

PUBLICATION

**Do Mobile Satellite Service Systems
Fundamentally Improve Military
Communications Capabilities?
An Operational Perspective**

**George W. Hays
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Executive Summary

Mobile satellite service (MSS) systems have the potential to expand the capabilities of military users significantly, especially at the tactical level. These systems feature small (typically handheld) portable terminals which allow users to communicate via new satellite technology that provides digital voice, data, paging, or facsimile service. Their salient advantage over most satellite systems used in the military today is that they enable users to communicate on the move without needing to transport bulky communications gear. In the past, the limited bandwidth available on Department of Defense (DOD) tactical satellites has restricted such communications ability to users with especially high status or deep pockets. The emergence of MSS systems will change that paradigm and allow a broad array of mobile users to enter the world of satellite communications (SATCOM), potentially affecting the command hierarchy by enabling individuals and small teams to exchange information directly and easily with much higher authority around the world.

DOD already uses military-unique enhanced MSS Iridium terminals to give tactical users a secure, handheld, and airborne commercial SATCOM capability; Inmarsat has provided portable and transportable ground and sea terminals to the military for over 16 years. As of mid-1999, at least eight other companies were developing or fielding MSS systems, many of which could potentially be secured to meet DOD requirements for survivability, assured access, low probability of intercept and low probability of detection, and antijam and networking capabilities. These commercial terminals cost 10 to 20 times less than the ultrahigh-frequency terminals that DOD now uses to meet most of its current and projected SATCOM needs.

This report describes past and current uses of mobile communication systems in the military, and offers a concise summary of the capabilities and costs of various commercial MSS systems. The paper then analyzes potential applications of these capabilities in both combat and non-combat missions, as well as in some civilian mobile operations relevant to military activities. The findings indicate that MSS capabilities provide DOD an opportunity to improve communications for the warfighter at a relatively low cost without sacrificing quality, although in the near term most of these systems may perform in a backup or augmentation role. DOD may wish to seek a balance between a smaller number of expensive systems for use in warfighting situations and a larger number of relatively inexpensive MSS systems for other functions. Given the length of the DOD acquisition cycle, now is the time to act—while DOD is procuring or developing SATCOM systems that may no longer be necessary for the majority of its activities.

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Chapter One

Introduction to Mobile Satellite Service Systems

1.1 Background and Purpose

Mobile satellite service (MSS) systems are emerging as an important addition to the many varieties of communications systems available today. These systems consist of small (typically handheld) portable terminals that allow users to communicate via new satellite technology that provides digital voice, data, paging or facsimile (fax) service.¹ MSS systems have the potential to expand the capabilities of military users greatly, especially at the tactical level.

MSS systems have a salient advantage over most satellite systems in the military today: they enable users to communicate while they are on the move, and to do so without transporting bulky communications gear. In the past, the limited bandwidth available on Department of Defense (DOD) tactical satellite systems restricted such communications ability to users with especially high status who also had validated mission needs. The extremely high costs of those systems further restricted users to those with deep pockets. The emergence of MSS systems will change that paradigm and allow a broad array of mobile users to enter the world of satellite communications, thereby potentially affecting the command hierarchy.

As of 1998, MSS systems had not attained widespread use, although several MSS systems already offered services to military users, notably Iridium² and ORBCOMM's³ low-Earth-orbit (LEO) satellite systems. At least eight other companies are currently fielding or producing MSS systems. As such systems become more widely available, and competition drives down the associated costs, the issue facing DOD and civilian organizations will no longer be whether to use these systems, but how much to use them and for which kinds of missions.

This study addresses military applications for MSS systems, in particular, ways to tie the new capabilities to operational needs. It poses two central questions: Do these new MSS systems fundamentally improve capability for military users? If so, how? More specific questions include:

¹*Joint Mobile User Study (MUS) Final Report*, A Tri-Service Study Co-Chaired by: Space, Information Warfare, Command and Control Directorate, CNO (N6B) and Program Executive Officer, Space Communications and Sensors, UFO Satellite Program Office PMW-146 (PEO-SCS) (Washington D.C.: U.S. Department of the Navy, March 24, 1998), 66–67.

²Chicago Tribune Business News, Internet Edition, Nov. 2, 1998. "First Global Satellite Phone System Now Available," [On-line]. URL: <http://www.chicagotribune.com/business/businessnews/article/0.1051.ART-17899.html> (Accessed Feb. 2, 1999.); Iridium LLC press release, "The World's First Global Satellite Telephone and Paging Company Starts Today," Nov. 1, 1998, [On-line]. URL: <http://iridium.com/english/inside/media/1998.html> (Accessed Jan. 14, 1999.)

³ORBCOMM press release, Nov. 30, 1998, "ORBCOMM Now in Full Commercial Service," [On-line]. URL: <http://orbcomm.com/news/status1130.html> (Accessed Jan. 14, 1999.)

- What effect might a global, lightweight, affordable, and accessible mobile system have on military and civilian users?
- What may the future warrior use for communication?
- How might this capability change the way missions are conducted and forces organized?
- Which current systems should DOD replace or augment as a result of the new MSS systems?

Depending on the answers, military planners must evaluate the extent to which MSS capabilities match and fit into their functions and missions. Further, they will need to determine how military operations might change at each level of command as a result of this new, distributed global mobile communications capability.

A great deal has changed in the MSS world since the first draft of this report was completed in May 1999. Future readers will no doubt notice that some information about Iridium or other companies has become outdated; however, the facts upon which this report is based were accurate at that time. It would be impossible to “shoot at a moving target” by attempting to keep every detail in this report up to date. Instead, the report seeks to present multiple characteristics that various new satellite systems might incorporate. Although the status of some companies may change, others currently offer or will probably soon offer the same capabilities. The capabilities outlined are presented as possible solutions for the requirements that are also presented. These salient aspects of this report remain constant and are not affected by the currency of the information presented on any particular MSS provider.

One of the purposes of conducting this study is simply to raise the level of awareness among military planners about these systems, their capabilities, and some of their possible applications—and implications. This may help to motivate planners throughout the military to think more about the impact MSS systems may have on their operations and how these systems could change or affect their particular mission in a positive way. Perhaps, in some way, this increased understanding may improve U.S. warfighting capability and therefore contribute to the subsequent achievement of national goals.

1.2 Scope of This Study

This report does not offer startling revelations regarding the technology or impact of MSS systems. Instead, it pulls together facts that are individually available within the SATCOM community, but have never previously been tied to the operational use of MSS systems. By consolidating information from a wide variety of sources in a single document, this report can provide a ready reference to help military planners evaluate how different MSS systems could help them to meet various field requirements at a reasonable cost.

A wide variety of new satellite communications systems, fixed and mobile, may have an impact on DOD and civilian applications. However, to narrow the focus, this study will cover

only those systems that are mobile in some sense: systems that can be taken into an area of operation to support the mobile/tactical warfighter. The Office of the Assistant Secretary of Defense for Command, Control, Communications and Intelligence (ASD C³I) defines mobile terminals as: “those that are vehicle mounted, aircraft mounted, and vessel mounted, along with paging and handheld terminals.”⁴ This study will also discuss wideband systems that may be portable (move by hand) or transportable (move by vehicle), which include most of the wideband systems outlined in **Chapter Three**. Individual users must determine which specific systems are suitable for their specific type of mobile needs.

This paper also mentions certain nonmilitary governmental and civilian uses for MSS systems to ascertain their potential impact on military applications. For example, communications capabilities useful for such functions as search and rescue (SAR) and humanitarian operations have a direct corollary to similar military endeavors. Both civilian agencies and the military will also apply the emerging LEO, medium-Earth orbit (MEO), and geosynchronous Earth orbit (GEO) satellites in such areas as astronomy, solar physics,⁵ weather, missile warning, surveillance, and possibly space-based radar,⁶ this study will only cover MSS systems used for communications purposes.

The study deliberately avoids certain issues that are either highly sensitive or cannot be assessed at this stage in the development and application of MSS systems. For example, some missions within DOD have requirements that include resource protection, assured access, low probability of intercept/low probability of detection (LPI/LPD) feature, and anti-jam capability. It is common knowledge that MSS systems do not meet most of these requirements.⁷ Although the study will address some of the limitations outlined above, it will not seek to identify specific system vulnerabilities associated with these limitations. This analysis does not intend to “take sides” or draw conclusions about the competitiveness of any company or the quality of their products. On the contrary, it seeks to maintain neutrality and report only openly available facts.

1.3 Organization of the Study

Chapter Two briefly outlines the history of military use of mobile communication systems, pointing out the shortcomings of such usage in the past. It then examines the current status of mobile satellite communications, with an emphasis on unmet needs and the gap between tactical needs and available bandwidth. **Chapter Three** describes the features of various MSS systems,

⁴Department of Defense, Assistant Secretary of Defense (C³I), *Mobile Satellite Communications, An Overview of Systems and Concepts* (Washington, D.C.: Office of the Assistant Secretary of Defense [C³I], Jan. 26, 1996), 2–7.

⁵*International Space Industry Report 3*, 2 (Jan. 18, 1999), 21.

⁶Richard B. Myers, “Moving Towards a Transparent Battlespace,” *Defence Review Magazine* (Spring 1999), [Online]. URL: <http://www.spacecom.af.mil/norad/defrev.htm> (Accessed April 14, 1999.)

⁷Personal interview by author with John Atwood, MSS engineer for The MITRE Corp., Sept. 3, 1998.

both those already available and those under development. It provides details on the three different types of satellite systems—LEO, MEO, and GEO—and on the services that different commercial systems will provide.

Chapter Four relates MSS capabilities to military needs, and discusses why DOD tactical users may in fact require more mobile satellite communications (SATCOM) than current acquisition plans reflect. It also suggests specific applications for such systems in both the military and civilian communities. Finally, it raises a key issue: What impact could the expanded communication capabilities offered by MSS systems have on the future of the military? **Chapter Five** summarizes the study and presents conclusions.

Chapter Two

Past and Current Uses of Mobile Systems

Throughout history, people have sought to communicate better over increasingly longer distances. Mobile communications users in the past have relied on methods that ranged from messengers to carrier pigeons to line-of-sight (LOS)¹ radio communications, such as ultra-high frequency (UHF) and very-high frequency (VHF) LOS radios. UHF or VHF LOS radio communications were used for short distances of normally not longer than 10 miles. High frequency (HF) communications systems were developed to go beyond LOS and became the standard long-range communications method for several decades. The development of beyond-LOS communications greatly expanded the range of activities possible and the effectiveness and speed at which they could be performed.

However, even after the use of HF radio communications became widespread, it did not prove a completely reliable means of communication.² Weather conditions, terrain, sunspots, time of day or night, and many other technical factors all affected the reliability of HF communications.³ The lack of reliable long-range communications systems limited the command and control capabilities for many activities and missions. It is difficult to find historical examples where missions were not completed or even initiated because they did not have reliable communications. It is not difficult to see that sending forces into forward areas without reliable communications increases the danger for the forces and the problems associated with a lack of continuous command and control over those forces.

Mobile communications capabilities have progressed well beyond those original systems to globally connected landline and satellite systems that allow people to communicate all over the world. Even so, ever since the first communications satellite was launched in 1958,⁴ satellite communications have focused primarily on fixed-site applications. The term “fixed satellite service” (FSS) systems refers to “a radio communication service between Earth stations at given positions when one or more satellites are used; the given position may be a specified fixed point

¹LOS refers to communications in which no physical obstacle prevents an electronic signal from reaching between the origin of the signal and the receiver. It does not mean that one can physically see from the point of transmission to the receive point. In optimum conditions LOS transmissions can go ten miles or more.

²John M. Collins, *Special Operations Forces, An Assessment* (Washington, D.C.: National Defense University Press, U.S. Government Printing Office, 1994), 127.

³The author was in charge of the Strategic Aircraft Reconstitution Team (SART) mobile HF radio system for Fairchild AFB in 1984, and in charge of mobile HF radio communications in the Joint Communications Unit, Joint Special Operations Command, from 1986–1990.

⁴Curtis Peebles, *High Frontier, The United States Air Force and the Military Space Program* (Washington, D.C.: U.S. Government Printing Office, 1997), 44.

or any fixed point within specified areas...”⁵ FSS was satisfactory when the only users did not move with the shifting battlefield. The relatively few users who have had access to mobile systems have enjoyed “high-priority” user status and/or have had large expense accounts to afford these systems. The emergence of MSS systems will change that paradigm and instead make it possible for a variety of users at all levels to have a global mobile communications capability.

2.1 Mobile Communications Systems: Past Examples

What lessons do historical examples offer military organizations concerning previous or existing mobile communications systems, in particular with respect to cost, size, availability of channels, and application to military missions? How were mobile systems used, and when? Have the requirements for military communications changed with the emergence of multiple MSS systems?

The “liberation” of Grenada in 1983 provides several particularly good examples where the military lacked sufficient long distance communications down to the unit level. During this conflict, “the U.S. armed services displayed an alarming inability to communicate with each other. One unit on the ground had to use a pay phone on the island to get word back to Washington requesting support from naval forces offshore. Despite appropriate criticism by many in Congress, including the Senate Armed Services Committee, complete systemwide communications interoperability among the services has yet to be achieved.”⁶ In a similar incident at Point Salines, Army paratroopers moving slowly across the island did not have their own helicopters for fire support and “without the helicopters, the paratroopers depended for fire support upon naval aircraft and naval gunfire. Since their radios could not communicate with the ships of the *Independence* battle group, Army radiomen were forced to send their request for fire support to Fort Bragg which in turn relayed them by satellite to the ships.”⁷ In the first example, one group of soldiers lacked a communications system, and in the second the personnel lacked the right type of communications to talk to the Navy. Since that time, DOD has improved the availability and interoperability of tactical communication systems; however, significant improvements still need to be made to ensure sufficient quantities of interoperable communications systems are deployed down to the unit level for our forces in the field.

⁵National Communications System Technology and Standards Division, Glossary of Telecommunications Terms: Federal Standard 1037C (Washington, D.C.: Telecommunications Reports International, Inc., Aug. 7, 1996), F-9.

⁶Frank Gaffney, “MILSTAR: Failure to Communicate,” *The Washington Times*, Oct. 22, 1990, Monday, Final Edition, Commentary, G-3.

⁷Ronald H. Cole, *Operation Urgent Fury, The Planning and Execution of Joint Operations in Grenada 12 October–2 November 1983* (Washington, D.C.: Joint History Office, Office of the Chairman of the Joint Chiefs of Staff, 1997), 52.

Various publications detail how the military used mobile satellite communications during the Gulf War⁸ and describe both the successes and shortcomings of those systems. The shortage of available bandwidth posed a special problem. Prior to the start of hostilities, the normal DOD traffic load over the Eastern Atlantic and Indian Ocean satellites was approximately 4.5 Mbps, equivalent to around 70 commercial voice circuits.⁹ Once the war began, the Defense Satellite Communications System (DSCS) satellites quickly became saturated and satellites had to be repositioned to add more circuits. By the end of the conflict DSCS was augmented by three more U.S. satellites and a British one. “By the time traffic to US forces in the Gulf had peaked ... the throughput had risen to 68 Mbps (1,100 voice circuits) ...”¹⁰ In future conflicts, the emerging MSS systems could at least partially meet this huge demand for bandwidth.

Another problem was interference among allied systems. According to Martin Faga, then assistant secretary of the Air Force, “One of the features we’ve found in operating in a desert environment like that where there’s not a lot of cities and infrastructure is that a lot of the communications tend to be satellite, even though the distances between parties may not be great. There is so much competition for resources there have been examples of unintended interference.”¹¹ Additional satellite systems are needed to alleviate this resource problem and provide dedicated communications channels and equipment down to the unit level.

As part of the effort to provide the greatest possible communications capability to the warfighter, the U.S. military has begun to use commercial satellites to an increasing extent. “During the Gulf War, 20 percent of the total satellite communications capacity was obtained from commercial satellite providers ... the military was so dependent upon communication satellites that every time a new bird [satellite] came on line, it was used up.”¹² A great deal of the satellite access needed was for mobile users. In Desert Storm communications satellites carried most of the military communications in and out of the area. “They provided tactical links within theater and bridges for other terrestrial VHF/UHF radio systems whose line-of-sight limitations prevented them from spanning the desert reaches. They provided total communications to ships at sea, to troops on the move and even to military aircraft.”¹³

⁸See, for example, Federation of American Scientists (FAS), *Desert Star: Military Space Operations and Desert Shield and Desert Storm* (Washington, D.C.: FAS, April 7, 1997), [On-line]. URL: <http://www.fas.org/spp/military/docops/operate/ds/communications.htm> (Accessed Aug. 21, 1999.)

⁹Peter Anson and Dennis Cummings, “The First Space War: The Contribution of Satellites to the Gulf War,” in *The First Information War: The Story of Communications, Computers and Intelligence Systems in the Persian Gulf War*, edited by Alan D. Campen (Fairfax, Va.: AFCEA International Press, 1992), 122.

¹⁰*Ibid.*, 123.

¹¹Interview with Martin Faga, Sept. 20, 1990, quoted in FAS, *Desert Star*, 9.

¹²J. Todd Black, “Commercial Satellites; Future Threats or Allies,” *Naval War College Review* **52**, 1, Sequence 365 (Winter 1999), 102.

¹³Anson and Cummings, 122.

Today's military uses thousands of LOS communications systems, which normally operate in the HF, UHF, and VHF bandwidths. Most of these systems have been used in the past in vehicles, aircraft, seacraft, fixed site, and manpack versions. At the military unit level, these LOS systems have been the main communications method back to headquarters and among units for decades. Still, LOS systems have been limited by range and terrain and in some situations have not been a reliable means of communications. Only HF can be used without repeaters for very long-range communications. Although the HF automatic link establishment capability, utilized in the last decade, has made significant improvements in HF communications, changing conditions in the ionosphere may still interfere with HF signals. The optimum transmission frequency varies depending on such factors as the solar cycle, the season, the time of day, and the relative locations of the transmitter and receiver; in addition, shortwave fadeouts and ionospheric storms can degrade HF communications.¹⁴ The bottom line is that none of these communications systems were highly reliable over long distances.

The DOD recognized that mobile/tactical users in all the services had critical needs for reliable long-range communications that could be provided through SATCOM. The U.S. Navy was assigned as the lead service¹⁵ on DOD's first operational satellite system for tactical users. This system, called the Fleet Satellite (FLTSAT) System, was launched in 1978.¹⁶ Although the Navy was the lead service on this system, it actually contains more Air Force Satellite Communications (AFSATCOM) channels than FLTSAT channels. The system consists of 10 25kHz FLTSAT channels, 12 5kHz AFSATCOM channels and 1 500kHz AFSATCOM channel used for the National Command Authorities. Users from all the services share these channels, with the Joint Staff deciding who has priority. As noted before, the limited number of channels meant that military users continued to face problems of channel access and terminal costs even after FLTSAT became operational.

In 1993, the Navy launched the first of 10 planned UHF Follow-on (UFO) satellites; the tenth was launched on November 22, 1999. An optional eleventh UFO satellite has now been planned.¹⁷ The UFO constellation has begun to replace FLTSAT as the older satellites cease to

¹⁴Patrick Phelan, "An Introduction to High Frequency Radio Propagation," IPS Radio & Space Services, Sydney, Australia, [On-line]. URL: http://www.ips.gov.au/papers/richard/prop_intro.htm (Accessed July 4, 1999.)

¹⁵All the services needed SATCOM: the Air Force for aircraft, the Army for all mobile field missions, and the Navy for seacraft. On joint service programs like this DOD assigns a lead service to coordinate the program; all the services then work together on the program. Today, the Army, Navy, and Air Force are each designated the lead service on different SATCOM programs.

¹⁶*Joint Mobile User Study (MUS) Final Report*, A Tri-Service Study Co-Chaired by: Space, Information Warfare, Command and Control Directorate, CNO (N6B), and Program Executive Officer, Space Communications and Sensors, UFO Satellite Program Office PMW-146 (PEO-SCS) (Washington, D.C.: U.S. Department of the Navy, March 24, 1998), 10.

¹⁷U.S. Navy, Space and Navy Warfare Systems Command, Office of Congressional & Public Affairs, San Diego, Calif., "Navy Communications Satellite Successfully Launched," [On-line]. URL:

function. Like FLTSAT, UFO is designed to serve primarily tactical users.¹⁸ While this new system provides some improvements in satellite communications, it does not greatly improve channel availability for the numerous tactical users. It is essentially a one-for-one replacement of the satellites that are already on orbit; the plan is still to have eight satellites in use at one time. While the new UFO satellites will provide significant improvement over the FLTSAT, UHF Gapfiller, and LEASAT programs, they do not provide anywhere near enough bandwidth to meet DOD requirements.

In 1996 the DOD inventory contained over 15,000 UHF SATCOM terminals.¹⁹ This may sound like a large number until we recognize that each of the UFO satellites has only 17 25-kHz channels and 21 5-kHz channels.²⁰ Even assuming that all eight UHF satellites were operational,²¹ this would give the military a worldwide capability of 136 25-kHz channels and 168 5-kHz channels. Unfortunately, in any one theater a user can normally only connect to two of those satellites. This actually brings the usable total of channels down to 34 25-kHz channels and 42 5-kHz channels in a theater of operation. This capability is being further enhanced by the demand assigned multiple access capability, which allows multiple users on the same channel. However, looking again at the figures for Desert Storm: “In excess of 1,500 satellite communications terminals were deployed to theater, of which over 75 percent were single-channel manportable military and commercial units.”²² It becomes very clear that when over 1,000 terminals are deployed to an area, even when many of them are on one net, there are not enough channels to go around.

The military has used some small and medium sized International Maritime Satellite (Inmarsat) Corporation terminals in the UHF and super high frequency (SHF) SATCOM bandwidths. Inmarsat service links operate in the UHF bandwidth and their feeder links operate in the SHF bandwidth. Although the new Mini-M terminal costs around \$1,500, the other Inmarsat

http://www.SPAWAR.navy.mil/corporate/spawarpao/newsreleases/nr99-10_f10_successful_launch.htm (Accessed Jan. 11, 2000.)

¹⁸FAS, Space Policy Project, Military Space Programs, “Ultra High Frequency Follow-On (UFO) Military Communications Satellite,” [On-line]. URL: <http://www.fas.org/spp/military/program/com/ufo.htm> (Accessed Aug. 13, 1999.)

¹⁹*MUS Final Report*, 43.

²⁰*Ibid*, 29.

²¹*Ibid*.

²²Jacquetta A. Dunmyer, “The Ultimate High Ground! Space Support to the Army—Lessons from Operations DESERT SHIELD and STORM,” U.S. Army Center for Army Lessons Learned (CALL), Fort Leavenworth, Kan., Newsletter No. 91-3, Chapter 4, 1, [On-line]. URL <http://www.call.army.mil/call/newsltrs/91-3/chap4.htm> (Accessed April 12, 1999.)

terminals are costly to procure and all are expensive to operate.²³ **Chapters Three and Four** will discuss the Inmarsat terminals in more detail.

Most of the other military SHF SATCOM capability lies in large transportable or fixed-site systems. The SHF DSCS has been the primary reachback²⁴ system for the military on worldwide deployments since 1967. DSCS systems can be either fixed or mobile. Even the mobile DSCS systems are bulky and heavy, and would require transport by aircraft, ship, or large truck.²⁵

The capability of extremely high frequency (EHF) SATCOM systems, such as Milstar, to communicate despite jamming has made the EHF bandwidth ideal for supporting military strategic-level command and control and nuclear forces missions. Some EHF channels have also been used to provide added communications capability to tactical users. It should be noted however, that this system is very expensive and operates on low data rates; this type of communication is therefore not feasible for most users.²⁶ Higher data rates will be available on Milstar II, however the system will still be extremely expensive and will remain limited to the users noted above.

All of our past systems give us various levels of capabilities and reliability. Most of these systems will continue to have required uses in the military due to the unique characteristics of those systems (i.e., anti-jam for EHF systems, foliage penetration for UHF). Overall though, none of these systems has given us an inexpensive way to provide large quantities of highly reliable, long distance communications down to the unit level.

2.2 Mobile Communications Systems: Current Uses

The military still relies primarily on military systems, including the augmented Iridium gateway. As noted above, the Navy has long used mobile communications on its ships, although users complain that while their communication capability is superb, it disappears as soon as the ship leaves port.²⁷ While the Navy is now getting better SATCOM by using commercial satellite

²³Inmarsat homepage, URL: <http://www.via-inmarsat.org/about/system/sysint/html> (Accessed Jan. 12, 1999.); *Encyclopedia of Electronics*, 2nd ed., Stan Gibilisco and Neil Sclater, co-editors in chief (Blue Ridge Summit, Pa.: TAB Professional and Reference Books, 1990); Reference Data for Engineers on Radio, Electronics, Computers, and Communications.

²⁴The term “reachback” refers to a system used to talk from a forward location back to the headquarters, normally located in the continental United States (CONUS).

²⁵Peebles, 44.

²⁶U.S. Army Training and Doctrine Command [TRADOC], Combat Developments Home Page, 2, [On-line]. URL: <http://www.tradoc.army.mil/dscsd/spaceweb/chap07b.htm> @Title-1=Satellite Communications (SATCOM) (Accessed April 11, 1999.)

²⁷See, for example, Barry M. Horowitz, “The Emergence of Data Systems: Cost and Technical Change in Military Systems,” in *Seminar on Intelligence, Command and Control, Guest Presentations, Spring 1993*, I-94-5 (Cambridge, Mass.: Harvard University Program on Information Policy, August 1994).

leases, there is still room for greater improvement at cheaper prices using emerging MSS systems. The Army deploys military-unique manpack tactical satellite (TACSAT) terminals worldwide to support command, control, and communications for Special Forces groups, Ranger battalions, airborne/air assault divisions, and selected light and mechanized infantry divisions. These systems operate in the UHF band, utilizing FLTSAT and AFSAT space segments. According to the Army Field Manual on Tactical Satellite Communications, “Mobile TACSAT terminals offset the need for providing protected multiple ground relay sites. In addition, it [sic] reduces exposure time to hostile actions. The protection of these terminals by terrain, such as valleys, further reduces the possibility of detection.”²⁸

Thus, the technical capabilities for robust communications systems certainly exist today. It is the availability of equipment and satellite channels that falls short of meeting military users’ needs.

Some commercial systems, such as Inmarsat, have already carved out a niche in the MSS marketplace, but are beginning to receive strong competition from newer systems. The Joint Communications Unit within the Joint Special Operations command used large, suitcase-sized versions of the Inmarsat-A systems in 1989 and 1990.²⁹ During the early 1990s, Inmarsat provided military communications during Operations Just Cause (Panama), Desert Storm, and Restore Hope (Somalia).³⁰ More recently, in December 1998, COMSAT’s Inmarsat mobile satellite phones and service were used to provide voice and data communications for disaster relief operations in Central America after Hurricane Mitch.³¹ DOD currently uses Inmarsat daily; however, the system is quite expensive and still lacks coverage over much of the earth. These details will be covered later in this paper.

For obvious reasons, humanitarian organizations have been major users of virtually all long-range telecommunications products and services. Five of the largest humanitarian institutions together own more than 250 land-mobile satellite terminals, in addition to thousands of VHF and

²⁸U.S. Army, *Tactical Satellite Communications, Field Manual 24-11* (Washington, D.C.: Headquarters, Department of the Army, Sept. 20, 1990), Chapter 2, [On-line]. URL: <http://fas.org/spp/military/docops/army/fm24-11/Ch2.htm> (Accessed Aug. 19, 1999.)

²⁹The author was a member of the Joint Communications Unit in the Joint Special Operations Command from October 1986 to November 1990. This unit used UHF MILSATCOM and Inmarsat systems worldwide for reachback communications to Fort Bragg, N.C.

³⁰TRADOC, 4.

³¹COMSAT Corp. home page, disaster relief sub-site, news article, “COMSAT Satellite Phones Provide Voice and Data Communications to Aid Hurricane Mitch Relief Effort,” [On-line]. URL: http://209.207.228.58/news/news_archive/1998/4qtr_98/mitch_12-7-98.htm (Accessed April 11, 1999.)

HF transceivers.³² Their experience may prove invaluable in guiding DOD as the military makes increasing use of MSS capabilities.

³²International Telecommunications Union Press and Public Information Service, “Telecoms Technology in the Field,” 1, [On-line]. URL: <http://itu.int/newsarchive/projects/ICET/technology.html> (Accessed April 11, 1999.)

Chapter Three

Emerging Mobile Satellite Service Systems

A new era of MSS systems began when the Iridium and ORBCOMM systems reached operational capability in November 1998. These two companies are the first of several MSS service providers to create a new family of lightweight (normally handheld) satellite communications devices that constitute the terminal portions of MSS systems.

3.1 Characteristics of MSS Systems

The emerging MSS systems may access signals from or send signals to satellites in LEO, MEO, or GEO orbits. A detailed technical review of these orbits is beyond the scope of this study, however, **Table 3-1** provides information that may be useful for understanding some of the basic differences among them.

The number of satellites employed in the various orbits depends on two factors: the “footprint” of each satellite, and whether or not the configuration is crosslinked. The footprint is the area on the ground that can actually receive the signal from the satellite; in other words, the ability of the satellite to send a signal to that portion of the earth that it can “see with its antennas. Depending upon the system, a satellite’s footprint may encompass the entire area on the earth that can be seen, or may be narrowed down to smaller areas called zone and spot coverages.

The majority of satellite systems receive a signal from the transmitter on Earth and send it directly to the receiver. By contrast, some satellites also have the capability to send signals to and receive signals from each other. When this capability exists on a satellite, it is called crosslinking, and the satellites are referred to as being crosslinked.

As shown in **Table 3-1**, LEO systems need 20–50 satellites for full earth coverage in a non-crosslinked configuration. A crosslinked configuration would require fewer satellites and fewer ground stations; however, such a system would not produce as much revenue for the host country or for the manufacturer. The reason is that a call originated from a host country goes through a gateway¹ in that country, and the local service provider charges a toll. The manufacturer also charges a percentage of each call. With system crosslinking, the signal goes up to a satellite and is transferred via crosslinked satellites to the satellite that has the downlink to the gateway (perhaps in another country) that the user is calling. The user thereby bypasses any gateway in the host

¹A gateway is “a ground station that acts as a relay between systems. It provides satellite to satellite, satellite to terrestrial, and terrestrial to satellite connectivity.” *Joint Mobile User Study (MUS) Final Report*, A Tri-Service Study Co-Chaired by: Space, Information Warfare, Command and Control Directorate, CNO (N6B) and Program Executive Officer, Space Communications and Sensors, UFO Satellite Program Office PMW-146 (PEO-SCS) (Washington, D.C.: U.S. Department of the Navy, March 24, 1998), 62.

Table 3-1
Characteristics of LEO, MEO, and GEO Satellites

Characteristics	Type of Orbit		
	LEO	MEO	GEO
Number of satellites required for full earth coverage ²	20-50	10-15	3
Size of footprint ³	4,800 km	12,800 km	15,900 km
One-way signal delay ⁴	3-13 ms	60-94 ms	247 ms
Distance of satellite orbit from earth (nm) ⁵	100-540 nm	540-18,225 nm	~19,300 nm
Advantages ⁶	<ul style="list-style-type: none"> • Smaller satellites need less power • Smaller handsets • Lower transmit power • Unnoticeable signal delays in voice communications 	<ul style="list-style-type: none"> • Essentially a compromise between the LEO and GEO systems 	<ul style="list-style-type: none"> • Fewest satellites • Bigger "footprint" • Reduced system cost • Less technical and easier to maintain

km = kilometers nm = nautical miles ms = microseconds

country and any toll charges in that country. Iridium illustrates how such a crosslinked system functions.

Its satellite-based technology could allow satellites to switch mobile telephone calls through each other and bypass Iridium ground stations; however, for network control and billing purposes, call information would need to be routed through the foreign-owned Iridium ground stations. As a result, defense planners must consider the potential impact that the use of foreign-controlled LEO systems may have on U.S. military operations

²The MITRE Corp., "Commercial Satellite Communication Systems and the DoD: A Basis for DoD Selection of Commercial SATCOM Systems," briefing presented by Leah Gaffney (POC) at MITRE, Bedford, Mass., Oct. 15, 1998, slide 8.

³COMSEARCH, Inc., "Emerging Satellite Services, An Update on the Impact of Developing Satellite Technologies on Private Microwave Spectrum," briefing presented by Ken Ryan at the UTC Telecom '98 Conference, Boston, Mass., July 1, 1998, slide 6.

⁴MITRE, Commercial Satellite Communication Systems, slide 8.

⁵MUS Final Report, 66.

⁶Mobile Satellite Communications, An Overview of Systems and Concepts, Department of Defense, Assistant Secretary of Defense (C³I) (Washington D.C.: Office of the Assistant Secretary of Defense [C³I], Jan. 26, 1996), 1-4.

overseas and the possibility that communications services may be denied due to foreign ownership or government control.⁷

Growing market demand for multimedia communications will provide the original impetus for developing the new wideband systems. These systems use small, inexpensive terminals to provide two-way connectivity at high data rates.⁸ Initially, wideband systems will be targeted to fixed users, but it is expected that airborne, ship, and even transportable applications will increase as the market demands rise.⁹ None of the companies listed in **Table 3-4** had determined per-minute costs as yet.

3.2 Capabilities of Selected MSS Systems

The companies listed in **Tables 3-2 to 3-4** are scheduled to place over 400 satellites in orbit during the next half decade. These systems will provide service for telephones, data devices, pagers, Internet access, tracking devices, and messaging. Many of them may replace mobile systems currently in use or under development—thereby posing an important challenge to the United States and its allies as they seek to determine how these new options might alter their acquisition plans. **Chapter Four** explores this issue.

Companies are fielding a highly diverse set of MSS systems. This study does not attempt to judge the validity of the performance claims made by these selected companies, but instead to present possible user opportunities based on emerging MSS system capabilities. The reader must then determine what course of action to take.

Users will soon be able to choose among competitors to find the services they want. **Tables 3-2 to 3-4** compare a selection of the existing and emerging MSS companies as of mid-1999. There are many more mobile systems than those listed, but for the purpose of managing the size and complexity of this study, the particular systems shown were selected as representative of capabilities common to all emerging MSS systems of a particular type. MSS system characteristics that relate to cost and capabilities have been included to give the reader a better understanding of these factors.

Some systems, such as Iridium, already cater to the DOD. In exchange for significant DOD funding—approximately \$150 million¹⁰—Iridium has provided a DOD-only gateway that gives the Department a secure voice telephone, provides access to the Defense Switched Network

⁷Ibid., 3-3.

⁸*MUS Final Report*, 50.

⁹MITRE, “Commercial Satellite Communications Capability Assessment Study,” slide 33. It should be noted that all systems must receive International Telecommunications Union (ITU) approval prior to launch.

¹⁰F. Whitten Peters and Michael E. Ryan, “Air Force Policy Letter on Use of the Iridium MSS,” Jan. 17, 1999, 1, [On-line]. URL: http://afca.scott.af.mil/gc/gcg/mss/iridium_policy.htm (Accessed Feb. 25, 1999.)

(DSN), protects user locations, and ensures that the gateway executes the call-setup procedures.¹¹ In 1998, Iridium became the first international company to obtain its own telephone country code, which allowed the company to assign each subscriber a unique number where he or she can be reached all over the world. As additional companies become operational, they may also provide the DOD with the specialized capabilities it needs on some missions.

Other systems can offer valuable services to the DOD using their standard capabilities. Inmarsat has provided portable and transportable ground and sea terminals to the military and other users for over 16 years, and currently supplies approximately 18,000 terminals on ships (civilian and military). Inmarsat also provides airborne terminals; over 1,800 of these terminals are now deployed on various airborne platforms.¹² Airborne, seaborne and ground versions of the Inmarsat are produced in a variety of sizes. While some are larger than a hand-held telephone, some are laptop computer size and most are easily transported. Government users have the option of securing all of these devices with standard cryptographic equipment. Ellipso will offer netted communications (a major DOD requirement) as part of its basic public service¹³ and ORBCOMM and Globalstar will provide messaging services that could be used for tracking containers. **Chapter Four** gives a more detailed list of applications.

Competition among MSS systems is expected to be very keen. One system, TRW's Odyssey, has already been terminated by its parent company, and its services have been merged with ICO Global Communications.¹⁴ Others are also expected to merge or fold completely before their systems become operational. In addition, many companies will concentrate on specialized services, such as Teledesic's "Internet in the Sky" or ORBCOMM's data messaging service.

LEO, MEO and GEO systems can be classified in a number of ways. **Tables 3-2 to 3-4** group them according to narrowband and wideband systems. This grouping stems from the differences in possible applications for the military: voice, data, fax, paging, and messaging for narrowband, versus video, videoconferencing, multimedia, and Internet for wideband.¹⁵ The transmit speeds for many of the systems listed in the tables may vary depending on the particular terminal used or whether the transmission involves voice or data communications.

Growing market demand for multimedia communications provided the original impetus for developing the new wideband systems. These systems use small, inexpensive terminals to provide

¹¹MITRE, "Commercial Satellite Communication Systems," Narrowband section, slide 15.

¹²Inmarsat home page, [On-line]. URL: <http://www.via-inmarsat.org> (Accessed Jan. 12, 1999.)

¹³ MITRE, "Commercial Satellite Communication Systems," Narrowband section, slide 20.

¹⁴ICO press release, Dec. 17, 1997, [On-line]. URL: <http://www.ico.co.uk/press/releases/199712/971217.htm> (Accessed April 7, 1999.)

¹⁵Sometimes referred to as broadband, but the terms mean the same thing.

Table 3-2
Characteristics of Selected Narrowband LEO MSS Systems

Characteristics	System/Company				
	Iridium ¹⁶ (Iridium LLC by Motorola)	ORBCOMM ¹⁷ (ORBCOMM)	Globalstar ¹⁸ (Loral Space and Communications, QUALCOMM Inc.)	ECCO ¹⁹	LEO One ²⁰ (dBx Corp.)
Capability	Voice, data, fax, paging	Data, messaging	Voice, data, fax, messaging	Voice, data, fax, paging	Data
Cost per terminal	\$3,000	\$200-\$300 each	\$750	\$1,500	\$150-\$500
Cost per minute	\$1.27-\$7.00	TBD	\$0.35-\$0.55 (wholesale)	\$0.26-\$1.00 (wholesale)	TBD
Cost per month	\$69.95	\$30	TBD	TBD	TBD
Year in service	1998	1998	1999	TBD	2001
Transmit speed	2.4 kbps	9.6 kbps	1.2-9.6 kbps	2.4-4.8 kbps	9.6 kbps
No. of satellites Active/Spare	66/12	28/10 ground spares	48/8	46/0	48/0
No. of Earth stations	12	14	50-70	TBD	U.S.: 3 Others: TBD

kbps = kilobytes per second TBD = to be determined

¹⁶Iridium LLC Company Profile and Company Capsule, [On-line]. URL: <http://wysiwyg://24/http://www.hoovers.com/premium/profiles/52946.html> (Accessed Jan. 12 and Feb. 3, 1999.); COMSEARCH, slides 10 and 11; MITRE, "Commercial Satellite Communication Systems," Narrowband section, slide 16.

¹⁷Mark H. Kagan, "Global Satellite Datalinks Connect Fixed, Mobile Users," *Signal* **53**, 4 (December 1998), 21-24; ORBCOMM press release, "ORBCOMM Now in Full Commercial Service," Nov. 30, 1998, [On-line]. URL: <http://www.orbcomm.com/news/status1130.html> (Accessed Jan. 14, 1999.)

¹⁸Globalstar fact sheets, sent to author Feb. 15, 1999, by J. Lee Murphy, manager, Globalstar Program Development; Globalstar home page, [On-line]. URL: <http://www.globalstar.com/system> (Accessed Jan. 18 and Feb. 3, 1999); COMSEARCH, slides 10 and 11.

¹⁹COMSEARCH, slides 10 and 11; MITRE, "Commercial Satellite Communication Systems," Narrowband section, slide 9.

²⁰LEO One home page, [On-line]. URL: <http://www.leoone.com> (Accessed Jan. 16, 1999.); Steve Smith, LEO One home page representative, personal e-mail to author, Jan. 19, 1999.

two-way connectivity at high data rates.²¹ Initially, wideband systems will be targeted to fixed users, but it is expected that airborne, ship, and even transportable applications will increase as the market demands rise.²² None of the companies listed in Table 3-4 had determined per-minute costs as yet.

Table 3-3
Characteristics of Selected Narrowband MEO and GEO MSS Systems

Characteristics	System/Company		
	ICO ²³ Intermediate Circular Orbit Global Comm, COMSAT, Inmarsat MEO System	Ellipso ²⁴ Mobile Comm Holdings Inc. ⁴ MEO System	Inmarsat ^{25, 26} COMSAT (in U.S.) GEO System
Capability	Voice, data, fax, messaging	Voice, data, fax	Voice, data, fax, video, remote messaging
Cost per terminal	\$1,000	\$700-\$800	\$3,000-\$50,000
Cost per minute	\$1.00-2.00	\$0.35	\$2.70-\$12.00
Year in service	2000	2001	1982
Transmit speed	2.4-9.6 kbps	300 bps-9.6 kbps	600 bps (Aero I) to 2.4 kbps (Mini-M); 64 kbps (Inmarsat-B)
No. of satellites	10 with 2 spare	17	9
No. of Earth stations	12	14	39

²¹MUS Final Report, 50.

²²MITRE, "Commercial Satellite Communications Capability Assessment Study," slide 33.

²³ICO home page, [On-line]. URL: <http://www.ico.com/system> (Accessed Jan. 18, 1999.); Michael Johnson, ICO public relations officer, personal e-mail to author, Jan. 19, 1999.

²⁴Ellipso home page, [On-line]. URL: <http://www.ellipso.com/overview> (Accessed Jan. 18, 1999.); Brian Willard, Ellipso director of corporate communications, personal e-mail to author, Jan. 19, 1999; COMSEARCH, slides 10 and 11.

²⁵Inmarsat home page, [On-line]. URL: <http://www.via-inmarsat.org/about/system/sysint.html> (Accessed Jan. 12, 1999.)

²⁶Nine satellites total (four in the Inmarsat-2 launch and five in the Inmarsat-3 launch).

Table 3-4
Characteristics of Selected Wideband MSS Systems

Characteristics	System/Company				
	Astrolink I ²⁷	Cyberstar ²⁸	Skybridge ²⁹	Spaceway ³⁰	Teledesic ³¹
	<ul style="list-style-type: none"> • Lockheed Martin Corp. • GEO System • Transportable System 	<ul style="list-style-type: none"> • Loral Space and Comm. Ltd. • GEO System • Transportable System 	<ul style="list-style-type: none"> • Alcatel • LEO System • Transportable System 	<ul style="list-style-type: none"> • Hughes Comm. Inc. • GEO System • Transportable System 	<ul style="list-style-type: none"> • Teledesic Corp. • LEO System • MSS and Transportable System
Capability	Multimedia (two or more of voice, video, or animation)	Multicast, digital broadcast: data, video, audio	Voice, data, video, Internet and multimedia	Voice, video, and data	Internet, voice, data, and video teleconferencing
Cost per terminal	TBD	TBD	\$700	TBD	TBD
Cost per minute	TBD	TBD	TBD	TBD	TBD
Cost per month	TBD	TBD	TBD	TBD	TBD
Year in service	2001	2004	2002	2002	2003
Transmit speed	416 kbps to 10.4 Mbps uplink 110 Mbps downlink	up to 29 Mbps	20 Mbps uplink 2 Mbps downlink	16 kbps-20 Mbps uplink 108 Mbps downlink	16 kbps-2 Mbps uplink 25 Mbps downlink
No. of satellites	9	3	80	17	288
No. of Earth stations	100	TBD	200	TBD	TBD

TBD = to be determined.

²⁷Astrolink home page, [On-line]. URL: <http://www.astrolink.com> (Accessed April 11, 1999.)

²⁸The MITRE Corp., "Commercial Satellite Communications Capability Assessment Study," briefing presented by John Atwood at The MITRE Corp., Bedford, Mass., Dec. 16, 1998, slide 36; Cyberstar home page, "Business at the Speed of Thought: Taking Extranets to the Next Step, with Superior Speed and Security," [On-line]. URL: <http://www.cyberstar.com> (Accessed April 7, 1999.)

²⁹Alcatel home page, [On-line]. URL: <http://www.alcatel.com> (Accessed April 10, 1999.); Skybridge home page, [On-line]. URL: <http://www.skybridgesatellite.com> (Accessed April 10, 1999.); MITRE, "Commercial Satellite Communications Capability Assessment Study," slide 36.

³⁰Danelle Barrett, "Communications, Commercial Satellite Constellation Offers Potential Military Benefits," *Signal* 53, 3 (November 1998), 43-45; MITRE, "Commercial Satellite Communications Capability Assessment Study," slides 17 and 31.

³¹Teledesic home page, [On-line]. URL: <http://www.teledesic.com> (Accessed March 29, 1999.); Nillofur Jasani, Teledesic public relations representative, personal e-mail to author, March 29, 1999; MITRE, "Commercial Satellite Communications Capability Assessment Study," slides 16 and 31

Chapter Four

Applications of Mobile Satellite Service Systems

The emergence of MSS systems will affect most of the mobile user community in one way or another. **Tables 3-1** through **3-4** indicated the types of MSS systems suitable for various types of missions, as well as the general capabilities of various current and planned systems. These capabilities will continue to evolve as technology improves; however, such improvements do not in themselves constitute the desired end state, but are of value only to the degree that they may further the ability of the users to accomplish their missions.

At present, mobile users primarily rely on military SATCOM or the commercial Inmarsat systems for their long-range narrowband requirements. The relatively few users who have a high enough priority and who can afford these systems enjoy reliable voice and data communications. However, as was stated earlier, many users, both within and outside the military, need such a long-range capability but do not have one. MSS systems may prove especially useful in mountainous terrain, remote areas, and in areas with very little communications infrastructure, by giving users in those environments a worldwide voice and data capability. These latter users also comprise the most promising potential customer base in the civilian sector.

Clearly, planners must explore various possibilities to determine whether users will receive fundamentally better service using mobile MSS terminals, as well as to identify new tasks that would become feasible with the widespread availability of affordable mobile communications. Military leaders must then determine as soon as possible how to adjust their particular service's acquisition plans to achieve the optimum balance, both operational and financial, between SATCOM systems already in the pipeline, new procurements of military-unique MSS systems, and commercially available products.

The military is well aware of the promise of MSS systems. According to F. Whitten Peters, then Acting Secretary of the Air Force:¹

It's very interesting when you look at these commercial systems. I think they will leverage a lot of the military systems we already have. ... I think we are looking at a whole new paradigm in space — the commercial providers are going to be much more capable of meeting military needs at a lower cost. Now we need to look at how we can do our missions to take maximum advantage of that.²

¹Mr. Peters was confirmed as Secretary of the Air Force on July 30, 1999.

²Results condensed from *Spacedaily News*, "Will Iridium Become SATCOM of Choice?" [On-line]. URL: <http://www.spacer.com/spacecast/news/satcom-99a.html> (Accessed April 10, 1999.)

Among other goals, this study seeks to highlight ways in which the new MSS systems eliminate barriers to and restraints on communications for warriors in the field. Current ideas for uses of MSS systems seem endless and will be further explored later in this chapter. With systems like these the soldier in the foxhole could call in needed information from anywhere, send required information to rear echelons, or receive broadcast messages from mobile headquarters.

4.1 DOD Bandwidth Requirements

DOD's Integrated Communications Data Base (ICDB) and Emerging Requirements Data Base (ERDB)³ list current and future requirements, respectively, for satellite accesses by all the military services. Together, these databases contain 730 requests for satellite accesses, with an estimated 7,000 associated users, to be loaded on the UHF Gapfiller system,⁴ a proposed series of three supplementary satellites to fill the gap (from 2003 to 2007) that exists between the time the current FLTSAT satellites are due to "die" and the time the new Narrowband Objective System satellites replace them.⁵ UFO satellites are currently replacing the remaining few FLTSAT UHF SATCOM satellites. The Gapfiller architecture recommends that three additional UFO satellites be launched between 2003 and 2007 to fill the gap.

One of the scenarios quoted by The MITRE Corporation from the ERDB can serve as a guideline to the magnitude of DOD SATCOM needs.⁶ The scenario gives 10.6 Gbps as the total communications requirements for DOD that must be filled by SATCOM. This is further broken down in **Figure 4-1** below.

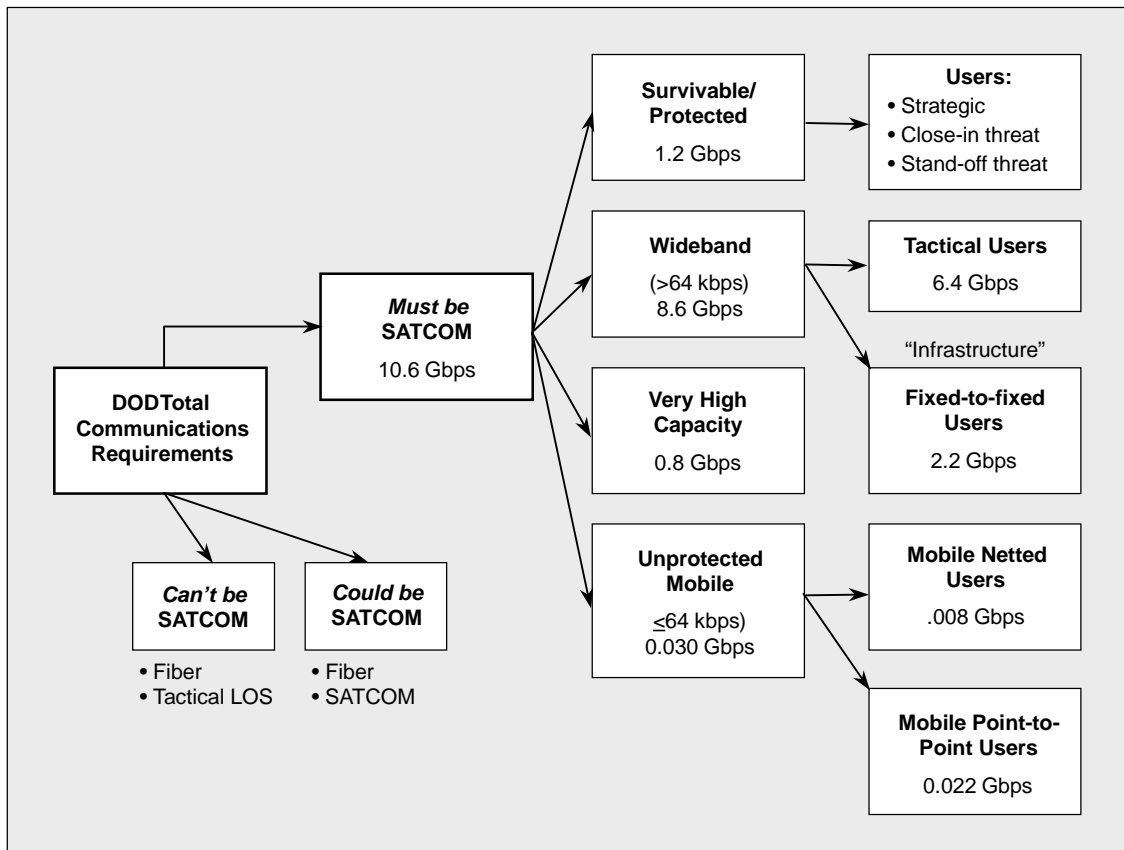
The majority of these requirements are for wideband services (8.6 Gbps), and of those the majority (6.4 Gbps) would support tactical users. These users are looking for expanded imagery, video or other capabilities that require wideband services. It should also be noted in **Figure 4-1** that even though the unprotected mobile portion of the DOD requirements is small in relationship to the overall DOD SATCOM total, many of these systems are 2.4 kbps to 9.6 kbps, and the 30 Mbps (0.03 Gbps) requirement listed above is therefore quite substantial. The 730 users associated with these requirements should be the best candidates for having their systems replaced by the new MSS systems.

³*Joint Mobile User Study (MUS) Final Report*, A Tri-Service Study Co-Chaired by: Space, Information Warfare, Command and Control Directorate, CNO (N6B) and Program Executive Officer, Space Communications and Sensors, UFO Satellite Program Office PMW-146 (PEO-SCS) (Washington, D.C.: U.S. Department of the Navy, March 24, 1998), 14.

⁴*Ibid.*, 31.

⁵*Ibid.*, 5 and 29.

⁶The MITRE Corp., "Commercial Satellite Communications Capability Assessment Study," briefing presented by John Atwood, MITRE, Bedford, Mass., Dec. 16, 1998, slide 44. The totals shown were derived from the CMTW Scenario, ERDB v5.1r1.



Gbps = gigabytes per second kbps = kilobytes per second LOS = line of sight SATCOM = satellite communications

Source: "Commercial Satellite Communications Capability Assessment Study," A briefing by John Atwood, MSS systems engineer, The MITRE Corp., Bedford, Mass., Dec. 16, 1998, slide 44. The totals shown here were derived from the CMTW Scenario, ERDB v5.1r1.

Figure 4-1
DOD SATCOM Requirements⁷

The *Mobile User Study* (MUS), conducted in 1998 at the request of the Joint Space Management Board, analyzed the ICDB and ERDB, and then estimated that commercial MSS services could fill approximately 25 percent of ERDB narrowband requirements,⁸ thereby reducing pressure on current and planned tactical communication satellites. In fact, the Senior Warfighter’s Forum recommended in 1998 that the military “mitigate the constellation risk from 2003–07 by utilizing MSS for UHF point-to-point, transitioning some users to EHF and SHF where it makes sense.”⁹

⁷Ibid.

⁸*MUS Final Report*, Executive Summary, 3.

⁹Ibid., 1.

4.2 Identification of Mobile SATCOM Requirements

Many needs for mobile communications remain unidentified, not merely unfilled. The ICDB and ERDB contain only those requirements formally validated by some level of DOD formal authority. As an example, within the Air Force, major commands (MAJCOMs) are the primary approval authority for requirements. Units submit requirements to their MAJCOMs, which must then affirm the validity of the need and formally approve it. The Air Force places the validated requirements in priority order to determine which ones will make the budget cut, be funded, and eventually procured. Validated requirements normally remain on the books, and advocates will renew their efforts to get them funded each year. All the services have similar methods for approving their requirements.

One of the problems with this system is that the official databases do not reflect many potentially useful applications for MSS systems. Numerous communications requirements have not made the budget cut in the past due to higher-priority warfighter requirements. Moreover, additional units need these MSS systems, but have not gone through the formal validation process, either because they could not afford the current expensive satellite systems or because their previous attempts did not result in approval. For example, such units as the Air Force Tactical Air Control Parties (TACPs) and other parts of the Tactical Air Control System currently rely on the Air Force Air Request Network (AFARN), an HF network that functions adequately most of the time, but can be unreliable due to various problems associated with skywave signals. These entities badly need better long-range communications systems, but could not obtain MAJCOM validation of their requests.¹⁰ Secure MSS systems might provide a valuable network to augment the AFARN.

High cost may explain why the Air Force has not validated certain SATCOM requests, even when existing LOS systems do not meet user needs. Current MSS systems cost more than many military units can afford. A typical UHF SATCOM system (Motorola LST-5D) costs \$40,995.¹¹ The full cost of an airborne SHF Inmarsat system will include about \$50,000 for the terminal, and an additional \$750,000 to \$1.4 million to install and integrate the system into the aircraft.¹² User fees on the Inmarsat normally run between \$3 and \$9 per minute depending upon the type of call. Inmarsat and UHF SATCOM systems, when available, also have directional antennas that must be pointed at the satellite and are not always compatible with a mobile “on the move” mission.

¹⁰Author was the chief of deployable requirements for HQ Air Combat Command from 1990–93. This included requirements for the TACPs.

¹¹Motorola Systems Solutions Group, Scottsdale, Ariz., Quotation #60703-5584, sent to the author, Feb. 19, 1999.

¹²The author was in charge of monitoring, for the Joint Staff J-6, installation of Inmarsat systems on five U.S. Air Force aircraft used by combatant CINCs from 1995–98. Prices were obtained from personal knowledge of the procurements and installations.

Commercial MSS terminals, on the other hand, are already being sold for between \$100 and \$4,000, and typical user fees will range between 30 cents to \$8 per minute (see **Tables 3-2 to 3-4**). These terminals will also have omnidirectional antennas that will work regardless of which direction the antenna is pointed. Thus, many organizations that could not afford existing satellite systems may be able to afford new MSS systems, and thereby expand their capabilities without putting undue strain on their (or their parent service's) budgets. As noted previously, the new Inmarsat Mini-M terminals are considerably less expensive than the large terminals; however, they still require directional antennas.

The multiple emerging MSS systems should also reduce the costs of certain existing systems, such as Inmarsat, and should foster competitive pricing that will continue to drive prices down. Inmarsat and some other suppliers to the military have already begun to produce smaller terminals to compete in the emerging market, thereby benefiting both military and civilian users.

Yet another reason why the military denied requests was bandwidth limitation. Even some of the military units that could afford to buy military SATCOM systems were often turned down when they tried to obtain permission to use the very limited bandwidth. These types of organizations, which did not have a high enough priority to get a satellite channel on UHF systems, may be able to gain access under these new commercial systems.

An in-depth analysis of the ERDB is beyond the scope of this study; however, military planners need to assess how many of previously unfilled requirements can now be met with the emerging MSS systems, and to analyze the operational utility of the new commercial satellite systems. This analysis should include both the official requirements that have been validated in the ERDB and a new call for other requirements that could be met with the MSS systems. Planners should carry out the assessment with a fresh look at the new capabilities and the significantly lower costs that would result from the use of MSS systems as opposed to exclusive reliance on UHF.

4.3 Military Applications of MSS Systems

All military services can benefit in some way from the new MSS systems. Narrowband and wideband systems offer many different types of MSS service capabilities, covering a variety of different service requirements. In its study of mobile SATCOM,¹³ the Office of the ASD C³I provided a partial list of potential applications for the new LEO (narrowband) MSS systems, including:

- Mobile telephone services for:
 - Logistics operations

¹³Department of Defense, Assistant Secretary of Defense (C³I), *Mobile Satellite Communications, An Overview of Systems and Concepts* (Washington, D.C.: U.S. DOD, Jan. 26, 1996), 1-3.

- Finance and accounting
- Medical services
- Personnel services
- Administration
- Paging, facsimile, e-mail, positioning (with GPS¹⁴ or RDSS¹⁵)
- Mobile messaging services
- Mobile data services for cargo tracking
- Metering and remote sensor reporting
- Positioning in remote areas (with GPS or RDSS)¹⁶

The *MUS* and other studies have initiated some research to identify types of requirements; however, there seems to be no comprehensive list of specific requirements to be filled or systems to be augmented or replaced by MSS systems. At a more conceptual level, the *MUS* reviewed over 100 requirements for low data rate netted communications and distilled them into the following eight high-level needs, prioritized in accordance with votes by each service staff, DISA, and the JCS:¹⁷

1. Assured access
2. Netted communications
3. Communications on the move
4. Joint interoperability
5. Worldwide coverage
6. Point-to-point communications
7. Broadcast capability
8. Polar coverage.

They offer excellent insight into the military's general preferences for satellite communications. The study concluded: "Overall, the MSS systems were unable to meet the top two *MUS* requirements of assured access and netted communications."¹⁸ However, it further stated that:

¹⁴Ibid., 2-21, explains that the Global Positioning System (GPS) is not a system of communications satellites but, rather, a one-way transmit signal from the satellite to the user on the ground. This capability must be added to the user's communications terminal.

¹⁵Ibid., 4-7 and A-6, defines RDSS as Radio Determination Satellite Service, which is another position-location capability that does not come as a standard capability of the terminal.

¹⁶*MUS*, 14-15.

¹⁷Ibid.

¹⁸Ibid., 27.

“MSS and alternate communications relays could augment, yet not replace, satellite communications.”¹⁹ If technically and fiscally possible, commercial companies might want to include all or some of these eight capabilities in future systems.

Meanwhile, without waiting for these future capabilities to come on-line, the military could act now and identify specific missions that could utilize existing or future MSS systems. To help users determine the applications for new MSS systems, sections 4.3.1 to 4.3.4 outline selected categories of missions, and indicate how they might utilize MSS systems. This list does not purport to be comprehensive, but instead is only a beginning from which readers could gain ideas for applications to their own type of mission.

4.3.1 DOD Enhanced MSS

The military’s communications requirements for certain types of missions—primarily those related to combat—include: (1) survivability, (2) assured access, (3) LPI/LPD features, (4) antijam and (5) networking capabilities. These requirements significantly increase the cost of each system. It is common knowledge that MSS systems cannot yet meet most of them. However, UHF SATCOM, Inmarsat, and Iridium systems can be made secure with National Security Agency (NSA) approved encryption.²⁰ The DOD-enhanced MSS (E-MSS) Iridium system already fulfills the requirement of securability. Inmarsat Mini-M terminals, which can be secured, are available today. The NSA also has phase 1 internal research and development programs in place with Globalstar and ICO to investigate the development of secure communications.

The Mobile Satellite Communications study concludes that:

Together, the proposed Big and Little LEO systems could provide a major improvement in communications services for combat *support* activities; however, their use for combat *operations* in or near the battle areas is not recommended. This is because the LEO systems, as currently envisioned, would be unencrypted, easily intercepted, readily jammed, and subject to foreign control.²¹ [emphasis in original]

In fact, the Iridium system, or one like it, could decrease or eliminate all of these problems. Encryption is planned for Iridium, and the crosslinked system Iridium employs would remove the possibility of foreign control. Additionally, an Iridium-like system with a frequency-hopping or code division multiple access capability could be reliable against jamming. Iridium or some other MSS system will undoubtedly employ these capabilities in the years to come.

¹⁹Ibid.

²⁰MITRE, “Commercial Satellite Communications Capability Assessment Study,” slide 34.

²¹*Mobile Satellite Communications*, 1-3.

For support missions, the security requirements may be a “gray area” or not needed at all. Military policymakers must ask themselves if they are applying a set of strict military communications requirements to missions that do not warrant those requirements. The military might want to seek a balance—between a smaller number of expensive systems for missions that would actually need them and a greater number of cheaper MSS systems for other types of missions that do not.

As of mid-1999, the military, and particularly the Air Force, hesitated to use any MSS system other than the Iridium E-MSS. Their reluctance stems from two significant factors: first, the \$150 million DOD investment in its own Iridium gateway, and second, the need to maintain operational security.²² As stated in an Air Force Policy Letter by Acting Air Force Secretary F. Whitten Peters and Chief of Staff General Michael E. Ryan, “Currently Air Force personnel are prohibited from using commercial handsets ... throughout the employment, deployment, and redeployment phases of any operation.”²³ The Iridium handsets registered to the government gateway and authorized by the government are not considered commercial handsets. The DOD enhanced system is expected to provide global, secure transmission (data, fax, paging, messaging, and precise position location [with GPS or RDSS] services), multimode service (which allows either terrestrial cellular or satellite communications on one phone), and interconnection to the public switched telephone network (PSTN).²⁴ Other MSS systems (see **Tables 3-2 to 3-4**) offer some of these services and features; however, they do not yet have a secure device or Iridium’s DOD-only gateway.

In its *Concept of Operations [CONOPS] for the DoD-Enhanced Mobile Satellite Services*, U.S. Space Command (USSPACECOM) lists several missions where the military might use the new E-MSS.²⁵ Most of the details below are quoted directly from the CONOPS or were condensed from the document’s paragraph on each mission. The missions include, but are not limited to, the following:

- En route communications: E-MSS could provide airborne and vehicular en route communications from command elements to forward and rear headquarters.
- VIP [very important person] travel communications: Over 10 VIP aircraft directly support CINC [commander in chief] travel, and another 18 aircraft in the 89th Air Wing support the President, Vice President, cabinet members, congressional delegations,

²²F. Whitten Peters and Michael E. Ryan, Air Force Policy Letter on Use of the Iridium MSS, Jan. 17, 1999, 1, [Online]. URL: http://afca.scott.af.mil/gc/gcg/mss/iridium_policy.htm (Accessed Feb. 25, 1999.)

²³Ibid.

²⁴U.S. Space Command/J-6S, *Concept of Operations for the DoD-Enhanced Mobile Satellite Services (MSS) [CONOPS]* [no date], 7–8. Current version forwarded to author on Feb. 10, 1999, by USSPACECOM/J6S.

²⁵Ibid., 9–14.

members of the Joint Staff, and other American and foreign dignitaries.²⁶ As noted in the CONOPS, “Communications support to VIP aircraft is required on a worldwide basis. The use of enhanced MSS as a service to satisfy this requirement may significantly reduce current tasking of tactical MILSATCOM assets for this purpose.”²⁷

- Strategic airlift operations: E-MSS could be used to “enhance coordination of aircraft routing, passenger data, crew scheduling, etc.”
- Special operations: “MSS capability could support special operations in remote, low visibility, contingency and small scale operations other than war. ... A mobile gateway may be required to provide an interface between Special Operations and ... [other networks].”
- SAR operations: “SAR forces command and control would be provided by other military satellite communications.” However, the E-MSS system “could augment the Search and Rescue Satellite geolocation system with voice and data for survivor-rescue force communications.”
- Global Broadcast Service (GBS) reachback: E-MSS would allow the field commander connectivity through the PSTN or the Defense Information Systems Network to communicate back to the GBS information manager or source of information.
- Polar region operations: E-MSS “will provide low data rate connectivity for application in many mission areas that do not require antijam/LPI/LPD previously constrained by a lack of beyond line-of-sight communications assets.”
- Humanitarian/disaster relief support: E-MSS can offer significant capabilities in these missions, especially when they occur in areas with very little communications infrastructure.
- Focused logistics: E-MSS combines digital data and geolocation capabilities to enable “worldwide in-transit visibility for logistics operations.”

The Gulf War offers one example of a need that the new MSS systems might remedy. According to the *Mobile Satellite Communications* study, “During Desert Storm, it is estimated that approximately half of all containerized cargo had to be opened in order to determine its contents and final destination.”²⁸ The cargo tracking application mentioned above as a possibility for LEO MSS systems could preclude a similar problem.

4.3.2 Applications of MSS in Military Operations Other Than War

The military has been tasked to conduct an ever-increasing number of military operations other than war (MOOTW). The expansion of these missions as a proportion of total activity may

²⁶Facts derived from author’s job in charge of Senior Leadership Travel Communications for the Joint Staff J-6, 1995–1998. See George W. Hays, “Senior Leadership Travel Aircraft,” Joint Staff/J6C Point Paper (Washington, D.C.: The Joint Staff, July 17, 1996).

²⁷CONOPS, 10.

²⁸*Mobile Satellite Communications*, 1-3.

have eliminated, or at least reduced, the need for some stringent requirements that were typical of previous military missions. Many MOOTW missions occur in environments of low threat where some unique military requirements, such as antijam, LPI/LPD, and assured access, may not be needed. In certain cases, therefore, military policy makers may still be applying requirements to missions where they are not currently needed.

Do MSS systems provide a fundamentally improved capability for MOOTW missions? The answer becomes a little more complicated. For example, MSS systems might easily replace or supplement the more expensive UHF or SHF SATCOM systems used in some MOOTW missions, but not be at all applicable in others. MSS systems could certainly offer telecommunication access to missions that hitherto have had none; for example, in cases where not enough global satellite communications systems are available, these MSS systems could be the only affordable option for long-range mobile communications, particularly communications down to the unit level.

Joint Publication 3-07, *Joint Doctrine for Military Operations Other than War*, lists 16 types of such missions.²⁹ **Table 4-1** outlines these missions and some of the MSS systems that may be applicable to them. Again, this list is not meant to be comprehensive, nor is it intended as the authority on whether these missions can use MSS systems or not. These suggested areas are intended to stimulate users' own ideas about MSS applications for their particular missions.

4.3.3 Administrative and Support Systems

Many administrative and combat support systems may also be good candidates for replacement, since they do not need the capabilities that support security requirements. The *Mobile Satellite Communications* study suggests that a significant number of such military systems could be candidates for replacement:

In the case of U.S. military operations overseas, big LEO³⁰ systems could provide satellite-based mobile telephone services throughout regions with little or no national or U.S. military communications infrastructure. This new service would be a major improvement over current U.S. tactical voice communications capabilities and could greatly increase the flow of communications among a host of combat support activities, including, logistics, finance, personnel, medical, and administrative operations. Moreover, the big LEOs' planned provision of facsimile, paging, and e-mail using these same cellular-sized telephones would provide users with important communications supplements that could further improve the

²⁹Joint Publication 3-07, *Joint Doctrine for Military Operations Other Than War* (Washington, D.C.: The Joint Staff, June 16, 1995), III-1.

³⁰“Big LEO” satellites offer voice or data communications and operate above 1 gigahertz (GHz) frequency.

overall effectiveness of combat support activities. Little LEOs³¹ could contribute significantly to U.S. combat support activities by providing increased efficiencies through messaging and cargo tracking services.³²

Wideband systems may also provide significant communications improvements for military users. Wideband GEO systems such as Spaceway, Cyberstar, and Astrolink, and LEO systems such as Teledesic and Skybridge, will offer a variety of services that can augment or replace some existing military systems. According to *Telecommunications* magazine: “The need for speed is the driving force behind this space race...this new group of broadband suppliers promises speeds up to 64 Mbps downlink and 2 Mbps uplink. The idea is to provide fat data pipes for Internet access, videoconferencing, e-mail, virtual private networks, and numerous other applications.”³³ Many of these systems will offer capabilities that may not have been possible with existing limited bandwidth. Examples include commercial satellite services to provide unclassified services, such as high-speed Internet access, video distribution, distance learning, or telemedicine, to troops deployed to remote locations.³⁴

4.3.4 Limitations of MSS Systems

Communications systems that directly support combat missions may not be good candidates for replacement by MSS systems. These missions have requirements for, as a minimum, guaranteed access and priority use. This means that the military would have to control access to the satellite and institute a priority user system for callers specified as being particularly important. As currently configured, no commercial systems provide these capabilities. According to one Navy assessment, even Iridium “does not have the ability to provide priority service; in other words it operates on a first-come, first-serve basis. If the U.S. military were to rely on such a system during a crisis, it might find itself competing with CNN or even its adversary for use of the limited number of access channels.”³⁵

³¹“Little LEO” satellites offer data communications only and operate below 1 GHz frequency.

³²*Mobile Satellite Communications*, 1–2.

³³Susan O’Keefe, “Watch Out DSL: Broadband Satellite Systems are Coming,” *Telecommunications* **32**, 10 (October 1998), 35.

³⁴Danelle Barrett, “Communications, Commercial Satellite Constellation Offers Potential Military Benefits,” *Signal* **53**, 3 (November 1998), 43.

³⁵J. Todd Black, “Commercial Satellites; Future Threats or Allies,” *Naval War College Review* **LII**, 1, Sequence 365 (Winter 1999), 106.

Table 4-1
Recommended Applications of MSS in MOOTW

Type of MOOTW Operation	Military Actions ³⁶	MSS Systems that Could be Used
1. Arms control	Seize WMD, escort, dismantle, destroy, or dispose of weapons	Military systems only
2. Combating terrorism	<ul style="list-style-type: none"> • Antiterrorism: defensive measures • Counterterrorism: offensive measures • Responses: preemptive, rescue, and retaliatory operations 	Military systems only
3. DOD support to counterdrug operations	Detect and monitor aerial and maritime transit of illegal drugs into the U.S.	DOD-E MSS; e.g., Iridium
4. Enforcement of sanctions/maritime intercept operations	Form a barrier—only allow authorized goods to enter or exit	DOD-E MSS; e.g., Iridium
5. Enforcement of exclusion zones	Prohibit specified activities in a specific geographic area (i.e., no-fly zone)	DOD-E MSS; e.g., Iridium
6. Ensuring freedom of navigation and overflight	Demonstrate U.S. or international rights to navigate sea or air routes according to international law	DOD-E MSS; e.g., Iridium
7. Humanitarian assistance (HA)	Relieve or reduce the results of natural or manmade disasters or other endemic conditions such as human pain, disease, hunger or privation outside the U.S.	WB and NB MSS
8. Military support to civil authorities (MSCA)	Provide temporary support to domestic civil authorities when permitted by law, restore law and order after riots, protect life and federal property, provide relief after natural disasters	WB and NB MSS
9. Nation assistance/support to counter-insurgency	Provide military assistance (other than HA). Includes security assistance, foreign internal defense, humanitarian and civic assistance (planned activities: medical, dental, veterinary, etc.)	WB and NB MSS
10. Noncombatant evacuation operations	Relocate threatened noncombatants from a foreign country. Limited force does a swift insertion, temporary occupation, and planned withdrawal	DOD-E MSS; e.g., Iridium
11. Peace operations	<p>Conduct military operations to support diplomatic efforts to reach a long-term political settlement</p> <ul style="list-style-type: none"> • Peacekeeping operations (with consent of major parties) • Peace enforcement operations (without consent of parties, to compel compliance with resolutions or sanctions) 	<p>Peacekeeping—WB or NB MSS</p> <p>Peace enforcement—DOD-E MSS; e.g., Iridium</p>
12. Protection of shipping	Protect U.S. flag vessels, citizens, and property against unlawful violence in and over international water. Includes environmental defense, coastal sea control, harbor defense, port security, and countermine operations	Military systems only unless overt, then WB or NB MSS

³⁶Ibid., III-1 through III-15. This version is condensed from the lengthy text found in Joint Publication 3-07 on each of the sixteen types of MOOTW operations.

13. Recovery operations	Search for, locate, identify, rescue and return personnel or human remains, sensitive equipment, or items critical to national security. May be clandestine, covert, or overt	Military systems only, unless overt, then WB or NB MSS
14. Show of force operations	Increase visibility of U.S. deployed forces in an attempt to defuse a specific situation	DOD-E MSS; e.g., Iridium
15. Strikes and raids	Strikes: offensive operations to inflict damage on, seize, or destroy objective for political purposes Raids: usually small-scale operations to secure information, confuse enemy, or destroy site.	Military systems only
16. Support to insurgency	Support an insurgency against a regime that is threatening U.S. interests	Military systems only

NB = narrowband WB = wideband WMD = weapons of mass destruction

Notes: Wideband MSS = >64 kbps systems; some or all of voice, data, multimedia, video, internet, and video teleconferencing capabilities may be used. Narrowband MSS = <64 kbps systems; some or all of voice, data, fax, paging, and messaging capabilities may be used. Backup only = Use a military system as the primary and the MSS system in a backup role.

The DOD may need to adapt some commercial systems to military uses, while others, such as Spaceway’s ultra small aperture terminal, may be ready for military use in certain settings as soon as they become operational. Users can deploy Spaceway’s lightweight, portable, and affordable two-foot dish within one hour, and establish an uplink at 384 kbps and downlink at 108 Mbps; one assessment notes that this feature would make Spaceway suitable for “mobile users or those with infrequent yet high data rate demands.”³⁷

4.4 Reliability Concerns

Field testing provides the best way to determine the actual usefulness of the new systems. The Air Force’s Space Battlelab began testing the new Iridium MSS system on December 1, 1998; the tests are continuing. In the final phase of its evaluation, the Battlelab sent Iridium satellite phones to all the warfighting CINCs, a total of 130 telephones worldwide. The MSS systems have already performed successfully in various settings. For example:

- Forward air controllers in Bosnia have used them to call in mock air support.
- Air traffic controllers have used them at Tuzla, Bosnia.
- Battlelab personnel have completed calls from an Air Force plane flying at 30,000 feet, and from a floating buoyant cable installed by the Navy 25 miles north of the Arctic Circle.³⁸

The U.S. Air Force Electronics Systems Command (ESC) has initiated a multipronged effort to assess how MSS capabilities match its mission needs. Under contract to ESC, The MITRE Corporation is conducting a commercial capabilities assessment study; ESC is gaining hands-on experience with the terminals of various emerging systems (e.g., conducting an

³⁷Barrett, 43.

³⁸Spacedaily News.

evaluation of the Iridium handset), and has incorporated MSS systems into such operational experiments as EFX-98 and EFX-99.³⁹ ESC tests equipment across a broad spectrum of missions and should be able to determine not only system capabilities, but also some of the possible mission applications for those capabilities. As of this writing, the results of these tests were not yet available for public release.

These and other encouraging examples should give military leaders confidence in the potential of MSS systems to perform in stressed conditions, and prompt them to explore further applications to their own needs. When DOD has verified the capabilities of the new systems and matched them with mission needs, the department should initiate a new service-wide call for requirements wherein approval for the requirement (not the allocation of the equipment) should be based on need and not on budget availability.

4.5 Interoperability with Civilian Systems

MSS systems have even greater potential for assisting civilian agencies at various levels than the military, although in the case of civilian agencies the use of any type of SATCOM might imply a need to examine an entirely new realm of communications possibilities. Because the possible applications seem endless, the following list of possible civilian government applications for MSS systems simply includes a few examples that may also have some correlation to military applications. The *Mobile Satellite Communications* report identifies the following possibilities:⁴⁰

- Mobile telephone services for:
 - Law enforcement operations
 - Forest fire reporting
 - Border Patrol surveillance
 - National parks management
 - Federal aircraft flight following
- Paging, facsimile, e-mail, positioning (with GPS or RDSS)
- Mobile data services for:
 - Covert tracking of illegal cargo
 - Tracking of nuclear materials
 - Tracking of hazardous cargo
- Metering services for:

³⁹The MITRE Corp., “Commercial Satellite Communication Systems and the DoD: A Basis for DoD Selection of Commercial SATCOM Systems,” briefing presented by Leah Gaffney (POC), MITRE, Bedford, Mass., Oct. 15, 1998, Overview, slides 4 and 5.

⁴⁰*Mobile Satellite Communications*, 1-3.

- Pipeline pressure reporting
- Water level and flow rate reporting.

Government organizations that will have these and other uses for the emerging MSS systems include, but are not limited to, the Federal Emergency Management Agency (FEMA), the U.S. Forest Service, the Department of Agriculture, National Oceanic and Atmospheric Administration, the State Department, the Department of the Interior (especially the National Parks Service and the U.S. Fish and Wildlife Service), the Federal Bureau of Investigation, the Central Intelligence Agency, and the Department of Transportation. Individuals and field offices of all of these agencies must retain the ability to operate effectively in situations where normal communications infrastructure becomes unavailable. For example:

- FEMA operators could communicate from a hurricane-damaged area where cellular sites have literally been “blown away.”
- Forest Service firefighters could make life-saving calls for help about changes in wind direction.
- Foreign embassies could receive guidance from State Department advisors if civil unrest or natural catastrophes damaged the electric power grid and thus their ability to communicate over non-satellite systems.

Should these agencies expand their options to include MSS systems, this would have important implications for the military as well. Military organizations, active or reserve, work with these civilian organizations at one time or another on different missions, but the lack of interagency and international interoperability has posed long-standing problems. Therefore, MSS systems might offer the additional benefit of serving as a bridge for interoperability between the military and other agencies and nations involved in an operation. Such organizations might include the Red Cross, Doctors Without Borders, and international programs to feed the hungry.

Commercial MSS companies have considerable knowledge and expertise in defining potential markets, and have already identified most of their target users. Some of the civilian activities also relevant to military applications include, but are not limited to:

- search and rescue,
- tracking of trucks and other vehicles,
- tracking storage and shipping containers,
- monitoring pipelines,
- television news,
- law enforcement,
- telemedicine,
- humanitarian operations,

- education via the Internet,
- crisis management, and
- maritime uses.

MSS systems will extend fixed and cellular service with their dual-mode telephones,⁴¹ but in most cases will not produce a breakthrough in capabilities for existing users. For many customers, military and civilian, MSS (sometimes also known in the commercial world as global mobile personal communications by satellite [GMPCS]) will be to the cellular system what cellular systems are to fixed systems—a service extension.⁴²

Developing nations, or countries with large amounts of rugged terrain and little infrastructure (such as the Siberian area of Russia) constitute the most obvious market for MSS systems. Unfortunately, precisely these users, with the greatest need, are least able to afford even the relatively low prices of the satellite up- and downlinks and of the terminal equipment. Still, in the future it might be more feasible to provide a satellite terminal to remote villages than to construct the repeaters that would be necessary were such users to rely on cellular telephones. Again, the existence of such capabilities could prove crucial for the military if the need for relief efforts, or a sudden local crisis, demanded military intervention.

4.6 How Might MSS Systems Change the Way the Military Operates?

How might military communications requirements at every level of command change with the emergence and widespread use of many MSS systems? What effect might a global lightweight, affordable, and accessible mobile system have on military and civilian users? What might the future warrior use for communications? Brigadier General Robert Shea, Assistant Chief of Staff, C4I, U.S. Marine Corps, outlined a scenario like this:

But if you took the Global Broadcast System and you gave a user—the user took a cellular phone *using a mobile subscriber service* which provides a low probability of intercept and detection—using that type of capability complementing GBS, he could call back to the theater and request different types of information that he might not otherwise be getting. So, I think we need to look at these things, the commercial

⁴¹The terms “mobile satellite service” and “global mobile personal communications by satellite” (GMPCS) refer to similar types of systems. The ITU defined a GMPCS system as: “Any satellite system (i.e., fixed or mobile, broadband or narrowband, global or regional, geostationary or non-geostationary, existing or planned) providing telecommunications services directly to end users from a constellation of satellites.” Although the ITU included “fixed” systems in the official international GMPCS definition, common use of the GMPCS term does not.

⁴²Marc Newman, “Globalstar LP,” briefing presented at the Global Mobile Personal Communications by Satellite (GMPCS) ’99 Conference, Washington, D.C., Jan. 26, 1999, slide 27.

systems, as complementary, as well as supplementary, to military systems.⁴³ [emphasis added]

Might every soldier, sailor, marine, and airman in the field have access to a personal satellite radio capable of reaching anyone, anywhere? Even if the technology and affordability allow it, *should* every warrior have such access, and for what purpose and with what limitations?

The senior military leadership has not overlooked these questions. In 1995, the chairman of the Joint Chiefs of Staff initiated an analysis of on this issue titled *The Unintended Consequences of Information Age Technologies*.⁴⁴ The findings in this report apply to all information technologies, and certainly to MSS systems. The analysis had two major purposes: “first, the identification and avoidance of adverse unintended consequences associated with the introduction and utilization of information technologies; and second, the ability to recognize and capitalize on unexpected opportunities.⁴⁵ After analyzing the pros and cons, the author concluded that “the potential benefits of information technology far outweigh the potential costs associated with unintended consequences. ... However,...this is predicated upon the adoption of an effective technology insertion strategy.”⁴⁶ In other words, the military must place proper limits on the use of technology and must train the participants effectively.

With the emergence of technological advances, civilian companies are eliminating levels of leadership and organizational echelons within their corporate structures to make management easier. Should the military follow suit? Downsizing has already led to a reduction in echelons, but perhaps the military should also examine possible reductions due to technological advances that eliminate the need for some leadership positions.

How might the new MSS capability, potentially available at all echelons of command, change the way missions will be conducted and forces organized in the future? The answers to this question are not within the scope of this study. The only useful response could come from

⁴³Robert Shea, “Getting the Right Information to the Warfighter,” quoted in Question and Answer Interview by Anthony Kimery, *Military Information Technology* 2, 5 (Winter 1998), 22.

⁴⁴David S. Alberts, *The Unintended Consequences of Information Age Technologies* (Washington, D.C.: National Defense University Press, April 1996).

⁴⁵Ibid., 4.

⁴⁶Ibid., 6.

experts in each of the military services who conduct the various missions where these MSS systems could be used. Only they can really determine if these systems will meet the requirements of their particular mission.

Chapter Five

Summary

MSS systems are one of the technological advances that are constantly improving our ability to communicate and thereby our ability to complete military missions successfully. This study has provided some of the basic facts about MSS systems and discussed some of the possible uses and the subsequent effects of these systems. At least two other studies have concluded that approximately 25 percent of tactical military communications (point-to-point) could be offloaded to commercial MSS systems.¹

The UHF and Inmarsat systems feature manpackable or laptop computer-size terminals. The newly procured Iridium terminals give DOD a secure, handheld, and airborne commercial SATCOM capability. Other vendors, whose offerings are outlined in **Chapter Three**, are also expected to provide terminals that can meet significant needs among DOD and civilian MSS users.

Wideband systems currently target fixed-site applications; however, Teledesic has also submitted an application to the Federal Communications Commission for mobile operations.² Additionally, such systems as Astrolink, Cyberstar, Skybridge, Spaceway, and others not listed,³ have planned or may soon include plans for transportable systems that members of the armed services could easily set up in theaters of operation.

It appears that many military and civilian mobile communications users should re-evaluate the new MSS systems for cost and capabilities benefits that match their requirements. While in the near term most of these systems may perform in a backup or augmentation role for the military's primary systems, they may eventually be able to completely replace some systems that are not used for direct combat. Given the length of the DOD acquisition cycle, now is the time to act—while DOD is acquiring, or developing, systems that may no longer be necessary.

The DOD inventory contained over 15,000 UHF SATCOM terminals in 1996. That number is expected to increase to 36,000 in 2004 and 52,000 in 2010.⁴ While this study does not

¹*Joint Mobile User Study (MUS) Final Report*, A Tri-Service Study Co-Chaired by: Space, Information Warfare, Command and Control Directorate, CNO (N6B), and Program Executive Officer, Space Communications and Sensors, UFO Satellite Program Office PMW-146 (PEO-SCS) (Washington, D.C.: U.S. Department of the Navy, March 24, 1998), 59; James Loiselle, Robert Tarleton, and Jerry Ingerski, *The Next Generation Mobile User Objective System (MUOS)*, AIAA-98-5246 (Reston, Va.: American Institute of Aeronautics and Astronautics, 1998), 3.

²The MITRE Corp., "Commercial Satellite Communications Capability Assessment Study," briefing presented by John Atwood, MITRE, Bedford, Mass., Dec. 16, 1998, slide 29.

³Approximately 40 systems have FCC wideband filings on record. See "Commercial Satellite Communications Capability Assessment Study," slide 14.

⁴*MUS Final Report*, 43–44.

advocate replacing the existing terminals and associated ground control facilities,⁵ which together represent an \$8 billion investment, DOD may discover that commercial MSS systems can meet many needs hitherto slated for UHF systems, and may choose to procure commercial MSS instead of many of the 37,000 additional UHF systems. This does not mean that none of the military-unique UHF systems are needed. There are essential reasons for keeping the UHF SATCOM system in operation, among them assured access, networked communications, penetration through weather and foliage, not being geolocated, and the need for security.⁶ There also seem to be some very logical reasons for procuring more of the MSS systems than currently seem to be planned. For example, as shown in **Chapter Three**, MSS terminals cost 10 to 20 times less than UHF SATCOM terminals.

While the military cannot sacrifice essential requirements simply for savings, DOD appears to have an opportunity to fundamentally improve communications for the warfighter without sacrificing quality. The Acquisition Strategy Development section of the *MUS* recommends that DOD: “[T]ake full advantage of emerging commercial systems by engaging industry now to incorporate military unique requirements into their commercial designs.”⁷ Part of this recommendation came about because of two key points. First, the *MUS* suggested that approximately 25 percent of ERDB narrowband requirements could be moved to commercial MSS services. Second, even with the Narrowband Objective System, DOD can only meet 85 percent of the remaining UHF narrowband ERDB requirements.⁸ In view of these considerations, the military will have little choice but to turn to the commercial MSS market to fulfill its requirements.

As discussed in **Chapter Four**, emerging MSS systems may even fulfill some of the needs mandated by certain types of missions. The UHF SATCOM, Inmarsat, and Iridium systems that DOD is currently using for its MSS requirements can be made secure with NSA-approved encryption.⁹ Three MSS systems (ICO, Inmarsat, and Iridium) intend to meet commercial airborne requirements for regular voice phones, video on aircraft, broadcast networks, and data transmissions, and four MSS systems (Ellipso, Globalstar, ICO, and Iridium) are examining the potential for a netted voice capability.¹⁰

The facts and figures provided in this study may have no operational utility on their own. Only through the analysis and application of this type of data can DOD make needed changes and subsequent progress. At present, no one can answer questions about the future, or even know all

⁵Ibid., 52.

⁶Ibid., 53.

⁷Ibid., 48.

⁸Ibid., 59.

⁹MITRE, “Commercial Satellite Communications Capability Assessment Study,” slide 34.

¹⁰Ibid., slide 10.

of the right questions to ask. The study includes some questions and possible answers for military planners to reflect on and possibly use in their analysis and application of future systems and capabilities. Each segment of the military must determine how its own communications requirements at every level of command might be able to change with the emergence of many MSS systems.

Could it be that MSS systems, combined with the multitudes of other C³I systems, have created a fundamental improvement in the abilities of all levels of organizations to communicate? If so, then could—or should—organizations that have these capabilities conduct conceptual revisions in their force structure and sizes? If knowledgeable individuals and small teams can easily communicate with much higher authority around the world, do we really need several layers of command and control between them? Technological advances that include C³ systems have allowed civilian organizations to flatten their organizational structures and take out a great deal of mid-level management. Military organizations should follow the examples of these companies and review their own organizational structures for possible reorganization.

The emerging systems will eventually replace many existing systems. It is for military planners to determine how soon that will occur and at what cost. In the words of the head of Pentagon C³I programs, Arthur Money; “Wouldn’t it be wonderful if every soldier, sailor, airman and Marine who needs a phone had something that would work anywhere in the world and would interoperate with each other [sic]?”¹¹

This study has sought to raise the level of awareness of these systems, their capabilities, and some of their possible applications. If it has succeeded in doing so, it may in some way contribute to improving the capability of U.S. warfighters and therefore the subsequent success of their missions.

¹¹Arthur Money, One on One (interview), *Defense News* **14**, 2 (Jan. 18, 1999), 22.

Acronyms

AFARN	Air Force Air Request Network
AFSATCOM	Air Force Satellite Communications
bps	bits per second
C ³ I	command, control, communications, and intelligence
C ⁴ I	command, control, communications, computers, and intelligence
CINC	commander in chief
CONOPS	concept of operations
DOD	Department of Defense
DSCS	Defense Satellite Communications System
EFX	Expeditionary Force Experiment
EHF	extremely high frequency (30–300 GHz)
E-MSS	Enhanced Mobile Satellite Services
ERDB	Emerging Requirements Data Base
ESC	Electronic Systems Center (U.S. Air Force)
FEMA	Federal Emergency Management Agency
FLTSAT	Fleet Satellite (satellite system managed by the U.S. Navy)
FSS	Fixed Satellite Service
GBS	Global Broadcast Service
GEO	geosynchronous earth orbit (beyond 19,300 nautical miles)
GHz	gigahertz
GMPCS	global mobile personal communications by satellite
GPS	Global Positioning System
HF	high frequency (3–30 MHz)
ICDB	Integrated Communications Data Base
Inmarsat	International Maritime Satellite
ITU	International Telecommunications Union
kbps	kilo (thousands) of bits per second (speed of data rate)
LEO	low earth orbit (100–540 nautical miles)
LOS	line of sight
LPD	low probability of detection
LPI	low probability of intercept

Mbps	mega (millions of) bits per second
MEO	medium earth orbit (540–18,225 nautical miles)
MOOTW	military operations other than war
MSS	mobile satellite service
MUS	Mobile User Study
NB	narrowband
NSA	National Security Agency
PSTN	public switched telephone network
RDSS	Radio Determined Satellite Service
SATCOM	satellite communications
SAR	search and rescue
SHF	super high frequency (3–30 GHz)
TACP	Tactical Air Control Party
TACS	Tactical Air Control System
TACSAT	tactical satellite
UFO	UHF Follow-on satellite
UHF	ultra-high frequency (300–3000 MHz)
USSPACECOM	United States Space Command
VHF	very high frequency (30–300 MHz)
WB	wideband
WMD	weapons of mass destruction

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