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AN ANALYSIS OF THE FEASIBILITY OF INCREASED DEPENDENCE ON COMMERCIAL COMMUNICATIONS SATELLITES FOR SATISFYING DOD REQUIREMENTS

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This report addresses the key issues involved in increasing the usage of and dependence on commercial satellite facilities to satisfy Department of Defense (DoD) communications requirements. The potential cost savings are analyzed and the constraints that are likely to limit the feasibility of fully realizing these savings are investigated. A properly conceived and managed program could result in savings exceeding a hundred million dollars per year compared to the current terrestrial system.

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FOREWORD

The Defense Communications Engineering Center (DCEC) Technical Notes (TN's) are published to inform interested members of the defense community regarding technical activities of the Center, completed and in progress. They are intended to stimulate thinking and encourage information exchange; but they do not represent an approved position or policy of DCEC, and should not be used as authoritative guidance for related planning and/or further action.

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Communications satellites provide the most flexible and adaptive form of communications yet devised and are, therefore, ideally suited to satisfy many critical military requirements. A number of obvious military communications requirements are currently satisfied by military satellite systems such as the Defense Satellite Communications System (DSCS). Also, in coordination with authorized commercial communications companies, the Defense Communications Agency (DCA) leases nearly 200 long-haul satellite communications trunks. The expanded utilization of commercial communications satellites for military purposes appears to be progressing without adequately formulated policy or proper consideration of all the constraints that may be placed on the users.

This report addresses the key issues involved in increasing the usage of and dependence on commercial satellite facilities to satisfy Department of Defense (DoD) communications requirements. The potential cost savings are analyzed and the constraints that are likely to limit the feasibility of fully realizing these savings are investigated. A properly conceived and managed program could result in savings exceeding a hundred million dollars per year compared to the current terrestrial system.

By providing background material and insight into important issues, this report provides guidance for decision makers in developing a policy for the DoD utilization of commercial satellite systems. An historic review of the development of United States and international policy, section II, delineates the political environment for entering the operational era of communications satellites. At present, INTELSAT is no longer the only operational system. Several domestic systems are coming on line and the DSCS has demonstrated a full capability. Background outlining the development of these systems and other systems are presented in section II. The communications requirements best suited for commercial satellite service are analyzed in section III. The alternative system concepts that are available to satisfy these requirements in the 1975-1980 time frame are also identified in section III. The military potentiality of these alternative system concepts are evaluated in section III. The costs for each of the system alternatives to satisfy the representative categories of requirements is derived and used in the tradeoff analysis of companion approaches in section IV. Conclusions and recommendations are set forth in section V.

The key issues that are presented and addressed in the various chapters of this report include:

- Advantages of satellite communications systems. (Section II)
- New implications caused by communications satellites. (Section II)
- Government-owned systems vs domestic commercial or INTELSAT systems. (Section II)
- The difference between military and commercial systems. (Sections II and III)
- Criteria for assigning requirements to commercial and military systems. (Section III)
- Availability of system alternatives in the 1975-1980 time frame. (Section III)
- Does adding military capability make systems significantly more expensive? (Sections III and IV)
- Why does INTELSAT service cost more than the DSCS service? (Section IV)
- Are domestic satellite systems cheaper than military systems and are they realistically priced? (Section IV)
- Is it feasible to replace the terrestrial facilities in the CONUS with satellite communications and incur substantial cost savings? (Section IV)
- Is Fleetsat a worthwhile program? (Section IV)
- Can the wideband capability and demand access feature of satellite communications systems save DoD money? (Section IV)

II. BACKGROUND AND POLICY CONSIDERATIONS

It is essential to present the proper perspective concerning the important elements that influence any decision concerning the utilization of commercial satellite communications systems. The most important elements are the governmental policies, the corporations and institutions involved, and the rapidly changing technology. These elements have molded an environment that is severely constrained for the next several years. The United States has capitalized on a technology developed primarily for military purposes (i.e., boosters) and established a new industry that has an international impact. The commercial interests have taken the initiative to shape United States and international policy that is conducive to profit making ventures. It would take a concerted effort over a long period of time to redirect the current course of events. The DoD should examine this trend and the resulting implications and determine the desirability of exerting influence to develop an environment that is more beneficial to the government.

On April 6, 1965, just a decade ago, the first commercial operational satellite was placed in synchronous orbit [1]. By June of 1965 this satellite was providing commercial satellite service to the Atlantic region of the world. It was not until July of 1969 that worldwide service was made available. In a single decade, communications satellites have increased the transoceanic communications capability by more than an order of magnitude. In addition to reduced operating costs and improved performance, users have been provided with completely new capabilities such as transoceanic television and high speed digital service. This revolution in international communications capability has only recently been able to affect the United States domestic scene. The Federal Communications Commission (FCC) experienced difficulty in establishing policy for the operation of U.S. domestic satellite systems such as existed in Canada (TELESAT) and the U.S.S.R. (MOLNIYA)[2]. In 1972, after five years of investigation, the FCC established the "Open Skies" policy for domestic satellite systems and accepted applications from six companies [3]. Therefore, U.S. policy and existing international agreements have established two categories of commercial communications satellite systems -- International Systems (controlled by INTELSAT) and Domestic Systems (U.S. and foreign).

1. INTELSAT AND COMSAT

The Communications Satellite Act, passed by Congress in 1962, formulated national policy "to establish, in conjunction and in cooperation with other countries, as expeditiously as practicable a commercial communications satellite system, as part of an improved global communications network, which will be responsive to public needs and national objectives, which will serve the communication needs of the United States and other countries, and which will contribute to world peace and understanding." [4]. In 1964 the United States and thirteen other nations signed the interim agreement that resulted in the formation of the International Telecommunication Satellite Organization (INTELSAT). In February of 1973, the Definitive Agreements went into effect and over eighty nations ratified it. More than one hundred countries, territories, or possessions were leasing satellite services (approximately 10,000 half circuits) on a full-time basis in 1974 [5]. The Communications Satellite Corporation (COMSAT) was established by Congress in 1963 as the U.S. representative to INTELSAT and has been the primary reason for the tremendous success of INTELSAT. The success of COMSAT in this international venture has been assured and COMSAT has branched out into other areas of interest as shown in this 1972 statement from the FCC:

"When the Satellite Act was enacted, Congress, in order to assure that the fledgling corporation (COMSAT) received needed communications expertise and guidance, made provision for communication carriers to own up to 50% of COMSAT's Board of Directors,.......... COMSAT was created by Congress primarily for the important and immediate purpose of representing and promoting this nation's interests in the establishment and operation, in conjunction with other nations, of a global international communication satellite system. That mission, with the aid and support of A.T.& T. and other carriers, has been achieved with a high degree of success. COMSAT is now seeking entry into the domestic communications field to compete with A.T.& T. and other carriers in supplying new and improved domestic communications services. However, in this field, the underlying considerations which motivated Congress to permit and encourage A.T.& T.'s ownership in COMSAT are no longer controlling. On the contrary, the competitive roles which COMSAT and A.T.& T. are assuming in the domestic communications field dictate the need for maximum independence from each other and an arms-length relationship" [6].

Thus, currently (in 1974), 99.7% of the outstanding COMSAT stock is held by public shareholders [7]. COMSAT was permitted to form a subsidiary corporation, COMSAT GENERAL, to enter into competitive commercial ventures.

2. DEVELOPMENT OF U.S. DOMESTIC POLICY AND SYSTEM

The polarization between international and domestic systems is a natural outgrowth of the regulatory authority that each nation has over the conduct of business within its national boundaries and is recognized in the INTELSAT operating agreement [8] where it states:

"(b) The following shall be considered on the same basis as international public telecommunications services:

(i) domestic public telecommunication services between areas not under the jurisdiction of the State concerned, or between areas separated by the high seas;

(ii) domestic public telecommunication services between areas which are not linked by any terrestrial wideband facilities and which are separated by natural barriers of such an exceptional nature that they impede the viable establishment of terrestrial wideband facilities between such areas, provided etc....

(c) The INTELSAT space segment established to meet the prime objective shall also be made available for other domestic public telecommunication services on a non-discriminatory basis to the extent that the ability of INTELSAT to achieve its prime objective is not impaired.

(d) The INTELSAT space segment may also, on request and under appropriate terms and conditions, be utilized for the purpose of specialized telecommunications services, either international or domestic, other than for military purposes, provided etc..........

(e) INTELSAT may, on request and under appropriate terms and conditions, provide satellites or associated facilities separate from INTELSAT space segment etc.........."

From these excerpts, it is clear that INTELSAT recognizes a responsibility (and a potential market) to satisfy domestic needs if in so doing it does not interfere with the primary mission of INTELSAT, i.e., global international telecommunications. Agreement (paragraph b, i above) would give high priority to links between the contiguous 48 states and Alaska or Hawaii, if the U.S. should desire such service. However, recently the FCC, which regulates all internal U.S. commercial communications, has taken the position of allowing the traffic between Alaska and the contiguous 48 states to be transferred from the global system to a domestic system. Similar rulings are expected to open the routes to Hawaii and Puerto Rico to competition from domestic systems. The authority for the FCC to do this was established in FCC 70-306 [9] which states:

"For the reasons set forth in the attached memorandum of law (appendix C), we conclude that we may authorize any non-Federal Government entity, including COMSAT, other common carriers, and non-carriers, to construct and operate (either individually or jointly) communication facilities for domestic use. We have also concluded that appropriate authorization of satellite facilities solely for domestic purposes is not inconsistent with the multilateral 1964 Executive Agreement establishing Interim Arrangements for a Global Commercial Communications Satellite System, to which the United States is a signatory and its related Special Agreement (TIAS No. 5646)."

Thus, it is considered consistent to participate in the INTELSAT consortium for international communications and compete with systems that include INTELSAT facilities as part of a system that is providing domestic service.

After establishing the authority of the FCC to regulate a separate Domestic Communications Satellite System, a policy governing the implementation of this service was established in FCC 72-1198 [10]. This order states: "The Second Report adopted a policy of affording a reasonable opportunity for entry into the domestic communications satellite field by qualified applicants subject to certain showings and conditions." This has generally entailed showing financial and technical viability, however, strict regulation is placed on spacecraft characteristics and position, and on ground station locations. This competitive policy was in opposition to a controlled monopoly such as exists with COMSAT in the international arena. There was a heated controversy for several years over the advantages and disadvantages of the different policy options. The decision in favor of open competition reflects the current political environment of increased competition, less regulation, and stricter antitrust law enforcement that prevails at the national level (both Congressional and Executive branches).

This general philosophy of increased competition has brought the communications industry into a dynamic new era which has culminated in the recent entry of specialized carriers into the common carrier field and the current antitrust suit against A.T.& T. [11, 12]. These actions will have a long-lasting effect on the industry, and the outcome of the series of interconnect hearings in process by the FCC will also impact the desirability to users of obtaining service from carriers other than A.T.& T. The FCC has ordered [13] ".......assuring that all carriers providing retail interstate satellite services (whether or not affiliated with Bell System Companies) have access at non-discriminatory terms and conditions to local loop and inter-exchange facilities as necessary for the purpose of originating and terminating such interstate service to their customers." Several specialized carriers, including domestic satellite companies, are claiming that A.T.& T. is discriminating against them. The FCC is proceeding with rulings on these cases. If the specialized carriers are forced to construct their own local terrestrial distribution system, they will not be competitive with A.T.& T. Thus, resolution of these important issues will have a serious impact on the desirability of the DoD using new domestic systems to satisfy DoD requirements.

As a result of the FCC ruling on domestic Communication Satellite policy [14], applications from eight companies were filed; two applications have since been withdrawn and five system operators were authorized to proceed with their plans. These five were: COMSAT GENERAL/A.T.& T., Western Union Telegraph Company, American Satellite Corporation, General Telephone and Electronics (G.T.& E.), and RCA Global Communications. CML, a company which was jointly owned by COMSAT GENERAL, MCI and Lockheed, was approved by the FCC, but no definitive operating plans have been submitted to the FCC. Since that time, G.T.& E. has merged its efforts with the COMSAT GENERAL/A.T.& T. team and the CML group has undergone several restructurings, the most recent being the purchase of the major portion of the stock (55%) by IBM with COMSAT GENERAL owning the remaining 45%. The FCC has ruled that IBM and COMSAT can each own a maximum of 49% which means a third partner must be admitted into the corporation. This arrangement has been contested by several entities and again must be resolved by the FCC. The shakeout of this infant industry is likely to continue for several years; at least until the market is well defined and all side issues and policy matters have been resolved.

Three companies are currently providing service to users, though Western Union is the only company to actually have operating satellites in orbit. The American Satellite Corporation is leasing transponders from Western Union and RCA GlobCom is leasing service from the Canadian TELESAT System. The first COMSAT GENERAL satellite is scheduled for launch in early 1976 and it will be utilized by A.T.& T. and G.T.& E. earth terminals [15]. RCA will also launch their own spacecraft in late 1975 or early 1976 [16]. American Satellite does not have definite plans for launching their own satellite.

Both American Satellite Corporation and CML plan to develop a multipoint satcom service. This service would utilize many small satellite terminals located at the users facilities and would, to a large extent, bypass dependence on A.T.& T. for local distribution of service.

Descriptions of all the domestic systems are included in Annex A.

3. DOMESTIC SERVICE FOR FOREIGN COUNTRIES

Foreign domestic satellite service will be available for certain applications. Most of these systems, however, are (or will be) nationally owned and operated systems. The TELSAT system is already available for service in the Canadian region. (A description of TELSAT is also included in Appendix A.) The MOLNYA system is primarily a domestic system (U.S.S.R.), however, because of a highly elliptical orbit, it has a usable pass over the northern hemisphere. The MOLNYA system, together with INTELSAT, will soon provide the operational links for the Washington-Moscow hotline service [17]. The U.S.S.R. is not currently a member of INTELSAT, but there are some indications that this may change in the near future. Other countries (e.g., Japan) and regions (e.g., Europe) are developing their own capability and will likely have operating systems in the 1980 time frame. Other countries such as Algeria [18] and Brazil are availing themselves of the transponder leasing service offered by INTELSAT. The interruptible service that Algeria is obtaining will give them an excellent system at a very reasonable annual cost. Indonesia has awarded contracts to Hughes Aircraft for spacecraft and terminals to provide domestic satellite service to that region of the Pacific [19].

4. SERVICE FOR MOBILE PLATFORMS

Specialized satellite service for ships at sea or aircraft crossing the oceans has been technically feasible for a number of years, but the difficulty of obtaining international political agreements has precluded such valuable service. The MARISAT system will provide service to commercial ships at sea using L-Band frequencies (1,535-1,660 MHz) and to U.S. Navy ships at VHF/UHF (200-400 MHz) [20]. European Space Research Corporation (ESRO) is pursuing a similar venture to be called European Maritime Communications Satellites (MAROTS) [21]. MAROTS is planned to be a worldwide system and to include wider participation than just European countries. ESRO is also a partner with Canada and the U.S. (COMSAT) in the Aerosat program, which will provide improved communications and surveillance for transoceanic air traffic control. The Federal Aviation Agency (FAA) will be the U.S. operator of the Aerosat system and plans to extend the system to include the Pacific basin.

From this discussion and previous sections, it should be apparent that a great deal of effort has been expended over the past decade establishing policy, operating agreements, and instruments for resolving controversy. The framework for the agreements and the initial structure for organizations to provide mobile service have finally evolved and the design and implementation of the actual satellite communications systems is well underway. This procedure, though painfully slow, seems to be the only effective course of action. As was the case with INTELSAT, once service is initiated, the number of users will expand rapidly and full blown operating systems will be available in five to ten years. Therefore, the DoD must develop a policy to effectively utilize these resources.

5. INTERNATIONAL REGULATION

The diverse and far reaching impact of communications satellites is apparent or should be evident by observing the great difficulty in arriving at useful operating agreements alluded to in previous paragraphs. The tremendous capability of communications satellites, the relatively large initial investment, and the almost immediate international implications require extensive negotiation among interested parties (and there are usually many) whenever a proposed system is presented for ratification by the affected parties. As a result of this process and the resulting strict regulations, it is difficult to offer new or unusual services, or extend established services, in a flexible manner.

Another important area of international regulation and control involves the International Telecommunications Union (ITU), which establishes frequency planning and spectrum utilization policy. This is the instrument that the World States have organized to determine which frequency bands should be set aside for providing specified services (e.g., satellite fixed, satellite mobile, television broadcast, etc.). The primary commercial satellite communications band, established by the ITU, is in the 4 and 6 GHz band and the primary military bands are 225-400 MHz (FLEETSAT/AFSATCOM) and 7 and 8 GHz (DSCS). The ITU meets every 5 to 10 years and reassesses the previous allocations to determine the necessity for change. It is not a policing or enforcement agency, but it is prudent, realizing that synchronous satellites radiate energy over a large portion of the earth's surface, to abide by its rules and regulations.

6. THE NEED FOR BOTH MILITARY AND COMMERCIAL SYSTEMS

The Communications Satellite Act of 1962 recognized the possibility that a broad spectrum of requirements (e.g., governmental needs, international carrier, domestic carrier, and mobile) could not be satisfied by a single system. The Declaration of Policy and Purpose of the Act states: "..... (d) It is not the intent of Congress by this act to preclude the creation of additional communication satellite systems, if required to meet unique governmental needs or if otherwise required in the national interest" [22). Thus, INTELSAT was developed for a single purpose, international carrier service, and the system is designed in the most economical manner to achieve that purpose. It is not surprising then if it does not effectively perform the other divergent missions that could be required of a satellite communications system.

In passing, note is taken of the last phrase of the sentence in the quote from the Act of 1962 "..... or if otherwise required in the national interest." This phrase was the object of lengthy discussion during the ensuing hearings and was the result of the Church-Laushe amendment. Senator Frank Church, while explaining this phrase, said: ".....since it could not now be foretold how well the new corporate instrumentality would serve the needs of the public. If rates charged were too high or the service too limited, or maximum benefits of the new technology were not forthcoming, then the Government might want to establish alternative systems" [23]. At issue here would be the use of "government systems" to compete with INTELSAT in its primary role as an international carrier if the service could be provided cheaper by the "government system." The intent of Congress is reflected by the conversation between Senators Gore and Church:

> Senator Gore: "In other words, if the government should find that by the establishment of a satellite communications system of its own, to be used for its own purposes, it can accomplish its objectives and save the taxpayers enormous sums of money, the national interest would require such use. Therefore, the amendment would prevent the section referred to from requiring the Government to use the corporation's system, if vast savings to the taxpayers could be accomplished through the use of the Government's own system."
>
> Senator Church: "The Senator is correct...."[24].

The DoD system has had such limited capacity over the years that this issue has not really surfaced until recently. The current DSCS could readily be expanded to carry substantial international DoD traffic. For several years there was great difficulty in determining the DoD policy in this matter and as a result the DoD programs suffered at least a 2-year delay. Secretary McNamara was primarily responsible for this delay. The House Committee on Government Operations in 1965, as the result of a hearing by the subcommittee of Military Operations chaired by Chet Holifield, made the following observation concerning this issue:

"..... The DoD, after long and fruitless negotiations with COMSAT, now has decided to proceed with the development of a separate communications satellite system to fulfill urgent Government requirements. The President of the United States affirmed this fact in a statement to the press on August 8.

The wisdom of Secretary McNamara's decision - unfortunately long delayed - is evidenced by the need for improved communications to remote areas in a world of recurring crises and constant danger of war. Satellites offer a means to establish these vital communication links. The Defense Department, overly sensitive to budgetary constraints and prior mistakes in satellite development has been too timid and uncertain about exploiting proven technologies for the establishment of a workable system of satellite communications. Valuable time has been lost. Had the department moved ahead according to plans and policies laid down two years ago and approved by the JCS, a system could have been operating by now" [25].

From the above discussion, it is clear that Congress has always intended to support the existence of commercial and government systems and that the Government should utilize these combined resources to the best interest of the United States Government.

7. DIFFERENCES BETWEEN COMMERCIAL AND MILITARY SYSTEMS

There are important differences between a system designed strictly for military purposes and one designed to be competitive in a commercial market. It is important to note that INTELSAT has competed only against submarine cables and then only in a highly regulated environment that has deliberately reduced the impact of competition. Most of the military features desired of a satellite communications system increase the cost of the system and would not be emphasized in designing a satellite system unless national interest is at stake. The Eighty-Ninth Congress, First Session House Report No. 178 presents an excellent summary of events preceding 1965. Because of the comprehensive and authoritative nature of that report, two portions of it are included in Appendix B: a portion of the "Military Requirements," Chapter V, pages 45 to 51, and the Concluding Observations and Recommendations, Chapter VIII, pages 105 to 113. The "Distinctive Military Requirements" described on pages 48 to 50 have not changed appreciably over the past ten years and are:

- Positive operational control
- Mobility and remote area access
- Protection against physical attack
- Protection against electronic countermeasures
- Low capacity and secret message transmission
- Separate frequencies for Military use.

Descriptions of these requirements are given in Appendix B.

To reduce confusion, the term "requirement" is now normally used to refer to a user-to-user requirement as opposed to a system requirement, or system characteristic, as shown in the above list. However, these items are still considered to be the most important attributes or features of a system designed to satisfy military user requirements. The first two items fall under the category of flexibility, which is probably the most unique characteristic of communications satellite systems. The third, fourth, and sixth items refer to the survivability of the system and a presumed high availability of the system even under the most adverse conditions. The fifth item addressed the security considerations of military traffic and is a statement which addresses the minimum essential aspects of military communications. The minimum essential aspects stress that connectivity (at even a low data rate) is essential, however, in many cases the cumulative capacity for real military requirements are substantial. A low capacity system can satisfy only the highest priority traffic during an emergency. If the utilization factor (or duty cycle factor) of the users is normally low, then, except during an emergency, a shared system with priority override capability can make a limited capacity system available to a large number of users.

The above military features have been designed into military systems such as the DSCS. It can generally be stated that increasing the measure of any of these features drives up system cost (e.g., increased flexibility or survivability has great impact). High values for all features, including high capacity, is essentially impossible in the near-to-mid-term time frame (i.e., before 1985). Therefore, it is generally impractical to satisfy all DoD requirements using strictly military communications satellites.

Even if the cost was not prohibitive, complete dependence on a single system would increase the attractiveness of that system as an enemy target to the point where it would be worth while for the enemy to expend large resources to destroy it. Certain DoD requirements, determined by the mission of the user, can justify as high a degree of military performance as is technically and economically feasible, others would be rated low for all features. Obviously, since very little attention is given to military features in a commercial system, except availability in a benign environment, it would be unrealistic to expect a commercial system to be used to satisfy the unique military requirements. On the other hand, if the requirement can be shown to need only the basic features provided by a commercial system, the selection process should be limited to economic considerations.

It is important to realize that there are two distinct issues, which are often confused by combining them into one; they are: justification for developing separate military and commercial systems, and selecting which of the existing communications satellite systems should be used to satisfy specific user requirements. Congress has clearly stated there will be separate military and commercial systems; therefore, the first issue has been resolved. The second issue can never be conclusively resolved without establishing very arbitrary rules which, in the case of satellite communications for DoD, could result in great economic penalties to the government.

Because there is not a full and continuous spectrum of systems, with varying military capabilities, it is necessary to differentiate between those requirements that are to be carried on the military systems and those that are to be carried on the civilian systems. Certain requirements are obviously military in nature and others can obviously be satisfied by the most economical means available. However, between these extremes there is a large gray area of requirements that could be satisfied by either system.

The Defense Communications Agency (DCA) is analyzing DoD user requirements to categorize each requirement according to the magnitude of each of the military features. The Military Satellite Communications Systems Office (MSO) of DCA has developed a computerized requirements data base to permit rapid retrieval of the requirements provided by the Joint Chiefs of Staff (JCS). This analysis is being performed in conjunction with the users and the JCS. This categorization will permit the circuit designators to assign requirements to the proper system for satisfaction.

8. DEPARTMENT OF DEFENSE SATELLITE COMMUNICATIONS SYSTEMS

The DoD has supported most of the technological developments that have established the basis for this rapidly expanding industry. Except for the U.S.S.R, the DoD and NASA still have the only major space launching capabilities in the world. Most commercial operating companies, including COMSAT, contract with NASA to provide launch services [26]. Until recently, when the U.S.S.R. placed a vehicle in synchronous orbit, the U.S. was the only country with a demonstrated capability of placing satellites in synchronous orbit. The U.S. has the only proven highly reliable capability to place relatively large payloads into synchronous orbit. This capability is an outgrowth of the DoD missile programs. Therefore, due to this unique capability, the Federal Government is still significantly involved in the establishment of the commercial satellite communications systems.

The original communications satellite programs were sponsored by the DoD, but as NASA evolved, much of R&D in this new field was transferred to NASA. However, the DoD has continued to develop communications satellite programs to satisfy "unique and vital" DoD requirements. The major operational DoD satellite communications system is the Defense Satellite Communications System (DSCS). The DSCS was placed in operation in 1967 and originally utilized nearly-synchronous satellites. In 1974, the "Phase II" DSCS satellites were declared operational in the Pacific and Atlantic regions of the world. The "Phase II" satellite is comparable to the INTELSAT IV spacecraft and has both earth coverage and narrow beam coverage capabilities [27].

The majority of DoD communications satellite facilities are still employing equipment that was procured for R&D programs and pressed into operational use when the operational feasibility was demonstrated. This has generally resulted in a lower system availability than comparable commercial systems that were designed to be operational from inception. The DSCS Phase II spacecraft, in conjunction with a new generation of earth terminals currently under procurement, will greatly enhance the availability of the system. The DoD also employed R&D assets to provide an Interim Operational Capability (IOC) for mobile users, primarily ships [28]. This capability lasted for nearly three years (1970-1972) using the TACSAT and LES-6 spacecraft. This service is to be restored using a leased spacecraft (MARISAT) in 1976. By 1978 the new FLEETSAT/AFSATCOM system will provide increased capability for this class of user. For the more distant future, DoD is looking to survivable satellite techniques which will enhance the command and control capability of the strategic forces and a DSCS Phase III spacecraft that will improve the responsiveness of the DSCS. A more detailed description of the Defense systems is included in Appendix C.

III. REQUIREMENTS ANALYSIS

The DoD has a broad range of communications requirements. Many of these are in support of the World Wide Military Command and Control System (WWMCCS) and are critical to the national defense. The WWMCCS uses a mix of transmission media in order to provide the needed reliability, availability, and survivability. Satellite Communications represent only one of these media. Thus, the portion of the overall requirements to be satisfied by communications satellites must be carefully selected so that the unique characteristics of communications satellites are used optimally in fulfilling the overall mission.

Evaluation criteria have been developed to filter these user-to-user requirements to determine those best satisfied by communications satellites. These evaluation criteria logically fall into two categories: those which capitalize on the unique capabilities of satellites (e.g., flexible service to military operations), and those of a secondary nature for which satellites must qualify competitively in terms of cost, performance, and versatility advantages (e.g., DCS trunking) [29]. The primary emphasis of this report centers around the second category of requirements and examines the policies and economic considerations that influence the media selection process. Therefore, the constraints established by policy are examined and a reasonable range of alternative system concepts is developed. For security reasons, specific user requirements cannot be addressed in this report, however, scenarios that include representative sets of user requirements are delineated in this section.

1. MILITARY VS COMMERCIAL REQUIREMENTS

The Communications Satellite Act of 1962 provided the basis for separating the uses of the commercial and military satellite communications systems. The DoD requirements which were "unique governmental needs or if otherwise required in the national interest" could be satisfied by military systems. The umbrella of "unique and vital" has been questioned with increasing regularity over the years and other documents have been published to bypass the difficulty of defining these words. The policy that has evolved has gone from generalized statements such as "unique and vital" to detailed justification for a specific requirement.

Office of Management and Budget (OMB) Circular A-76 states: "The guidelines in this circular are in furtherance of the Government's general policy of relying on the private enterprise system to supply its needs. In some instances, however, it is in the national interest for the Government to provide directly the products and services it uses. These circumstances are set forth in paragraph five of this circular" [30]. Circumstances under which the Government may provide a commercial or industrial product or service for its own use are as stated in paragraph five:

"a - Procurement of a product or service from a commercial source would disrupt or materially delay an agency's program.

b - It is necessary for the Government to conduct a commercial or industrial activity for purposes of combat support or for individual and unit retraining of military personnel or to maintain or strengthen mobilization readiness.

c - A satisfactory commercial source is not available and cannot be developed in time to provide a product or service when it is needed.

d - The product or service is available from another Federal Agency.

e - Procurement of the product or service from a commercial source will result in higher cost to the Government" [31].

Clause b above provided a rather general statement that did not need a detailed justification, however, the other clauses require a significant amount of justification.

OTP Circular No. 13, June 1974, further reduces the reasons for Government provided telecommunications services. It states:

"1. Purpose. This circular establishes guidelines designed to clarify the normal Federal role as a user, rather than a provider, of telecommunication service. The policy emphasizes the need to place maximum reliance on the private sector in providing telecommunication service to the Federal Government.

2. Background. It is a long-standing policy of the Federal Government to rely on the private enterprise system to satisfy its needs.....

3. Policy. The Federal Government places heavy reliance

on the private sector in providing telecommunication service for its own use. This means that all functions normally associated with providing the service shall be performed by the private sector. These functions include design, engineering, system management and operation, maintenance and logistical support.

In order to emphasize the Government's proper role as a user, any proposal designed to provide needed telecommunication service, which requires the Federal Government to perform any of the "provider" functions such as those listed above, shall be adopted only if commercial service is: Policy

1) not available to the user during the time needed;

2) not adequate from either a technical or operational standpoint; or

3) Significantly more costly.............. savings must exceed 10% of the cost of the commercial service. The cost estimate of the non-commercial approach must include, as a minimum, all of the factors called out by OMB Circular A-76 ...." [32].

All of these reasons require justification and no general escape clause exists for the DoD. This practice has generally been adhered to by the DoD, however, a new era is emerging which presents new alternatives. These new alternatives stem from the rapidly expanding domestic satellite capability, increased DoD operational communications satellite capability, apparent increased flexibility in the INTELSAT definitive agreements, and availability of leasing options from hardware and system developers. The role of each of these resources, together with terrestrial networks, are examined in this report. The last transition of this magnitude resulted in significant interest shown by Congress.

Report No. 1836 of the Ninetieth Congress (1968) states:

"In the procurement of commercial satellite services, the DoD has been faced with vexing problems. Seeking to exploit the new satellite technology in the form of greatly reduced rates offered by COMSAT for circuits in the Pacific area, the Department found that the established

U.S. carriers were interposed between COMSAT and the Government. This interposition was decreed by the FCC decision in the "authorized user" case, with the consequence, as noted earlier, that the DCA contract for procurement of thirty circuits from Hawaii to Far East points was reassigned from COMSAT to the U.S. international carriers.

Our committee had recommended this assignment on the pragmatic grounds that substantial savings to the U.S. Government would be derived, exceeding $6 million a year. Such savings were made possible when the U.S. international carriers offered to reduce their composite cable-satellite rates in the Pacific in amounts ranging from twenty five to forty percent as a condition of getting an assignment of the contract (in appropriate shares allocated among them) initially awarded to COMSAT. Since the U.S. Government leases many long-distance cable circuits, the composite rate reductions would yield larger aggregate savings than the COMSAT offer for satellite circuits alone" [33].

The Committee displayed particular interest in the foreign rates:

different Rates between U.S. and foreign carriers

"In a previous report the subcommittee examined the problem of differential rate practices as between U.S. and foreign carriers. When rate reductions are made by U.S. carriers for their portion of the traffic, the foreign carriers on the other end may or may not reduce their rates commensurately. In its 1967 report the Committee urged the Department of State and the FCC to make every appropriate effort to gain comparable rates from the foreign countries concerned. The Committee renews its recommendation along this line,..."[34].

As can be seen from these quotes, the subject of international tariffs is very complex and very political in nature and can not be addressed blithely as an economic tradeoff, as inferred by OTP Circular No. 13. A relatively straightforward lease of thirty circuits, to the lowest bidder, resulted in a long deliberation that involved the highest levels of DoD, the FCC, Congress, the State Department, foreign governments, and the international carriers. It also shows that prices are fairly flexible and difficult to define, particularly when several pockets are available for shuffling. Therefore, the difference of 10 percent as the economic justification for using government facilities might be worth proving from an accounting standpoint, in a static well structured non-political environment, but in the real world where large sums of money are at stake, a broader interpretation should be used.

In the past, the DoD has been hindered, during the bargaining process, by two major factors: inability to determine a reasonable cost to the common carrier for the service he is in turn supplying to the DoD, and no other choice or alternative for obtaining the service. These hindrances no longer need to exist. As will be shown later, it is relatively easy to determine basic costing estimates for satellite systems (at least within 25 percent). In this new and rather risky industry, a 25 percent uncertainty can be handled in many ways, particularly if the proper incentive is present. If a reasonable price cannot be negotiated, the DoD systems now provide an alternative for the service. However, if the DoD is willing to insist on mutually beneficial pricing, it can be expected that this negotiation process will be very long and political in nature.

2. ALTERNATIVE SYSTEM CONCEPTS

The Congress has left several alternatives open to the government, in particular the DoD, to satisfy user requirements. The DoD, as a large potential user of communications satellites, should not consider individual user requirements, but should look at the aggregate of requirements to determine if a substantial economic advantage can be passed on to the taxpayer by economy of scale and innovative system design, as enjoined by Senators Gore and Church. The initial investigation should include the full spectrum of all reasonable system alternatives for satisfying DoD user needs. Therefore, initial alternative solutions considered herein include bulk rates, transponder leasing, satellite leasing, systems leasing, system procurement, etc., to satisfy categories or aggregates of user requirements. This set of alternatives covers a complete spectrum from full military control to no military influence whatsoever. These satellite communications system alternatives are classified in reference to their military vs commercial capability as a function of ownership of the spacecraft, ownership of the terminals, and operational control of the system. These areas of commercialization are considered to be the most likely applications of commercial resources.

Figure 1 shows the range of alternatives considered for satisfaction of future DoD requirements. The development time to implement certain of these alternatives may be prohibitive for consideration as near term solutions. The military class of systems have been designed considering all the desired military features including

ALTERNATIVE	1		2		3		4	
	FULL MILITARY DoD OPERATED		QUASI MILITARY CONTRACTOR OPERATED		QUASI MILITARY DoD OPERATED		QUASI MILITARY CONTRACTOR OPERATED	
	SPACECRAFT OWNED	TERMINAL OWNED	SPACECRAFT OWNED	TERMINAL LEASED	SPACECRAFT LEASED	TERMINAL OWNED	SPACECRAFT LEASED	TERMINAL LEASED

ALTERNATIVE MILITARY SYSTEMS

5		6		7		8		9	10
QUASI COMMERCIAL DoD OPERATED		COMMERCIAL CONTRACTOR OPERATED		COMMERCIAL COMMERCIAL OPERATED		COMMERCIAL COMMERCIAL OPERATED		COMMERCIAL COMMERCIAL OPERATED	COMMERCIAL COMMERCIAL OPERATED
SPACECRAFT OWNED	TERMINAL OWNED	SATELLITE LEASED	TERMINAL LEASED	CHANNEL LEASED	TERMINAL OWNED	CHANNEL LEASED	TERMINAL LEASED	CIRCUIT BULK LEASED	CIRCUIT SINGLE LEASED

ALTERNATIVE COMMERCIAL SYSTEMS

Figure 1. Alternative Systems Considered in Study

hardening, secure command of the spacecraft, antijam capability, flexibility, and normal operation in the military frequency band. The commercial systems on the other hand, would only be as survivable as good commercial design dictates. Full military infers military operated, but in many cases supported by civilian or contractor personnel. Contractor operated means the DoD has let a contract to operate and maintain the system, but planning and management is still a function of the DoD. When the facilities (i.e., spacecraft or terminal) are also carrying other traffic, the interest of the commercial operating entity is no longer in complete harmony with DoD interests. The spacecraft and terminals can be either owned by the government or leased.

The military system can be fully owned and operated by the DoD as in Alternative 1 (e.g., DSCS), or it can be made up of leased spacecraft or leased terminals with military features and can be operated by contractor personnel except for tactical support, as in Alternatives 2, 3, and 4. The commercial system could also be fully owned and operated by the DoD as in System 5, or terminals and spacecraft could be leased, if that is the most economical approach (i.e., System 6). It is also possible to lease only a portion of a commercial spacecraft as is the case in System Alternatives 7 and 8. Bulk service is available as are individual circuits at regulated rates; these possibilities are included as Alternatives 9 and 10 respectively.

Figure 2 shows the capability of each of the system alternatives to meet the military features described in section II, 7. A rating of Good indicates that the alternative is completely satisfactory, a Fair rating indicates it is likely to meet a large portion of the needs in that area, and a Poor rating indicates it is likely to be unresponsive. The performance of the alternative as a function of the military features is as follows:

- <u>Physical Survivability</u>

  All military systems are designed to have good physical survivability characteristics. Standard spacecraft design will provide a limited degree of hardness and earth terminals on military sites will provide some physical protection against sabotage. However, when the military circuits are treated like other commercial circuits, the physical security is likely to be poor.

- <u>Electronic Survivability</u>

  Military systems are again designed to exhibit good

|← Equal Performance → |
preferred because of system cost

ALTERNATIVE	MILITARY SYSTEMS				COMMERCIAL SYSTEMS					
	1	2	3	4	5	6	7	8	9	10
MILITARY CHARACTERISTICS	FULL MILITARY DoD OPERATED	QUASI MILITARY CONTRACTOR OPERATED	QUASI MILITARY DoD OPERATED	QUASI MILITARY CONTRACTOR OPERATED	QUASI COMMERCIAL DoD OPERATED	COMMERCIAL CONTRACTOR OPERATED	COMMERCIAL COMMERCIAL OPERATED	COMMERCIAL COMMERCIAL OPERATED	COMMERCIAL COMMERCIAL OPERATED	COMMERCIAL COMMERCIAL OPERATED
	SPACECRAFT OWNED / TERMINAL OWNED	SPACECRAFT OWNED / TERMINAL LEASED	SPACECRAFT LEASED / TERMINAL OWNED	SPACECRAFT LEASED / TERMINAL LEASED	SPACECRAFT OWNED / TERMINAL OWNED	SATELLITE LEASED / TERMINAL LEASED	CHANNEL LEASED / TERMINAL OWNED	CHANNEL LEASED / TERMINAL LEASED	CIRCUIT BULK LEASED	CIRCUIT SINGLE LEASED
PHYSICAL SURVIVABILITY	GOOD	GOOD	GOOD	GOOD	FAIR	FAIR	FAIR	POOR	POOR	POOR
ELECTRONIC SURVIVABILITY	GOOD	GOOD	GOOD	GOOD	FAIR	FAIR	POOR	POOR	POOR	POOR
POSITIVE CONTROL	GOOD	FAIR	GOOD	FAIR	FAIR	FAIR	POOR	POOR	POOR	POOR
HIGH AVAILABILITY	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
FLEXIBILITY	GOOD	GOOD	GOOD	GOOD	FAIR	FAIR	FAIR	FAIR	POOR	POOR
MOBILITY	GOOD	FAIR	GOOD	FAIR	FAIR	FAIR	FAIR	FAIR	POOR	POOR
SECURITY	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	FAIR	POOR
CAPACITY	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	FAIR	FAIR	POOR	POOR

Figure 2. Performance Evaluation of Alternative System Concepts

electronic survivability. The transponders of commercial satellites are not likely to have sufficient bandwidth, stability, or phase linearity to provide good electronic survivability. The shared channel and terminal are not conducive to military operations. Individual circuits provide no potential for electronic survivability.

- <u>Positive Control</u>

  A military system will normally have a positive military control as the basis for system operation. Contractor support personnel may not be willing to provide adequate support during hazardous conditions or in support of tactical operations. Commercial spacecraft do not have protected control links and the conflict between user interests would reduce the likelihood of the military influencing important decisions (e.g., location of the spacecraft).

- <u>High Availability</u>

  All satellite communications systems are designed for high availability under normal operating conditions. The exceptions to this are covered under physical and electronic survivability.

- <u>Flexibility</u>

  Flexibility is one of the most important characteristics of satellite communications systems, but the flexibility of commercial systems is severely reduced by regulations and their normal deployment of large fixed terminals. Virtually no flexibility is available when circuits are leased from a common carrier, and the associated interconnect facilities from the carrier's terminal to the user's operating facility are usually extensive.

- <u>Mobility</u>

  The ability to serve mobile users is determined by how easily the satellite terminal integrates into the mobile platform. This is usually more effective when the terminal is part of the operational equipment of the mobile force.

- **Security**

  Voice security requires digitization of the voice signal. Voice digitization normally requires data rates in excess of 16 kb/s. Therefore, it is not practical to provide high quality secure voice over a 3-kHz analog voice circuit. A more detailed consideration of these military features is found in the Defense Communications Engineering Center (DCEC) technical report TR 2-74 [35].

3. SELECTION OF REALISTIC SYSTEM CONCEPTS FOR CONSIDERATION IN FURTHER ANALYSIS

Ten system alternatives, each of which could be implemented in several ways, present too many permutations to be tractable in the scope of this study. Therefore, each of the alternatives is examined in this section to determine its unique contribution and whether it should be included in the remainder of the analysis. The performance of Systems 1 through 4 are essentially the same except for the problems associated with using civilians in combat zones. This problem is solved if combat units have satellite terminals as part of their operating equipment and operate them with assigned troops. This is not unreasonable, since the number of combat units that would not be amenable to this restriction is small. Therefore, a mixture of terminals with civilian operators wherever possible (i.e., heavy terminals, medium terminals, MSC 46, and light terminals with 20-ft. antennas) and combat troops where necessary (i.e., TSC-85, etc., of crews of aircraft and ships), would make the performance of the first four systems equivalent. Rotation of combat troops to the U.S. can be included as participation in an improved training program. Operational evaluation of the satellite terminals has constantly shown the need for developing improved training programs [36]. Thus, the primary reason for selecting between Systems 1 through 4, with the above stipulations, would be system cost.

From an economic standpoint, the main advantage of leasing spacecraft or terminals is the ability to defer costs until the system is operational. Leasing can also provide a more constant rate of expenditure for the program.

It is frequently stated that leasing is a better approach to obtaining a capability because the contractor takes the risk. In most leasing arrangements, the contractor is penalized a certain portion of his fee if he fails to meet agreed-to objectives, or he is paid only for the time the service is provided. This economic incentive forces the contractor to minimize the risks of not performing satisfactorily up to the point where it is necessary to spend more money guaranteeing performance than he would lose if poor performance resulted in loss of the incentive payments. When the contractor starts losing money on the contract, the objectives of the procuring agency of a military system and the contractor no longer coincide. To prevent divergent objectives, the contract has to include a large enough incentive to force the contractor to want success as much as the procuring agency. It is not generally possible to include this large a reward or penalty in a government contract. Therefore, the contractor is taking only a nominal financial risk, but the government is taking a significant risk in not being able to perform the critical mission the system was designed to execute. When the risk for the contractor and the risk for the government are equivalent, and the government incorporates an assurance program to maintain this balance of risk, the overall leased costs will normally be greater than the costs to procure the same capability. Therefore, the risk argument is not valid for a military system, (i.e., guaranteed minimum risk for the government), but it is valid for commercial systems where the traffic is not critical and the primary concern is economic.

The argument that it is cheaper to lease than buy has no foundation, unless the purchased system is a failure or you replace it after only a short time. The DoD expects its satellite communications system to be a success, to be economical, and to operate over a relatively long life span. The contractor will expect to pay for the system in 3 to 5 years of successful operation and if it lasts longer he starts into the profitable portion of the contract. The government would expect terminals to last 10 to 15 years and satellites to last at least 5 years. Therefore, over a 10-year period the DoD could expect to pay at least twice as much for a leased system as an equivalent purchased system. It is not good business practice to let the user of the leased system save on total life cycle costs if the system operates successfully over the expected life of the system (that means the system owner would lose money). From the above, it would not be practical to lease military systems, therefore, Alternatives 2, 3 and 4 are not considered to be viable long term options, but might be useful as a stopgap measure. The issue of contractor operation of a completely owned DoD system is not considered to be enough different to be a separate system concept, but it introduces a possible impact on availability and is worth further consideration. Therefore, Alternative 1 is included for further analysis with both DoD operation and contractor operation. Alternatives 2, 3, and 4 do not introduce sufficient uniqueness to be worthy of consideration except as a stopgap measure.

Leasing

Due to the necessity to perform extensive engineering design, system management, and other "provider" functions described in OTP Circular 13, it is against U.S. policy for the DoD to own systems that compete directly with U.S. commercial firms. Therefore, it would be an unusual circumstance that would force the DoD to purchase its own commercial system, Alternative 5. Any cost advantage that could be gained from DoD ownership of the spacecraft will become apparent in the examination of Alternative 6. Figure 3 shows that there is essentially no difference in performance between Alternatives 5 and 6. Therefore, System Alternative 5 is also eliminated from further consideration in this study. Alternatives 7 and 8 are different with respect to the ownership of the commercial terminals. The resulting difference in quality is significant enough to include both in further analysis. Alternatives 9 and 10 differ primarily in cost, except for the constraint a single voice channel places on security, but the cost differential is sufficient to consider both in further analysis.

Obviously, Alternatives 9 and 10 have no assured military performance, therefore, user requirements satisfied by Alternatives 9 and 10 are basically nonmilitary and not critical to defense. The only exceptions would be when there is no other means of satisfying the requirement, which probably means the priority is low, or when sufficient alternative routes are provided to assure a reasonable confidence of successful communications even in a hostile environment. It is assumed that the exceptions do not apply and that the only reason to use Alternatives 9 and 10, for a long term solution, is economic as outlined under reason three of paragraph five of OTP Circular 13. Therefore, the only comparison between Alternatives 9 and 10 and the other remaining alternatives (i.e., 1, 6, 7, 8) is economic.

As an extension of the previous argument, Alternatives 6, 7, 8, 9, and 10 have poorer military performance than Alternative 1 (see Figure 2). Likewise, Alternatives 7, 8, 9, and 10 have poorer performance than Alternative 6. Each remaining alternative has poorer performance than any alternative that has a lower number (i.e., performance is monotonically decreasing as a function of increasing alternative number). If we were to give 12 points for each good, 8 points for each fair, and 4 points for each poor rating, the performance of the remaining alternatives would be as shown in Figure 3. Therefore, the only reason to select a higher numbered alternative is economic. The converse of this argument would be: if Alternative 1 is significantly more economical than the remaining alternatives, by at least 10%, there is no argument, except political pressure, to even consider the other alternatives.

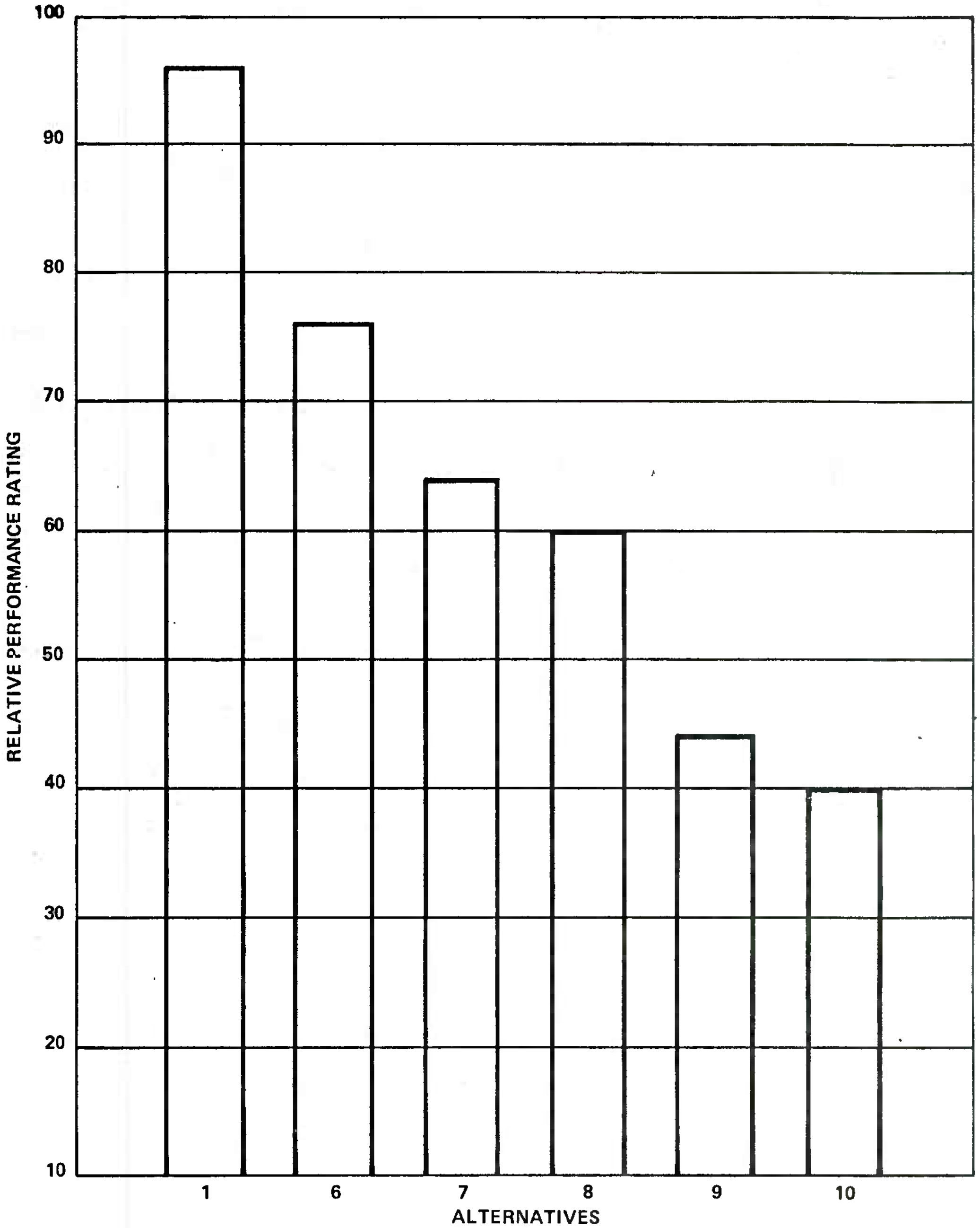

Figure 3. Relative Performance of System Alternatives

4. EXAMPLES OF SYSTEM ALTERNATIVES

A tradeoff analysis based on conceptual designs is likely to include a bias that is dependent on the analyst's understanding of the implementation of the concepts. There is also great difficulty in predicting operational dates and performing cost comparisons between equipments bought at different times in the future and equalizing all costs to constant dollars. It is much more conclusive if comparisons are between existing systems at contracted prices and established fees. Therefore, the existing satellite communications systems are examined to determine how closely they fit the preferred Alternatives (1, 6, 7, 8, 9, and 10) and what issues can be resolved by using established data. If the important issues cannot be resolved by examining existing and proposed capabilities, then hypothetical systems will be proposed and analyzed.

For the period 1975 to 1980, the following operational systems will be available to satisfy DoD worldwide requirements:

- U.S. Domestic Region:
  - Terrestrial Domestic Common Carrier Network (including Autovon and FTS)
  - Terrestrial Special Service Carriers
  - Domestic Satellites
  - DSCS (Phase II)
  - Leased Arrangements (dedicated for DoD use)
  - Government-Owned Commercial Grade Facilities (dedicated for DoD use)
- International Regions:
  - International Carriers (cables)
  - INTELSAT
  - DSCS (Phase II)
  - Leased Arrangements (dedicated for DoD use)
  - GAPSAT (MARISAT)

- Government-Owned Facilities (Troposcatter, LOS, and Cables)

- Oceanic Regions:
  - HF Network
  - MARISAT and Fleetsat
  - DSCS (Phase II)
  - AEROSAT and AFSATCOM
  - Leased Arrangements (dedicated for DoD use).

Beyond 1980, new systems will be introduced that will be capable of satisfying DoD requirements (i.e., foreign, domestic, etc.), however, the introduction of these systems does not significantly expand the alternative solutions to the problem under consideration.* From another perspective, the development of the correct methodology for allocating requirements to the competing systems in these three categories (during the 1975 to 1980 time frame) should address the complete spectrum of policy issues. As stated previously, this problem was addressed on a limited scale in the Congress.

The DSCS and Fleetsat fall under Alternative 1 and though they will be improved as military systems, their current military performance exceeds commercial systems sufficiently to make the categorization realistic. The circuits provided by INTELSAT and the Domestic Satellite Companies are certainly representative of Alternatives 9 and 10. The service provided DoD by American Satellite Corporation, RCA, and the systems being established for Algeria and other developing countries provide examples of Alternatives 7 and 8.

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*The Fleetsat versus MARISAT and AEROSAT issue is addressed in section IV and the introduction of advanced Fleetsat or Survsat will primarily improve obviously military performance parameters and will only impact the tradeoffs between military systems. The use of foreign, domestic and regional satellite systems to satisfy DoD needs would certainly be limited to cases where a significant cost advantage would be realized, therefore, the analysis for U.S. domestic satellites could readily be expanded to handle this limited class.

GAPSAT (MARISAT) will provide a reasonable approximation to Alternative 6, however, it may also be necessary to extrapolate this information to get the desired conclusions.

For U.S. domestic applications, it is necessary to compare domestic satellite systems with the terrestrial common carriers, including the special carriers such as DATRAN and MCI. The DSCS is compared with this result and the possibility of special leased arrangements is also introduced. The government-owned commercial grade services are not considered extensive enough to warrant further consideration.

For international regions, the rates for INTELSAT have been artificially tied to the rates of the cable to prevent real competition. Therefore, it is assumed that no tradeoff analysis between INTELSAT and submarine cables is necessary and that cable rates are the same as the established INTELSAT rates. INTELSAT rates are compared with the DSCS, and leased transponders and terminals are evaluated. GAPSAT has very limited capacity and will be used only for the highest priority users. Even though it is not militarized, it has only Fleetsat as a contender and the analysis for the oceanic coverage area is considered adequate for the international coverage area. Government-owned terrestrial systems were installed overseas to reduce the dependence of the U.S. military on foreign-owned and controlled public telephone companies. This is still considered to be an important objective. Except for those high density trunks with many access points (London to Italy via Germany), military satellite systems can reduce the necessity for these terrestrial facilities. Thus the main competition to military terrestrial networks are U.S. military satellite systems (i.e., DSCS) not commercial systems, therefore, it is military capability versus military capability tradeoff and is outside the scope of this study.

For the oceanic region, it is the general consensus that High Frequency does not provide reliable communications [37]. However, it is the only existing long distance communications capability for most mobile platforms (i.e., ships and airplanes) operating in or over the oceans. The main purpose of Fleetsat will be to improve that situation. In the interim, until Fleetsat is launched, MARISAT (GAPSAT) will provide a nonmilitary operational capability. After Fleetsat is operational, MARISAT and AEROSAT will be competitors to satisfy nonmilitary requirements. The DSCS will only satisfy military requirements for a limited set of mobile users, such as the Advanced Airborne Command Post, and is not in competition with the commercial systems, therefore, it does not need to be considered in the oceanic analysis. Leased arrangements other than GAPSAT are also explored as possible solutions.

The operational (or soon to be operational) satellite communications systems provide a sufficient range of alternatives to provide the basis for a tradeoff analysis that is highly representative of the system concepts proposed in Figure 1. This analysis should permit realistic economic and performance comparisons. Hypothetical comparisions could be developed that would be more optimum, but the degree of confidence in the results of such a comparison would lack the credibility of established performance and cost data. Therefore, sensitivity analysis is performed to insure that the interpretation of results is not extended beyond justifiable bounds. The representative systems that are analyzed and compared in this study are shown in Figure 4.

5. CLASSIFICATION OF DoD REQUIREMENTS

The DoD services and agencies have submitted what they consider to be satellite requirements. As stated previously, the DoD has analyzed these user requirements and the results are being reviewed with the users and will provide the basis for an update of the computer data bank. Preliminary categorization of these classified requirements, following the methodology of Figure 5, however, permits unclassified scenarios to be constructed that are representative of these sensitive military requirements. The DoD requirements are assigned to the military system if the mission analyses justify it, or if the responsiveness or flexibility demands cannot be satisfied by any other means.

This study addresses only those remaining requirements that can be assigned for strictly economic reasons. There is another group of requirements that falls outside this analysis methodology and is handled by the common user system, the Defense Communications System (DCS). These requirements have priorities associated with them, but generally no clear guidance as to the media for satisfying them (i.e., cable, troposcatter, satellite, etc.). The high priority traffic (critical WWMCCS circuits) that traverses the DCS warrants the provision of alternate routing between certain key points. This is accomplished in the U.S. by the Autovon terrestrial polygrid network, but transoceanic and overseas traffic is usually very dependent on single-thread transmission lines and on single gateway points. This means that the overseas DCS is susceptible to sabotage. Several years ago commercial satellite links were added to alleviate this problem and recently the DSCS has been able to take on an increased role in support of the DCS.

ALTERNATIVE	1		6		7		8		9	10
	FULL MILITARY DoD OPERATED		COMMERCIAL CONTRAC. OPER.		COMMERCIAL COMM. OPER.		COMMERCIAL COMM. OPER.		COMMERCIAL COMM. OPER.	COMMERCIAL COMM. OPER.
	SPACE CRAFT OWNED	TER-MINAL OWNED	SAT-ELLITE LEASED	TER-MINAL LEASED	CHAN-NEL LEASED	TER-MINAL OWNED	CHAN-NEL LEASED	TER-MINAL LEASED	CIRCUIT BULK LEASED	CIRCUIT SINGLE LEASED
DOMESTIC REGION	DSCS				W.U. R.C.A. A.T. & T.		W.U. R.C.A. AMER. SAT.		W.U. AMER. SAT. R.C.A. A.T. & T. GTE SAT	W.U. AMER. SAT. R.C.A. A.T. & T. GTE SAT
INTER-NATIONAL REGION	DSCS FLEETSAT				GAPSAT INTELSAT		INTELSAT COMSAT		INTELSAT VIA CARRIER	INTELSAT VIA CARRIER
OCEANIC REGION	FLEETSAT				GAPSAT MARISAT AEROSAT		MARITIME AEROSAT		MARITIME AEROSAT	MARITIME AEROSAT

Figure 4. Proposed Representative Systems (1975-1980)

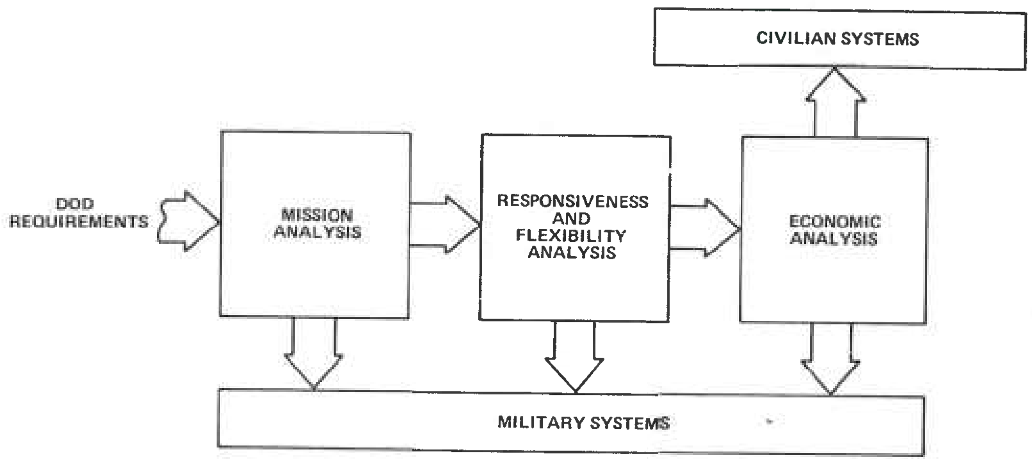

Figure 5. Assignment of Requirements for Satisfaction

The current philosophy for international DCS traffic emphasizes the utilization of three completely separate transmission paths, usually cable, INTELSAT, and DSCS. Any two of these separate paths should have sufficient combined capacity to permit the highest priority calls to be completed with practically no delay when the third path has been interrupted. The high cost of long haul circuits has prevented leasing an adequate number of circuits to permit a high grade of service for the lower priority traffic. This has affected the efficiency of conducting normal DoD business.

The question that arises again, when consideration is given to increasing the number of long haul circuits, concerns the proper mix of channels for the separate transmission paths. Should the 1/3-for-each-path rule be extended to the larger number of channels or should some other apportionment criteria be employed? If the survivability criteria for the highest priority users is met by the existing number of circuits, then it would not be necessary to extend the 1/3-for-each-path rule, and the additional circuits could be provided by the most economical means. As a matter of fact, with the reduction in force levels overseas, it may be possible to reduce the number of core circuits that warrant the 1/3-for-each-path rule. With economic factors the most important consideration in this application, it should be included as a possible requirement to be satisfied by commercial communications satellites.

Doubling the number of circuits carried by commercial satellites in the Pacific should be one of the scenarios to be analyzed. There are 134 voice-equivalent circuits currently carried by commercial satellites in the Pacific area. Introducing 133 additional voice circuits in the Pacific area (the single circuit to Hong Kong is left out) is the main basis for comparing system alternatives in the international arena. The military data bank indicates the need for wideband circuits which may not necessitate use of a military system, therefore, channels with information rates of approximately 50 kb/s, 100 kb/s, 1.5 Mb/s, 6.0 Mb/s, 10 Mb/s, and 100 Mb/s are evaluated.

Fortunately, for analysis purposes, the cost of satisfying user requirements via communications satellites is relatively independent of the distance between satellite ground terminals or the actual location of the terminals. Tariffs for commercial satellite circuits are usually distance dependent because the original tariffs were established by the competing terrestrial service which is distance dependent. Short-distance terrestrial service is more economical than satellites, and at longer distances satellites become more economical. The crossover point normally occurs between 100 and

Costs

800 miles. The actual crossover point depends on the cost of the terminals, the data rate, and the operation and maintenance philosophy. Thus, utilizing the current terrestrial and domestic satellite rates, the crossover point is between 700 and 1,000 miles.

Reviewing the current DCS circuit distributions, there are several hundred circuits which could traverse over a 1000 miles without being broken out at intermediate points. Therefore, a network that would include 15 large terminals, 1 in Hawaii, 2 in Alaska, 3 in the Western states, 3 in the Eastern states, 3 in the Central states, and 3 at special locations would be a realistic scenario. Initially 400 channels would be distributed among these 15 terminals. There is also a need for the distribution of wideband data (i.e., 1 Mb/s to 30 Mb/s) between certain pairs of these terminals.

Another justifiable extension would address the inclusion of several remote facilities that have need for transmitting wideband data. A network of 15 medium size terminals seems appropriate to be included. The cost of terrestrial access lines for high-speed digital voice (50 or 64 kb/s) can be very high and is also a reasonable application for small (economical) satellite terminals. Fifteen such locations could readily be identified. Therefore, fifteen small terminals providing access to secure voice or computer users should also be included as a basis of comparing the military system (DSCS) with domestic satellite systems.

The evolutionary development of an integrated digital DCS could include phases that require extending this access approach to many more users than fifteen; therefore, the provision of a random access capability to 100 and 200 subscribers should be included. This type of service takes advantage of the inherent flexibility of satellite communications systems and should prove to be a useful application worthy of further consideration. A DCEC study [38] has indicated that it may be possible to realize significant cost savings if satellite links are used more extensively in the DCS, thus both 2400 and 4800 voice-channel networks should be investigated.

Teletype service is essential to ships and planes traversing the oceans. Therefore, one teletype circuit into several hundred mobile stations is an essential requirement. Certain users require more than a single teletype circuit, thus groups of four teletype, eight teletype, and sixteen teletype are also used for comparison purposes. There is a strong desire to include voice service to many of these mobile platforms, therefore, a single voice circuit, on a demand basis, is needed into approximately 30 ships and 20 aircraft. Figure 6 is a summary of the requirements addressed in the remainder of this report.

ALTERNATIVE	1		6		7		8		9	10
	FULL MILITARY DoD OPERATED		COMMERCIAL CONTRAC. OPER.		COMMERCIAL COMM. OPER.		COMMERCIAL COMM. OPER.		COMMERCIAL COMM. OPER.	COMMERCIAL COMM. OPER.
	SPACE CRAFT OWNED	TER–MINAL OWNED	SAT–ELLITE LEASED	TER–MINAL LEASED	CHAN–NEL LEASED	TER–MINAL OWNED	CHAN–NEL LEASED	TER–MINAL LEASED	CIRCUIT BULK LEASED	CIRCUIT SINGLE LEASED
DOMESTIC REGION	133, 2400, 4800 DEDICATED VOICE CIRCUITS 400, 800 DEMAND VOICE CIRCUITS 9.6, 50, 100 Kbps, AND 1.5, 6, 10, 100 Mbps		SAME		SAME		SAME		SAME	SAME
INTER–NATIONAL REGION	133 DEDICATED VOICE CIRCUITS 9.6, 50, 100 Kbps AND 1.6, 6, 10, 100 Mbps		SAME		SAME		SAME		SAME	SAME
OCEANIC REGION	1, 3, 8 TELE–TYPE CIRCUITS DEDICATED AND DEMAND SINGLE VOICE CIRCUITS		SAME		SAME		SAME		SAME	SAME

Figure 6. Requirements Used in Tradeoff Analysis

The policy guidance established by OTP and OMB was shown to be unrealistic when dealing with future capabilities and high leverage services. The number of possible system alternatives was reduced to a tractible number and the existing and planned systems were shown to satisfactorily represent most of the reasonable system alternatives. It was shown that cost is the only reason to select a commercial system over a military system and the possibility of cost savings by utilizing commercial systems is the motivation to continue the tradeoff analysis. It was also shown that an advanced DSCS and AFSATCOM will only improve military capability and will not provide substantial cost improvements and are thus not candidates for further analysis in this report. A representative set of requirements was developed and used as the basis for comparing the system alternatives.

IV. TRADEOFF ANALYSIS FOR ALTERNATIVE SYSTEMS

The analysis in this section deals primarily with the cost advantage gained by utilizing the commercial system alternatives to satisfy DoD communications requirements. The commercial alternatives are compared with the military alternatives for satisfying requirements in the international, domestic, and oceanic regions of the world. Special emphasis is placed on satisfying digital requirements and expanding satellite service to a broader community of users. The cost advantage gained by replacing terrestrial facilities by a satellite communications capability is also addressed in this chapter. This effort was undertaken to determine the feasibility of increasing the reliance on communications satellites in the future DCS. Survivable systems such as AFSATCOM are not included, because survivability is not a major consideration. However, the number of satellites that will be visible during this time frame, and the selectivity of the area coverage antennas, should provide significant survivability improvement when used in conjunction with the existing public telephone service.

The existing, or soon to be operational, commercial communications system alternatives were shown (in section III, 4) to adequately represent the desired conceptual alternatives established in section III, 2. The system alternatives considered in the tradeoff analysis in this section are summarized in Figure 4. The requirements used as a basis to compare system alternatives as a function of cost and performance are summarized in Figure 6.

There exists a strong argument that it is always cheaper to use commercial facilities when they exist; this is the inference of OTP circular No. 13. This argument is based on the knowledge that the militarization of certain equipments usually results in at least doubling the cost of the equipment. Extending this reasoning to highly available space communications systems is not necessarily justified. Much of the additional cost of military equipment results from the extensive verification and testing program, however, commercial satellites are also tested extensively. Military systems must be highly reliable in an adverse environment; commercial satellite systems have essentially the same operational criteria, thus commercial terminals must also include the redundancy and an automatic switchover capability in order to provide the same high level of availability. When the high availability criterion is compromised in a common carrier system, the impact on the users is disastrous.

The other ingredient that generally makes commercial equipment cheaper than military equipment is the commitment to large production runs. The advantage of large production runs has not been achieved, to date, in any spacecraft production, except to some degree in the Hughes HS-333 domestic spacecraft used by ANIK and Western Union. Usually, terminals have been procured in small quantities seldom exceeding more than ten in a single contract. Two exceptions to this rule are the Navy UHF transceiver WSC-3, and the COMSAT General maritime transceivers, where several hundred terminals are being procured. Accepting the performance and availability penalties that a marginal economical design would give could certainly result in a cheaper system, however, even most commercial system managers have not been willing to accept this as a realistic alternative. Therefore, the comparison of the actual costs of the system components for the DSCS and INTELSAT in Table I does not reflect the significant savings that might otherwise be expected. All costs in Table I are stated in current 1975 dollars. Even the costs of the ATT/COMSAT domestic system, that is essentially of similar guaranteed quality, are not strikingly different from the DSCS.

The launch costs to the DoD are cheaper, thus the on-orbit cost for a DSCS satellite is less than an INTELSAT satellite. The INTELSAT spacecraft, however, are simpler and have a higher predicted reliability. The procedure for calculating reliability and the criteria for successful performance are different for military and commercial spacecraft and difficult to relate, but the INTELSAT spacecraft should have an appreciably higher reliability. However, due to anomalies detected in the INTELSAT IV spacecraft, COMSAT has ordered three additional INTELSAT IVA satellites. It will be several years before actual reliability figures are available. Therefore, a conservative estimate, favoring commercial spacecraft, would be to require 1.5 times more DSCS spacecraft to support an orbital station than commercial spacecraft. However, it must be remembered that the DSCS spacecraft is less reliable because it has more potential capability and more is demanded of it.

There is no significant difference in reliability for the other system components. The NATO III spacecraft is of comparable complexity to the Hughes HS-333 and the resulting costs are approximately the same. A big cost differential exists between the small militarized terminal and the small commercial terminal. This is particularly true when only a few terminals are procured. The development costs for a military terminal, designed for combat, are much higher than its commercial counterpart. If the development cost can be spread over several hundred units, the differential between the unit price for a military terminal and the unit price for a

TABLE I. COSTS FOR SYSTEM COMPONENTS
(Costs in Millions of Constant 1975 Dollars)

	DSCS	INTELSAT	COMSAT/A.T.& T.	W.U.	AMER. SAT.
Spacecraft	16.7[1]	16.2[2]	16.5[2]	10.3[4,5]	Leased
Booster	14.0[3]	22.5[2]	22.5[2]	15.0[4]	Leased
On-Orbit Cost	30.7	38.7	39.0	25.3	Leased
Annual Satellite Cost	9.1	7.7	7.8	5.1	
Annual Channel Cost	1.14	.64	.37	.43	
Large Terminals	6.0[1]	5.0[2]	3.5[6]	3.0[6]	2.5[6]
Medium Terminals	5.0[1]	3.0[6]	2.5[6]	2.0[6]	1.7[6]
Small Terminals Small Number	1.5[1]	.7[6]	0.5[6]	0.5[6]	0.5[6]
Small Terminals[6] Large Number	0.8	0.5	0.4	0.4	0.4
Small Terminals[6] Economical (i.e., lower avail.)	0.4	0.3	0.3	0.3	0.3

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[1] Computer Sciences Corporation, prepared for DCA, "MILSATCOM Cost-Performance Models, Final Report," June, 1974.

[2] COMSAT, annual report to the President and Congress, 1974.

[3] DCEC TR 2-74, DSCS Design Considerations, March 1974.

[4] DCA, "A Digest of Satellite Communications Systems," Vol. IV, September 12, 1973, P. 8-56.

[5] "Hughes Let $71.1 million Indonesia Sat Pacts," Electronic News, February 24, 1975, p. 22.

[6] Representative costs derived from industry inquiries.

commercial terminal is much smaller. There are many applications and, of course, these are the same applications where it would be feasible to consider using a commercial satellite system (i.e., operating in the commercial satellite frequency band). Therefore, comparisons between standard commercial terminals (4 and 6 GHz) and military terminals (7 and 8 GHz) built to best commercial practice should be included in the analysis.

The investment costs shown in Table I indicate the degree of savings that are possible if the DoD could lease services from the carriers at bare bones costs. Of course, observing the initial investments, it is reasonable to expect lower rates from the domestic satellite companies than from INTELSAT. The DSCS was not designed for this particular application and the inherent ability of the DSCS to direct higher power into small contingency areas and accept broader band signals cannot be factored directly into these figures. The penalty placed on the DSCS is realistic, however. Therefore, for this application INTELSAT is nearly twice as cost effective as the DSCS on an equivalent per channel basis, and the domestic satellites are nearly three times as cost effective. This cost differential is due almost entirely to the variance in predicted reliability and the different channelization approaches.

The large standard DSCS terminals are only approximately twenty percent more costly than the large INTELSAT terminals, but nearly twice as costly as the domestic satellite terminals. The smaller DSCS terminals designed to best commercial practice are expected to cost about twice as much as the domestic satellite counterpart.

1. INTERNATIONAL ALTERNATIVES

From the costs shown in Table I, it would appear that for point-to-point applications the commercial satellite entities should have a decided cost advantage over the DSCS. Examination of several scenarios will determine if this savings can be realized in practical system implementations. The first comparison is a network of several terminals utilizing the INTELSAT Pacific satellite. The configuration for this network is shown in Figure 7. The costs that DoD paid last year for this service are shown in Table II. The total cost of $19,281,276 for 134 circuits was paid to several common carriers (A.T.& T., RCA, WUII, ITTW, HAWTELCO) who in turn paid INTELSAT 134 x $18,000 = $2,412,000. The remaining $16,869,276 went to the satellite terminal owners and the common carriers.

The initial annual capital investment for INTELSAT was $640,000. Since 134 channels is equivalent to approximately one third of a standard commercial transponder, the DoD equivalent initial investment

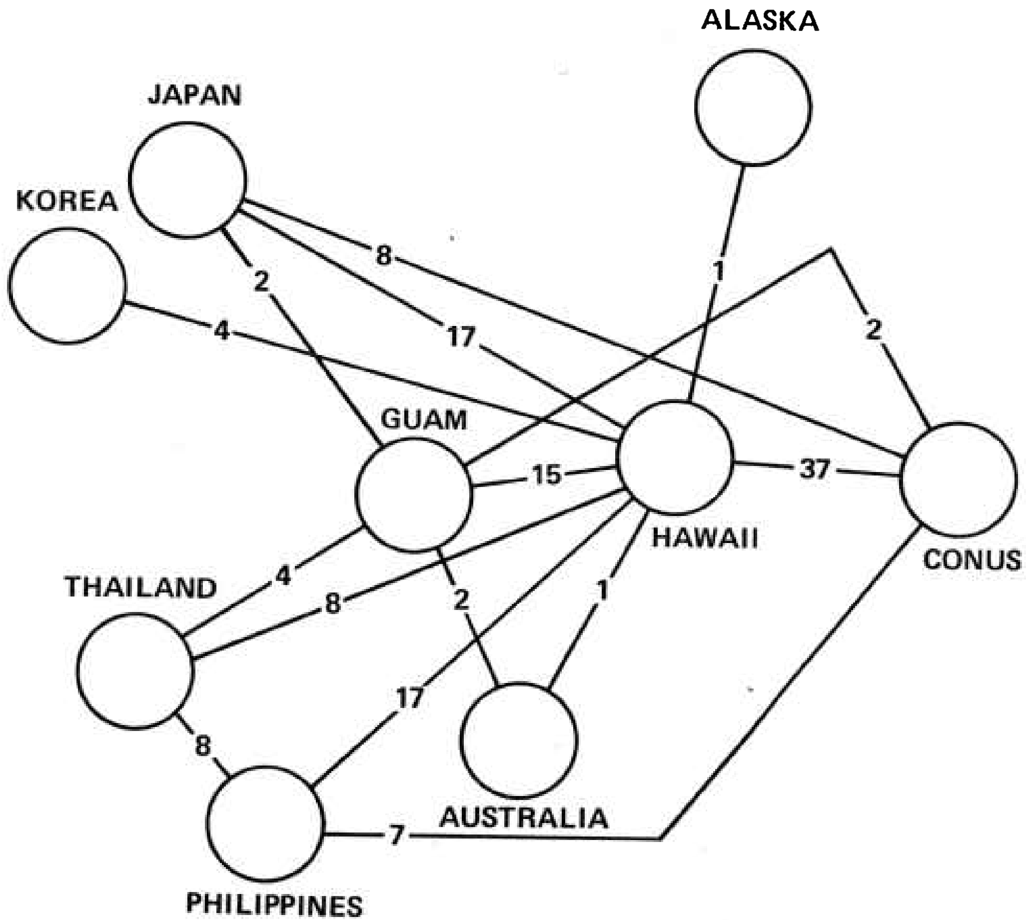

Figure 7. Pacific Commercial Network

TABLE II. INTELSAT LEASE COSTS

Locations of Terminals	No. Channels X Cost/Channel	Total Monthly Lease Cost
CONUS/Hawaii	37 X 5,200	$192,400
CONUS/Guam	2 X 11,800	23,600
CONUS/Philippines	7 X 18,900	132,300
CONUS/Japan	8 X 21,137	169,096
Alaska/Hawaii	1 X 7,968	7,968
Hawaii/Guam	15 X 8,500	127,500
Hawaii/Philippines	17 X 13,450	228,650
Hawaii/Japan	17 X 16,199	275,383
Hawaii/Korea	4 X 16,440	65,760
Hawaii/Thailand	8 X 14,375	115,000
Hawaii/Australia	1 X 21,014	21,014
Guam/Japan	2 X 11,413	22,826
Guam/Hong Kong	1 X 11,342	11,342
Guam/Thailand	4 X 13,775	55,100
Guam/Australia	2 X 19,917	39,834
Philippines/Thailand	8 X 14,875	119,000
Total	134 Circuits[2]	$1,606,773[1]

[1]Annual Cost = $19,281,276

[2]Average Monthly Cost/Channel = $11,991

is 1/3 x $640,000 = $213,333. The transponder is backed up by a similar 1/3 transponder to give a total equivalent initial investment of $426,666. The difference between $2,412,000 (paid to INTELSAT) and $426,666, or approximately $2,000,000, is allocated to overhead, operating expense, interest, and profit.

There were 13 INTELSAT terminals in the Pacific, plus 5 additional antennas, for a total initial investment of approximately $80 million. These terminals would normally last 15 years, but if a 10-year life is used (as COMSAT does), the initial investment cost is $8 million a year for the terminals. There were 1151 circuits on the Pacific satellite during 1973. Assuming the same number of circuits during 1974 (it probably increased), $\frac{\text{134 circuits (DoD)}}{\text{1151 circuits (total)}}$ = .12. Thus 12 percent is the DoD share of the initial investment in terminals, and the DoD equivalent investment in terminals is $8,000,000 x 0.12 = $960,000. The difference between $16,869,276 and $960,000, or approximately $16 million, is allocated to operating expenses, common carrier interface boxes, interest, overhead, and profit.

As indicated by the COMSAT annual report [39], COMSAT is a very profitable business, but as seen from Table II, some of the foreign terminals operators charge four times the rates of COMSAT. From this analysis, without stating what is a reasonable operating expense or profit, it can be clearly seen that it would not be too difficult to operate a system at these rates and achieve a substantial profit. It can also be seen that the initial investment costs constitute a very small portion of the total charges. These results are very insensitive to the costs of satellites or terminals (i.e., a factor of 100% is barely perceptible).

From the foregoing, it is obvious that it doesn't take much effort to show that the DSCS can perform this same task at a fraction of the cost. Table I shows that it costs $9.1 million dollars a year to maintain a DSCS phase II spacecraft on station. The DSCS Program Plan [40] states that it would take approximately 8.5% of the DSCS satellite's capacity to support a network similar to the one shown in Figure 7. This would be equivalent to $773,500/year in initial investment. To achieve the same availability as INTELSAT requires two DSCS spacecraft. Therefore, the initial annual investment is equivalent to $1,547,000. A way to verify this figure would be to take one third of the annual transponder cost from Table I, which is $380,000. This indicates that the $1.5 million figure is probably conservative by a factor of two and is consistent with the use of 64 Kb/s instead of standard analog FM channels.

Assuming nine terminals are required for this service (the one circuit to Hong Kong does not warrant a terminal), the DSCS terminals would represent an initial investment of $54 million (Table I shows terminals cost $6 million each). Using a ten year life again yields $5.4 million/year. Rounding the 8.5% up to 10% (to be conservative) yields $540,000 as the cost of the terminals to be charged for this purpose. The total initial annual investment for terminals and spacecraft is thus $2.1 million.

Assuming each terminal is a large AN/FSC-78, the total annual operating cost would be 9 x $470,000 = $4,230,000. The portion of this cost to satisfy the stated requirement would be $423,000. The cost to control the satellite is approximately $100,000/year of which $10,000 would be assessed against satisfying this requirement.

The total DSCS annual investment and operating cost is $2,540,000. A sophisticated computer cost model for the DSCS, that includes previous R&D efforts, present value weighting, etc., yields a DSCS cost of $2,754,000 [41] for a medium loaded system. This more sophisticated model is good for getting accurate total system costs, however, it is easy to lose sight of the major factors that are influencing cost. It is easier to understand the tradeoffs between alternatives if the analysis is kept in the simpler terms of investment and operating costs that yield an annual figure of $2,540,000. As may be observed in most of the comparisons, a 10 percent error is not significant and if it is, the more accurate model is used.

In actuality, the DSCS terminals are already installed at these locations, in support of WWMCCS, and it costs relatively little to equip them to provide the additional 133 circuits (i.e., $1.7 million total or $170,000/year). No additional operating expense would be incurred by placing these additional circuits on the system. Therefore, the spacecraft costs dominate and the total cost would be approximately $1,717,000 (this is less than 10 percent of current DoD lease costs -- quite a bit less than the 10 percent less stipulated by OTP Circular No. 13).

These results show the fallacy of assuming that it is always cheaper to go commercial. The commercial rate is only cheaper if true competition or purposeful regulation exists. No real competition exists in the case of international satellite circuits, as a matter of fact, and as indicated previously, they are held unrealistically high to permit cables to be competitive. It is unlikely that the standard rates, to all common carrier users, will be changed significantly as long as nations continue to protect their investment in cables. Therefore, it is essential for DoD to seek a nonstandard type of service that can be bid at a fixed price not to exceed a specified number of dollars/year. This price should be determined by the DoD, based on a reasonable cost established by determining the DSCS cost to provide the same services, and used as a ceiling.

Another commercial alternative would utilize a leased INTELSAT transponder. Leasing a protected INTELSAT transponder (i.e., backed up) for $3.240 million/year and establishing a 400-channel network using 10 commercial terminals, results in a system initial investment and operating cost of $1.63 million per year for 133 voice channels. If the terminals are also leased, the annual system cost would be $2.16 million.

For this application (point-to-point trunking), it would be realistic to introduce a commercial class of terminal into the DSCS. The cost to set up a 1200-channel network in the Pacific would require approximately $40 million. If such a network existed, the annual cost for 133 voice channels would be $1.42 million, or the individual voice channel cost would be $890/month. If only 400 channels were used, the annual cost for 133 channels would be $2.20 million and an individual voice channel would cost $1390/month.

Since satellite circuit costs are essentially independent of location and distance, it would be informative to extend the foregoing analysis to examine the costs of providing 133 voice circuits in the CONUS utilizing a domestic satellite with 10 terminals. The domestic tariffs are much lower than the international rates and would establish a lower bound on the network costs. The cost per domestic transponder (shown in Table I) is $430,000; if completely backed up each transponder would have an initial investment cost of $860,000. This service can be leased for $1.7 million/year. The 2x implementation cost equals selling price rule of thumb is followed in this case. When four or more transponders are ordered simultaneously, the price drops to $1.5 million/year.

The cost for ten terminals at $1.7 million each is equal to $17 million total initial investment cost and is equal to $1.7 million/year. Assuming these terminals are located on military bases to reduce interconnect costs, first the total cost of the terminals is assessed against the satisfaction of the 133 voice channels. This results in an initial investment cost of $2,560,000. The operating cost would be in the neighborhood of $1.5 - $2.0 million. Therefore, taking the highest costs for all the terminals and the entire transponder, the annual system cost would be approximately $4,560,000.

Actually this capability could support three times the capacity, or 399 voice channels, with no increase in cost. If the need for 400 channels existed, it would be reasonable to charge only one third of the total cost against the 133 channels, or the cost could be as low as $1,520,000 in most situations. If the network were to use three transponders and carry 1200 voice channels (i.e., similar to INTELSAT), the total system cost would be only $7.28 million and the 133-channel portion would be approximately $806,000. This is equivalent to $505/month per channel.

A comparable service provided by the DSCS would require $2.28 million/year for the satellite transponder, $3 million/year for commercial grade terminals, and $2 million/year for operational costs. The total costs would be approximately $7.28 million/year for 400 channels or approximately $1.22 million prorated for 133 channels (assuming the terminals are used in a 1200 channel network). This is approximately $764/month per channel.

Taking the domestic tariff for intermediate distances ($870/month), which would require interconnects if established common carrier terminals are used, 133 channels would cost $1,389 million/year. The total yearly investment and operation and maintenance (O/M) costs for the contractor to provide this service would be approximately one half the cost required to cover the investment and operating costs for the fully militarized DSCS equipped to provide equivalent service, but approximately equivalent if the DSCS were to utilize terminals built to best commercial practice. As described previously, the cost for leasing INTELSAT transponders and using commercial government terminals at user locations would cost approximately the same ($1.63 million/year) as the domestic tariff. The interconnect costs, however, could be appreciably less for the leased transponder case. This cost analysis is summarized in Table III.

Column five (total yearly investment and O/M) of Table III can be used as a basis to develop intrinsic comparisons. These numbers do not include overhead, G & A, or profit for the commercial companies, or the planning and management costs for the DoD. It is often argued that DoD is very inefficient at managing programs and therefore this kind of figure should not be used by the DoD as the cost to the government for using a DoD system. This may be true, but the DoD inefficiency is not generally in the overhead function but rather in planning and getting the program initiated (i.e., many false starts). When the program reaches the implementation stage, the DoD usually has a very low overhead; many times too low to properly manage the system operations. Nevertheless, these are the only

TABLE III. COST FOR 133 VOICE CIRCUITS - INTERNATIONAL REGION
(Costs in Millions of Constant 1975 Dollars, Except Monthly Channel Cost in Dollars)

	Alter-native	Terminal Initial Investment $ Millions	Spacecraft Initial Investment $ Millions	O/M $ Millions	Total Yearly Investment and O/M $ Millions	Tariff Yearly Total $ Millions	Channel $/Month
DSCS All Military	1	0.540	1.547	0.433	2.540		1,591
Modified DSCS Terminals	1	0.170	1.547		1.717		1,076
INTELSAT[1]	9	0.960	0.427	0.900	2.287	19.145	11,996
DSCS Commercial Terminals[2]	1a	0.400	0.720	0.300	1.42		890
Domestic U.S.[3]	10	0.299	0.286	0.221	0.806	1.389	870
Leased Transponder & DoD Commercial Terminals[2]	7	0.300	1.080	0.250	1.63		1,021
Leased INTELSAT Transponder Leased Terminals[2]	8	1.08	1.08		2.16		1,353

[1] The single circuit to Hong Kong is excluded from the analysis.
[2] Based on a 1200-channel network.
[3] Domestic cost is shown for comparison purposes only (1200-channel network).

consistent figures that can be used for a realistic comparison and if the reader keeps this constraint in mind and weighs the results based on his experience there should be no serious distortion. The implications of this expediency on the conclusions are addressed during the tradeoff analysis.

It can be assumed, in the Aerospace industry, that if the selling price is between 2 and 2.5 times the investment and operating costs, the price is competitive. A factor of 2 times the investment and operating costs for the DSCS (i.e., $2.540 million x 2) should certainly cover all related government costs. For example, $2.5 million/year would support at least 50 people full time for this one requirement, and at this rate, well over 500 people would be required for just the trunking portion of the DSCS. Therefore, Alternative 1, for less than $5 million, would provide a high quality secure voice service that has full military capability. A $2.85 million ($1.42 x 2) system, utilizing DSCS spacecraft and commercial terminals (Alternative 1a), would be more equivalent to the service provided by INTELSAT (Alternative 10). This would also be the approximate cost of an all-military system utilizing 32 Kb/s for secure voice in place of the conventional 64 Kb/s.

The lowest domestic satellite tariff is the bulk rate of $350/month per voice channel for users leasing over 300 voice channels. Appendix D verifies these tariffs as being reasonable and fair by applying the above logic to the initial investment and operating costs for a fully loaded domestic system. Using the same logic, the INTELSAT prices should be in the order of $4.5 million/year and no more than $6 million/year. This is for a lightly-loaded satellite and the cost should be reduced proportionately as the satellite is more fully loaded. In other words, these are prices that allow INTELSAT and participating earth terminal operators to take very little risk, particularly since many of the terminals should be nearly paid for by now. The high total of $6 million/year is equivalent to an average cost of $3,760/month per voice circuit. This is still 4.3 times as expensive as an equivalent domestic satellite voice channel, but it is much better than the 14.0 times the domestic rate that DoD is currently paying. Column 6, Tariff Yearly Total, of Table III gives the total costs for 133 voice circuits leased from the international common carriers, who in turn lease from INTELSAT, and the cost to obtain a similar service from a domestic satellite carrier. Column 7 shows the average monthly rate for this service.

In summary, the existence of the DSCS (Alternative 1) in the Pacific, with large WWMCCS terminals at the desired locations, makes it possible to provide a full military capability at the lowest cost. Leased INTELSAT transponders and owned (Alternative 7) or leased terminals (Alternative 8) to parallel the DSCS network, would only become competitive if the requirement were to exceed 800 voice circuits, which is unlikely. The artificially high prices of the INTELSAT network (Alternative 10) would warrant reducing the number of commercial satellite voice circuits, unless a special rate (Alternative 9) could be negotiated. For survivability reasons (i.e., alternate routings) they should not be reduced below 100 voice circuits. Therefore, the reason to maintain a sizable number of commercial circuits is not for economic reasons, but to maintain military survivability.

Point-to-point trunks could be more economical by commercial carrier (i.e., INTELSAT) if both ends required new terminals and there were never a need for additional connectivity to other terminals in the network -- this is an unlikely circumstance. Certain requirements when examined in isolation appear to be strictly point-to-point requirements, but when the aggregate requirements for the location are examined, the need for a multidestination capability becomes apparent.

At current INTELSAT leasing rates for transponders, the DSCS satellite transponder is cheaper and the DSCS commercial grade terminals (Alternative 1a) are not significantly higher. If a decision is made to develop an extensive DSCS domestic capability, a family of commercial grade DSCS terminals would need to be procured to offset any current INTELSAT economic advantage.

2. DOMESTIC ALTERNATIVES

The policy of the FCC to allow competition in the domestic satellite communications industry has resulted in several suppliers of this service as shown in Figure 4. These companies were requested to indicate their interest in providing these services to the DoD.* CML was interested, but unable to provide any definitive costing information at this time. RCA, Western Union, and American Satellite Corporation indicated interest in providing most of the services indicated in Figure 4, and representative prices from their budgetary estimates are used in the following analysis. General Electric and Philco also provided information on the price of system components. A.T.& T. and GTE were interested primarily in providing standard

*A copy of this letter is shown in Appendix E.

voice circuits through their planned terminals. This is a very competitive industry that is evolving rapidly and this study addresses new services that are in the planning stages and have not been filed or advertised. Therefore, to retain competition and the confidentiality of the information, only representative cost figures are used. This is sufficient for this current analysis, which has the purpose of examining feasibility and establishing guidance in this field. Budgetary quotes are not expected to be highly accurate, but they establish lower bounds that can provide insight for examining pertinent issues.

The first requirements scenario used for comparing the system alternatives shown in Figure 4 is provision of the 133 voice circuits between 10 terminals as discussed in the previous section and summarized in Table III. In this case, however, the operational date is post-1978 thus permitting consideration of 32 Kb/s for secure voice. This would reduce the costs for the all-military DSCS (Alternative 1) of Table III to those shown in Table IV. The total yearly investment and operating costs of $1.519 million are comparable to the non-discounted domestic charge (Alt 10) of $1.389 million/year. The 30 percent discounted price (Alternative 9), however, would be $1.11 million/year which is appreciably cheaper than the all-military DSCS rate. The DSCS, using terminals built to best commercial standards (Alternative 1a), could provide the 133 voice channels for $1.22 million/year which is comparable to the commercial tariff rate. The costs for the DSCS do not include indirect costs, but the DoD terminals would be adjacent to the user and thus access line costs would be much less. In this case costs would be close enough to allow selection on strictly a performance basis.

If a domestic commercial channel is leased (Alternative 7) and the 133 voice channels are part of a larger 1200-voice-circuit network, the cost allocated to the 133 channels would be only $0.800 million/year. This is appreciably cheaper than the DSCS alternatives, except for the case where the DSCS terminals are in place (Alternative 1b) servicing WWMCCS users. The DoD-owned commercial terminals could also be located close to the user. If sufficient capacity is required between these same terminals (i.e., greater than 3000 channels) to warrant leasing an entire satellite (Alternative 7a), the costs would drop to approximately $.460 million/year for a 5000 channel network. This is an appreciable cost savings, however, with 5000 channels going into only 10 terminals, there will undoubtedly be additional costs for access lines.

The final commercial alternative would be to also lease the terminals (Alternative 8). For the 1200-channel network case, the

TABLE IV. COST FOR 133 VOICE CIRCUITS - DOMESTIC REGION
(Costs in Millions of Constant 1975 Dollars, Except Monthly Channel Cost in Dollars)

	Alternative	Terminal Initial Investment \$ Millions	Spacecraft Initial Investment \$ Millions	O/M \$ Millions	Total Yearly Investment and O/M \$ Millions	Tariff Yearly Total \$ Millions	Channel \$/Month
DSCS All Military	1	0.420	0.774	0.433	1.519		951
Modified DSCS Terminals	1	0.085	0.720	0.030	0.835		523
DSCS Commercial Terminals	1a	0.300	0.720	0.200	1.22		764
Leased Transp. & DoD Commercial Terminals[1]	7	0.150	0.500	0.150	0.800		501
Same as Above[2]	7a	0.080	0.300	0.080	0.460		288
Leased INTELSAT Transponder Leased Terminals[1]	8	0.600	0.500	0[3]	1.10		689
Same as Abvove[2]	6	0.240	0.300	0[3]	0.540		338
Domestic Single	10					1.389	870
Bulk	9					1.11	695

[1] Operating in 1200-Channel network
[2] Operating in a 5000-Channel network
[3] O/M costs included in terminal costs

leased terminal costs for 133 channels would be approximately $600,000/year. Therefore, system costs would be $1.10 million/year. For the 5000-channel network case (Alternative 6), the leased terminal costs for 133 channels would be approximately $240,000/year and the system costs would be $0.540 million/year.

In summary, comparisons between Alternatives 1 and 10 indicate that little is gained by leasing individual commercial circuits, particularly when the additional cost of access lines is added to Alternative 10. The greater access line cost for the commercial alternatives, using their currently planned terminal locations, is attributable to the more optimum placing of DoD owned or leased terminals in conjunction with the military users. Alternative 9 is attractive enough to warrant usage of the domestic service to satisfy requirements that terminate and originate near currently planned domestic terminals. Alternatives 1a and 1b would indicate that even Alternative 9 would not be used if existing DSCS terminals were capable of carrying the traffic over approximately parallel routes. Comparisons between Alternatives 1b, 7, and 7a (likewise 1b, 8, and 6) show that it is not profitable to install a commercial network paralleling an existing DSCS network unless network capacity exceeds 1200 channels. If the capacity gets as great as 5000 channels, the parallel commercial network becomes very attractive.

Comparing Alternative 1a and 7 and 7a demonstrates the desirability of utilizing the commercial capability to serve a new DoD network, one that has no planned colocated DSCS facilities, even when the capacity is as low as 1200 channels. The cost per channel to lease terminals also goes down as the number of channels increases and for a large network, it would probably be worthwhile to lease terminals. The total additional cost to lease terminals (for 5000 channels) would be approximately $3 million a year, out of a total cost of approximately $20 million/year. At this rate, 25,000 long distance circuits could be provided for less than $100 million a year, with approximately one terminal in each state.

In order to provide a flexible capability to a larger community of users, an additional domestic scenario was postulated for analysis purposes. This scenario introduces a large number of smaller terminals (G/T ≈ 27 dB) operated in a demand access mode. These small terminals are integrated into a network of 15 large terminals (G/T ≈ 39 dB) and 15 medium terminals (G/T ≈ 33 dB). Two demand access scenarios are used, one servicing 20,000 users and one servicing 40,000 users. These numbers of users are compatible with the requirements addressed in a DCEC report [42] investigating the feasibility of wider use of communications satellites to supplement or replace terrestrial transmission facilities for the DCS. The number of satellite terminals addressed in that report ranges from 10 to nearly 1000 to satisfy up to 251,000 users.

A typical curve from that report, showing the 10-year cost of the network as the number of satellite terminals increases, is shown in Figure 8.

The terrestrial network cost decreases as the average length of terrestrial access lines is reduced. At a certain point, however, the cost of the small satellite terminals becomes significant and becomes the dominant portion of the satellite costs as the number of terminals increases beyond 500. The system cost is the summation of the terrestrial network and satellite network costs. The average yearly cost, for that model, for a completely terrestrial network, would be approximately $120 million. That report includes a generalized parametric tradeoff addressing a range of possible terminal costs and, depending on the cost of the satellite terminals, predicts that as much as $60 million a year could be saved by the proper mix of satellite links and terrestrial facilities. Figure 8 was selected out of the many curves presented in that report as representative of the more realistic costing data developed in this present study.

In this scenario the previous analysis is extended to include the cost impact of extending DCS service, via communications satellite, to numerous distant locations, and then to even shorter access links as more satellite terminals are introduced into the system. Table V and Table VII address 2 scenarios that include 100 small terminals and 200 small terminals respectively. Table VI and Table VIII provide backup information to Tables V and VII. Both scenarios expand the network of large terminals to 15. The requirements analysis indicates this would be sufficient to support all the major commands and would provide expanded capability as the number of small terminals increases. The number of carriers, modems, and multiplexers also increases as the size of the dedicated network increases. The DSCS options include consideration of the existence of ten large WWMCCS terminals that require only minor modification for this application. A group of medium size terminals, 15, was introduced to handle medium capacity switching centers and special wideband requirements. The 30 large terminals will also be used as the primary entry points for the small terminals. The small terminals remain the same in both scenarios, only the number increases. Scenario 1, Table V, provides 2400 duplex voice channels to a dedicated network comprised of the 30 larger terminals and 400 satellite channels to all 130 terminals, to be utilized in a demand access network. A small terminal will be able to communicate directly with another small terminal, but this is not expected to be the normal mode of operation. Therefore, the large terminals are modified to include a demand access capability including system control. Each small

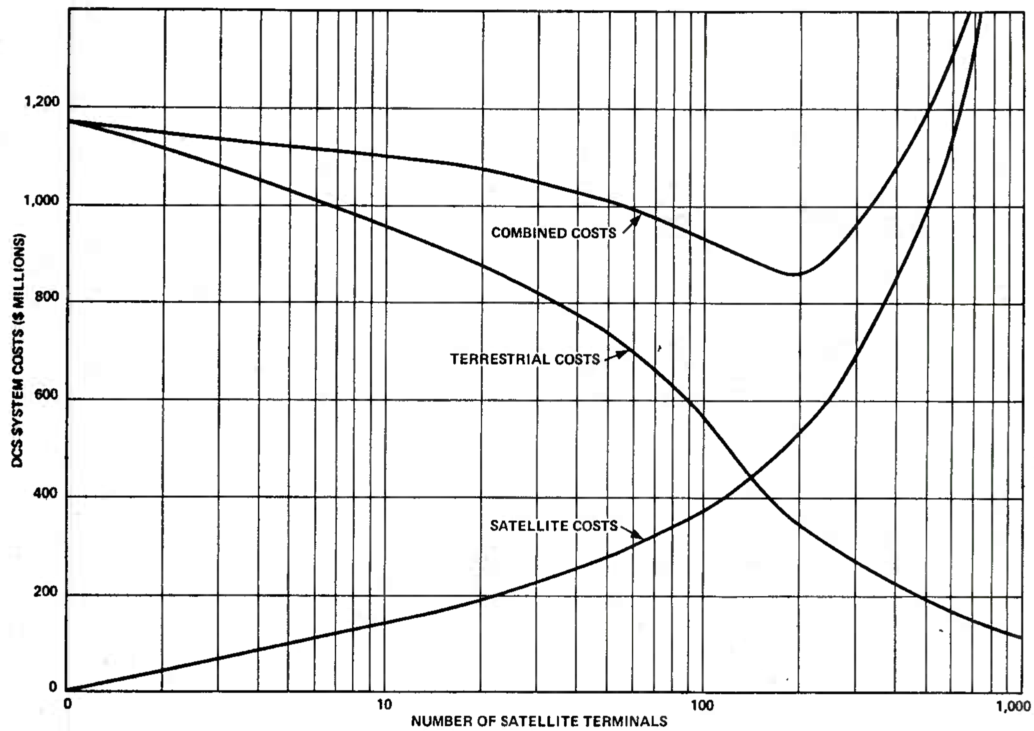

Figure 8. The 10-Year DCS System Costs With Integration of Satellites

TABLE V. COST FOR COMPLETE DOMESTIC SYSTEM - 2400 Dedicated Channels, 400 Demand Access Channels (Costs in Millions of Constant 1975 Dollars, Except Monthly Channel Cost in Dollars)

	Alter-native	Dedicated Network $ Millions	Channel $/Month	Demand Access Network $ Millions	Channel $/Month	Users(20,000) $/Month	Annual System Total $ Millions
DSCS All Military	1	32.47	1,128	60.64	12,633	253	93.0
DSCS Commercial Terminals	1a	25.5	885	24.2	5,042	101	49.7
Leased Transp. & DoD Commercial Terminals	7	28.4	986	15.0	3,125	63	43.4
Leased Domestic Transponder Leased Terminals	8	36.5	1,267	19.5	4,062	81	56.0
Domestic Single	10	25.1	870	4.2[1]	870		29.3[2]
Domestic Bulk	9	20.0	695	3.3[1]	695		23.3[2]

[1] Demand access would be at the Carriers Terminal.

[2] The advantage that the demand access network had gained by reducing terrestrial access lines has been lost and a large terrestrial interconnect cost would have to be added to compensate for using only 10 to 15 earth terminals.

TABLE VI. COST FOR COMPLETE DOMESTIC SYSTEM - 2400 DEDICATED CHANNELS
400 Demand Access Channels (20,000 Users @ 0.02 Duty Factor)[1]
(Costs in Millions of Constant 1975 Dollars,
Except Monthly Channel Cost in Dollars)

	Alter-native	Large & Medium Terminals $ Million	Small Terminals $ Million	Space Segment $ Million	O/M $ Million	Annual System Total $ Million	Channel $/Month
DSCS All Military[2]	1	22.0	52.9	18.1	0[3]	93.0	2,768
DSCS Commercial Terminals[2]	1a	6.0	7.0	18.1	18.6	49.7	1,479
Leased Transp. & DoD Commercial Terminals	7	7.5	5.0	11.0	19.9	43.4	1,292
Leased Domestic Transponder Leased Terminals	8	27.0	18.0	11.0	0[3]	56.0	1,667
Domestic Single	10					28.0[4]	870
Domestic Bulk	9					23.4[4]	695

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[1] 15 large terminals, 15 medium terminals, 100 small terminals; Space Segment requires 6 domestic transponders or DSCS equivalent.

[2] Assumes 10 of the large terminals (HT) are part of WWMCCS and includes $10 million for modification for DAMA and additional channels.

[3] Price of terminals includes O/M.

[4] Must include much higher interconnect costs.

TABLE VII. COST FOR COMPLETE DOMESTIC SYSTEM - 4800 Dedicated Channels, 800 Demand Access Channels (Cost in Millions of Constant 1975 Dollars, Except Monthly Channel Cost in Dollars)

	Alter-native	Dedicated Network $ Millions	Channel $/Month	Demand Access Network $ Millions	Channel $/Month	Users (40,000) $/Month	Annual System Total $ Millions
DSCS All Military	1	36.3	630	113.8	1,185	238	150.1
DSCS Commercial Terminals	1a	30.9	521	41.0	4,270	85	71.9
Leased Transp. & DoD Commercial Terminals	7a	34.35	596	29.0	3,020	60	63.35
Leased Domestic Transponder Leased Terminals	6	47.6	826	38.0	3,958	79	85.6
Domestic Single	10	50.2	870	8.4[1]	870		58.4[2]
Domestic Bulk	9	40.0	695	6.7[1]	695		46.7[2]

[1] Demand access would be at the Carriers Terminal.

[2] The advantage that the demand access network had gained by reducing terrestrial access lines has been lost and a large terrestrial interconnect cost would have to be added to compensate for using only 10 to 15 earth terminals.

TABLE VIII. COST FOR COMPLETE DOMESTIC SYSTEM - 4800 DEDICATED CHANNELS 800 Demand Access Channels (40,000 Users @ 0.02 Duty Factor)[1] (Costs in Millions of Constant 1975 Dollars, Except Monthly Channel Cost in Dollars)

	Alter-native	Large & Medium Terminals $ Million	Small Terminals $ Million	Space Segment $ Million	O/M $ Million	Annual System Total $ Million	Channel $/Month
DSCS All Military[2]	1	25.0	105.8	19.3	0[3]	150.1	2,232
DSCS Commercial Terminals[2]	1a	9.0	14.0	19.3	29.6	71.9	1,070
Leased Transp. & DoD Commercial Terminals	7a	10.5	10.0	13.0	29.85	63.35	945
Leased Domestic Transponder Leased Terminals	6	36.6	36.0	13.0	0[3]	85.6	1,265
Domestic Single	10					58.5[4]	870
Domestic Bulk	9					46.7[4]	695

[1] 15 large terminals, 15 medium terminals, 200 small terminals; Space Segment requires a complete domestic satellite or DSCS equivalent.

[2] Assumes 10 of the large terminals (HT) are part of WWMCCS and include $10 million for modification for DAMA and additional channels.

[3] Price of terminals includes O/M.

[4] Must include much higher interconnect costs.

terminal is provided with up to 12 demand access channels depending on the number of users in that region. The large terminals are equipped with a correspondingly greater number of channels depending on the expected demand.

Table V summarizes the costs for scenario one. The costs for the dedicated network and the demand access network are separated. Again, Alternative 1, with all militarized terminals, is approximately twice the cost of a completely commercial system, Alternative 7. The DSCS with commercial grade terminals, Alternative 1a, is approximately twelve percent greater than the all commercial network, Alternative 7. If the commercial terminals are also leased, Alternative 8, the DSCS, with commercial grade terminals, Alternative 1a, is less by approximately twelve percent.

When the service is expanded to a 4800-dedicated-voice-channel network and 800 satellite demand access channels serving 230 terminals, Table VII, the ratios and percentages remain approximately the same. When the number of small terminals is increased to 500, the cost of the small terminals dominates system costs and drives the total system cost to unacceptable levels.

The number of demand access channels were determined by assuming a 2 percent factor for each of the 20,000 or 40,000 users. The peak factor is not as critical in a demand access satellite network as for terrestrial trunks because all users are drawing on a common reserve, which already includes a system margin that is relatively unaffected by this small portion of the total capacity. In addition, the traffic peaks occur at different times for different geographical locations (e.g., Hawaii and New York) and tend to be smoothed out when users from all locations draw upon the same satellite reserve.

Figure 9 shows the total cost of the different alternatives as the number of terminals range from 30 to 500. The decreasing cost of the terrestrial network is also shown. The terrestrial costs are combined with the costs for each of the alternatives to show the total DSCS transmission costs and demonstrate the savings incurred by increasing dependence on satellite communications in the DCS. The annual savings could be as much as $30 million if 100 to 200 satellite terminals are integrated into the terrestrial facilities of the DCS.

The cost figures used in these calculations are quite conservative and in particular, the O&M philosophy is based on current practices within the DoD that would not be used in a competitive commercial market. These conservative estimates are presented to

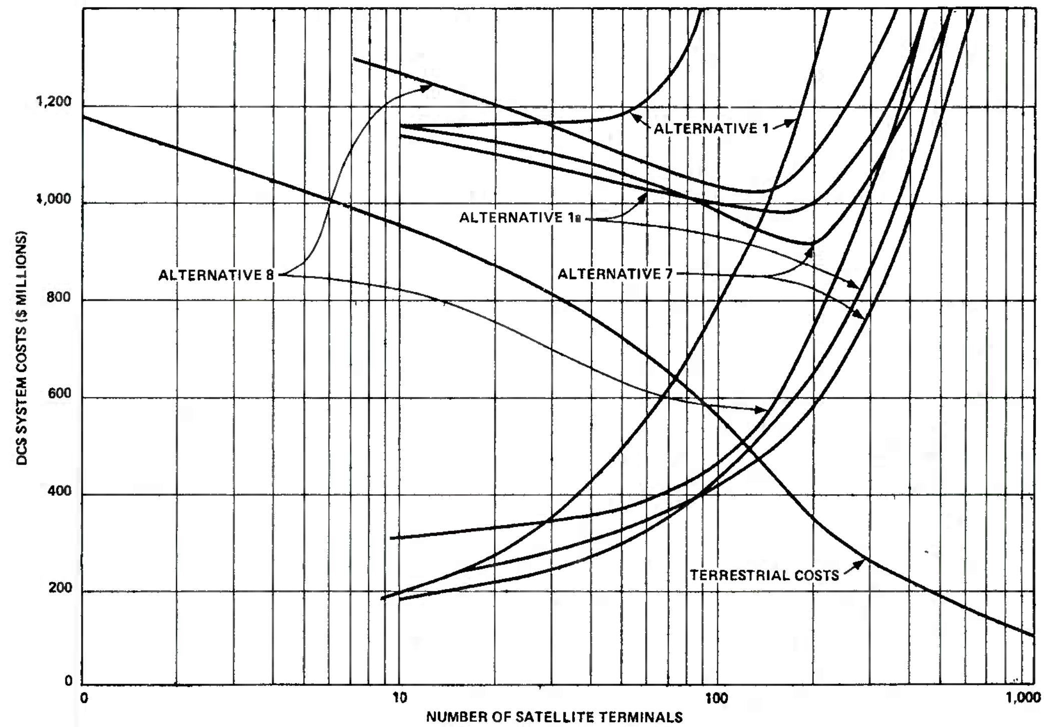

Figure 9. Alternative 10-Year DCS System Costs With Integration of Satellites

determine the feasibility of replacing a portion of the terrestrial facilities with communications satellites. The comparison between system alternatives, however, is a more relative evaluation. The trend in the commercial systems is to install unattended terminals with maintenance personnel on call* [43]. The commercial domestic terminals are highly reliable redundant terminals, as are all of the terminals costed in this study, and do not require extensive onsite sparing. Figure 10 extends the previous analysis to include a somewhat more optimistic learning curve for production of terminals and an efficiently instituted O&M support system. Tables IX and X give the breakdown of the system costs for the different alternatives. These costs indicate an additional $10 million a year can be saved with proper planning and management. Therefore, introducing 100 to 200 satellite terminals into the domestic DCS could save as much as $40 million a year.

In summary, it should be apparent that the demand network of Alternative 1, utilizing fully militarized small terminals, is not a viable alternative. The dedicated network subsystem costs, however, are close enough to the other alternatives to be considered, particularly if the WWMCCS requirements have previously justified a significant number of the terminals. The excessive access line costs rule out Alternatives 9 and 10, except to satisfy a limited requirement. The real cost savings result from implementing either Alternative 1a or Alternative 7. Both alternatives require the DoD to set up an effective O&M support system. Both systems also require the DoD to plan and manage the system. Therefore, the choice between these alternatives can be made on a performance basis, which would of course favor Alternative 1a. On the other hand, Alternative 1a, implemented with commercial grade terminals, does not provide a large enough performance advantage to preclude consideration of Alternatives 7 or 8, if other pressures become significant. Therefore, the cost analysis does not indicate a clear cut economic advantage for one of the alternatives, but does provide a means to evaluate a specific implementation. It is also important to evaluate the aggregate of the requirements to take advantage of the economy of scale that the purchase of a large number of terminals would provide.

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*The Canadian Telesat System has successfully operated and maintained forty-one terminals in all regions of Canada with a staff of two supervisors and six technicians, plus less than eleven weeks of contract support during the entire year.

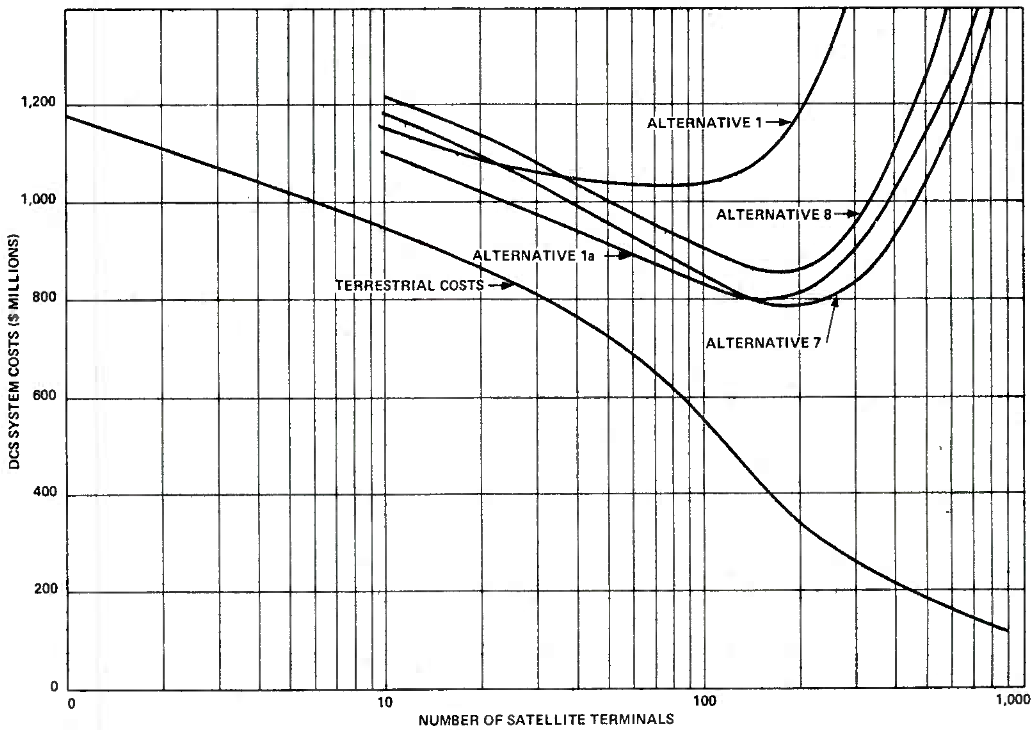

Figure 10. Alternative 10-Year DCS System Costs With Integration of Satellites (Optimistic)

TABLE IX. COST FOR COMPLETE DOMESTIC SYSTEM (OPTIMISTIC) - 2400 Dedicated Channels, 400 Demand Access Channels (Costs in Millions of Constant 1975 Dollars, Except Monthly Channel Cost in Dollars)

	Alternative	Dedicated Network $ Millions	Channel $/Month	Demand Access Network $ Millions	Users (20K) $/Month	Annual System Total $ Millions
DSCS All Military	1	25.2	875	31.3	130	56.5
DSCS Commercial Terminals	1a	17.2	597	15.3	64	32.5
Leased Transp. & DoD Commercial Terminals	7	22.5	781	10.5	44	32.5
Leased Domestic Transponder Leased Terminals	8	26.0	903	13.8	58	39.8
Domestic Single	10	25.1	870	4.2[1]	870	29.3[2]
Domestic Bulk	9	20.0	695	3.3[1]	695	23.3[2]

[1] Demand access would be at the Carriers Terminal.

[2] The advantage that the demand access network had gained by reducing terrestrial access lines has been lost and a large terrestrial interconnect cost would have to be added to compensate for using only 10 to 15 earth terminals.

TABLE X. COST FOR COMPLETE DOMESTIC SYSTEM (OPTIMISTIC)
4800 Dedicated Channels, 800 Demand Access Channels
(Costs in Millions of Constant 1975 Dollars,
Except Monthly Channel Cost in Dollars)

	Alter-native	Dedicated Network $ Millions	Channel $/Month	Demand Access Network $ Millions	Users(40K) $/Month	Annual System Total $ Millions
DSCS All Military	1	32.37	560	62.0	129	94.27
DSCS Commercial Terminals	1a	24.27	421	28.0	58	52.27
Leased Transp. & DoD Commercial Terminals	7	28.5	494	19.0	40	47.5
Leased Domestic Transponder Leased Terminals	8	33.0	572	23.2	48	56.2
Domestic Single	10	50.2	870	8.4[1]	870	58.4[2]
Domestic Bulk	9	40.0	695	6.7[1]	695	46.7[2]

[1]Demand access would be at the Carriers Terminal.

[2]The advantage that the demand access network had gained by reducing terrestrial access lines has been lost and a large terrestrial interconnect cost would have to be added to compensate for using only 10 to 15 earth terminals.

3. OCEANIC ALTERNATIVES

Procurement data is not as well developed on system components for the satellite communications systems to satisfy oceanic requirements as for systems operating in the other regions of the world. Therefore, certain aspects of the analysis rely on available data that is extrapolated to provide the best insight possible. The COMSAT contract for the Marisat [44] spacecraft is $40 million for three spacecraft. This number of satellites is expected to provide satellites at 2 locations for 5 years, or dividing $40 million by 10 yields a cost of $4 million/year for each on-orbit satellite. The booster costs assessed against each satellite are approximately $4.5 million a year and thus the total cost is $8.5 million/year to maintain a satellite on-orbit. This amounts to $17 million a year for maintaining two satellites on-orbit. Approximately $1 million/year can be charged to the satellite control facility, therefore, the investment and operating costs are approximately $18 million a year. The DoD pays $23 million/year for the UHF portion of those satellites. This shows that the DoD is essentially paying for Marisat while COMSAT is developing a market among the maritime users. The terminals for the Navy Fleetsat system and the Marisat system are both approximately $30 thousand, however, integration and antenna costs can run the total cost to over $100 thousand for each terminal installation.

If the charge for a 1-minute ship-to-shore voice conversation were in the order of $10, the annual revenue could be approximately $5.3 million for each satellite voice channel. Therefore, 10 such channels with a duty factor of 50 percent would yield approximately $26 million/year. Therefore, if each Gapsat utilized more than five voice channels, 50 percent of the time it would be cost effective. If teletype channel charges are half of this ($5/minute minimum), Gapsat would need to provide only 10 channels per satellite to be cost effective. Thus, with several hundred UHF satellite terminals becoming available over the next three years, it appears that Gapsat is a cost efficient approach to obtain an interim capability. However, the DoD could have obtained this capability at a lower total system cost if the spacecraft had been procured from the contractor by DoD and launched by DoD taking advantage of the DoD discount on launch charges. The probability of three spacecraft maintaining sufficient on-orbit satellites for five years is not as high as would be expected of a military system, but the contractor is willing to take the risk of not getting paid for a certain portion of that time. This is consistent with the nonmilitary posture of Gapsat.

The Fleetsat spacecraft cost will be approximately $30 million and the launch costs approximately $25 million. Therefore, the total annual on-orbit cost for each satellite is $11.0 million. If one satellite is used to back up two on-orbit satellites, as is the case with Gapsat, the annual cost goes to $16.5 million. For two locations, similar to Gapsat, the annual cost would be approximately $33.0 million, which is $10 million more than DoD pays to COMSAT for the Gapsat capability. The terminals are the same, therefore, the total system cost would be $10 million more a year for Fleetsat. The Fleetsat satellite has considerably more capacity, not to mention military capability, and the resulting channel costs would be about one-half of the Gapsat costs. There are additional costs associated with Fleetsat, however, these investments (i.e., SHF terminals) provide a military capability that is not obtainable by a Gapsat class of spacecraft.

In summary, Fleetsat, Alternative 1, provides a flexible military capability at a lower cost than Gapsat, Alternative 7, or Marisat, Alternative 8. Marisat and Aerosat costs to the DoD will be higher due to the necessity to install duplicate terminals on the mobile platforms. This is necessary because mobile military users require a primary connectivity with the military network in order to perform their intended mission. Therefore Gapsat is adequate for an interim capability, but in order to provide a military capability, with less total system cost, it is essential to develop the Fleetsat class of spacecraft.

4. DIGITAL TRAFFIC

The scenario that is used for comparing alternatives to satisfy digital requirements includes a large terminal, that is also part of a larger network, and a medium terminal that is installed at the source of data to handle this specific requirement, except where service terminates at the common carrier terminal (Alternatives 9 and 10). It is assumed that the large terminal was previously handling 10 Mb/s of data, therefore, the new requirement is apportioned according to the new total traffic handled by the terminal. For instance, if the new requirement is 10 Mb/s, one-half of the large terminal cost would be assessed against the new requirement, and if the new requirement is 100 Mb/s, nearly all of the large terminal cost will be assessed against the new requirement.

All of the cost of the medium terminal is assessed against the new requirement, unless the requirement is less than the capacity for a secure voice circuit. It is assumed that the high data rate is in one direction, received by the large terminal, and a return link is provided that operates at 0.1 of the rate of the forward link.

Table XI shows the results of costing out this scenario for different alternatives as the data rate varies from 10 Kb/s to 100 Mb/s. At the lower data rates, as can be seen from Table XI, the medium terminal costs dominate and there is very litte differential between the alternatives, except for the domestic Alternatives 9 and 10. Alternatives 9 and 10 require additional costs to extend the service from the common carrier terminal to the user. At the medium data rate, 1.5 Mb/s and 6 Mb/s, the INTELSAT costs become appreciably higher than the DSCS, or the domestic carriers. At 10 Mb/s the DSCS, Alternatives 1a and domestic, Alternatives 7 and 8 are nearly equal. The tariffed rates, Alternatives 9 and 10, are not competitive, particularly when the additional interconnect links are included. Tariffed rates will not be provided for 100 Mb/s. The DSCS is clearly superior for these high data rates. These cost estimates were verified by a recent DECCO inquiry [45] and proposed rate structures that have been filed with the FCC.

In summary, the DSCS is very cost competitive with either domestic or INTELSAT systems in providing digital service. These rates also assume the DoD is an authorized user of COMSAT which, as noted previously, would require examination by the FCC. The DSCS is particularly superior for data rates exceeding 40 Mb/s. Even with militarized terminals the DSCS costs are only 40 percent higher at the medium rates, but 50 percent less at the higher rates.

5. DEMAND ACCESS SERVICE

DoD has had great difficulty, as indicated by the Congressional records concerning leasing channels in the Pacific, achieving direct access to COMSAT earth stations as an authorized user. This is a complex issue and assuming that resolution is in favor of DoD and the authorized user status is achieved will only lead to another set of difficult problems concerning obtaining agreements with the many foreign carriers who operate the other ends of the satellite links and provide the interconnecting facilities. The billing procedure for short calls is complicated and the foreign national Ministries of Posts and Telecommunications are not accustomed to interfacing with the many entities that are considered normal in a free market economy. Introducing a new government agency into this maelstrom would not be received by participating INTELSAT governments with very much enthusiasm. The international carriers are also able to influence the climate of acceptance in certain foreign countries. Therefore, it appears the best approach would be to develop an international WATS type of service through the international carriers. Based on the COMSAT charge of $0.46/minute, however, it is unlikely

TABLE XI. COSTS FOR DIGITAL TRAFFIC - POINT-TO-POINT
(Costs in Constant 1975 Dollars (Thousands per Month)

Alternative Data Rate	DSCS Alt. 1	DSCS Alt. 1a	INTELSAT Alt. 7	INTELSAT Alt. 8	INTELSAT Alt. 9 & 10	Domestic Alt. 7	Domestic Alt. 8	Domestic Alt. 9 & 10
9.6 Kb/s	12	8	8.6	16	6	8	6	4.6
50 Kb/s	12	8	8.6	16	6	8	6	4.6
100 Kb/s	12	9	9.6	17	12	8	6	6.1
1.5 Mb/s	42	30	38.0	62	144	34	29	31.1
6 Mb/s	85	70	101.0	151	532	66	61	120.0
10 Mb/s	113	93	164.0	229	980	89	84	180.0
100 Mb/s	283	250	1,040	1,140	0[2]	506	500	0[2]

[1]Traffic is assumed to be between a large terminal that is already carrying 10 Mb/s, and a medium terminal located at the source of data, except for Alt. 9 and 10. Data is one-way with 1/10 this rate on return path.

[2]Service will not be provided.

that savings of more than a factor of two would be realized.

A normal Washington-to-United Kingdom telephone call costs $5.40 for the first 3 minutes. If COMSAT charges $1.30 for its half-circuit and the United Kingdom charges at least that much (foreign operators usually charge quite a bit more), then the satellite link has cost $2.60, which is approximately half of the charge. Unless a special multinational rate structure is negotiated, it is unlikely that total costs will be less than twice the COMSAT rate. COMSAT rates are being reduced approximately 20 percent as the result of FCC direction, and it is anticipated that the international carriers will pass this savings on to the user. The overall reduction may not be as great as this if there are strong pressures to subsidize the submarine cables, or if the foreign terminal operators continue to charge excessive rates. Therefore, the prospects of realizing significant savings by capitalizing on the SPADE capability are poor. The advantages of demand access service for the domestic systems were demonstrated in the section discussing domestic alternatives. The advantages are possible in the domestic region because the number of terminals is larger and the administration and political problems are much simpler.

Significant savings are achievable, however, if the SPADE channel is used for 50-Kb/s secure voice or computer traffic. This is achieved by dedicating one of the SPADE channels for a specific requirement. The transmission channel for SPADE is digital and readily adapts to receive digital traffic up to 56 Kb/s. Since no more bandwidth or power required, it is possible to obtain 50-Kb/s service at a rate that is only 1.5 times the cost of a normal analog circuit. This is much cheaper than the 12 times the cost of an analog circuit to obtain the same service if normal analog techniques are employed. This factor of 12 is necessary because a group of 12 analog circuits is required to transmit 50 Kb/s. Therefore, savings of a factor of eight could be realized if secure voice channels are between locations where INTELSAT SPADE terminals have been installed.

There are several ways to satisfy a given requirement. For instance it would be desirable to supply a 50-Kb/s link from Washington to Stuttgart (approximately 4,200 miles) and Honolulu (approximately 4,900 miles). This requirement could be satisfied by strictly terrestrial analog circuits at 12 times the single voice circuit rate, or $130,000/month to Stuttgart and $68,000/month to Honolulu. The Stuttgart requirement could also be satisfied by using a dedicated INTELSAT SPADE channel to a Germany INTELSAT terminal, and a terrestrial interconnect to Stuttgart, for approximately $20,000/month. The Honolulu requirement could be satisfied by a terrestrial lease across CONUS to the Jamesburg earth station in California, and then routed via a dedicated INTELSAT SPADE channel to the Hawaii earth station and on in to Honolulu, for approximately $25,000/month. The DSCS could provide this service to either Honolulu or Stuttgart for approximately $2,000/month, plus the costs for a short interconnect link. The domestic carriers would be willing to provide service to Honolulu for approximately $7,000/month. INTELSAT is the only commercial satellite service to Germany.

In summary, the prospects of achieving significant savings by making special use of the INTELSAT SPADE capability is small. The savings realized by introducing a large number of small demand access terminals into the domestic DCS is very significant. Significant savings can be realized if dedicated INTELSAT SPADE circuits are used to carry digital data streams of 10 Kb/s to 56 Kb/s.

This section has compared the costs for implementing the system alternatives, derived in section III, to satisfy the representative requirements. It was shown that the DSCS can provide international service, both analog and digital, much cheaper than the current rates charged by the international carriers who are in turn leasing service from INTELSAT. It was also shown that integrating 200 to 300 satellite terminals into the DCS could appreciably reduce total system costs. This is accomplished by reducing the terrestrial circuit miles that would otherwise have to be leased from A.T.& T. It was concluded that the DSCS is generally as economical or more economical than the other alternatives for satisfying wideband requirements. Domestic satellite systems are very competitive for satisfying new requirements where all new terminals need to be installed. Tariffed domestic satellite service is reasonable if the interconnect distance to the users is short.

V. CONCLUSION AND RECOMMENDATIONS

This study addresses several important questions pertaining to the utilization of satellite communications systems and the practicality of employing commercial satellite systems to satisfy DoD communications needs. Insight into these important issues is provided by reviewing policy and background that has evolved over the past decade and examining satellite communications systems that are either in operation or will soon go into operation. System alternatives are developed and tradeoff analyses are performed which compare the cost for each of these alternatives to satisfy representative categories of DoD requirements. The following conclusions can be made as the result of this analysis:

- Communications satellites provide important new services that are not economically supplied by other means. They are also inherently very flexible and are thus important as a military capability. It has been demonstrated that satellite communications are the most economical means of communications for long-haul circuits unless extremely high capacities permit the construction of special terrestrial facilities.

- The potential radio frequency interference problems and coordination procedures that are involved in establishing satellite communications systems result in a long and highly political review process. The time consuming process has a serious impact on the flexibility of the systems.

- Satellite communications systems can be used to satisfy several classes of user requirements and a system that is optimized to efficiently satisfy one class of requirements may not be effective if used to satisfy one of the other classes of requirements. Therefore, it has been demonstrated that several different types of satellite systems are required to satisfy the broad spectrum of requirements. This need was recognized by Congress and in the past they have devoted a considerable amount of their time to satellite communications problems.

- Congress made provision for separate government systems and intended the military to develop its own system. They also included a clause in the Communications Satellite Act of 1962 that would allow the government to develop government systems if that would result in significant savings to the government.

- Military satellite communications systems should be developed to support the missions of the DoD in any adverse environment. Therefore, the military systems should provide a high degree of survivability, flexibility, mobility, positive control, security, and availability. These features have been designed into the military systems, however, the only one of these features that has been deliberately designed into the commercial systems is high availability. The strictly military features generally cause the cost of the system to increase, and therefore the commercial designers have not placed emphasis in these areas. Improved flexibility could have been designed into the commercial systems without much increase in cost, but the frequency clearance problems and politics have reduced the incentive for including it as a major consideration.

- The United States policy is to utilize commercial facilities whenever possible unless such use interferes with accomplishing the mission of the user, delays the program schedule, or is appreciably more expensive. The criteria for determining cost is quite rigid and unrealistic when considering the establishment of a new service such as domestic satellites. It would be possible to juggle cost figures to prove a 10 percent differential either way and the corporations involved have sufficient flexibility in pricing to make thresholds of this nature meaningless. Therefore, costs that are within 10 to 15 percent should be considered essentially equal and attention given to the other implications affecting the decision. With this as a basic premise, initial investment and O/M costs were used as the primary vehicle for cost comparisons. These are the only firm costing figures that are available and can provide adequate insight into the issues under consideration.

- The meaningful alternatives that are available consider the degree of ownership and control by the DoD. Thus, if the system is completely owned, operated, and controlled by the DoD, it is considered to be an all military system. The other end of the spectrum would be service obtained from a common carrier where the DoD owns no part of the system and has virtually no control of the system. The range of alternatives is shown in Figure 1.

- The military capability of these alternatives ranges from very high for the all military system to very poor for the commercial carrier service. The performance rating is shown in Figures 2 and 3.

- The DSCS is operational and Fleetsat is expected to be operational by 1978. INTELSAT provides an operational example of an international system and Marisat and Aerosat other examples that will be operational before 1980. There are several entrants in the domestic satellite field and three are already operational. Figure 4 shows the representative systems, by geographical region, that will be available during the next five years. Therefore, there are enough real systems to provide a basis for a meaningful experiential study.

- DoD requirements can be classified into certain categories. The truly military category has not been addressed in this report, but those requirements that can be satisfied by utilizing either a military system or a commercial system, depending on the most economical means of satisfaction, are used as the basis for comparing alternatives in section IV. Figure 5 shows the methodology used in categorizing requirements. Figure 6 shows the categories of requirements that are best suited for satisfaction by a commercial satellite system and that are used in the tradeoff analysis.

- INTELSAT rates have been deliberately established to be non-competitive with submarine cables. Therefore, because INTELSAT is not in a competitive satellite market, the DSCS can provide the same service at a fraction of the cost. No effective international regulation exists and even though the INTELSAT transponder rates are fairly reasonable, as are COMSAT's rates, the foreign operators and international carriers are receiving excessive profits. Cost comparisons between the different alternatives are shown in Table III.

- The domestic systems are significantly cheaper than the DSCS if the DSCS utilizes all-military terminals. If the DSCS deploys a terminal built to best commercial practice, the initial investment and O/M costs are close enough to give the domestic systems only a slight advantage. Military performance would of course favor the DSCS, thus, when the satellite terminals are placed on the user's site, the decision between using the DSCS or the domestic system can be based on other than performance or cost factors. Service provided at the common carriers standard terminals is not cost competitive, except for a limited number of requirements. Significant savings could be realized, however, if 100 to 200 small demand access terminals were integrated into the terrestrial facilities of the DCS. These savings, shown in Figure 9 and 10, are possible only if the system is properly managed and an effective O/M system is instituted. Indications are that a contractor could provide this O/M service for DoD-owned terminals at a price commensurate with providing a $30-to-$40 million annual saving for the DCS. DoD ownership of the terminals is preferable due to the increased flexibility and long term cost savings.

- Gapsat provides a good interim capability until Fleetsat is developed sufficiently to be declared operational, but even from a cost standpoint, Gapsat, Marisat, or Aerosat provide no advantage. This is particularly true if the mobile platform is required to also operate in the military satellite network in order to perform the users primary mission.

- The satellite communications systems can be utilized effectively for transmitting wideband data while realizing significant savings. The DSCS should be used for those requirements where at least one end of the link already has an established DSCS terminal, see Table VI. A parallel commercial network must carry a large volume of traffic to offset the costs the DSCS gains by sharing facilities. Links between two new locations are cheaper utilizing domestic satellite systems unless the data rate exceeds 40 Mb/s. This discussion also applied to other wideband service, such as television. The demand access capability supplied by satellite communications systems will provide a marked improvement for secure voice and computer networking at very reasonable costs.

- Special actions should be taken in the following areas:

  - Increased participation in the ITU to obtain conditions favoring flexible use of satellite communications systems.

  - Analysis of the aggregate of requirements to obtain maximum advantage of economy of scale. When considering requirements that can be satisfied by commercial systems, the requirements of other government departments and agencies should be considered in the aggregate (i.e., NASA, FAA, GSA, etc.).

  - Recognition of the DoD as an authorized user of COMSAT should be pursued.

  - Pressure should be increased on the foreign INTELSAT terminal operators and international carriers to reduce rates.

  - DoD should develop a cost data base that establishes the cost for which DoD can supply a particular service. This would be a useful tool in negotiating fair prices from contractors.

- DoD should investigate the feasibility of establishing an O/M system to economically support DoD-owned commercial grade satellite terminals.

To retain the United States technological initiative in the communications satellite field, and to capitalize on the current lead, the United States Government should establish national policy by pursuing the following actions:

- The OTP and the FCC should work closely with the DoD and other government agencies to develop a flexible policy that will permit the government to take advantage of the new services at the most economical terms possible.

- The government agencies, under the guidance of the NCS, should develop a management plan to provide a cohesive capability for all government users. To enhance survivability, interoperability criteria should be developed to permit satellite terminals to operate with any of the satellites. This reduces the impact of a single point failure by any of the satellites.

- The same group should also develop a comprehensive R&D program that gives guidance to the DoD, NASA, and the commercial carriers to establish complementary efforts that assure a dynamic expansion of capability in the communications satellite industry.

In order to increase the options available to the DoD, and assure the DoD a good bargaining position, during the next series of negotiations with the carriers for satellite service, the following recommendations are made:

- Expand the WWMCCS secure voice and computer networks utilizing a mix of DSCS and domestic satellite circuits. Use DSCS circuits where the DSCS terminals are already in existence and use domestic satellite circuits where existing domestic terminals are convenient and where both ends of link require new terminals.

- Increase the number of DCS circuits carried by the DSCS.

- Gradually reduce the number of INTELSAT circuits, unless a special international type of WATS service can be offered.

- For all long-haul service, domestic and international, the DoD should determine a price that is fair and reasonable and only lease circuits if that price is offered. The DSCS would provide the alternative means of satisfying this class of requirement. The initial investment plus O/M costing procedure outlined in this report provides an initial starting point to develop these prices. It is true that several factors were not included, but all of these additional factors should be dependent on the initial investment and O/M costs as a basis. The weighting multipliers that modify these factors may vary from company to company, but it should be possible to establish a reasonable and acceptable spread for these weighting multipliers.

- Lease a Domsat transponder and establish a precedent of the government operating a network with commercial characteristics. In parallel with this effort, conduct a detailed study to verify the desirability of Domsats carrying a significant amount of AUTOVON and AUTODIN traffic in and between the 50 states and Puerto Rico. This study should address cost (satellite network and terrestrial network), survivability implications, performance, and operational difficulties.

- Establish a pilot demand access network that could operate in either a domestic satellite network, a DSCS network, or both.

- Develop a standard family of commercial grade DSCS terminals and establish a special O/M system to efficiently operate them.

- Make sure the design of the DSCS Phase III spacecraft will effectively accommodate the special small terminal networks discussed in this study.

- Continue the Fleetsat program to expand the service available to mobile platforms. Sufficient capacity should be provided to satisfy logistic requirements, in addition to the critical command and control requirements, because the cost of equipping these mobile platforms with duplicate satellite terminals to operate in a commercial system would be excessive.

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GLOSSARY OF ACRONYMS

AEROSAT . . . . Aeronautical Satellite

AUTODIN . . . . Automatic Digital Network

AFSATCOM . . . . Air Force Satellite Communication System

A.T.& T. . . . . American Telephone and Telegraph Company

AUTOVON . . . . Automatic Voice Network

COMSAT . . . . Communications Satellite Corporation

DCA . . . . Defense Communications Agency

DCEC . . . . Defense Communications Engineering Center

DCS . . . . Defense Communications System

DoD . . . . Department of Defense

DOMSAT . . . . Domestic Satellite

DSCS . . . . Defense Satellite Communications System

ESRO . . . . European Space Research Corporation

FAA . . . . Federal Aviation Agency

FCC . . . . Federal Communications Commission

FLEETSAT or FLTSAT . . . . Fleet Satellite

FTS . . . . Federal Telecommunication System

GAPSAT . . . . Gap Filler Satellite

GSA . . . . General Services Administration

INTELSAT . . . . International Telecommunication Satellite Organization

ITU . . . . International Telecommunications Union

JCS . . . . Joint Chiefs of Staff

MARISAT . . . . Maritime Satellite

MSO . . . . Military Satellite Communications Systems Office

NASA . . . . National Aeronautics and Space Admin.

NCS . . . . National Communications System

O/M . . . . Operation and Maintenance

OMB . . . . Office of Management and Budget

OTP . . . . Office of Telecommunications Policy

R&D . . . . Research and Development

WATS . . . . Wide Area Telecommunication Service

WWMCCS . . . . World Wide Military Command and Control System

APPENDIX A

NORTH AMERICAN DOMESTIC SATELLITE SYSTEM

1. U.S DOMESTIC SYSTEM

Five of the six potential domestic satellite system operators have been authorized by the FCC to proceed with their initial plans. Market forces are likely to place some constraint on the actual number of systems implemented.

a. COMSAT/A.T.& T. COMSAT General, a subsidiary of COMSAT, has under construction a satellite system using Atlas/Centaur-launched satellites produced by Hughes Aircraft using a design approach similar to the INTELSAT IV and IV-A series. Three such satellites in orbit will be made available for use by A.T.& T. and recently General Telephone and Electronics Corporation (GTE). A.T.& T. plans to establish 4 earth stations in the contiguous United States employing a total of 10 large antennas (30 meters). This system projects service within the continental United States, with terminals near New York City, Chicago, San Francisco, and Atlanta. Service is also proposed to Alaska and Puerto Rico.

A.T.& T.'s current plans emphasize the economic integration of high capacity satellites with the large terrestrial broadband network. Another prime objective involves essential research in the bands above 10 GHz. Each satellite will have 24 transponders operating at 6/4 GHz and two research beacons operating at 10 and 28 GHz. Each transponder, when operated between 97-foot antennas, can accomodate 1200 one-way voice channels or the equivalent capacity in television or high speed data.

b. Western Union Telegraph Company. Western Union has successfully operated their satellite system (WESTAR) using satellites of the Delta-launched type developed for the Canadian domestic system. The first launch was April 13, 1974 and operation commenced on July 15, 1974. The satellite's primary coverage is the contiguous 48 states plus coverage of Hawaii and Alaska at reduced power levels. Each of the 2 in-orbit satellites in the system contain 12 transponders operating in the 6/4 GHz bands.

The earth stations are located at the tail ends of the existing Western Union microwave network so as to directly augment the long distance Western Union terrestrial transmission system. In an effort to minimize costs, each earth station will employ a single antenna, and except for the control center, will be unattended. The reliability of the overall system will be enhanced by alternate routing through the terrestrial Western Union microwave system. Western Union will offer a complete line of services through its own earth stations located in New York, Chicago, Atlanta, Dallas, and Los Angeles, or customer-owned facilities. This service includes voice, data (low speed, medium-speed, high-speed), video, and facsimile.

c. American Satellite Corporation. The American Satellite Corporation (ASC), which is owned by Fairchild Industries, had originally planned a 3-phase program, beginning with a lease of transponders in the Canadian domestic satellites, followed by deployment of their own satellites (Eagle I and II) in 1975. However, ASC has introduced major changes in their plans. The first phase, now operational, includes the lease of three transponders in the Western Union System for service to New York, Los Angeles, and Dallas. Service to San Francisco and Chicago will be instituted by leased terrestrial facilities, initially, and upgraded to full satellite service with ASC-owned-and-operated earth staions at a later date. The contract for 6/4 GHz Eagle satellites has been terminated and ASC is now evaluating the feasibility of communications transmission in the 14/12 GHz range. ASC also provides special point-to-point service for DoD.

d. General Telephone and Electronics (G.T.& E.). G.T.& E., through its subsidiary, GTE Satellite Corporation (GSAT), has planned a domestic satellite system to provide a trunking capability between areas which it serves. The FCC had authorized GSAT to construct five earth stations in Hawaii, California, Pennsylvania, Indiana, and Florida, and to lease 10 transponders in a 12 transponder satellite to be owned by National Satellite Services, Inc., a Hughes Aircraft Company subsidiary. Last year, GTE Satellite Corporation entered an agreement with the A.T.& T./COMSAT team to share the costs of their spacecraft and implement a complementary terrestrial network. GTE Satellite Corporation is planning terminals in Florida, California, and Hawaii.

Because of the restrictions imposed by the FCC, G.T.& E. will provide only message toll telephone service for a period of three years. There are two exceptions to this restriction. G.T & E. is authorized to carry private line services over its system between Hawaii and the mainland, and it is also authorized to carry private line services for the United States Government over any part of its system.

e. RCA Global Communications. Domestic satellite communications services were initiated in January of 1974 by RCA Global Communications, Inc., and RCA Alaska Communications, Inc. This service is provided through transponders in the Canadian Satellite system to four United States earth stations, one each located in Pennsylvania and California and two located in Alaska. The second phase in the RCA plan involves three satellites, each containing 24 transponders and a network of earth stations to serve the 50 United States. The satellites are of a new design and will be supplied by the RCA Astro Electronics Division. The first launch is scheduled for late 1975 or early 1976 using the Thor-Delta 3914 launch vehicle, which is an augmented version of the standard Delta. A comparatively large number of earth stations (16 initially) are planned for Alaska due to the state's unique topograpical features and population patterns.

Most of the earth stations will employ 32-foot antennas, although the two control stations will have 98-foot antennas. Procurement of single-channel-per-carrier (SCPC) equipment from General Electric is in progress.

f. CML. In December 1972, the FCC approved the formation of CML, a company jointly owned by COMSAT General Corporation, MCI Communications Corporation, and Lockheed Aircraft Corporation. IBM recently purchased 55% of the CML stock and COMSAT holds 45%. The FCC has ordered still another restructuring that will take several months to resolve.

Although CML has not published firm program plans, nor has it applied for FCC authorization to proceed, the thrust of its efforts appear to be directed at the private line and point-to-point commercial market. This is manifested in two ways, first the planned use of frequencies in the 14/12 GHz bands in contrast to the planned use of the 6/4 GHz bands by other domestic satellite system operators, and second the emphasis on small earth stations and single-channel-per-carrier (SCPC) multiple-access. Use of the higher frequencies eliminates the problem of terrestrial microwave relays interfering with the earth stations, thus allowing location of the earth station antennas within the city and, perhaps, on the roofs of the customer's facilities. Unlike the other system plans, the CML concept envisages literally hundreds of antennas of various sizes tailored to meet the specific communications needs of individual customers.

2. CANADIAN TELESAT SYSTEM.

Canada has established its own satellite system for domestic communications purposes. The first satellite (called ANIK), launched in November 1972, was followed by a second satellite launched in April of 1974. They are stationed at 114°W and 109°W longitude and have antenna beams which illuminate Canada from East Coast to West Coast and from the United States border to the Far North. The spacecraft is of the basic design developed by Hughes Aircraft, designated HS-333, for launch by the Delta launch vehicle. This basic satellite design has also been adopted by Western Union, a United States domestic system applicant. Each satellite has 12 transponders each of which can be used for 480 duplex voice channels or 1 color television channel. The initial system includes several different classes of earth stations, ranging from the large 98-foot antennas for the heavy routes, to 26-foot antennas for the remote television stations. There are approximately 40 Telesat ground stations. The major customers are the Canadian Broadcasting Corporation (TV), and Trans-Canada Telephone System, and the Canadian National and Canadian Pacific Railways. Of particular importance to Canada, of course, is the fact that this system can provide reliable service to its remote northern locations.

APPENDIX B

Military Requirements
Chapter 5, Pages 45-51

and

Concluding Observations and Recommendations
Chapter 8, Pages 105-113

of

Satellite Communications
(Military-Civil Roles and Relationships)

U.S. Congress. House. Committee on Government Operations.
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V. MILITARY REQUIREMENTS

While NASA and other Federal civilian agencies are mandated by law to provide certain support services to the Communications Satellite Corp., no such distinctive role is assigned to the Department of Defense. The Communications Satellite Act of 1962 nowhere mentions the Department by name and calls for no direct Defense assistance. If NASA's launching services for the corporation, for example, require boosters developed under Defense Department sponsorship, then NASA serves as the intermediary.[43]

The Defense role, as represented in the formative days and months of the new legislation, was one not differentiated from other assistance to private endeavors. To the extent that technical information derived from its contract studies and development programs for satellite communications could be placed in the public domain, it would be made available to the corporation and any other interested party, public or private. The Defense Department would even perform appropriate support services to assist and promote the corporation's endeavors because it favored the creation of the new business entity,[44] but mainly the Department was bent on developing its own system.

In the debates preceding passage of the Communications Satellite Act of 1962, the considerable research and development work done by the military as well as NASA provided the core of the argument of those who advocated retention by the Federal Government of the responsibility for exploiting satellite communications potentials to meet commercial as well as Government needs.

Defense officials, for their part, asserted the need for their own system to meet unique military requirements. This was understood and accepted as part of the legislative history of the Communications Satellite Act of 1962 and was reflected in specific wording of the law. True, it was plainly indicated that the U.S. Government would be a large user of communications services to be provided by the corporation; and indeed, the act empowers the corporation "to contract with authorized users, including the U.S. Government, for the services of the communications satellite system." The President is mandated, furthermore, to "take all necessary steps to insure the availability and appropriate utilization of the communications satellite system for general governmental purposes except where a separate communications satellite system is required to meet unique governmental needs, or is otherwise required in the national interest."

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[43] An interesting question is whether the corporation could bypass NASA and procure launching services directly from the Defense Department. The incentive to the corporation might be more favorable terms of reimbursement; for example, the Defense Department might not charge for aborted launches, whereas NASA presently takes the position that the cost of all launches for the corporation will be reimbursed. If the corporation were to procure launching services on a fixed-price basis, presumably the Government would absorb the cost of unsuccessful launches.

[44] See "Communications Satellite Act of 1962," hearings before the Committee on Foreign Relations, U.S. Senate, 87th Cong., 2d sess., on H.R. 11040, August 1962, pp. 290-291. Secretary McNamara submitted a statement to the Senate committee on the Defense Department's proposed cooperation with industry in satellite-based telecommunications.

SEPARATE SYSTEM CONCEPTS

The qualifying language here is important. Two issues are to be distinguished: The Federal Government reserved "unique governmental needs" for separate system operation in accord with testimony by Secretary of Defense McNamara and other defense authorities that the military needed its own system; [45] but beyond a separate system for unique governmental needs, the act expressly reserves the right and opportunity for the establishment of separate satellite communications systems, under public or private management, if the Communications Satellite Corp. should be wanting in performance.

The legislative history of the provision for separate and alternative systems was established by the introduction of the Church-Lausche amendment during the consideration of the communications satellite bill in mid-1962. As approved by Senate committee action, the bill included in its "Declaration of Policy and Purpose":

> It is not the intent of Congress by this act to preclude the use of the communications satellite system for domestic communication services where consistent with the provisions of this act nor to preclude the creation of additional communications satellite systems, if required to meet unique governmental needs or if otherwise required in the national interest.

In the substantive section directing the President to use the commercial system for general governmental purposes except where a separate system is needed for unique governmental needs, the reported bill did not contain the phrase "or if otherwise required in the national interest." The Church-Lausche amendment was introduced to conform the substantive provision with the declaration of policy and purpose. Senator Frank Church, in explaining the rationale of the amendment, observed that the phrase in the declaration of policy and purpose "or if otherwise required in the national interest" was wisely written, since it could not now be foretold how well the new corporate instrumentality would serve the needs of the public. If the rates charged were too high or the service too limited, or maximum benefits of the new technology were not forthcoming, then the Government might want to establish alternative systems. To give effect to this safeguard in the bill, Senator Lausche pointed out, the language in the substantive part should conform. His amendment, therefore, wrote into what is now section 201(6) the phrase "or is otherwise required in the national interest." [46]

This amendment was accepted by the Senate. In the floor discussion, Senator Kefauver said it was his understanding that without the language of the amendment, Government operation of a "unique" system would be too restrictive in that it would be limited to coded or secret military messages. The amendment would allow broader Government use of separate systems, as for example, U.S. Information Agency broadcasts to other countries. Senator Church agreed with

[45] See Secretary McNamara's testimony in hearings cited in footnote 41, p. 289 ff.; also letter by Cyrus R. Vance, General Counsel, Defense Department to Senator Magnuson, chairman of the Senate Committee on Commerce, printed in "Communications Satellite Legislation," hearings before the Committee on Commerce, U.S. Senate, 87th Cong., 2d sess., on S. 2814, April 1962, pp. 400–402.

[46] "Communications Satellite Act of 1962," report to accompany H.R. 11040, Committee on Foreign Relations, U.S. Senate, S. Rept. 1873, 87th Cong., 2d sess., p. 14.

this interpretation of the amendment. Although Senator Robert Kerr, as chairman of the Senate Committee on Aeronautical and Space Sciences, expressed the opinion that there was no inhibition in the bill against the Government establishing communications satellite systems, he agreed that the amendment would make this clear beyond any question.[47]

PROCUREMENT OF COMMUNICATIONS SERVICES

The case for a separate military system, although taken for granted in the years preceding the creation of the new corporate entity, was sharpened and amplified in the context of policy laid down in the 1962 law. In this context it was made clear that while a separate military system is needed, it would be a unique or special-purpose system, so far as the military were concerned. If and when a commercial system were developed, the Department of Defense intended to purchase communications services from that system, or from carriers contracting with it, for routine or peacetime traffic. Undoubtedly the Department of Defense would be one of the corporation's largest customers if it adhered to the customary practice of utilizing commercial carriers for routine communications. Most military point-to-point communications within the United States are carried over commercial facilities in accord with prevailing Government policy.[48] Routine military communications with oversea bases, and to some extent locally in Europe and Japan, also make use of common carriers where services are available and efficient. Commercial communications companies provide by contract special services, leased lines, and secure channels to meet various military requirements. Leasing costs for commercial service in the Defense Communications System, which covers the long-haul point-to-point telecommunications requirements of the Department of Defense,[49] are estimated at $211 million a year.

This is not to say that the Department relies exclusively or even primarily on common carrier services. More than half (52 percent) of the 96,600 channels in use are Government-owned. The Defense Communications System includes an enormous Government-owned plant, which a Government telecommunications expert estimated to exceed $2 billion in initial investment by the Army, Navy, and Air Force, with annual operating costs of about $750 million. (The Defense Department annual cost figure is $528 million, excluding military personnel costs.) These annual costs for defense communications, moreover, have been increasing at the rate of 10 to 15 percent a year, reflecting the steady growth of military traffic.[50]

While a commercial satellite system in operation could carry a large amount of routine military traffic, it would not necessarily meet special requirements for resistance to jamming, transmission of encrypted data, protection against physical destruction, and other de-

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[47] Congressional Record, Aug. 13, 1962 (daily edition), pp. 15334–15336.

[48] Bureau of the Budget Bulletin No. 60–2, dated Sept. 21, 1959, directs Government agencies not to engage in industrial or commercial type activities where these are satisfactorily available from industry sources.

[49] The Defense Communications System excludes tactical communications which are self-contained within tactical organizations; self-contained information gathering and/or transmitting processing facilities which are normally local in operation and use; land and airborne terminal facilities of broadcast ship-to-ship, ship-to-shore, and ground-air-ground systems; and intrasite communications for command countdown, range safety and weapons destruct at missile and air defense launch and firing complexes.

[50] 1964 hearings, pt. 1, pp. 295, 297.

sired characteristics. Conversely, the military system is not intended to accommodate the services readily suited to a commercial system. Lt. Gen. Alfred D. Starbird, Director of the Defense Communications Agency, made it clear in earlier testimony to the subcommittee that the military satellite communications system would not be designed to handle bulk traffic.[51]

This is a matter of policy. There are no technical reasons why a military system could not be designed to accommodate bulk traffic. This depends in the main on designing and installing large ground station equipment, which does not figure in Defense Department plans. As far as economy is concerned, it is difficult to state with confidence at this time whether the Government could purchase satellite communications services from carriers more cheaply than by providing them itself.[52] If economies through direct Government operation could be demonstrated, the Church-Lausche amendment was expressly intended to leave the door open for Government operation to effect these savings. This is shown in the following colloquy:[53]

> Mr. GORE. In other words, if the Government should find that by the establishment of a satellite communications system of its own, to be used for its own purposes, it can accomplish its objectives and save the taxpayers enormous sums of money, the national interest would require such use. Therefore the amendment would prevent the section referred to from requiring the Government to use the corporation's system, if vast savings to the taxpayers could be accomplished through the use of the Government's own system.
>
> Mr. CHURCH. The Senator is correct * * *

The military system under design when the Communications Satellite Corp. was created sought to satisfy specialized military requirements, not to promote economies by Government handling of bulk traffic. Because military needs for such services were steadily increasing, the Department of Defense was quite content to have an expanded commercial system through the use of satellites as well as conventional means.

DISTINCTIVE MILITARY REQUIREMENTS

For several years through its Advent and other projects, the Defense Department had been studying the potentials and conducting experiments looking toward future operational systems of satellite communications. Prior to 1961, there had been stated military requirements to ARPA, but no JCS-approved ones. In late 1961, the Joint Chiefs of Staff validated a requirement for a military communications satellite capability to be integrated with the Defense Communications System. The approved plans stemmed from a document known as MESU (minimum essential survivable communications). Although

[51] "Military Communications Satellite Program," hearings before the Military Operations Subcommittee of the Committee on Government Operations, House of Representatives, 88th Cong., 1st sess., April 1963, p. 36.

[52] Compare Secretary McNamara's statement before a Senate committee in August 1962: "It would be my purpose to design our system to contain sufficient capacity only to carry the unique military traffic and to place all other military traffic on the commercial system, and having designed it so. I am confident that the lowest cost form of operation would be to follow that principle and place all nonunique traffic on the commercial system." Hearings cited in footnote 41, p. 303.

[53] Congressional Record, Aug. 13, 1962 (daily edition), p. 15336.

criticized for its lack of precision, this document was the key to prescribing a workable military system of satellite communications. For the first time, requirements were stated that could be satisfied without inordinately high power within the satellite or complicated stabilization and command control schemes.

The time scale was initial capability by April 1963 and full system operation by August 1964. This requirement took on added urgency, since the "Year of the Quiet Sun" was predicted for 1964, introducing a period of reduced solar activity which could disrupt long-distance radio transmissions.[54] Microwave satellite relays would not be affected by these phenomena.

For an operational system the military have posed these distinctive requirements:

(1) *Positive operational control.*—The system must be under military command and control at all times without dependence on foreign companies or governments. A commercial system requires negotiations, agreements, and cooperative working arrangements with many nations and their carriers. Although military base rights would have to be negotiated with sovereign governments to permit installations when and where needed for operation of a U.S. military system, command and control would not be affected.

(2) *Mobility and remote area access.*—Military communications cannot be limited to fixed stations and points of high-density traffic. A commercial system can employ large, elaborate ground stations to handle the traffic burden of populous areas, but a military system must be able to penetrate remote and sparsely populated areas as emergencies dictate. Relatively simple, transportable ground stations are required to quickly establish communications among many terminal locations and to move out on short notice. Also, communications must be maintained with flying aircraft and ships at sea, and communications satellites hold forth the promise of capabilities in this direction.

(3) *Protection against physical attack.*—Whereas a commercial system is designed for normal peacetime operations, a military system demands special protective measures both for the ground stations and the satellite repeaters. Hardening, dispersal, and mobility are protective factors for ground stations; the space repeater system should be designed to operate even if some of the repeaters are destroyed by hostile action.

(4) *Protection against electronic countermeasures.*—Even in peacetime, a military system must be able to overcome jamming action. This requires the ability to switch from one frequency to another and entails a much larger ratio of radiofrequency bandwidth to information bandwidth than would be normally used in a commercial system. Different modulation techniques and higher transmitter powers also may be required to protect against jamming.

(5) *Low capacity and secret message transmission.*—Unlike commercial systems, which are designed for capacities of hundreds of standard voice channels or one or two TV channels operating primarily

[54] An international program of scientific research in 1964–65, with active participation by the United States, is planned for study of the quiet sun. See National Academy of Sciences-National Research Council, "Proposed U.S. Program for the International Years of the Quiet Sun, 1964–65," February 1963.

on a trunk basis, a military system requires relatively low capacity for a few voice, teletype, or digital data channels. However, redundant or multiple channels are important in case of countermeasures. Also cryptographic security requires bandwidth and transmission features not normally required of commercial systems.

(6) *Separate frequencies for military use.*—The choice of frequencies for use in satellite communications poses difficult problems. The military now have bands of frequencies assigned for their own use in the United States. They also intend to take full advantage of the special bands set aside in the Geneva radio revisions discussed in section VII for satellite communication services. International agreement on the use of civilian bands now shared among diverse types of users for military satellite communications purposes might be difficult or impossible under a commercial satellite system encompassing military requirements.

The concept of a military communications satellite system, as formulated in general terms by the Defense Communications Agency and approved by the Joint Chiefs of Staff, was to seek a minimum essential capability in the earliest possible time within cost limitations. In the short range, the satellite communications capability was viewed as a "redundancy" or additional resource to back up or supplement existing long-haul military communications, which are accomplished by various means and combinations, including high-frequency circuits, ionospheric and tropospheric scatter circuits, cables, and microwave systems. As time went on and technology advanced, it was expected that the satellite communications system would grow in reliability, coverage, and versatility, and would acquire the full range of military characteristics advanced in justification for a separate military system.

The rationale for a separate or unique military system was developed by the Defense Department both preceding and following the enactment of the Communications Satellite Act of 1962, since there were recurrent questions by Members of Congress as to the need for separate systems which might be duplicative and, in any case, would be very costly.[55]

In making their case the military authorities did not deny that commercial systems could be designed to accommodate, in lesser or greater degree, their special requirements, providing the extra costs, the technical complications, and the inconveniences were accepted. Considering, however, the widely divergent needs of a commercial system committed to economic operations in a friendly peacetime environment and a military system which must be prepared for a whole range of contingencies in both friendly and hostile environments, there seemed to be no likelihood that the two would merge. Indeed, a RAND study concluded that a separate military system not only would best meet our security needs but actually would help to promote the success of the commercial system and our foreign policy objectives. Other coun-

[55] See testimony by John H. Rubel, "Project Advent—Military Communications Satellite Program," hearings before the Subcommittee on Space Sciences, Committee on Sciences and Astronautics, House of Representatives, 87th Cong., 2d sess., August 1962, p. 84 ff.; Gen. Bernard A. Schriever, commander, Air Force Systems Command, "Systems Development and Management," hearings before the Military Operations Subcommittee of the Committee on Government Operations, House of Representatives, 87th Cong., 2d sess., August 1962, pp. 910–911; Lt. Gen. Alfred D. Starbird, Director, DCA, and Rear Adm. Jack S. Dorsey, Deputy Director, DCA, "Military Communications Satellite Program," hearings before the Military Operations Subcommittee of the Committee on Government Operations, House of Representatives, 88th Cong., 1st sess., April 1963.

tries would be more inclined to participate in a commercial system not intermixed with military operations.[56]

SECRETARY M'NAMARA'S LETTER

Notwithstanding the well-developed rationale, the settled policy, and the continuous military planning and experimenting in satellite communications—which dated back to 1958—Secretary McNamara came up with a question which reopened the whole issue: Why not get the commercial company to provide the unique as well as the bulk traffic requirements of the military? The Secretary put the proposal in a letter to Dr. Charyk dated October 11, 1963.[57]

The time was rather late. The Advent program had been reoriented in May 1962, and program definitions for the MACS system had been completed. The Secretary was faced with a decision whether to permit contracts to be awarded to suppliers for system hardware. As he estimated it then, "an interim global operational capability is expected to be about $165 million," including $60 million for the development and construction of the satellites. This assumed 10 launches. The cost of maintaining the space segment of the system, after this initial capability, was estimated at $111 million for a 5-year period.

If the corporation could "provide acceptable service at substantially lesser cost," the Secretary would refrain from making an award. Therefore, he wanted to be advised of the "corporation's ability to obtain the required funding, management talent, and technical facilities necessary to establish a satellite system in the early future." He also wanted to know whether these services could be supplied to the Defense Department with a stated degree of confidence. The corporation would have to show how it could meet the military need for "freedom from jamming, control of the terminals, and availability of a minimum essential number of channels to remote areas and upon a short notice." These would have to be weighed against the corporation's international commitments and arrangements, involving such things as "determination of priorities, assignment and reassignment of satellites, choices of modulation, and frequency allocations." Cost of services for a 5-year period would have to be stated.

The Secretary asked for an answer to the letter by October 26 "at the latest." He assured Dr. Charyk that in any event the Defense Department and the corporation could maintain a "close relationship," and that the corporation could supply a substantial portion of the Department's international communications where common carrier facilities were appropriate.

Although the Secretary's letter of inquiry was dated October 11, he referred to prior discussions "aimed at determining the extent to which the Communications Satellite Corp. could in the future meet essential military requirements of the Department of Defense." When the basis was laid for these discussions is not precisely known. Secretary McNamara did say at a recent press conference regarding joint military-civil operations: "We have worked toward that objective for 2 years." Taken literally, this remark suggests that he entertained a joint or shared concept from the very beginning of the corporation's existence.

[56] M. L. Schwartz and J. M. Goldsen, "Foreign Participation in Communications Satellite Systems: Implications of the Communications Satellite Act of 1962," RAND Corp. Memorandum RM-3484-RC, February 1963, p. 22.
[57] 1964 hearings, pt. 1, pp. 31–32.

VIII. CONCLUDING OBSERVATIONS AND RECOMMENDATIONS

In this report we have reviewed 6 years of Government effort in promoting, planning, designing, and developing communications satellites. We have tried to identify the basic policy issues in a complex and complicated field of Government activity and to recount what has been done to resolve them.

In broad compass there are three main sectors of research and development in satellite communications, military, civil, and commercial; and three corresponding action agencies, the Department of Defense, the National Aeronautics and Space Administration, and the Communications Satellite Corp. Each has a statutory mission and important responsibilities bearing upon the security, welfare, and prestige of the United States. Each has a vital interest in the work of the others, and in many ways, subtle or obvious, their efforts are competitive as well as mutually supporting.

For these reasons, understandably, the Congress has been concerned about high program costs, overlap and duplication, extent of interagency coordination, the "subsidy" issue in Government assistance to the commercial sector, and the justification for separate systems. Underlying these concerns is a deeper issue: What must be done to establish workable satellite communications systems which will enhance the security of the United States and best promote its national objectives?

Our report unravels some of these intricate issues and agency interrelationships and, hopefully, will contribute to a better understanding of the responsibilities, functions, and aims of the organizations involved. We also make recommendations in this section which we ask the responsible parties to consider carefully and in the same good faith and constructive spirit in which our committee has approached this inordinately difficult subject matter.

The public hearings held by the Military Operations Subcommittee over a period of weeks in the present session of Congress, at which more than 50 witnesses appeared, already have helped to clear up one crucial matter and to bring about a decision which we consider of paramount importance to the national security. The Department of Defense, after long and fruitless negotiations with the Communications Satellite Corp., now has decided to proceed with the development of a separate communications satellite system to fulfill urgent Government requirements. The President of the United States affirmed this fact in a statement to the press on August 8.

The wisdom of Secretary McNamara's decision—unfortunately long delayed—is evidenced by the need for improved communications to remote areas in a world of recurring crises and constant danger of war. Satellites offer a means to establish these vital communications links. The Defense Department, overly sensitive to budgetary constraints and prior mistakes in satellite development, has been too timid and uncertain about exploiting proved technologies for the establishment of a workable system of satellite communications. Valuable time has been lost. Had the Department moved ahead according to plans and policies laid down 2 years ago and approved by the Joint Chiefs of Staff, a system could have been operating now.

The search for economies is essential in military spending, which accounts for half of the yearly national budget. Indeed this committee has worked long and hard and has made many constructive recommendations in support of objectives strongly espoused by Secretary McNamara—more efficient procurement, integrated supply management, interservice cooperation, and other measures for improved performance. We do not believe, however, that economizing efforts should throttle programs essential to the national security. Satellite communications is one of the most vital and relatively less costly of our major defense programs.

Perspective is needed. To develop, produce, and deploy a major weapon or space system often is a multibillion-dollar affair. Less promising development programs, after expenditures of hundreds of millions, have been terminated from time to time. When Project Advent, for synchronous satellite communications, after the expenditure of about $170 million and 2 years of effort, threatened to become a $350 million project, Secretary McNamara ordered it canceled and approved a less ambitious, less costly program for a medium-altitude system. Two more years passed, and still we have no working system. The technology is known, the components are proven, a reliable booster is available, the specifications are firm, the preliminary design work is done. The effort was halted when Secretary McNamara decided to explore whether the unique military requirements could be met by the Communications Satellite Corp. This exploration took the better part of a year.

The Secretary apparently was moved by the conviction that the corporation could provide satellite communications services to meet unique military needs more economically than the Defense Department itself, even though the corporation would draw upon the same contractor sources for designing and building the satellites and depend upon the Government to place them in orbit. An immediate advantage to the Defense Department of such a transfer of responsibilities was that it could delete this item from the budget for the next few years. The corporation, using funds from stockholders and foreign participants in the global system, would study U.S. military as well as global commercial requirements, and build one system to satisfy both. Later on, when the system was working and the services available, the Department of Defense would lease satellite communications channels at FCC-approved tariff rates and pay for shared use of the single system through yearly budget funds for procurement of communications services. If handled through revolving management funds, the specific item of payment for satellite communications services would never appear as a separate item in the military budgets.

The Communications Satellite Corp., for its part, would have advance commitments and a "built-in" customer good for at least $35 million a year in billings—a most advantageous arrangement and a bargaining factor in dealing with other domestic and foreign carriers.

Why and how this plan failed we have recounted in sections V and VII above and need not repeat here. It will suffice to say that the committee believes the effort for a military tie-in with the commercial system was ill advised, poorly timed, and badly coordinated.

While we commend the decision of the Defense Department now to go about its proper business of building a communications satellite system for military needs and leaving the corporation to build the global commercial system as part of an international consortium, we still detect uncertainty and overeconomizing in the Defense Department approach. The Secretary has released very limited funds for a risky and insufficient effort which is neither the medium-altitude system he endorsed 2 years ago and represented as a most important and urgent defense program, nor the synchronous stationary system which remained under study as a future alternative.

The Secretary's announced plan is to launch an interim system of 24 satellites in near-synchronous orbit using three booster shots in the Titan III–C development program, scheduled for 1966. In this way, the Department hopes to get a "free ride" and save launching costs for satellite communications, since the $800 million Titan III development already is funded under other programs. Certainly every effort should be made to save money by piggyback rides and single launches of composite experiments, but why introduce a new large element of uncertainty in the long-delayed satellite communications program?

The Atlas-Agena's originally earmarked for the program are reliable workhorse launch vehicles and available now. The Titan III–C is yet to be proved, and while there are high hopes for its success, booster development programs are marked by many vicissitudes. The committee sees no warrant in risking further possible delays. The lessons of the Advent project ought to be kept in mind. It came to grief in large part because it was hooked to the Centaur development, an unproved upper-stage booster.

The better part of wisdom, in the committee's view, is to continue with the plan laid down in 1962 for a medium-altitude random-orbit system using Atlas-Agena launch vehicles. This plan has been carefully studied. More than $5 million already has been spent in program definition studies of the spacecraft, with another $22 million for boosters and design modifications to accommodate the satellites. The 1962 plan also contemplated a future development of a synchronous stationary satellite system. The Titan III development vehicle could well be used to launch truly synchronous satellites in orbit to test out this concept. Satellites account for a relatively small part of total costs, and higher risks could well be taken with a "free ride" on the Titan development boosters for a synchronous system, since the basic dependence for the initial system capability will be on the medium-altitude system, the more conservative, less risky approach, using Atlas-Agena's.

If the Defense Department does not elect to use the Titan III development boosters for testing out the synchronous stationary satellite system, there is another alternative which merits careful consideration. That is to procure communications satellites which can be used on both the Atlas-Agena and the Titan III development vehicles, and to minimize risk and achieve some economies simultaneously by launching two satellite systems for complementary coverage. Satellites on the Atlas-Agena could be boosted into medium-altitude polar orbits and on the Titan III–C into equatorial near-synchronous orbits. A combined program would provide broad complementary communications coverage if both launch systems go well, and low-risk substantial coverage with the Atlas-Agena launches alone if one or more of the Titan III development launches fail. With relatively little extra cost, the satellites and dispensing mechanisms can be designed for use on both boosters.

In choosing the Titan III–C interim approach, the Defense Department is not only gambling with additional time delays but is leaving to an indefinite future the important considerations of system growth to accommodate technological advances and diversified tactical and other military needs. The medium-altitude system, as earlier planned, was designed for systematic improvement in coverage, performance, and maintenance. At an appropriate stage, for example, gravity gradient techniques were to have been introduced, promising manifold increases in the efficiency of satellite performance and permitting small mobile surface stations to be used for tactical purposes on land and sea. With the Titan III–C launches into near-synchronous orbit, gravity gradient techniques may prove to be much less effective because of the long distance from the earth. Indeed, the Defense Department proposes to skip the gravity gradient experiments in the Titan III "interim" effort and pick them up some years later in follow-on systems.

According to the Defense Department, follow-on systems for satellite communications are contemplated when the Titan III booster is proved out and put in production for space missions. Because of its enormous thrust power, a single Titan III booster could launch 15 or 20 lightweight satellites, so that one successful launch would be sufficient to establish a whole system. This time is in the future, after a long development period has elapsed and vehicle missions have been determined. Capability is needed now and should be achieved as quickly as possible.

In sum, the committee believes that the Department's plan for short-range economies depending on a high-risk program may prove very costly in the end. The more economical and efficient method is to build a system that has a high assurance of success and planned growth potential. A well-planned, high-confidence system can enable the Government to save money in the years ahead by incorporating technical improvements and weeding out less efficient conventional means of long-distance communications.

We see no indication that the budget restraints imposed by the Secretary of Defense on communications satellite system building reflect the intent of the Congress. We are confident that the Congress recognizes the vital importance of improved means of communications for military and other governmental purposes. The committees of authorization and appropriations, aware that the Department was negotiating for many months with the corporation, have deleted some budget request items only because of the uncertainty and indecision as to the outcome of the negotiations. A clear statement of national security needs presented to the Congress would, in our judgment, be met with a positive response.

Recommendation No. 1

The committee recommends that the Department of Defense proceed without further delay to establish a medium-altitude, random-orbit *satellite communications system for operational use. To achieve this objective in the most expeditious way, planning and design work already accomplished to date should be carried forward and Atlas-Agena launch vehicles employed.*

Recommendation No. 2

To achieve additional experimental and practical benefits from the Titan III development launches, designated Titan development vehicles should be used to launch communications satellites either in synchronous stationary orbit or in near-synchronous random orbit to supplement the capability of the medium-altitude system recommended above.

Recommendation No. 3

Since delayed decisions in the Defense Department have caused satellites rather than boosters to be the pacing item in establishing satellite communications systems, and since the satellites are relatively inexpensive, sufficient satellites should be procured to permit timely system establishment and maintenance.

Recommendation No. 4

The Department of Defense should give emphasis and attention to tactical military needs and to this end should aggressively support experiments in gravity gradient and other techniques to improve the efficiency of satellite performance and thereby permit the use of small mobile land, shipboard, and aircraft stations. As immediate steps, the Department of Defense should (a) immediately request the National Aeronautics and Space Administration to perform the early gravity gradient experiment for which funds were authorized in the fiscal year 1965 budget; and (b) design and procure very small mobile land and shipboard terminal stations for test purposes.

The committee understands the need for tight management and control of costly research and development programs to prevent duplicating, unnecessary, or unpromising expenditures. We appreciate the enormity and the demanding nature of this responsibility which Secretary McNamara has taken upon his shoulders. At the same time, the committee must observe that highly centralized control of research and development could have unintended and untoward consequences which must be carefully watched and guarded against.

Our review of the communications satellite experience suggests to us that in some ways there has been overmanagement and underperformance. Too tight control and direction could have these undesirable results: dry up initiative in the action agencies, disrupt planning, diffuse responsibility, delay decisions, and keep talents in the field idle. With the best of intentions and the greatest of skills, the top-level men in charge do not have enough hours in the day to handle in depth or detail the immensely varied and complex programs which are competing for their attention. Too much time with one program means only superficial review of another. And the process of direction from the top, if exercised in program details, feeds upon itself. It immerses the top managers in programs which they cannot thoroughly know and causes them to assume the wrong responsibilities—or else to minimize risk to themselves by heavy use of the veto or approving only the "minimum" program.

Decisionmakers at the apex of government are presumed to have a superior command of talent or at least of sources of information, and to be accordingly wiser in their judgments. If they are too busy to be well informed, there is the danger that they will simply use their authority without knowledge, in which case the sources of information are tapped post hoc to make the decision look well considered if not wise. The decision to negotiate with the Communications Satellite Corp. for many months, and to persist in these negotiations despite the accumulating evidence that the Government's best interests would not be served by a joint military-commercial system, appears to be one of those awkward situations.

Although many agencies and resources were at the Defense Secretary's command, his agents did not draw upon them consistently for expert judgment and advice nor keep them posted on developments in the protracted negotiations with the Communications Satellite Corp. The erratic, constantly changing course of these negotiations, when technical positions were advanced and modified or reversed from week to week, had an air of improvisation and hasty, weekend staffing.

The Defense Communications Agency, with its triservice specialists in communications and its technical support contractor (ITT) in satellite communications, was kept on the sidelines and called upon only for very limited tasks in connection with the shared system discussions. Service agencies in the field waited for defense-level decisions, while contractors were kept at low, inefficient levels of performance. Everything depended on the word from the directorate of Defense Research and Engineering.

The committee believes that the D.D.R. & E. has talented, dedicated, and hardworking men. Their proper role is policy and general supervision. It appears that they have gotten too deeply involved in the day-to-day details of the communications satellite program. The program suffers from too many layers of supervision, the lack of clear-cut responsibility in a single agency, and sluggish channels of departmental communication. Because earlier management arrangements were not considered wholly satisfactory, the DCA was assigned the integrating management task at the Defense level. It should be allowed to do its job rather than serve as mere technical staff to the D.D.R. & E.

Recommendation No. 5

The Secretary of Defense should reexamine the role of the directorate of Research and Engineering to insure that it does not get involved in detailed program direction. The Defense Communications Agency should be made clearly responsible for technical management of the communications satellite program and be enabled to exercise its full responsibility and competence in cooperation with appropriate elements of the military services.

The negotiations between the Defense Department and the Communications Satellite Corp. not only failed to bring to bear in an organized way the immense technical resources of the Department but were pursued without considering needs, interests, and responsibilities of other major agencies of the Government. These agencies have important communications requirements and several of them are included in the National Communications System which President Kennedy established after the Cuban crisis. The Secretary of Defense filled a leadership gap and essayed to make Government policy in the satellite communications sector since there was no central agency or office for discussion and resolution of complex policy issues.

Many persons in and out of Government, with the best of intentions, tried to work their individual wills on the resolution of major public issues in the field of communications during the period of negotiations between the Defense Department and the Communications Satellite Corp. There was no firm policy direction which would take into full account the needs and responsibilities of the agencies concerned and develop a unified Government position. The chief result was confusion and conflict. The episode demonstrated faulty planning, incomplete staffing, and uncoordinated effort in an aggravated form.

The Office of the Director of Telecommunications Management, who also serves as Special Assistant to the President for Telecommunications, was vacant during the largest part of the time of the negotiations. There were competent persons in the National Aeronautics and Space Council, the Office of Science and Technology, the Office of Emergency Planning, and elsewhere who served informally as an ad hoc coordinating committee, but it was not until a Director of Telecommunications Management was appointed, after our hearings started, that issues began to fall into place.

By law and policy the President is charged with important duties and responsibilities in communications which he must fulfill with the help of competent advisers and specialists in the Executive Office. The Director of Telecommunications Management, who serves as the President's adviser, also is concerned with mobilization functions as an Assistant Director in the Office of Emergency Planning. One line of authority runs directly to the President and the other to the OEP Director.

The committee believes that the Office of Director of Telecommunications Management should be elevated in status and strengthened with a staff of specialists in technical, management, and policy aspects of communications. An appropriate means of accomplishing this objective is the submission to the Congress of a Presidential reorganization plan, particularly since the President's Executive Office is involved.

Recommendation No. 6

At the earliest practicable date, the President should submit to the Congress a reorganization plan to reconstitute the functions and responsibilities of the Director of Telecommunications Management in a separate office in the Executive Office of the President, and take steps to insure that the office is adequately staffed.

By Presidential directive, the Director of Telecommunications Management now is assigned responsibility for policy direction in the integration and improvement of the national communications system. Among the important tasks of that Office, if it is given the requisite status and staffing, will be to coordinate Government research activities in telecommunications and direct a thoroughgoing study of our Government communications resources and arrangements, giving attention to needs, existing facilities, and development programs. The Government stake in communications is an extremely large one, transcending agency lines and jurisdictions. Nothing less than a governmentwide study effort will bring the problems into clear focus. In this study, the first order of business should be an outline of requirements. Then a review of existing facilities and components should be made. This is particularly necessary in view of Government and commercial competition for frequency uses and the congestion in the high frequency portion of the radiospectrum. Demands placed on high frequencies will mean serious trouble to the United States during the 1965 International Telecommunications Union Conference unless adequate plans are made in advance.

Many of the communications facilities are outdated and inadequate to do the job. Satellite communications systems undoubtedly can replace many of these facilities and, at the same time as improvement and reliability are achieved, substantial savings in upkeep and plant can be gained. Government-owned assets probably exceed $2½ billion in original cost and about $1 billion a year is required to maintain them (including personnel costs). The Defense Department accounts for the bulk of the system assets and costs. Advancing technologies and consequent improvements in long-haul carrier communications suggest that the trend toward Government use of common carrier services will be continued. The proposed study of communications should also consider lines of future policy in procurement of carrier services and weeding out of high-cost, inefficient Government facilities on a carefully selected basis.

Recommendation No. 7

The Office of the Director of Telecommunications Management, when reorganized and properly staffed, should undertake a study of the National Communications System and the long-range requirements and policies of the United States in the telecommunications field.

The Communications Satellite Corp. will play an important part in supplying required Government services. Government policy will have to take careful account of the fact that the corporation is the chosen instrument for commercial satellite communications on a global basis, while at the same time submarine cables will provide other efficient means of long-distance communications. These alternative sources will have to be put in proper balance so far as Government requirements are concerned.

Research and development programs of the Defense Department and the National Aeronautics and Space Administration will be useful to the corporation. Services of a direct subsidy nature are not contemplated by the law and are to be avoided. Otherwise, in accord with existing law, we believe that every proper effort should be made by Government to assist its chosen instrument in a successful venture. Nothing less than the prestige of the United States is at stake.

While the corporation will benefit from Government-sponsored research and from selling communications services to the Government, it will have, in turn, important responsibilities to act for the United

States in global system arrangements and to continuously safeguard the interests of the U.S. Government. The corporation, though privately owned, is clothed with Government-type responsibilities and charged with a statutory mandate to work toward objectives important to our foreign policy. We urge the corporation authorities to keep ever in mind a high sense of national purpose and their responsibilities to the Government which created their organization.

The Department of Defense and the National Aeronautics and Space Administration together have programed about $150 million for communications satellite research during the past 5 years. Both agencies have sponsored flight programs as well as analytical studies, laboratory research, and component development, although the only Government-owned satellites presently in orbit and useful for communications experiments are NASA's. In projecting its research and development program for the years ahead, NASA has formulated and received authorization for composite experiments in satellites, including communications. These experiments will be of great importance to both military and commercial systems.

Beyond the experimental work, the communications capacity of the advanced technological satellites will be substantial and will operate on frequencies now assigned for commercial service. Although this capacity will not be available for several years, at which time both the Defense Department and the Communications Satellite Corp. may have some system capabilities, evidently NASA is creating a substantial communications resource as a byproduct of its research and development work. Although it is not clear at this time in what manner this resource can be utilized, it would seem that consideration should be given by appropriate Government users to obtaining some operational use from the considerable expenditure in the advanced technological satellite program.

The committee is unable to observe any clear lines of division of work between the DOD and NASA. There are mechanisms for cooperation, and the military are responsible for the ground stations of NASA's Syncom program. It may be possible to effect a clearer definition of appropriate divisions of effort, but the committee believes that it is important to have a unified program of both agencies for a broad, active research and development program in satellite communications which will contribute toward national objectives. There are many technical avenues to be explored and techniques to be exploited.

Recommendation 8

Instead of the inadequate cooperation that has characterized the NASA/DOD efforts to date in communications satellite research and development programs, we recommend that military and civil agency programs be defined and planned in complementary fashion. There are sufficient coordinating instruments to effect better integration of these activities.

APPENDIX C

MILITARY SYSTEMS

The United States Department of Defense has been active in satellite communications programs for over a decade. These early efforts resulted in the first operational defense system known as the Interim Defense Communications Satellite Program (IDCSP) and now renamed the Defense Satellite Communications System (DSCS) Phase I. This system consisted of 26 simple spin-stablized satellites launched, between June, 1966 and June, 1968, into quasi-synchronous equatorial orbits. The orbits were chosen to produce a satellite drift rate over the equator of approximately 30° per day. These satellites operate in the 7/8 GHz bands. Of the 26 satellites placed into orbit, 5 are still performing satisfactorily. Some 36 R&D earth terminals were developed for this program, which has demonstrated the feasibility of military satellite communications and has been supporting operational traffic for several years.

The follow-on DSCS Phase II satellites, developed by TRW, also utilize spin-stabilized satellites, but they are station-kept in geostationary orbits. The DSCS Phase II satellite is much larger, with greatly improved capability over the Phase I satellite, having, in addition to the earth coverage channels, narrow beam (2.5°) antennas to more readily accommodate communications with small terminals now under development. The second two satellites were launched in December, 1973. They underwent evaluation testing during January and February of 1974 and were placed into operation in March of 1974.

The United Kingdom entered into a cooperative effort with the United States during Phase I of the DSCS. After extensive testing, the United Kingdom established an operational capability designated SKYNET. The system included large fixed earth stations and shipborne and land-mobile terminals. In 1966 a Memorandum of Understanding was signed by the United Kingdom and the United States whereby the United States built and launched two SKYNET I satellites. The SKYNET II program was initiated in early 1971 with satellite construction performed by G.E./Marconi in Portsmouth, England. The first launch of SKYNET II, which occurred in January, 1974, resulted in loss of the spacecraft due to a malfunction of the booster. The second SKYNET II satellite was launched successfully in November, 1974, and is currently operational.

The NATO satellite communications program has also consisted of several phases. Phase I was conducted between 1967 and 1970 as a test and evaluation program. These tests were successful and Phase II was implemented in March, 1970 to provide an operational capability during the 1971-1974 time frame. With assistance from the United States, two satellites were launched successfully into synchronous orbit in March, 1970 and February, 1971. The operational system includes 12 fixed earth stations located near the capitals of the 12 participating countries. During the next phase, NATO Phase III, it is planned to increase this number to 22 earth stations and to add 2 large transportable stations. It is also expected that service will be extended to ships that would be under the operational command of NATO. Construction of the NATO Phase III spacecraft, developed by Philco-Ford, was ordered early in 1973 for launch in late 1975. One transponder in the satellite will be connected to a widebeam antenna to provide coverage of the entire NATO area, while a second transponder will be connected to a narrowbeam antenna to provide coverage throughout Europe.

The Department of Defense has also been developing the capability to provide satellite communications service to mobile and tactical users. This has been primarily accomplished through systems using the 225 to 400 MHz band. This capability was originally demonstrated by the Lincoln Experimental Satellite (LES 5). The TACSAT program was an outgrowth of this effort and demonstrated operational capability and was used with LES 6 to provide an interim operating capability (IOC) from 1970 until 1972. LES 6 still provides some UHF capability. This tactical capability will be expanded when Fleetsatcom is launched in 1978. In addition, the United States Navy has contracted with COMSAT General for the lease of UHF channels in its Marisat system to serve as an interim capability prior to the Fleetsatcom launch.

The Fleetsatcom capability will provide service to ships at sea, submarines, and the Air Force, in particular the Strategic Air Command. To provide additional capability in the future, the Defense Department is looking to survivable satellite techniques which will enhance the command and control capability of the strategic forces.

The AFSATCOM system consists of a combination of special communications transponders and channels carried on board "host" satellites placed in orbit for other missions (e.g., Navy FLTSATCOM satellites) plus numerous ground and air terminals. This deliberately redundant satellite system will assure that essential NCA instructions reach the forces. It will also enable the forces to report back the data needed by the NCA to maintain sure control and to execute a variety of nuclear options.

Service test models of the various terminals have been acquired and are now in test and evaluation. The production of terminals is scheduled to begin in late 1975. Host satellite launches are also scheduled to begin in 1975.

AFSATCOM II is now in program definition. The prinicipal objective of AFSATCOM II is to achieve a major upgrade in ECCM capability over AFSATCOM I, and to further enhance the physical survivability of the space segment. AFSATCOM II consists of the AFSATCOM I earth terminal segment, modified to give it a much higher antijamming capability, and a new space segment (SURVSAT I) to be installed in upgraded host, or possibly dedicated, satellites. The LES 8 and 9 experimental satellites, which are scheduled to be launched in 1976, will demonstrate new technology for improvements in the physical and ECCM survivability of satellites. The results of these experiments are expected to influence significantly the definition and design of the SURVSAT I system.*

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*Department of Defense Publication, "Annual Defense Department Report FY1976 and FY197T," James R. Schlesinger,February 5, 1975.

APPENDIX D

PRICE VERIFICATION FOR DOMESTIC SATELLITE RATES

Extending the costing analysis of section IV to the heavily loaded domestic satellite case (i.e., 5000 channels), the cost of the domestic satellite from Table I is $10.3 million each, or $20.6 million for two satellites on orbit, or $4.1 million/year for a protected satellite. The terminals for this network cost approximately $3 million, thus for 15 terminals, the initial investment would be $45 million or $4.5 million/year. The operating cost is approximately $1.5 million, thus the annual system cost is the sum of these costs or $10.1 million/year. The annual cost per voice channel is $10.1 million/5000 = $2,020. This is equivalent to $168/month per channel. Twice this is $337/month, which is probably adequate to recover system cost plus overhead, but it is unlikely that any profit is included. The longer distance channels are priced appreciably higher and would yield good profit margins, commensurate with the risk. Therefore, these tariffs appear to be fair and reasonable and are likely to be relatively stable.

APPENDIX E

INQUIRY LETTER

Dear Mr.

I am conducting a study to determine the proper role of commercial satellite systems in satisfying Department of Defense (DoD) communication requirements. I am requesting assistance from several corporations during the course of this study. I would appreciate your assistance in answering the following questions:

1. Would you be interested in leasing satellite transponders to the DoD? If yes, when would they be available and at what price (budgetary)- What frequency bands, bandwidth, coverage area, and output power?

2. Would you be interested in leasing satellite terminals to the DoD? What would be the date of availability and the price (budgetary) for small, medium and large terminals? How much to equip them with 3, 12, 24, 48, or 96 channels, include capability for 1, 3, or 9 carriers? How much to equip terminals with a demand access capability of 1 or 3 accesses. What would be the yearly cost to maintain and operate the terminals.

3. Would you be interested in leasing a system to the DoD that would include a transponder as under question 1, and a mix of terminals as under question 2, 15 large terminals and 15 small terminals, total channels 180 or 360? Also a system composed of two transponders, 15 larger terminals, 15 medium terminals, and 100 small terminals in a Demand Access Net? What would be the price for providing operation and maintenance?

4. What are your rates to lease 50 kilobits, 100 kilobits, 200 kilobits, 1.544 M bits, 6.312 M bits, and 100 M bits? Available at the terminal and at locations 100 miles remote from the terminal?

Would you also indicate what areas of the world could be serviced by these systems?

Your budgetary prices will be kept in complete confidence, unless released by you or published in the open literature; only a representative price of the participating group will be used in the report.

Thank you very much for your cooperation.

Sincerely yours,

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Engineering Center
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