed for UAVs," *Army Times*, October 28, 1996, p. 12.

28. *Ibid*.

29. Wagner, p. 174.

30. *Ibid*., p. 181.

31. *Ibid*., p. 180.

32. W. Seth Carus, *Cruise Missile Proliferation in the 1990s,* Washington, DC: Center for Strategic and International Studies, Praeger Publishers, 1992, p. 86.

33. Doug Richardson, *ARMADA International*, October/November 1996, p. 20.

34. *UAV Annual Report, FY 1996*, p. 6.

35. Most international weapon agreements do not include UAVs, the Missile Technology Control Regime being a noteworthy exception.

36. Carus, p. 89.

37. Defense Airborne Reconnaissance Office, *UAV 1995 Annual Report, FY 1995*, August 1995, p. 8.

38. Richard T. Wagamon, Address before UV-95 Conference, Paris, June 1995.

39. Wagner, p. 186.

CHAPTER 4

STRATEGIC LOGISTICS FOR INTERVENTION FORCES

Yves J. Fontaine

[Editor's Note: Lieutenant Colonel Fontaine presents evidence of a slow learning curve when it comes to solving logistics management problems. He points to potential near term solutions for many existing problems, but makes clear that many greater changes will be required throughout the force before any revolution in military logistics can be expected to become a reality. DVJ]

INTRODUCTION

In every overseas deployment since the Spanish-American War, the responsiveness of the logistics system was degraded by lack of information concerning personnel, equipment, and requisitions status. Moreover, an enormous amount of materiel was shipped to the theater, but was not readily available because of this poor information, which in turn reduced the combat forces' ability to accomplish their mission. This paper analyzes the strategic logistics systems of recent force projection operations covering the entire spectrum of war, to include Operations DESERT SHIELD/DESERT STORM, RESTORE HOPE, SUPPORT HOPE, and JOINT ENDEAVOR. It identifies problems with tracking the status of supplies, building the Time-Phased Force Deployment Data (TPFDD), attaining Automated Data Processing (ADP) compatibility, and securing unity of command and control over the various logistical inputs. The paper concludes with recommendations for logistics concepts which should support the Army through the opening decades of the next century.

HISTORICAL ANALYSIS

Operation DESERT SHIELD/DESERT STORM.

On August 2, 1990, Iraq invaded Kuwait and seized control of the country.[1] In response, the U.S. military began deploying personnel, equipment, and supplies to seaports and airports in Saudi Arabia.[2] The brevity of the warning time, the massive size of the coalition force, the lack of prepositioned equipment, and the distances between the United States and Saudi Arabia required U.S. logisticians to mass enormous lift assets in a short period of time.[3]

U.S. Central Command (CENTCOM) was responsible for theater logistics management. It developed policy and monitored and coordinated transportation and distribution operations. CENTCOM tasked the Army component (ARCENT) with management of seaport and airport operations. ARCENT also managed theater surface transportation and distributed common items such as food, clothing, lubricants, and munitions to all services.[4] ARCENT operated the theater Communication Zone, coordinating joint, combined, and coalition operations to include Host Nation Support (HNS).

Because of the immediate threat from Iraq, CENTCOM decided to deploy mobile combat units first, bringing in logistics units later. This decision to deploy service support units later in the deployment sequence seriously degraded ARCENT's ability to provide support. Initially ARCENT had to rely heavily on HNS for the operation because U.S. forces had limited in-country capability to move, store, and retrieve equipment and supplies. This CENTCOM decision also triggered instant allocation of the most available and fastest strategic lift assets to combat units. This ultimately resulted in an unsynchronized buildup of a theater infrastructure. The inserted force was dangerously unsustainable for the initial period of Operation DESERT SHIELD because of a significant shortage of Army surface transportation assets, including heavy equipment transporters, tractor trailers, and materiel handling equipment.[5] This meant that the Army could not fulfill its mission of providing support, thus leaving the Air Force and Marines no choice but to establish their own transportation systems, which further complicated matters.[6]

An automated data system was supposed to regulate the massive flow of cargo and people into the theater of war, but CENTCOM had not finalized its Saudi Arabian plan. Thus, deployment data were not automated. Most of the movement was managed manually, and planners improvised the force deployment list as they executed it. This lack of automation and midstream revisions prevented airlift and sealift from operating at full capacity. Deploying units often did not know where and when to meet aircraft, or how to marry equipment with departing ships, thus causing planes to fly empty or with low priority cargo and forcing units' equipment to be piecemealed on several ships.[7] Such a large operation needed a well-planned, automated guidance system for orderly deployment.

Logisticians admitted that they were unable to track equipment and supplies arriving in theater. They knew when a ship was scheduled to arrive, but they had only a general idea of the cargo. Ships had incomplete manifests and mislabeled containers. During the initial phase of the operation, logisticians at the ports had to empty containers in order to determine where to ship the contents.[8] Because of the constant changes in the deployment sequence, some equipment arrived before its unit did. Logisticians at the ports did not have knowledge of the units' arrival, nor did they know their location in-country after the units had deployed. Supplies piled up at the port, overwhelming the supply personnel, and the proverbial iron mountain started to rise.

Container management was nonexistent, so throughput became impossible. The Army had no viable tracking systems, used sloppy documentation procedures, and lacked sufficient materiel handling equipment to move the containerized cargo to appropriate distribution centers. To assure maximum use of ship capacity, shippers filled the containers full regardless of destination. Containers were filled with supplies addressed to several consignees, or were loaded with unidentifiable loads with minimum documentation. Because the personnel needed to document the receipt of the materiel were not deployed early, stacks of containers piled up unprocessed in the ports. Lack of documentation further degraded the tracking of supplies, and 50 percent of the arriving containers had to be opened to identify their contents. The lack of materiel-handling equipment and transportation assets worsened the backlog. Units lost confidence in the system and reordered "missing" items, thereby compounding the problem.[9] Finally, even logisticians bypassed the supply system and established direct logistics links with their home bases to obtain critical items.

The airlift system was overloaded and could not keep up with demands. By December 1990, 7,000 tons of cargo were lying on the ground at Dover Air Force Base, Delaware, awaiting shipment to Saudi Arabia. This supply remnant exceeded the total airlift capacity sixfold.[10] Units saturated the airlift system with high priority demands because they had lost confidence in the standard logistics system. Because cargo and supplies were not properly prioritized, first in/first out became the rule, and high priority items were delayed in reaching deployed units. To partially correct the problem, Transportation Command (TRANSCOM) established the Desert Express and the Desert European Express Systems to deliver critical repair parts overnight from the United States and Europe. Although successful, the system bypassed the established procedures—at enormous extra cost.[11] Ingenuity, not consistently applied logistical practices, saved the day!

Operation RESTORE HOPE, Somalia.

In April 1992, the United Nations (U.N.) Security Council approved Resolution 751, establishing the U.N.

operation in Somalia (UNOSOM). Its mission was to provide humanitarian aid and facilitate the end of hostilities.[12] During the next 6 months, U.N. forces delivered supplies to Somalia. However, by December 1992, the security situation worsened, forcing the United Nations to initiate Operation RESTORE HOPE. The United Nations assigned the United States to lead and to provide military forces to a multinational coalition; to secure air and naval ports; to secure key installations and food distribution points; and to provide security for convoys and relief. This operation, which involved more than 38,000 troops from 21 nations, finally succeeded in providing security and food throughout the country.[13] In May 1993, the United Nations assumed the mission to provide humanitarian support under Operation UNOSOM II. U.S. participation was then reduced to providing logistical support and a quick reaction force.[14]

Upon initial notification, CENTCOM deployed a humanitarian assistance survey team to assess the situation, then activated a Joint Task Force (JTF) to conduct emergency airlift of food and supplies into Somalia. In December 1992, CENTCOM ordered the 1st Marine Expeditionary Force to become the nucleus of the 20-nation combined task force. Concurrently, CENTCOM alerted the 10th Mountain Division to prepare to serve as the headquarters for all Army forces in Somalia and to conduct military operations to provide security for the relief effort.[15]

The deployment of forces and equipment to Somalia encountered problems similar to those in operation DESERT SHIELD/DESERT STORM. During the planning phase, the 10th Mountain Division had to contact four different headquarters to determine deployed force strengths. Strategic planners had developed plans for the operation but sought little input from the tactical units. This caused significant problems since the strategic planners did not anticipate the large number of logistics personnel required to support a bare base logistics operation.[16] Transportation problem solvers did not deploy early enough to detect on a timely basis the terminal and port problems stemming from absence of a host country infrastructure. Without this on-site expertise, major problems were inevitable.

The 10th Mountain Division deployed to Somalia expecting to provide self-contained logistics, but it was ill-equipped to overcome the logistical nightmare it encountered. The unit was not prepared to handle problems associated with downloading prepositioned ships and operating sea and air ports of debarkation. The rapid arrival of Army combat units soon overwhelmed the initial support capability provided by the Marine Corps Force Service Support Group; 10th Mountain Division logistics units had to be consolidated to perform wholesale logistics functions.[17]

There was no preexisting plan for Somalia, and the deliberate planning process failed as the TPFDD continuously changed.[18] The CENTCOM-developed TPFDD was valid for only a few days at a time as subordinate units made changes on the ground without coordination. Loaded cargo never left the port of debarkation or had to be unloaded at another port because it was no longer needed. Likewise, airlift was sent to carry cargo that never appeared.[19]

The lack of automation interface caused significant problems in tracking. Unforecasted cargo, inaccurate data, and differences between codes used by deploying units were as prevalent as in DESERT SHIELD/DESERT STORM. The lack of interface between Joint Operations Planning and Execution Systems (JOPES) and the military standard transportation and movement procedures resulted in a loss of materiel tracking, tracing, and status awareness. So once again, items could be found only after physical checks were made.[20] At one time the Army was sending excess equipment back to the United States while the Marines were requesting augmentation of the same equipment.[21]

Six separate supply support systems were used in the Somali theater. Units used the standard Unit Level Logistics System to request supplies; requisitions were transferred through the Direct Support Unit to the Defense Automated Addressing System for routing into the National Inventory Control Point (NICP); units also used direct requests such as E-mail and phone to home station; in desperation, units called directly to depots and NICPs to shorten order and shipping time. The wholesale level honored the system, but tracking was difficult. At times, units used the U.N. system to obtain common use items, but the system was slow, quality was uncertain, and delivery was erratic. Action officers and general officers also made direct requests, triggering movements of supplies without the knowledge of logistics personnel in the theater. Finally, Army Materiel Command established a back-up system using logistics representatives to obtain supplies. These systems got the job done, but the logistics ADP infrastructure did not work.[22] The lack of a theater level supply command to discipline the supply system led to waste, and the iron mountains started to appear on the horizon again.

Operation SUPPORT HOPE, Rwanda.

On July 4, 1994, Kigali, the capital of Rwanda, fell to the Tutsi dominated Rwandan Patriotic Front. Thousands of Hutus, fearful of genocide, fled to Zaire or French safe zones in south Rwanda and Burundi. Most fled to Goma, Zaire, which exploded into a refugee camp of one million refugees. Soon humanitarian organizations were overwhelmed by the need for food, medical assistance, and clean water.[23] By July 24th, U.S. military personnel deployed to Kigali, Goma, and Entebbe, Uganda, to establish the infrastructure for humanitarian support. Civilian Military Operation Centers were established immediately in Goma and Kigali to synchronize support requirements with the Non-Government Organizations (NGO). U.S. policy at this time was to assist the humanitarian effort, take no casualties, and leave. The United States subordinated its logistics effort to U.N. control.[24] The primary U.S. mission was to provide clean water and then to collect and distribute food and other necessities.

Upon notification of the crisis, the U.S. European Command (USEUCOM) JTF deployed a survey team to provide on-the-scene assessment of the situation.[25] This early assessment was vital in determining the composition and flow of follow-on forces to accomplish the mission. However, the JTF commander found it very hard to influence the deployment of forces once requirements became more clear. The deployment was managed by phone, which resulted in inefficient use of airlift. The JTF commander lacked the ability to enter the JOPES system in order to build his force. Present procedures call for the TPFDD to be built by unified commands, but in nonstandard contingency operations, each of which presents its own unique problems, the commander should have the authority to reach deep into unit structures and call upon the capabilities required to accomplish the mission following his assessment of the situation.[26] That is to say, he should be able to tailor his forces to fit the unique circumstances of his mission. This requires the Army to review how it structures forces and builds TPFDDs.

As in Operations DESERT SHIELD/DESERT STORM and RESTORE HOPE, several commands and agencies were involved in TPFDD input, creating problems in synchronization. As the JTF Forward was trying to pull units it needed for the mission, the JTF Rear and supporting commands were pushing units to the theater based on the previously established TPFDD. Additionally, and peculiar to this operation, international relief and NGO requirements were added on top of an already confusing TPFDD without consideration of timing or flow. This resulted in a backlog at ports of embarkation, unnecessary movement delays, and a loss in status awareness. Finally, the JTF gained control of the movement and circumvented the broken system by resorting to teleconferences and daily airlift messages.[27]

The Material Management Center and the Arrival/Departure Airfield Control Group were bumped by higher priority units and did not arrive in theater until C+21. Prior to their arrival, no structure was in place to maintain accurate status information on supplies and equipment.[28] Personnel did not use the proper cargo documentation and manifesting procedures, which resulted in the loss of transit status information once again. These problems forced the JTF commander to allocate personnel to the aerial port of debarkation to meet each aircraft, identify the cargo, break it out, and get it to the proper place.[29]

The JTF also encountered problems in ADP. It had no capability to track individual loads precisely or forecast arrivals because of an interface problem between the Global Decision Support System (GDSS) and JOPES. The interface works only when the GDSS data is loaded into the JOPES in a timely and correct manner. Headquarters Air Mobility Command was responsible to load GDSS into JOPES, but poor quality input caused problems. The Army needs a link to interconnect strategic airlift, the JTF, and the customers.[30] During Operation SUPPORT HOPE, the Standard Army Automated Requisition System was introduced early, but proved unable to transmit requisitions for several days because of delays in establishing communications.[31]

Operation JOINT ENDEAVOR, Bosnia.

Operation JOINT ENDEAVOR offers yet another example of flawed logistics planning. The Dayton agreement (December 1995) led to a general accord for peace among warring parties in Bosnia. The mission to implement the peace agreement fell to the North Atlantic Treaty Organization (NATO). The United States committed the 1st Armored Division to NATO's Allied Ready Reaction

Corps (ARRC) for the operation. The United States also provided augmentation to the ARRC headquarters and a National Support Element in Hungary and Croatia.[32]

Strategic ambiguity plagued the operation from the start. It was not clear until the actual signing of the peace agreement what type of force package was needed to accomplish the mission. At the conclusion of the planning phase, the TF commander's plan called for a deliberate, balanced deployment so he could tailor his forces in-country. The force package would augment the V Corps National Support Element in establishing the intermediate staging base in Hungary. The TF would then insert engineers and combat forces to establish lines of communication into Bosnia. The JOINT ENDEAVOR organization anticipated a single U.S. division organized with multiple brigades, numerous corps level support units directly under division control, and U.S. Army Europe (USAREUR) forward as the National Support Element. However, the final peace agreement called for the immediate entry of a sizable combat force into Bosnia. This altered the deployment packages and delayed deployment of combat service support assets, desynchronizing the deployment plan. [33]

Once again, the decision to deploy combat forces at the cost of logistics forces affected the sustainment of these same forces in country. USEUCOM enlisted the Logistics Civil Augmentation Program (LOGCAP), so civilian contractors would build the forward logistics bases as forces arrived in the area. LOGCAP's requirements for movement of supplies conflicted with requirements to move the combat forces. Lift for the combat forces was accorded a higher priority, causing a shortage in logistics support. Once again we had inserted an unsustainable force. Unit deployments had to be delayed or diverted until bases were established. The Task Force arrived without its main support and repair parts stocks. Had the TF been required to undertake combat operations, it would have found its combat power severely constrained.[33]

Several deployment management systems designed to assist in deploying the force were either overlooked or inefficiently used. The failure to use the Transportation Coordinator Automated Command and Control Information System, which automates the input of unit movement data and generates deployment equipment lists for loading in the JOPES system *via* the computerized movement planning and status system, prevented JOPES from automating construction of the TPFDD and contributed to the inability to maintain accessible information on the composition of the projected force.[35]

Operation JOINT ENDEAVOR benefited from ADP technological improvements identified as necessary in past contingency operations. In this operation, logisticians sought to achieve Total Asset Visibility by tracking the location, condition, and consignee of supplies and equipment from the factory to the foxhole. Logisticians planned to use radio frequency tags, detection devices, and computer systems to track the movement of items through the entire distribution system.[36] Even though Radio Frequency (RF) tags were used to maintain visibility over equipment throughout the deployment, these tags did not sustain visibility as planned. Only one station was set up to load the RF tags with the data needed for tracking of containers and supplies, and it could not handle the large quantity of containers being tagged. Next, "interrogator" hardware was not established at all major intersections along the Lines of Communication, thus preventing logisticians from tracking RF tagged items. Third, the Automated Manifest System (AMS), used by the direct support units to improve accuracy and expedite processing, did not arrive in country until late in the deployment; therefore, containers received prior to their unit's arrival were not processed correctly. Once operational, the AMS was able to track and distribute supplies.[37]

In summary, the U.S. Army encountered the same problems in deploying and maintaining visibility of personnel, equipment, and supplies in support of four recent contingency operations.

WHAT IS TO BE DONE?

We have unquestionably identified the problems, now can we fix them? If we are going to provide the 2025 force adequate logistical support, we need to make critical changes in four areas: force structure, ADP improvement, C3, and technology.

It is a given that, regardless of the type of operation, combat forces will always deploy first at the expense of combat services support (CSS) forces. The TPFDD will always change, and human errors will always play havoc with deployment documentation and manifests. We must anticipate these realities and change the way we look at the CSS force structure. We need a CSS force based on a modular system. We must build logistics modules tailored to perform specific functions. We should develop such modules to serve as receiving units at aerial ports of debarkation or as seaport unloading units, armed with the technology to perform these functions. The unit should be able to talk directly to the national provider and to the JTF commander to obtain follow-on support and to keep the commander aware of the support situation. These modules must deploy **as part of the combat forces**. This approach to force structure is not new. USEUCOM attempted to use this approach during the initial deployment for operation JOINT ENDEAVOR. The CSS community must refine its structure and build units in accordance with the functions they must accomplish, while keeping them small but technologically updated.

The modular system allows for flexiblility and the capability to move modules within the TPFDD once on the ground. The system must allow the TPFDD to evolve from the present system to a more agile system ready to respond to changes in the fast-paced situation.

The commander's ability to manipulate the TPFDD is directly linked to the level of ADP support he will receive. By 2025, ADP improvements must enable commanders to obtain and maintain visibility of all assets at all times. This will provide commanders the ability to influence not only the movement and deployment of initial entry forces, but also to influence logistics flow throughout the operation. The Joint Total Asset Visibility (JTAV) program, built in response to the growing importance of TAV to a restructured Defense Logistics System, has developed an implementation plan that integrates TAV throughout the Department of Defense. The objective of JTAV is to develop a responsive, user-friendly system, easily understood by all and capable of rapid deployment to contingency areas. CINCs and JTF commanders will use the system to enhance the planning, deployment, and movement of forces and to respond to changing strategic guidance. The system will enable logisticians to track orders, shipping activities, and port operations throughout the supply system; it will give strategic level materiel managers visibility of all assets throughout all systems.[38]

The JTAV implementation plan synchronizes four national systems to accomplish TAV. The Logistics Information Processing System (LIPS) will serve as DOD's central repository for requisitions status. The Inventory Control Point Automated Information System will be the permanent data repository for information on all ICP-managed assets from retail to wholesale levels. The Global Transportation Network (GTN), developed by TRANSCOM, will provide visibility of unit and nonunit shipment data (personnel, equipment, and supplies) to include information on medical patients. Finally, the JTAV will develop the Joint Theater Logistics Automated Information System to provide visibility of the location and status of in-theater logistics assets.[39] JTAV plans to use a client server architecture consisting of a server/database manager, a network manager, and a communications manager. It will develop a deployable JTAV package in conjunction with the CINCs to support activities equivalent to an Army Corps, Marine Expeditionary Force, Navy Fleet Headquarters, or numbered Air Force. Deployed units will be able to access JTAV with existing military applications.[40] The JTF staff will be able to access supplies in transit and in storage. It will process information from CONUS through the links with LIPS and GTN and merge this information with the information received from in-theater logistics modules, thereby giving the JTF commander the status on all his assets and the capability to manipulate logistics to meet mission requirements.

The JTAV modernization system not only allows logisticians to obtain and maintain visibility of all personnel, equipment, and supplies in the system but also to modify the logistics request system significantly. Since managers will have visibility of supplies at all times and have the ability to change the flow of supplies at a moment's notice, there will be no need for the existing priority system and the large stockpiles of supplies. The new ADP system gives the logisticians the opportunity to streamline logistics into a more flexible and responsive system.

The ability to control agile CSS modules on the battlefield and to harness the power of the revolution in information technology brings to light the need for a centralized logistics command and control system. Command structures, such as a JTF, should contain a logistics commander with the necessary ADP and trained personnel to monitor all logistics assets in the theater of operations. The logistics commander should deploy early to assess the situation and take immediate strategic level action concerning movement of personnel and equipment (both military and civilian) to respond to mission changes. The JTAV ADP system, previously discussed, would give the JTF logistics commander the ability to modify the TPFDD as soon as he is on the ground, plus the ability to maintain visibility of personnel, equipment, and supplies shipped to the area of operations. However, although technology will give logisticians the ability to know where the assets are at all times, it likewise demands stronger restrictions on the manipulation of the system. Given the new JTAV capability, a JTF logistics commander must establish strict guidelines on who can input changes to the deployment of forces and who monitors the arrival and transfer of logistics assets. Such real-time, on-site control and authority over logistics is revolutionary but absolutely essential. In the past, the logistics tail could unfortunately wag the JTF dog. Now that big dog will wag his tail any time, any way he sees fit!

Finally, ADP improvements are a subset of the revolution in information technology. They allow logisticians to improve logistics systems during contingency operations. Nevertheless, the level of technology available today (and probably in 2025) does not significantly change the way we do business as logisticians. Current technology allows improvement of logistics systems by giving total visibility of all assets and by enabling faster processing of information, but it does not yet alleviate the need for the extensive quantity of logistics to support U.S. deployments throughout the spectrum of war.

ONE OBSTACLE REMAINS

Careful analysis of the primary logistics requirements in a conflict reveal, as always, the critical need for fuel, ammunition, and food as the most significant logistics requirements for any force deployment. Consequently, the revolution in information technology does not mean a massive decrease in the U.S. Army logistics tail. Prior to a significant change in logistics or implementation of a genuine logistics revolution, the U.S. Army must undergo a deeper technological revolution and develop radically new systems, such as tanks that do not use conventional fuels and ammunition. In other words, the U.S. Army must develop systems that require very little or no logistics tail. The U.S. services need to increase budget share allocated to Research and Development (R&D) on behalf of such systems, even at the cost of force structure. Once these systems are identified, all services must join in procuring and using common versions to the maximum extent feasible, rather than each service designing, developing, and deploying its unique version. The result will be a simple logistics system, a small logistics tail, and a lethal but smaller and supportable contingency force.

CONCLUSION

This study has identified key logistics problems that occurred during recent contingency operations. Problems in materiel visibility, building and managing the TPFDD, ADP compatibility, and command and control hampered logistical support to varying degrees in each operation. Logisticians are aware of these issues and have taken steps to resolve them by developing and implementing the JTAV plan. On a more fundamental level, we need to build a centralized and permanent command and control system that includes a logistics commander and a logistics force composed of tailored logistics modules. This new capability would enable logisticians to take full advantage of the JTAV plan. These steps capitalize on the revolution in information technology; they will certainly improve today's logistics systems.

What these improvements will not do is create the revolution in military logistics that is needed by 2025. The real revolution in military logistics will occur only after our research community provides us with revolutionized combat equipment that minimizes the logistics tail needed to support it. The Army leadership must realize the need for new equipment and allocate the necessary resources to develop it.

ENDNOTES - CHAPTER 4

1. Scott W. Conrad, *Moving the Force, Desert Storm and Beyond*, McNair Paper No. 32, Washington: National Defense University Press, December 1994, p. 13.

2. U.S. Congress, Senate, Subcommittee on Oversight of Government Management, Committee on Governmental Affairs, *Desert Storm Transportation and Distribution of Equipment and Supplies in Southwest Asia,* General Accounting Office Report, 1991, p. 1.

3. Scott, p. 3.

4. General Accounting Office, p. 1.

5. Scott, p. 28.

6. General Accounting Office, p. 4.

7. Scott, p. 25.

8. General Accounting Office, p. 7.

9. Scott, p. 36.

10. *Ibid*., p. 26.

11. U.S. Congress, Senate, *Desert Shield/Storm Air Mobility Command's Achievement and Lessons for the Future*, General Accounting Office Report, 1993, p. 27.

12. Kenneth C. Allard, *Somalia Operations: Lessons Learned*, Washington: National Defense University Press, 1995, p. 14.

13. *Ibid*., p. 16.

14. *Ibid*., p. 18.

15. *Ibid*., p. 3.

16. David T. Stahl and S. L. Arnold, "A Power Projection Army in Operations Other Than War," *Parameters,* Vol. XXIII, No.4, Winter 1993-1994, p. 11.

17. Jeanette K. Edmunds, "Organizing Logistics for Peace and War: The Necessity of a Trained Joint Logistics Support Command Headquarters," in *Essays On Strategy,* Vol. XIII, Washington: National Defense University Press, 1996, p. 235.

18. David B. Kassing, *Transporting the Army for Operation RESTORE HOPE*, Santa Monica, CA: RAND, 1994, p. xii.

19. *Ibid*., p. 13.

20. Allard, p. 46.

21. *Ibid*., p. 47.

22. Department of the Army, UNOSOM II *Lessons Learned*, Fort Leavenworth: Center for Army Lessons Learned, 1996, p. II-10-21.

23. Edmunds, p. 139.

24. *Ibid*., p. 140.

25. Headquarters U.S. European Command, *Operation SUPPORT HOPE, 1994 After Action Review*, 1995, p. 2.

26. *Ibid*., p. 34.

27. *Ibid*., p. 14-4.

28. *Ibid*., p. 8-4.

29. *Ibid*., p. 8-5.

30. *Ibid*., p. 14-9.

31. *Ibid*., p. 8-2.

32. Department of the Army, *Operation JOINT ENDEAVOR Task Force Eagle Initial Operations*, Fort Leavenworth, KS, U.S. Army Training and Doctrine Command, Center for Army Lessons Learned, May 1996, p. ix.

33. *Ibid*., p. 9.

34. *Ibid*., p. 5.

35. *Ibid*., p. 13.

36. *Ibid*., p. 163.

37. *Ibid*., p. 164.

38. U.S. Department of Defense, *Defense Total Asset Visibility Implementation Plan*, Washington, November 1995, p. 1-5.

39. *Ibid*., p. 2-3.

40. *Ibid*., p. 6-4.

CHAPTER 5

LOGISTIC SUPPORT TO THE ARMY AFTER NEXT WARFIGHTERS: A TIME FOR FUNDAMENTAL CHANGE

Gary J. Motsek

PROLOGUE

Captain Mike Thomas did a quick check of his info screens. He had just ordered his battle team to disengage from contact with the foe. With dominant battlefield awareness, he knew the Joint Task Force J-3 could keep "eyes" on the enemy and redirect other teams to swarm in and engage them according to the plan. His group of seven mobile assault vehicles (each with a two-man crew operating ground and air defense weapon systems) was in pretty good shape. Nobody killed or injured, the bio-monitors on his people showed him that. Fuel and ammunition, according to the readouts, were low, and two vehicles had significant damage. Imbedded onboard diagnostics were performing the required emergency repairs, and both could still move under their own power. If either failed completely, the support scavenger team would retrieve the vehicle and crew. Those same systems had already transmitted back to the loggies which locally replaceable units had failed and ordered the replacements needed to bring the vehicles to full capability. Thomas verbally instructed his display to show his next refit/rearm location. As expected, nothing was there yet. Large logistic points were just too tempting a target for the enemy. Nonetheless, Mike saw on his screen the icons of the support elements rapidly converging to the point designated for his team and the several other points for his counterpart teams. Clearly, they would be up and running by the time he gave the command to sortie his folks to the location. The team would receive its critical materiel and *repairs, and then, just as quickly, the logistic elements would disperse. Both combat and support forces constantly worked to stay "demassed" until absolutely necessary. Momentarily, his thoughts wandered to the historical study he had read of the revolutionary way warfare changed in the 20 years between the 20th century world wars. The 25 years following Operation DESERT STORM brought their own changes as well, especially in support. Heck, the sergeant major still talks about the old "sneaker net Army" and transporting floppy disks of supply data around the battlefield to get a repair part or a round of ammunition. You've got to wonder how they ever won a war.*

INTRODUCTION

How will logisticians support the battles of the future? Do the techniques and procedures of today have to be fundamentally altered? Why?

It is generally accepted that we are in a period of profound change for the U.S. military. The degree of this transformation is uncertain, and there is wide disagreement whether the change will be evolutionary and incremental or truly revolutionary and radical. The fact is that the technology of the world, and information technology in particular, is advancing at a profound rate which virtually assures change for the military. *Joint Vision 2010*, issued in order to shape and focus the near future, acknowledges the emerging importance of information superiority.[1] The Army, through Force XXI initiatives and *Army Vision 2010,* has articulated a similar picture of leveraging technology to gain information dominance and superiority directed to the same ends.[2] In fact, the Army is already extending the institutional long range vision beyond the year 2010 horizon to the 2025 timeframe under the aegis of the Army After Next (AAN) effort. The AAN guidance issued by the Army Chief of Staff is clear—narrow the gap between heavy and light forces, improve mobility, enhance firepower, and, finally, revolutionize logistical concepts.[3] As the Army Deputy Chief of Staff puts it bluntly, "Without an RML [Revolution in Military Logistics], there will be no RMA [revolution in military affairs] or AAN."[4] New technologies must provide agility, support force projection, reduce excess demand and waste, and be tailorable to requirements. Only with profound, indeed revolutionary, changes can we lessen the logistics tail. Without advances in logistics, an RMA for U.S. forces, and for the Army in particular, is not possible.[5]

Why is the commitment to RMA in logistics critical today? Why is the close of the 1990s an important decision point? To put it simply,

> as we move beyond 2010, most of the major weapon systems supporting Force XXI will be approaching the end of their life cycle. The Army will be faced with the decision to either continue investing in incremental improvements in existing platforms which could extend their usefulness to about 2025, or taking the steps required to replace these aging weapon systems with totally new systems designed to take advantage of the technological advances which have occurred over the years.

Force XXI, an incremental step along the way, is not the RMA. It was initially envisioned to be a rapidly tailorable, rapidly expandable, and strategically deployable force capable of supporting the two major regional conflict (MRC) construct. A key goal was to make these forces lighter without sacrificing lethality and survivability, but it is extraordinarily difficult to change the nature of warfighting radically while retaining existing equipment.[7] The 70 ton, M-1 series tank, with all its strengths and limitations, will remain through the early 21st century without regard to informational technology appliques. Force XXI divisions will see little organizational change since the major existing systems will still be in place. Important possible exceptions are the Commanche helicopter and perhaps the Crusader. New technology may raise the cost to the point at which the nation can afford only a small high-tech force which will have difficulty with asymmetric responses.[8]

The Army must be able to perform successfully in a force projection role deploying primarily from the continental United States (CONUS). This drives considerations for major weapon and support systems.

> Technology is changing at an exponential rate. The Force XXI systems may not be the world's leading warfighting systems if we do not improve them over time. Technology growth will require organization changes in both the assets and business practices used. This march of technology will result in the need for spending more time and money to keep ourselves and products current.

If we retain the existing systems, only marginal improvements are possible. The Division XXI Tables of Organization and Equipment show no important changes in the Division Support Command other than the consolidation of maintenance resources from the maneuver brigades. The primary weapon systems remain the same, the logistical burden remains essentially constant. As the Air Force demonstrated with the C-17, one must specifically design the new platform with reduced support, but streamlined C-17 support procedures cannot be applied backward to the existing C-5 fleet. Likewise, unless the probability of hit and kill per round from a given weapon system markedly improves, logisticians still need to provide the warfighter with essentially the same number of rounds as today. Improving probability of kill from 77 to 80 percent has only a marginal effect on the support structure, which measures resupply in terms of truckloads.

If the way the land force maneuvers, moves, and fights changes because of profound improvements in the capabilities of their platforms, the logistical tail can and must be changed as well. A logistician that cannot keep up or see the friendly forces, cannot adequately support. If the combat platforms dramatically increase in speed and maneuver, support vehicles must have a commensurate improvement. The two systems are inextricably linked.

THE NEAR FUTURE PICTURE

In the broadest terms, *Joint Vision 2010* considers focused logistics as one of the four key operational concepts. *Army Vision 2010* complements this with a pattern of operation entitled "Sustain the Force," one of five key patterns listed in the document. The Force XXI effort establishes the framework and environment for the Army Strategic Logistics Plan which in turn provides focus to synchronize Army logistics support for this near future force.[10] The Army Strategic Logistics Plan postulates profound re-engineering and redesign of the logistics community and possibly profound cultural changes as well. This radical approach is not reflected within existing Force XXI force documents, which is based rather upon a level of iterative change and leveraging of some technology enablers along the way to a more radical future.

When *Joint Vision 2010* is largely realized, the battlefield of the past will be largely replaced by a nonlinear battlespace.[11] U.S. forces, through information and technological innovations, will have achieved dominant maneuver, increased ability for precision engagement, more control of the battlespace through full dimensional protection, and some measure of focused logistics.

What happens to logistics with this near future force? The vision documents perceive:

> the fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while enroute, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level of operations.[12]

Yet, additional technological enhancement is the key to achieving logistical improvements in this timeframe, since the force will still be utilizing today's support systems (wheeled trucks, palletized loading system, rotary and fixed wing aircraft). Clearly, reducing the size of theater stocks, the iron mountains of the past, will make the logistical tail of the fighting force smaller and more agile. Logistics are more predictive, responsive, and visible to the operators and those supported; large, brute-force push packages have been largely supplanted by smaller, rapidly moving pull packages; the past practice of physically stockpiling 30 days or more of supplies in theater for everything the warfighter believed he needed are gone. On-ground stockpiles of critical items are measured in terms of 2, 3, or 5 days of supply. The goal is affordable and responsive support that is modular and thus tailorable to mission requirements.

The 2010 logisticians should enjoy a mature capability of total asset visibility (TAV) for materiel and personnel. Through the interconnection of new and legacy information and management systems, a worldwide asset picture should be available. However, some of those same legacy systems will inevitably inhibit complete real-time access and operation. The Global Combat Support System (GCSS), the logistical component of the Global Command and Control System (GCCS), has established the common information/communication technology environment. Until all subsystems are compliant and interactive, logisticians will be constrained by some aged information. Despite these limitations, the supported warfighter should see a dramatically improved snapshot of all resources allocated to him. The resources no longer need to be physically in the theater. Admittedly, this is the military equivalent of commercial "just in time" delivery, a profound cultural change for a warfighter. It can result in a controlled supply rate, established by the warfighter, for all classes of supply wherein resources are allocated strictly for the mission at hand—with confidence that the follow-on mission will be preceded by follow-on supplies. In other words, you get only what you need, not what you want.

Velocity Management should be the accepted doctrine of the time. It posits a responsive transportation system to further reduce in-place stockpile requirements. The capability of a "FEDEX style" package delivery is available for rapid delivery of low density, high value, and critical items wherever needed.

"Stovepipe" logistics have been significantly reduced with increased reliance and compliance of the GCSS environment. The captains trained in the late 1990s at a common logistics advanced course will now be the colonels in command of multi-functional units which are modular and capable of reconfiguration based upon mission requirements. These colonels' most important function is to serve as Battle Command Logisticians who command the logistics elements and provide all of the tactical warfighting support. Logistical command layers have been reduced, and nonvalue-added accounting and management steps largely eliminated. The multi-functional elements have direct access to national logistical information, can fix by replacement or evacuation, and handle all resupply coordination.[13]

Although the United States should enjoy dominant battlefield awareness, there is a recognition that centers of gravity and critical points need to be reduced. For logisticians, this will provide additional incentive to avoid large static piles of materiel within the battlespace. Tactical and operational logisticians will "reach back" as far as necessary, even to the CONUS base, to fulfill requirements while keeping the battlespace logistical footprint small.

Although not consolidated, there will be increased cooperation among the logistical components of the services, the Defense Logistics Agency, and private industry. Common application of electronic management and information systems will create linkages from factory to foxhole, with the civil sector assuming more responsibility for warehousing, maintenance, and materiel management at one end of the pipeline and the Logistic Civil Augmentation Program (LOGCAP) at the other.[14] The Army will still have both Table of Organization and Equipment (TO&E) and Table of Distribution and Allowances (TDA) units within the logistics structure, although they will be composed of smaller modular units that, at the appropriate level, are capable of task organization.

Finally, it should be recognized that there are at least two tiers of forces within the Army. Clearly, the Army cannot equip the full force with the digital technology presently being evaluated by the experimental force (EXFOR) of the 4th Infantry Division. A corps, perhaps two at the maximum, will be equipped with the necessary appliques and provided the additional resources, such as improved communications, to meet the desired capabilities of Force XXI and *Army Vision 2010*. Logisticians will likely be expected to support two tiers of active combat forces and additional tiers in the reserve structure.

In summary, logistics in 2025 will have changed. Instead of forward deployed resources, the bulk of stocks will be CONUS based. The focus is no longer the North Atlantic Treaty Organization (NATO) environment of Europe, but one of rapid response to a variety of locations and multiple missions. Massive in-place stockpiles are largely supplanted by a responsive, high velocity transportation system. Asset visibility has been markedly improved.[15] Finally, although joint operations are the norm, the individual services' Title 10 responsibilities, which include sustainment of the force, remain fundamentally unchanged although increasingly challenged by other DoD organizations, such as the Defense Logistics Agency and the Department of Defense Information Systems Agency, which push inexorably towards consolidation.

THE FUTURE OF ARMY AFTER NEXT (AAN)

Given that Force XXI and *Army Vision 2010* provide the template for the interim force that is largely composed of existing platforms, some predictions can be made of the AAN future, where those same platforms finally have been replaced. The specific year of the future, 2020, 2025, or whatever, is not as critical as acceptance of the assumption that new systems will continue to build upon and further develop the trends of the interim force. For example, one can reasonably assume that information and communication technologies will continue to develop to improve our ability to see the battlefield in real time and that larger and larger volumes of data will be handled as a matter of course. Similarly, if we intend to further develop the enablers of *Army Vision 2010*, the M-1 tank replacement will likely be lighter (to enhance strategic mobility and power projection), multi-capable (possessing ground and air attack capability?), and equipped with integral and embedded technologies that could only be crudely replicated by the appliques of the past. One need only consider the embedded computer and diagnostic capability of a 1997 commercial automobile as compared with a car of 25 years ago to visualize the possible technology jump. On-board systems will monitor performance and consumption rates, predict and diagnose potential and real failures (at 99+ percent accuracy), and digitally link to the supporting logisticians. Decreased consumption rates for the two largest classes of supply, III (fuel), and V (ammunition) should further diminish the logistical footprint. Vehicle energy costs could be reduced by as much as 50 percent. Through the use of new materials ammunition packaging could have 30 percent less weight and volume.[16] Line unit replacement of failed components can be performed on many sub-systems by the operator crew without technician intervention.

What appears to be generally consistent among the AAN fighting concepts is that the battle force will have radically increased mobility, and will have all combat operating systems organic to it.[17] Some combat organizations will strategically deploy directly from CONUS. This suggests an ability to transition directly from the strategic movement to combat without pause. Forces will be increasingly joint in character and composition, single service operations being an exception to the rule. The command and control structure will become even flatter, cellular rather than hierarchical, with fewer levels of intermediate command.[18]

Operational orders and schemes of maneuver will be transmitted immediately to all subordinate commanders from the primary planner.

Technology will continue to improve battlefield awareness. Although the United States is likely to maintain dominance, the technologies associated with this awareness are increasingly available on the commercial market for use by potential enemies. Even rogue nations and their warriors will have access to cheap satellite imaging and pinpoint navigation systems.[19] This further increases the need for friendly forces to avoid presenting centers of gravity or critical points. To stay massed invites attack. Therefore, forces will have developed a swarming scheme of maneuver. Combat forces remain demassed in numerous small elements and, when directed, mass to concentrate overwhelming power for short periods of time. Upon order, they again demass. This cycle of sorties continues until the enemy is defeated. Because of dominant battlefield awareness, contact does not have to be maintained to fix the enemy. It provides the ground force commanders their picture of the battlespace much the same way the present Airborne Warning and Control System (AWACS) provides the Air Force a full picture of its operational space. Because of this knowledge of the enemies' location, friendly forces may sortie in and out of the immediate battlespace. The concepts of dominant maneuver and precision engagement become complementary.[20] Ground forces of tomorrow could maneuver to position advantage the same way a combat aircraft is directed towards the target area by AWACS controllers today, then strike from that location with precision and immediately leave the area.

This constant massing and demassing of forces is possible only with the maturation of the operational concepts of *Joint Vision 2010* and the necessary technology. It suggests that the bulk of critical logistical support (fix, fuel, arm) are provided during those times when the battle force is demassed. It suggests that logistical support forces will have many of the characteristics of the battle forces.

Just as the combat forces mass only when required, the logistical elements will do likewise and form support locations only as required, quickly diffusing when the immediate support mission is accomplished. The joint task force J-3 and J-4 will have to work current operations in close coordination and harmonization. Logisticians within the battlespace will have to become experts in maneuver. The movements and massing/demassing of the combat and logistical forces must be carefully synchronized to assure success.

Within the battlespace, the logistician's main protection is the same battlefield awareness enjoyed by his combat compatriot. The combat team leaders and their supporting logisticians must see and work with a common battlefield picture, common planning tools, and common predictive models. A key capability of the vehicles supporting the battle force must be equality in range and speed. The envisioned battlespace is not linear, meaning that logisticians must quickly maneuver to meet the combat forces in temporary relatively safe spaces scattered around the area of operation.

> Fixed and slow-moving targets will fare poorly on tomorrow's battlefield. Any object with a fixed latitude and longitude can be targeted (with low-cost, highly accurate aiming systems) and struck. These weapons will use a combination of improved gyroscopes and accelerometers, navigational devices, global position system (GPS) satellites, and local positioning signals from pre-positioned emitters.[21]

Additionally, speed provides protection in itself and offsets the lack of other forms of protection by limiting exposure in dangerous areas. To provide the logistic vehicles with heavy protection approximating the fighting force would necessarily limit their load capacity. Every pound of armor is one less pound of support materiel. This tradeoff, again, is not unlike the support arms of the sister services, which do not heavily armor tankers (air or sea) or supply ships. The support ships (or aircraft) rapidly move in and then move out, their speed and short time exposure being their primary protection.

Outside the immediate battle area in relatively safer zones, logisticians may operate mobile bases that provide more extensive support. This could include prepositioned afloat intermediate support bases consisting of ships designed for a support function, which is a logical extension of the present Marine Corps concept of ship-based logistics. Combat forces could move to these safe areas and obtain resupplies fabricated from raw materials, as well as availing themselves of creature comfort supply and services. Combat systems would have major battle damage repaired and components with a predicted failure replaced. The battlespace logisticians reach back to these bases for their resupply.

"Procurement agility" becomes a strategic matter, and national resources, because there is total visibility of assets and capability, can be leveraged to support the battle directly.[22] Requirements may be placed directly on the industrial base with a "just in time" delivery directly to the battlespace. In fact, this principle is implemented today with Class VIII medical materiel requirements sent directly from the commercial supplier to the user. We will need a cultural shift from unit ownership of resources to national ownership, though the unit will require the discipline of management responsibility. Although located in a specific location, unit resources are part of the national "virtual warehouse" under consolidated materiel management. Thus with an integrated distribution system (with mature Velocity Management), an item in unit stockage, such as an Army standard load (ASL) or basic load (or their AAN equivalents), will be available for a contingency across the world if not specifically authorized retention due to an authorized higher priority.

Who controls logistic support and these priorities of materiel in behalf of the warfighter? As envisioned, only those supporters operating directly in the battlespace are under the direct command and control of the geographical commander-in-chief (CINC) or joint task force (JTF) commander. Unlike the present environment where support is fragmented among the service commodity commands and DoD agencies, the rest of the logistic structure "tail" is envisioned to be under the control of a single commander. This change is akin to the previous consolidation of service strategic transportation resources and their control and management under the United States Transportation Command (TRANSCOM). Like that consolidation of service resources under a single supporting CINC, there is tremendous opposition to this concept and organization. It directly challenges the services and would be a direct attack on their U.S. Code Title 10 responsibilities to "equip the force." Yet, these responsibilities have already been eroded in other areas as well, such as with the establishment of the Defense Logistics Agency (DLA) in 1962. Today DLA:

> manages and purchases items used by all military services and some civilian agencies, including fuel, food, clothing, medical supplies, construction material, and the hardware and electronic items used in the maintenance and repair of military equipment.

Additionally, the Army itself serves as the DoD executive agent for most conventional Class V ammunition and munitions for all the services. The contracted LOGCAP support, initially envisioned to support Army soldiers, has now routinely expanded to support all forces within the joint task force. These three cases demonstrate that Congress or the Secretary of Defense will modify the means of support, Title 10 notwithstanding. Consolidation of responsibilities and functions should improve the effectiveness and the efficiency of the armed forces.

The next reasonable consolidation of functions to support the AAN is the establishment of a national level logistics provider. As in the Division XXI design where support was removed from the maneuver brigades and consolidated in the Division Support Command (DISCOM), the same general logic applies at the higher echelons. As envisioned by the Logistics Integration Agency:

> The Army National Provider contains the national level capability to manage, resource, and control the materiel management, maintenance, procurement, distribution, and deployment functions for the Army or other joint and combined customers. The Army National Provider brings the full power of the National Logistics Base (DoD Civilian resources as well as our U.S. Industrial Base), to satisfy the logistics needs of the supported CINC over a seamless pipeline of support that extends directly to the warfighting element.[24]

The National Provider is responsible for filling the common pipeline to the warfighting CINCs and owns all resources above that which is traditionally accepted as direct support. This system fundamentally changes the concept of ownership of stocks, whatever the class. A unit may maintain a stock and store it, but it remains under the ownership of the National Provider who may direct usage elsewhere. Lest we think this is too revolutionary, we should recall that overseas Army Class V stocks are treated in this way today, with only a fraction of the in-theater stocks actually "owned" by the geographical CINC. The remainder may be swung to whomever the national priorities dictate. Likewise, prepositioned afloat resources may be directed wherever needed.

The National Provider would also control DoD industrial operations and maintain the contractual relationships with the civilian industrial base. Again, comparison with TRANSCOM cannot be avoided. CINCTRANS is the single DoD point of focus to contract and leverage civilian transportation resources to support the requirements of plans and ongoing operations. TRANSCOM performs the transportation feasibility analysis and determines whether national transportation resources can adequately support strategic operation plans. Likewise, the National Logistics Provider (CINCLOG) would do the same. There would be a single command to define the requirements, contract with the industrial base, keep warm key operations, maintain key stocks, and ensure a seamless plug-in to the battle area logisticians. This command would determine the logistical feasibility of the plans of warfighting CINCs. There would be one voice for strategic and operational logistic support.

Because of the existing responsibilities already incumbent on the Army to support other forces and establish common lines of communication, maintain the LOGCAP contract, and control most wholesale Class V, it is a logical candidate to serve as the National Provider. Just as the commander of the Air Force Air Mobility Command is dual hatted as CINCTRANS, the commander of the Army Materiel Command could also serve concurrently as CINCLOG.

PITFALLS AND CONCLUSIONS

The envisioned logistical organization for the forces of the Army After Next clearly brings with it an additional set of risks which must be carefully considered. First, it is unlikely that the Army will have the resources to fully modernize the entire force. There will be, inevitably, tiered forces. Some, perhaps only the "tip of the spear," will be a fully modernized battle force. The remainder of the Army will remain more traditional, probably similar to the forces of today. The logistical structure in place must be flexible enough to accommodate multi-tiered forces.

Secondly, the logisticians within the battlespace must have high-speed mobility comparable to that of the force being supported. The nonlinear nature of the battle and the fact that the logisticians are maneuvering constantly to support the battle swarms require this capability. Organic transport capability to provide such high-speed mobility must be provided.

Finally, without a CINCLOG, it is unclear how the resources of the nation could be effectively focused to provide the necessary support in light of the inevitable reductions of stocks available to DoD. The "iron mountains" are to be eliminated, and their replacement, the "virtual mountains" located throughout the world, must be managed and allocated according to national priorities.

These steps represent fundamental cultural changes in the way logisticians support and how the warfighters measure it. The new system gives up proven but excessively expensive ways of doing the support business in exchange for major technological innovation. It requires unparalleled trust, coordination, and synchronization between the G/J-3s and G/J-4s of the future. It is indeed a revolution in logistical affairs which, if successful, will help provide the funds, through substantial savings in stocks, to modernize the force. The choice for the Army is actually quite simple: stay with the existing logistical organization, structure, and functions and have, at best, an evolutionary change in force capability; or take the visionary approach, leverage the information age and other technologies, and revolutionize logistics.

ENDNOTES - CHAPTER 5

1. Chairman of the Joint Chiefs of Staff, *Joint Vision 2010*, Washington, DC: Chairman of the Joint Chiefs of Staff, 1996, p. 16.

2. Army Chief of Staff, *Army Vision 2010*, Washington, DC: U.S. Department of the Army, 1996, p. 10.

3. Deputy Chief of Staff for Doctrine, U.S. Army Training and Doctrine Command, briefing, "The Army After Next Project. Current Thoughts on the Army After Next," 1996.

4. Army Deputy Chief of Staff for Logistics, *Revolution in Military Logistics,* Washington, DC: U.S. Department of the Army, 1997, p. 18.

5. Scientific Applications International Corporation, Contract #MDA-903-93-D-0020, *Proceedings of Workshop III on Dominating Maneuver and the RMA,* 1995, p. 10.

6. Department of the Army, ODCSLOG, *Revolution in Military Logistics (Draft 1 Release)*, Washington, DC: U.S. Department of the Army, September 11, 1996, p. 17.

7. U.S. Army Training and Doctrine Command, TRADOC PAM 525-5, *Force XXI Operations,* Fort Monroe, VA, August 1, 1994), p. 3-1.

8. Steven Metz, *et al.*, *The Future of American Landpower: Strategic Challenges for the 21st Century,* Carlisle, PA: U.S. Army War College, 1996, p. 13.

9. Department of the Army, ODCSLOG, p. 17.

10. Logistics Integration Agency, *The Army Strategic Logistics Plan Battlespace Logistics—The Vision*, Alexandria, VA, undated, p. 4.

11. Charles Link, "21st Century Armed Forces-*Joint Vision 2010*," *Joint Force Quarterly*, Autumn 1995, pp. 69-73.

12. Chairman of the Joint Chiefs of Staff, p. 24.

13. Logistics Integration Agency, pp. 6-7.

14. U.S. Training and Doctrine Command, pp. 3-14, 3-15.

15. Department of the Army, *Functional Area Assessment of the Army Title 10 Functions "Equip/Supply/Maintain" (Draft Interim Report),* Washington, DC: U.S. Department of the Army, October 20, 1995, p. III-5.

16. U.S. Army Combined Arms Support Command, *CSS Technology Vision for Army After Next*, Information Papers, August 27, 1996.

17. Scientific Applications International Corporation, Contract #DASW-01-95-D-0060, *Dominating Maneuver Workshop IV Summary Report*, 1996, tab c.

18. Deputy Chief of Staff for Doctrine, U.S. Army Training and Doctrine Command, Briefing, *The Army After Next Project. Emerging Impressions*. 1996.

19. Jake Tapper, "A Nation's Future Foretold," *George*, February 1997, pp. 68-77.

20. Deputy Chief of Staff for Doctrine, U.S. Army Training and Doctrine Command, Briefing, *The Army After Next Project. Current Thoughts on the Army After Next*.

21. National Defense University Institute for National Strategic Studies, *Project 2025*, Washington, DC: National Defense University Press, 1991, p. 37.

22. Deputy Chief of Staff for Doctrine, U.S. Army Training and Doctrine Command, Briefing, *The Army After Next Project. Emerging Impressions*.

23. George T. Babbitt, "Meeting Today's Logistics Challenges," Issue 1, *Defense*, Washington, DC: U.S. Department of Defense, 1997, p. 7.

24. Logistics Integration Agency, p. 9

CHAPTER 6

MANAGING THE INTELLIGENT INFORMATION GRID FOR THE ARMY AFTER NEXT

Paul T. Hengst

[Editor's Note: Virtually everything associated with future thinking about warfare depends upon a fully functioning intelligence system. Entire sensor suites are supposed to be able to locate every friendly element and most enemy elements, too. Distributed communications are supposed to enable many-to-many communications so that individual action within the commander's intent will produce an overwhelming effect upon the enemy. Lieutenant Colonel Hengst describes what this system must look like and then asks whether we are, in fact, headed in the right direction. DVJ]

THE INTELLIGENT INFORMATION GRID

Information superiority will be key to the Army After Next (AAN).[1] To achieve this superiority, the AAN will rely on information networks. These networks will be combined to form "a single grid so powerful and intelligent that it will be able to provide common situational awareness to friendly forces, real-time intelligence on enemy forces and fire control."[2] This intelligent information grid (I^2G) will be capable of connecting the multitude of sensors and information systems together into a seamless information environment.

Decreases in Department of Defense (DoD) funding and manpower are driving planners to develop a grid that will operate in a "management-by-exception mode without human interface."[3] It will represent an enormous departure from current network management techniques where thousands of people perform day-to-day network management functions. The purpose of this paper is to examine the I^2G.

WHAT THE I^2G MAY LOOK LIKE

The best analogy to what the I^2G should look like is the human nervous system. That system is a remarkable information-sensor network of hundreds of miles of nerves running through the body connecting all the major sensory centers. The sensors and nerve network work in harmony to provide the individual total awareness of his surroundings. Within this network, the brain acts as a central computer, while the spinal cord is the backbone. Connected to the spinal cord are the various major nerve bundles that provide the path for sensory inputs to travel to the brain. This complex network foresees problems and responds to threats. Should a major attack on a component of the network occur, like an injury, the brain automatically responds so as to limit the damage. The network of nerves can also be self-healing when minor damage occurs. This nervous system analogy is so accurate that some AAN planners have described the I^2G as a "living internet."[4]

The future challenge is developing control mechanisms in the I^2G that are similar to our nervous system. But, unlike the homogenous, single, connected network of the human body, the AAN will still be operating under a system-of-systems concept in which multiple systems will exist and be connected together.[5] The number of individual systems can be divided into two major areas, communications systems and information systems. For clarity, each area will be discussed as a separate entity.

Communications Systems.

The human nervous system can be broken down into the brain, spinal cord, and nerves. Similarly, the I^2G can be broken into three key components. First is the backbone system, analogous to the spinal cord and major nerve bundles, capable of carrying a high capacity of information. The second area is the local systems that extend from the backbone to the individual nerves, or users. The final area is the switching or transfer of signals between local and backbone systems.[6]

Backbone Systems. The backbone network will be comprised of the major communications systems we use today: satellites, microwave, and cable. No major technological leap is predicted for backbone systems. However, developing technology will drive these systems to ever increasing bandwidths necessary to handle the volume of expected traffic.

Satellites will become increasingly important for two major reasons. First is the flexibility needed to move fairly quickly to extend the backbone to areas without terrestrial systems; and second is the need to cover large geographic regions with a single platform. Evolving compression techniques will increase bandwidth; however, transmission delays due to distance will still be a limiting factor for satellites.

The bulk of the terrestrial backbone will continue to be microwave and cable systems. As in the case of satellites, technology will continue to push terrestrial systems to handle larger bandwidths. The current trend to replace copper-based cable with fiber optic cable will increase available bandwidth.[7]

As with our current force, the AAN will contract with commercial vendors to provide the bulk of the backbone systems, primarily for economic reasons.[8] Expected future budgets preclude installation, operation, and maintenance of DoD-unique global communications networks; technology upgrades necessary to remain state-of-the-art will require manpower to operate and maintain backbone systems. In addition, an infrastructure based on commercial standards will help ensure interoperability.

Local Systems. Local systems connect users through voice and data networks to the backbone. Like the backbone, DoD will continue to use today's line-of-sight radio, cable, single channel satellites, and cellular systems. Increases in bandwidth are also expected. At this level, military-unique systems will fill niche requirements unavailable from commercial vendors.

The local communication system in the AAN will fill two major requirements. First is portability.[9] Using a combination of terrestrial and projected space-based cellular systems, such as IRIDIUM, cellular technology offers the flexibility necessary to communicate in fluid and widely dispersed operations.[10] Second is that cellular technology offers a cheap alternative to installing a permanent cable-based infrastructure.[11] This is especially critical for contingency operations in lesser developed areas. Local and space based cellular systems will also reduce the "rolling stock" infrastructure equipment and manpower currently delivered during deployments.

Switching. Unlike backbone and local systems, which will see a gradual technological evolution to better, higher bandwidth systems, switching will undergo two major technological leaps, the combining of analog and digital switching and the arrival of the communications unmanned aerial vehicle (UAV).

The development of a single device to quickly switch both voice and data will greatly reduce the infrastructure burden. Currently, parallel switched networks are required: analog for voice and digital for data. The cost of such parallel networks will be unaffordable in the AAN. Additionally, parallel networks complicate the information sharing necessary to create common situational awareness. Technological improvements in optical switches will also increase switching speed, preventing the switch from becoming a bottleneck.[12]

The second technological leap in switching is the communications UAV. Used in a quasi-satellite role, UAVs will be used as relay/switching stations between networks. Future enhancements, like in-flight refueling, will increase loiter time, making UAVs candidates to supplement or replace existing military communications satellites. Additionally, these UAVs could provide the switching link from terrestrial cellular systems to the space backbone, particularly for deployments outside the normal commercial satellite footprint.

In summary, the communications systems of the AAN can be characterized as a commercial based system augmented by military assets to create a system-of-systems grid. The predominant communications architecture at the local level will be a cellular system based on commercial standards and protocols. Maximum use will be made of space based communications platforms. New technological developments will be integrated into an increasingly fiber optic based infrastructure.

Information Systems.

The five senses—smell, touch, taste, sight, and hearing—comprise the sensors of our human system. Input from the sensors combine with the brain's stored knowledge to help us make decisions. In the AAN, information systems will include the full range of sensors, automated decision support tools, and databases working in a common operating environment to aid commanders in decision making. The processes used by our brain to make these decisions are analogous to application programs.

Common Operating Environment (COE). The development of the COE will be critical to prevent some of the information systems problems we currently experience. A COE provides a common look, touch, sound, and feel to the user, and COE ensures the interfaces from platform to platform are consistent.[13] The COE attempts to create a homogenous environment, much like our nervous system, where data is defined and shared easily between systems. In order to obtain a common picture of the battlespace and take advantage of the vast amounts of data being collected, systems must be totally interoperable and capable of sharing collected data. To ensure this interoperability, the COE will establish standards for a wide range of items, including operating systems, communications protocols, and individual data elements.

Applications. The types of applications working in this COE will range from military-unique command and control to administrative. Commercial software industry will provide the necessary applications; however, some applications will require development of military-unique interfaces.

The bulk of the applications developed will be systems that collect information from a variety of databases. These databases will be built from the vast number of sensors expected to be in the AAN information environment. They will be linked via the I^2G to ensure information availability. These interconnected databases will give an increasing amount of battlespace information to the commander, and research is underway to solve information overload problems.[14] Two intertwined concepts, data-mining and digital agents, will come to fruition in the AAN to assist commanders in grappling with information overload. Additionally, by permitting the commander to test multiple courses of action prior to making final decisions, simulations will help in managing information overload.

Data-mining is the ability to take advantage of the vast amounts of data being collected and stored in various, often unrelated databases. Military applications are just scratching the surface of this area. In the commercial sector, data-mining determines individual buying patterns. A grocer may determine that most customers who purchase a particular snack food usually buy the same type of soda, and that they purchase the items late in the week. By placing the two items close together on the shelf or combining them in a package, the grocer may increase his sales. The grocer also establishes delivery dates for both items late in the week to reduce the amount of time he has to warehouse the items. All the data revealing such purchase patterns are gathered when the items are scanned at the point of purchase. Using data-mining concepts, logistics units can use similar techniques to determine key item delivery dates. Operational units can use data-mining to correlate data from multiple sensors to establish possible tactical and operational patterns, both ours and the enemy's.

Digital agents are "computer surrogates that possess a body of knowledge both about something (a process, a field of interest, a way of doing) and about you in relation to that something (your taste, your inclination, your acquaintances)."[15] With the perceived glut of information available to the commander, the use of digital agents will assist him in profiling critical information requirements necessary for decisionmaking and could also reduce the human staffs that now collect and store this critical data.

Simulation is the final piece assisting the commander with information overload. The nonlinear battlefield has too many variables for most commanders to assimilate.[16] Simulation will allow commanders to pull information into the simulator, test assumptions, and help determine the factors critical to success prior to conducting an operation. Simulations will take into account the multitude of factors in a nonlinear problem that linear database searches, employing data-mining or digital agents, cannot. Additionally, the visual nature of simulations assists the commander in retaining information in his mind.

The I^2G, then, will consist of commercial-based communications systems at the backbone and local level. The communications systems will link the various components, sensors, databases, and application programs into a system-of-systems. Intelligent applications connected by the I^2G will greatly assist the commander in decision-making.

WHAT TO MANAGE

With the I^2G now described, it is necessary to determine what functions within the grid need to be managed. As mentioned, the goal is a grid that requires minimum human intervention. This implies that a certain amount of intelligence must be built into the systems that make up the I^2G. With 25 years of unfulfilled promises of artificial intelligence (AI) in the past, it is unlikely that AI will progress in the next 25 years to the point where no human intervention is required. Therefore, the I^2G will use a combination of artificial and human intelligence to manage the major functions of configuration control, security, and repair.

Configuration Control.

There are three major configuration control areas: architecture, device addressing, and bandwidth.

Architecture. While not a real-time management feature, many current problems in network management are born of a lack of architectural control. Once again, it is possible to look at the nervous system as an analogy. One of the beauties of the human body is that underneath the skin we are pretty much alike. This is not true for our current information and communications systems. Not having a standard system architecture, we often rely on one or two gurus who understand how our systems work. If a problem occurs and the gurus are gone, nothing happens until they return. To overcome this problem, a standard architecture must be adopted. The Army has recently published the Army Technical Architecture (ATA) to help standardize the way we put networks together.[17] The ATA is also being used as the baseline for the development of a Joint Technical Architecture.[18] This will help ensure interoperability in the joint information environment.

Device Addressing. The second issue of configuration control is knowing what devices are in the network, such as satellites, switches, routers, computers, weapons platforms, and sensors. The expected fluid nature of warfare in the AAN requires devices that are self-addressing. Current manpower intensive addressing schemes, such as call signs on a radio net, a phone number, or an Internet Protocol address, will be unacceptable in an era of reduced manpower. Maximum use will have to be made of intelligent devices capable of registering themselves in the I^2G.

Bandwidth. The final aspect of configuration control is bandwidth. By controlling the configuration of the connected devices, the grid should be able to self-configure to ensure that necessary bandwidth is available to all users. As noted in the communications system description, available bandwidth is expected to increase in the AAN; however, it will still be possible that multiple devices could overwhelm a particular link, which would decrease performance for all who use that link. Although irritating today, it could become life threatening when soldiers and weapons platforms are waiting for critical intelligence or "shooting" data. Therefore, certain platforms and sensors will have to receive priority for the available bandwidth, with administrative traffic riding in the holes between priority traffic.

In summary, configuration control will be provided by a common grid architecture, the addressing scheme of the device, and, finally, the allocation of bandwidth across the grid. Critical to the success of configuration control is a certain degree of intelligence built into the network to achieve the objective of minimum human intervention.

Security.

The second major function to manage is security, which must likewise require minimum manpower. The three major security items that require management are access security, information assurance, and infrastructure protection.

Access Security. Unlike our current security protection architecture where we build separate systems of different security classifications, in the AAN we will have one grid with access security being provided at the "point-of-entry." This is not a new concept and is used in our current voice networks. For example, the STU-III telephone connected to a commercial line off-post is just as secure as when it is connected to a government-owned line on an installation. Point-of-entry security is now being developed for a variety of devices, including cellular telephones[19] and computers.[20] Point-of-entry security implies that we will have achieved a certain degree of multilevel security, which allows a single computer to operate at different security levels. The planned battlefield combat identification system for the identification of friendly vehicles can be used as a model for access security. Under this scheme, a device would enter the grid, be queried for its address and routing information, be identified as an authorized device, and then be connected to the I^2G.[21]

Information Assurance. The second area of security is information assurance. We must retain the ability to protect the information we are using. Information assurance has four elements: availability, integrity, confidentiality, and nonrepudiation.[22] Availability assures access to information by authorized users, integrity protects the information from unauthorized change, while confidentiality protects the information from unauthorized disclosure. Finally, nonrepudiation is the undeniable proof that users are who they say they are. Loss of information assurance will make all data suspect. Such loss would be catastrophic to an Army that relies on information to maintain battlefield dominance.

Infrastructure Protection. The final security area is infrastructure protection, currently addressed as command and control warfare in Army Information Operations terms,[23] or as Defensive Information Operations in joint terms.[24] Infrastructure protection is the ability to protect the grid from attack and takeover. The importance of this issue is well-known, being the driving force behind the recent President's Commission on Critical Infrastructure Protection.[25] The commission examined the "cyber" threats to the national telecommunications infrastructure. If used properly, the output of this commission will result in shared responsibility between government and the commercial sector to provide adequate infrastructure protection. This shared responsibility will be critical to a military dependent on commercial communications systems.

Repair.

The final function to manage is repair. Repair of the I^2G resembles the healing process of our body; some repair is self-healing, and some requires external intervention. Similar to the case of configuration control and security, manpower to perform repair functions must be kept to a minimum. The loss of manpower combined with the increasing complexity of network repair will pose a critical challenge to AAN.[26]

The complexity of repair will reduce most local maintenance to no more than item/board replacement. Diagnostic work will be accomplished through the grid by a centralized maintenance facility with the intelligent tools capable of analyzing the full range of possible alternatives. Individual platforms will have some limited self-diagnostic capability, but it is unlikely that crew members on informational weapons platforms like Crusader or Commanche will be able to do more than board level replacement.

Like other management functions, the diagnostic repair tools will require some degree of artificial intelligence. The greatest technological leap in this area will be in the tools that not only find the problem, but correct it without human intervention. These maintenance tools would automatically create a log of their actions. The log would be reviewed by maintenance personnel in conjunction with other intelligent tools as a basis for further action. For example, the grid diagnostic tool would notice that a network laser at a remote unmanned communication node was pulsing too fast. Automated maintenance tools would take the laser out of service and activate the backup laser. The action would be recorded in the log, and the automated maintenance supervisor tool would prompt the repair person to physically replace the bad laser with a new one. For catastrophic problems, the automated maintenance supervisor would call or page the on-call repair person to immediately perform the necessary repair.

While we may never fully get away from some manpower requirements such as hardware replacement, most of the maintenance functions of the I^2G must be self-repairing. Intelligent programs, able to identify errors and take corrective measures to repair the damage, are critical in this area.

WHO MANAGES THE I^2G

After identifying what we will manage—the grid and individual functions—it is necessary to determine who will do the managing. When asked who controls your body, most of us would state, "I do." But what makes up the "I" in the grid will not be replicated by a single entity as our brain does for our body. Like today, the I^2G will be managed from a variety of sources, some managing global functions, others managing local functions.

There will be two factors driving the "who"—jointness and manpower. Almost all operations will be joint; therefore, all service elements will require interoperable systems that are managed by a joint force, although it will probably not be the Joint Information Corps proposed by some authors.[27]

The reduction of manpower will manifest itself in some type of consortium of commercial vendors and military units. These two factions will be combined in a virtual operations cell to manage the function of the grid. Given the current state of deregulation, there may be a number of service providers in the operations cell. The consortium will conduct a variety of tasks, from day-to-day operations to standards setting. Military personnel will monitor the commercial networks and establish priorities between them. Both the Gulf War and the Force XXI demonstrations have shown the utility in using contractors to supplement military communications management.[28]

The development of a consortium to mange the I^2G will be an evolutionary process. Reliance on commercial vendors to perform tasks such as logistics, maintenance, and communications will make this concept more acceptable. Additionally, joint military and commercial efforts will help develop relationships necessary to support the transition to the consortium concept.

WHERE TO MANAGE THE I^2G

Thus far, we have examined what to manage in the grid and who will do the management. It is also necessary to examine where we will manage the grid. Unlike the human nervous system, there will not be a single centralized management center. More likely, the widely dispersed system-of-systems will be managed at different locations, with each location being visible to all the other systems.

The majority of these centers will almost certainly be located in the continental United States (CONUS). However, recent efforts to complete "a global pact that would phase out monopolies and restriction on competition" across the world-wide telecommunications industry may result in some centers residing in other countries.[29]

Military management centers will also be in CONUS. These centers can be collocated with commercial vendors, but more likely will reside on existing installations with communications links to the commercial centers. Based on the amount and type of service being contracted, liaison officers may be collocated with the commercial vendor.

A capability will exist to establish deployable forward mini-centers to give commanders on the ground the ability to reallocate scarce resources and exercise limited control over portions of the grid, especially if the grid is established in a remote area. Additionally, local grid managers will have the capability of keeping the system running if cut off from CONUS based management centers. However, primary management responsibility will remain with the CONUS centers. This reality argues for deploying the smallest force and being able to mass quickly, complete the mission, and disperse the force.

In an age of information warfare, where borders no longer matter and asynchronous attacks against our systems are expected, the lack of one central control location will be an advantage. This de-massification of network management will enhance the redundancy and survivability of the grid. Therefore, the majority of network management functions for the I^2G will be controlled from CONUS centers in a tightly coupled military-commercial management structure. The military will continue to maintain some type of deployable centers with limited ability to manage local assets.

IMPLEMENTATION CONCERNS— ARE WE HEADED IN THE RIGHT DIRECTION?

Some of the changes predicted above are built on evolutionary change, i.e., use of commercial vendors, while other changes may be more revolutionary, i.e., UAVs. The concerns about the success of these concepts can be broken down into two broad areas, technology and management.

Technology.

Improvements in three technological areas are needed if the I^2G described above is to work. First, there have not been significant advances in producing **artificial intelligence** in almost 40 years.[30] Some progress has been made around the edges, with fuzzy logic and pattern recognition, but true intelligence replicating human analytical reasoning has not occurred. The I^2G described above requires significant artificial intelligence, particularly self-repair and access control.

Second, like artificial intelligence, much has been promised in the area of **multilevel security**, with very little result. Some products, like the multilevel security personal computer card, FORTEZZA, may lead to a breakthrough in this area. Without multilevel security, the necessary security at the point-of-entry may be more difficult.

Third is **database technology**, particularly those areas that support data-mining and warehousing. It will be critical to wrap all the sensor information into a framework understood by the decisionmaker. Without improvement in the database area, data will be collected and stored, but commanders will be unable to use it. While the use of digital agents may assist in this area, there is also a downside to their use. As we collect information about one topic, we often incidentally discover information about something else that adds to our knowledge. By limiting the amount and type of information to just the few items a digital agent gathers, it is possible for the commander to miss other information that could impact on his decision.[31]

Management.

There are three major concerns with the management of the I^2G: reliance on commercial systems, funding, and necessary future decisions.

Commercial Systems. The I^2G will rely predominantly on commercial systems. While this is not a great leap from where we are today, changes in the nature of the telecommunications business, such as global business groups and deregulation, will greatly change the way we interact with the vendors. The critical point is how the business world responds to what the military perceives as a crisis situation. As we rediscovered in the Gulf War, we cannot always adequately predict what assets we will need.[32] If limited assets are available, service providers may have to choose between military units and commercial customers to increase profits or support a crisis. This becomes particularly challenging as telecommunications companies take on a more multi-national role, and appeals to patriotism cease to resonate. This may require changes in contracting mechanisms to support military requirements in times of crisis. A communications program similar in principle to the Air Force Civil Reserve Air Fleet program is another possible option.

Funding. We rely on commercial systems for funding because we cannot afford to replicate the global networks commercial vendors have built. This will not change in the future and defines us as simply another customer in the open market. Vendors will continue to find new and unique ways of billing, which could increase our overall information costs. This is particularly true for funding contingency operations, where contractual agreements may not exist. Sufficient funding will be necessary to take advantage of technological gains and, in some military-unique cases, push research. Trying to balance manpower, technology, and systems fielding will be difficult with limited funding. However, the recent decision by the Army's Deputy Chief of Staff for Operations to skip a generation of equipment and concentrate on information technology should assist in focusing available funding.[33] Finally, funding must be made available to upgrade our installation infrastructure, especially replacing copper and lead cable unable to handle the expected bandwidth requirements of future information systems.

Necessary Future Decisions. The final management area concerns future decisions. These decisions encompass development responsibility, acquisition, risk, interoperability, and training.

The overall requirement to develop an I^2G must be assigned to one organization. Currently the services and separate DoD agencies are working on unique systems, often without coordination. The Defense Information System Agency or Assistant Secretary of Defense C3I may be in the best position to pull the individual efforts together, including continuation of the current move toward a Joint Technical Architecture.

The I^2G will not come to fruition until the acquisition/procurement problem is fixed. Given a 12-18 months life span of most computer related equipment, the time now required to obtain state-of-the-art information technology is unacceptable. Strides have been made with the procurement of commercial-off-the-shelf products, but, if we continue with current methods, information technology will continue to outpace our ability to put the latest technology in the hands of the soldiers. Additionally, leaders and managers must accept some individual responsibility for funding upgrades instead of waiting for everything to be pushed down from higher levels.

The Army will have to accept the risk of using commercial systems or it will have to fund a separate communications infrastructure which it cannot afford. The crux of the problem is weighing the potential information warfare (IW) threat against the billions of dollars it may take to build an alternative global system. Building separate systems will be expensive in both equipment and manpower, but it significantly lowers IW risk. Complicating the decision is determining whether an IW attack constitutes an attack on the homeland and whether it necessitates a military response.

To improve interoperability, tactical communication systems, like Mobile Subscriber Equipment, must work smoothly with commercial systems. This requires some equipment/technological changes as well as policy changes. Multi-level security equipment expected to be fielded in the next 5-10 years should help to resolve the policy issue of classified networks being connected to unclassified networks. Seamless communications from deployed locations to CONUS installations cannot truly be accomplished until the link between tactical and commercial systems is fixed.

The final issue that must be addressed is training. One author has called for the immediate training in knowledge-based warfare for "soldiers, sailors, marines, and airmen at all levels of professional military education."[34] This is necessary if we are to understand not only how to operate and maintain the I^2G, but also take advantage of the opportunity it offers in the way of information operations.

CONCLUSIONS

The AAN will require an I^2G capable of supporting the commander's information needs. The human nervous systems provides the architects of the I^2G the best example of what the grid should be. It should be a self-controlling and self-healing grid that users can plug into anywhere in the world. Technology will not fully take care of all grid management requirements. Therefore, human intervention will be necessary, but must be kept to a minimum in light of dwindling manpower resources.

The critical functions the I^2G must manage include architecture, device addressing, and bandwidth. Of these, architecture may be solved in the not too distant future when all services will be using a common joint architecture developed from the Army Technical Architecture model. Device addressing will be critical to quickly linking the full array of sensors, information systems, and communications devices to the grid. Progress will have to be made in database technology to fully solve the device addressing issue. Finally, bandwidth may no longer be a problem as new techniques and mediums increase the amount of bandwidth available. However, in crisis or outages, bandwidth will still have to be managed and allocated to high priority users.

Security will continue to be a major concern in the AAN, particularly as we become completely reliant on information technology. The threat of an asymmetrical attack against our information systems will continue to drive security technology. Of particular concern is the access security necessary to validate each device in the network and the assurance that the information is secure. Finally, we must protect the infrastructure from attack.

The I^2G will be managed by a consortium of business and military personnel from locations primarily in CONUS. We will continue to rely on commercial communications systems to provide the bulk of our communications requirements. The rapid changes in the telecommunications industry will drive us to establish new ways of doing business. For example, new statutory and contractual instruments that provide for the reallocation of critical communications infrastructure in times of crisis will be required.

The proposed management of the I^2G is cause for concern. Technological issues in database technology, multi-level security, and artificial intelligence may delay the development of the I^2G. Additionally, without establishing working relationships with commercial vendors and assurance of funding, the I^2G can not be realized.

The creation of an I^2G has already started, with the linking of current communications and information systems. However, at best it could be described as a conglomeration of often non-interoperable, manpower-intensive systems unable to share information. This conglomeration must be turned into a seamless information grid capable of providing commanders with the necessary information tools to aid in decisionmaking. All of this must be accomplished with a minimum of human intervention.

Without an I^2G, the information dominance necessary to achieve success in the AAN will not be obtainable.

ENDNOTES - CHAPTER 6

1. "Information superiority is the ability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same." John M. Shalikashvili, *Joint Vision 2010,* Washington, DC: The Joint Staff, 1996, p. 16.

2. *TRADOC Annual Report to the Chief of Staff of the Army on Army After Next Project*, Fort Monroe, VA: Training and Doctrine Command Army After Next Staff, June 1996, p. 13.

3. *Ibid*.

4. The term "living internet" or internetted "living" system of systems is from the Training and Doctrine Command Army After Next briefing to the U.S. Army War College Army After Next Advanced Course on October 23, 1996.

5. William A. Owens, "The Emerging System of Systems," *US Naval Proceedings* Vol. 121/5/1,107, May 1995, p. 37; and Thomas G. Mahnken, "War in the Information Age," *Joint Force Quarterly,* Vol. 16, Winter 1995-96, p. 40.

6. Switching in this context takes in the entire range of switches, routers, and other devices used to switch signals between systems.

7. Vincent W. S. Chan, "All-Optical Networks," *Scientific American,* Vol. 273, No. 3, September 1995, p. 73; and David L. Osborne, *Domestic Trends to the Year 2015, Forecasts for the United States,* Washington, DC: The Library of Congress, 1991, p. 190.

8. Robert K. Ackerman, "Digital Formats Complicate Information Security Tasks," *Signal,* Vol. 51, No. 6, February 1997, p. 22.

9. George I. Zysman, "Wireless Networks," *Scientific American,* Vol. 273, No. 3, September 1995, p. 71.

10. When it becomes operational in 1998, the IRIDIUM system will provide portable, universal service through a constellation of 66 satellites in low earth orbit. Subscribers will use pocket-size, hand-held IRIDIUM telephones transmitting through digital facilities to communicate with any other telephone in the world. The IRIDIUM system is being financed by an international investor consortium to

telecommunications and industrial companies. "IRIDIUM" available from http://www.computerreview.com /iridium.htm; Internet, access March 15, 1997; and "Totally Global, Global Mobile Personal Communications by Satellite Offers New Vision," *Iridium on line* magazine, Fall 1996, available from http://www.iridium.com/public/fall/pubcov.html; Internet, access February 20, 1997.

11. Zysman, p. 70; and Sheldon Teitelbaum, "Cellular Obsession," *Wired,* Ed. 5.01, January 1997, p. 147.

12. During a visit to Lucent Technology Center in Homdel, NJ, the author was briefed on an all-fiber switch that was being developed; and Chan, p. 73.

13. Shawn Butler, David Diskin, Norman Howes, and Kathleen Jordan, "Architectural Design of the Common Operating Environment for the Global Command and Control System," *IEEE Software,* Internet, http://www.computer.org/pubs/software/extras/butler/butler.htm, accessed March 15, 1997, p 8.

14. Andrew C. Braunberg, "Brain's Affinity for Imagery Eases Information Overload," *Signal,* Vol. 51, No 4, December 1996, p. 49. Also see Lawrence E. Casper, Irving L. Halter, Earl W. Powers, Paul J. Selva, Thomas W. Steffens, and T. Lamar Willis, "Knowledge-Based Warfare: A Security Strategy for the Next Century," *Joint Force Quarterly,* No. 13, Autumn 1996, p. 84.

15. Nicholas Negroponte, *Being Digital,* New York: Vintage Books, 1995, p. 151.

16. Thomas J. Czerwinski, "Command and Control at the Crossroads," *Parameters,* Vol. XXVI, No. 3, Autumn 1996, p. 126. Also see Glenn M. Harned, *The Complexity of War: The Application of Non-linear Science to Military Science*, Paper Submitted At the Marine Corps War College, Quantico, VA: The Marine Corps War College, June 5, 1995.

17. *The Army Technical Architecture, Version 4.0, Executive Summary*, Washington, DC: The Army Staff, January 30, 1996, p. 1.

18. Address by LTG Otto Guenther, DISC4, The Army Staff, to the USAWC Class of 1997 on January 29, 1997. The Joint Technical Architecture being developed by the Joint Staff will use the Army Technical Architecture as the base model.

19. Sean Patrick Burgess, "Art of the Small Supplies Secure Cellular Voice, Data," *Signal,* Vol. 51, No. 1, September 1996, p. 60.

20. “What is DMS,” available from the DMS Program Manger at internet, http://www.monmouth.army.mil/dms/whatis.htm; and National Security Agency Multilevel Information Systems Security Initiative (MISSI) Program explained by Defense Information System Agency (DISA) at internet, http://www.disa.expoqa3.html.

21. Scott R. Gourley, “The Battlefield Combat Identification System,” *Army,* Vol. 47, No. 1, January 1997, p. 52.

22. The Joint Staff currently uses 5 elements: availability, integrity, identification and authentication, confidentiality, and non-repudiation. In the I^2G, identification and authentication is accomplished by access security. The Joint Staff, *Joint Doctrine for Information Operations, First Draft,* JCS Pub 3-13, Washington, DC: The Joint Staff, January 21, 1997, p. III-2.

23. Department of the Army, *Information Operations*, Field Manual 100-6, Washington, DC: U.S. Department of the Army, August 27, 1996, pp. 3-5.

24. JCS Pub 3-13, p. III-6.

25. President William J. Clinton, Executive Order 13010, Critical Infrastructure Protection, July 15, 1996. Taken from the *Federal Register*: July 17, 1996, Vol. 61, No. 138, 37345, *Federal Register Online,* internet, wais.access.gpo.gov.

26. Solving individual network problems has become increasingly complex. With computers now being connected to networks or, in some cases, multiple networks, an individual problem could have one of four possible outcomes. The problem could be hardware, software, network, or some combination of the three.

27. Martin C. Libicki, *The Mesh and The Net: Speculations on Armed Conflict in a Time of Free Silicon*, Washington, DC: National Defense University Press, 1994, p. 52.

28. Dennis Steele, “Countdown to the Next Century,” *Army,* Vol. 46, No. 11, November 1996, p. 21.

29. “US Keeps World Waiting on Communications Deal,” Carlisle *Sentinel*, February 15, 1997, p. A3.

30. Douglas B. Lenat, “Artificial Intelligence,” *Scientific American,* Vol. 273, No. 3, September 1995, p. 80; and H. M. Collins, *Artificial Experts: Social Knowledge and Intelligent Machines*, Cambridge, MA: The MIT Press, 1990, p. 3.

31. Cliff Stoll in his book, *Silicone Snake Oil,* discusses at several points the topic of searching for information leading to other information. In particular, see Chapter 11, "Wherein the Author Considers the Future of the Library, the Myth of Free Information, and a Novel Way to Heat Bathwater," *Silicone Snake Oil,* New York: Doubleday, 1995, pp. 173-214. Also see Jaron Lanier, "My Problem with Agents," *Wired,* Ed. 4.11*,* November 1996, p. 157.

32. Alan D. Campen, "Gulf War's Silent Warriors Bind U.S. Units Via Space," *Signal,* Vol. 45, No. 12*,* August 1991, p. 81.

33. "Modernizing to Achieve a Capabilities-Based Force," Army Deputy Chief of Staff for Operations briefing to the Army Research Laboratory (ARL) on February 18, 1997, and further discussed with U.S. Army War College Army After Next students on a visit to ARL on March 3, 1997.

34. Casper, *et al*., p. 89.

CHAPTER 7

DATA INTEROPERABILITY FOR SYSTEMS OF SYSTEMS: OUR ACQUISITION PARADIGM MUST CHANGE TO ACHIEVE IT

William T. Lasher

[Editor's Note: While Lieutenant Colonel Hengst's paper addresses the necessity for an Intelligent Information Grid, this paper illuminates some of the problems that must be overcome to arrive at a point where systems of systems can become an operating reality. Together, these two papers lay one of the the foundation stones for the Army After Next. DVJ]

INTRODUCTION

Success of the Army After Next (AAN) will be heavily dependent on our ability to manage information adeptly. *Army Vision 2010* calls for us to "gain information dominance . . . to create a disparity between what we know about our battlespace . . . and what the enemy knows about his."[1] *Joint Vision 2010* foresees:

> increased access to information and improvements in the speed and accuracy of prioritizing and transferring data brought about by advances in technology of old. We must have information superiority: the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying our adversary's ability to do the same.[2]

It calls for us to develop "a new conceptual framework for operations. The basis for this framework is found in the improved command, control, and intelligence which can be assured by information superiority."[3]

To attain this information superiority, we will have to do much more than buy new hardware and develop advanced software. We will need to build new systems which can freely interoperate. We will need to build systems of systems. DoD's current acquisition paradigm, however, does not enforce development of interoperable systems.

This paper discusses the types of interoperability necessary to create a system of systems, shows why the current acquisition system severely inhibits achieving data interoperability necessary for the realization of this goal, and, finally, discusses alternatives to the current acquisition strategy that could provide the type of interoperability that facilitates development of joint systems of systems.

THE NEED FOR SYSTEMS OF SYSTEMS

In his visionary article, "The Emerging System of Systems," Admiral William Owens describes a future battle environment where "systems of systems" will synergistically improve the strategic leader's abilities to command and control joint forces. They promise to keep commanders at all levels fully informed, assist them in better and timelier decisionmaking, and, in some cases, automatically detect and respond to events, a feat largely beyond our grasp today.

So what is a system of systems? In essence, it is an executive level automated system that pulls data from functional level information systems (IS). As shown in Figure 2, the executive information system could poll subordinate information systems for either raw (base level) data, or some form of aggregate or abstract data derived from the subordinate system's base level data. Subordinate information systems could be programmed to pass critical data to the executive system periodically or as triggered by key events. The executive level system could then present this information to senior commanders to assist in decisionmaking.

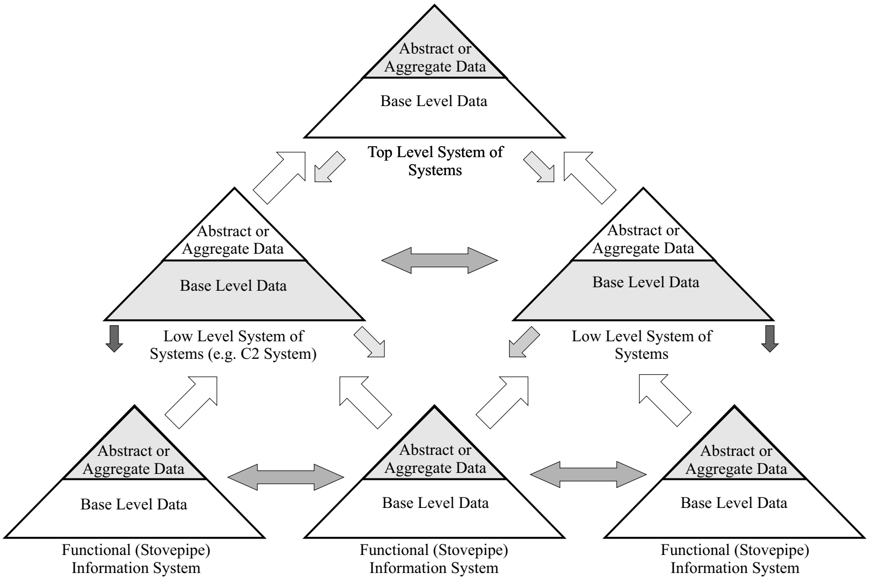


Figure 2.
Illustration of a System of Systems.

In some predetermined cases, executive level systems could instruct subordinate information systems to take action based on an automated analysis of the available information, for example, detection of a missile launch.

Actually, military systems of systems have existed for centuries. A standard command and staff structure is essentially a system of systems. Subordinate commanders and staffs freely communicate laterally. They provide information and recommendations to the commander; based on his interpretation of the information, the commander returns guidance. While we have automated functional information systems which assist staff officers and commanders, the interface between these systems is still a human one. In a true system of systems, as Admiral Owens envisions it, data would be freely passed between functional and executive level information systems without requiring human interpretation or intervention. It is this total interoperability between systems that will ultimately allow us to improve battlefield awareness and dramatically shorten our decision cycles.

CONSIDERATIONS IN BUILDING INTEROPERABLE SYSTEMS

Three primary challenges must be overcome to allow any two systems to "talk" to each other directly (see Figure 3). First, the systems must be technically compatible; that is, System A must have a communications interface electronically compatible with that of System B. Second, a communications link must be established between the systems. Third, System A must correctly interpret the information it gets from System B.

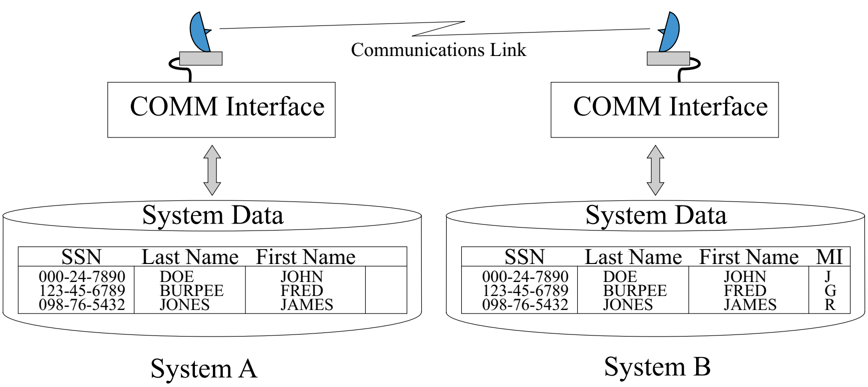


Figure 3.
Communicating Between Systems.

The Technical Challenges.

The first two "technical" challenges can be solved, given the right hardware, software, and technical expertise (i.e., enough money). Modern network technology and maturing industry standards (such as those used for the internet) are making the technical problems far less formidable than they once were.

The Data Challenge.

The third and most difficult challenge in allowing systems to talk to each other is getting them to exchange data. This is actually a design problem. It can be difficult, or impossible, to properly exchange data between systems which have different data designs.

The Growing Need for Sharable Data.

The Department of Defense (DoD) has long recognized the need for building systems with sharable data. In the stovepipe era, however, information systems were built primarily to perform one and only one function (e.g., the Joint Uniformed Military Pay System). These were large, self-contained systems with massive databases run on mainframe computers from a central location.

This method of system development tended to ensure that data design was consistent (thus data were sharable) within that large system. The need for sharing data across these large "legacy" systems, however, while important, was not critical since each generally performed a different and completely independent function.

As computer technology has advanced, we are moving away from the centralized mainframe environment to one that is highly distributed. Advancing technology is effectively removing a discipline previously imposed by the size and expense of mainframe computers.

We are seeing the appearance of multiple systems built at different echelons that perform similar functions and track similar (sometimes even the same) data. But, again, the focus of each is usually exclusive to the one function it is to perform, at the expense of interoperability. In this new distributed environment, it is becoming absolutely critical to design information systems that can share data.

The 1993 Army Enterprise Strategy specifically mandates that "all information systems will use Army standard data elements. This will increase the accuracy and timeliness of the data, increasing interoperability during all operations."[4]

The Director of the Defense Information Systems Agency has stated, "There is no greater imperative than to deliver to warfighters fully integrated systems that provide [a] fused, real-time, ground truth picture of the battlespace."[5] The goal is clear and relatively simple. Developing a method to achieve it is another matter.

THE FLAW IN OUR CURRENT ACQUISITION PARADIGM

Why is building information systems that share data so hard? A great deal of the problem has to do with the way we acquire data. DoD and service information systems are built using the standard DoD acquisition model. Each major system is, for the most part, developed independently by a program manager (PM) who is provided reasonable autonomy and held responsible for progress in system development and fielding. The PM's primary motivation is delivery of a system on time and within budget. While the PM undoubtedly desires interoperability with other systems, there is little hope of coordinating the system design with every other system that may someday require interface.

DoD funding mechanisms focus narrowly on independent systems. As Admiral Owens points out, "We have cultivated a planning, programming, and budgeting system [PPBS] that tends to handle programs as discrete entities. The PPBS cycle forces us into a compartmentalized perspective."[6]

Thus, DoD's acquisition system is really designed to optimize the efficiency and effectiveness of individual systems at the expense of developing (or even allowing the development of) systems of systems with their promised synergistic performance.

The Method: How We Build "Watches" Now.

To illustrate why we are where we are (having spent billions of dollars constructing sophisticated information systems which, for the most part, do not interoperate), we need to review how we design and build information systems. Figure 4 shows the typical "waterfall" development model used to build software during the mainframe era.[7] Figure 5 shows the newest software development lifecycle model approved as part of DoD's Military Standard 498. Both are process- or function-centered models. If one envisions a pie representing all functions performed across the services, these models take a slice of that pie and automate the functions within (possibly a very small part of) that slice (see Figure 6). A portion of the development effort involves designing the system database—or building a system data architecture.

Take the Standard Installation/Division Personnel System, for example, or substitute your favorite system

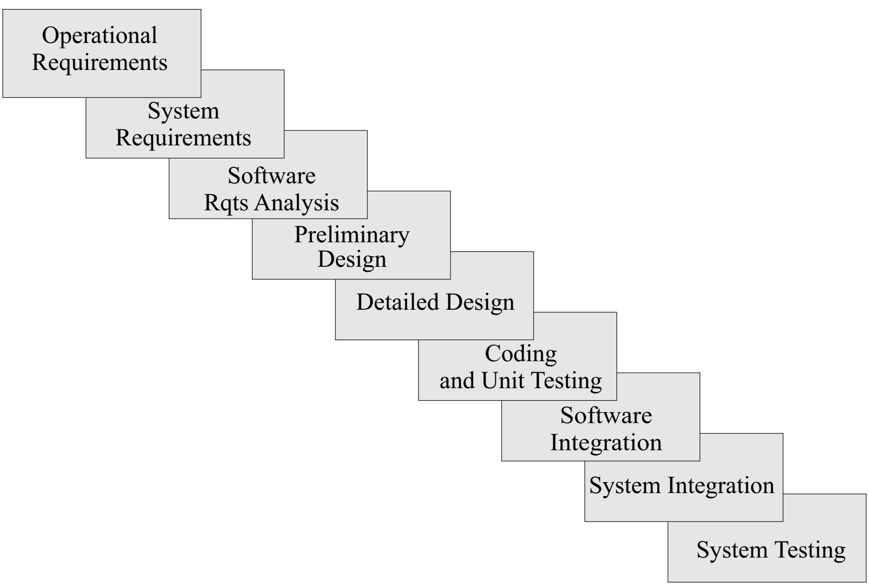
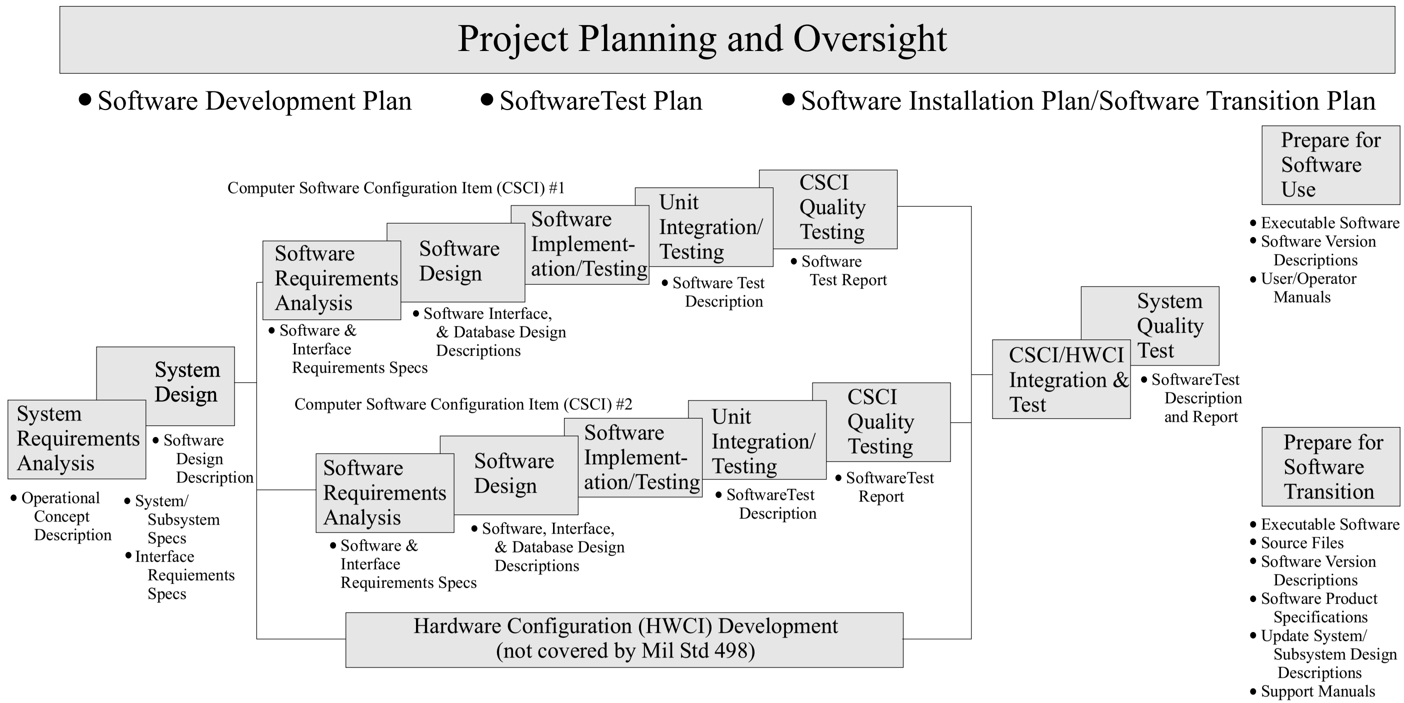


Figure 4.
The Waterfall Life Cycle Model.



Basic Software Development Model Depicted in Mil Standard 498

Figure 5. Military Standard 498 Software Development Cycle.

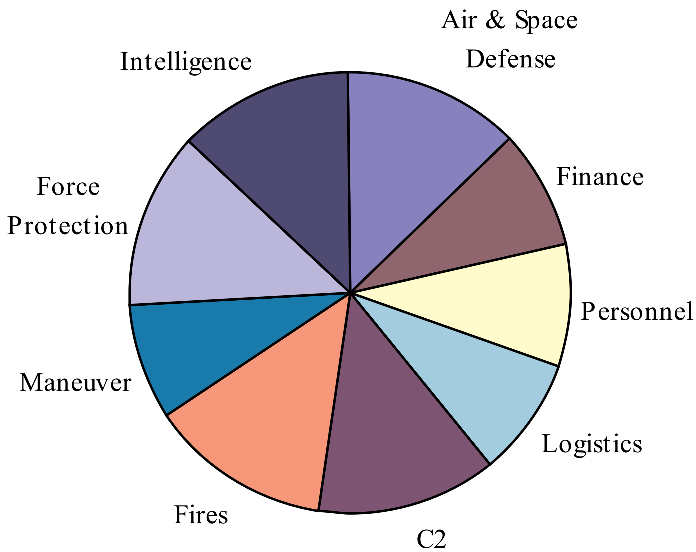


Figure 6.
The Functional Pie: Illustrative Slices.

here. Under these models we would conduct a thorough analysis of all the processes involved in managing personnel at divisions and installations. Based on that analysis, we would develop a set of requirements to automate these processes, a data architecture for the system, and ultimately a detailed design to automate these processes.

The Problem With the Single System Focus.

From its genesis, the entire system is narrowly oriented on the slice of pie involving one particular function (in this case, personnel management), inherently driving the system developer into a stovepipe. Once the system developer is given his charter ("Go forth and automate function xyz."), our system development models effectively call for him to concentrate within that narrow lane. There is no construct in the formal models that causes the PM to look outside his lane and integrate his system with others. There are no provisions in these models that compel a system developer to design interoperability into the system. In fact Military Standard 498, which is just over two years old, does not even mention interoperability of data. Thus, interoperability is typically handled as an adjunct to building the basic system.

If the PM strictly followed the formal system development models, he or she might well have fully developed the system's data architecture before even considering interoperability.

OPTIONS FOR ACHIEVING AN INTEROPERABLE DATA ENVIRONMENT

There are at least three general courses of action DoD could pursue in developing systems which could freely exchange data. It could centralize all systems development efforts under one organization within DoD. It could continue to allow decentralized development while insisting developers adhere to strict interoperability standards. Or it could change the acquisition method by making system development a joint effort between the system developer and an organization responsible for development of an enterprise data architecture. Each of these options is discussed in more detail below.

Centralize: Develop Systems only at the DoD/Joint Level.

Under this "massive centralization" course of action, system development efforts and expertise reside in a central department under DoD. This agency would be responsible for development of all new information systems within DoD. It would implement rules and procedures to ensure that systems interoperability was developed.

Standardize: Remain Decentralized but Build and Enforce Standards.

DoD has commonly called this the "data standardization program." It is the course of action both DoD and the Army have been pursuing in some form for at least the last 30 years.[8] The persistent and widespread lack of interoperability within DoD systems today would seem to indicate that this course of action is just not working.[9]

The Concept. Data standardization calls for development and implementation of technical and data interoperability standards to which system development efforts would be held. Data standards are centered around an enterprise data architecture (data model) and uniformly defined pieces of data called "standard data elements." These are kept in a repository, or dictionary, which would be universally available to system developers.

In theory, system designers could go to the dictionary and pull out the "standard" definition for any DoD data and use that in their design. Under the current guidance, if the developer does not find a suitable standard to use, he or she is then responsible for developing a *proposed* standard and submitting it to the DoD Data Administrator for approval.[10] In this manner, the DoD enterprise data architecture is supposed to be developed over time as new systems are built.

The Fallacy of Standard Data. The word "standard" evokes an image of a set of rules, protocols, or specifications which rarely change over time and need little periodic maintenance. Unfortunately, construction of an enterprise data architecture is a massive project requiring significant development effort and considerable upkeep.

Database design is a major portion of the development effort on behalf of any information system. Developing an enterprise data architecture is, in essence, the construction of a high level data design for every functional area in the enterprise. It is more an engineering effort than one of developing a standard, and, while a system's data architecture is relatively fixed compared to other system components, it can change over time. Thus calling it a standard can be deceiving.

The implication behind the data standardization program is that at some point the data architecture will be "finished." However, experience during the Army's data modeling efforts in the early 1990s showed that as new functional areas were modeled, inconsistencies, oversights, and errors were consistently revealed in the existing data architecture.

The current DoD Data Model, which is relatively young, has 3,453 entities, with another 5,000 under development. The DoD Data Dictionary System, which is used to store DoD standard data elements, has 23,658 elements approved, proposed, or under development to date.[11] Obviously, as future information systems are developed, the data model and the number of required standard data elements will grow.

As with most engineering products, the utility of any data architecture is highly dependent on its quality. If it fails to accurately represent the entities and business practices of an enterprise, it will not support construction of useful information systems. Unfortunately, once a data architecture is defined and systems are built to its specification, it becomes an expensive proposition to change the architecture upon discovery of an error. Thus, development of an accurate, high-quality data architecture from the start is crucial.

Determining the correct entities, relationships, and business rules for a large data architecture is an exceptionally difficult mental drill. Managers who participate in data modeling sessions often find themselves rigorously defining their business practices and realizing they have never really done so before.

A PM, whose primary motivation is delivery of a system, is unlikely to take the care desired in developing his portion of the enterprise data architecture. With this method, the potential for developing a high-quality enterprise architecture is quite poor.

COMBINE CENTRALIZATION AND STANDARDIZATION

The third possible course of action is to modify the DoD acquisition paradigm by effectively incorporating the essentials of the two previous options, but with a major difference in focus. This course of action splits development strategy for information systems into two parts. Development of the data architecture would be done centrally, while allowing the remainder of system development to stay decentralized.

The Concept.

Under this approach, the enterprise data architecture would be viewed as a major engineering project, not a set of standards. DoD would fund, build, and maintain a data architecture as a major system development effort. Unlike most development projects, however, the product would not be a system designed for end users. It would instead be a system built exclusively to support other information system development efforts. In essence, this approach advocates construction of DoD's enterprise data architecture as a large infrastructure project that provides a foundation upon which end user information systems are built (see Figure 7).

A necessary step in this process would be development of a comprehensive information system designed to support construction of the data architecture. This system would be a type of Computer-Aided Software Engineering (CASE) tool designed to assist users in navigating and modifying the data architecture. It would also assist system

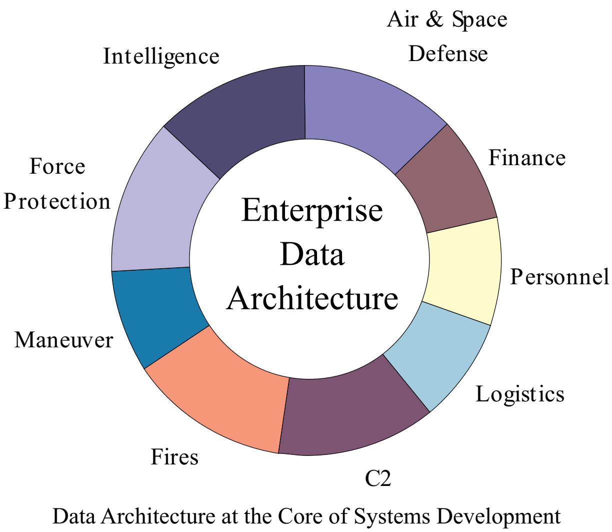


Figure 7.
Enterprise Data Architecture.

developers in incorporating the architecture into new information system design.

This approach would also recognize the inevitable need to maintain the data architecture over the long term. An organization's data needs and business practices will change (usually slowly) over time. If the data architecture doesn't change with the organization, it becomes obsolete and ultimately useless.

To retain its utility, the architecture would have to be modified periodically. This modification must be closely controlled to ensure components of the architecture (models, data elements, etc.) remain consistent. Mechanisms must also be built which eventually cascade changes in the enterprise data architecture down to existing information systems.

The Organization.

Under this approach, we would charter a high level office at Office of the Secretary of Defense or Joint Staff level to ensure that DoD's data architecture would be centrally developed and maintained by an organization charged with assisting information system developers in using the enterprise data architecture to design and build new systems. A proposed organization appears at Figure 8.

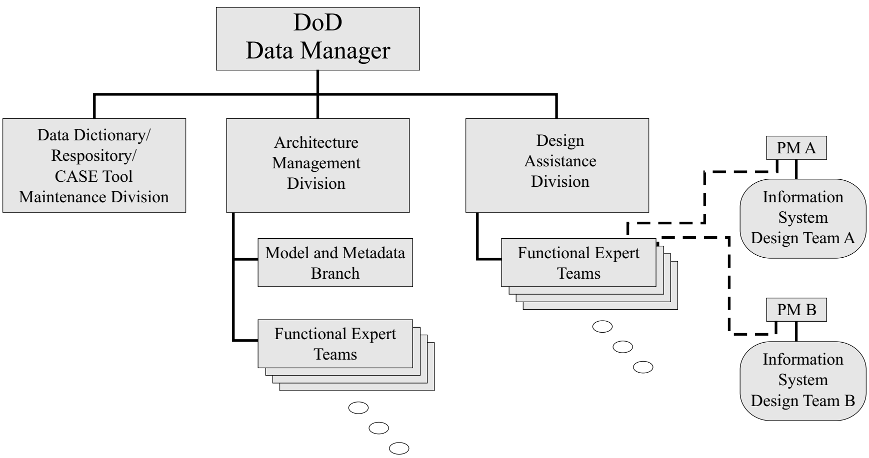


Figure 8.
Possible Layout for DoD Data Management Organization.

The Dictionary/Repository division would be responsible for maintaining the information system (CASE tool) in which the architecture is kept. The Architecture Management Division would continually update and maintain the architecture to ensure its currency, quality, and consistency. Teams of functional experts would be responsible for portions of the architecture that fall into their particular functional area.

The Design Assistance Division would be composed of several design-build teams. Each design-build team would work with an individual information system (IS) developer during system development on a dedicated basis. The team would assist the IS design-build team in database specification, design, and development, and would monitor and assist the PM as needed on all database redesign issues through the entire life cycle of the program.

Building the Architecture.

As noted earlier, construction of the architecture would clearly be a massive job in itself; however, it could be done incrementally given the right organization and a consistent funding stream. As design teams developed additions or corrections to the architecture, the Architecture Management Division could integrate them into the enterprise architecture, ensuring they remained consistent with existing portions.

While this approach to building an enterprise architecture is similar to the approach DoD is currently pursuing under the data standardization program, it differs in that only the DoD Data Manager is responsible for the architecture. The DoD Data Manager's focus is primarily on development of a high-quality, consistent enterprise architecture. The PM, on the other hand, can focus on building a system without having to devote his or her resources toward building the enterprise architecture.

Advantages and Disadvantages.

This approach could have several advantages over our current standardization approach. It removes the burden of developing an architecture from the PM and places it on an organization designed and staffed to do that job. Design-build teams would be fully familiar with the enterprise architecture, and new projects could immediately take advantage of existing protocols and apply them to new development efforts. It also means they could quickly identify omissions, inconsistencies, or errors in the enterprise architecture and work to get them corrected. Finally, quality, consistency, and integrity should be considerably better than one developed by multiple organizations.

However, there are clearly some tough issues that must be addressed with this "team" approach to information systems development. The fundamental change from the PM's point of view is that he or she would no longer have exclusive control over the database design team. Database design would instead be a joint effort between the PM's office and a DoD design-build team.

Design-build teams would initially require time to become familiar with the specific project. There is no reason to believe they would require significantly more time than any normal development team starting a project, however.

Despite these challenges, this approach offers considerable promise. It explicitly recognizes the need to undertake a major infrastructure-type project to build and maintain a high-quality enterprise data architecture. It provides for an organization to do so. It provides tools and personnel to assist the system developer in building new information systems. And it promises true DoD-wide data interoperability and potential long-term cost savings.

POTENTIAL BENEFITS OF AN INTEROPERABLE DATA ENVIRONMENT

DoD-wide data interoperability, in turn, would provide a common shared data environment across DoD. The potential benefits of such a common data environment are extraordinary.

Systems compatible with the DoD enterprise data architecture could, in theory, freely pass data between themselves without translation and with assurance that definitions behind the data are common. This "complete interoperability" would make it possible to build systems of systems without having to modify the underlying functional information systems and without having to build translators.

A fully developed DoD data architecture also promises to eliminate significant portions of individual system development efforts, since much of the database definition within any functional area would already exist. In fact, given new CASE tools, one could envision database design being done by merely selecting the desired entities, relationships, and attributes from an already-constructed DoD data model.

This shared data environment would also facilitate development of truly reusable software. Both the Army and DoD have long pursued a goal of establishing a repository to maintain reusable software modules. This goal has eluded them largely because software operates on data, and, if two systems design their data definitions differently, they generally cannot use the same software. Interoperable data promises to make reusable software a viable possibility.

The ultimate goal for an enterprise data architecture could be the development of an integrated system of functional on-line databases. Given the near universal accessibility that internet technology provides, developing an information system in the future could be no more complicated than forming a series of queries against these already existing databases.

CONCLUSION

The potential advantages that integrated systems of systems offer truly are synergistic. Unfortunately, our current acquisition model inhibits the development of systems which can freely share data and interoperate. If DoD is to develop interoperable systems, we should fund and undertake a major development effort to build an enterprise data architecture. We must staff an organization of experts responsible for the maintenance of this architecture. Further, we should alter our acquisition model such that database design and development occur jointly between the PM's office and the organization responsible for the DoD enterprise architecture.

In the words of the Honorable Emmett Paige, Assistant Secretary of Defense (C3I):

> Information that is part of a shared integrated information database, accessible by a wide user base that can collaborate, has tremendous value. The rapid pace of technological advance, coupled with an unpredictable world situation, demands that we pursue this goal with all deliberate speed.[12]

ENDNOTES - CHAPTER 7

1. Army Chief of Staff, *Army Vision 2010,* Washington, DC: U.S. Department of the Army, 1996, p. 17.

2. Chairman of the Joint Chiefs of Staff, *Joint Vision 2010*, Washington, DC: Chairman of the Joint Chiefs of Staff, 1996, p. 16.

3. *Ibid*., p. 19.

4. Department of the Army, "Army Enterprise Strategy, The Vision," Washington: U.S. Department of the Army, Office of the Secretary of the Army, DISC4, July 20, 1993, p. 22.

5. Defense Information Systems Agency Memorandum for Program Managers and Developers, "Implementing DoD Standard Data Elements," April 1996, p. 1.

6. William A. Owens, "Emerging Systems of Systems," *U.S. Naval Institute Proceedings,* Vol. 121, No. 5, May 1995, p. 36.

7. The model shown in Figure 3 is taken from Major Paul D. Condit, USAF, *Principles of Information Resource Management: A Foundation for the Future*, research report, Maxwell Air Force Base, AL: Air University Press, 1992, p. 40.

8. U.S. Department of Defense, *Data Elements and Data Codes Standardization Program*, DoD Directive 5000.11, dated December 7,

1964 (since rescinded). DoD Directive 8320.1, *DoD Data Administration*, September 26, 1991, replaced this document.

9. John G. Roos, "Ending the C4I Tunnel of Babel," *Armed Forces Journal*, Vol. 132, No. 3, October 1994, P. 19. Mr. Roos states that "decades of independent technical and procurement decisions have left the services with a hodgepodge of command, control, computer, and intelligence, C4I systems, making it difficult—in some cases impossible—to communicate across service lines. The problem has been obvious for years." See also Peter Rackham, "Uniting the Tower of Babel," *Jane's Defence Weekly*, Vol. 22, No. 16, October 22, 1994, p. 26. Mr. Rackham states that "the U.S. Department of Defense operates the world's most diverse array of information systems with a vast collection of computer architectures, operating systems, hardware, programming languages, software applications, database languages, and protocols. While each information system was designed to do a particular task, many perform similar functions and yet few can interoperate or share data."

10. DISA Memorandum.

11. Pam Baylon, Information on number of entities in the DoD Data Model and number of data elements in the DDDS provided by electronic mail message <baylonp@ncr.disa .mil>, subject: "DoD Data Model," to Lieutenant Colonel W. Lasher <lasherw@carlisle-emh2.army.mil>, March 19, 1997.

12. Emmett Paige, Jr., "Achieving the Integrated Systems Concept," Keynote address at the Armed Forces Communications and Electronics Association International Technet 1996 Convention, Washington, DC, June 4, 1996, as published in *Defense Issues,* Vol. 11, No. 51, June 1996, p. 5.

ABOUT THE AUTHORS

BILLY WELLS graduated and was commissioned in the Infantry from Mississippi State University in 1975. Lieutenant Colonel Wells has served at almost every level of Infantry assignment including command of the 3rd Battalion, 15th Infantry. He served successively as Chief, Doctrine Division, and as Chief, FORCE XXI Office, U.S. Army Infantry School, prior to attending the U.S. Army War College.

BARBARA JEZIOR graduated from the University of Rhode Island with a B.A. degree in German in 1976. Ms. Jezior subsequently took a masters degree in psychology from Fitchburg University in 1983. Beginning her government career as an Instructor at the U.S. Army Intelligence School, she served as a Research Psychologist and Project Officer at Natick Research, Development and Engineering Center; then as a Systems Integrator in the Office of the Deputy Chief of Staff for Operations. She returned to Natick as Chief, Consumer Resource Branch, then went back to the Pentagon as a Program Analyst in the Office of the Secretary of the Army for Research, Development and Acquisition. Prior to her assignment to the U.S. Army War College, she was Director, Plans and Operations Division, Soldier Systems Command, Natick.

ARTHUR SOSA graduated from the University of West Plattville in 1971 with a B.S. degree in science and biology. Lieutenant Colonel Sosa returned to that university and took a masters degree in counseling in 1977. An Army National Guard officer, he was commissioned in Aviation and has served in a variety of aviation assignments including command of the 1st Battalion, 147th Aviation, Wisconsin National Guard, just prior to attending the U.S. Army War College.

GARY J. MOTSEK, an Ordnance officer, currently commands Pine Bluff Arsenal. He graduated from Syracuse University in 1974 with a B.S. in engineering. Colonel Motsek took a masters degree in management from Troy State University in 1982, and attended the U.S. Army Command and General Staff College in 1984. He has served in Field Artillery, Ordnance, and Maintenance units, commanding successively the NATO Support Activity, Brussels, Belgium, and the 15th Ordnance Battalion, Muenster, Germany. Prior to attending the U.S. Army War College, he was a Joint Staff Officer, J-4, the Joint Staff.

YVES FONTAINE is an Ordnance Corps officer currently assigned as G-4, 101st Airborne Division (Airmobile). He graduated from La Salle College with a B.S. degree in business in 1975. Lieutenant Colonel Fontaine took a masters degree from Webster University in business in 1989. Following attendance at the U.S. Army Command and General Staff College and the School of Advanced military Studies, he was awarded a master of military arts and science degree in 1990. He has served in Maintenance and Ordnance units in the United States, Germany, and Belgium and commanded the 82nd Forward Support Battalion, 82nd Airborne Division, immediately prior to attending the U.S. Army War College.

PAUL T. HENGST graduated and was commissioned in the Signal Corps from the United States Military Academy in 1977. Lieutenant Colonel Hengst took a masters degree in information systems from the Naval Postgraduate School in 1987 and attended the U.S. Army Command and General Staff College in 1990. He has served in a variety of Signal Corps assignments including command of the 112th Signal Battalion prior to his attendance at the U. S Army War College.

WILLIAM T. LASHER graduated from the United States Military Academy with a B.S. degree in engineering in 1977. Lieutenant Colonel Lasher went on to take a masters degree in computer science from the University of Texas in 1988, following which he attended the U.S. Army Command and General Staff College. He has served in a variety of Signal Corps assignments including duty in Somalia and Haiti. Just prior to attending the U.S. Army War College, he commanded the 125th Signal Battalion, 25th Infantry Division.

DOUGLAS V. JOHNSON II graduated from the United States Military Academy in 1963, took his masters degree from University of Michigan in 1973 and his doctorate from Temple University in 1992, both in history. He attended the U.S. Army Command and General Staff College in 1974, to which he returned in 1981 where he became co-founder of the School of Advanced Military Studies. Retiring in 1992 after 30 years service as an artilleryman, Dr. Johnson is currently an Associate Research Professor, National Security Affairs, and directs the USAWC Army After Next Seminar.

U.S. ARMY WAR COLLEGE

Major General Robert H. Scales, Jr.
Commandant

*****

STRATEGIC STUDIES INSTITUTE

Director
Colonel Richard H. Witherspoon

Director of Research
Dr. Earl H. Tilford, Jr.

Authors
Lieutenant Colonel Yves J. Fontaine
Lieutenant Colonel Paul T. Hengst
Ms. Barbara A. Jezior
Lieutenant Colonel William T. Lasher
Colonel Gary J. Motsek
Lieutenant Colonel Arthur J. Sosa
Lieutenant Colonel Billy E. Wells, Jr.

Editor
Dr. Douglas V. Johnson II

Director of Publications and Production
Ms. Marianne P. Cowling

Publications Assistant
Ms. Rita A. Rummel

*****

Composition
Mrs. Mary Jane Semple

Cover Artist
Mr. James E. Kistler