STRATEGY RESEARCH PROJECT

THE DIMMING OF JOINT VISION 2020: A CONCERN THAT THE LACK OF MILITARY SATELLITE COMMUNICATIONS WILL IMPEDE THE FUTURE FORCE

BY

LIEUTENANT COLONEL STEVEN G. FOX
United States Army

USAWC CLASS OF 2001

U.S. ARMY WAR COLLEGE, CARLISLE BARRACKS, PA 17013-5050

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LTC STEVEN G. FOX
UNITED STATES ARMY

PROFESSOR MALCOLM C. COWLEY
PROJECT ADVISOR

U.S. ARMY WAR COLLEGE
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

AUTHOR: Lieutenant Colonel Steven G. Fox, U.S. Army

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Given the lack of political will to reverse the drawdowns of the military force structure of the 1990s, our National Military Strategy will continue to emphasize a strategy based on the ability to project forces quickly and as lightly as possible. Joint Vision 2020 (JV2020) articulates that in future warfare "information superiority" is a fundamental enabler to successful operations. To achieve information superiority, it will be crucial that the deployed warfighter has extensive communications connectivity on demand to move information when and where it is needed. The Global Information Grid (GIG) is a concept envisioned as a global, network-centric, end-to-end set of information systems where communications are fully integrated with computing, applications, and weapons systems. The GIG's requirement for communications infrastructure will increase as JV2020 becomes reality. Many senior leaders, joint architects, and planners understand the benefits that information based systems and weapons bring to a force. As processors and applications become more sophisticated, designers often overlook that the need to communicate data among geographically dispersed users is increasing beyond projected capabilities. Historically there has been a mismatch between satellite communications (SATCOM) capabilities and operational requirements. To move from yet to be realized legacy SATCOM systems of the next ten years to advanced programs of the 2010s requires an enormous amount of organizational discipline and programmatic truthfulness. Using SATCOM as the primary means for network connectivity to operationally deployed forces is essential for the JV2020 force. Depending upon commercial communications systems to augment military capabilities is likely to leave warfighters short of needed connectivity and lacking in information superiority. Fundamental to achieving JV2020 for deployed forces will be a reliable, responsive and well-sized military satellite communications (MILSATCOM) architecture that does not rely upon commercial systems.

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2020 SCENARIO

It is the year 2020 and a small streamlined Joint Task Force (JTF) forms overnight for a mission in some forgettable corner of the world.[1] Like many JTFs during the first two decades of the century, the mission concerns a region of the world where there is little political and ethnic stability or commercial viability. As a consequence, it is a region with limited infrastructure.

The JTF commander is optimistic. The U.S. force is the most modern in the world and is equipped with the latest in information technologies; smart sea-, land- and air-based weapons systems are all capable of being networked together to provide situational awareness and an accurate common operational picture. DoD has performed several simulations and exercises preparing for such a contingency that falls within the "Full Spectrum Dominance" doctrine developed at the turn of the century.

Anticipating the feed of national-level sensors (e.g., satellites or electronic listening posts, seismic and acoustic systems, etc. . .), the JTF commander expects he will receive additional information from local and long-haul data collection platforms under his control (e.g., AWACS, JSTARS, AEGIS, Global Star UAV, etc. . .),[2] supported by information from tactically deployed and dispersed air, water and ground sensors of various types.[3] Even during the early stages of operations before information pours in at a fervent pace, the JTF commander expects that the initial amount of information will still be more than any human can handle. The commander is ready because the JTF employs automated information management processing systems with well trained operators standing by to analyze, dissect, apportion, and disseminate information to various and widely dispersed subordinate elements. The flood of data never comes.

As the operation continues, instead of the expected flood, the JTF commander receives only a trickle of information. Like rush hour traffic, the data is jammed; the communications network is at full capacity trying to fulfill the data transmission requirements of sensors, weapons, and collection platforms. Weapons systems requiring information for targeting fail to finalize target solutions. Dispersed and isolated land forces are unable to synchronize their efforts.

The network cannot handle the initial surge during this real-world operation. Unable to transmit the right information to the right place at the right time, the JTF fails to perform as planned. With the mission at risk, the JTF commander begins to understand the consequence of underestimating the network-centric communications requirements of real military operations.

FUTURE CONCERN

Given the lack of political will to reverse the drawdowns of the military force structure of the 1990s our National Military Strategy will continue to emphasize the ability to project forces quickly and as lightly as possible (i.e., minimal logistics, airlift, and equipment). Joint Vision 2020 (JV2020) articulates that in future warfare "information superiority" is a fundamental enabler to successful operations. Force projection in 2020 requires the ability to achieve information superiority through a reach back capability. To achieve information superiority, the mobile and deployed warfighter must have extensive communications connectivity to move information on demand when and where it is needed.

Developing communications architectures for the future is complicated by the desire of DoD to pursue the Global Information Grid (GIG). The GIG concept envisions a global, network-centric, end-to-end set of information systems in which communications are fully integrated with computing, applications, and weapons systems. For future weapons systems to function effectively, it will be vital that the military communications architecture be designed to handle surges and provide global service, particularly to units deployed in areas with limited communications infrastructure.

The GIG's requirement for communications infrastructure will increase as we implement JV2020. Many senior leaders, joint architects, and planners understand the benefits that information based systems and weapons bring to a force. As processors and applications become more sophisticated, designers often overlook that the need to communicate data among geographically dispersed users is increasing beyond projected capabilities. The increase is not readily apparent to joint architects and planners due to the inaccurate forecast of communications requirements to support individual weapon systems and the complexities of predicting multi-theater intra- and inter-communications requirements.

This paper will present a concern that military forces will depend upon military satellite communications systems that will have neither the capacity nor the reliability to meet crucial operational requirements. Using satellite communications (SATCOM) as the primary means for network connectivity to operationally deployed forces is essential to JV2020 force implementation. Historically there has been a mismatch between SATCOM capabilities and operational requirements. The transition from yet to be realized legacy systems of the next ten years to advanced programs of the 2010s requires enormous organizational discipline and programmatic truthfulness. Using commercial communications systems is likely to leave warfighters short of needed connectivity. As a consequence, they will lack information superiority. Fundamental to achieving JV2020 will be a responsive, reliable and well-sized military satellite communications (MILSATCOM) architecture for deployed forces.

JOINT VISION 2020

JV2020 describes the nature of modern warfare in the information age. The JV2020 document articulates a vision of four interdependent warfighting concepts: Precision Engagement, Dominant Maneuver, Focused Logistics, and Full-Dimensional Protection. These pillar concepts allow the United States "Full Spectrum Dominance" (Figure 1)[4]. Full Spectrum Dominance refers to the ability to conduct a full range of military operations from humanitarian assistance, through peace operations, up to and into the highest intensity conflict.[5]

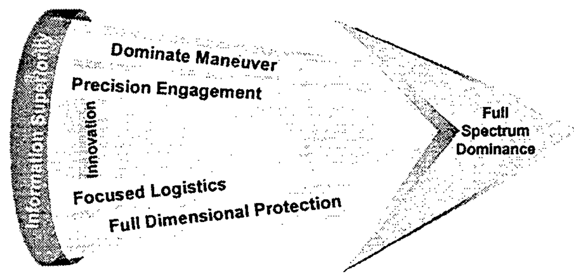

FIGURE 1 – JOINT VISION 2020 FULL SPECTRUM DOMINANCE

INFORMATION SUPERIORITY

The JV2020 document describes information superiority as the fundamental enabler for future warfare. In simple terms, information superiority[6] means "getting the right information to the right people at the right time in the right format while denying an adversary the same capability."[7] Information superiority is achieved when friendly forces have the information they need to efficiently achieve operational objectives.

While the creation of information superiority is not an end in itself, it is a required step towards conducting a full range of military operations. Taking this step yields a competitive advantage when information is translated by information systems and people into superior knowledge and superior decisions.[8] The competitive advantage will emerge from the commander's ability to share the common operational picture. The common operational picture allows for collaboratively planned strikes and retargeting of weapons platforms in near real time. The effect is the acceleration of battle tempo by reducing decision cycle times. Superior knowledge, such as a common operating picture, is obtained by integrating information operations with battlespace awareness and all-source intelligence, surveillance, and reconnaissance.

The central nervous system of this integrating process is a robust network that provides an "unblinking eye" across the expanded battlespace through continuous Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) coverage. The C4ISR network must support a dynamic operational tempo, seamless sensor-to-shooter and command and control linkages, as well as an enhanced reach back capability to the sustaining base. In pursuit of achieving information superiority, DoD is developing an open C4ISR architecture that will facilitate the development of revolutionary improvements in joint military capabilities.[9] One of the components of C4ISR will be the Global Information Grid (GIG).

GLOBAL INFORMATION GRID (GIG)

JV2020 explains that information, information processing, and communications networks are at the core of all military activity. The key to obtaining information superiority is a joint concept labeled the (GIG).[10] General Shelton, Chairman of the Joints Chiefs of Staff, told Congress "an important aspect of future operations will be the development of a Global Information Grid, or GIG, to provide the network-centric environment required to achieve information superiority."[11] The foundation for obtaining information is the communications network that provides raw data for processing and for dissemination of processed information—now called knowledge—to the right fighting element.

The GIG is envisioned as a network-based globally interconnected end-to-end set of information capabilities that provides information on demand to warfighters at all echelons.[12] The architectural framework of the GIG is comprised of weapons systems, connectivity, computing capabilities, applications, basic foundation concepts, network operations and information management (Figure 2[13]).[14] The overarching system-of-systems approach will not only interconnect information systems to improve the ability to employ weapons beyond line of sight but also to enable the use of "massed effects instead of massed forces."[15]

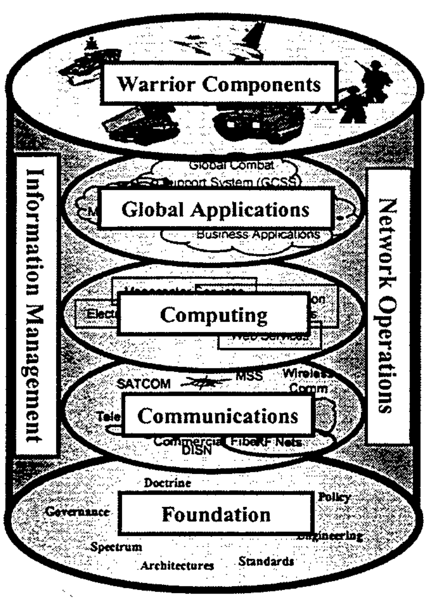

FIGURE 2 – GLOBAL INFORMATION GRID CONCEPT

COMMUNICATIONS NEEDS

The GIG's requirements for communications infrastructure will increase as JV2020 becomes reality. Table 1[16] shows the growing variety of information requirements for supporting future warfighting. These span strategic through tactical requirements.

Warfighting Functions	Information Capabilities
Mobile Command and Control *Collaborative Planning* *Cooperative Engagement* *Battle Management*	C2 Networks and Video Teleconferencing Interactive Common Operating Picture Interactive Data Networks and Distributed Databases (e.g. NIPRNET, SIPRNET, Contingency Theater Air Planning System [CTAPS], Global Command and Control System [GCCS], etc.) Trunked Common User Voice and Data Networks
Intelligence, Surveillance, and Reconnaissance (including Geospatial and Environmental data)	Sensor and intelligence data (Direction, collection, processing/production and dissemination) Imagery and related products Video Applications Terrain Visualization and AOR and Site Updates Maps-Charts-Geodesy Weather and Oceanographic reports Navigation, Position Locating, and Reporting
Precision Strike	Automatic Target Recognition Wide Area Targeting OTH/BLOS weapons/sensors control & feedback (including BDA) Mission Data and target/threat updates Enroute Communications Dual Phenomenology Sensor Coupling Cooperative Engagement; Combat Identification Automatic Weapon/Target Pairing; Missile Defense
Theater and Strategic Warning and Surveillance	Missile Warning Reconnaissance, Acquisition, Targeting
Training and Planning	War-game/Simulation; Course of Action Analyses Decision Support Tools Proficiency Training and Mission Rehearsal/Preview
Combat Support -- Logistics, Personnel, Finance, Transportation, Strategic & Tactical Lift, Contracting, etc.	"Reachback" of deployed forces to the "split"/sustaining base Telemedicine, Tele-maintenance, Tele-training Distributed Databases and Networks (e.g., Global Combat Support System [GCSS]) "In-Transit Asset Visibility (ITV)", "Just in Time" Delivery Movement Tracking System Global Transportation Network (GTN) Joint Mobility Assistance Teams (JMAT) Morale, Welfare, and Recreation Activities
Space Support	Satellite Control Space Surveillance and Tracking, Space C2 Space Launch Support

TABLE 1—GROWING INFORMATION REQUIREMENTS FOR JV2020

Heuristically, the smaller the force structure the greater the need for better command and control. The fewer troops, aircraft, or combat ships available to the commander, the more critical his assets become since there is less to lose to the "fog of war." Since these assets are limited and the lethal nature of future warfare will render them vulnerable, the commander will widely disperse them throughout the area of operations to improve survivability. This beyond line-of-sight or over the horizon dispersal will exceed communications equipments' range.

Commanders enlarge communications demands by: embracing internet-like technologies; increasing numbers of nodes to which intelligence and orders must be transmitted; desiring video teleconferencing; requiring on-the-move capabilities; and pressing for more timely and comprehensive intelligence as a means to cope with the increased size and tempo of the battlespace.

Precision weapon systems and sensor-to-shooter systems will also require additional communications for coordination and synchronization. An Achilles heel of modern weapon systems and sensors is that accurate near-real time information is required by the weapon system to process and engage targets and by the commander to effectively deploy combat assets in support of the operational plan. The more dispersed the force, the more dependent it becomes upon the various weapon systems to act as force multipliers. Any lack of communications results in a larger operational shortfall. As our forces and weapons become increasingly dependent upon information based systems, these systems can act as force dividers and can precipitate increased casualties, if proper connectivity is not assured.

The unintended consequence of an increased reliance on information technologies is an acute dependence upon an uninterrupted flow of quality information to support military operations. This dependence has created a growing information flow vulnerability. It is not likely that science holds a magic fix in the form of data compression algorithms, more efficient bandwidth transmissions (e.g., Asynchronous Transmission Mode (ATM)), or reduced data flow software standards. While these technologies provide some improvement, the prediction is they will not be efficient enough to meet the growing demand. Technologies that significantly or radically alter our manner of conduct—the automobile, modern medicine, precision warfare, phones and computers—result from many small discoveries and incremental improvements.[17] If there is going to be a revolution in communication technologies by 2020, one should have an inkling of those technologies now. Anyone following information technologies can observe that the demand for the amount and reliability of communications is accelerating and shows no sign of slowing.

Generally, network-based distributed information systems are engineered to support users in a benign steady state or non-dynamic load condition. Networks do not react well to surge loading. Due to limited communications capacity during surge loading, a network can quickly become over subscribed causing every subscriber's service to suffer.

Since Advanced Warfighting Experiments (AWEs) technologies are frequently adopted into future systems, they can ultimately contribute to unanticipated network loading. AWEs, designed to flush out new concepts and technology, are conducted under artificial communications environments. Often communications dependent technology tends to excite senior leaders based on overall outcome, but do so without clarifying how vital a role communications play. For example, during the mid-1990's, senior Army leaders were given a demonstration of the first digitized brigade demonstration/exercise at Fort Hood. What was not advertised was that units were dispersed in a manner that line of sight communications or fixed-post communications could be used.

Experience shows DoD has traditionally underestimated communications—especially SATCOM—requirements necessary to support Operational Plans (OPLANs). During Desert Storm, the U.S. underestimated the surge requirements for deployed SATCOM and many of the networks became saturated.[18] There must be a balanced approach toward developing the GIG. The lack of development of any one component, such as deployed terrestrial or satellite communications capabilities, impacts the whole GIG concept.

COMMUNICATIONS REALITY FOR FUTURE DEPLOYED FORCES

The warfighter must have extensive connectivity on demand to move information when and where it is needed. The GIG's challenges of filtering, processing and fusion of information is frustrating enough, but the most forbidding challenge will be dissemination and receipt of information across the battlespace. Developing JV2020's basic communications connectivity, which is compounded by dispersion of forces, increased data requirements, reduced force structure, and an increased operational tempo, is a formidable task. The task gets harder unless SATCOM is given a high priority and utility within the GIG's operationally deployed architecture. Focusing on non-SATCOM alternatives as primary connectivity to deployed forces is a recipe for disaster for the joint force of 2020.

SATELLITE COMMUNICATIONS

Using satellite communications as the primary means for network connectivity to operationally deployed forces is essential for the JV2020 force. There are several reasons or this. First, network-centric systems are all digital. Digital requirements associated with information systems and communications to link them will continue to increase data transmission requirements. A SATCOM architecture can easily support digital transmissions and can be engineered to meet capacity requirements.

Second, the relationship between the nature of future combat, strategy, and technology will continue to evolve operational communications requirements away from terrestrial systems, until requirements will only be satisfied by massive increases in satellite communications.[19] The small, dispersed and mobile nature of our future forces, along with the doctrine to project force from the United States and overseas bases, requires SATCOM technology. SATCOM is a technology, which is available on-demand that "can span beyond line of sight and support mobile and rapidly relocatable air, sea, and land platforms in all military mission environments and locales."[20] Communications technology suitable for fixed base, post, or camp locations, such as terrestrial communications systems, does not work at sea or across deployed large theater or regional areas of operations.

SATCOM facilitates communications over long or short distances. SATCOM addresses the needs of a mobile widely dispersed joint force providing instant accessibility, survivability, coverage, flexibility, mobility, and global reach.[21] This is especially true for remote locations with limited infrastructures.

Finally, SATCOM is interoperable across service, agency, and coalition boundaries on a large geographical scale.[22] The U.S. prefers to fight as part of a coalition. Although we have reliable allies, it is unknown which countries, currently not aligned with the U.S., will be coalition partners. Multinational interoperability is difficult to plan.

ALTERNATIVES TO SATELLITE COMMUNICATIONS

Although land-, sea-, and air-based communications systems are important capabilities, they do not meet all the warfighter's information needs. Alternatives, such as Unmanned Aerial Vehicles (UAV), line-of-sight radio systems or fiber/cable systems, are specialized solutions that will contribute to the GIG. None of these options provide the necessary mobility, flexibility, coverage, or global access that forward deployed units need. They will supplement—not replace—MILSATCOM as the primary GIG component for deployed forces.

The UAV study conducted by ASD (C3ISR & Space) shows cost effectiveness for narrow-band communications (less than 64 kilobits per second (kbps)[23]), but are not cost effective for wideband communications (greater than 1.54 megabits per second (mbps)[24]).[25] From an operational point of view, UAVs introduce issues associated with: deconflicting air space in what military pilots might already consider crowded; vulnerability to attack; regional coverage that lacks global reach; frequency management; and duration on station. It is acknowledged however, there will be significant advances in UAV technology over the next twenty years. For example, with support from NASA, AeroVironment has developed an UAV solar-electric airplane, which is capable of continuous flight for six months at 60,000 feet (stratosphere)—above the weather and commercial traffic.[26] While future UAVs will be impressive by today's standards, they will still be less reliable than space-based communications and still provide only regional coverage. UAV reliability is important since providing assured communications is essential. Although UAV technology was new to the battlespace, it is still noteworthy that during the 78-day Kosovo air operation, NATO lost between 20-30 UAVs. They were either shot down or suffered technical failures.[27]

Line of sight systems are not flexible, mobile or global. They require extensive time for engineering and set up, a larger communications support force structure and tend to have a large deployment footprint restricting their mobility during a crisis. Since they are line of sight systems, they are also not suitable for all types of terrain.

Fiber optic or traditional metal cable systems cannot duplicate certain functions for which satellites are ideally suited. The primary drawback of fiber is its lack of mobility and flexibility in a theater of operations.[28] This is acute in areas of the world where the infrastructure is limited and fiber has yet to be laid. According to a National Space Security Architect study, a large number of worldwide secured fiber entry points are required for assured global access. To assure continuous access, combat forces are required to protect the fiber route since fiber is easily cut. Ships at sea do not have access. Finally, quick access at "H-hour" or during early entry is unlikely or impossible operationally due to security issues, as well as practical technical "hook-up" considerations. Access at anytime may require host nation cooperation.[29]

SATELLITE COMMUNICATIONS

REQUIREMENTS

Satellite communications requirements can be thought to have two dimensions, "quantitative and qualitative."[30] The capacity needed in terms of the numbers of subscribers within a network and the throughput or data rate required is considered quantitative. In contrast, qualitative requirements are quality metrics such as amount of coverage, protection, survivability, control, security, ruggedization and interoperability.[31] Both quantitative and qualitative requirements are documented in the Joint Staff and Services developed Integrated Communications Database (ICDB) and the Emerging Requirements Database (ERDB) maintained by DISA. The ICDB contains a consolidated repository of currently validated DoD SATCOM requirements and the ERDB identifies all projected future SATCOM

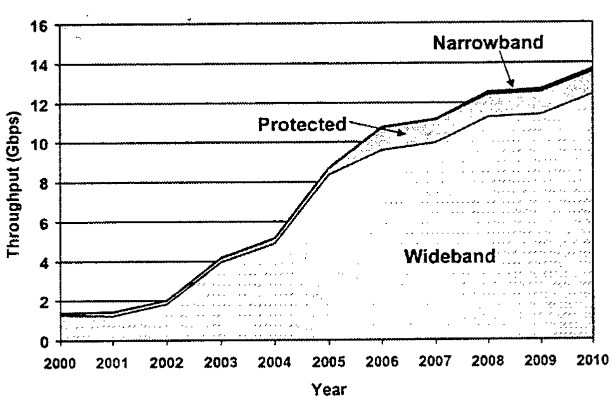

FIGURE 3—SATCOM REQUIREMENTS FOR A COMBINED THEATER OF WAR

requirements two years or greater into the future. The Joint Staff and DISA further group requirements into three sets of common characteristics: wideband, protected, and narrowband.

Quantitatively, the ERDB shows a growing appetite for communicating information via satellite. Figure 3[32] shows the projected growth in SATCOM requirements for a combined major theater of war. The 1997 SATCOM Senior Warfighter Forum's (SWarF)—forum of representatives from OSD, Joint Staff, Unified CINCs, Services, and Agencies—predicted capacity requirements of 10.6 gigabits per second (gbps).[33] This requirement was revised after the Spring 2000 meeting to 13.7gbps.[34] This represents nearly a 30% increase in predicted capacity requirements. Since Operation Desert Storm, DoD has been experiencing increasing demands from all echelons for MILSATCOM.[35] DoD will continue to see future increases in capacity demands.

Wideband services meet significant demand for global high capacity and broadcast communications. This type of requirement represents the bulk of the MILSATCOM capacity requirements.[36] Wideband data rates are equal or greater than 64 kbps, but are normally in the

Characteristic	RATIONALE (WHY REQUIRED)
COVERAGE	Global national interests and threat environment. Regional conflicts/crises unpredictable in location, time, intensity and duration. Smaller US force structure; globally dispersed land, sea, air, and space operations. Time and geographically varying user population densities.
CAPACITY	Warfighter information demands are growing in response to doctrine and technology. Information + C4ISR + Precision Munitions = Combat Power. Connectivity cannot be a limiting factor in the application of combat power. MILSATCOM = Assured warfighter connectivity when/where needed. MILSATCOM provides dynamic, multiple information transfer capabilities.
PROTECTION	Our C4I is a prime target and a center of gravity which we expect adversaries to attack. Must deny adversaries the ability to decapitate our C2 and ISR capabilities. Nuclear deterrence remains a top DoD priority (and requires survivable C2). Must provide anti-jam, protection from SIGINT, information security,and other defensive information operations measures.
ACCESS AND CONTROL	Access to information and comm. on-demand: fundamental need of the warfighter. Warfighters must have control over their information and MILSATCOM domains. Military resources must be rapidly and dynamically reconfigured to respond to changing operational situations and priorities.
INTER-OPERABILITY	MILSATCOM is the space portion of the Defense Information Infrastructure. Most operations are joint in nature and execution (Land, Air, Naval, Mobility, Combat Support and Special Operations Forces). US Forces conduct missions with Allies, Coalition Partners, and Government Agencies. Warfighters use a variety of communications to effect needed information transfers.
FLEXIBILITY	Warfighters prosecute military operations across a wide spectrum of conflict. Need to accommodate evolving doctrine, requirements, threats, technologies. Emphasis is on fast-paced mobile operations. A wide variety of operating frequencies is required to support the warfighters' needs. Warfighters' must make efficient use of limited frequency spectrum. Systems should be reliable, easy to use, and safe to operate.
QUALITY OF SERVICE	Supported warfighting and combat support systems drive performance criteria. Information must be transferred accurately and unambiguously.

TABLE 2—SATCOM REQUIRED SYSTEM CHARACTERISTICS

megabit per second range. These requirements have seen the largest growth within the last ten years and it is expected that they will continue to rise beyond current projections.[37]

Protected SATCOM capacity requirements, such as anti-jam and low probability of intercept or detection, are reserved for those users who must operate in nuclear or jamming environments and/or have special requirements for protection from interception and analysis or information attacks. Protection requirements are technically difficult to satisfy due to high developmental costs and changing threats. Operational commanders will generally prefer protected anti-jam satellite communications versus non-protected, but not at the expense of lower throughput capacity. There is an inverse relationship between capacity and protection. If the force of 2020 is to rely on assured and deployable communications, then it is likely that protected SATCOM requirements will increase.

Narrowband service, less than 64Kbps, is generally for mobile users who must maintain communications in a quickly changing environment. Many of the requirements in this area are for tactical land and sea forces, special operations, command networks at all echelons, and data links.[38]

The United Space Command developed the April 1998 Advanced MILSATCOM Capstone Requirements Document (CRD), which qualitatively defines seven technical system characteristics based in part on the ICDB and the ERDB. Table 2[39] summarizes the satellite technical characteristics and why they are required. Depending on the mission, the importance of the parameters will vary. These capstone parameters are used to help develop new program's Operational Requirement Documents (ORD).

Other considerations are the relationship between throughput, capacity, and coverage in terms of dispersion of users, mobility, and protection. Figure 4[40] shows the relationship of throughput to various parameters. Technology continues to increase terminal throughput but not likely enough to completely satisfy requirements. Asynchronous Transmission Mode (ATM) technology is one such technology that is helping. Unit dispersion, the need to service an

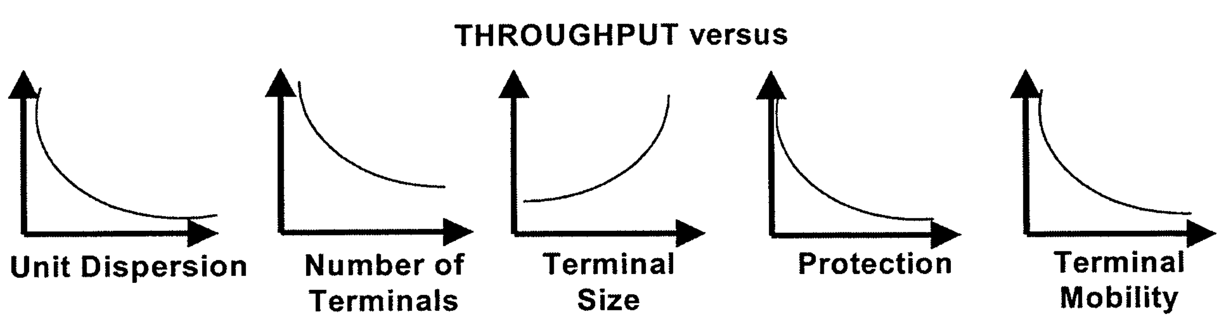

FIGURE 4—SATCOM CONNECTIVITY VARIABLES

increased number of terminals, and the requirement for mobility counter balances many of the throughput gains brought about by technology.

ARCHITECTURE

Satellite communications systems are not inexpensive. Over the last ten years, communicators have had a tough time convincing senior leaders, who control the purse strings, that requirement increases occurring were real and have impacts on weapons systems employment.[41] During the 1990s, DoD grappled with developing a coherent Military Satellite Communications (MILSATCOM) architecture. DoD senior leaders concerned about funding still

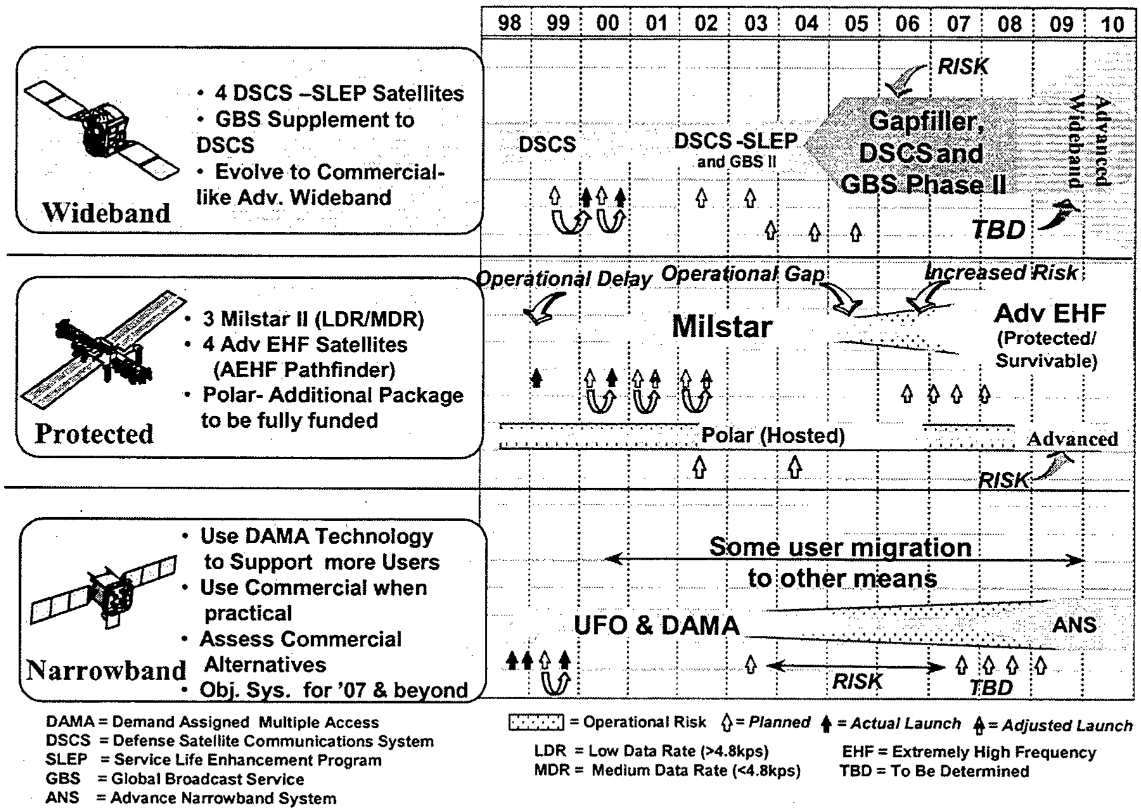

FIGURE 5—MILSATCOM ROAD MAP

debate how much of the projected demand must be met with military systems and how well commercial satellite services might reliably fulfill the remaining needs.

Military Architecture

In 1997, the SWarF crafted the initial MILSATCOM roadmap and validated it with the Joint Requirements Oversight Council[42] (JROC). The current roadmap depicted in Figure 5[43] is meant to guide the DoD Space Architect to develop a "systems-of-systems" architecture.[44] This architecture takes into account in varying degrees the required satellite characteristics: coverage, protection, access and control, inter-operability, flexibility, and quality of service. The main shortfall is a lack of capacity that represents an operational risk.

The road map details the approach for Wideband, Protected, and Narrowband and a migration strategy for each. Assuming that satellite systems have a life expectancy between seven to ten years, the roadmap represents a significant portion of the kind of capabilities that will be on hand during 2020. Designers of other systems not yet approved or proposed will have to begin formal discussions within the next two to three years. This is especially true if there are major technology departures from current capabilities. Figure 6[45] shows the future capacity demand versus what the future architecture will bring. There is a capacity shortfall within all three categories. The figure shows a significant mismatch between current requirements and capability.

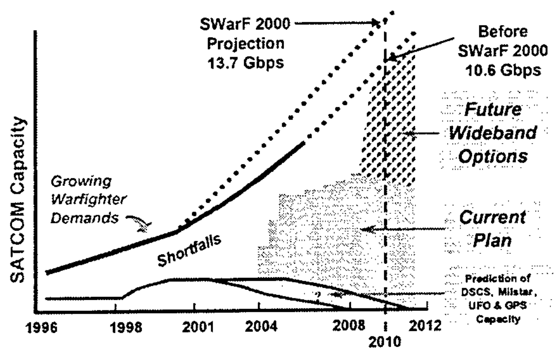

FIGURE 6—GROWING SATCOM DEMAND VERSUS ARCHITECTURE

The strategy for wideband communications services is to launch the four remaining Defense Satellite Communications System (DSCS) satellites. These satellites include the Service Life Enhancement Program (SLEP) that will provide the warfighter with three times the worldwide tactical capacity available today. Global Broadcast Service (GBS) payloads on the Ultra-High Frequency Follow-on (UFO) will supplement the DSCS system. Starting in 2004, three Wideband Gapfillers will be launched to reduce a growing gap between tactical wideband requirements and capabilities. A more capable "commercial-like" Advanced Wideband System will be launched around 2008.[46] The design for this system has not yet been determined.

Protected services use the Extremely High Frequency (EHF) band along with a specialized waveform to provide some resistance against degradation, disruption, denial, unauthorized access, or exploitation of communications services by adversaries or the environment. The goal is to provide as much capacity for DoD's protected and survivable requirements as possible.

Protected SATCOM communications' strategy is to launch four Milstar II satellites by 2002 as planned, followed by the initial launch of a more capable Advanced Extremely-High Frequency (EHF) system in 2006.[47] EHF systems cost more than non-protected systems relative to the amount of information they carry.

Narrowband strategy is to use ground-based Demand Assigned Multiple Access (DAMA) technology to provide service to tens of thousands of users. However, user duty-cycle demand cannot exceed assumed expectations. As the number of subscribers increases the service degrades in reliability and quality.

The narrowband strategy is to supplement the current constellation with a satellite in 2003 and to maintain the system through 2007 to provide networked, multi-party and point-to-point links. In 2008, DoD plans to launch a UFO replacement system known as the Advanced Narrowband System or Mobile User Objective System (MUOS).[48]

Commercial Satellite Augmentation

The roadmap (Figure 5) does not illustrate that in order for DoD to meet operational mission requirements the plan is to augment DoD-owned systems with commercial SATCOM. It is DoD's strategy to transition from current systems to the future architecture by leveraging commercial satellite communications to the maximum extent possible.[49] This is due in part to lessons learned from Desert Storm, and pressure from Congress incorrectly thinking commercial leasing is less expensive.[50]

The use of the Orion satellite transponder in support of the Joint Broadcast System in Bosnia is an example of augmentation. The Defense Information Switched Network[51] (DISN), and Defense Information Systems Agency's (DISA) Commercial Satellite Communications Initiative (CSCI), and INMARSAT, INTELSAT and others are examples of situations in which DoD regularly uses commercial SATCOM when it is feasible.[52]

Commercial SATCOM has grown at an explosive rate during the 1990s but does not satisfy all of the required military satellite characteristics defined in Table 2. Coverage, protection, and access and control will present the greatest challenges. Commercial satellites have enormous capacity as a whole but are unevenly distributed geographically.[53] In geographic regions where there is little demand (e.g., Africa), commercial solutions may still be sparse.[54]

Commercial users (e.g., banking industry) have not experienced loss significant enough to raise their consciousness; consequently, there is little commercial interest in trying to satisfy DoD protection requirements.[55] Commercial SATCOM is vulnerable to "cheap kills." Required features to counter jamming or nuclear-induced threats are not yet cost effective for the commercial industry.

The Access and Control criterion is supportable, if DoD has exclusive rights use. Exclusive rights may not include reorientation of coverage if it interferes with other customers.

Consortiums of nations own many of the commercial systems. These nations do not necessarily have to grant U.S. military access in time of need. Some satellite system's owners forbid use in support of military operations. There is also the issue of securing the permission of host country (i.e., landing rights) to use commercial systems in sovereign countries; in some countries it takes years.[56] Figure 7[57] illustrates the approximate time needed for obtaining landing rights. While we can anticipate that previously negotiated landing rights will be adequate for some future operations we cannot assume that will always be the case.

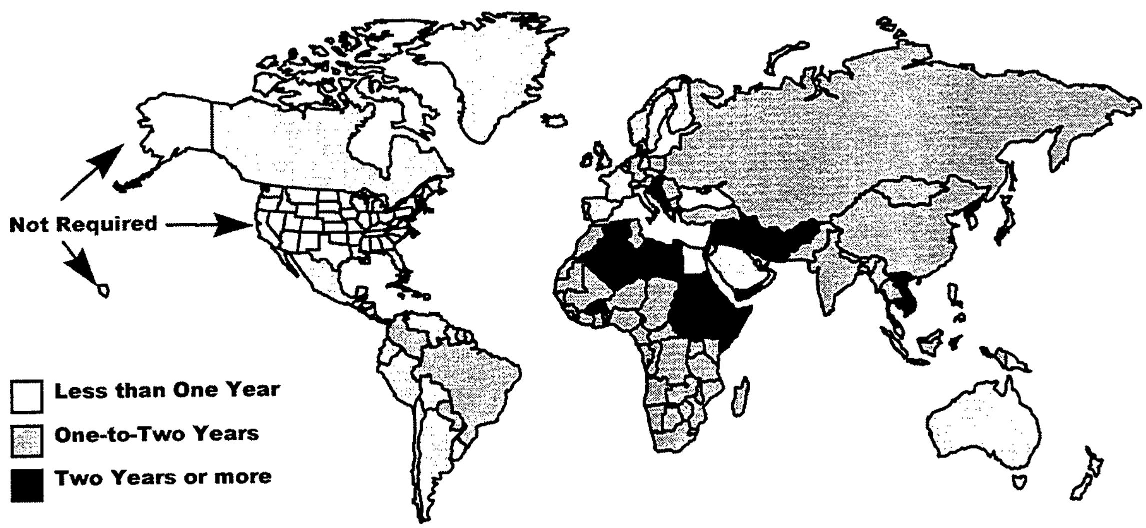

FIGURE 7—TIME LINE FOR SECURING HOST NATIONAL APPROVAL FOR SATELLITE COMMUNICATIONS

Although commercial satellites do not satisfy all of DoD's needs, DoD senior leadership considers them a hedge against inadequate MILSATCOM capacity. Similar to the Military satellite systems, the commercial systems can be categorized into two distinct types, wideband and narrowband. Tables 3 and 4[58] represent a sampling of emerging narrowband and wideband commercial systems, respectively. The tables show a wide scope of uses, coverage areas, capacities, and owners. There are many different types of commercial satellites many of which are not designed to support DoD deployed users and require specialized ground terminals.

SATELLITE COMMUNICATIONS CONCERNS FOR JV2020

It is likely quantitative requirements will continue to escalate beyond most predictions and exceed capabilities. As DoD information systems become more advanced, information needs of warfighters, combat support, and weapons systems will become greater. To meet this expected

SYSTEM	Major Backers	Use	Coverage Area	Data Throughput	Operation Starts
ELLIPSO	Harris, Lockheed-Martin, Boeing (www.ellipso.com)	Voice, Fax, Messaging, Paging, Geolocation	Global north of 50 S	Up to 9.6	2002
NEW ICO	Hughes Space Telecom, Ericsson, GMPCS for Africa (www.ico.com)	Voice, IP Data, and messaging	Global	2.4Kbps voice; up to 128 Kbps data	2001
GLOBAL STAR	Loral, Qualcomm, Alcatel (www.globalstar.com)	Voice, Data, and Fax	Global Between 70N to 70S	Up to 9.6 Kbps	Nov 1999
ORBCOM	Orbital Sciences Teleglobe (www.orbcomm.com)	Two-way msg. and Asset Tracking Msg. size 6-250 bytes	Global	2.4 Kbps Up/ 4.8 Kbps Down 9.6Kbps future	1995
IRIDIUM	Motorola (www.iridium.com)	Voice, Data, Fax, and Paging	Global	2.4Kbps	Nov 1998

TABLE 3—EMERGING NARROWBAND COMMERCIAL SYSTEMS

need there is a great deal that must be accomplished prior to 2020 to overcome the mismatch of SATCOM communications capabilities with expected operational requirements. To transition from yet to be realized legacy systems of the next ten years to advanced programs of the 2010s requires enormous organizational discipline and programmatic truthfulness. Assuming away a lack of operational connectivity with commercial communications systems is likely to leave warfighters short of needed connectivity, and severely restrict information superiority. Senior leaders need to understand that supplementing MILSATCOM with commercial satellite systems presents a high risk for deployed users. They need to consider the right mix of MILSATCOM to insure deployed forces are not at risk.

MILSATCOM

Satisfying the needs of MILSATCOM requires the right mix of affordable wideband, protected, and narrowband systems. In 1998, it was predicted that existing DoD-owned SATCOM systems would be due for re-capitalization.[59] Fortunately, DoD developed and is aggressively pursuing the current MILSATCOM architecture—albeit short on capacity. If Gapfiller meets the objective requirement (3.6gbps vice 1.26gbps threshold[60]) per satellite, many believe the increases in growth of wideband communications requirements will be nearly met. This assumes—contrary to expectation—that capacity requirements stay the same, all planned launches are perfect, and on-orbit hardware operates without failure. Very few space systems are without anomalies. During the last ten years on-board hardware losses of the DSCS III system, the failure of the first UFO satellite, and the failed launch of the $1 billion

MILSTAR Flight 3 satellite testify that this scenario is optimistic.[61] A failure free scenario is unrealistic.

SYSTEM	Major Backers	Use	Coverage Area	Data Throughput	Operation Starts
CYBERSTAR	Loral with Alcatel (www.cyberstar.com)	Data, Video IP Multicast	N. America, Asia, Europe	128 Kbps up 1.5 Mbps down	2001 transponded
ASTROLINK	Lockheed Telespazio, TRW Liberty Media Group (www.astrolink.com)	Data, Video, Rural Telephony	Four major population land masses	400Kbps, 2Mbps, 20Mbps	2003 Processed (Switched)
TELEDESIC	Craig McCaw, Bill Gates, Motorola, Saudi Prince Alwaleed Bin Talal, Boeing (www.teledesic.com)	Voice, Data, Video Conferencing	Global; 100% of Population; 95% of Land Mass	Boadband terminals: up to 64Mbps two-way. Most users 2Mbps up link	2004 Processed (Switched)
SPACEWAY	GM-Hughes (www.hns.com/spaceway)	Data, Multimedia	Four major – population landmass regions	16Kbps to 6Mbps up link	2004 Processed (Switched)
SKYBRIDGE	Alcatel with Loral (www.skybridge satellite.com)	Voice, Data, Video Conferencing	Global between 68N to 68S	16Kbps-2Mbps up 16KBPS-60Mbps Down	2003 Transponded
NETSAT28	EMS Technologies (www.netsat28.com)	Internet Access Bandwidth on Demand	N. America	2Mbps up 30Mbps Down	2002 Transponded
WILD BLUE	Arianespace Liberty Media, TV Guide Telesat/Loral/Arianespace (www.isky.net)	Internet Access	Americas	400Kbps up 1.5Mbps Down	2001 Transponded
INTELSAT	Intelsat (Privatization efforts under way) (www.intelsat.int)	Voice, Data, Video Conferencing	Regional Focus with Global coverage	Changes depending on model or use of particular SAT.	In operation Transponded
PANAMSAT	Panamsat (www.panamsat.com)	Internet Access	Global	64Kbps up 45Mbps down	In operation Transponded
SES ASTRA	SES Multimedia S.A.	Data, Video	Europe; eventually Global		In Operation Transponded
EUTELSAT	Eutelsat	Telephony, Data, Video Radio	Africa, Middle East Europe, Russia	Up to 40Mbps per transponder in broadcast mode	1980s Transponded
AIRLINK HSD	Inmarsat Ball Aerospace	Voice, File Transfer/e-mail Internet.SIPRNET. Video	Global +\- 85degrees latitude	64Kbps to 864Kbps	2000/2001/ 2004

TABLE 4—EMERGING WIDEBAND COMMERCIAL SYSTEMS

If the current roadmap architecture is maintained (Figure 5), systems like Gapfiller, DSCS and Global Broadcast System will begin to be phased out around 2008 as the Advanced Wideband system begins to come on line. This phase out assumes that DoD acquisition of Advanced Wideband goes as planned.

A recent Defense Science Board report studying tactical battlefield communications noted that DoD acquires Information Technology C4ISR systems through a "fifteen to twenty-year acquisition cycle."[62] The report may be harsh, since most acquisition experts believe that funding stability causes much of the delays rather than technical issues.[63] Regardless of funding, it is hard to find anyone who believes procurements of major systems do not take more time than desired. Using best commercial practices in acquisition of C4ISR systems, DoD tends to impose some joint technical standard that generally prolongs the process. The requirements discussions started during the fall 2000 for the Advanced Wideband System, which has an initial launch date sometime in 2008. Many of the warfighting systems that will need SATCOM during the 2010s are still on the drawing boards and their requirements have not been finalized. Requirements definition will not be easy. These discussions are just the beginning of the acquisition process. Even if the legacy systems remain on orbit until 2010 this schedule is likely to prove optimistic.

The importance of the emerging Advanced Wideband system is that it represents the segment of future capability in which requirements are increasing every year beyond the ERDB initial predictions. It is unlikely that requirements being designed into the system in 2001 or 2002 will fully anticipate the demands of JV2020. As stated before, systems will not be available in 2020 if planning does not start within the next two to three years. One is drawn to the conclusion that in twenty years there will still be a requirements capability mismatch. This future mismatch, unlike today's, will be amplified by a greater dependence on satellite communications for deployed forces as a component of achieving information superiority.

During the next several years there are interesting metrics for senior leaders to track. First, how much will requirements continue to grow? DoD should expect requirements will increase beyond what is documented. Like good civil engineers who regularly over design bridges to withstand loading factors that exceed twice what is anticipated, perhaps DoD should consider over designing MILSATCOM capacity. DoD needs to be flexible in adapting to the change by modifying the current architecture to increase capacity.

Second, how well will the acquisition of the MILSATCOM architecture proceed? Current problems with cost, schedule, or performance could be a bad omen for the next generation satellite systems. The systems currently in design and production were designed in part to implement the needs associated with Joint Vision 2010. With the exception of the Navy led narrowband Mobile User Objective System (MUOS), DoD is expected to fully fund all of the systems in the FY2002-2007 POM.[64, 65] How specific programs like Gapfiller and DSCS-SLEP proceed will foretell the future warfighter's ability to achieve Information Superiority during the second decade of the 21st Century.

COMMERCIAL SATELLITES

Commercial systems cannot meet important DoD requirements for both wideband and narrowband deployed users. There are several areas were commercial systems need to improve before they can be a reliable asset for the force of 2020. As previously discussed, commercial systems are not available for the protected category of users. Wideband commercial SATCOM must be able to meet adaptable regional surge. DoD will go to unpredictable areas on short notice with a varied user mix. The need will be for high capacity that supports deployed and mobile users with rapid network reconfiguration, and acceptable encryption[66] of satellite command links. Finally, there will need to be a seamless interoperable interface with the GIG.[67] Special military narrowband needs are: a mobile single channel or a conferencing capability that can allow many users to simultaneously participate; approved encryption;[68] a capability to communicate through thick foliage, weather or in the urban environment without stopping and setting up; and a seamless interface with the GIG.[69]

The wideband and narrowband needs present a difficult problem for commercial systems. Deployed military users tend to concentrate the need for capacity to a relatively small region of the world. Due to capacity limitations, coverage, or existing customer demands, commercial systems tend not to be able to react quickly to regional increases in user density. In place commitments associated with the 2000 summer Olympics in Sydney, Australia, prevented DISA's CSCI program from fully providing requested operational support for East Timor, and African embassies.[70] These requirements had to be allocated to MILSATCOM. During conflicts the military tends to concentrate SATCOM requirements within a small geographical area. This requirements density makes it unlikely that any one system will ever satisfy all requirements, thus introducing interoperability issues. Also, commercial systems are not inclined to be designed for the stressed environment of jungle canopy and heavy rain conditions.

For the last eight years there has been a great clamor from senior DoD leadership—especially civilian—for DoD to use more commercial satellites. The primary motivation is the perception that commercial systems are less expensive. The perception is incorrect. It is not proper to apply the business model developed for Information technology or terrestrial communications to commercial SATCOM. With SATCOM, there are barriers to entering the market, such as higher initial entry costs, limited capacity, and technical and administrative hurdles to overcome (e.g., frequency and orbital assignment, reliability, and country licensing). There have been numerous independent, non-DoD studies that have consistently concluded it is generally cheaper for DoD to own SATCOM as opposed to buying or leasing it on the market.[71] If one needs to use a moving truck once, it is cheaper to lease the truck. If one has to use a moving truck more frequently, then economics favor ownership. SATCOM is no different.[72]

The commercial satellite industry is currently experiencing an era of lowered market expectations that will ultimately translate into building fewer commercial systems resulting in less commercial capacity. The "right" satellite systems may not be available for the future 2020

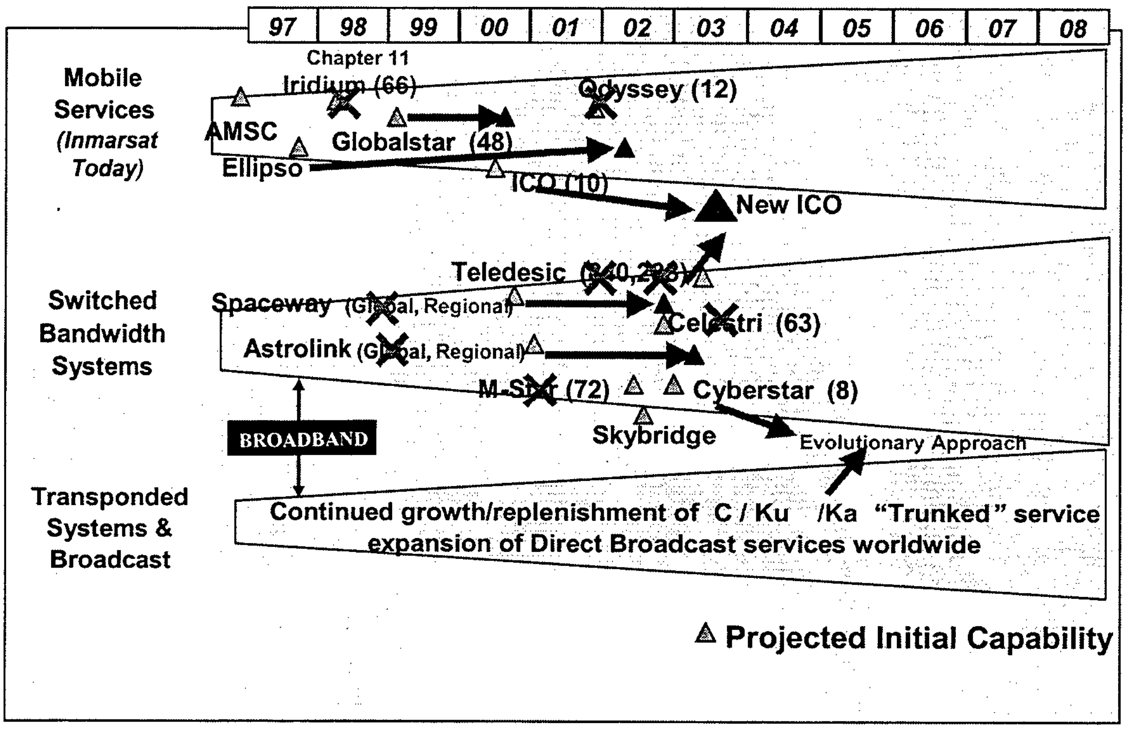

FIGURE 8—FUTURE COMMERCIAL SATELLITE COMMUNICATIONS

force. Commercial SATCOM systems are vulnerable to bankruptcy and other financial restructurings. Figure 7[73] shows that many commercial SATCOM programs DoD has been tracking for future use are suffering major delays, reduced service areas, restructuring, mergers or bankruptcy. As a measure to keep Iridium from going bankrupt, DoD recently awarded a 24 month $74 million contract to provide service to the government.[74] Iridium represents a very high risk for DoD. For Iridium to have a long-term viability, it needs a plan and money to replenish the constellation. Many commercial systems are experiencing significant challenges. A few of the challenges are: establishing a consortium; receiving regulatory approval; securing uninterrupted financing; building global networks; and dealing with broken contracts.[75]

Delays caused by these challenges can only hurt the industry since delays allow for other alternatives, such as terrestrial based cellular phones and fiber cable, to reach commercial markets first. These are the same markets that the commercial satellite industry, when developing their business plans, expected to serve.[76]

These challenges do not go unnoticed by the financial community. The significant change in the market has resulted in uncertainty and has chilled investors. There is a future for commercial SATCOM but not without significant risk.[77]

Military forces cannot accept the uncertainty of the commercial SATCOM market. Since market forces drive the availability of commercial systems, emerging systems have yet to demonstrate a capability to satisfy DoD requirements. DoD SATCOM architects should not expect huge changes by 2020. It is a risky plan to assume commercial satellite systems will be able to adequately augment MILSATCOM systems for deployed and mobile users in 2020.

CONCLUSIONS

Joint Vision 2020 states that information superiority—the right information, to the right place, at the right time—will enable U.S. forces to be more effective. To improve information flow, architects are designing the next generation command and control and weapons systems to be network based and integrated into the Global Information Grid. As a consequence, critical systems will not properly or efficiently function if network communications are inadequate.

While it is likely that DoD's GIG architects will continue to rely on a diversity of communications means, both commercial and military, services within the GIG should ideally be transparent to the user. However, for future JV2020 planning, deployed operations are better served with military space-based communications versus commercial systems. The preference emerges from many of the positive and unique qualitative characteristics of MILSATCOM that are not transparent to users, such as accessibility, survivability, coverage, control, flexibility, mobility, and global reach. Current trends show that at the "tip of the spear," warfighters and their support community are increasingly dependent upon MILSATCOM to meet their information needs.[78]

Satellite communications is a necessary and primary capability by which the tenets of JV2020 will be realized. The transformation to a more agile, deployable and lethal force is dependent upon the liberal use of space-based communications. Today, the Joint staff manages MILSATCOM as if it is a scarce resource.[79] This type of management is contrary to the reality of JV2020's operational goals. Future warfighters are going to want MILSATCOM connectivity like they want ammunition—in abundance. DoD needs to create more MILSATCOM capability now to avoid future scarcity. U.S. forces cannot accept the uncertainty of market driven Commercial SATCOM. Commercial SATCOM systems will not satisfy many of the military requirements—coverage, protection, and access and control. The enabler for Joint Vision 2020 is at risk. DoD needs to commit to development of a MILSATCOM architecture that will serve the 2020 force.

WORD COUNT = 6,505

ENDNOTES

[1] Martin C. Libicki, The Mesh and the Speculations on Armed Conflict in a Time of Free Silicon (Washington, D.C.: National Defense University, 1995), 23.

[2] AWACS – Airborne Warning and Control System; AEGIS – Airborne Early Warning/Ground Environment Integration System; JSTARS – Joint Surveillance and target Attack Radar System; UAV – Unmanned Arial Vehicle.

[3] Libicki, 33.

[4] GEN Henry H. Shelton, Joint Vision 2020, (Washington D.C.: U.S. Government Printing Office, 2000), 2, (hereafter cited as JV2020).

[5] JV2020, 25.

[6] Author's note: Information Superiority is defined in JV 2020: "The capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same. (JP1-02) Information superiority is achieved in a noncombat situation or one in which there are no clearly defined adversaries when friendly forces have the information necessary to achieve operational objectives." JV2020, 8.

[7] Congress, House, Committee on Armed Services Subcommittee Military Readiness Subcommittee Research and Development, Statement for the Record by LTG John L. Woodward, USAF, Director for Command, Control, Communications, and Computer Systems Joint Staff, 106th Cong., 8 March 2000; available from <http://www.fas.org/irp/congress/2000_hr/00-03-08woodward.htm>; Internet; accessed 17 December 2000. (hereafter cited as Statement of Record Woodward).

[8] JV2020, 8.

[9] William S. Cohen, Annual Report to the President and the Congress (Washington D.C.: U.S. Government Printing Office, 2000), 131.

[10] Statement of Record Woodward.

[11] Statement of Record Woodward.

[12] JV2020, 9.

[13] National Security Space Architect, "The 'Sight Picture' from the Space Architect Briefing to the Senior Warfighter Forum," briefing slides with scripted commentary, Washingtion D.C. March 2000, 23.

[14] Statement of Record Woodward.

[15] Statement of Record Woodward.

[16] Department of Defense, MILSATCOM Capstone Requirements Document (Colorado Springs: HQ, U.S. Space Command), 1-7, (hereafter cited as MILSATCOM CRD). Figure Originally titled "Growing Information Requirements—Enabling Joint Vision 2010."

[17] Libicki, 23-24

[18] Office of the Under Secretary of Defense (Acquisition & Technology), Report to Congress on Impediments to the Innovative Acquisition of Commercial Satellite Communications (Washington, D.C.: Department of Defense, June 1998), 7 (hereafter cited as Innovative Acquisition).

[19] COL Jack A. Hook, Jr., Military Dependence on Commercial Satellite Communications Systems--Strength or Vulnerability? (Maxwell Air Force Base: Air War College, Air University, April 1999), 11.

[20] MILSATCOM CRD, 1-8.

[21] MILSATCOM CRD, 1-2.

[22] Mary Ann Lawlor, "Pacific Command Builds Electronic Bridges," Signal, May 2000, 55.

[23] Kilobits per second is $1x10^{3}$ bits per second.

[24] Megabit is equivalent to $1x10^{6}$ bits per second.

[25] Virginia Wiggins, "Study Task 3, Communications Unmanned Aerial Vehicle Final Briefing," briefing slides with scripted commentary, Washington, D.C., Joint Decision Support Center, 15 Sep 1998.

[26] AeroViroment, "Helios Telecommunications Potential, AeroVironment Solar/Electric Aircraft-Based Telecommunications Platforms"; available from <http://www.aerovironment. com/area-telecom/telecom.html>; Internet; accessed 3 Nov 2000.

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[28] TRADOC Systems Manager for Satellite Communications, The Army Satellite Communications (SATCOM) Architecture Book (Fort Gordon, GA: TRADOC), April 2000. 1-1.

[29] CDR Cheryl Spohnholtz, "Five CA Point Designs," briefing slides, Washington D.C., National Security Space Architect, 2000. Study states 525 points are needed for world wide coverage. This is based on a node in every 5 by 5 degree area of landmass between 70 degrees N-S latitude.

[30] Hook, 12.

[31] Hook, 12.

[32] Office of Deputy Assistant Secretary of Defense (C3ISR & Space)/C3, briefing slide, Washington D.C., Department of Defense, December 2000. Data derived from the Emerging Requirements Data Base (ERDB).

[33] Gbps refers to gigabit per second or $1x10^9$ bits per second.

[34] RADM Robert Nutwell, Deputy Assistant Secretary of Defense (C3ISR & Space)/C3 "Future MILSATCOM," briefing slides with scripted commentary, Washington D.C., Department of Defense, 24 Oct 2000, 4.

[35] MILSATCOM CRD, ES-2.

[36] MILSATCOM CRD, ES-7

[37] Stephen A. Stoops, Systems Director, C4I Architecture, Space Systems Group, The Aerospace Corporation, interview by author, 27 Nov 2000, Falls Church, VA.

[38] Data Link examples: TRAP(TDDS) and Tactical Intelligence Broadcasts System (TIBS)).

[39] MILSATCOM CRD, 1-19.

[40] MILSATCOM CRD, 4-4

[41] Nutwell, 4.

[42] Joint Requirements Oversight Council is the approval authority for requirements for major Acquisition Category 1 systems. The group is chaired by Vice Chairman, JCS, with Services Vice Chiefs as members.

[43] Nutwell, 3.

[44] MILSATCOM CRD, 1-14.

[45] Nutwell, 4.

[46] Cohen, 94.

[47] Cohen, 94.

[48] Cohen, 94.

[49] Cohen, 93.

[50] Innovative Acquisition, ii and D1.

[51] Defense Information Switched Network (DISN) comprises elements such as the secret Internet protocol routing network (SIPRNET), the nonsecure Internet protocol routing network (NIPRNET), the defense red switched network, the defense switched network, and video conferencing.

[52] Innovative Acquisition, 5.

[53] Tom Bonds, et al., Employing Commercial Satellite Communications, Wide Band Investment options for the Department of Defense (Santa Montica: Rand, 2000), xvii.

[54] Innovative Acquisition, 10.

[55] MILSATCOM CRD, ES-7.

[56] MILSATCOM CRD, 3-7.

[57] Robert P. Lasky, Chief, SHF MILSATCOM Strategy, Defense Information Systems Agency (DISA) briefing slide, Crystal City, VA, Department of Defense, 27 November 2000.

[58] Office of Deputy Assistant Secretary of Defense (C3ISR & Space)/C3, "Emerging Commercial Systems," briefing slides, Washington D.C.:, Department of Defense, 30 May 2000. ODASD(C3ISR & Space)/C3 tracks major future wideband and narrowband satellite communications system using this format.

[59] MILSATCOM CRD, 1-11.

[60] In major DoD acquisition programs there are generally two types of requirements--objective and threshold--levied by the Operational Requirements Document (ORD). "Objective" requirements are those that a program *tries* to meet given the constraints of cost, schedule and other performance factors, whereas "Threshold" requirements are those that a program *must* meet if the program is to continue.

[61] DSCS III were initially plagued by TWT failures. The first Medium Data Rate MILSTAR Flight 3 satellite failed to reach proper orbit when the second stage failed to operate properly.

[62] Defense Science Board, "Report of the Defense Science Board Task Force on Tactical Battlefield Communications" (Washington D.C.: Office of the Under Secretary of Defense For Acquisition, Technology & Logistics, February 2000), x.

[63] Stephen A. Stoops, "Comments to the Defense Science Board (DSB) Task Force Report on Tactical Battlefield Communications, dtd Feb 2000" (Falls Church, VA: Aerospace Corporation, n.d.).

[64] Dennis R. Birchell, Satellite Communications Analyst, Adroit Systems, Inc., telephone interview by author, 27 November 2000.

[65] Joan Smith, Office of the Director for Information Systems, Command Control Communications and Computers, telephone interview by author, 27 November 2000.

[66] This is generally Type 1 encryption. Type 1 encryption is an NSA description of encryption equipment approved for DoD operations.

[67] Nutwell, 6.

[68] This is generally Type 1 NSA approved encryption.

[69] Nutwell, 7.

[70] Robert P. Lasky, Chief, SHF MILSATCOM Strategy, Defense Information Systems Agency (DISA), interview by author, 27 November 2000, Crystal City, VA.

[71] Innovative Acquisition, D-1.

[72] Innovative Acquisition, D-1.

[73] Maj Justin Keller, "Military Use of Commercial SATCOM: The Future Ain't What it Used to Be" (briefing presented at the MILSATCOM 2000, Los Angeles, October 2000), 12.

[74] Department of Defense, "News Release 729-00: Department of Defense Announces Contract for Iridium Communications Services" (Washington D.C.: Office of the Assistant Secretary of Defense (Public Affairs), 6 December 2000).

[75] Maj Justin Keller et al, "Military Use of Commercial Satellite Communications: The Future Ain't What It Use To Be, paper presented at MILCOM, October 2000, Los Angeles. 2.

[76] Keller, 3

[77] Keller, 5

[78] MILSATCOM CRD, ES-1.

[79] MILSATCOM CRD, 1-12.

GLOSSARY

ANS – Advanced Narrowband System

ASD (C3ISR) & Space – Assistant Secretary of Defense (Command, Control Communications, Intelligence, Surveillance, Reconnaissance and Space)

ATM – Asynchronous Transmission Mode

AWE – Advanced Warfighting Experiment

BOA – Battle Damage Assessment

C2– Command and Control

C4ISR – Command,. Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance

CINC – Commander in Chief

CRD – Capstone Requirements Document

CSCI – Commercial Satellite Communications Initiative

CTAPS – Contingency Theater Air Planning System

DAMA – Demand Assigned Multiple Assess

DISA – Defense Information Systems Agency

DISN – Defense Information Switched Network

DoD – Department of Defense

DSCS – Defense Satellite Communications System

EHF – Extremely High Frequency

ERDB – Emerging Requirements Data Base

gbps – gigabit per second

GBS – Global Broadcast Service

GCCS – Global Command and Control System

GCSS – Global Combat Support System

GIG – Global Information Grid

GTN – Global Transportation Network

ICDB – Integrated Communications Data Base

ISR – Intelligence, Surveillance and Reconnaissance

JMAT – Joint Mobility Assistance Teams

JROC – Joint Requirements Oversight Council

JTF – Joint Task Force

JV2020 – Joint Vision 2020

kbps – kilobits per second

LDR – Low Data Rate

mbps – megabits per second

MDR – Medium Data Rate

MILSATCOM – Military Satellite Communications

MUOS – Mobile User Objective System

NASA – National Aeronautical Space Administration

NATO – North Atlantic Treaty Organization

NIPRNET – Nonsecure Internet Protocol Routing Network

NSSA – National Space Security Architect

OPLAN – Operational Plan

ORD – Operational Requirement Document

OSD – Office of Secretary of Defense

POM – Program Objective Memorandum

SATCOM – Satellite Communications

SIGINT – Signals Intelligence

SIPRNET – Secret Internet Protocol Routing Network

SLEP – Service Life Enhancement Program

TWT – Traveling Wave Tube

TBD – To Be Determined

UAV – Unmanned Aerial Vehicle

UFO – Ultra High Frequency Follow-On

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