2.0 Insight and Future Vision

2.1 A Dynamic World

We live in a dynamic world, an era of contradictory trends shaped by two great forces, one strategic, the other technical -- the advent of the Information Age. The scale and pace of recent change has made traditional means of defining future military operations inadequate. In the absence of a relatively fixed, strategic environment, we are faced with a far more complex world that defies authoritative forecasts of the future.

Absent a reversal in Russia, there is now no credible near-term threat to US existence. That fact does not mean the nation's vital security interests will go unchallenged during this period of great strategic reordering. As a result US armed forces will remain fully engaged throughout the world, meeting the nation's security needs and helping shape what will prove to be a very fluid future environment.

The types of military operations we have experienced since the end of the Cold War will continue well into the decades of the twenty-first century. During this period the military will be called upon to defend and promote national and collective security interests throughout the world, often on short notice.

2.2 Future Challenges

In addition to strategic challenges, other challenges are associated with entry into the Information-Age. Information technology will make a thousand fold advance over the next twenty years in terms of the volume, speed and the number of individuals accessed by the global flow of information. Developments in this area have begun to revolutionize -- how nations, organizations, and people interact. The rapid diffusion of information enabled by these technological advances challenges the relevance of traditional operations. Most importantly, that commercial technology is not necessarily easily available to the US military, and an adversary is not constrained by our slow approach to the acquisition and use of modern information systems technology can buy that technology off the same shelves we can -- and use it to get inside our "turn radius", or information cycle.

Future information technology will greatly increase the volume, accuracy, and speed of battlefield information available to commanders. These technologies will allow organizations to operate at levels their adversaries cannot match, while simultaneously protecting their own capability -- this is called information dominance. Information dominance is a relatively new concept, one that is moving to occupy center stage in our thinking about modern war. Information dominance of the battlespace and winning at information warfare will be critical to successful joint and coalition military operations.

2.3 The Nature of Space

Space, as the ultimate high ground from a military standpoint for broad area reconnaissance, surveillance, and communications will be critically important to information dominance. It is substantially different from the air, land and sea mediums because it is global by nature. Space is fundamental in achieving global presence, global reach, and global force and we must learn how to efficiently manage our space assets consistent with rapid technology evolution and shrinking resources.

Air, land and sea are mediums of local equilibrium, that is, the force of gravity is repelled by local point forces acting on the body. In the case of air, land, and sea locally generated interacting force are required to control the vehicle and continuing expenditure of energy is required to keep it moving.

In orbit, gravitational force is in equilibrium with centrifugal force of the spacecraft, thus it is not dependent on the local medium for its support, but on global forces. Since in space we are operating outside of the sensible atmosphere we need to expend essentially no energy to maintain forward motion, however, position is not instantaneously at the will of the operator as is the case of air, land and sea. In order to achieve the necessary velocity to reach it, it is necessary to expend a large amount of energy initially, the problem of the booster rocket. As a consequence large expenditures of energy are also required to change the orbital characteristics. Also because space is remote and difficult to access, maintenance and logistic resupply are generally not available. The space environment is hostile in the sense it is a vacuum with large swings in temperature as the spacecraft is exposed to the sun and then the shadow of the earth. The region of space in which spacecraft operate contains high energy and particle radiation in the form of x-rays, gamma rays, electrons, protons as well as meteorites and space debris.

The space age was essentially ushered in by the Soviet launch of Sputnik in October 1957. This event awoke the United States to the national importance of being the predominant power in space. The National Aeronautics and Space Act of July 29, 1958 created NASA and set the stage for President Kennedy to declare the objective of putting a man on the moon by the end of the decade (1970). The Apollo program met this objective and demonstrated our preeminence in space.

Military space was also driven by the Soviets, first by the need for gathering intelligence and then from surveillance of their nuclear missile forces -- our very survival in the nuclear age dependent on our ability to know the real capabilities of our adversary. The space program was initially directed at strategic considerations such as acquiring intelligence on Soviet capabilities, developing target lists, providing ballistic missile attack warning, and communicating to fixed ground terminals. Tactical considerations were a distant second in terms of expenditure of funds and effort until the third decade of the space age when systems such as GPS came into being. Exploitation of overhead reconnaissance data was initiated with TENCAP, but it took the Air Force almost ten years to fully get aboard the program. Space was considered from the strategic view point rather than an every day asset of the warfighter.

Military space is an outgrowth of the ballistic missile programs. Space boosters were slightly modified missiles and some of the first spacecraft were designed to acquire data on the space environment and re-entry physics to support the missile programs. Initially spacecraft were fairly small, somewhat experimentally built, the technology was immature and failure was not an unusual event. As time went on requirements on satellites grew, particularly from the survivability standpoint, and they became bigger, heavier and, of course far more costly.

Today’s satellites are highly reliable with multiple redundancy and generally pushing the state of the art in mechanical and electronic technology at the time of design. The cost of space systems has grown from several hundreds of millions of dollars, to programs in excess of ten billion dollars (Milstar). The weight of satellites has grown from less than a thousand pounds for GEO satellites, to satellites exceeding 10,000 pounds. For LEO the bigger satellites are on the order of 40,000 pounds.

Our proud heritage in space in space was born out of the ballistic missile and space races with the Soviet Union with national prestige and survival at stake. All along the way space was the domain of technologist and the “Big” user. Size, survivability, sensitivity, redundancy were absolutely not to be traded.

Desert Storm changed all this and proved the value of space in modern warfare. GPS derived data was used extensively to support ground, sea and air operations. The demand was so great that 15,000 commercial receivers were procured for use by the military. Weather data was largely supplied by satellites as was much of the long haul communications using both commercial and defense satellites. Imagery and electronic order of battle information was available, and DSP data was used to determine Scud missile tracks to alert Patriot air defense batteries and support counter air strikes against the launchers -- although with no success.

While Desert Storm demonstrated the value of space to the warfighter, it also demonstrated the need for far greater responsiveness in terms of coverage, timeliness, and content. The value of getting the right information to the right place in time to really make a difference for the warrior has been established. What remains now is to reevaluate the military use of space in its full context as an essential element of the entire military force structure.

2.4 Space Applications Evolution

The collapse of the Soviet empire has created a substantially changed security environment. While survival is no longer at risk as during the Cold War, threats to the vital interests of the U.S. and its allies can be created by a number of power centers, including narco-terrorists or extreme ideological groups. Fueling this increased threat is the proliferation of weapons and expertise available globally. Complete weapons systems or their components are available from virtually all arms producers. Whatever one’s politics, arms are available. Of key concern is the disposition of the massive weapon inventory held by countries of the former Soviet Union. A primary threat to U.S. interest stems from the marriage of even modestly capable military forces, with the expansion in the commercial availability of space resources and sophisticated consumer electronics technologies applied to weapon systems. The international commercial space markets are now providing both products and systems for communications, position/navigation, weather, reconnaissance, surveillance, and remote sensing. Other countries also understand the lesson of Desert Storm, and in particular, the force multiplier effect of space systems. Proliferation of cheaper launches and availability of satellite technology encourages potential enemies to use space as a force multiplier, and to consider measures to negate U.S. space systems. Information-based warfare is emerging as the dominant form of war, and future wars, whether local, regional, or global, will be won by the side winning the battle for information dominance.

One issue that will continue to constrain space applications is the cost and difficulty of space launch. No fundamental breakthroughs in propulsion technology are foreseen in the near future in any studies conducted to-date. While incremental changes promise some improvements, we have to accept for now the limitations in space launch. However, advances in micro-electronics and sensors are leading to order of magnitude changes in satellite size and capabilities, leading to much smaller more operationally friendly or more economical launchers to achieve similar mission performance.

The U.S. currently has a clear technology lead that must be maintained. The current U.S. space force structure consists of systems that can cover the entire earth and thus provide global presence not possible with terrestrial forces. Having friend and foe alike know that we know what is happening is a deterrent capability of immense proportions. However the U.S. current dependence on large expensive systems has several weaknesses. They are inflexible, not responsive to mission changes, and when they become critical to mission success they will become points of vulnerability.

U.S. military space planning will be affected by realities of the rapidly expanding markets, both national and global. Commercial products are developed much faster than military products. For example, the GPS receiver development cycle dropped from 44 months to 5 months. Computer new product cycle time is down to 18 months. Due to this rapid development cycle commercial electronic products contain more recent and often higher technology than their military counterparts. Commercial high technology products have a short half life due to technology advances. They are highly reliable during use periods, and system longevity is not a factor due to rapid replacement. This is a key issue in the development of the new low earth orbit communications systems. What should the satellite design life be? U.S. military systems become quickly obsolete if developed under the current DoD acquisition cycle. The U.S. can no longer control proliferation of systems, technology, or expertise. International systems are now developing without U.S. participation. Opponents may be able to acquire military systems inside our development cycle, as technology and expertise are widely available, as well as greater understanding of space systems technology leading to better countermeasures. The U.S. may face a situation where an adversary may have sufficient high technology systems to create problems for the U.S., yet be “underdeveloped” and less vulnerable.

Developments in commercial space globally will revolutionize military space by providing the capability to fully implement information based warfare and exploit the compression of time in military operations. We need to understand the implications of these changes and how the military can benefit from them. The key question to answer is - what is the right mix of dedicated military and civil/commercial systems, and how to integrate them to support the warfighter?

Commercial space can help the U.S. military maintain information dominance in the 21st century by some combination of purchasing products, buying systems, or use of commercial components. In Desert Shield/Storm, the U.S. purchased products from a number of U.S./Allied commercial space systems. This included 350 communications circuits from over a dozen carriers; used civil weather data; purchased 189 Spot images; Landsat imagery was used extensively; and government, as well as individual purchase and use of commercial navigation receivers were one of the wonder stories. The GPS success has created an international political dilemma on how to satisfy the needs of both the commercial and military users in a dual use system. The international pos/nav community does not want to become dependent on a U.S. military system that may be denied. This concern is reflected in Inmarsat discussions on developing an international system, Europeans looking at GNSS, and other regional systems.

Commercial low altitude communications satellites will rapidly proliferate as both the big and little LEO systems (six different constellations proposed, e.g., Iridium, Teledesic, etc. as shown in Figure 2.1 Proposed LEO Communications Systems) become operational in the late 1990's providing a massive redundant, and survivable communications network available to the military.

Overview Of Proposed Leo Telecommunications Satellite Systems (> 1 Gh$_Z$)

	COMPANY	# SATELLITES	ORBIT/ ALT	ORBIT/ INCLINATION	FREQ	WT	COST	IOC	REMARKS
TELEDESIC	MICROSOFT (GATES)/ MCCAW	900 (40+4 IN EACH PLANE)	700 KM	21 PLANES 98.2° SUN SYNC	Ka Band 20-30 GHZ TDMA	750 KG	$15B	2001	Telephones broad band to remote areas & dev. countries. Packet Switching Network
IRIDIUM	MOTOROLA, LOCKHEED	66 (+7 SPARES)	780 KM	6 PLANES/ 11 EACH	L-BAND TDMA	700 KG	$3.4B	1998	Worldwide digital, cellular PCS. Russian & MacDac booster
GLOBAL STAR	LORAL QUALCOM& SPACE SYS.	48 (6X8) (+8 SPARES)	1390 KM 47%	8 PLANES 52°	16-25 MHz CDMA	400 KG	$1.8B	1997	Worldwide cellular voiced data & RDSS
ELLIPSO	ELIPSAT CORP./ WESTINGHOUSE FAIRCHILD	14-18 SATELLITES	2,900 KM X426 KM	ELIPTICAL 63.4°	L-BAND CDMA	175 KG	$650M	1998(?)	Mobile voice & RDSS for US
ODYSSEY	TRW	12-15	10,354 KM 55°	55° 3 PLANES 4 SAT	S&L CDMA	?	$1.3B ($52M/SAT)	1999	Voice data paging, msg.
CONSTELLATION (FORMERLY ARIES)	CONSTELLATION COMMUNICATIONS, INC. & DEFENSE SYSTEMS	48 4X12	1,000 KM	4 PLANES; CIRCULAR	16-65 GHZ S&L BAND CDMA	?	$300M ($1.5M/SAT)	1994 (FOC 1996)	Low-cost RDSS for US. OBEX launch vehicle

Figure 2.1. Proposed LEO Communications Systems

The U.S. military can buy commercial systems or be a user of commercial services. Satellite commercial reconnaissance systems are proliferating, e.g., 1 meter imagery systems are being offered by three U.S. companies. The U.S. operating commands may choose to buy, lease or use services from commercially available systems cheaper than they could develop one for military applications. Commercial software packages having requisite capabilities are available for a wide array of activities. The ground segment is also commercially available, ranging from COTS ground stations to portable antennas. Commercial enterprises can provide launch services to support surge requirements or to provide routine launches

The key military requirement is to assure availability of space support, whether by owning, leasing or using commercial system services, through CRAF-like arrangements with the ability to invoke national priority during times of crisis. Although CRAF concepts may work during times of unambiguous national emergency, it is not clear how these arrangements will work during military operations of lesser nature, which are expected to be the more prevalent situation.

2.5 International Developments in Space

New space powers are emerging. This trend is accelerating due to the proliferation of capabilities occurring globally, to include: 1) space technology, both as a commodity, and through classic technology transfer; expertise; systems; and through technical training and education. Foreign nations, particularly European nations and Japan, have targeted space as an area of strategic importance to their economic future. This is also one of the few areas where China, Russia, and other former Soviet republics can field technologies capable of competing on the world market. Eight countries currently, with another seven countries that are either actively developing, or planning to develop a national launch capability. Eighteen countries can build satellites, and 20 own satellites. Also 15 international consortia and joint ventures are currently flying. This widely available space launch system capability translates into a proliferation of systems available for foreign military space applications. These include:

Launch Systems. Over 50 launch vehicles are currently in with 20 more just for LEO payloads (Figure 2.2 New Launchers Under Development For Leo Orbits) under development. This does not include the various space launchers derived from ICBM/SLBM launchers, as proposed by U.S., Russia, and Ukraine. Although it may be more cost-effective to buy launch services, many countries will develop their own capabilities for a combination of reasons, to include national security, prestige, the development of an indigenous industrial base, and ensuring that they are part of the wave of the future. Russia is offering cheap launch services, with the START vehicle quoted at $2M. Russia is also offering converted ICBM/SLBM launchers for cheap rates. The presence of an abundance of cheap launchers for small satellites to LEO/MEO may have the effect of developing a market for such satellites and accelerating acquisition of space capabilities by other aspiring nations.

Communications. The satellite communications industry is the most mature of all space industries, with most of the present and almost all of the emerging space communications systems are owned, built and launched by multinational consortia.

Positioning. Eight commercial companies are providing or advertising a global differential GPS service; INTELSAT is discussing development of an international system for the commercial market and European nations are discussing a regional system called Global Navigation Satellite System (GNSS). While some countries may be willing to depend on an international provider, it is highly likely other countries will develop their own pos/nav capability. Technology is available to do some fairly cheap systems in a region.

Early Warning. France, Saudi Arabia, WEU., Turkey, and Japan have expressed interest in space based early warning capabilities, and this number can be expected to grow as the ballistic missile threat increases. While many countries would be content to depend on some type of alliance consortium, many will want their own capabilities.

Reconnaissance. Ten countries have remote sensing systems, and the number will grow (Figure 2.3 Commercial Imagery Market). France, Italy, and Spain have collaborated on Helios 1A, Germany may participate in the $2.1B Helios 2, although Lockheed has offered Germany a 1 meter resolution satellite at 1/5 the cost of Helios 2 (~$400M). Germany is expected to take the lead on developing an imaging radar spacecraft, designated Osiris/Horus, at a cost of $2-3 Billion. A rapidly growing market is developing for products with Russia offering 2 meter optical and 5 meter SAR, and a number of other countries offering similar products. Three U.S. companies

Company Name	Launcher Name	Payload	Orbit	First Launch	Price	Status
Orbital Sciences Corp.	X-34	1,500 lb	100 n.mi., 28.5°	scheduled for 1998	$4-6 million	contract award 1995; in development
Lockheed Martin	LLV-1	1,750 lb	100 n.mi., 28.5°	2nd quarter 1995	$16 million	launch imminent
	LLV-2	4,000 lb	100 n.mi., 28.5°			
	LLV-3	8,000 lb	100 n.mi., 28.5°			
	Multi-Service Launch System		100 n.mi., 28.5°			in development
AeroAstro	Pac-Astro PA-X	225 kg	suborbital	late 1996	$1.6 million	in development
	Pac-Astro PA-1	1,150 kg	suborbital	1998	$6-7 million	in development
	Pac-Astro PA-2	250 kg	100 km			in development
	Pac-Astro PA-3	1,450 kg	1,000 km			in development
CTA	Orb-X	425 lb or 885 lb (polar or equatorial)	400 n.mi. polar or 200 n.mi. 28.5°	no date	$8-10 million	on hold
	Start	1,000 lb	400 n.mi. orbit	no date	$8-10 million	on hold
E'Prime	Eagle	3,000 lb	200 n.mi. circular	1997	$10-35 million	seeking financing
	Eagle S1	6,000 lb	200 n.mi. circular	1997	$10-35 million	seeking financing
	Eagle S2	10,000 lb	200 n.mi. circular	1997	$10-35 million	seeking financing
EER	Conestoga	1,910 lb	250 n.mi., circular	July 1995	$25 million price to BMDO in 1992; $18-19 million quoted today	launch imminent
Eurockot, Daimler Benz	Rockot	1,000-2,000 kg	500 km	Mid 1997	No price available	in development
Amroc	Aquila series Aquila A	1,000 lb	199 n.mi., 28.5°	No date set	No firm price; touted as low cost	on hold
	Aquila series Aquila B	3,000 lb	199 n.mi., 28.5°	No date set	No firm price; touted as low cost	on hold
	Aquila series Aquila C	4,000 lb	199 n.mi., 28.5°	No date set	No firm price; touted as low cost	on hold

Figure 2.2. New Launchers Under Development For Leo Orbits

are offering systems with 1-5 meter resolution, and six commercial systems have been licensed, with two more applications pending. Russia has offered several of its reconnaissance satellites for sale, and other countries are entering the competition. Ukraine is offering an advanced ocean monitoring spacecraft (OKEAN-O) which provides multi-spectral, optical radar and microwave systems.

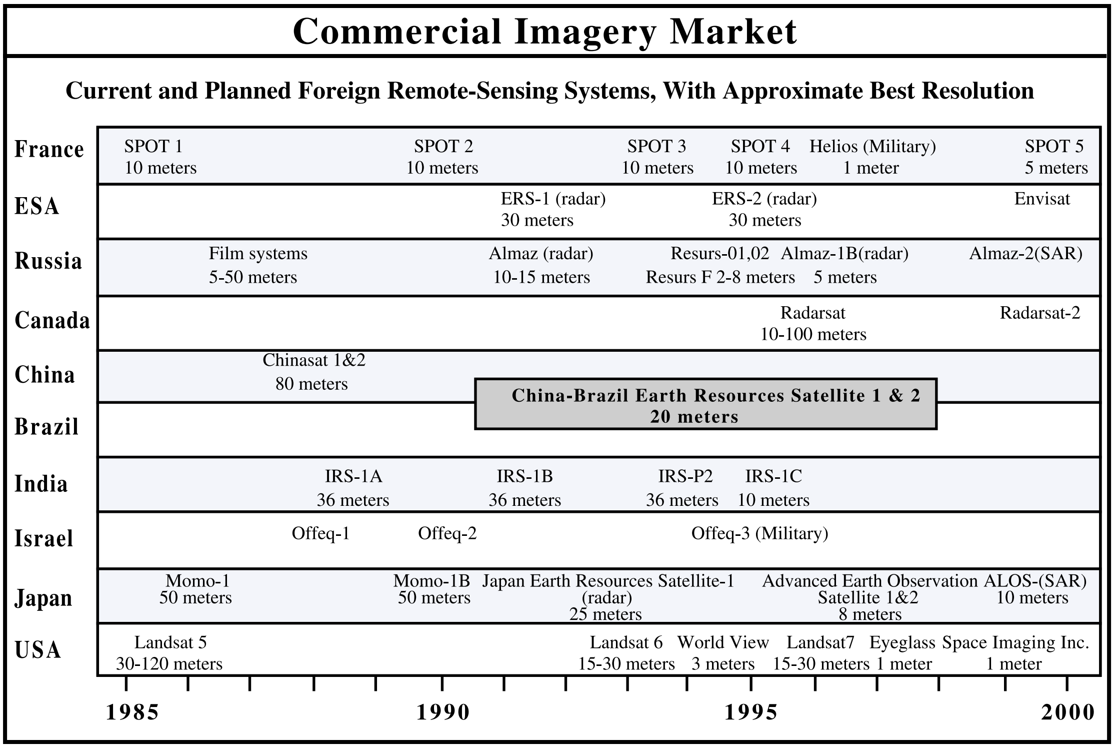

Figure 2.3. *Commercial Imagery Market*

Environment. Most countries will depend on international space weather data to supplement their ground based weather prediction capabilities. For example, the Europeans formed EUMETSAT, composed of 17 countries, and Canada is deploying a radarsat.

International Interdependency. International cooperation will increase, especially among the “have-nots.” Consortia based on alliances to provide needed capabilities can be expected to increase. Increasingly complex international relationships in space are likely, providing global access to space and a broad spectrum of players. For example, U.S./Russian cooperation is continuing and broadening to include, not only the Shuttle/MIR activities and international space station, but also cooperation in launcher developments, and the use of Russian rocket engines on U.S. and other international launch vehicles. European/Russian cooperation is continuing and broadening, with Russia evaluating European advanced cryogenic engines. Future U.S. space applications must accommodate this emerging cooperation in international space activities. This will include providing support to warfighters by exploiting international and civil sources of technology and services; the need for space control, some elements driven by national interests, others derived through international cooperation or alliances; and an uncompromising objective of maintaining U.S. global leadership in space.

At the same time, a proliferation of threats to U. S. space interests will evolve and would come primarily from primitive and not-so-primitive ASATs. Any country that has, or can build, a ballistic class missile can place any U. S. satellite in LEO (< 500 Km) at risk. However, to place a satellite at MEO (> 1500 Km) at risk requires an ICBM class booster, and even higher orbits require an SLV. Furthermore, there is a significant difference between attacking one or two satellites to achieve a political objective, and conducting a militarily effective campaign over time.

Other threats such as Directed Energy Weapons, High Power Microwave Weapons should be of little concern in the foreseeable future, except for threats from electronic interference. Other than a recovered Russia, no nation is likely to have developed sufficient capability to be able to gain control of space, although a number of countries, either industrialized, or those with sufficient money to buy sufficient ASAT capability may be able to cause damage.

A growing issue is the increased dependence of the U.S. on foreign suppliers of space system components and launch services. The threats to the ground segment also must be considered, but prudent planning to provide an adequate combination of security, defenses, proliferation, hardening, on-orbit autonomy, and cross-links, should provide sufficient protection for most conflict scenarios.

2.6 Military Space Systems and the Principles of War

As we can see from the foregoing, the world is a rapidly changing place - a place with continuously disruptive impact on even the best military planners' approaches to the architecture of our military forces. Without well founded underpinnings for our military force architecture, force structure and training , we often are accused of preparing for the next war by designing the last one. For this reason it is instructive to return to first principles when we examine the needs for our space architecture of the future. As the race of technology unquestionably establishes space as a future theater of war, it is important that we build an architectural foundation for space which draws on the principles of war. These principles have been stable over the ages, changing only in their implementation through technology rather than their fundamental thrust and provide general guidance for the conduct of war at the strategic, operational, and tactical levels.

As space capabilities are applied to terrestrial systems, they so change the terrestrial force capabilities that the application of the principles of war begin to change fundamentally. This in turn is reflected in the command, control, and employment of the forces, and even in the form of warfare that may be employed, and the very objective of the conflict may change as new means become available to influence the enemy decision maker.

Independent of what changes occur, just as with the concept of freedom of navigation on the seas, we must guarantee the right of free passage of U.S. and friendly flag carriers in and through space as well as deny that ability to space systems who threatens our national security interests in time of war. We must guarantee that free right of passage because space systems can make valuable contributions to our civil, commercial, and land, naval, air and space war-fighting forces, whether in day-to-day, peace time operations or as we employ whatever force is required to meet our national security objectives.

For years the military has considered space in the context of mission areas such as communications, navigation, or tasks such as space control and force enhancement. Much of the way we currently view space systems is channeled by these convenient, but often over-simplified definitional areas. Modern day thought about satellites stands where our thinking about the airplane stood at the early stages of World War I - as scouts or messengers. Most contemporary thought about the contribution of space systems to the military has started from today's requirements , and most of it, while making valuable contributions, has concentrated only on pointing out current shortfalls and describing how to make only incremental advances to today's state of the art. Those advances have been aimed at satisfying near-term requirements.

Looking ahead we should consider three types of contributions that space systems can make to future warfare: (1) as support to all terrestrial warfighting, (2) as support to individual land, naval and air components, and (3) as a separate, unique warfighting arena. In terms of Principles of War the impact that space systems can have on future warfighting can be described as follows:

Objective. - directs every operation toward a clearly defined, decisive, and attainable objective. Space provides the means for precise coordination of beyond-the-horizon land, sea, air and space operations and will contribute to the outcome of conflicts either as weapons or as critical parts of the military decision cycle. They will assist in the direction of fire and targeting of weapons, especially as space systems become critical parts of weapon loops. Increasingly, space control broadly defined as both physical control and information control will be a prerequisite for effective land, sea and air control.

Defense. - resists attack through appropriate operations, positions, or attitudes. Detection satellites will provide warning to terrestrial forces, giving the time needed to defend against attack and gain offensive initiatives. Information gathering provides indications of enemy actions and intentions and optimizes defensive positions. The proliferation and omnipresence of space assets will make defense of terrestrial assets much more difficult. The attack potential from space will stimulate the development of defensive weapons and countermeasures such as lasers, directed energy, and kinetic energy weapons.

Offense. - is a decisive way to seize, retain, and exploit the initiative, and with it, gain freedom of action to pursue the objective. Space operations provide the capability to project power globally, and disrupt, or even completely unhinge, an enemy's strategy by forcing the foe to react, rather than act, and conducting the conflict in a time and place of our choosing. Proliferated satellites will provide timely information to globally dispersed users, assisting coordinated offensive operations among multiple forces. Long range terrestrial offensive weapons supported by space systems will increasingly threaten all fixed and moving targets. Offensive operations against satellites will first include physical attacks from the ground and inevitably later from space. Farther in the future weapons in space are inevitable. The ability to strike with space-based weapons can produce substantial global threats. Such a capability will provide a strong incentive for the development of precisely targeted weapons from space to ground or space to space.

Surprise. - is to strike at a time, place, and manner for which the enemy is neither prepared, nor expecting an attack. The high dependence of the military on satellites will make space a good candidate for initiation of hostilities. Surprise strikes will result from satellite collection, and synchronization of those strikes involving separate force components will be aided by satellites. Strikes conducted directly from space will give a new surprise dimension to warfare. Satellites can also provide early warning of attack to reduce surprise.

Mass and Concentration. - focus of combat power at the decisive point in time and space. Rapid deployment and dispersal of forces will be aided by space systems, both to support normal operations for forces on the attack and to avoid attack. Using space systems precision target interdiction effectiveness will be considerably improved. Positioning satellites will provide a uniform position and time grid permitting massing, rendezvousing and refueling, close-in surgical strikes, and concentration of forces to take place with increased precision.

Concealment and Deception. - is to hide forces from observation; cover, mask, and disguise them; mislead, delude, beguile, and divert the enemy by all possible means. Specially designed systems can be used to assist in the detection and identification of camouflaged and concealed forces. Locations of military forces can be denied to space systems only by effective deception. Because of the multiplicity of space systems, deception against detection must be effective against many space systems, and the high probability against simultaneous deception of all space systems will be a major driver for the need of antisatellite weapons. Collection and dissemination of false data will deceive an enemy, while properly executed deceptions will draw an enemy to vulnerable locations. Effective use of maneuver and system design techniques will contribute to surprise, deception, and survivability.

Economy of force - calls for allocating minimum essential combat power. Space systems increase the effectiveness of terrestrial combat. Satellites will optimize target sets for strikes by a spectrum of weapons systems, and will reduce the need for organic assets. Space systems will allow a better determination of optimum attack/defense force ratios. In general the transfer of good information between ground and space-based assets will optimize the use of all weapons systems, assuring economy of action.

Maneuver, timing, speed and tempo - place the enemy in a position of disadvantage through the flexible application of combat power. The keys to effective use of satellites in wartime are rapid tasking, data collection and fast delivery of targeting information to the shooter. Such a process will operate in an environment of near real-time, near-continuous coverage of force movements by space systems. More accurate position determination from satellites, combined with accurate timing of maneuvers, will lead to better coordination of strikes and maneuvers, tighter operational timing, higher speed maneuvers, and more effective use of smart munitions. Better satellite-derived positions will permit forces to fight battles at more advantageous time and places, and allow the strategic direction to be rapidly changed, unhinging the enemy defense.

Deployment - is to rearrange forces for the attack, or spread them out to minimize the effects of enemy attack. Space navigation systems will provide very precise timing and position information for force deployments and the optimum, timely execution of those deployments will be improved. Vectoring of forces onto strategic and tactical targets will be more effective through the use of precise navigation information. The global communications provided by satellites will optimize deployment of forces; space will continue to be a major player in strategic deployment. A rapid on-orbit replenishment, replacement, or deployment capability for satellites will be required under most wartime military scenarios. Satellite deployment will consist of launched on schedule , surge on demand, or the activation of satellites stored on orbit.

Battlefield Friction, the Fog of War. - Varying levels of confusion exist during combat engagements. Denial of satellite-derived information will tend to blind operating terrestrial forces, reducing their effectiveness and slowing them down, and the disruption of satellite communications will be a major contributor to battlefield confusion. Since most satellites are unmanned, identification of the source of a "soft" attack on a satellite is difficult. Disruption of relay satellites will be a force multiplier in the fog of war, for many links to decision makers will take place simultaneously for many operating satellites through relay satellites.

2.7 Future Space Applications

As we apply space power to the principles and practices of war, it is critical to exploit space to attain and maintain information dominance of the future battlespace. As this revolution in military affairs is occurring - the major driver will be space systems support to the warfighter, producing a significant force multiplier effect. Space systems provide the capability of maintaining tempo of combat operations day/night and all-weather. The product is an integrated and synchronized terrestrial force such that decisive combat power can be applied at the desired time and place, thereby rapidly overwhelming the enemy with minimal friendly losses. This means we need a paradigm shift from the old way of thinking about space to new ways. We need a "system of system" approach, rather than the "stove pipe" approach of the past, The focus on future dedicated military systems has to include civil and commercial, national and international elements and technologies.

A major force propelling and shaping this paradigm shift is the importance of information. Information for most conflicts has become the center of gravity, and the capability to wage information warfare becomes essential to win. Information warfare may be more effective in collapsing the enemy than traditional military force. Furthermore, as information becomes increasingly pervasive, concepts for information based warfare will be developed, further changing the nature of warfare and force size, structure, and capabilities requirements.

The space systems role in information-based warfare has become central to military operations. Space is crucial for the "information" in information-based warfare, so that U. S. forces can respond to changing operating environments and advanced threats. A huge mass of data will be available from collection systems, and many different users, and this data needs to be processed into information to be useful to the warfighter. He needs just the right information at just the right time--day/night and all-weather. This means information fusion for true global presence. To create and distribute knowledge as a commodity, reliance will shift from large expensive national systems to integrated architectures of distributed systems and smaller tailored satellites deployed to support warfighters. Total awareness of the environment will become a necessity for global presence and with it the knowledge of who and where is the enemy and where are the friendly forces. The end goal will be the omnipresent view of the battle field in real time in all weather. It will require continuous world wide coverage of any location at militarily useful resolution in addition to exquisite information levels of special areas for technical intelligence.

Dominance of information based warfare requires control of space. Space control will be exercised at all levels of escalation by detection, denial, degradation, disruption and destruction. Passive and active protection measures will be taken for friendly space assets. Space warfare will expand to include not only LEO/MEO/GEO assets, but also military operations may well extend to the moon and Lagrangian Points, as well as deep space.

Eventually for the U. S. to exercise its superpower status it will be necessary not only to show global awareness and presence through space based information which would aid in lethal precision strike with submeter accuracy, but also to be able to project power from space directly to the earth's surface or airborne targets with kinetic or directed energy weapons.

Just as terrestrial geography is important to terrestrial operations, the geography of space and space weather will become important to space operations. Space debris will be controlled through international discipline and agreements, active avoidance measures and clean up. This will require synoptic monitoring of space debris.

A number of new or enhanced technologies will emerge, to include the following:

- Technology for multi-spectral and hyper-spectral imagery, distributed optical phased array apertures and efficient transmit/receive modules to facilitate comprehensive surveillance platforms using all appropriate bands of the electromagnetic spectrum
- Real-time, all source intelligence fusion in command centers and readily available by push or pull by user at all echelons
- Massive on board processing to facilitate reliable automatic target recognition and target damage assessment
- Space based submarine detection and real-time ship tracking
- Space relay of terrestrial data free of bandwidth limitations
- Improved, non-jamable positioning information on weapon and target location at all times providing weapon delivery with centimeter accuracy
- Routine global, real-time equipment/logistics monitoring and reporting system
- Information on demand will be available to the local commander anywhere on the globe anytime. Local theater exclusions and enhancements will be developed to fight wars without disrupting global commercial operations.
- Power beaming to transmit energy to space and energy from space to ground will become a major element of space operations. We will learn to use tethers in space for survivability and exchange of power for energy to affect space maneuvers.
- Completely internetted information systems will change the way our armed forces fight. Human machine interfaces will be anthropomorphic leading to eventual human/satellite fusion. Humans will be able to manage at higher levels and let the machines assign and do specific tasks.
- The deployment of a robust space transportation system composed of reusable and expendable launch vehicles which will make access to space affordable and

provide services at cost competitive to airborne/ground systems with better global presence and timeliness will be completed. The space launch capabilities will include launch on need, transatmospheric vehicles, and a capability to place payloads in moon, and deep space orbits.

While the decades-long debate on the utility of military human in space still continues, it has been clear that space systems are manned by military personnel on earth. Looking to the future, military operations may well require that military personnel operate in space if the value of trained observers operating in conjunction with other equipment proves to be significant. The application of human capabilities applicable to on-orbit operations has been tempered by the constraints on men operating in a hostile space environment and the associated high costs. We need to gain better understanding of the man/machine trades relating to space support such as maintenance/assembly activities or an R&D laboratory to develop optimum designs of space systems and to determine the optimum mix of manned and remotely-controlled space systems for cost-effective space operations.

Complicating such a program is the difficulty in developing a dedicated military system. A manned military laboratory could be part of the International Space Station, but there are obvious drawbacks in establishing and operating a military laboratory in an international environment. If other countries have modules dedicated to national activities, such drawbacks may be mitigated.

A Summary Vision: Information-based warfare is creating a paradigm shift for space forces. They must be global, routine, timely, reliable, trusted, user friendly, just enough, survivable, affordable, and with a goal of creating a unified battlefield. These capabilities, which evolve from the "system of systems," resulting from space application "push" will cause fundamental modifications in the employment of terrestrial systems that implement the principles of war.