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THE ECONOMIC VALUE OF REMOTE SENSING OF EARTH RESOURCES FROM SPACE: AN ERTS OVERVIEW AND THE VALUE OF CONTINUITY OF SERVICE

VOLUME VI

LAND USE

PART II:

THE ROLE OF ERTS IN THE ESTABLISHMENT AND UPDATING OF A NATIONWIDE LAND COVER INFORMATION SYSTEM

Prepared for

National Aeronautics and Space Administration
Office of the Administrator
Washington, D.C.
NASW-2558

October 31, 1974

NOTE OF TRANSMITTAL

This report on the role of an ERTS satellite system as a component of a nationwide land cover information system is prepared for the Office of Applications, National Aeronautics and Space Administration under NASW-2558. It is also submitted here under Article 1.C.1 of contract NASW-2580 as a part of the ECON, Inc. assessment of the economic value of remote sensing of earth resources from space because of its in-depth assessment of the cost-effectiveness of ERS satellites as a component a land cover information system.

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ABSTRACT

This study analyzes the utility of an ERS system as an effective tool in Land Use management. The approach taken here divides the analysis into two parts, 1) a qualitative study of potential Land Use resource management functions (RMF's)(Part I), and 2) a cost effectiveness comparison between alternative Earth Resource Survey (ERS) systems based on various projected levels of demand (Part II). The study of ERS information as applied to Land Use management is a relatively new field. As a result, the primary purpose of Part I is to explore this new area by qualitatively examining the potential new capabilities a space-based ERS system could offer the Land Use manager. A variety of RMF's are postulated within which ERS activities might occur and the present ERTS investigations in these areas are outlined.

The second part of this volume addresses the issue of the cost effectiveness of satellites as a component of an ERS system. This study contains an estimate of the Federal legal and statutory requirements for remote sensing as they form a lower-bound estimate of the demand for remote sensing. The study indicates a cost savings potential of from $7.9 to $37.1 million annually attributable to the inclusion of ERTS-like satellites in the ERS system.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

1.0 EXECUTIVE SUMMARY

1.1 The Purpose and Major Findings of the Study

The purpose of this study was to examine the economic potential, defined for this study as cost savings, of an ERTS type satellite in the development, updating and maintenance of a nation-wide land cover information system in the post-1977 time frame. As envisioned in this study, the national information system must be capable of satisfying at least the land cover information requirements of all Federal civilian agencies under existing Federal statutes. The study examines several alternative acquisition systems for land cover data and the relevant information acquisition, data processing and interpretation costs associated with each alternative. The basic problem was to determine, on a total life cycle cost* basis, under which conditions of user demand (area of coverage, frequency of coverage, timeliness of information, and level of information detail) an ERTS type satellite would be cost effective and, if so, what would be the annual cost savings benefits.

Major conclusions of this study are:

1. An ERTS type satellite is a cost-effective system for satisfying the expected level of demand for land cover information in the post-1977 period. This is predicated upon an annual demand level of six times coverage of the

*Throughout this report we refer to life cycle costs which were computed over the period 1975-1993 in 1973 dollars discounted at 10% to 1974.

continental United States plus Alaska, with each mapping mission to be completed within 60 days and the mapping information classified to Level II detail, (USGS - Circular 671 classification scheme) <u>and</u> more detailed coverage (Level III) of the same area once every five years. To satisfy this demand level, the cost-effective system requires two satellites simultaneously in orbit. However, high and low altitude aircraft with ground survey teams are also necessary components of a cost-effective data acquisition and processing system for this level of demand.

2. A three-satellite system with high and low altitude aircraft and ground survey teams is cost-effective at an annual demand level of twelve times coverage of the U.S. at Level II, with each mapping mission to be completed within 30 days and Level III coverage of the U.S. once every five years.

3. In the post-1977 time frame, automatic (e.g. computer) interpretation and classification techniques will be technically and economically preferred over manual interpretation methods.

4. The expected annual cost savings that accrue from an operational ERTS as a component of a Nationwide Land Cover Information System is $23 million of un-discounted 1973 dollars (as compared to an aircraft only system).

5. The satellite configuration assumed for purposes of this analysis is not the optimum configuration to accomplish both the U.S. and the global coverage missions at minimum cost. Further cost savings can be realized by modifying the configuration of an operational ERTS system. A joint systems engineering and economic analysis of various satellite configurations for accomplishing both missions should be undertaken.

The following sections of this chapter will address several important questions relevant to the purpose and findings of this study. What is the basis or need for a nationwide land cover information system and how might such a system be organized and operated? What will be the likely demand for land cover information in the post-1977 time frame, and what are the technical alternatives for satisfying these demands? Finally, what are the major variables which impact the life cycle cost of the alternative data acquisition systems and which system alternatives are economically preferred at various levels of demand for land cover information?

1.2 The Need for a Nationwide Land Cover Information System

In July of 1973, a Federal Mapping Task Force which had earlier been established by the Director of the Office of Management and Budget issued a report* on Federal agency surveying and mapping activities. This report summarized the work and results of a major inquiry concerning: (1) the existing data collection programs of various Federal civil agency and military domestic mapping programs, and (2) an investigation of systems and procedures to achieve both improved economies in these data collection programs and increased responsiveness to user needs. The Task Force report underscored three major problems which have long been associated with Federal civilian mapping programs:

- uncoordinated, single-purpose surveys and mapping which benefit only one user agency
- a growing mass of unmet national demand for mapping data and products
- the inability of the present structure of data collection programs to deal efficiently and responsively with growing and changing demand requirements.

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* Report of the Federal Mapping Task Force on Mapping, Charting, Geodesy and Surveying, July, 1973

Throughout our own study we have repeatedly confirmed these earlier observations. We have inquired into the present day data collection activities of various Federal agencies, we have studied reports on the utility of more extensive and more timely earth resources information, and we have interviewed responsible officials of civilian Federal agency mapping programs concerning their data needs and their present efforts. We find that the need for land cover information in the United States far exceeds the present day data collection activities.

We agree with the primary conclusion of the Federal Mapping Task Force, that in order to rectify this imbalance most efficiently, there is an urgent need to consolidate the fragmented data collection efforts of the many Federal agencies into a new centralized mapping organization. This need leads directly to a Nationwide Land Cover Information System.

1.3 Conceptual Description of a Future Nationwide Land Cover Information System

Figure 1.1 provides an overview of the organization and operation of a future Nationwide Land Cover Information System. At the outset, two points must be clearly understood. We have not undertaken in this study a systems engineering analysis of a Nationwide Land Cover Information System. We have

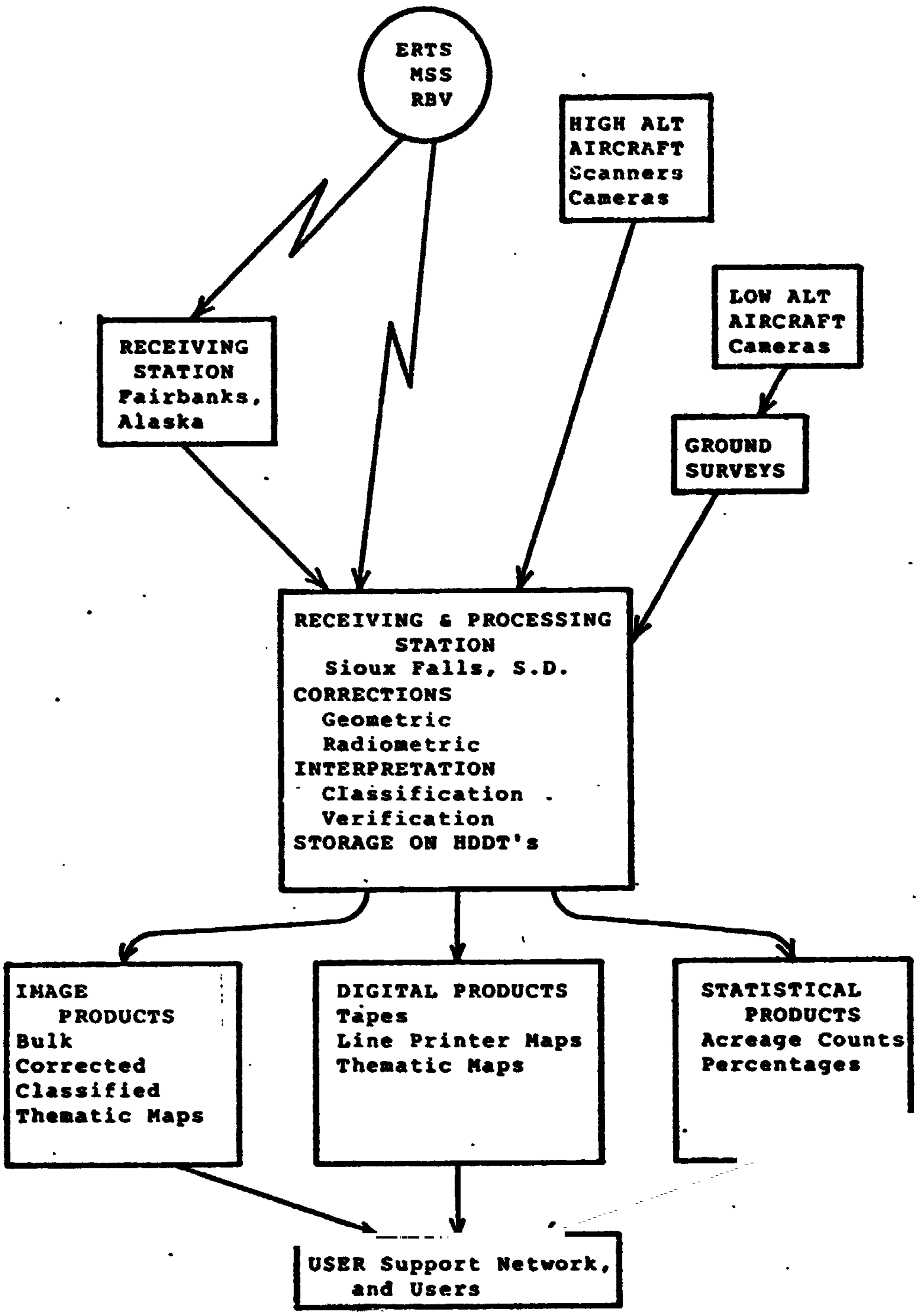

Figure 1.1 Conceptual Flow Through Land Cover Information System

only sketched out our own rough concept of a national information system for the purpose of identifying the cost elements that are relevant to a cost effectiveness analysis of an ERTS type satellite as a major information acquisition component. A second, related point is that we considered in this analysis only the central core of a nationwide land cover information system. It is likely that there will be a network of user service facilities, organized perhaps on a regional basis, which will distribute resource management data products from the core facility to the various users. The support network of user service centers has not been considered in this study since the investment and operations cost of any such network would be common to all the alternative data acquisition systems.

Table 1.1 lists the remote sensing platforms which acquire data for the national information system. The projected 1977 capabilities of the several sensors for acquiring information at various levels of detail are shown in Table 1.2. The method of processing and classification, manual or automatic (computer) techniques has a major influence in this regard. Using manual interpretation methods, ERTS images can provide Level I information, as has been demonstrated by several ERTS investigators (See References 1, 6, 8 and 9 on page III - 19 of Appendix III). Many investigators reported manual mapping of some Level II

Table 1.1 Remote Sensing Data Acquisition Elements For A Nationwide Land Cover Information System	
Platform	Sensor
Satellite - ERTS -type	Multispectral scanner Return Beam Vidicon
High Altitude Aircraft-U-2	Multispectral Scanner 6 inch metric camera
Low Altitude Aircraft - Commercially Available	9" x 9" 1:24,000 photographic images

Table 1.2 Projected Sensor Capabilities For Acquiring Information At Various Levels of Detail

Manual Processing				Automatic (Computer) Processing			
	ERTS	HA	GT		ERTS	HA	GT
Level I	✓	✓	✓	Level I	✓	✓	✓
Level II		✓	✓	Level II	✓	✓	✓
Level III			✓	Level III		✓	✓

categories from ERTS but they could not satisfy the 90% accuracy standard recommended in the USGS-Circular 671. Typical accuracies reported for Level II information obtained via manual techniques range from 50% to 70%. Computer processing and classification techniques are relatively new and the state of the art is in its infancy. Already, very promising results have been reported by ERTS principal investigators; the only type of information for which consistent difficulties have been encountered is the Urban subcategories of the USGS land use classification scheme, specifically, Urban-commercial, Urban-industrial and Urban services. With the exception of these Urban subcategories, computer processing of ERTS images will undoubtedly permit the mapping of Level II information* at 90% accuracy standard. Figure 1.2 is an example of a computer generated color coded land use map prepared by NASA/JSC Earth Resources Laboratory of the Mississippi Test Facility in Bay St. Louis, Mississippi.

1.4 Overview of the Study Approach

Figure 1.3 depicts the study approach in overview form. The analysis begins with projections of the demand for land cover information which each technology system must satisfy on an equal capability basis. For the purposes of this analysis only demand which requires full target coverage is considered. Thus, demand requirements which can be satisfied by a probability sample of a given target area have been excluded from our analysis.

The analysis of demand for remotely sensed land cover information focuses on four major characteristics of user demand: area of target, timeliness of information, frequency of update,

*See References 10, 13, 14, 15 and 17 on page III-20.

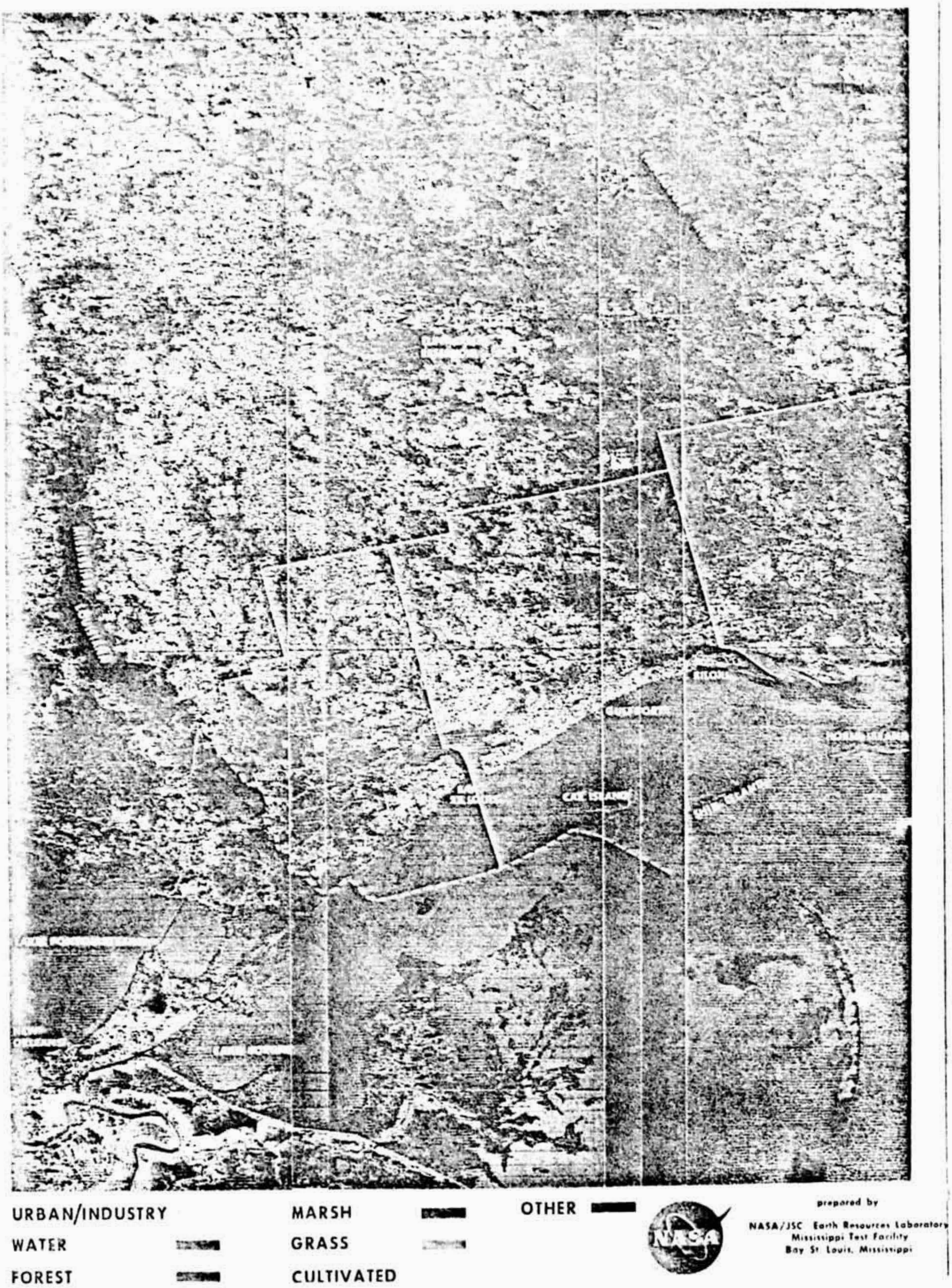

Figure 1.2 Computer Derived Land Use Classification of ERTS-1 Data Acquired August 7, 1972--Mississippi Gulf Coast

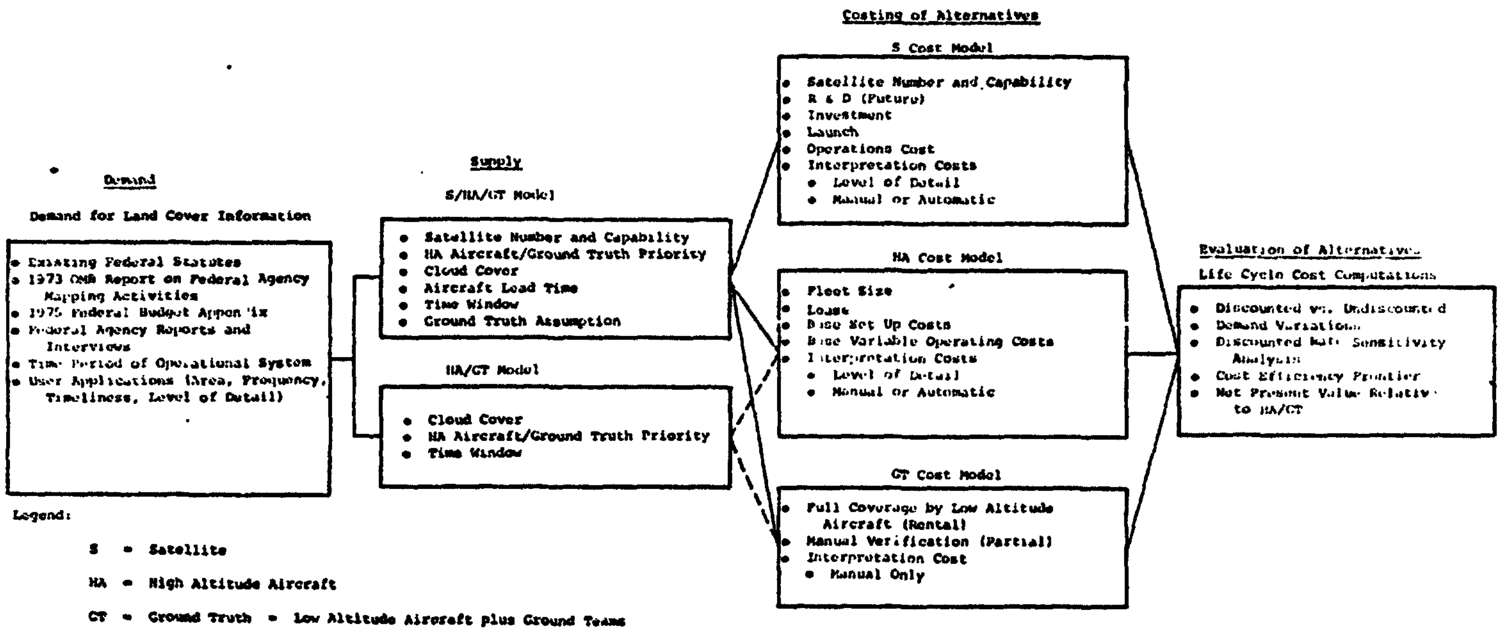

Figure 1.3 Overview of the Study Methodology

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and level of information detail. The target area refers to the percentage of the United States that must be covered to satisfy a specific demand requirement. Though actual user desired targets vary continuously from small regions of the United States to the full United States, this analysis classifies user demand into one of four area requirement categories: 100%, 10%, 1% or .1% of the United States. Timeliness of information (also called user time window) refers to the maximum allowable elapsed time (in days) during which the remote sensing of land cover information must be completed in order to satisfy the user. This important characteristic varies from once every five years to weekly. The frequency of coverage refers to the number of times that targets of a given size, timeliness and level of detail requirement are covered during one year. Note that the frequency of coverage is a composite of users who want repeated coverage of a given target area as well as users who want one-time coverage of targets of a given size which are geographically or temporally distinct. The level of information detail reflects the scale required which, in turn, is determined by the type of information needed to fulfill the user requirements. In our study, Level I information corresponds to a mapping scale of 1:500,000, Level II, 1:125,000 and Level III, 1:24,000.

Using the above four demand characteristics, a search was made of the existing Federal statutes that either mandate or enable Federal civil agency land cover mapping programs. An analysis of Federal Agency demand for remotely sensed land cover information in the 1977 time frame (under existing Federal statutes) was made for the "land use planning community" and separately, for "all land cover users." Our detailed findings are documented in Chapter 3 and Appendix III of this report. After eliminating overlapping data gathering requirements of the various Federal agency users, we concluded that most of the Federal demand requirements for both user groups is for Level II information; the coverage requirement extending over the entire continental United States and Alaska land area at an annual mapping frequency of four times, seasonally, i.e. within 90 days. The vast majority of Federal agency demand for full target coverage (non-sampling applications) arises from the land use planning community. We did not identify any Federal requirements for Level I information for either the land use planning community or other Federal land cover users. In any event, however, it should be noted that Level II mapping information can readily be aggregated to provide Level I information. We did find substantial Federal demand for Level III information, but full coverage of the United States is required only once every five years.

Demands upon a national land cover information system will not be limited to Federal users only. A separate ECON study documents the need for earth resource management data from state, regional and local government units as well as the needs of the industrial and academic community. Quantitative estimates of the demand for land cover information in the post-1977 period from all sources are highly uncertain, at present. We have therefore explored the economics of ERTS over a range of future demand levels, from two times coverage of the U.S. at Level II within 180 days to twelve times coverage of the U.S. at Level II within 30 days.

On the supply side of the analysis, there are several alternative technical systems considered for the acquisition and processing of the land cover user requested data. Each technical system is made up of two or more of three basic remote sensing components; namely an ERTS-1 type satellite, high altitude aircraft and a ground truth system which is defined to mean a low altitude aircraft with ground follow up teams. These remote sensing components (hereafter designated S, HA and GT), are combined to form the several data acquisition systems indicated in Table 1.3.

For purposes of this analysis, each of the two and three tier technology choices listed in Table 1.3 has an implied

Table 1.3 Alternative Data Collection Systems For Nationwide Land Cover Information System

Three Tier Systems	Two Tier Systems
1. S/HA/GT	1. HA/GT
2. 2S/HA/GT	2. S/GT
3. 3S/HA/GT	3. 2S/GT
	4. 3S/GT

Legend: S refers to an ERTS type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow up teams

priority ranking associated with the use of its constituent data acquisition systems. The priority ranking is defined by the ordering of the components of a given technology choice. For example, the S/HA/GT technology implies that in our analytical models the satellite component will satisfy as much of the user demand as is possible, consistent with its capability to satisfy the level of information detail requirement of the user, and the user timeliness requirement and to overcome cloud cover problems. Whatever portion of user demand that cannot be satisfied by the satellite is assigned to high altitude aircraft and whatever demand is left unsatisfied by that component is assigned to the ground truth system. To illustrate, if the user demand were to obtain Level II information over one tenth the area of the

U.S. within a specific 30 day period then, given an 18 day satellite revisit time, the satellite would acquire only a fraction, say p , of its assigned target, where p depends the amount of cloud interference that it encountered over the target during 1-2/3 passes. In this case, the high altitude aircraft component (HA) of the S/HA/GT technology would be assigned to provide remote sensing coverage over that portion of the user target area left unsatisfied by the satellite. Moreover, the HA component may also fail to complete the mission due to cloud cover problems and tight time requirements; in which case, the ground truth component (GT) consisting of low altitude aircraft and supporting ground teams are assigned to complete the task. The specific assumptions and methodolgy that are used for analysis of the three tier and two tier systems are described of this Chapter 4 of the report.

The analytical models depicted in Figure 1.3 allocate the projected user demand to the S, HA and GT components in accordance with the characteristics of user demand, cloud cover problems, capabilities of the component sensors and operational constraints imposed on the analytical models. Once the demand has been allocated to the three basic remote sensing components, the costs of satisfying these demands are calculated in the costing models, taking into account the many investment and operating cost elements of each system. The basic annual cost information for each of the technology choices are then reassembled and compared in the evaluation model.

1.5 Results

Life cycle costs were computed for each of the two and three tier data acquisition systems previously described. Total program cost comparisons were made for the alternative systems (1) over a range of land cover demand levels, (2) using automatic and manual data processing and interpretation techniques and (3) under two different user cloud cover requirements. The basic problem underlying and guiding these life cycle cost comparisons was to determine under which conditions of user demand (area of coverage, frequency of coverage, timeliness of information and level of information detail) an ERTS type satellite would be cost effective and, if so what would be the annual cost savings benefits.

Our analysis begins by considering only Federal user agency demand for land cover information under existing Federal statutes. Next, we address the national resource management information needs of all user groups, Federal and otherwise. For this case, demand projection in the post-1977 time frame are highly uncertain; thus a parametric demand-cost analysis is made. Finally, in order to estimate the likely cost savings benefits of ERTS, we evaluate the system alternatives for three particular demand scenarios which we believe will bracket the actual national demand for land cover information in the post-1977 time period. A description of the results of these analyses follow.

A comparison was made of the life cycle costs required to satisfy 1977 Federal agency demand using either manual or automated data processing and classification techniques. Life cycle summary costs are shown separately in Table 1.4 for the "land use planning community" and, separately, for "all land cover users." The projected 1977 Federal agency-Land Use Planning demand* principally involves four times annual coverage of the U.S. at Level II, Level III coverage of the U.S. once every five years and fractional coverage of the U.S. at Level II and Level III at more frequent time intervals. The projected 1977 Federal agency-All Land Cover Users demand* encompasses the Land Use Planning demand and additional fractional coverage of the U.S. at Level II and Level III at more frequent intervals. Two different user cloud cover requirements, 0-30% and 0-10% allowable cloud coverage, were also considered. The cost-effectiveness analysis of the technical alternatives for satisfying Federal agency information demands revealed two important results:

1. An all aircraft system is cost-effective when considering only Federal agency demands for U.S. coverage and a mixture of satellite, high and low altitude aircraft provide the next best alternative.

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* Precise descriptions of demand are provided in Tables 3.4 and 3.5 of Chapter 3.

Table 1.4 Discounted Total Program Cost to Satisfy 1977 Federal Demand For Land Cover Information Under Existing Federal Statutes (Millions of 1973 Dollars Discounted at 10% to 1974)

User Cloud Cover Requirement / User Group	Allowable Clouds 0-30%		Allowable Clouds 0-10%	
	Manual Interpretation	Automatic Interpretation	Manual Interpretation	Automatic Interpretation
Land Use Planning Community Only	518.9 HA/GT 688.9 S/HA/GT	316.5 HA/GT 337.1 S/HA/GT	616.7 HA/GT 786.7 S/HA/GT	428.0 HA/GT 454.2 2S/HA/GT
All Land Cover Users	937.2 HA/GT 1107.2 S/HA/GT	613.3 HA/GT 701.8 2S/HA/GT	1120.1 HA/GT 1290.1 S/HA/GT	835.7 HA/GT 881.6 2S/HA/GT

Legend: S refers to an ERTS-type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

2. Automatic data processing techniques are economically preferred over manual methods.

The fact that a satellite component does not emerge as an essential component of a cost-effective system for satisfying Federal agency demand can be attributed to the Level III information requirements of Federal users. While these requirements cannot be satisfied by ERTS, they can be satisfied by high altitude aircraft and at less cost than would be required by low altitude aircraft and ground survey teams. Subsequent analysis shows that the satellite component becomes economically attractive with increasing Level II information demands and that when the projected demands arising from all earth resource management needs are considered, a "with" satellite system is cost-effective.

As regards automatic versus manual data processing, Table 1.4 indicates that in every instance of comparison, there are significant cost savings advantages that accrue to the automatic techniques over manual techniques. This result was to be expected given the differences in the projected capability of these techniques in the 1977 time frame for acquiring increasingly detailed land cover information. Using ERTS, manual techniques can provide only Level I information with the necessary accuracy while automated techniques can provide both Level I and Level II type information. Similarly, using high altitude aircraft, manual techniques can provide Level I and Level II while all levels of classification detail can be obtained from automatic techniques.

Table 1.4 also provides some interesting insights into the effects of users cloud free coverage requirements. As one would expect, the more stringent cloud free coverage requirement of 0-10% causes a major increase in total program costs. This is due to the fact that in order to satisfy a fixed user timeliness requirement, the satellite and high altitude aircraft systems must yield a greater portion of the user target to the low altitude aircraft and ground survey teams. Thus, in addition to incurring expensive investment cost of the satellite and high altitude aircraft systems, one is forced to increase the activity level of the most expensive (incremental cost) data acquisition component. The impact of more stringent user cloud free coverage requirement will, of course, grow increasingly severe as the user timeliness requirement is tightened. Subsequent results quantify this effect.

Federal statutory demand for land cover information constitutes only a segment of the national demand. State governments, regional and local governmental units, industrial and academic users will also contribute to the total demand. It is difficult to project, quantitively, the scope and nature of the total national demand. Consequently, a parametric set of demand requirements were considered which focused on increasing Level II information requirements for continental US and Alaska. The annual Level II coverage requirement was varied from two times coverage within 180 days each to twelve times coverage within

30 days for each coverage. In addition to the varying, the full US-Level II requirement, the parametric demand analysis includes the other information requirements* that were projected for the 1977 Federal agency demands (All Land Cover Users) under existing Federal statutes.

The results of the parametric demand -- cost analysis is shown in Table 1.5. For each demand level, total program costs are compared for the all aircraft system and the lowest cost two or three tier "with" satellite system. This analysis is based upon automatic data processing methods which previously were shown to be economically preferred over manual methods. It is clear from this table that ERTS is cost-effective at an annual demand level of six times coverage of the U.S. with a user timeliness requirement of 60 days for each such coverage. Note however that a two satellite system is required in order to overcome cloud cover problems. Another interesting effect concerning the impact of cloud cover is evident from Table 1.5. The more stringent cloud cover requirement (0-10%) reduces the multiple satellite system breakeven demand level. Table 1.5 shows that a two-satellite system is cost effective at six times coverage of the U.S. given a (0-30%) cloud cover requirement, while for the same demand level a three-satellite system is cost effective given a (0-10%)

*See Table 3.5 of Chapter 3.

Table 1.5 Summary of Total Program Cost (1977-1993) to Provide Level II Mapping Information of Continental U.S. and Alaska Using Automatic Data Processing (Millions of 1973 Dollars Discounted at 10% to 1974)

Annual Level II Coverage Frequency and Timeliness	Allowable Cloud Cover 0-30%	Allowable Cloud Cover 0-10%
Twice at 130 days each	488.5 HA/GT 646.9 S/HA/GT	616.3 HA/GT 779.2 S/HA/GT
Four times at 90 days each	613.3 HA/GT 701.7 2S/HA/GT	835.6 HA/GT 881.6 2S/HA/GT
Six times at 60 days each	815.6 HA/GT 758.4 2S/HA/GT	1137.3 HA/GT 984.4 3S/HA/GT
Eight times at 45 days each	1044.3 HA/GT 798.2 3S/HA/GT	1476.5 HA/GT 1129.5 3S/HA/GT
Twelve times at 30 days each	1548.3 HA/GT 997.9 3S/HA/GT	2168.3 HA/GT 1603.4 3S/HA/GT

Legend: S refers to an ERTS-type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow up teams

cloud cover requirement. As expected, the cost savings of the "with" satellite system over the aircraft only system increase substantially as the demand for Level II information increases beyond six times coverage of the U.S.

Figure 1.4 displays the cost-capability frontier for the two user cloud free coverage requirements explored in this study. The cost-capability frontier is defined by the locus of the lowest program cost alternatives for varying capability levels. The full cost ERTS curve represents the cost-capability frontier under the assumption that the total program cost are borne entirely by a U.S. coverage mission. The incremental cost ERTS line represents the cost capability frontier under the assumption that the investment costs for a one satellite system would be incurred in any event for a global coverage mission.

Thus far, the analysis has identified the cost-effective mixture of satellites, high and low altitude aircraft and ground truth for satisfying various demand requirements that may arise during the period of an operational Nationwide Land Cover Information System. The final phase of the analysis estimates the <u>likely</u> future demands for land cover information considering all potential users and the economic benefits that are likely to accrue to ERTS. Despite the uncertainties inherent in estimates of future nationwide demand, we have defined three demand scenarios

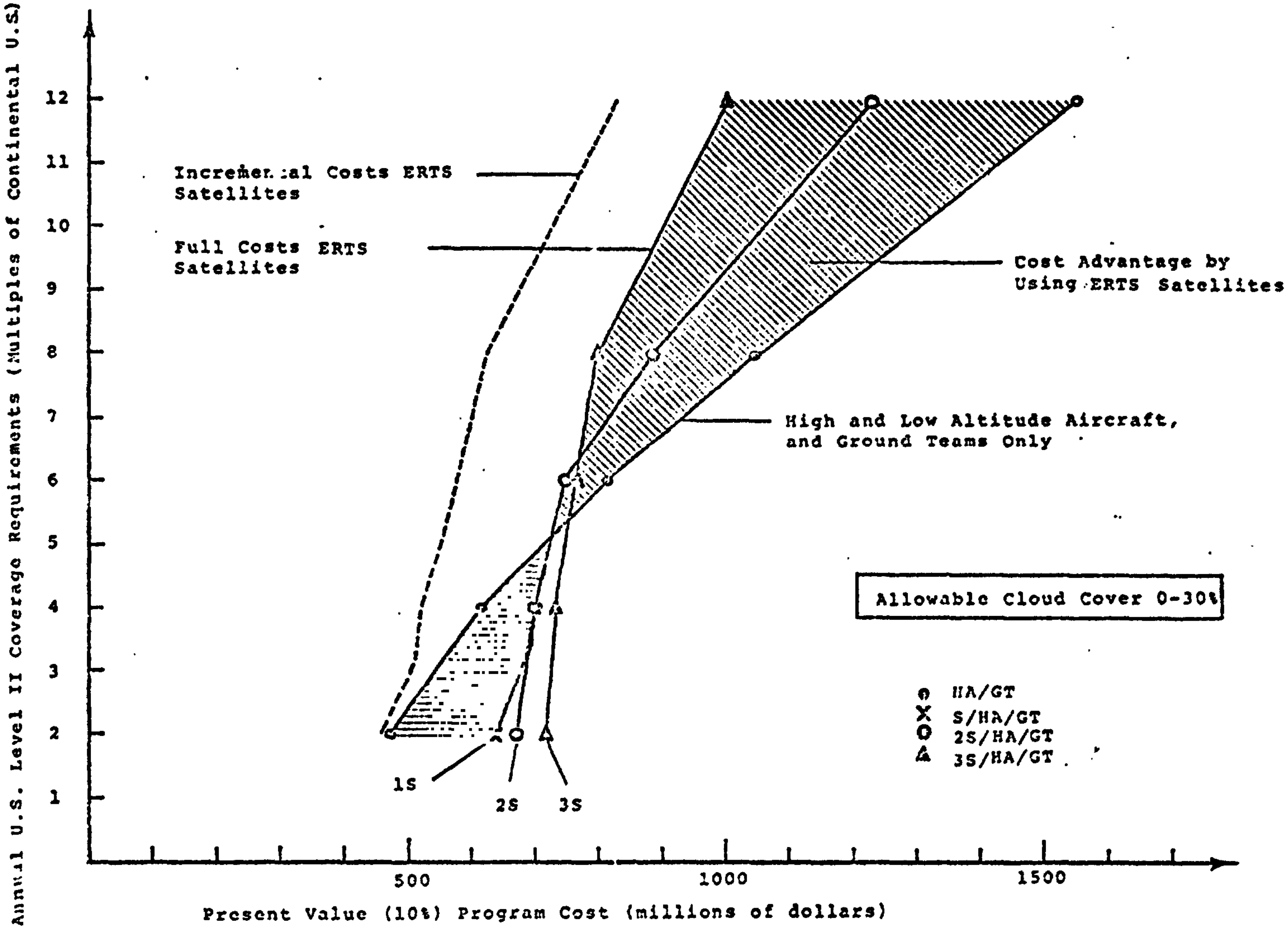

Figure 1.4 The ERS Cost Efficiency Frontier

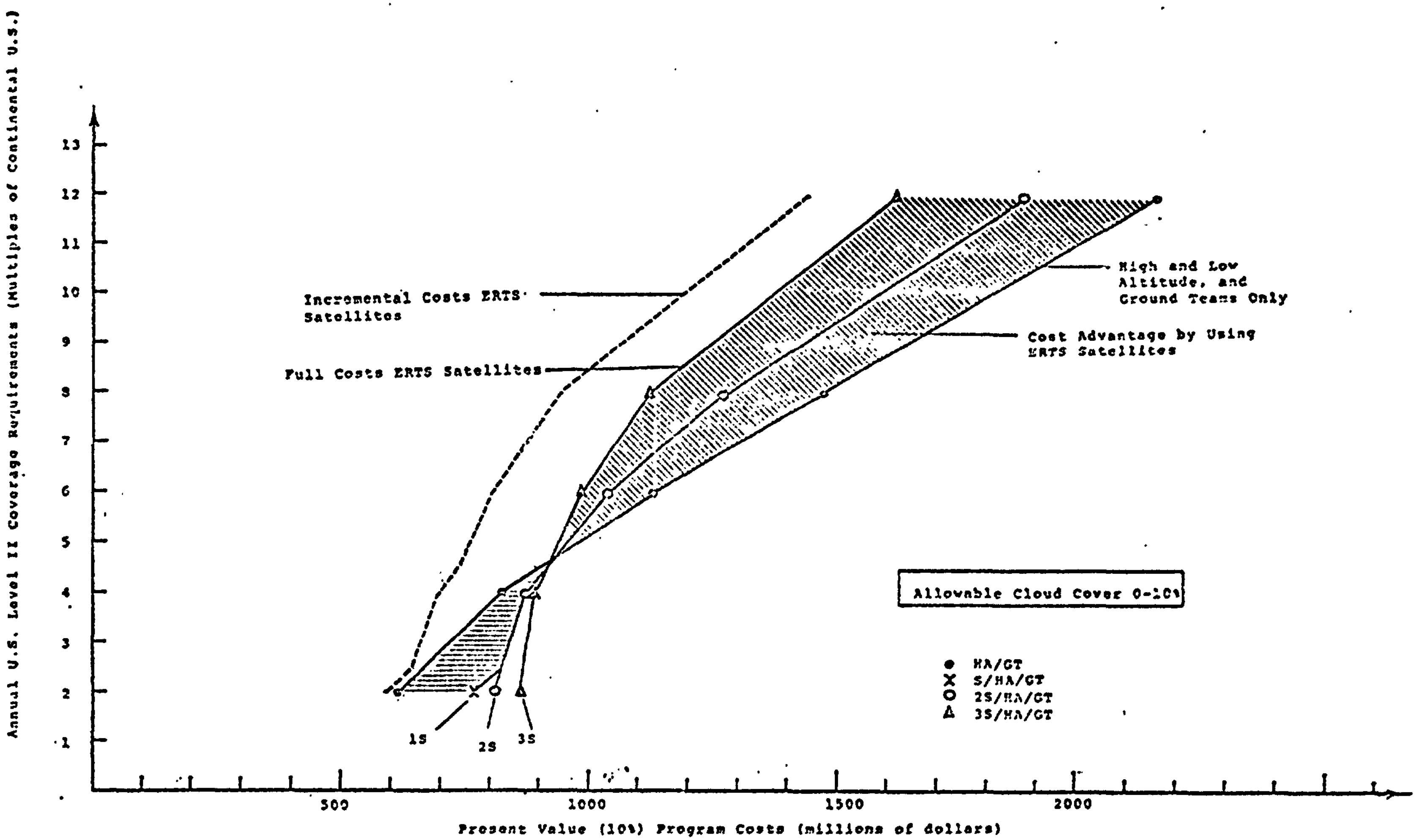

Figure 1.4 The ERS Cost Efficiency Frontier (Continued)

that we believe will bracket the actual future nationwide demand for land cover information. Each demand projection includes all the projected information requirements of Federal agency users in 1977 except the full U.S., Level II coverage. In addition, we have included Level II information requirements for the U.S. plus Alaska at annual frequencies varying from six times coverage within 60 days each during the period 1977-1993 to six times coverage within 60 days over the period 1977-1980 and eight times coverage within 45 days each over the period 1981-1993.

The cost-effectiveness analysis for these projected demand levels is based upon automatic data processing methods which previously were shown to be economically preferred over manual methods. Table 1.6 displays the total program costs for the lowest cost "with" and "without" satellite systems to satisfy these future demand levels given a user allowable cloud cover requirements of 0-30%. Also shown are the net present values (discounted cost savings) of the lowest cost "with" satellite system relative to the lowest cost "without" satellite system and the equivalent undiscounted annual cost savings of the "with" satellite system over the period 1977-1993. Table 1.7 provides corresponding results for an allowable cloud cover requirement of 0-10%. As indicated in these tables, the annual economic benefits (cost savings) of ERTS as a component of a Nationwide Land Cover Information

Table 1.6 Discounted Total Program Cost (1977-1993) to Satisfy the Projected Future Nationwide Demand for Land Cover Information -- Level II Information -- Automatic Data Processing -- Allowable Cloud Cover (0-30%) (Millions of 1973 Dollars Discounted at 10% to 1974)

Projected Level II Demand	All Aircraft System	Lowest Cost With Satellite System	Net Present Value	Equivalent Undiscounted Annual Cost Savings 1977-1993
1977-1993 Six times at 60 days	815.9 HA/GT	758.4 2S/HA/GT	57.5	7.9
1977-1984 Six times at 60 days 1985-1993 Eight times at 45 days	892.3 HA/GT	797.4 2S/HA/GT	94.9	13.0
1977-1980 Six times at 60 days 1981-1993 Eight times at 45 days	954.2 HA/GT	829.9 2S/HA/GT	124.30	17.0

Legend: S refers to an ERTS type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

Table 1.7 Discounted Total Program Cost (1977-1993) to Satisfy the Projected Future Nationwide Demand for Land Cover Information -- Level II Information -- Automatic Data Processing -- Allowable Cloud Cover (0-10%) (Millions of 1973 Dollars Discounted at 10% to 1974)

Projected Level II Demand	All Aircraft System	Lowest Cost With Satellite System	Net Present Value	Equivalent Undiscounted Annual Cost Savings 1977-1993
1977-1993 Six times at 60 days	1137.6 HA/GT	984.5 3S/HA/GT	153.1	21.0
1977-1984 Six times at 60 days 1985-1993 Eight times at 45 days	1251.0 HA/GT	1032.5 3S/HA/GT	218.5	30.0
1977-1980 Six times at 60 days 1981-1993 Eight times at 45 days	1342.7 HA/GT	1072.0 3S/HA/GT	270.7	37.1

Legend: S refers to an ERTS type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

System are projected to range from \$7.9 to \$17.0 million or from \$21.0 to \$37.1 million depending upon the user cloud cover requirement. The best point estimate of the annual cost savings that accrue to ERTS is probably defined by the middle of the projected range of cost savings, this being \$23 million.

1.6 Recommended Future Study Efforts

This study has not attempted to answer all major questions that arise with respect to a nationwide land cover information system and/or the role of ERTS in such a system. Indeed, there are several important limitations of this study which should be highlighted:

- The treatment of the cloud-cover--data accuisition problem represents only a first cut analysis. A more in-depth study of the impact of cloud cover is warranted
- Within the context of an ERTS type satellite, the satellite system configuration analyzed in this report is <u>not</u> an economically optimum one for satisfying both the U. S. and global coverage mission. A joint systems engineering and economic analysis of various satellite configurations for accomplishing both missions should be undertaken. Parameters of the ERTS systems can be improved, at little added RDT & E cost, and with substantial reduction in total space system life cycle costs. These include the life time of spacecraft and instrumentation, reliability of space system and subsystems,

onboard data processing - data relay systems - ground processing (real time), and space shuttle system impact on reducing launch cost (joint missions to polar orbits), subsystems costs and minor repair and refurbishment capabilities. All of these potentially important (and cost saving) aspects have not been considered here.

- Satellites with greater technical capability than ERTS (higher spatial and spectral resolution) have not been considered in our analysis. Though we have postulated the use of an ERTS type satellite over the 1977-1993 time frame, we do not rule out the possibility of realizing further cost reduction by the introduction of more sophisticated satellite system such as EOS in the 1980's. The economically preferred IOC date of an advanced satellite system should be investigated.

2.0 CONCEPTUAL DESCRIPTION OF A FUTURE NATIONWIDE LAND COVER INFORMATION SYSTEM

In Chapter 1 we have described the need for a centralized land cover information system. In this chapter, we discuss in overview form the anticipated components, organization, and operation of such a system. Figure 2.1 presents a conceptual diagram of the flow of information through the system. At the outset, two points must be clearly understood. As indicated in Chapter 1, we have not in this study undertaken a systems engineering analysis of a Nationwide Land Cover Information System. We have only sketched out our own rough concept of a national information system for the purpose of identifying the cost elements that are relevant to a cost effectiveness analysis of an ERTS type satellite as a major information acquisition component. It is likely that there will be a network of user service facilities, organized perhaps on a regional basis which will distribute resource management data products from the core facility to the various users. The supporting network of user service centers have not been considered in this study since the investment and operations cost of any such network would be common to all the alternative data acquisition systems considered here.

Table 2.1 lists the remote sensing platforms which acquire data for the national information system. The projected 1977 capabilities of the several sensors for acquiring information at various levels of detail are discussed later in this

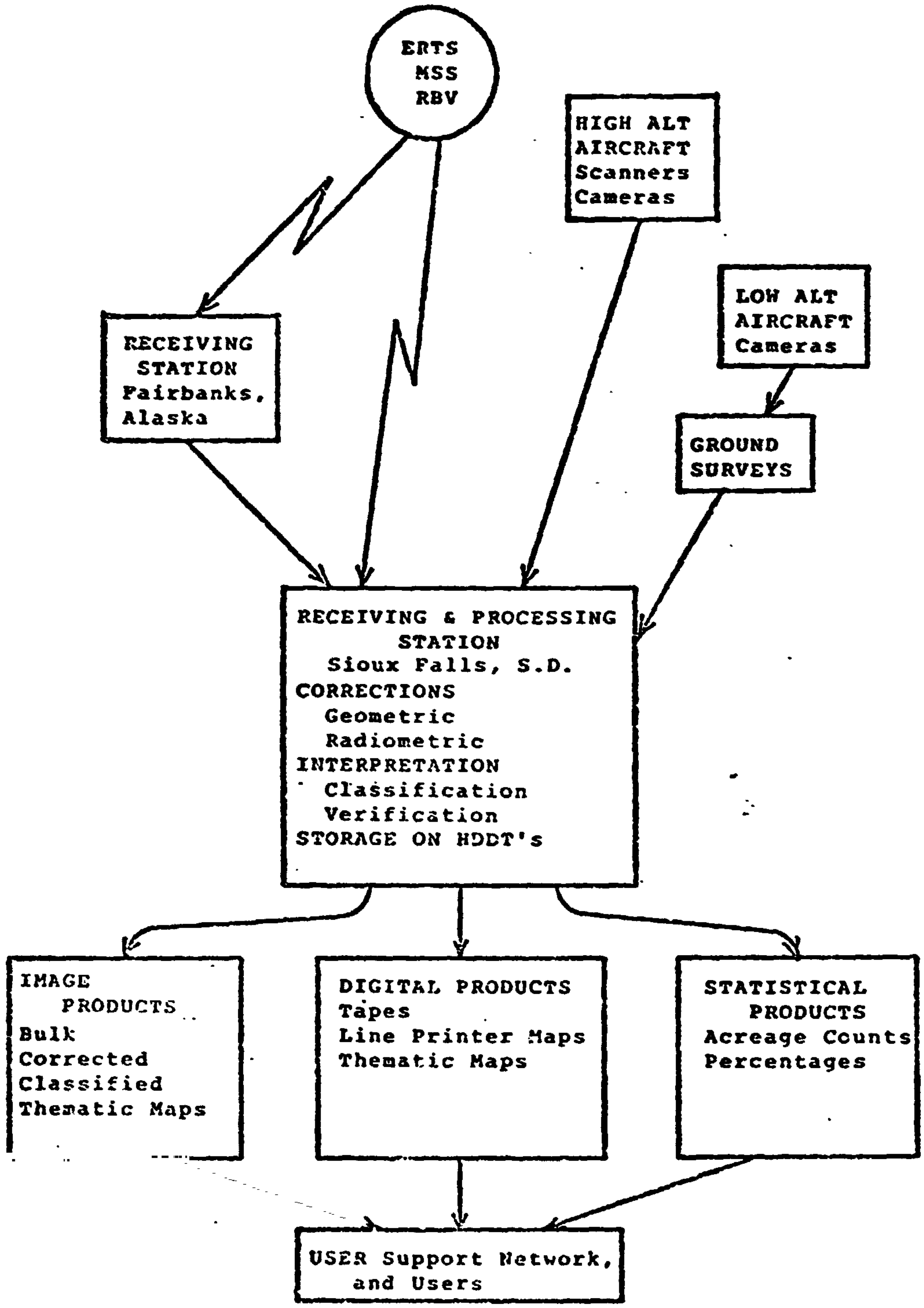

Figure 2.1 Conceptual Flow Through Land Cover Information System

Table 2.1 Remote Sensing Data Acquisition Elements For A Nationwide Land Cover Information System

Platform	Sensor
Satellite - ERTS -type	Multispectral scanner Return Beam Vidicon
High Altitude Aircraft-U-2	Multispectral Scanner 6 inch metric camera
Low Altitude Aircraft - Commercially Available	9" x 9" 1:24,000 photographic images

Chapter. The investment and operating costs of the various sensors are discussed in Appendix III of this report.

2.1 Functions of a Land Cover Information System

The major functions of a Land Cover Information System are four: (1) Control and operation of the sensors, (2) Acquisition of the sensor data, (3) Preprocessing and interpretation of the data, and (4) Dissemination and archiving of the resultant data products.

2.1.1 Control and Operation

The control and operation of the sensors consists of their scheduling and maintenance in a manner which optimizes the available coverage. In the case of the satellite system, this function consists of compiling the orbit parameters and time phasing of the satellites in a manner which would maximize the utility of the coverage. Once in orbit, however, the satellite is particularly insensitive to isolated user demands; and the control responds mainly to preestablished priorities such as the maintenance of the overall best time of day for coverage.* In the case of the high altitude aircraft, the control and operation is a highly interactive procedure. The aircraft must respond not only to the user demand but also to the effects of cloud cover. The maintenance of the aircraft and the aircraft bases to provide for high aircraft availability is a necessary subfunction. In the case of ground truth, which we have defined as a combination of low altitude aircraft and ground survey teams, this function corresponds to the establishment and development of relations with several commercial firms capable of satisfying data and imagery requirements with a very short lead time. Such a relationship is necessary in order to provide timely information required by the users.

2.1.2 Acquisition

With the capability for the timely coverage of the user required area well controlled, the second major function of the Land Cover Information System is the collection of the data from the various sensors into a centralized location. The satellite in orbit will transmit data to two ground receiving stations, one in Fairbanks, Alaska and the main receiving and processing station in Sioux Falls, South Dakota. These two stations allow for the real time coverage of the entire continental U.S., and global coverage is also possible using only the two ground stations by the transmission of the on board

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*A high resolution pointing imagery (HRPI) as proposed for an EOS satellite would make the satellite especially responsive to the isolated demands.

recorded data during the nighttime passes of the satellite. The data transmitted to the Fairbanks station may be relayed by a direct, high quality phone or radio link to the station in Sioux Falls so that the delay involved in the mailing of the digital tapes does not hinder the timeliness of the information. In any event, all satellite data will be collected onto digital tapes at the Sioux Falls processing center.

In the automatic data processing mode high altitude aircraft will collect data by means of a multispectral scanner; this data will be in a digital form when the planes arrive back at their bases in Dayton, Denver, and Alaska. Again, to save the time of mailing, acknowledging the utility of the timeliness data, the aircraft tapes need not be mailed to Sioux Falls but instead transmitted by a means similar to the satellite data connection from Fairbanks. For the manual data processing mode, high altitude and low altitude aircraft photography will be used to acquire land cover data; the photographs could be shipped in an expedient manner to Sioux Falls. If the time constraint on this data renders conventional shipment of data infeasible, then the data could be digitized by means of a photographic scanning device and transmitted to Sioux Falls.

2.1.3 Preprocessing and Interpretation

The third phase, the preprocessing and interpretation of the data, should be designed with sufficient flexibility to meet the majority of user specific demands for land cover information. This process should recognize the data needs and formats which are common to many users and handle all data to meet those needs. Individually tailored, one-time requests should be fulfilled through separate user service facilities. The prepocessing should include geometric and radiometric corrections of the data and the interpretation should include the classification of the data into land cover categories at an acceptable accuracy (now considered to be 90%). As this report considers the cost effectiveness of satellite systems as compared to aircraft systems at an equal capability, no attempt will be made to detail the effects of user specific products; rather we shall treat the equal capability assumption as the fulfillment of the requests for the standardized data formats. These standard data products are bulk imagery, processed (corrected) imagery, and interpreted (classified) imagery.

2.1.4 Dissemination and Archiving

The fourth function of the Land Cover Information System is the dissemination and archiving of the data products. The system must recognize the fact that users will seldom be knowledgeable of the exact satellite image or aircraft flight line which is of the most utility to their respective application. An archiving system should be established which makes readily accessible the characteristic annotations on each image. The characteristics should include general statistics: the sensor, longitude, latitude, cloud cover, time of day, etc. as well as unique characteristics such as the geometric and radiometric qualities, the number of land cover categories, etc. A computer file of these image annotations should be maintained which allows the user to input a specific set of parameter requirements, and a computer search program would output a list of the available images which correspond to the given requirements. The file and the search program could be stored on a nationwide computer time sharing system to assure that the users in all regions have quick access to the catalogue. In addition, special processing centers should be established which would fulfill the isolated data requests. These centers could be divided by either region or discipline and should have the capability to satisfy all of the specific user data needs.

The storage of the digital data should be on high density digital tapes (HDDT) wherever feasible since a compression ratio of at least 4:1 is possible , decreasing the physical storage requirement. A reliable recording device should be employed as the accuracy of the processed data is of the utmost importance.

2.2 Land Cover Information Products

Recognizing the fact that the various land information disciplines (cartography, agriculture, forestry, etc) have diverse data requirements, the products coming out of Sioux Falls, S.D. should be, within broad limits, individually tailored to the specific user demand. The users will have highly variable requirements upon such parameters as scale, photographic density, spectral bands, or whether a photographic product or a digital product is more suitable to their needs. The output products are divided into 3 basic data modes:

1. Image products
2. Digital products
3. Statistical products

The major portion of the image products could be produced by means of either an electron beam recorder or a laser beam recorder. These devices, which represent the current state of the art of high resolution film recorders, transform digitized data into color image products. These products can be produced at any scale from the digital data by adjusting the physical printing size of a pixel. These high resolution film recorders are capable of reproducing either positive or negative color prints or transparancies as well as black and white prints and transparencies. Recognizing the diverse needs, bulk imagery, corrected imagery, classified imagery, and thematic maps will be available through this system.

The digital products will be available in the form of either computer compatible tapes or line printer maps. Both the tapes and the line printer maps can consist of the same data modes as the photographic products, that is, the bulk imagery, the corrected imagery, the classified imagery, or the thematic imagery. In this manner, the user has the capability to order the digitally manipulated data in the precise form which is most suitable to his specific application.

The statistical products available should be items such as acreage counts and percentages of a given area covered by any given land cover class. The acreage counts would be useful in determining items such as crop yield or area of water in a certain region. The percentages would give the distribution of various land cover categories within a given area.

2.3 Technical Alternatives for the Processing of Land Cover Data

Of the four phases in the conceptual framework of the Land Cover Information System, two are highly sensitive to choices in technical alternatives for the processing of the land cover data: (1) the preprocessing and interpretation and (2) the dissemination and storage. If we assume that the storage and archive system will be strictly digitized, then only the preprocessing and interpretation would be highly impacted by technology choices.

2.3.1 Capabilities of Data Processing Alternatives

A major choice encountered in the establishment of a data processing system is whether to employ manual photographic techniques or automated digital techniques in preprocessing and interpretation of the data. The capabilities of the two systems vary significantly in their ability to discern levels of detail in land cover information. Using strictly ERTS multispectral imagery, both have demonstrated the capability to interpret the data for Level I at 1:500,000 of the USGS Circular 671 scheme. The manual techniques have distinguished selected Level II categories from ERTS imagery but not to the overall consistancy required.* Automated classification techniques on ERTS imagery have demonstrated the capability to consistantly extract all the Level II information at 1:125,000** except for the urban category. The problems encountered in this category are largely due to the classification scheme and not to either processing technique. At any scale, large flat top buildings with parking lots and main access roads could be associated either with an industrial park or a commercial area; and without a prior knowledge of the area, the distinction is nearly impossible.

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* See references 1,6,8 and 9 on page III-19.

** See references 10,13,14,15,17 on page III-20.

Using aircraft multispectral scanner data, manual techniques have demonstrated the capability to extract Levels I and II information while automated techniques can discern Levels I, II, and III. The ground truth data, by assumption, will be manually interpreted to extract each of the three levels of information. These capabilities are summarized in Table 2.2.

2.3.2 Problems in Classificiation

As previously mentioned, a major difficulty encountered in the classification of remote sensor imagery is the strict compatibility of the categories to the available information. The USGS Circular 671 attempted to define a classification scheme compatible to remotely sensed data given in Table 2.3.

Table 2.2 **Projected Sensor Capabilities For Acquiring Information At Various Levels of Detail**

Manual Processing				**Automatic (Computer) Processing**			
	ERTS	**HA**	**GT**		**ERTS**	**HA**	**GT**
Level I	✓	✓	✓	**Level I**	✓	✓	✓
Level II		✓	✓	**Level II**	✓	✓	✓
Level III			✓	**Level III**		✓	✓

The category which has presented the most consistent difficulties to remotely sensed data is the USGS designated Level I and II Urban category. In particular, the major point of difficulty is the recognition of the specific categories of industrial, commercial, and services. The differences between these physical plants are in general virtually, and visually, indistinguishable. The current method for the discrimination of these categories is the association of objects surrounding the point in question. Thus, a commercial area is identified not only by the large flat asphalt roofs of the buildings but also by parking lots and main access

Table 2.3 Sources and Scales of Land Cover Information by Level of Detail

Level	Source	Scale
I	Satellite	1:1,000,000 - 1:250,000
II	Satellite and high altitude	1:250,000 - 1:50,000
III	Medium altitude, topographic maps, substantial supplemental information	1:50,000 - 1:15,000
IV	Low altitude, mainly supplemental information	1:15,000 - 1:1

Source: Adopted from U.S.G.S. circular 671 roads. Unfortunately, industrial parks have the exact same characteristics as do certain service installations; and all classificiation techniques are destined to failure without ground confirmation.

2.3.3 Preprocessing

The preprocessing stage, which consists of refining the geometric and radiometric qualities of the imagery, assures that the images are geometrically fitted as near as possible to their actual cartographic locations and that the density of the image is rendered consistent. In manual techniques, these corrections are completed but with a significant loss of the resolution of the first generation imagery; the largest scale that will comply with National Map Accuracy Standards using manual techniques is 1:500,000 - 1:250,000. Using digital techniques, a program was created which geometrically, sufficiently corrects ERTS imagery in order to correspond to National Map Accuracy Standards at a scale of 1:250,000 - 1:125,000. These manual and automatic accuracies correspond to an average rms error of 115 and 60.6 meters, respectively. The capability to digitally photomosiac has recently also been impressively demonstrated by the International Business Machines

Corporation in a project funded by the Bureau of Land Management where they digitally merged eight ERTS frames from successive two days into one large (4 x 2) image. Both the geometric and radiometric characteristics of the images are comparable to those of a single frame.

The major source of the difference between the systems in the maximum locational accuracy is that the manual corrections are done through photographic fitting techniques during which the imagery becomes very distorted at the extreme large scales. Digital techniques, on the other hand, employ a procedure which examines the individual pixels and fits them to their most likely positional location in a manner to minimize the overall locational rms error.

2.3.4 Interpretation

The interpretation phase of data processing should be carried out by a special purpose computer which is designed solely to process the land cover information since at least an order of magnitude decrease in computer time should be possible over the other alternative systems. This technology corresponds to the experimental MIDAS system currently in testing by the Environmental Research Institute of Michigan which uses a parallel processing computer. (Other established methods are the table look-up approach and the maximum likelihood classifier.) These three alternative classifiers have sufficiently demonstrated* that they will be cost effective over the manual techniques when operational demand is considered. The accuracy and reproducibility of results in the automatic mode are also superior to the manual mode.

The approximate order of magnitude of the speed in the alternative processing procedures in the MIDAS system, table lookup, and the maximum likelihood is 1:20:300 times the processing time. All of these techniques employ a supervised classification scheme. It is highly likely that in the future development of the state of the art that an unsupervised (clustering) method of classifying land cover information will be sufficiently developed to replace the supervised techniques. The tradeoff is that the unsupervised techniques require more computer time but less man hours to process an image, but present day experience with unsupervised classifiers does not warrant their immediate preferability to the supervised techniques.

The major portion of errors in the automated techniques arises in the human supervision stage which is the definition of training samples. If the supervision is not

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* See references 10,14,15,16,17

accurate, then the algorithms cannot be accurate in their classifications. Furthermore, for an established automatic technique, poor classification accuracy statistics can usually be traced to the human definition of training samples (i.e. the characteristics which define the spectrally homogeneous group). Unsupervised techniques should help to alleviate these errors by grouping strictly by spectral homogeneity and leaving only the definition of these homogeneous regions to the interpreter.

3. DEMAND FOR LAND COVER INFORMATION

3.1 Characteristics of Land Cover Information Demand

The analysis of the demand for remotely sensed land cover information focuses on four major characteristics of user demand: area of target, timeliness of information, frequency of update, and level of information detail. The target area refers to the percentage of the United States that must be covered to satisfy a specific demand requirement. Though actual user desired targets vary continuously from small regions in the United States to the full United States, this analysis classifies user demand into one of four area requirement categories: 100%, 10%, 1% or .1% of the United States. Timeliness of information (also called the user time window) refers to the maximum allowable elapsed time (in days) during which the acquisition of desired land cover information must be completed in order to satisfy the user. This important characteristic varies from once every five years to weekly. The frequency of coverage refers to the number of times that targets of a given size, timeliness requirement, and level of detail are to be covered during one year. Note that the frequency of coverage is a composite of users who want repeated coverage of a given target area as well as users who want one-time coverage of targets of a given size which are geographically or temporally distinct. The level of information detail reflects the scale required which, in turn, is determined by the amount of information needed to fulfill the user requirement. This characteristic of demand is complex; it requires further discussion.

For the purpose of this study the level of detail is defined as the type of land cover information that can be obtained from remotely sensed data at several fixed map scales. The information may be obtained from either aerial photography or remotely sensed digital data. The three levels of information detail (I, II and III) correspond to the map scales of 1:500,000, 1:125,000 and 1:24,000. Land cover as defined in this study includes a broad range of earth resource fields, each with its own unique classification scheme. Table 3.1 lists the various land cover categories that apply to the requirements of the Federal statutory demands. The level of detail assigned to these categories reflects the estimated scale needed to obtain that information. Of greatest importance are the land use inventory categories Levels I and II, these categories correspond to the Levels I and II of the U.S.G.S. Circular 671 land use classification scheme. For land cover information to be of value, the U.S.G.S. Circular 671 recommends an interpretation accuracy level of 90%. In this study this minimum accuracy requirement is imposed on all three sensors ERTS, high and low altitude aircraft. As discussed in Chapter 2, the capabilities of ERTS, high altitude aircraft and ground truth (low altitude aircraft with ground follow up teams) to acquire information at various levels of detail depend upon the interpretation technique that is utilized.

Table 3.1 Land Cover Categories Related to Federal Statutory Demands

INFORMATION DETAIL LEVEL

1	2	3	
			(LAND USE INVENTORY)
A.			Urban and Built-up Land
	1.		Residential
		a.	Single family (high density)
		b.	Single family (low density)
		c.	Multiple family (low density)
		d.	Multiple family (high density)
	2.		Commerical and Services (Including Institutional)
		a.	Type of Services
	3.		Industrial
		a.	Type of Industry
	4.		Extractive (Excluding strip mining, quarries, and gravel pits, etc.)
	5.		Transportation, Communications, and Utilities
	6.		Mixed (Including Strip and Clustered Settlement)
	7.		Open and Other
B.			Agricultural Land
	1.		Cropland and Pasture
		a.	Crop Type
	2.		Orchards, Groves, Vineyards, and Ornamental Horticultural Areas
		a.	Crop Type
	3.		Confined Feeding Operations
	4.		Other
C.			Forestland
	1.		Deciduous
		a.	Vegetation Community
	2.		Evergreen (Coniferous and Other)
	3.		Mixed
D.			Wetland
	1.		Forested
		a.	Vegetation Community
	2.		Non-Forested
		a.	Type
		b.	Permanence
E.			Rangeland
	1.		Herbaceous Range
		a.	Vegetation Community
	2.		Shrub-Brushland Range
	3.		Mixed
F.			Water
	1.		Streams/Rivers
	2.		Lakes
	3.		Reservoirs
	4.		Bays and Estuaries
	5.		Other

Table 3.1 Land Cover Categories Related to Federal Statutory Demands (Continued)

INFORMATION DETAIL LEVEL

1	2	3	
			(LAND USE INVENTORY) Continued
G.			Tundra
H.			Permanent Snow, Icefields, and Glaciers
I.			Barren Land
	1.		Salt Flats
	2.		Beaches (Including Mudflats)
	3.		Sandy Areas Other than Beaches
	4.		Bare Exposed Rock
	5.		Strip mines, quarries, and gravel pits
	6.		Transitional Areas
	7.		Other
			(SOIL CLASSIFICATION)
A.			Groups
	1.		Families/Associations
		a.	Types
			(MINERAL DEPOSITS)
A.			Surface (Extant)
	1.		Strip Mines
		a.	Ore Type
		b.	Ore Quality (Economic Significance)
	2.		Quarrying
	3.		Potential Deposits (Areas)
B.			Subsurface
	1.		Metallic
		a.	Type
		b.	Quality
	2.		Fossil Fuels (Excluding Petroleum)
	3.		Petroleum
	4.		Geothermal
	5.		Other Non-Metallic

Table 3.1 Land Cover Categories Related to Federal Statutory Demands (Continued)

INFORMATION DETAIL LEVEL

1	2	3	
			(GEOLOGIC STRUCTURE)
A.			Anticlines
B.			Snyclines
C.			Domes
D.			Barriers
E.			Folds
F.			Fault
G.			Fractures
H.			Lineaments
I.			Karst Topography
J.			Bedding
K.			Schistosity
L.			Stratigraphy
M.			Circular Features
			(LITHOLOGY)
A.			Sedimentary
	1.		Chemical
		a.	Type
	2.		Granular
		b.	Type
B.			Metamorphic
	1.		Type
C.			Igneous
	1.		Intrusive
		a.	Type
	2.		Extrusive

Table 3.1 Land Cover Categories Related to Federal Statutory Demands (Continued)

INFORMATION DETAIL LEVEL			
1	2	3	
			(WATER)
A.			Standing
	1.		Lakes (Permanent)
		a.	Quality
		b.	Suspended Materials
		c.	Circulation Patterns
		d.	Volume
	2.		Lakes (Ephemeral)
	3.		Wetlands (Vegetated)
	4.		Wetlands (Non-Vegetated)
	5.		Reservoirs
B.			Flowing
	1.		Rivers
	2.		Streams
	3.		Creeks
			(WATERSHEDS/DRAINAGE BASINS)
A.			Mapping
B.			Permanence (Perrenial, Seasonal, Ephemoral)
C.			Discharge (3 Categories)
	1.		5 Categories
		a.	7 Categories
D.			Flood Potential (3 Categories)
E.			Erosion Potential (3 Categories)
F.			Sediment Transport (3 Categories)
			(SLOPE)
A.			3 Categories
	1.		5 Categories
		a.	7 Categories
			(GEOGRAPHIC ASPECT)
A.			No Level I
	1.		4 Categories
		a.	8 Categories

Table 3.1 Land Cover Categories Related to Federal Statutory Demands (Continued)

INFORMATION DETAIL LEVEL

1	2	3	
			(GEOMORPHIC FORM)
A.			Plains
	1.		Specific Environments (Lithic, Structural, Erosional and Depositional Processes)
		a.	Specific Form (Area Dependent)
B.			High Table Lands
C.			Mountains
D.			Widely Spaced Mountains
E.			Hills
F.			Depressions
			(DRAINAGE PATTERN)
A.			Trellis
B.			Derdritic
C.			Rectangular
D.			Radial
E.			Annular
F.			Irregular
			(VEGETATION TYPE)
A.			Forest
	1.		Vegetation Community
		a.	Association/Species
B.			Grass
C.			Shrub
D.			Desert
E.			Agriculture
			(COASTAL ZONE WATER FEATURES)
A.			Bays
	1.		Circulation Pattern
	2.		Erosion Deposition
	3.		Volume of Runoff
	4.		Wind Effects
	5.		Tidal Effects
	6.		Upwellings
B.			Estuaries
	1.		Circulation Pattern
	2.		Erosion Deposition
	3.		Volume of Runoff
	4.		Wind Effects
	5.		Tidal Effects
	6.		Upwellings
	7.		Saltwater/Fresh Water Delineation

Table 3.1 Land Cover Categories Related to Federal Statutory Demands (Continued)		
INFORMATION DETAIL LEVEL		
1	2	3
C.		Oceans
	1.	Circulation Pattern
	2.	Erosion Deposition
	3.	Volume of Runoff
	4.	Wind Effects
	5.	Tidal Effects
	6.	Upwellings
	7.	Ice Quantity

Extracted from Earth Satellite Corporation, Interim Report - Analysis of Costs and Benefits from Use of ERS Data in State Land Use Planning, Study for the U.S. Department of Interiors, Geological Survey, May 1974.

3.2 Federal Statutory Demand For Land Cover Information

Federal statutory demand for remotely sensed land cover information is described in detail in Sections A and B of Appendix II. This information has been condensed into four demand matrices representing the number of units of demand created by the "land use planning community only" and, separately, "all land cover users" for both the 1974 and 1977 time periods. The four demand matrices used for the analysis of federal statutory demand for land cover information are presented in Tables 3.2 through 3.5.

The matrices reflect the information demands associated with specific Federal statutory requirements and information collection programs presently in operation within the Federal

Table 3.2 Federal Statutory Demand for Nationwide Land Cover Information (Frequency of Coverage) by Land Area and Level of Classification

Land Use Planning Community Only - 1974

Level of Classification Detail	Area Mapped and Classified			
	CUS & Alaska	1/10 CUS	1/100 CUS	1/1000 CUS
Level I	None identified	None identified	None identified	None identified
Level II	None identified	90 days 25	None identified	None identified
Level III	1 year once every 5 years	90 days 1	90 days 2	15 days 54

Legend: The numbers in the lower portion of each cell represent the indicated annual frequency of coverage. Overlapping demand requirements of Federal users have been omitted. (See discussion of primary and secondary users on page 3-15.) The numbers in the upper portion of each cell represents indicated user timeliness requirements.

Note: CUS refers to Continental United States

Table 3.3 Federal Statutory Demand for Nationwide Land Cover Information (Frequency of Coverage) by Land Area and Level of Classification Detail

All Land Cover Users - 1974

Level of Classification Detail	Area Mapped and Classified			
	CUS & Alaska	1/10 CUS	1/100 CUS	1/1000 CUS
Level I	None identified	None identified	None identified	None identified
Level II		90 days 25	None identified	None identified
Level III	1 year Once every 5 years	90 days 2	7 days 67	15 days 117

Legend: The numbers in the lower portion of each cell represent the indicated annual frequency of coverage. Overlapping demand requirements of Federal users have been omitted. (See discussion of primary and secondary users on page 3-15). The numbers in the upper portion of each cell represents indicated user timeliness requirements.

Note: CUS refers to Continental United States

Table 3.4 Federal Statutory Demand for Nationwide Land Cover Information (Frequency of Coverage) by Land Area and Level of Classification Detail

Land Use Planning Community Only - 1977

Level of Classification Detail	Area Mapped and Classified			
	CUS & Alaska	1/10 CUS	1/100 CUS	1/1000 CUS
Level I	None identified	None identified	None identified	None identified
Level II	90 days 4	None identified	None identified	7 days 100
Level III	1 year once every 5 years	1 year 1	90 days 2	15 days 104

Legend: The numbers in the lower portion of each cell represent the indicated annual frequency of coverage. Overlapping demand requirements of Federal users have been omitted. (See discussion of primary and secondary users on page 3-15). The numbers in the upper portion of each cell represents indicated user timeliness requirements.

Note: CUS refers to Continental United States

Table 3.5 Federal Statutory Demand for Nationwide Land Cover Information (Frequency of Coverage) by Land Area and Level of Classification Detail

All Land Cover Users - 1977

	Area Mapped and Classified			
Level of Classification Detail	CUS & Alaska	1/10 CUS	1/100 CUS	1/1000 CUS
Level I	None identified			
Level II	90 days	15 days	7 days	7 days
	4	12	52	100
Level III	1 year	90 days	30 days	7 days
	once every 5 years	2	17	268

Legend: The numbers in the lower portion of each cell represent the indicated annual frequency of coverage. Overlapping demand requirements of Federal users have been omitted. (See discussion of primary and secondary users on page 3-15). The numbers in the upper portion of each cell represents indicated user timeliness requirements.

Note: CUS refers to Continental United States

government. The 1974 "land use community only" demand matrix specifies the number of demand units needed to fulfill the requirements of the Federal users whose existing programs are used principally for land use planning purposes. The long timeliness requirements and the low amount of demand in level III reflects a limited number of programs with broad, easily satisfied requirements. The 1974 demand matrix for "all land cover users" specifies the number of demand units created when the requirements of the broad land cover management users are combined with those of the land use planning community only. The large increase in demand in the small area categories (1% and .1%) reflects a large number of specific projects covering a small, unique area that are needed today to fulfill the land cover management information demands. The demand analysis for the 1977 land use planning community time frame indicates a significant shift in both the level of information detail and in the quantity of land cover information. The vast majority of the projected 1977 Federal agency land cover demand under existing statutes is for Level II information. This shift in demand arises chiefly from the requirements of Land Inventory and Monitory (LIM) programs of the Soil Conservation Service of the U.S. Department of Agriculture. The statutory basis for this program is the Rural Development Act of 1972. The LIM program is itself a central data bank system for resource management information used and collected by USDA. Under the statutory requirement, we project an annual demand for four time coverage of the entire U.S. at Level II, seasonally, i.e. within 90 days.

The 1977-all land cover users information matrix gives the number of units of demand created when future requirements of the land cover management users are combined with those of the land use planning community only. The increase in demand for level II information which occurs for target areas of 10% and 1% of the U.S. reflects a demand for a periodic monitoring capability to supplement the existing programs. The large increase in the small area categories of level III reflects an anticipated increase in demand for land cover information by 1977.

The units of demand given in the four demand matrices represent the requirements of so called primary users only. These are users whose requirements cannot be satisfied by the information collection program of any other users. In addition, there are many so called secondary users whose requirements can be satisfied by one or more primary users. The procedure used to condense the Federal statutory demand given in Appendix II into the primary users for each of the four matrices was one of elimination of overlapping data gathering requirements. This procedure assumes that a well-coordinated data collection program would be implemented by the various federal agencies and departments in order to reap the benefits of a nationwide land cover information system. The demand characteristic of each statute noted in Section A and B of Appendix II was compared to every other statute to determine which statutory demands could be satisfied by others. For example, the Flood Control Act of 1960 requires that flood damage be assessed for all major floods in the United States. To satisfy this requirement by 1977, Level II information will be needed within one week for the estimated 100 flood occurrences during a year. The National Flood Insurance Act of 1968 requires information on these same flood occurrences at the same level of detail. Thus, when imagery is obtained to satisfy the Flood Control Act demand it can also be used to satisfy the National Flood Insurance Act demand.

By process of elimination, the primary -rs noted in Tables 3.6 and 3.7 were determined. Of the primary users listed, those shown in Tables 3.8 and 3.9 satisfied the requirements of the secondary users listed below each primary user.

Table 3.6 1974 Primary Federal Users Listed By Level of Detail and Size of Area Affected

Level II - 10% of U.S.
- * Dam Safety Act

Level III - 100% of U.S.
- * Rural Development Act of 1972 (L.I.M. Program)

Level III - 10% of U.S.
- * Geological Survey (Topographic Mapping)
- Food and Agricultural Act of 1965

Level III - 1% of the U.S.
- * Forest Resources Act
- * Housing Act of 1954, as amended
- Plant Disease and Pest Control Act
- Geological Survey (Mineral Exploration)
- Fish and Wildlife Act of 1950
- Water Resources Planning Act, Alaskan Water Resources
- Federal Water Pollution Control Act of 1972

Level III -.1% of the U.S.
- * Water Bank Act
- * Bureau of Land Management
- * Taylor Grazing Act
- * Watershed Protection and Flood Protection Act
- * Flood Control Act of 1960
- Forest Pest Control Act
- Soil Survey Act
- Coal Mine Fire Safety Act

Detailed information for primary Federal users can be found in sections A and B of Appendix II.

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

Table 3.7 1977 Primary Federal Users Listed By Level Of Detail And Size Of Area Affected.

Level II - 100% of the U.S.
- * Rural Development Act of 1972 (L.I.M. Program)

Level II - 10% of the U.S.
- Statistical Reporting Service

Level II - 1% of the U.S.
- Federal Water Pollution Control Act of 1972

Level II - .1% of the U.S.
- * Flood Control Act of 1960

Level III - 100% of the U.S.
- * Rural Development Act (L.I.M. Program)

Level III - 10% of the U.S.
- * Housing Act of 1954
- Food and Agriculture Act of 1965

Level III - 1% of the U.S.
- * Forest Resources Act
- * Cooperative Agreements for Surveys and Investigations
- Soil Survey Act
- Plant Disease and Pest Control
- Geological Survey (Geologic Mapping)
- Geological Survey (Mineral Exploration)
- Fish and Wildlife Act of 1950
- Water Resources Planning Act, Alaskan Water Resources

Level III - .1% of the U.S.
- * Water Bank Act
- * Bureau of Land Management
- * Taylor Grazing Act
- * Watershed Protection and Flood Protection Act
- * Flood Control Act of 1960
- Forest Pest Control Act
- Coal Mine Fire Safety Act
- Federal Water Pollution Control Act of 1972

Detailed information for primary Federal users can be found in sections A and B of Appendix II.

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

Table 3.8 1974 Secondary Federal Users and Related Primary Federal Users Listed by Level of Detail And Size of Area Affected

<u>Level III - 100 % of the U.S.</u>

- * Rural Development Act of 1972
  - * Agricultural Research Act
  - Soil Conservation Act of 1935

<u>Level III - 10% of the U.S.</u>

- * Geological Survey (Topographic Mapping)
- Food and Agricultural Act of 1965
  - Agricultural Adjustment Act of 1938 (Cotton)
  - Agricultural Adjustment Act of 1938 (Peanuts)
  - Federal Reclamation Law

<u>Level III - 1% of the U.S.</u>

- * Forest Resources Act
  - * Timber Development Organization
  - * Clarke McNary Act
  - * National Wilderness Preservation System
  - * Oregon and California Grant Lands
- Fish and Wildlife Act of 1950
  - Fish and Wildlife Act of 1949
  - Fish and Wildlife Act

<u>Level III - .1% of the U.S.</u>

- * Housing Act of 1954
  - * National Flood Insurance Act of 1968
  - * Cooperative Agreements For Surveys and Investigations

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

Table 3.8 1974 Secondary Federal Users and Related Primary Federal Users Listed By Level Of Detail And Size of Area Affected (Continued)

<u>Level III - .1% of the U.S.</u>

- * Water Bank Act
    - * Fish and Wildlife Act of 1956
- * Taylor Grazing Act
    - * Oregon and California Grant Lands
- * Watershed Protection and Flood Protection Act
    - American-Mexican Chamiza Convention Act of 1964

The following acts have extremely broad information requirements that are satisfied by the joint demands of several primary federal users.

- * Outdoor Recreation Act
- * Water Resources Planning Act
- Geological Survey (Geological mapping)
    - Extension of Cooperative Work to Puerto Rico
- Wildlife Protection from Pollution
- Statistical Reporting Service
- Agricultural Marketing Act of 1946
- Cotton Act

Detailed information for secondary users can be found in Sections A and B of Appendix II.

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

Table 3.9 1977 Secondary Federal Users And Related Primary Federal Users Listed By Level Of Detail And Size Of Area Affected.

<u>Level II - 100% of the U.S.</u>

- * Rural Development Act of 1972 (L.I.M. Program)
  - * Water Bank Act
  - * Agricultural Research Act
  - * Fish and Wildlife Act of 1956
  - * Forest Resources Act
    - * Timber Development Organization
    - * Clark-McNary Act
    - * National Wilderness Preservation Act
    - * Oregon and California Grant Lands
  - * Taylor Grazing Act
  - * Water Resources Planning Act
  - * Watershed Protection and Flood Protection Act
  - * Cooperative Agreements For Surveys and Investigations
  - Water Resources Planning Act, Alaskan Water Resources
  - * Dam Safety Act
  - American-Mexican Chamizal Convention Act of 1964
  - * Housing Act of 1954
  - Soil Conservation Act
  - * Geological Survey (Topographic Mapping)
  - Geological Survey (Geological Mapping)
  - Geological Survey (Mineral Exploration)
  - Extension of Cooperative Work to Puerto Rico
  - Fish and Wildlife Act
  - Fish and Wildlife Act of 1950
  - Fish and Wildlife Act of 1949

<u>Level II - 10% of the U.S.</u>

- Statistical Reporting Service
  - Agricultural Marketing Act of 1954
  - Cotton Act
  - Plant Disease and Pest Control Act
  - Federal Reclamation Law
  - Forest Pest Control Act
  - Food and Agriculture Act of 1965
  - Agriculture Adjustment Act of 1938 (Cotton)
  - Agriculture Adjustment Act of 1938 (Peanuts)

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

Table 3.9 1977 Secondary Federal Users And Related Primary Federal Users Listed By Level Of Detail And Size Of Area Affected. (Continued)

<u>Level II - .1% of the U.S.</u>
- * Flood Control Act of 1960
  - * National Flood Insurance Act of 1968

<u>Level III - 100% of the U.S.</u>
- * Rural Development Act (L.I.M. Program)
  - * Agricultural Research Act
  - * Geological Survey (Topographic Mapping)
  - * Dam Safety Act
  - Soil Conservation Act

<u>Level III - 10% of the U.S.</u>
- * Housing Act of 1954
  - * National Flood Insurance Act
- Food and Agriculture Act of 1965
  - Agricultural Adjustment Act of 1938 (Cotton)
  - Agricultural Adjustment Act of 1938 (Peanuts)
  - Federal Reclamation Law

<u>Level III - 1% of the U.S.</u>
- * Forest Resources Act
  - * Timber Development Organization
  - * Clarke - McNary Act
  - * National Wilderness Preservation System
  - * Oregon and California Grant Lands
- Fish and Wildlife Act of 1950
  - Fish and Wildlife Act of 1949
  - Fish and Wildlife Act
- Geological Survey (Geologic Mapping)
  - Extension of Cooperative Work to Puerto Rico

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

Table 3.9 1977 Secondary Federal Users And Related Primary Federal Users Listed By Level Of Detail And Size Of Area Affected. (Continued)

Level III - .1% of the U.S.

* Water Bank Act
  - Fish and Wildlife Act of 1956

* Taylor Grazing Act
  - Oregon and California Grant Lands

* Watershed Protection and Flood Protection Act
  - American-Mexican Chamizal Convention Act of 1964

The following acts have extremely broad information requirements that are satisfied by the joint demands of several primary federal users.

* Water Resources Planning Act
* Outdoor Recreation Act
  Wildlife Protection from Pollution
  Statistical Reporting Service
  - Agricultural Marketing Act of 1946
  - Cotton Act

Detailed information for secondary users can be found in Sections A and B of Appendix II.

* Federal statutory demand for remotely sensed land cover information related to land use planning only.

3.3 Projections of Future Demand for Resource Management Needs

Federal statutory demand for land cover information constitutes only a segment of the total demand. The entire land cover user community includes not only Federal users but state government; regional and local governmental units; commercial and academic users. In a separate ECON report we document the sources of demand for land cover information arising from resource management needs. An indication of the scope of this demand is given in Table 3.10 which list eight Resource Management Areas. Each Resource Management Area has been further subdivided according to the Resource Management Activities listed in Table 3.11. Table 3.12 provides an example of the classification of the Resource Management Area - Inland Water Resources by Resource Management Activities.

A quantitative assessment of the future demand for land cover information arising from resource management needs is difficult given the broad scope of user types. Therefore, a parametric analysis of user demand will be conducted over a range of information requirements that are considered to be feasible during the period of an operational nationwide land cover information system. The parametric demand analysis will focus mapping the land over the entire continental U.S. and Alaska at Level II information detail and at annual coverage frequency ranging from four times, each coverage within ninety days to twelve times, each coverage within thirty days.

Table 3.10 Resource Management Areas	
1.	Intensive Use of Living Resources: Agriculture
2.	Extensive Use of Living Resources: Forestry, Rangeland and Wildlife
3.	Inland Water Resources
4.	Land Use
5.	Nonreplenishable Natural Resources: Minerals, Fossil Fuels and Geothermal Energy Sources
6.	Atmosphere
7.	Oceans
8.	Industry

Table 3.11 Resource Management Activities	
1.	Cartography, Thematic Maps and Visual Display
2.	Statistical Services
3.	Calendars
4.	Allocation
5.	Conservation
6.	Damage Prevention and Assessment
7.	Unique Event Recognition and Early Warning
8.	Research
9.	Administrative, Judicial and Legislative

Table 3.12 Example Classification of Resource Management Area - Inland Water Resources		
Resource Management Activity		
3.1	Cartography, Thematic Maps and Visual Displays	
	3.1.1	Map and survey free water areas
	3.1.2	Map and survey snow, ice and glacier
	3.1.3	Map and survey ground water and other acquifiers bound in the hydrological cycle
	3.1.4	Map watershed areas
	3.1.5	Map water pollution
	3.1.6	Map potential water impoundment areas
3.2	Statistical Services	
	3.2.1	Predict fresh water supplies and floods
	3.2.2	Inventory fresh water supplies and snow cover
	3.2.3	Gather information for hydrological models of water impoundment areas and free water areas
	3.2.4	Inspect water impoundment areas
	3.2.5	Monitor stream salinity and pollution
	3.2.6	Monitor thermal pollution of free water
3.3	Calendars	
	3.3.1	Monitor changes in free water areas
	3.3.2	Monitor changes in snow, ice and glaciers
	3.3.3	Monitor changes in ground water and acquifiers
	3.3.4	Monitor evapo-transpiration, soil moisture and water drainage patterns
	3.3.5	Monitor cyclical pollution patterns

Table 3.12 Example Classification of Resource Management Area - Inland Water Resources (cont'd)

3.4	Allocation	
	3.4.1	Manage water impoundment systems - for power generation
	3.4.2	Manage water impoundment systems - for flood control
	3.4.3	Manage water impoundment systems - for urban water supply
	3.4.4	Manage water impoundment systems - for commercial and agricultural water supply
	3.4.5	Manage water impoundment systems - for recreational purposes
	3.4.6	Manage water impoundment systems - for navigation
	3.4.7	Plan changes in drainage and water impoundment systems
3.5	Conservation	
	3.5.1	Conserve fresh water resources
3.6	Damage Prevention and Assessment	
	3.6.1	Assess and reduce flood damage
	3.6.2	Reduce damage to water impoundment systems from silting and sedimentation
	3.6.3	Reduce pollution of free water
3.7	Unique Event Recognition and Early Warning	
	3.7.1	Provide early warning of disastrous floods
	3.7.2	Provide early warning of lake eutrophication
	3.7.3	Monitor changes in surface water supply due to geological changes

Table 3.12 Example Classification of Resource Management Area - Inland Water Resources (cont'd)

3.8	Research
	3.8.1 Conduct hydrological research
	3.8.2 Conduct flood control research
	3.8.3 Conduct water pollution research
3.9	Administrative, Judicial and Legislative
	3.9.1 Design government programs to reduce flood damage
	3.9.2 Increase compliance with water pollution regulations
	3.9.3 Aid in designing legislative controls for policy implementation
	3.9.4 Aid in planning government projects for future water supply

CHAPTER 4.0

QUANTITATIVE ECONOMIC ANALYSIS

4.1 The Framework of the Economic Analysis

In trying to apply economic principles when determining the value of satellite systems, the analysis is hampered by one major drawback when compared to the economic evaluation of other systems: there does not, at present, exist in the United States economy any "free" market where the demand for satellites and the supply of satellites are determined by the interplay of many consumers and many producers. Rather, we find a situation similar to that of Department of Defense decisions where major consumers are government agencies such as the National Aeronautics and Space Administration and the Department of the Interior. On the supply side, we find, at most, ten to twelve major companies competent to compete for major aerospace hardware systems. Thus, huge investment expenditures are decided on the basis of technical criteria, political processes, national priorities, etc.

This restriction in the number of buyers and sellers does not mean that economic decisions made in such an environment have to be less rational than those made in the free market. However, the means of arriving at economic decisions is different. The basic assumption of an economic analysis in the absence of market indicators is, and has to be, that the decisions on the actual budgets -- the budgets for the 1970's and the 1980's -- do reflect in effect national priorities. One has to assume further that, within each agency, the programs selected for implementation outrank, in priority, projects not undertaken by the agency. In other words, we have to make the assumption that the resources allocated to space sensing activities by NASA are efficient in an economic sense; that the needed resources of NASA are minimized to achieve a given capability demanded by Congress or the Administration -- i.e., cost minimization is achieved -- or, given the resources allocated to NASA, a maximum capability is developed with these funds within NASA. Given that the agency funds compete with other programs within the same agency, the assumption of economic efficiency within each agency is not completely unreasonable. In this analysis, we do not have to assume that the budget level is optimal.

Given this basic assumption, cost-effectiveness analysis, in a strict sense, is only concerned with identifying technically feasible systems that assure either a maximum of ERS capability at any given budget level or a minimum cost for any given ERS capability. Although, in economic theory this task is rather straight-forward, in practice it proves very difficult to determine the cost-effective systems, either for the present technology or for the projected new ERS systems. Figure 4.1 shows a hypothetical example of the cost efficiency frontier for the ERS program in terms of 1975-80 technology. The vertical axis in Figure 4.1 represents the capability measured in terms of the number of images produced, and the horizontal axis measures the costs (the budgets

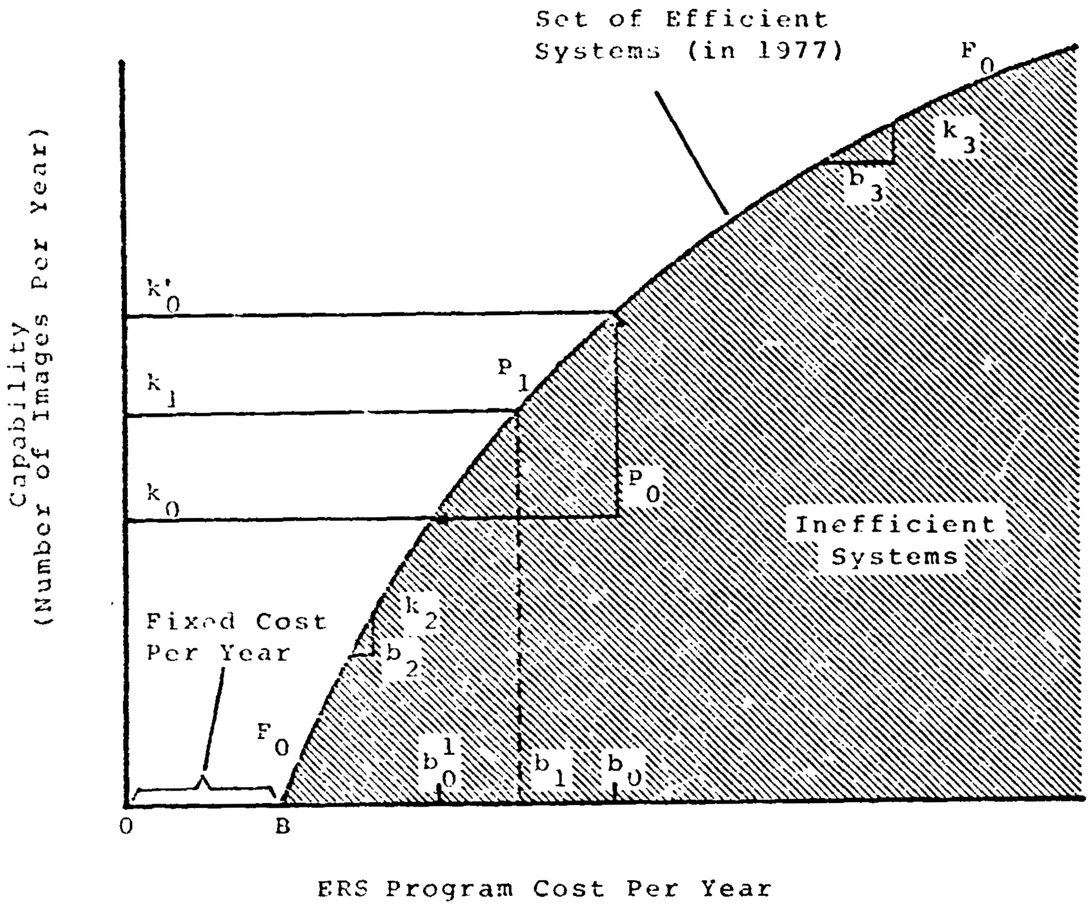

Figure 4.1 The Theoretical ERS Cost-Efficiency Frontier

required) to produce that number of images. The figure is basic to an understanding of cost-effectiveness calculations for analyzing the economics of ERTS-like satellites. The shaded area in Figure 4.1 shows the region of possible costs of ERS systems. That is, a given space sensing program capability of, say, k_1 can be delivered for a budget of b_1. The same capability, k_1, can also be produced for more than b_1. Such a cost-capability combination would lie to the right of k_1 in the shaded area shown in Figure 4.1 below the efficiency frontier (cost curve). Similarly, for the same budget of b_1, we could have a smaller ERS program, for example, a capability k_0. Again, these combinations would lie below the efficiency frontier within the shaded area of Figure 4.1. As we move from one point within the shaded area -- the feasible region of space sensing cost combinations -- toward the left and upward, we improve the economics of systems choice. Cost-effectiveness analysis is concerned with finding satellite sensing programs where no increased capability (more images at a fixed resolution produced per year) is possible without a corresponding increase in cost. The set of cost-efficient points -- the cost curve -- is shown by the boundary of the shaded area, F_0F_0, in Figure 4.1. By inspection, we see that P_0 -- a point not on the frontier -- is not cost-effective. The system P_0 requires a budget of b_0 and promises a capability of k_0. We can find other ERS programs different from P_0 that offer more capability or less cost or both.

One such program is shown at P_1 with a budget requirement of b_1 (smaller than b_0) and a capability of k_1 (larger than k_0).

From the shape of the cost efficiency frontier, we also observe that, by increasing the budget of the space sensing program, we increase the level of capability. But as we move out to larger and larger funding levels, any additional funding yields smaller and smaller increments in capability. In other words, the shape of the efficiency frontier reflects increasing incremental costs as the capability requirements of ERS expand. In Figure 4.1, two cases are shown to illustrate this point. The change in capability of Δk_2 is equal to the change in capability Δk_3 -- at a higher funding level. But the absolute increase in capability is bought at an increased incremental cost ($\Delta b_3 > \Delta b_2$). In many large-scale, advanced technologies, this efficiency frontier may well be a straight line over a considerable range of the cost efficiency frontier. The intercept of the efficiency frontier with the horizontal axis does indicate the minimum (fixed) costs of buying any amount of space sensing capability. Thus, a straight line efficiency frontier with a positive intercept at the cost (budget) line would indicate an ERS system with constant marginal (incremental) costs and decreasing average costs. The case shown in Figure 4.1 is more general and includes, in principle, the more specific case of the ERS systems.

We have focused the discussion thus far on the use of cost-effectiveness analysis for evaluating remote sensing systems. The task of benefit-cost analysis is more demanding. While cost-effectiveness analysis tries to identify the systems (for space sensing programs) along the "efficiency frontier" (the cost curve), benefit-cost analysis attempts to select a single space sensing program from all possible cost-effective candidates. To do this, however, we have to use a benefit (utility or value) measure of conceivable space sensing programs within the range of technology--a task we do not propose to solve and which may be an intractable task. Given information on the economic value of these programs, we can then, in theory, select on optimum space sensing program.

This choice process can be illustrated with the aid of Figure 4.2 which shows the cost curve and the benefit curve confronting the decision maker and the actual capability and cost levels of several space sensing programs. It should be noted, first of all, that the cost curve in Figure 4.2 differs from that shown in Figure 4.1. The latter denotes "recurring costs per year" as a function of "capability per year". The cost curve in Figure 4.2, on the other hand, refers to "total program costs over the entire planning horizon". Since "total program costs" are incurred over time, it must be assumed that all costs are adjusted for the time value of economic resources. The time stream of space sensing program benefits, summed up in the benefit curve, also is assumed to have been discounted appropriately.

Figure 4.2 illustrates the general relationship between the program costs and the program benefits. Observe that, at higher and higher levels of capability, additional information becomes increasingly more costly -- the incremental cost of information increases while, at the

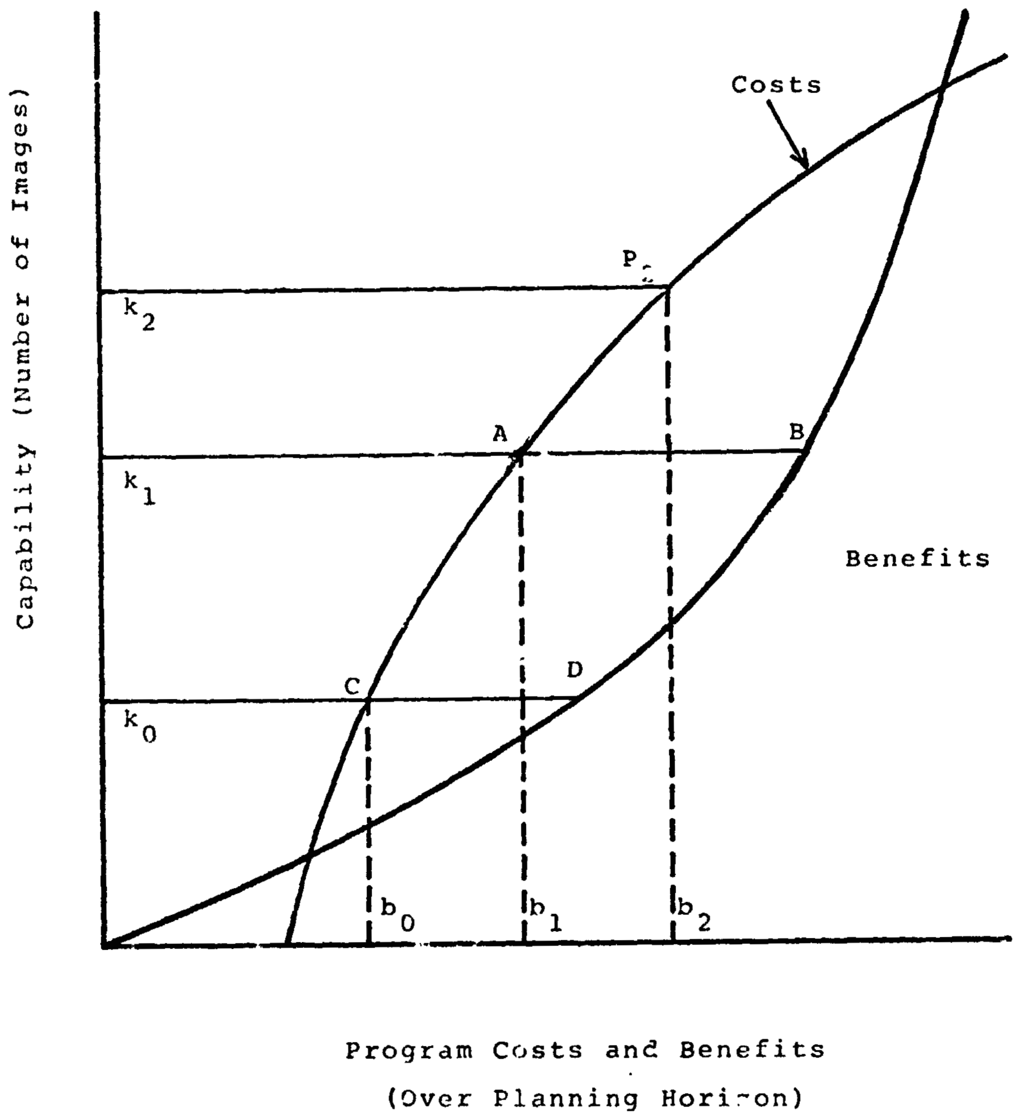

Figure 4.2 The Cost Benefit Relationship

same time, the incremental benefit derived becomes increasingly smaller. The assumption of progressively decreasing incremental benefits is based on the notion that successive additions to information will be less valuable and at some point may well reach a saturation point, which means that the benefit curve in Figure 4.2 will eventually become vertical.

At a given level of capability, say k_0, "net program benefit" is measured by the horizontal distance between the benefit and cost curves. In Figure 4.2, the net benefit at k_0 is given by the distance CD; at k_1, it is given by AB. Recall that the cost curve is really an efficiency frontier associating a given level of capability with the least cost ERS system which, with given technology, will provide that capability. The proper satellite program, therefore, is the one corresponding to the scenario at which the distance between the total benefit and the total cost curves, i.e., the total net benefit is maximized. It is the capability level at which the cost curve and the benefit curves have the same slope, i.e., at which incremental benefits are just equal to incremental costs. In Figure 4.2, this optimum satellite program is k_1.

Having established these fundamental points, we must observe that the benefit relationship of satellite programs within the range of technology cannot be measured quantitatively at present -- if it can ever be. It is for this reason that in this study we will employ cost-effectiveness analysis to determine the economic value of ERTS in establishment and maintenance of a nationwide land cover information system. The next section explains the economic analyses possible within the confines of cost-effectiveness analysis.

4.1 Equal Capability and Equal Budget Analysis of the ERTS System

The above general definition of cost-effectiveness analysis can be applied to the analysis of an ERTS-type satellite system. The ERTS program will change the efficiency frontier (cost curve of space information programs). In general, technological change will shift the efficiency frontier F_0F_0 of Figure 4.1 upward and toward the left -- i.e., it will lower costs or increase capabilities. Figure 4.3 shows that shift from F_0F_0 to F_1F_1. If the ERTS system brings about increased efficiency at larger scales of operation only, which appears to be a reasonable assumption, then the shift in F_0F_0 will take place only at larger cost/budget levels and leave the lower points of F_0F_0 more or less unchanged.

Therefore, within the confines of cost-effectiveness analysis (strictly defined), one may ask the following two questions:

(a) Equal capability efficiency for a given capability level: What are the net cost savings that can be achieved by adopting ERTS (for example, the distance P_0P_1)? (Figure 4.4).

(b) Equal budget efficiency: What increases in capability are brought about by ERTS at the same budget level after the new system has been introduced?

In this report, an equal capability approach is used for the benefit-cost evaluation of the land cover applications of ERTS.

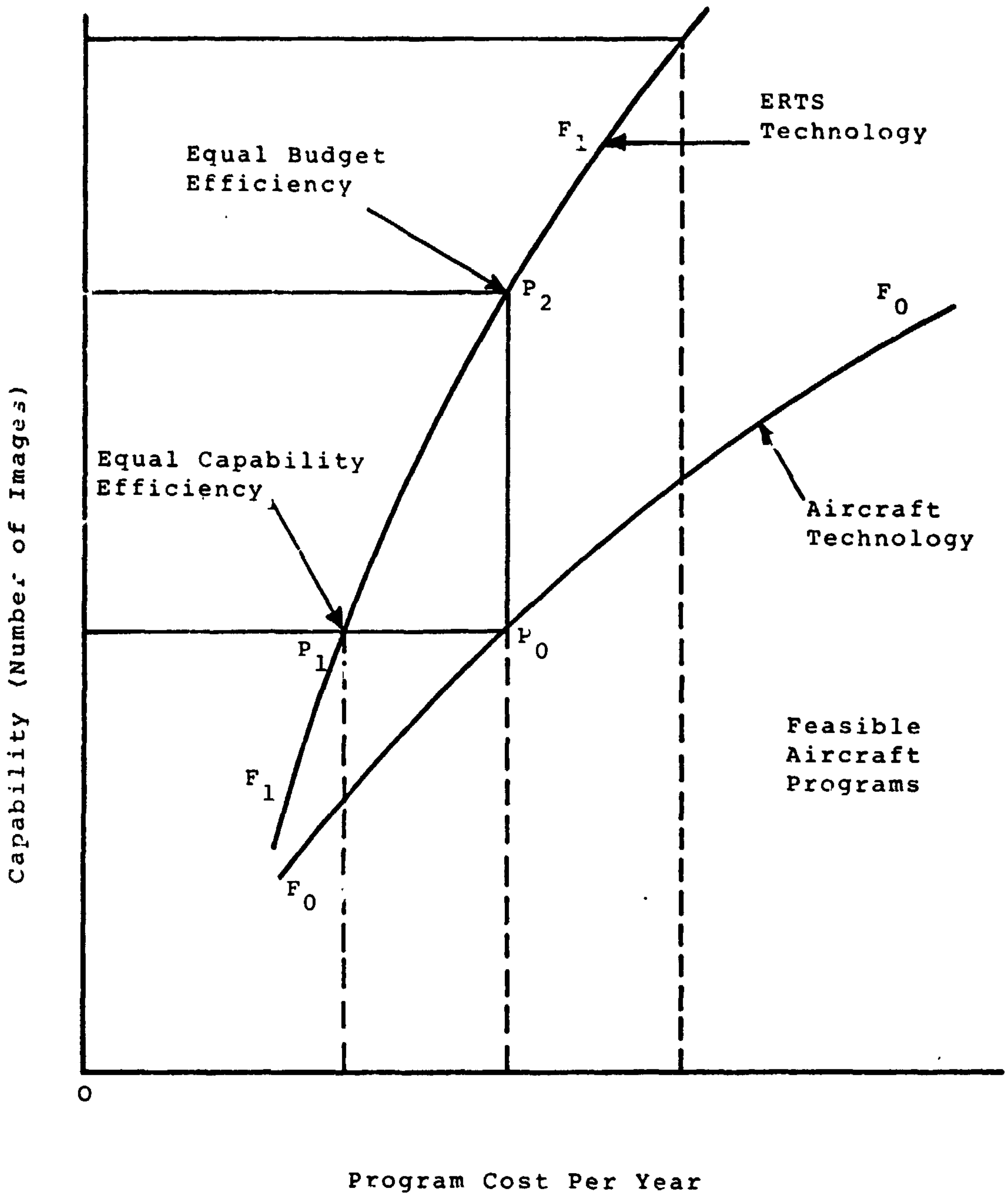

Figure 4.3 Cost-Effectiveness Analysis of Technological Change: The Case of ERTS

The equal budget approach could also be analyzed, but from both an empirical and theoretical standpoint, it would appear to be considerably more difficult to do. This difficulty primarily arises from the multi-dimensional characteristics of capability. Some acceptable and non-arbitrary scheme of weighting the different characteristics of capability would have to be derived before comparisons could be made using an equal budget approach. Therefore, it would be much more expensive and involve much greater risks to analyze ERS using an equal-budget approach. The same qualitative answer, i.e., whether to have or not to have an ERTS-type satellite system would occur with either type of approach, though the quantitative degree to which an ERTS-type satellite system makes a difference would differ with each approach.

This study will focus on life cycle cost comparisons for several "with satellite" remote sensing systems and several "without satellite" remote sensing systems (high altitude and/or low altitude aircraft systems with associated ground support teams). The "with" and "without" satellite systems are always compared at the <u>same</u> level of capability, but demand is varied parametrically about the expected level of Federal civil agency statutory demand to see what effect different levels of demand have on the relative merits of a "with" and "without" satellite system.

Demand for a satellite system can be viewed in the abstract as a demand for certain types of information. However, to simplify the analysis without distorting it in any essential way, it is necessary to move from the abstract representation of demand for information to an appropriate physical analog. Distortion will be avoided if the proper physical analog is chosen. For our purposes, the best unidimensional physical analog for quantity of information demanded appears to be the number of ERTS-type frames demanded.

Demand is subdivided into twelve categories. These categories are based on users requirements for geographical area of coverage, timeliness of information, the level of information detail and annual frequency of coverage. If demand were not subdivided in this manner, then a completely distorted analysis of the "with" and "without" satellite systems would emerge. This distortion would occur for two reasons: (1) it would be unreasonable and logically inconsistent to make an equal capability assumption, and (2) it would suppress the relative advantages and relative disadvantages of the satellite system for different categories of information.

Without subdivision of demand, the equal capability assumption could be set with requirements such that only the satellite, but not the aircraft, or only the aircraft, but not the satellite, could satisfy the demand requirements. The second reason why lumping all demand together would lead to a bad analysis is that the results obtained by using aggregate demand by definition omits certain information that would be available from disaggregate demand. Therefore, the results obtained from a disaggregate demand approach should be superior to those of an aggregate demand approach.

Total cost to meet all requirements using a mix of satellite, high and low altitude aircraft will be compared to total cost to meet all requirements using only high altitude and low altitude aircraft systems. If the total cost is less using the "with" satellite system over the "without" system, then there is a positive net benefit to having the ERTS-type satellite system, (namely, the equal capability cost savings) irrespective of its potential role in other applications. If ERTS does provide large benefits in applications other than land cover, then the net benefit computed for ERTS in the land cover role will considerably understate the economic value of ERTS. This understatement occurs because the land cover applications in the present analysis will bear the full fixed costs of the ERTS system.

C/8

4.2 Overview of the Study Approach

In this study the economic value of an ERTS in the development, maintenance and updating of a Nationwide Land Cover Information System is measured by the equal capability cost savings that accrue to a "with" ERTS data acquisition over a "without" ERTS data collection system.

The magnitude of the equal capability cost savings that accrue to a with ERTS system primarily depends upon four factors

- the land cover information requirements imposed upon the nationwide information system (i.e. user demand)
- the set of feasible, technical alternative systems for satisfying user demand on an equal capability basis.
- R & D, investment and operations costs required for the implementation of each alternative data acquisition system
- the economic parameters used in the evaluation process, for example, the discount rate, the project horizon.

On the demand side, it is necessary to project user land cover data requirements over the period of a future operational nationwide information system (1977-1993). These projections are particularly difficult and highly uncertain at present. The major underlying difficulty is that there is no such system in operation today. Instead, there are many separate data gathering and management information systems designed to serve specific users.

On the Federal level, there are large scale efforts involving, e.g., the Land Use and Data Analysis (LUDA) program of the Department of Interior and the Land Inventory Monitoring Program (LIM) of the Department of Agriculture. New and potentially major initiatives in this area are about to emerge from within the Environmental Protection Agency. The Administrator of the EPA, Mr. Russel E. Train, has recently announced plans to establish a division within the Agency to deal with land use problems. In addition, on the State Government level, there are several comprehensive land cover programs and information systems; notably the Land Use and National Resources Inventory (LUNR) system of New York and Minnesota Land Management Information System (MLMIS).

These data collection programs and information systems will undoubtedly contribute importantly to the demand placed on a Nationwide Land Cover Information System. However, it appears unlikely that all data collection and processing requirements of these many user groups will be imposed on a national system. Federal and State Agency resistance to a completely uniform data aquisition processing, interpretation and dissemination system will not yield to any such effort. Neither would resistance to total uniformity be illfounded. In general, there may be many dimensions to the data requirements of the various user groups any one of which, if left unsatisfied by the rigidities of a uniform system, would seriously impair the effectiveness of the user's data for his particular resource management program. The implication of the above considerations is that some user requirements for land cover information will continue to be satisfied by special purpose user data collection programs and information systems while other requirements will be fulfilled by a nationwide program. The determination of which subsets of the present day requirements of the various user groups will contribute to the demand imposed on a nationwide system will likely be made by the users themselves. The "retain/relinquish" decision process of the users may initially be largely influenced by political considerations, and perhaps equally, by technical considerations, e.g. the present day accuracy and level of information detail requirements. In time, economic considerations should dominate their selection processes. As this occurs, demands upon the nationwide system from these user groups will likely increase over their initial demand levels because of the relatively low incremental costs of acquiring data from the nationwide system.

The initial land cover information demand that actually will be imposed on a nationwide system from known users is somewhat uncertain at present. Even at the Federal government level, initial demand upon a nationwide system is uncertain; this is due in large measure to two factors:

(1) the lack of documented evidence concerning the effectiveness and economic value of the technical characteristics of data presently collected by these agencies (e.g., given that a certain type of information, say the presence or absence of land cover type x, is to be collected over a region of y square miles at intervals of time t, what is the effectiveness of that information in the management of the resource for which the agency has responsibility and if the time period of observation were reduced from t to $t/_5$ or the region of coverage reduced from y to $y/_{10}$ what increase/decrease would result in the effective management of the resource and what would be the economic value (gain or loss) that results.

(2) the lack of knowledge concerning the cost-effectivness of alternative data collection systems to provide the information equivalent of existing data collection programs.

Undoubtedly, as the time of an operational ERS draws near, additional knowledge from in-process and future studies will be acquired, which will allow accurate forecasts of both the initial demand upon a nationwide system and the growth and changing nature of the user demand measurements over time.

We have said that the economic value of ERTS in the establishment of a nationwide land cover information system depends to a major degree upon the level of demand which this system could be required to satisfy. We have also said that present day estimates of user demand levels must be regarded as highly uncertain. These statements may appear to imply that the present study is doomed to be a meaningless exercise but we are sanguine that this is not the case. Rather we believe that the cost to the user of satisfying land cover information requirements will be a major "driver" of user demand.

Theoretically, as demand at a given price increases, the quantity demanded increases at an even faster pace, provided that images are supplied at average rather than incremental cost. This is illustrated by Figure 4.4. Average cost falls from Level A in time period t to Level C at time period t+1. However, greater total benefit would be obtained by setting the image charge at the incremental cost level. In fact, if the average cost of images using aircraft is less than the average cost of images using ERTS in time period t, and pricing is based on average cost, then the demand curve will not shift to the right over time as shown by Figure 4.4. In essence, the lower initial price (incremental rather than average) allows introduction or "learning to take place at a faster rate. Such a pricing policy means that the potential net benefits of ERTS will be more quickly realized, and net costs minimized.

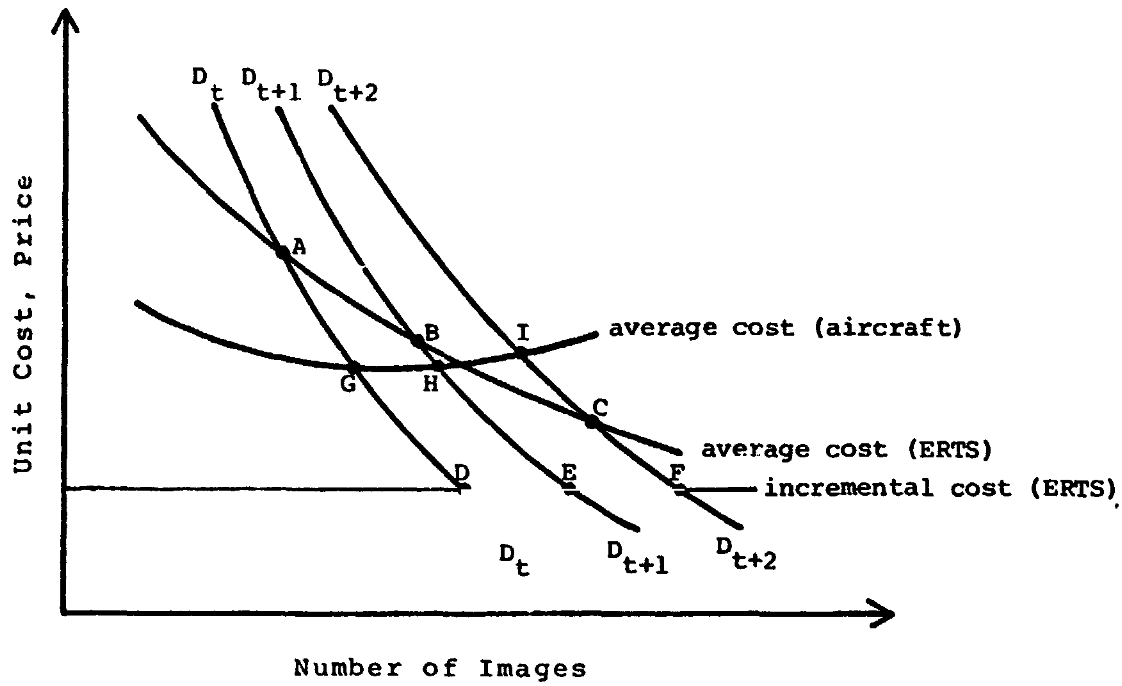

Figure 4.4 Relationship Between Demand, Cost and Time for ERTS-Type System

It follows that in order to develop any reliable estimates of user demand on a nationwide system, it is necessary to determine the lowest cost approach to acquire and process land cover information at various levels of user demand. This is how the present study will proceed; we shall seek the optimum mix of satellite and high and low altitude aircraft sensor system for satisfying various levels of user demand. The cost-efficiency frontier will be developed for a nationwide land cover information system that should be an important aid to the various user groups in deciding what part of their current data requirements might most economically be satisfied by a national system.

Figure 4.5 depicts in overview form, the approach that will be used for the analysis. The analysis begins with projections of the demand for land cover information which each technology system must satisfy on an equal capability basis. For the purposes of this analysis only demand which requires full target coverage is considered. Thus, demand requirements which can be satisfied by a probability sample of a given target area have been excluded from our analysis. Section 4.31 will describe the demand portion of the analysis in greater detail.

On the supply side of the analyses, there are several alternative technical systems considered for the acquisition and processing of the land cover user requested data. Each technical system is made up of two or more of three basic remote sensing components; namely an ERTS-1 type satellite, high altitude aircraft and a ground truth system which is defined to mean a low altitude aircraft with ground follow up teams. These remote sensing components (designated S, HA and GT hereafter), are combined to form the several data acquisition systems indicated in Table 4.1.

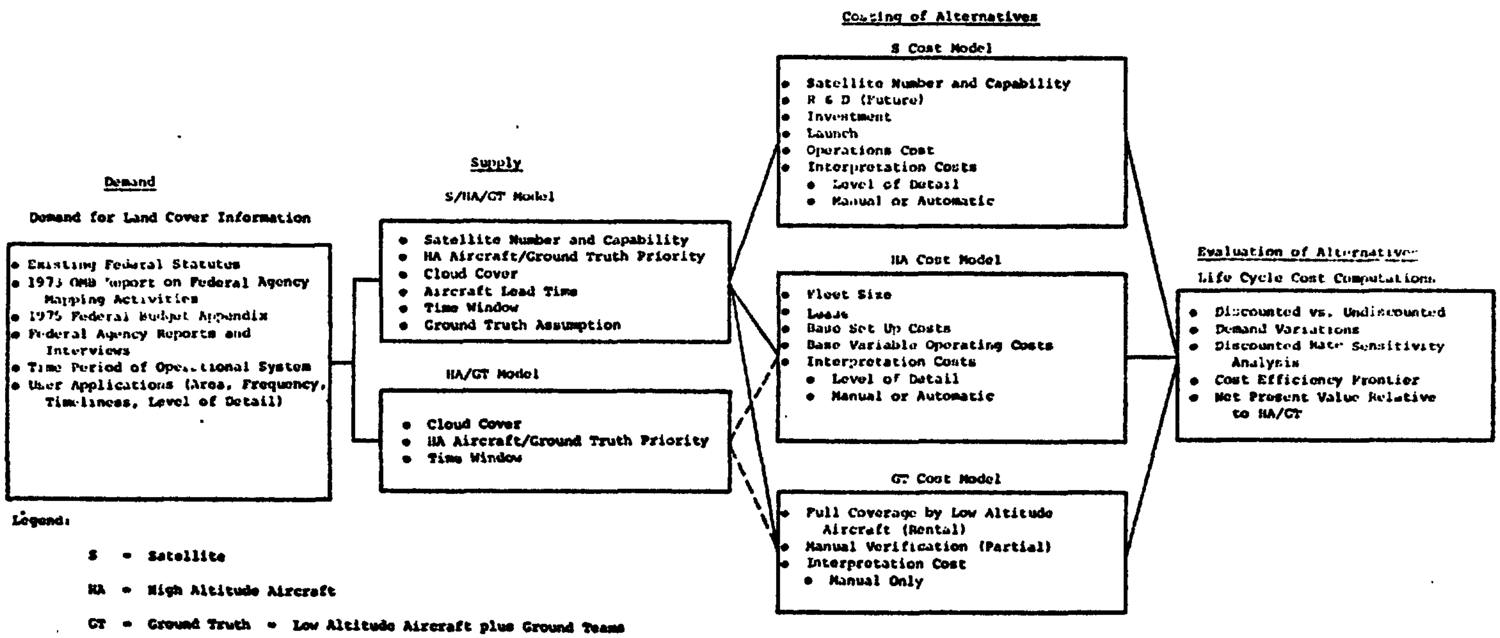

Figure 4.5 Overview of the Study Methodology

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Table 4.1 Alternative Data Acquisition Systems For A Nationwide Land Cover Information System	
Three Tier Systems	Two Tier Systems
1. S/HA/	1. HA/GT
2. 2S/HA/GT	2. S/GT
3. 3S/HA/GT	3. 2S/GT
	4. 3S/GT

For purposes of this analysis each of the two and three tier technology choices listed in Table 4.1 has an implied priority ranking associated with the use of its constituent data acquisition systems. The priority ranking is defined by the ordering of the components of a given technology choice. For example, the S/HA/GT technology implies that in our analytical models the satellite component will satisfy as much of the user demand as is possible, consistent with its capability to meet the level of detail of the user information requirement, the user timeliness requirement and to overcome cloud cover problems. Whatever portion of user demand cannot be satisfied by the satellite is assigned to high altitude aircraft and whatever demand is left unsatisfied by that component is assigned to the ground truth system. To illustrate, if the user demand were to obtain Level II information over one tenth the area of the

U. S. within a specific 30 day period then, given an 18 day satellite revisit time, the satellite would acquire only a fraction, say q , of its assigned target, where q depends the amount of cloud interference that it encountered over the target during 1-2/3 passes. In this case, the high altitude aircraft component (HA) of the S/HA/GT technology would be assigned to provide remote sensing coverage over that portion of the user target area left unsatisfied by the satellite. Moreover, the HA component may also fail to complete the mission due to cloud cover problems and tight time requirements; in which case, the ground truth component (GT) consisting of low altitude aircraft and supporting ground teams are assigned to complete the task. The specific assumptions and methodology that are used for analysis of the three tier and two tier systems are described later in Section 4.3 of this chapter. For now, we wish to emphasize some important factors concerning user demand that impact the economic choice of which technology might be used to satisfy user demand and to indicate in overview form how these factors are treated in this analysis.

First, there is the level of information detail requirements: which components can satisfy Level I, II and III requirements? The answer of course, depends upon the definition of the level of detail classification scheme and the projected technical capabilities of the various sensors and associated software systems in the time period of the operational system.

Next, there is the question of cloud cover which when coupled with user timeliness requirements raises important trade-off questions concerning how much time to allow for the HA component to complete the unsatisfied portion of the satellite assigned target. The shorter the HA aircraft lead time, the greater will be the required aircraft fleet and/or the greater will be the demand assigned to the ground truth. On the other hand, the larger the aircraft lead time, the larger will be the target that is assigned to the HA aircraft.

Refering to Figure 4.5, these issues are analyzed by the indicated supply models. These models allocate the projected user demand to the S, HA and GT components in accordance with the characteristics of user demand, cloud cover problems, capabilities of the component sensors and operational constraints imposed on the analytical models. Once the demand has been allocated to the three basic remote sensing components, the costs of satisfying these demands are calculated in the costing models taking into account the many investment and operating cost elements of each system. The basic annual cost information for each of the technology choices are then reassembled and compared in the evaluation model.

4.3 Models and Inputs

4.3.1 Demand for Land Cover Information

The analysis will start with an estimate of user demand based solely upon the present day data collection and processing requirements of Federal agency programs that have been mandated by specific Federal statutory requirements or that have been initiated under Federal enabling legislation. Taking this as a minimum baseline demand which a national system would be called upon to satisfy, the analysis proceeds in steps to even higher projections of user demand which are expanded to include state and land government agencies, commercial and academic users. Annual demand projections will be made over the time period of an operational system. Four major characteristics of user demand will be considered for these projections, namely

- user application area coverage requirement
- user timeliness requirement (this is the time period over which the information must be acquired, e.g., -- seasonal coverage)
- level of information detail
- frequency of coverage

The demand projections are based upon the analysis of present day Federal statutory requirements and, more generally, all land cover resource management information needs during the period of an operational nationwide land cover information system. The specific quantitative demand projections employed in the analysis have been described in Chapter 3 of this report.

4.3.2 High Altitude Aircraft/Ground Truth (HA/GT) Model

The model for allocating user demand to either high altitude or low altitude aircraft with manual follow up teams is straightforward and involves three major factors: the user time window requirement, the priorities for high and low altitude aircraft and problems of cloud cover. The user time window requirement establishes the opportunity for the flexible (daily) routing of aircraft over the user target area. The time window implicitly determines the expected fraction of the target which would receive cloud free coverage by the high altitude aircraft (see the discussion on cloud cover below). The remaining portion of the target must be covered by low altitude aircraft and ground survey teams. The high and low altitude aircraft priority factor allows one to assign certain types of targets exclusively to the low altitude aircraft thus prohibiting the use of high altitude aircraft for the coverage of certain types of targets. For example, ground truth can be forced to satisfy all Level III type coverage requirements; this constraint is employed in the HA/GT model when manual interpretation methods are used. In addition, the nominal priority rule is to:

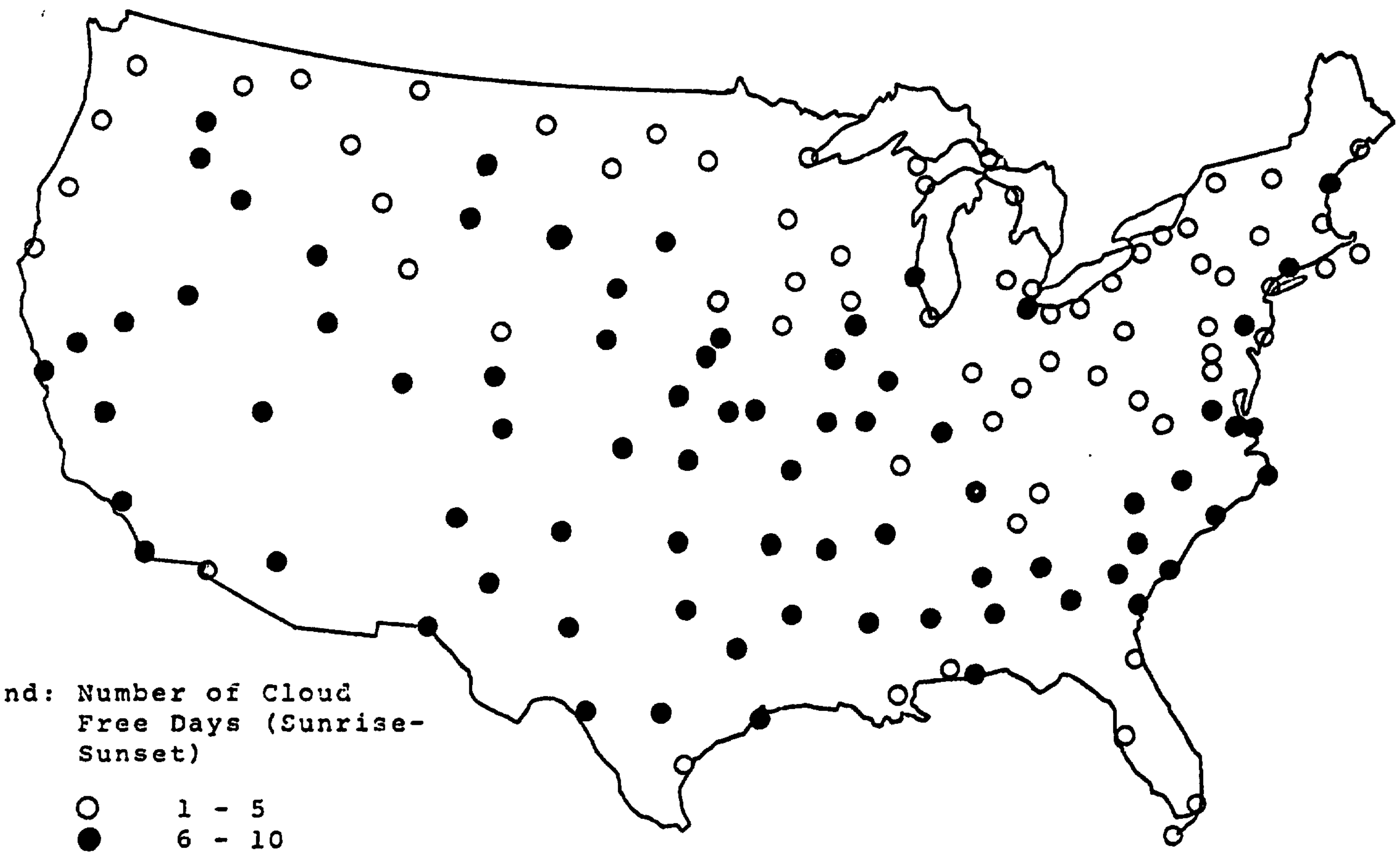
1. Assign to the high altitude aircraft all targets having a time window requirement of more than a specified number of days, say m, and
2. Assign to the low altitude aircraft all targets having less than a (m+1) day time window as well as all

"mop up" requirements arising from incomplete cloud free coverage of high altitude aircraft targets.

This nominal mode priority rule implicitly assumes that the HA aircraft component has a resolution capability (both spatial and spectral) to satisfy Level I and II demand requirements given manual interpretation and levels I, II and III information requirements given computer interpretation methods. All targets assigned to the ground truth component are assumed to be completely covered, cloud free, regardless of the level of information detail required. The third factor in the HA/GT model, cloud cover, is a major variable throughout this analysis. This variable, cloud cover, thus, requires some general introductory discussion before we explain how it is treated in the HA/GT model.

Cloud cover effects present a major obstacle to the acquisition of land cover information via the remote sensing systems considered in this study. Historical data on the extent of cloud cover over the continental U.S. is presented in the form of a color coded map in Figure 4.6. From this map, it is immediately apparent that for most of the U.S. land area, (yellow and purple dots) the average number of cloud free days (0-10% clouds from sunrise to sunset) per month is ten or less. Moreover, there are strong regional cloud cover effects indicated which result in vast contiguous areas of the U.S. (roughly 50%-yellow dots) where the average number of cloud free days per month is five or less. These regional effects obviously increase the

Figure 4.6 Average Number of Days per Month with Clouds 0.1 or Less
United States Department of Agriculture
Agricultural Adjustment Administration



Legend: Number of Cloud Free Days (Sunrise-Sunset)

○ 1 - 5
● 6 - 10
● 11 - 15
○ 16 - 22

Source of Data--Weather Bureau Compilation--Agricultural Adjustment Administration and Soil Conservation Service severity of the cloud cover problem by limiting cloud free coverage opportunities in several geographical areas. Further restrictions of coverage opportunities by geographical region arise from the seasonal effects of cloud cover. Figures 4.7 and 4.8 illustrates the problem by providing historical data on cloud cover over the U.S. during the months of January and September.

The impact of extensive cloud coverage on remote sensing programs over the U.S., coupled with its regional and seasonal characteristics is to significantly increase the time and/or cost required to obtain complete land cover information for any subset of the U.S. over what would be required for a continuously cloud free area of comparable size. To fully assess the time and/or cost impact of cloud cover, it would be necessary to undertake an exhaustive statistical study of the spatial and temporal distribution of clouds by seasons and regions of the U.S. as well as, the distribution of cloud cover persistence by seasons and regions of the U.S.* These data would have to be compared with an exhaustive list of user demand for land cover information which specifies the geographical location of the target area, dates during which coverage is required, level of information detail, etc. Finally, one would have to consider various operational strategies in the deployment of remote

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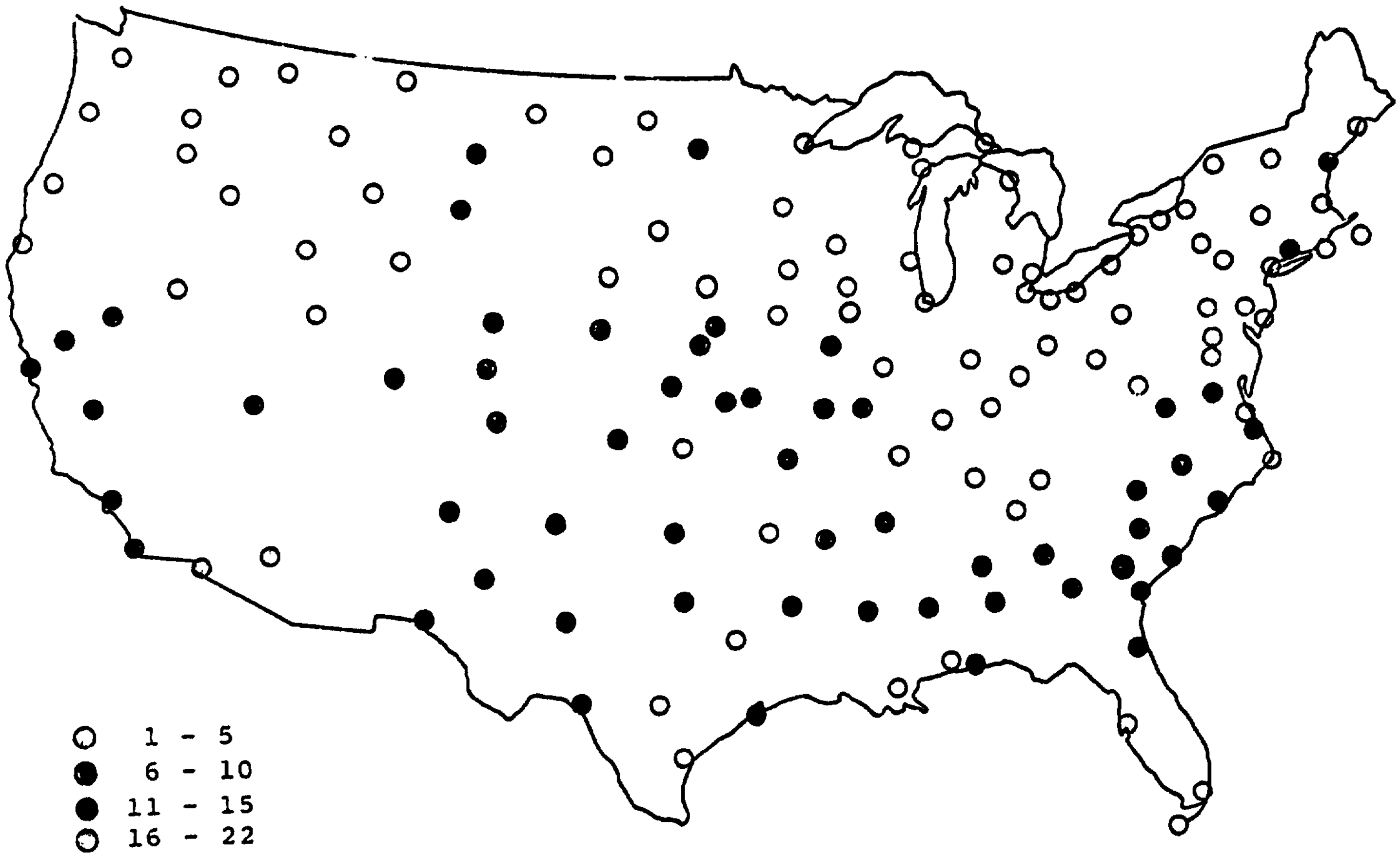
* Allied Research Associates, Inc. conducted an extensive analysis of the cloud cover problem in a report to NASA, "Worldwide Cloud Cover Distribution for Use in Computer Simulations," NASA CR 61226, June 14, 1968. This analysis of the statistics of cloud cover did not however include a corresponding analysis of the geographical and temporal characteristics of user demand.

Figure 4.7 Average Number of Days During the Month of January with Clouds 0.1 or Less



Legend: Number of Cloud Free Days
(Sunrise-Sunset)

sensing systems to acquire the necessary information. Multi-stage sampling is one such important strategy, wherein a satellite, high and low altitude aircraft are used to cover only portions of the target area and yet can obtain sufficient information to satisfy the users requirement. Forest inventories provide a typical example of the potential applications of multistage sampling. A recent ERTS-1 experiment,* showed that ERTS digital tape data could successfully discriminate forest from non-forest land and thus provide a basis for selecting primary sampling units for the first stage of a multistage forest inventory information sampling system.

We have not undertaken such an extensive analysis f the cloud cover problem in this study. Instead, we have made a number of simplifying assumptions concerning the cloud cover problem in order to gain some immediate insight into the potential time and/or cost impact of this factor on the several remote sensing technologies under consideration.

High Altitude Aircraft Cloud Cover Assumptions:

1. All user demand must be satisfied by imagery which is cloud free, defined henceforth as either (0 - 30% clouds) or alternatively as (0 - 10%) clouds.

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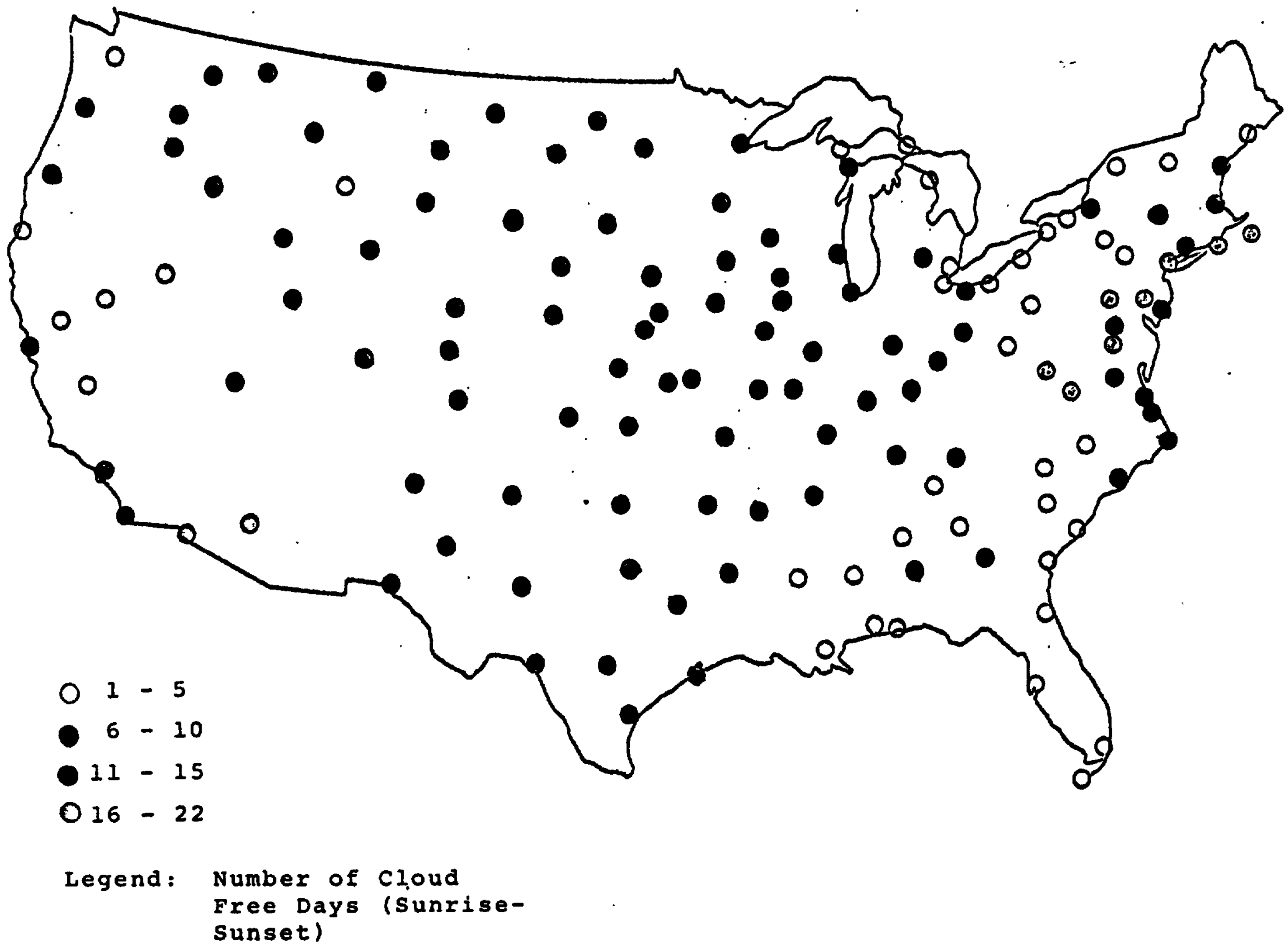
* UN-257, Center for Remote Sensing Research, Berkely (Nichols, et al.)

Figure 4.8 Average Number of Days During the Month of September with Clouds .1 or Less



2. All user demand is considered to be scheduled (non-random) demand. This implies that an aircraft has been assigned to cover a target over a specified time period and further that efforts can and will be made to inquire which areas of the targets are cloud free on any given day. This permits the aircraft to fly the target in a manner to minimize the effects of cloud cover, i.e., it flies the cloud free areas first. To further enhance the flexibility of the high altitude aircraft to cover the target cloud free, the aircraft fleet assigned to the target will be 120% of the minimum required fleet for target coverage during perfect cloud free weather.

3. Concerning expected cloud free coverage versus user time window requirement, the following two sets of numbers in Table 4.2 will be used.

4.3.3 Satellite/High Altitude/Ground Truth (S/HA/GT) Model

There are several factors in S/HA/GT model which determine the manner by which demand is allocated to the remote sensing components of this technology. Each of these is discussed below.

Table 4.2 High Altitude Aircraft - Average Percentage of Cloud Free Target Coverage vs User Time Window Requirement		
User Time Window Requirement (days)	Allowable Clouds (0 - 30%)	Allowable Clouds (0 - 10%)
365	99.99	99.9
180	99.9	99.0
90	99.0	90.0
60	94.0	82.0
45	90.0	77.0
30	85.0	70.0
15	78.0	60.0
10	75.0	56.0
5	70.0	50.0

The capability of the satellite to satisfy the level of information detail of user demand varies depending upon the interpretation method that is used. For manual interpretation, ERTS can provide Level I information only, while for computer (automatic) interpretation, ERTS can provide both Level I and Level II information. In this manner the capability of the satellite as determined by the data interpretation method used defines the user demands which the satellite attempts to satisfy.

The number of satellites in orbit determines the satellite system revisit or cycle time. With a one satellite ERTS-1 type system, the cycle time is 18 days, while the assumed cycle time for a two and three satellite system is nine days and six days respectively. The cycle time, coupled with the user time window requirement and the assumed probability of a cloud free satellite pass, determines the average percentage of cloud free target coverage that is achieved by the satellite and the target area remaining to be covered by the HA and/or GT component (see subsequent cloud cover discussion).

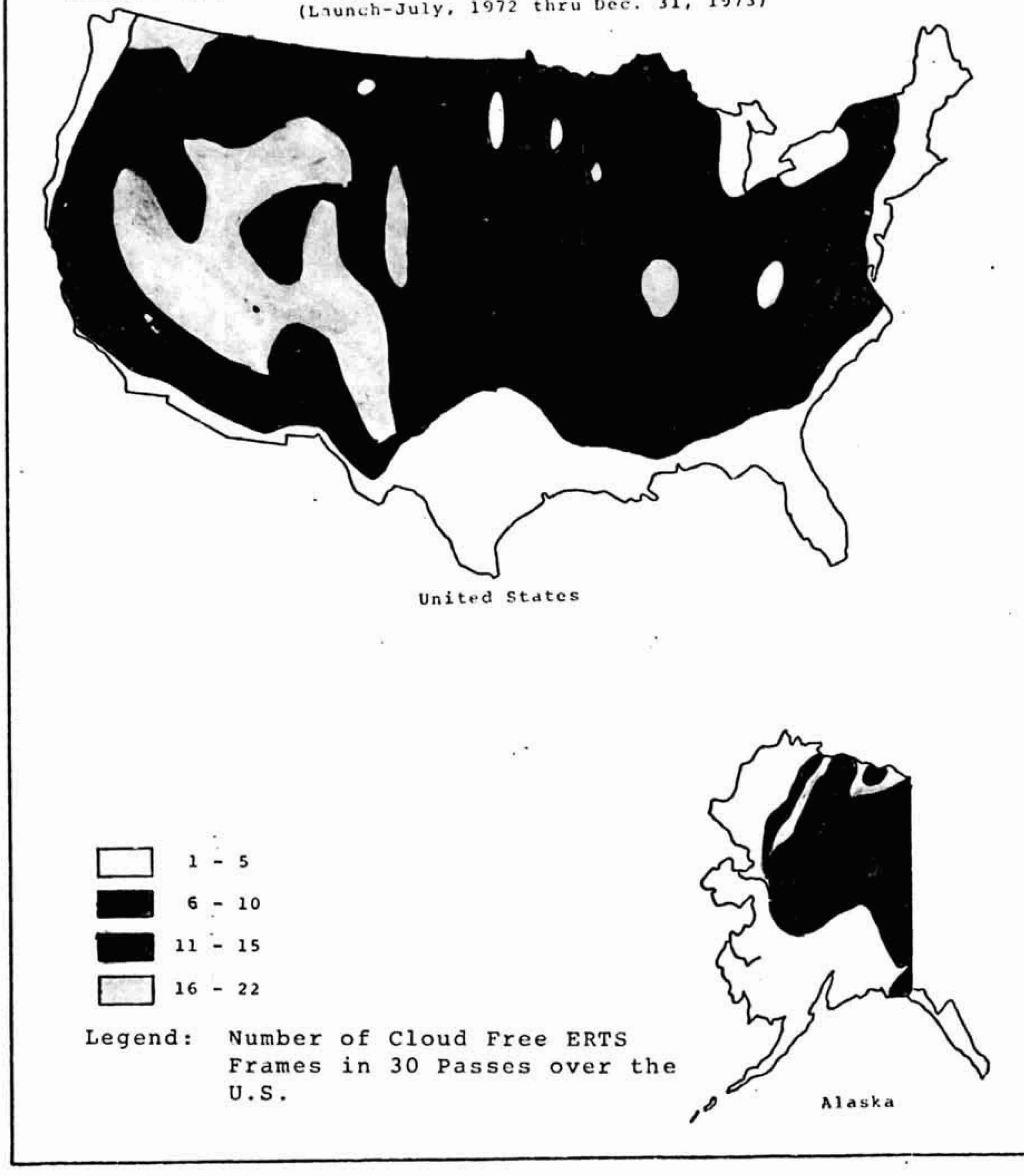
Time Window

As previously noted, user demand is assumed to have an associated timeliness requirement which specifies the number of days during which target coverage is required. The last day of the user time window is reserved for ground truth coverage of the target area not previously covered by either the satellite or the HA aircraft. The satellite is assumed to be active for all but the last day of the user time window while the HA aircraft is assigned to the target during the latter part of the user time window (see the subsequent discussion on HA aircraft lead time).

Cloud Cover

Figure 4.9 provides a map display of the number of cloud free (0 - 30% clouds) ERTS frames that were obtained for various

Figure 4.9 ERTS-1 Cloud Free Coverage (0-30%)
(Launch-July, 1972 thru Dec. 31, 1973)



geographical regions of continental U S. and Alaska during some 30 passes of ERTS-1 over the U.S. (July 1972 - December 31, 1973). Based upon these data, we have assumed for this analysis that on any one pass over the U.S., the satellite will obtain fifty percent of its frames cloud free (0 - 30%), and 30% of its frames cloud free (0 - 10%). Moreover, we assume that for successive passes of the satellite over a given region (whether the cycle time is 18 or 9 or 6 days), cloud cover is independent. This assumption leads immediately to a convenient formula for determining the average percentage of a target (P) that is covered cloud free by the satellite.

Let

TW = user time requirement in days for coverage of an area π

q = probability of a clouded ERTS frame

$p = 1-q$ = probability of a cloud free ERTS frame

c = cycle time = 18 days/number of satellites in orbit

$r = \left[\frac{TW}{c}\right]$ largest integer contained in (TW/c)

= the number of complete statellite passes over the target within the time window TW

$$f = \left(\frac{TW-rc}{c}\right)$$

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= fraction of an additional satellite pass over the U.S. that can be completed within the time window TW

P = Average percentage of cloud free coverage of the users' target

Then,

$$P = \frac{\{\pi(1-f)\} \quad (1-q^r)}{\pi} + \frac{(\pi f) \quad (1-q^{r+1})}{\pi} \qquad (\ )$$

or

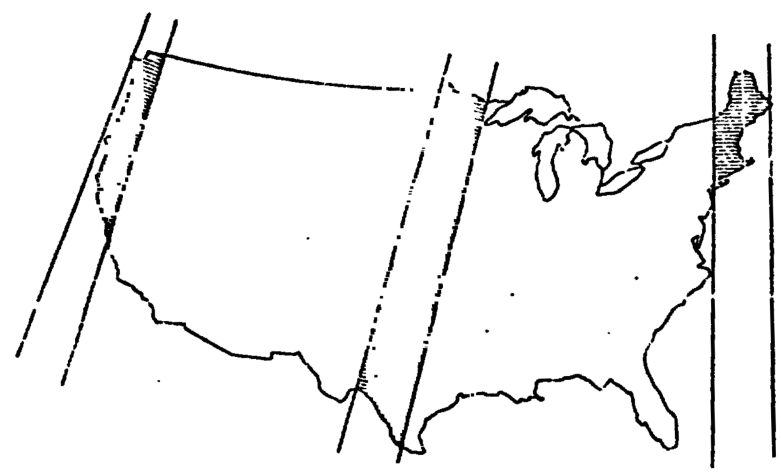
$$P = (1-q^r) + f\ q^r\ (1-q) \qquad (2)$$

Using equation (1), Table 4.3 contrasts the expected cloud free coverage attainable with single and multiple satellite systems with that attainable via high altitude aircraft for various user time window requirements.

The justification of equation (1) can most easily be explained by reference to Figure 4.10 which illustrates the problem of satellite coverage of the full U.S. i.e. π = full U.S. The probability of cloud free ERTS frame over any area of the U.S. for a single pass of ERTS is $p = (1-q)$ and for k independent passes of ERTS is $(1-q^k)$. For the two mutually exclusive regions of the U.S., $(f\ \pi)$ and $(1-f)\ \pi$ which are covered by r and (r+1) passes respectively, the average cloud free area covered in each region is $(f\ \pi)\ (1-q^r)$ and $(1-f)\ \pi$

Table 4.3 Comparison of Average Percentage of Cloud Free Target Coverage - High Altitude Aircraft vs Satellite Coverage

User Time Window Requirement (days)	Allowable Clouds (0 - 30%) HA Aircraft	One Satellite	Two Satellites	Three Satellites	Allowable Clouds (0 - 10%) HA Aircraft	One Satellite	Two Satellites	Three Satellites
365	99.99	100.0	100.0	100.0	99.9	99.9	100.0	100.0
180	99.9	99.9	100.0	100.0	99.0	97.0	99.9	100.0
90	99.0	97.0	99.9	100.0	90.0	83.0	97.0	99.5
60	94.0	90.0	99.0	99.9	82.0	69.0	91.0	97.0
45	90.0	81.0	97.0	99.0	77.0	58.0	83.0	93.0
30	85.0	67.0	90.0	97.0	70.0	44.0	69.0	83.0
15	[illegible]	42.0	67.0	81.0	60.0	25.0	44.0	58.[illegible]
10	75.0	28.0	53.0	67.0	56.0	17.0	32.0	44.0
5	70.0	14.0	28.0	42.0	50.0	8.0	17.0	25.0



Designates target area rf which is covered by (r+1) satellite passes
Designates target area r(1-f) which is covered by r satellite passes

Figure 4.10 Illustrative Example of Satellite Coverage of the U.S.

$(1-q^{r+1})$ respectively. The expected cloud free coverage of the total target area is therefore the sum of these two components. In the case of a target π which is only a subset of the total U.S. area, equations (1) and (2) are still applicable because with respect to the fractional pass of the satellite over the U.S. after r complete passes, the target π is treated as being randomly located within the U.S. area.

High Altitude Aircraft Lead Time

When the HA aircraft operates in the mode of "mopping up" after the satellite, the problem arises as to how many days to allocate to the HA aircraft to attempt this task. If an area of say five percent of the U.S. is expected to remain after the satellite has completed its last full pass over the U.S. and if there remained only 2 days for the HA aircraft to attempt to complete the mop up task, then it would be necessary to acquire a relatively large fleet of aircraft to cover the remaining area in a two day period. This can of course lead to gross inefficiencies in terms of the fleet size. One alternative would be to assign the mop up task to the ground truth system, but the relatively high incremental cost per square mile of coverage makes this alternative undesirable. The preferred approach is to establish and reserve a minimum aircraft lead time which results in an economical allocation of the satellite mop up task to both the HA and the GT components. The idea is to reserve the last m days of the total user time window, TW, for mop up coverage by the HA component and to reserve the last day of the user time window to GT mop up after the HA component. If it happens that for a particular type of user demand, the value of m is at least as large as the user time window TW, then the coverage of the user target area is left entirely to the GT component. On the other hand, if the value of m is less than TW, the HA system will be sized to cover the target area once during the m day period and the GT component will be assigned to mop up that portion of the target where cloud free coverage was not obtained from the HA component.

There is one further consideration that should be pointed out concerning the use of the HA aircraft lead time in the S/HA/GT supply models. If the HA component is used to mop up after the satellite and if the satellite system is not turned off during the m day HA coverage period, then there will be redundant target coverage during the m day period. In practice, redundant target coverage should be permitted since the satellite and HA component need not be imaging the same area of the target on the same day. The redundant coverage is therefore desirable since it will increase the percentage of the target that is acquired cloud free without resorting to the relatively expensive GT system. The redundant coverage however may result in some duplication of cloud free coverage; the model therefore has made provisions for subtracting out the expected duplication when computing the average cloud free coverage of the target acquired by the satellite and the high altitude components. With this type of procedure imbedded in the logical structure of the S/HA/GT model, one can explore the economic implication of various values of the aircraft lead time, m, via separate runs of the model.

HA Aircraft/Ground Truth Priority

This factor is treated in the S/HA/GT model in much the same way as it is in the HA/GT model, previously discussed. It is used more extensively in S/HA/GT model however. One new application of the HA/GT priority factor in this context is to eliminate the HA component altogether, thus creating a S/GT model or a 2S/GT or 3S/GT model. Another role played by this factor is to designate the levels of information detail which each component, S, HA and GT is allowed to satisfy. The allocation of demand by level of detail requirements differs depending upon whether a manual or automatic data processing capability is used. Table 4.4 indicates the projected capability of the various sensors in the post 1977 time frame for both manual and automatic processing.

Table 4.4 Projected Sensor Capabilities For Acquiring Information At Various Levels of Detail							
Manual Processing				**Automatic (Computer) Processing**			
	ERTS	**HA**	**GT**		**ERTS**	**HA**	**GT**
Level I	√	√	√	**Level I**	√	√	√
Level II		√	√	**Level II**	√	√	√
Level III			√	**Level III**		√	√

4.3.4 Satellite Cost Model

The satellite cost models receive as input a statement of the number of satellites simultaneously in orbit during the operational period of 1977-1993 and a statement of the average quantity of cloud free Level I and Level II information provided by the satellites for each year of the operational period. This information permits calculation of the annual satellite costs (investment and operations) that would be incurred over the operational period. A description of the satellite system and the constituent cost elements used in the costing model follows.

The satellite system is assumed to employ ERTS-1 like spacecraft equipped with a Multispectral Scanner, Panchromatic Return Beam Vidicon and two wide beam video tape recorders in order to permit global coverage. There will be two tracking and data acquisition stations and the data processing will be all digital. The major cost elements of the satellite system are defined in Table 4.4. Cost estimates for the investment and operations elements have been extracted from an earlier NASA document* and are provided in detail in Appendix III. (Tables 2, 3 and 4 of Appendix III provide annual phased program costs for a one, two or three satellite system.) User Product Processing Costs have been estimated from several sources (see Appendix III for details).

We summarize in Table 4.5 the cost estimates included in the satellite cost model. Though these summary cost estimates provide a useful guide to interpretation of the study results, the reader is cautioned to bear in mind that the actual time phasing of these costs over the program is not a uniform one. For example, most of the satellite investment costs is assumed to be incurred two years prior to satellite launch. Thus, the use of an average annual satellite cost over the period 1977-1993 can be misleading. Reference should be made to Appendix III for actual time phased costs that are used in the satellite cost model.

4.3.5 High Altitude Aircraft Cost Model

Cost data for all HA aircraft system elements are developed primarily as function of the number of aircraft and types of their bases, and flight hours per year per vehicle. Cost components have been subdivided into the following categories:

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* Earth Resources Survey (ERS) Operation System Study Final Report

Table 4.5 Major Cost Elements of the Satellite System

<u>R&D</u> - Assumed Completed

<u>Investment</u>

- Spacecraft
- Payloads
- Operating Control Center (OCC)
- Data Processing Facilities (DPF)
- Tracking and Data Acquisition System (TDAS)
- Launch Vehicle

<u>Operations</u>

- OCC
- DPF
- TDAS
- NASA Civil Service Cost

<u>User Product Processing Costs</u>

- Manual Interpretation
- Automatic (Computer) Interpretation

a. Investment (Initial) costs; including acquisition of aircraft and sensors, modification of aircraft or sensor installation and acquisition of the required facilities to house and operate the aircraft fleet (i.e. hangers, offices, shops, ground equipment, etc.).

b. Variable Annual Operational Costs; are those which tend to increase most directly with the use or output of a given unit (i.e. personnel, aircraft spaces, maintenance, fuel and sensor spaces)

The specific cost estimates for each system component are given in Appendix III . To assist the reader in the interpretation of the study results, we summarize below major costing assumptions and the HA aircraft cost data.

Aircraft Bases

The cost model assumes the cost of three HA aircraft bases, one main base in Denver, one remote base in Dayton, and one staging base in Alaska. The staging base especially allows fueling stops while the main and remote bases are fully operational, staffed with operating and maintenance personnel. The investment and operating cost of the bases are assumed to be dependent upon the size of the aircraft fleet that is required. Summary cost data is provided in Table 4.5.

Table 4.6 Summary of Satellite Cost Estimates (Millions of Undiscounted 1973 Dollars)

Number of Simultaneously Active Satellites in Orbit	1	2	3
Investment Cost	258.0	464.0	645.0
Operating Cost	84.0	117.0	150.0
Civil Service Cost	26.0	40.0	58.0
Total (Exclusive of User Products)	368.0	621.0	853.0
Average Annual Cost Over 16-1/2 Years	22.1	39.4	56.8

User Product Processing Costs ($\$/m_i^2$)	Manual Technique	Automated Technique
Level I - Scale 1:500,000	$.14/m_i^2$	$.048/m_i^2$
Level II - Scale 1:125,000	NA	$.194/m_i^2$

HA Aircraft Assumptions

The HA aircraft assumed for this study is the U-2. This aircraft is assumed to be equipped with a 5 channel MSS and a six inch metric camera and is procured by a ten year leasing agreement at $840,000 per year exclusive of sensor costs. Each aircraft in the fleet can be utilized up to a maximum of 1000 flight hours per year at a maximum rate of five hours every other day (of which four hours is the maximum aircraft imaging time).

The sizing of the aircraft fleet is accomplished via outputs from the S/HA/GT and the HA/GT models which specify the target area to be covered by the HA aircraft and the time period during which coverage is required. Given a specific aircraft target requirement, the procedure used to determine the fleet size is as follows:

$$\text{Fleet Size} = \left[\frac{A \cdot f}{e \cdot h \cdot a \cdot w}\right] + 1$$

where,

- $[x]$ = the largest integer contained within the value of x.
- A = target area to be covered.
- f = factor to increase the aircraft fleet over the minimum fleet required during perfect cloud free weather (f = 1.2 throughout the analysis)
- w = HA aircraft time window.
- h = maximum imaging hours per aircraft flight = 4 hours
- e = flight efficiency or the average fraction of the maximum aircraft imaging time which is achieved by an HA aircraft on any given flight. This factor is assumed to depend upon the size of and spatial

distribution of the target to be covered. For large contiguous area target, the flight efficiency is assumed to be high while for relatively small "mop up" targets the efficiency is assumed to be low since the aircraft may be required to expend some of its allowable imaging time traveling between spatially disjoint areas of the target. The specific assumptions made with respect to flight efficiency are

$$
\begin{aligned}
e &= 90\% \text{ for } \leq \text{ full U.S. target} \\
&= 88\% \text{ for } \leq 1/10 \text{ U.S. target} \\
&= 60\% \text{ for } \leq 1/100 \text{ U.S. target} \\
&= 30\% \text{ for } \leq 1/1000 \text{ U.S. target}
\end{aligned}
$$

$\dot{a}$ = incremental area covered by one U2 during one hour of flight = 12537 km^2. This figure is based upon an aircraft speed of 710 km/hr, a swath width of 19.6 km and 10% sidelap.

It should be noted that the above formula determines the necessary fleet size to cover a target of size A once during a time window of w. In general, however, user demand may require multiple coverage of targets of size A within time window w in any given year. If a fleet of size n_0 is sufficient to cover an area of Size A during w days, then this same fleet is adequate to provide repeated coverage of such targets, up to k_0 = [365/w] repetitions. If the frequency of user demand in any one year for coverage of targets of size A during a window w day exceeds k_0, then additional planes will be required.

The HA aircraft cost model makes use of simple arithmetic procedures in order to determine the total fleet size needed to cover all targets of size A with time window requirements of w. Moreover, as previously noted, user demand inputs provide for as many as twelve different types of targets annually. These are comprised of four different size areas at three levels of information detail with each combination having some associated user time window requirement. Consequently, the HA aircraft cost model also incorporates arithmetic procedures for determining the total fleet requirements in any given year by "summing" over the fleet size requirement for each of twelve distinct types user demands. More precisely, starting with target k=o the model determines the fleet size requirements for target (k+1), checks to see whether the unused capacity of the existing fleet, y_k, is sufficient to cover target (k+1), and increments the existing fleet to a level y_{k+1} sufficient to satisfy the requirements of the first (k+1) targets. The process is repeated until the fleet size required to obtain all twelve target types has been determined.

Aircraft Costs

Having determined the aircraft fleet size, n, that is required to fulfill all user requirements, aircraft program component costs are computed using the summary data of Table 4.6. Under the heading of investment, it should be noted that the Initial Setup Costs, as the name implies, are one time charges and are phased in one year before the initiation of the operational system. The aircraft leasing cost is based upon a ten year life of the aircraft and is allocated to investment during every year of the operational system. The Variable Annual Costs are calculated on the basis of the actual utilization (n^*) of the aircraft, to allow for the possibility of less than full use of the aircraft during any given year.

An increasing demand over the years can be expected in an operational system, it should be expected that the initial setup will not be sufficient to accomodate the aircraft required in the later years. Such expansions in the bases and number of aircraft are assumed to be made in the year preceding actual requirement for additional aircraft. Furthermore, given the ten year expected life of the aircraft, a resetup, and modification cost for the aircraft and sensor must be repeatedly incurred every ten years.

When an all aircraft system is utilized, a data processing facility must be established to process the information gathered from the high altitude aircraft and ground truth. The costs of such a facility for automatic data processing are: a setup cost of $5.9M, and a fixed annual cost of $0.8M. The corresponding costs for manual data processing are $1.1M and $.944M, respectively.

Table 4.7 High Altitude Aircraft (U2) Costs
(Thousands of 1973 Dollars)

Initial Set Up Costs			
Main Base		803 + 202.n	
Remote Base		675 + 195.n	
Staging Base		675 + 195.n	
Aircraft Installation		200.n	
Sensors		260.n	
		2153 + 1052.n	
Aircraft Leasing Charges		840.n	
Fixed Annual Costs			
Main Base		105	
Remote Base		105	
Variable Annual Costs			
Main Base		278 + 722.n*	
Remote Base		240 + 805.n*	
Sensor Spares		26.n*	
Sensor Techniques		50 + 30.n*	
		568 + 1583.n*	
User Product Processing Costs		Manual Technique	Automated Technique
Level I	Scale 1:500,000	1.13	.80
Level II	Scale 1:125,000	1.60	.97
Level III	Scale 1:24,000	NA	1.42

Note: n = size of HA aircraft feet
n* = portion of the HA fleet actually used in any one year.

4.3.6 Ground Truth Cost Model

In the ground truth model we assume that all desired low altitude aircraft coverage will be contracted to a commercial firm on the basis of a per square mile of coverage. There are many factors governing such prices, and it is common that prices will vary seasonally and from firm to firm. Based upon the information given in Appendix III (in 1973 dollars) for acquiring information at scale of 1:24,000 is estimated at $6 per square mile. User Product Processing Costs for the Ground Truth Component Care shown in Table 4.7. For low altitude aircraft, manual interpretation of land cover data is assumed.

Table 4.8 User Product Processing Costs ($/mi^2) - Low Altitude Aircraft

	Manual Interpretation Only
Level I	11.0
Level II	12.5
Level III	14.6

4.3.7 Life Cycle Cost Computations

In order to observe the complete effects of technology choices and demand variations, several computer runs of the model were made. Included in these runs was the assumption that the system initiation, that is the initial setup including procurement and modification of the sensors and their associated facilities, will begin in 1975 and that the operational demand will begin in 1977 and continue through 1993. The two year phase in period allows for the operational system to be ready in 1977.

The life cycle costs of the systems were computed in both the undiscounted base and discounted to 1974 at 10%. The discounted version lends insights into the total program costs while the undiscounted version illustrates the actual cost variations in year to year operations.

The outputs for the computer analyses are presented in Appendix IV. Each computer run is divided into two major sections, each section having the same three components. The first major section is the undiscounted costs, and the second is the discounted costs. The first component of each section is a summary of the total yearly costs in RDT&E, Investment, and Operations (activity level dependent, and activity level independent). The next two components are the detailed breakdowns for these costs distributed to the satellite, high altitude aircraft, and ground truth systems.

For these analyses we have assumed that all RDT&E spending has been completed before 1974 and that there will be no further RDT&E efforts for any of the sensors. The Investment costs correspond to both the initial setup costs of the facilities required to house and operate the sensors, and the year to year changes to procure new satellites, aircraft leasing, etc. The activity level dependent costs are those which vary most directly with the level of activity of the sensor. These costs correpsond to the maintenance, fueling, and personnel required to sustain the required utilization level. Included also in these costs is the interpretation and production costs required to provide the land cover information to the various users. The activity level independent costs are those which do not vary as a function of the utilization of the facility or of the sensors. They correspond to the cost required for the basic management of the facilities.

Presented along with each of the cost breakdowns is a description of the demand and technology for which the respective tables are created. By carefully examining the outputs, one is able to observe in the cost differences the effects of the system charges.

4.4 Results

Life cycle costs were computed for each of the two and three tier data acquisition systems previously described. Total program cost comparisons were made for the alternative systems (1) over a range of land cover demand levels, (2) using automatic and manual data processing and interpretation techniques and (3) under two different user cloud cover requirements. The basic problem underlying and guiding these life cycle cost comparisons was to determine under which conditions of user demand (area of coverage, frequency of coverage, timeliness of information and level of information detail) an ERTS type satellite would be cost effective and, if so, what would be the annual cost savings benefits.

Our analysis begins by considering only Federal user agency demand for land cover information under existing Federal statutes. Next, we address the national resource management information needs of all user groups, Federal and otherwise. For this case, demand projection in the post-1977 time frame are highly uncertain; thus a parametric demand-cost analysis is made. Finally, in order to estimate the likely cost savings benefits of ERTS we evaluate the system alternatives for three particular demand scenarios which we believe will bracket the actual national demand for land cover information in the post-1977 time period. A description of the results of these analyses follow.

4.4.1 Total Program Costs to Satisfy Federal Statutory Demand For Land Cover Information

The analysis of total program costs to satisfy Federal statutory demand for land cover information focused on two distinct time frames, 1974 and 1977. Though Federal statutory demand in the 1974 time frame is not directly relevant to the question of the cost-effectiveness of ERTS in the context of a national land cover information system in the post-1977 time frame; nonetheless, it does provide a useful point of departure for such an analysis. The magnitude and the major characteristics of Federal statutory demand in 1974 and 1977 were defined in Chapter 3. Separate demand matrices were given for two Federal agency user groups, the "land use planning community" and all "land cover users" (see Tables 3.3 through 3.5). Results of the analysis of the cost to satisfy these different user demand levels with each alternative system are shown in Tables 4.9 and 4.10. Table 4.9 considers 1974 demand under existing Federal statutes; Table 4.10 considers 1977 demand under existing Federal statutes. In each case, the lowest cost "with" satellite system was compared to the lowest cost "without" satellite system using alternative data processing and interpretation techniques (manual versus automatic) and for two user cloud cover requirements. From these tables several observations are evident. First, Federal user demand under existing Federal statutes is, by itself, insufficient to economically justify an ERTS system for a U.S. only coverage mission. An all aircraft system is cost-effective for satisfying

Table 4.9 Discounted Total Program Cost to Satisfy 1974 Federal Demand for Land Cover Information Under Existing Federal Statutes (Million of 1973 Dollars Discounted at 10% to 1974)

User Cloud Cover Requirement / User Group	Allowable Clouds 0-30%		Allowable Clouds 0-10%	
	Manual Interpretation	Automatic Interpretation	Manual Interpretation	Automatic Interpretation
Land Use Planning Community Only	294.2 HA/GT 464.2 S/HA/GT	156.3 HA/GT 250.6 S/HA/GT	352.2 HA/GT 522.2 S/HA/GT	224.2 HA/GT 323.9 S/HA/GT
All Land Cover Users	567.9 HA/GT 737.9 S/HA/GT	269.2 HA/GT 377.6 S/HA/GT	626.0 HA/GT 796.0 S/HA/GT	382.4 HA/GT 529.2 S/HA/GT

Legend:
S refers to an ERTS-type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

Table 4.10 Discounted Total Program Cost to Satisfy 1977 Federal Demand For Land Cover Information Under Existing Federal Statutes (Millions of 1973 Dollars Discounted at 10% to 1974)

User Cloud Cover Requirement / User Group	Allowable Clouds 0-30%		Allowable Clouds 0-10%	
	Manual Interpretation	Automatic Interpretation	Manual Interpretation	Automatic Interpretation
Land Use Planning Community Only	518.9 HA/GT 688.9 S/HA/GT	316.5 HA/GT 337.1 S/HA/GT	616.7 HA/GT 786.7 S/HA/GT	428.0 HA/GT 454.2 2S/HA/GT
All Land Cover Users	937.2 HA/GT 1107.2 S/HA/GT	613.3 HA/GT 701.8 2S/HA/GT	1120.1 HA/GT 1290.1 S/HA/GT	835.7 HA/GT 881.6 2S/HA/GT

Legend:
S refers to an ERTS-type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

Federal agency land cover demands under existing Federal statutes. This result is driven by the level III information requirements of the Federal agency user groups which cannot be satisfied by ERTS. Subsequent analyses show that ERTS is cost-effective given a demand for six times coverage of the U.S. annually at Level II. This demand level is considered highly likely in the post-1977 time frame when all users needs (Federal and non-Federal) for land cover information are considered. A second important observation that can be made from the analysis of Federal statutory demand is that automatic data processing and interpretation techniques are economically superior to manual techniques. In every instance of comparison, there are significant cost savings advantages that accrue to the automatic techniques over manual techniques. This result was to be expected given the differences in the projected capability of these techniques in the 1977 time frame for acquiring increasingly detailed land cover information. Using ERTS, manual techniques can provide only Level I information with the necessary accuracy while automated techniques can provide both Level I and Level II type information. Similarly, using high altitude aircraft, manual techniques can provide Level I and Level II while all levels of classification detail can be obtained from automatic techniques. Lastly, Tables 4.9 and 4.10 provide some interesting insights into the effects of users cloud free coverage requirements. As one would expect, the more stringent cloud free coverage requirement of 0-10% causes a major increase in total program costs. This is due to the fact that in order to satisfy a fixed user timeliness requirement the satellite and high altitude aircraft systems must yield a greater portion of the user target to the low altitude aircraft and ground survey teams. Thus, in addition to incurring expensive investment cost of the satellite and high altitude aircraft systems, one is forced to increase the activity level of the most expensive (incremental cost) data acquisition component. The impact of more stringent user cloud free coverage requirement will, of course, grow increasingly severe as the user timeliness requirement is tightened. Subsequent results quantify this effect.

4.4.2 Total Program Costs for Parametric Analysis of Nationwide Demand for Land Cover Information

As noted earlier, Federal statutory demand for land cover information constitutes only a segment of the national demand. State governments, regional and local governmental units, industrial and academic users will also contribute to the total demand. It is difficult to project, quantitively, the scope and nature of the total national demand. Consequently, a parametric set of demand requirements was considered, which focused on increasing Level II information requirements for continental U.S. and Alaska. The annual Level II coverage requirement was varied from two times coverage within 180 days each to twelve times coverage within 15 days for each coverage. In addition to the varying full U.S.-Level II requirement, the parametric demand analyses includes the other information requirements* that were projected for the 1977 Federal agency demands (All Land Cover Users) under existing Federal statutes.

The results of the parametric demand--cost analysis is shown in Table 4.11. For each demand level, total program costs are compared for the all aircraft system and the lowest cost two or three tier "with" satellite system. This analysis is based upon automatic data processing methods which previously were shown to be economically preferred over manual methods. It is clear from this table that ERTS is cost-effective at an annual demand level of six times coverage of the U.S. with a user timeliness requirement of 60 days for each such coverage. Note however that a two satellite system is required in order to overcome cloud cover problems. Another interesting effect concerning the impact of cloud cover is evident from Table 4.11. The more stringent cloud cover requirement (0-10%) reduces the multiple satellite system breakeven demand level. Table 1.5 shows that a two-satellite system is cost-effective at six times coverage of the U.S. given a (0-30%) cloud cover requirement,

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* See Table 3.5 on page 3-12.

Table 4.11 Summary of Total Program Cost (1977-1993) to Provide Level II Mapping Information of Continental U.S. and Alaska Using Automatic Data Processing (Millions of 1973 Dollars Discounted at 10% to 1974)

Annual Level II Coverage Frequency and Timeliness	Allowable Cloud Cover 0-30%	Allowable Cloud Cover 0-10%
Twice at 180 days each	488.5 HA/GT 646.9 S/HA/GT	616.3 HA/GT 779.2 S/HA/GT
Four times at 90 days each	613.3 HA/GT 701.7 2S/HA/GT	835.6 HA/GT 881.6 2S/HA/GT
Six times at 60 days each	815.6 HA/GT 758.4 2S/HA/GT	1137.3 HA/GT 984.4 3S/HA/GT
Eight times at 45 days each	1044.3 HA/GT 798.2 3S/HA/GT	1476.5 HA/GT 1129.5 3S/HA/GT
Twelve times at 30 days each	1548.3 HA/GT 997.9 3S/HA/GT	2168.3 HA/GT 1603.4 3S/HA/GT

Legend: S refers to an ERTS-type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow up teams

while for the same demand level a three-satellite system is cost-effective given a (0-10%) cloud cover requirement. As expected, the cost savings of the "with" satellite system over the aircraft only system increase substantially as the demand for Level II information increases beyond six times coverage of the U.S.

Figure 4.11, displays the cost-capability frontier for the two user cloud free coverage requirements explored in this study. The cost-capability frontier is defined by the locus of the lowest program cost alternatives for varying capability levels. The full cost ERTS curve represents the cost-capability frontier under the assumption that the total program cost are borne entirely by a U.S. coverage mission. The incremental cost ERTS line represents the cost capability frontier under the assumption that the investment costs for a one satellite system would be incurred in any event for a global coverage mission.

Thus far, throughout the discussions of the analysis we have subdued the aircraft lead time variable. In the methodology section, it was pointed out that in the case of the three tier satellite system, the latter portion of the user timeliness requirement was reserved for high altitude aircraft "mop up" coverage of the target area that had not previously been mapped by the satellite. We indicated that to achieve efficiency in the sizing of the aircraft fleet, several different values of

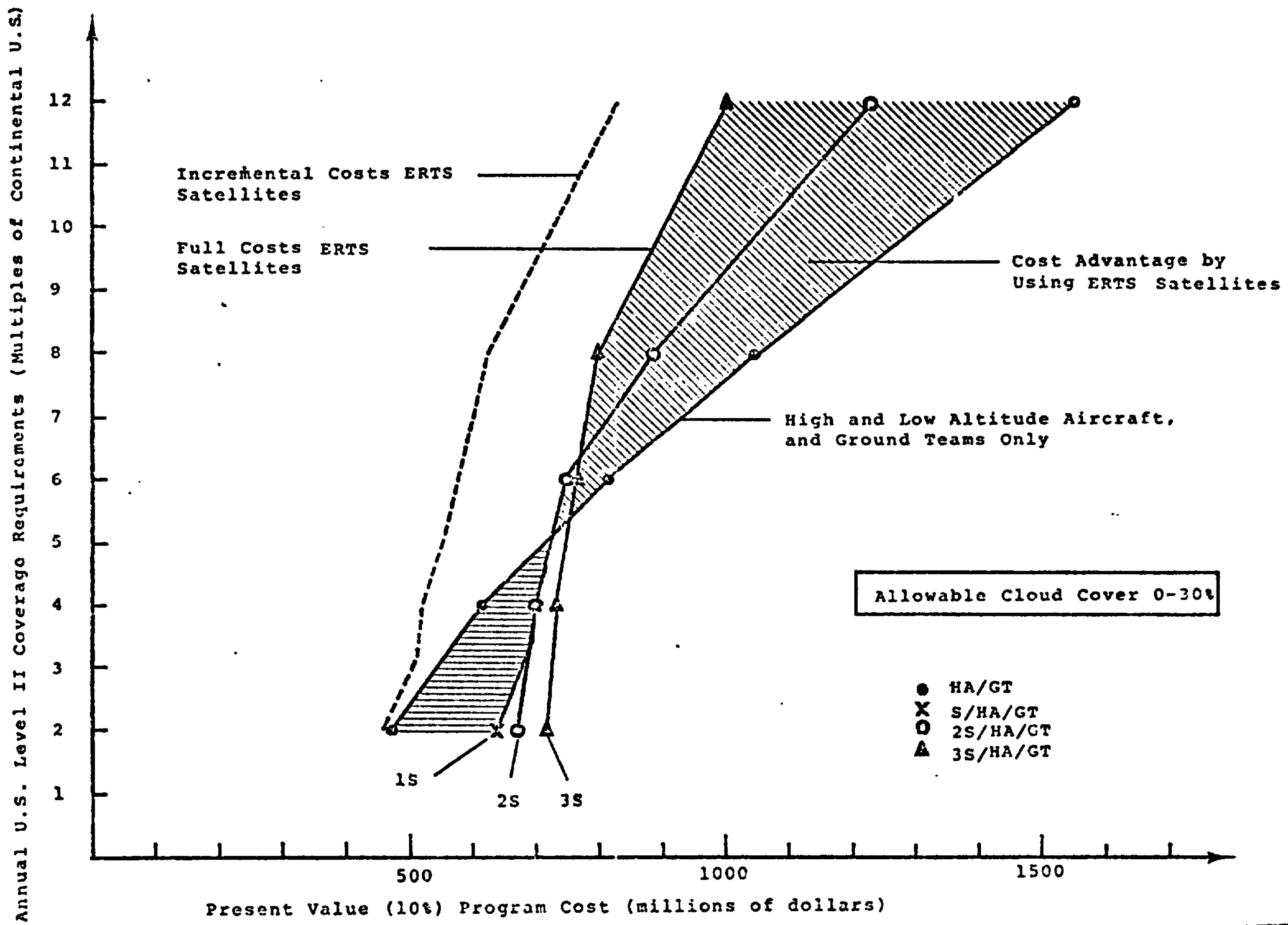

Figure 4.11 The ERS Cost Efficiency Frontier

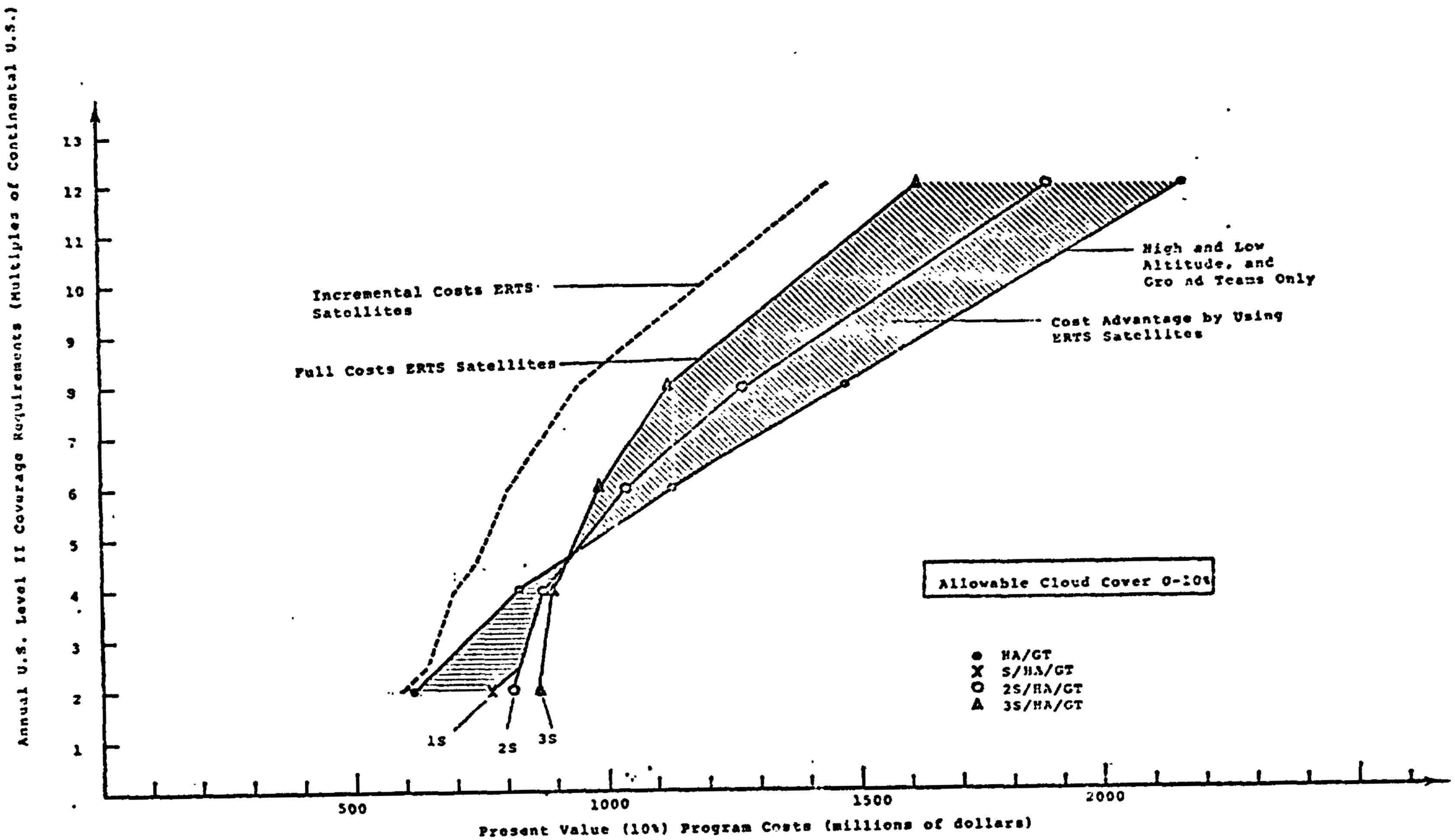

Figure 4.11 The ERS Cost Efficiency Frontier (Continued)

the aircraft lead time would have to be investigated for each user demand level and timeliness requirement. Thus, in our life cycle cost computations, repeated runs of the analytical models were made in order to assure that the lowest total program cost was identified for the three tier data acquisition systems. Table 4.12 illustrates the impact of the aircraft lead time variable on total program costs to satisfy a given demand level. Given the particular demand levels selected for illustrative purposes, a lead time of 14 days yields the lowest total program cost. For other demand requirements and for other data acquisition alternatives, e.g. two and three satellite systems, other values of the aircraft lead time variable yield the lowest cost results.

4.4.3 The likely Cost Savings Benefits of ERTS

Despite the uncertainties inherent in future estimates of nationwide demand, we have defined three demand scenarios that we believe will bracket the actual future nationwide demand for land cover information Each demand projection includes all the projected information requirements of Federal agency users in 1977 except the full U.S., Level II coverage. In addition, we have included Level II information requirements for the U.S. plus Alaska at annual frequencies varying from six times coverage with 60 days each during the period 1977-1993 to six times coverage within 60 days over the period

Table 4.12	Impact of Aircraft Lead Time on Total Program Cost of 2S/HA/CT Coverage of the U.S. at Level II and at Indicated Annual Frequency and During Indicated Time Window--Automatic Classification--Allowable Cloud Cover (0 - 10%) (Million of 1973 Dollars Discounted at 10% to 1974)	
	Aircraft Lead Times (in days)	
U.S. Coverage	5 days	14 days
4 time at 90 days	966.1	881.6
6 times at 60 days	1203.0	1045.3
8 times at 45 days	1563.2	1285.5

1977-1980 and eight times coverage within 45 days each over the period 1981-1993. The cost-effectiveness analysis for these projected demand levels is based upon automatic data processing methods which previously were shown to be economically preferred over manual methods. Table 4.13 displays the total program costs for the lowest cost "with" and "without" satellite systems to satisfy these future demand levels given a user allowable cloud cover requirement of 0-30%. Also shown are the net present values (discounted cost savings) of the lowest cost "with" satellite system relative to the lowest cost "without" satellite system and the equivalent undiscounted annual cost savings of the "with" satellite system over the period 1977-1993. Table 4.14 provides corresponding results for an allowable cloud cover requirement of 0-10%.

As indicated in these tables, the annual economic benefits (cost savings) of ERTS as a component of a Nationwide Land Cover Information System are projected to range from $7.9 to $17.0 million or from $21.0 to $37.1 million depending upon the user cloud cover requirement. The best point estimate of the annual cost savings that accrue to ERTS is probably defined by the middle of the projected range of cost savings, this being $23 million.

Table 4.13 Discounted Total Program Cost (1977-1993) to Satisfy the Projected Future Nationwide Demand for Land Cover Information -- Level II Information -- Automatic Data Processing -- Allowable Cloud Cover (0-30%) (Millions of 1973 Dollars Discounted at 10% to 1974)

Projected Level II Demand	All Aircraft System	Lowest Cost With Satellite System	Net Present Value	Equivalent Undiscounted Annual Cost Savings 1977-1993
1977-1993 Six times at 60 days	815.9 HA/GT	758.4 2S/HA/GT	57.5	7.9
1977-1984 Six times at 60 days 1985-1993 Eight times at 45 days	892.3 HA/GT	797.4 2S/HA/GT	94.9	13.0
1977-1980 Six times at 60 days 1981-1993 Eight times at 45 days	954.2 HA/GT	829.9 2S/HA/GT	124.30	17.0

Table 4.14 Discounted Total Program Cost (1977-1993) to Satisfy the Projected Future Nationwide Demand for Land Cover Information -- Level II Information -- Automatic Data Processing -- Allowable Cloud Cover (0-10%) (Millions of 1973 Dollars Discounted at 10% to 1974)

Projected Level II Demand	All Aircraft System	Lowest Cost With Satellite System	Net Present Value	Equivalent Undiscounted Annual Cost Savings 1977-1993
1977-1993 Six times at 60 days	1137.6 HA/GT	984.5 3S/HA/GT	153.1	21.0
1977-1984 Six times at 60 days 1985-1993 Eight times at 45 days	1251.0 HA/GT	1032.5 3S/HA/GT	218.5	30.0
1977-1980 Six times at 60 days 1981-1993 Eight times at 45 days	1342.7 HA/GT	1072.0 3S/HA/GT	270.7	37.1

Legend: S refers to an ERTS type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

APPENDIX I

Federal Budgetary Activities Potentially
Impacted by Remote Sensing

The programs and activities of federal government agencies have been researched to determine the potential budgetary impact of remote sensing and ERTS. The budgetary figures listed in this appendix represent money requested for land cover programs. The amount spent for remote sensing varies according to the information requirements of the program. In many cases, the expenditures for remote sensing represent only a very small per cent of the budget request with ERTS sharing a varying proportion of this cost. Those programs which can be said to be greatly impacted by ERTS are noted by an asterisk (*).

The sources used for this appendix are: Office of Management and Budget Federal Mapping Task Force Report, 1972; House Appropriations Hearings (Agriculture); House Appropriations Hearings (Interior); House Appropriations Hearings (Public Works); House Appropriations Hearings (Special Energy); Senate Appropriations (Interior); Appendix, FY 1975 Budget; and Army Corps of Engineers Circular, March 25, 1974, Table 3.

Figure 1 displays the FY 1972 budget of the various Federal departments and agencies for land cover information programs. These budgetary figures were determined by considering all programs relevant to land cover activities out of all mapping, charting, and geodesy activities within each agency. The same figures for FY 1973, FY 1974, and FY 1975 were lacking in detail for the agency breakdown. The available figures for these three years are given in the table in Appendix I; the last page of this table summarizes the budgetary information by Federal departments.

Considering the present demand for remote sensing information, it seems likely that ERTS will have a substantial impact on future budgetary figures used by Federal agencies for land cover programs.

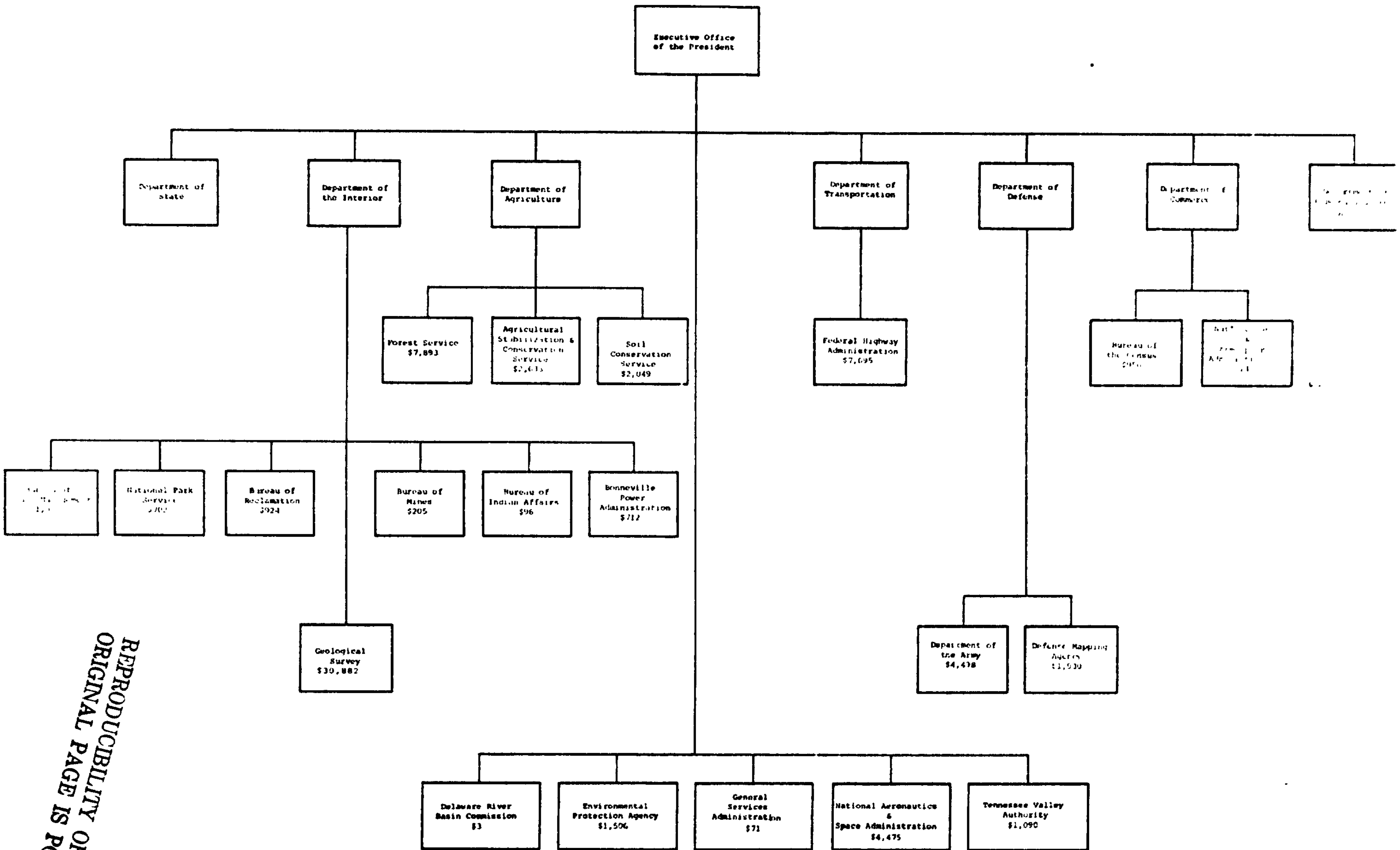

Figure 1 FY 1972 Budget of Federal Departments and Agencies for Land Cover Programs (in thousands of dollars)

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APPENDIX I - Federal Budgetary Demand

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Department of Agriculture					
Agriculture Stabilization and Conservation Service *Water Bank Act (60 USC 1301)		10,000	10,000		House Appropriations (Agriculture) Fiscal Year 1975
Aerial Photography	2,633	NA**	NA	NA	OMB Federal Mapping Report, p. 63
Forest Service *Forest Resource Evaluation (Primary Forest Survey)		3,544	3,649	3,820	House Appropriations (Interior) Fiscal Year 1975, p. 282 (60 USC 581)
Forest Survey	3,421	3,293	NA	NA	The Senate Appropriations (Interior) Fiscal Year 1973, pp. 1742-1744
*Land Classification	NA	461	787	825	House Appropriations (Interior) Fiscal Year 1975, p. 193
Planimetric Maps	280	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	808	NA	NA	NA	OMB Federal Mapping Report, p. 63

* Programs estimated to be significantly impacted by an operational ERTS system.
** NA means not available.

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Aerial Photography	1,693	NA	NA	NA	OMB Federal Mapping Report, p. 63
*Soil and Water Science from Management Support	NA	7,232	8,333	8,900	House Appropriations (Interior) Fiscal Year 1975, p. 173
Thematic Mapping	1,077	NA	NA	NA	OMB Federal Mapping Report, p. 63
Topographic Maps	614	NA	NA	NA	OMB Federal Mapping Report, p. 63
Soil Conservation Service *Land Inventory and Monitoring	NA	NA	8,000	NA	Senate Appropriations (Interior) Fiscal Year 1973
Other Maps	198	NA	NA	NA	OMB Federal Mapping Report, p. 63
Photos	1,626	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	225	NA	NA	NA	OMB Federal Mapping Report, p. 63

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
*The River Basin Surveys and Investigations (P.L. 83-566)	NA	11,452	13,585	14,227	House Appropriations (Agriculture) Fiscal Year 1975, p. 250
*Snow Survey	NA	NA	NA	2,450	House Appropriations (Agriculture) Fiscal Year 1975, p. 352
Department of Agriculture TOTAL	12,575	35,982	44,354	31,122	

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Department of Commerce					
The Bureau of Census 1974 Census of Agriculture	NA	NA	1,963	8,422	Appendix, Fiscal Year 1975 Budget, p. 227
Other Maps	182	NA	NA	NA	OMB Federal Mapping Report, p. 63
Planimetric Maps	774	NA	NA	NA	OMB Federal Mapping Report, p. 63
Environmental Research Laboratories, NOAA Other Maps	140	NA	NA	NA	OMB Federal Mapping Report, p. 63
Office of Coastal Environment, NOAA *Coastal Zone Management	NA	NA	12,000	12,000	Appendix, Fiscal Year 1975 Budget, p. 245
Department of Commerce TOTAL	1,096	0	13,963	20,422	

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Department of Defense					
Corps of Engineers, U.S. Army					
*Comprehensive Basin Studies	NA	3,975	3,000	3,500	Appendix, Fiscal Year 1975, Budget, p. 358.
Data Communications	NA	120	120	240	Army CE Circular, March 25, 1974, Table 3, A-12
Digital Processing	NA	NA	14	NA	Army CE Circular, March 25, 1974, Table 3, A-12
*Environmental Impact	NA	70	35	94	Army CE Circular, March 25, 1974, Table 3, A-12
Flood Plain Mapping	NA	NA	31	NA	Army CE Circular, March 25, 1974, Table 3, A-12
*Inventory of Dams	NA	600	1,500	1,500	Appendix, Fiscal Year 1975 Budget, p. 358
*Land Cover	NA	65	115	149	Army CE Circular, March 25, 1974, Table 3, A-12
Other Maps	306	NA	NA	NA	OMB Federal Mapping Report, p. 63

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Photos	1,006	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	2,177	NA	NA	NA	OMB Federal Mapping Report, p. 63
Topographic Maps	664	NA	NA	NA	OMB Federal Mapping Report, p. 63
Defense Mapping Agency					
Photos	930	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	300	NA	NA	NA	OMB Federal Mapping Report, p. 63
Topographic Maps	700	NA	NA	NA	OMB Federal Mapping Report, p. 63
Mississippi River Commission U.S. Army					
Photos	8	NA	NA	NA	OMB Federal Mapping Report, p 63

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Project Maps	171	NA	NA	NA	OMB Federal Mapping Report, p. 63
Topographic Maps	166	NA	NA	NA	OMB Federal Mapping Report, p. 63
Department of Defense TOTAL	6,428	4,830	4,815	5,483	

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Department of the Interior					
Bonneville Power Admin. Project Maps	712	NA	NA	NA	OMB Federal Mapping Report, p. 63
Bureau of Indian Affairs					
Photos	21	NA	NA	NA	OMB Federal Mapping Report, p. 63
Planimetric Maps	75	NA	NA	NA	OMB Federal Mapping Report, p. 63
Bureau of Land Management					
*Forestry	NA	7,721	8,256	8,998	House Appropriations (Interior) Fiscal Year 1975, Pt. III, p. 485
Other Maps	1,384	NA	NA	NA	OMB Federal Mapping Report, p. 63
Photos	50	NA	NA	NA	OMB Federal Mapping Report, p. 63
Planimetric Maps	230	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	242	NA	NA	NA	OMB Federal Mapping Report, p. 63

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
*Range Management	NA	7,109	7,973	9,133	House Appropriations (Interior) Fiscal Year 1975, Pt. III, p.485
Recreation & Wild Life	NA	5,733	6,606	9,513	House Appropriations (Interior) Fiscal Year 1975, Pt. III, p. 485
Research Management Conservation & Protection *Land & Minerals Management	NA	19,118	26,409	45,731	House Appropriations (Interior) Fiscal Year 1975, Pt. III, p. 485
Soil & Watershed Conservation	NA	13,387	14,341	16,565	House Appropriations (Interior) Fiscal Year 1975, Pt. III, p. 485
Bureau of Mines					
Project Maps	205	NA	NA	NA	OMB Federal Mapping Report, p. 63
Bureau of Sports, Fisheries & Wildlife					
*Comprehensive Natural Resource Planning	NA	NA	2,563	3,613	House Appropriations (Interior) Fiscal Year 1975, Pt. IV, p. 541

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
*Increased Spending - Coastal Ecosystems	NA	NA	NA	+500	House Appropriations (Interior) Fiscal Year 1975, Pt. IV, p. 546
*Increased Spending for National Wetlands Inventory	NA	NA	NA	+600	House Appropriations (Interior) Fiscal Year 1975, Pt. IV, p.547
*Increased Spending for Western Water Allocation	NA	NA	NA	+350	House Appropriations (Interior) Fiscal Year 1975, Pt. IV, p. 546
Bureau of Reclamation					
Photos	19	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	905	NA	NA	NA	OMB Federal Mapping Report, p. 63
Geological Survey					
*Earth Resource Observation Systems (EROS)	NA	7,689	8,954	7,573	House Appropriations (Special Energy) Fiscal Year 1975, pp. 472-476. OMB Federal Mapping Report, p. 63

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Land Resource Analysis Program	NA	1,000	NA	NA	Senate Appropriations (Interior) Fiscal Year 1973, p. 601
*Land Use & Data Analysis Program (LUDA)	NA	NA	NA	2,509	House Appropriations (Special Energy) Fiscal Year 1975, pp. 478-480
*The Resource & Land Investigations (RALI)	NA	NA	944	954	House Appropriations (Special Energy) Fiscal Year 1975, p. 477
*Special Resource and Environmental Projects (Urban Area Studies)	NA	986.7	1,020	1,027	House Appropriations (Special Energy) Fiscal Year 1975, p. 407
Topographic Division, GS					
Topographic Maps	28,100	NA	NA	NA	OMB Federal Mapping Report, p. 63
Photos	1,540	NA	NA	NA	OMB Federal Mapping Report, p. 63
Increased Spending for High Altitude Photography	NA	NA	NA	+900	House Appropriations (Special Energy) Fiscal Year 1975, p. 414

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Small Scale & Special Mapping	1,198	NA	NA	NA	OMB Federal Mapping Report, p. 63
*Small Scale & Special Mapping	NA	1,793	2,349	2,775	House Appropriations (Special Energy) Fiscal Year 1975, p. 415
Water Resources Division, GS					
Other Maps	44	NA	NA	NA	OMB Federal Mapping Report, p. 63
National Park Service					
Land Use Studies	NA	NA	488.2	488.2	House Appropriations (Interior) Fiscal Year 1975, Pt. IV, p. 188
Other Maps	428	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	274	NA	NA	NA	OMB Federal Mapping Report, p. 63
Office of Land Use & Water Planning	NA	NA	253.7	257.7	House Appropriations (Interior) Fiscal Year 1975, Pt. IV, p. 776
Department of the Interior TOTAL	35,427	64,536.7	80,156.9	111,486.9	

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
<u>Department of Housing and Urban Development</u>					
Comprehensive Planning Grants	(701)				
*Grants to States and Other Bodies	NA	74,233	106,471	118,000	Appendix, Fiscal Year 1975 Budget, p. 498
Studies, Research, and Demonstrations	NA	1,532	3,529	NA	Appendix, Fiscal Year 1975 Budget, p. 498
Federal Insurance Administration					
Federal Disaster Protection Act 1973	NA	6,076	8,645	17,625	Appendix, Fiscal Year 1975 Budget p. 509
Project Maps	8,276	NA	NA	NA	OMB Federal Mapping Report, p. 63
Department of Housing and Urban Development TOTAL	8,276	81,841	118,645	135,625	

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Department of Transportation					
Federal Highway Administration					
Other Maps	586	NA	NA	NA	OMB Federal Mapping Report, p. 63
Photos	363	NA	NA	NA	OMB Federal Mapping Report, p. 63
Planimetric Maps	4,701	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	2,045	NA	NA	NA	OMB Federal Mapping Report, p. 63
Department of Transportation TOTAL	7,695	0	0	0	

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
<u>Independent Agencies</u>					
Delaware River Basin Commission					
Other Maps	3	NA	NA	NA	OMB Federal Mapping Report, p. 63
Environmental Protection Agency					
Other Maps	1,500	NA	NA	NA	OMB Federal Mapping Report, p. 63
Photos	6	NA	NA	NA	OMB Federal Mapping Report, p. 63
General Services Administration					
Photos	71	NA	NA	NA	OMB Federal Mapping Report, p. 63
National Aeronautics & Space Administration					
Other Maps	98	NA	NA	NA	OMB Federal Mapping Report, p. 63

APPENDIX I - Federal Budgetary Demand (Continued)

Department Agency Item	Federal Budgetary Request ($ 000) Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975	Source
Photos	4,377	NA	NA	NA	OMB Federal Mapping Report, p. 63
Tennessee Valley Authority					
*Other Maps	119	NA	NA	NA	OMB Federal Mapping Report, p. 63
Photos	63	NA	NA	NA	OMB Federal Mapping Report, p. 63
Project Maps	474	NA	NA	NA	OMB Federal Mapping Report, p. 63
Remote Sensing	NA	86	106	102	House Appropriations (Public Works) Fiscal Year 1975, Pt. IV, p. 275
Topographic Maps	434	NA	NA	NA	OMB Federal Mapping Report, p. 63
Valley Mapping	NA	370	309	293	House Appropriations (Public Works) Fiscal Year 1975, Pt. IV, p. 274
Independent Agencies TOTAL	7,145	456	415	395	
GRAND TOTAL	78,642	187,645.7	262,528.9	304,533.9	

APPENDIX I - Federal Budgetary Demand (Continued)

	SUMMARY BY DEPARTMENT			
	Fiscal Year 1972	Fiscal Year 1973	Fiscal Year 1974	Fiscal Year 1975
Department of Agriculture	12,575	35,982	44,354	31,122
Department of Commerce	1,096	0	13,963	20,422
Department of Defense	6,428	4,830	4,815	5,483
Department of the Interior	35,427	64,536.7	80,156.9	111,486.9
Department of Housing and Urban Development	8,276	81,841	118,645	135,625
Department of Transportation	7,695	0	0	0
Independent Agencies	7,145	456	415	395
GRAND TOTAL	78,642	187,645.7	262,528.9	304,533.9

APPENDIX II

Existing Federal Statutory Demand For Remote Sensed Land Cover Information

Appendix II details the Federal statutory demand for remote sensed land cover information. It is divided into four sections.

- Section A — Federal Statutory Demand For Remote Sensed Land Cover Information Related to Land Use Planning
- Section B — Federal Statutory Demand For Remote Sensed Land Cover Information For Other Than Land Use Planning Purposes
- Section C — Future Federal Statutory Demand Remote Sensed Land Cover Information
- Section D — Summary Descriptions of Federal Statutory Pertaining to Remote Sensed Land Cover Information

For Sections A and B the remote sensing demand created by each statute is subdivided into two parts. The top row indicates the 1974 requirements placed on remote sensing to obtain the land cover information. The bottom row indicates the anticipated requirements placed on remote sensing in the year 1977.

For Section A, the level of detail used for evaluating remote sensing requirements is given in the land use inventory classification scheme found in Table 2-2 of the EarthSat

Interim Report "Analysis of Costs and Benefits from Use of ERS Data in State Land Use Planning".

For Section B, it is assumed that ERTS can obtain the level of detail I and II representing the scales 1:500,000 and 1:125,000. Level of detail III representing the scale 1:24,000 would be obtained by high and low altitude aircraft. The sources for the information presented in this Appendix include: a survey of the Federal statutes listed in the Department of Justice U.S. Code information system (JURIS) that create a demand for remote sensing, documents on existing Federal agency remote sensing activity and the various reports on the significant results from ERTS-1 principal investigators.

Section A. Federal Statutory Demand for Remote Sensed Land Cover Information Related to Land Use Planning

Title of Statute	Statutory Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Current/Future Data Data Acquisition Methods
Department of Agriculture Forest Resources Act, as Amended (WD-P)	16 USC 581	Forest Management	1	90 Dy	III	1	Present: Aerial Photography - Sampling
			1	[illegible] Dy	II	10	1977: ERTS - Aerial Photography - Sampling
			1	90 Dy	III	1	
Timber Development Organization (Est.)	40 USC 204	Forest Management	1	90 Dy	III	1	Present: ASCS Photography - Sampling
			1	90 Dy	II	1	1977: ERTS - Aerial Photography - Sampling
			1	90 Dy	III	1	
Clarke-McNary Act (Est.)	16 USC 567A	Forest Management	1	90 Dy	III	.1	Present: ASCS Photography - Ground Survey - Sampling
			1	90 Dy	II	.1	1977: ERTS - Aerial Photography - Sampling
			1	90 Dy	III	.1	
National Wilderness Preservation System (WD-L)	P.L. 88-577	Wilderness Area Mapping	1	1 Yr	III	1	Present: Any Available Source Incl: Aerial Photography
			1	1 Yr	II	1	1977: Any Available Source Incl: ERTS & Aerial Photography
			1	1 Yr	III	.1	
Rural Development Act of 1972 (Bankhead-Jones Farm Tenant Act, as Amended) (WD-L,P)	P.L. 92-419 7USC 1010	Soil, Water, and Related Resource Conditions	1/5	1 Yr	III	100	Present: Any Available Source Aerial Photography - Sampling
			4	90 Dy	II	100	1977: Any Available Source ERTS - Aerial Photography
			1/5	1 Yr	III	100	
Agricultural Research Act (WD-P)	7 USC 427,4271	Survey of Land, Forest and Water Resources	1/5	1 Yr	III	100	Present: Any Available Source ASCS Photography -
			4	90 Dy	II	100	1977: Any Available Source ERTS - ASCS Photography Sampling
			1/5	1 Yr	III	100	
Water Bank Act (Est.)	16 USC 1301	Wetlands Mapping	1	90 Dy	[illegible]	.1	Present - Ground Survey ASCS Photography
			4	90 Dy	II	.1	1977: Ground Survey - ERTS - ASCS Photography
			1	90 Dy	III	.1	

Legend: (WD-L) - Well Defined by Statute
(WD-P) - Well Defined by Program
(Est.) - Requirement Estimated

Section A. Federal Statutory Demand for Remote Sensed Land Cover Information Related to Land Use Planning (Continued)

Title of Statute	Statutory Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Current/Future Data Acquisition Methods
Department of Interior Geological Survey (WD-P)	43 USC 31	Land Use Mapping Topographic Mapping	1	90 Dy	III	10	Present: Aerial Photography Ground Survey
			4 1 1/5 1/10	90 Dy 90 Dy 1 Yr 1 Yr	II II III III	1 10 10 100	1977: ERTS - Aerial Photography - Ground Survey
Bureau of Land Management (Est.)	43 USC 2	Survey of Public Lands	1	1 Yr	III	.1	Present: Ground Survey-Limited Aerial Photography
			1	1 Yr	III	.1	1977: Ground Survey Limited Aerial Photography
Taylor Grazing Act (WD-P)	43 USC 315 a,f	Range Management	1	90 Dy	III	.1	Present: Ground Survey Limited Aerial Photography
			1 1	90 Dy 90 Dy	II III	.1 .1	1977: Ground Survey - ERTS Limited Aerial Photography
Oregon and California Grant Lands (Est.)	43 USC 1181	Resource Management	1	1 Yr	III	.1	Present: Ground Survey Aerial Photography
			1 1	90 Dy 1 Yr	II III	.1 .1	1977: Ground Survey - ERTS Aerial Photography
Outdoor Recreation Act (Est.)	P.L. 88-29 77 Stat. 49	Outdoor Recreation Resources	1	1 Yr	III	1	Present: Ground Survey
			1	1 Yr	III	1	1977: Ground Survey
Fish and Wildlife Act of 1956 (Est.)	16 USC 742	Wildlife Resource Information	1	1 Yr	III	.1	Present: Ground Survey Aerial Photography
			4 1	90 Dy 1 Yr	I III	.1 .1	1977: Ground Survey ERTS - Aerial Photography

Legend: (WD-L) - Well Defined by Statute
(WD-P) - Well Defined by Program
(Est.) - Requirement Estimated

Section A. Federal Statutory Demand for Remote Sensed Land Cover Information Related to Land Use Planning (Continued)

Title of Statute	Statutory Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Current/Future Data Acquisition Methods
Environmental Protection Agency, Coast Guard Federal Water Pollution Control Act of 1972 (WD-P)	33 USC 1151 P.L. 92-500	Monitoring of Water Pollution	52	1 Wk	III	.1	Present: Aerial Survey
			52 52	1 Wk 1 Wk	II III	1 .1	1977: ERTS - Aerial Survey
Department of State American-Mexican Chamizal Convention Act of 1964 (Est.)	22 USC 277D-17	Study of Water Resources on U.S.-Mexican Border	1	1 Yr	III	.1	Present: Aerial Photography - Ground Survey
			1 1	1 Yr 1 Y	II III	.1 .1	1977: ERTS - Aerial Photography - Ground Survey
Department of Commerce Fish and Wildlife Act of 1950 (Est.)	16 USC 760a	Survey of Coastal Fish Resources	1	1 Yr	III	1	Present: Ground Surveys, Aerial Surveys
			1 1	1 Yr 1 Yr	II III	1 1	1977: Ground Survey, Aerial, ERTS Surveys
Fish and Wildlife Act of 1949 (Est.)	16 USC 759	Survey of Shad Resources	1	1 Yr	III	1	Present: Ground Surveys, Aerial Surveys,
			1 1	1 Yr 1 Yr	II III	1 1	1977: Ground Surveys, Aerial Surveys, ERTS
Fish and Wildlife Act (Est.)	16 USC 744	Study of Coastal Fish Resources	1	1 Yr	III	1	Present: Ground Surveys, Aerial Surveys
			1 1	1 Yr 1 Yr	II III	1 1	1977: Ground Sruveys, Aerial Surveys, ERTS

Legend: (WD-L) - Well Defined by Statute
(WD-P) - Well Defined by Program
(Est.) - Requirement Estimated

Section A. Federal Statutory Demand for Remote Sensed Land Cover Information Related to Land Use Planning (Continued)

Title of Statute	Statutory Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Current/Future Data Acquisition Methods
Department of Interior, Agriculture, H.E.W., and Federal Power Commission Water Resources Planning Act (Est.)	42 USC 1962A-1 P.L. 89-80	Water Resources	1/2	1 Yr	III	100	Present: Any Available Date - Remote Sensing Imput Unknown
			1/2 1/2	1 Yr 1 Yr	II III	100 100	1977: Any Available Source - ERTS
Department of Housing and Urban Development National Flood Insurance Act of 1968 (WD-P)	42 USC 4102-£ P.L. 90-448 Title XIII	Flood Plain Mapping	1	1 Yr	III	.1	Present: Aerial Photography - Ground Survey
			100 1	1 Wk 1 Yr	II III	.1 .1	1977: ERTS Aerial Photographs Ground Survey
Housing Act of 1954, as Amended (WD-P)	P.L. 90-448 Title VI 40 USC 461	Land Use Planning	1	1 Yr	III	1	Present: Aerial Photography - Ground Survey
			1 1	1 Yr 1 Yr	II III	10 10	1977: ERTS - Aerial Photography - Ground Survey
Department of Defense - Civilian Dam Safety Act of 1972 (WD-P)	P.L. 92-367	Inventory of Impoundments	25	90 Dy	II	10	Present: Ground Survey - ERTS Aerial Photography
			2 5 1/5	90 Dy 90 Dy	II III	.1 1	1977: ERTS - Aerial Photography - Ground Survey
Department of Defense - Civilian and Agriculture Watershed Protection and Flood Protection Act, as Amended (Est.)	16 USC 1001-1009	Flood Protection	1	1 Yr	III	.1	Present: Aerial Photography
			1/5 1	1 Yr 1 Yr	II III	1 .1	1977: ERTS - Photography - Ground Survey
Cooperative Agreements for Surveys and Investigations (Est.)	33 USC 883E	Resource Surveys	1	1 Yr	III	1	Present: Aerial Photography - Ground Survey
			1/5 1	1 Yr 1 Yr	II III	10 1	1977: ERTS - Aerial Photography - Ground Survey
Flood Control Act of 1960, as Amended Title II (Est.)	33 USC 709a P.L. 86-645	Flood Damage Assessment	50	15 Dy	III	.1	Present: Aerial Photography - Ground Survey
			100 100	1 Wk 15 Dy	II III	.1 .1	1977: ERTS - Photography - Ground Survey

Legend: (WD-L) - Well Defined by Statute
(WD-P) - Well Defined by Program
(Est.) - Requirement Estimated

Section B. Federal Statutory Demand for Remote Sensed Land Cover Information for Other than Land Use Planning Purpose

Title of Statute	Statutory Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Current/Future Data Acquisition Methods
Department of Agriculture							
Soil Conservation Act of 1935 (WD-P)	16 USC 590	Soil Erosion	1/10	1 Yr	III	100	Present - Any Available Data - Ground Survey
			1 1/5	1 Yr 1 Yr	II III	10 100	1977: ERTS - Any Available Data - Ground Survey
Soil Survey Act (WD-P)	42 USC 3272	Soil Survey	1	90 Dy	III	.1	Present: Aerial Photography - Ground Survey
			1	90 Dy	III	1	1977: No Change from Present
Food and Agriculture Act of 1965 (WD-P)	P.L. 89-321	Acreage Allotment Enforcement	1	90 Dy	III	10	Present Aerial Photography - Ground Survey
			12 1	1 Mo 90 Dy	II III	10 10	1977: ERTS - Aerial Photography - Ground Survey
Agricultural Adjustment Act of 1938 (Est.)	7 USC 1344	Cotton Acreage Allotment Determination	1	90 Dy	III	.1	Present: Ground Survey - Aerial Photography
			1 1	90 Dy 90 Dy	II III	.1 .1	1977: ERTS - Aerial Photography Ground Survey
Agricultural Adjustment Act of 1930 (Est.)	7 USC	Peanut Marketing Quota	1	90 Dy	III	.1	Present: Ground Survey Aerial Photography
			1 1	90 Dy 90 Dy	II III	.1 .1	1977: ERTS - Aerial Photography Ground Survey
Statistical Reporting Service (WD-L,P)	7 USC 411a,b	Crop Estimates	12	1 Mo	III	10	Present: Ground Surveys - Sampling
			12 12	15 Dy 1 Wk	II III	10 1	1977: Ground Survey - Sampling - ERTS
Agricultural Marketing Act of 1946 (WD-L,P)	7 USC 1622	Crop Estimates	12	1 Mo	III	1	Present: Ground Survey - Sampling
			12 12	15 Dy 1 Wk	II III	10 1	1977: Ground Survey - Sampling - ERTS
Cotton Act (Est.)	7 USC 475,476 P.L. 92-331	Condition and Progress of Cotton Crop	10	1 Mo	III	.1	Present: Ground Survey Sampling
			10 10	15 Dy 15 Dy	II III	.1 .1	1977: ERTS - Ground Survey Sampling
Forest Pest Control Act (WD-P)	16 USC 594	Survey of Forest Insect Pest and Tree Diseases	50	1 Yr	III	.1	Present: Aerial Sketching Sampling
			12 100	1 Mo 1 Yr	II III	10 .1	1977: ERTS - Aerial Sketching - Sampling

Legend: (WD-L) = Well Defined by Legislation
(WD-P) = Well Defined by Program
(Est.) = Requirement Estimated

Section D. Federal Statutory Demand for Remote Sensed Land Cover Information for Other than Land Use Planning Purpose (Continued)

Title of Statute	Statutory Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Current/Future Data Acquisition Methods
Department of Agriculture Plant Disease and Pest Control (Est.)	7 USC 147a	Plant Disease and Pest Control	10	1 Mo	III	1	Present: Aerial Sketching Ground Survey
			12 10	15 Dy 1 Mo	II III	10 1	1977: ERTS - Aerial Photography - Ground Survey
Department of Interior Geological Survey (Est.)	43 USC 31	Geologic Mapping	1	1 Yr	III	10	Present: Aerial Photography Ground Survey
			1 1	1 Yr 1 Yr	I-II III	10 10	1977: ERTS - Aerial Photography - Ground Survey
Extension of Corporative Work to Puerto Rico (Est.)	43 USC 49	Geologic Mapping	1	1 Yr	III	.1	Present: Aerial Photography Ground Survey
			1 1	1 Yr 1 Yr	II III	.1 .1	1977: ERTS - Aerial Photography - Ground Survey
Geological Survey (Est.)	30 USC 641	Mineral Exploration	1	1 Yr	III	1	Present: Aerial Photography Ground Survey
			1 1	1 Yr 1 Yr	I-II III	1 1	1977: ERTS - Aerial Photography - Ground Survey
Department of Interior Coal Mine Fire Safety Act (Est.)	P.L. 83-738 30 USC 553	Underground Coal Fires	12	15 Dy	III	.1	Present: Remote Sensing Ground Survey
			12	15 Dy	III	.1	1977: Remote Sensing Ground Survey
Wildlife Protection from Pollution (Est.)	16 USC 665	Effects of Pollution on Wildlife	1	1 Yr	III	.1	Present: Aerial Surveys - Ground Surveys
			1 1	1 Yr 1 Yr	II III	.1 .1	1977: ERTS - Aerial Survey Ground Survey
Water Resources Planning Act Alaskan Water Resources (Est.)	42 USC 1962D-12	Investigation of Water Resource Projects in Alaska	1	90 Dy	III	1	Present: Aerial Photography Ground Survey
			2 1	90 Dy 90 Dy	II III	1 1	1977: ERTS - Aerial Photography - Ground Survey
Federal Reclamation Law (Est.)	43 USC 405g	Inventory of Irrigated Lands	1	1 Yr	III	1	Present: Ground Survey
			12 1	1 Mo 1 Yr	II III	.1 1	1977: ERTS - Ground Survey

Legend: (WD-L) - Well Defined by Statute
(WD-P) - Well Defined by Program
(Est.) - Requirement Estimated

Section C. Future Federal Legislative Demand For Remote Sensed Land Cover Information

Title of Legislation	Legislative Reference	Type of Information	Frequency of Coverage	Timeliness of Coverage	Level of Detail	Area % of the United States	Future Data Acquisition Methods
Department of Interior							
Land Use Policy and Planning Assistance Act of 1973	S. 268	Land Use Planning Information	4	90 Dy	II	100	ERTS - Aerial Photography
	H.R. 10294		1/5	1 Y	III	100	
Surface Mining Control and Reclamation Act of 1973		Inspection of Surface Mining and Reclamation Operations	12	1 Mo.	II		ERTS - Aerial Photography
	H.R. 11500		1	90 Dy	III	10	
National Resources Lands Management Act	S. 1041	Inventory of Bureau of Land Management Lands	4	90 Dy	II	10	ERTS - Aerial Photography
	H.R. 5441		1	1 Yr	III	10	

Section D. Summary Descriptions of Federal Statutes Pertaining To Remote Sensed Land Cover Information

Section D-1

FEDERAL STATUTES RELATED TO LAND USE PLANNING

Forest Resources Act, As Amended
16 USC 581

Agency Affected: Department of Agriculture, Forest Service

Date Passed: 22 May 1928; 14 December 1967

Data Collection
Statutory Requirement: In co-operation with the states and other public and private agencies, USDA is directed to make and keep current a comprehensive survey of:

- present and future requirements for timber and other forest products,

- present and future timber and forest product supplies, including determination of forest land productivity and other necessary information.

Specificity: Law mandates the collection of specific types of information. Frequency of updating is left open, although a maximum funding level for updating is specified.

Comments: Remote sensing by satellite has potential for application in determining supplies and productivity of forest lands.

Funding Level Ceilings

pre-1962	$1.5 million
1962-1967	$2.5 million
1967-present	$5.0 million

Supplementary Information: The present program is known as the Forest Survey. A nationwide report on the condition of forest and timber resources is issued once every 10 years. Frequency of resurvey varies by forest district and by states within each district. Present resurvey interval for the states varies from 8-15 years. Aerial photography plays an important role in the forest survey as a means of locating and evaluating sampling plots for further detailed ground investigation. The Forest Service is presently required to use ASCS aerial photography whenever possible

Demand Matrix Input: The present activity level represents the requirement of the forest survey. During one year, level III information taken during the summer season is required for 3% of the U.S. This results at the end of a ten year period in all of the forestland within the U.S. being surveyed.

The 1977 requirements for level II information reflect the inputs of an operational ERTS system. The impact of this system on the present forest survey program will be to supplement and increase the accuracy of the forest survey but not to replace the existing procedures.

Source: Clawson, M. and Stewart, C.L., Land Use Information (Baltimore) The Johns Hopkins Press, 1965, Appendix C.

Timber Development Organizations
40 USC 204

Agency Affected: Department of Agriculture

Date Passed: 11 October 1967

Data Collection
Statutory Requirement: The Secretary of Agriculture is authorized to provide technical assistance in the organization and operation, under state law, of private timber development organizations having as their objective the carrying out of timber development programs to improve timber productivity and quality.

Comments: Remote sensing is applicable as part of forest management. Technical assistance could easily include utilization of ERTS imagery. No specific level of program activity is stated or implied, however.

Supplementary Information: The present program activity is estimated. We assume this activity would be determined by the agreements reached between the Forest Service and private corporations. Most of the information is gathered by ground survey; data from aerial photography would be provided by the Forest Survey.

Demand Matrix Input: Present and future requirements reflect the requirements of the Forest Survey.

Source: General information on the operation of the Forest Service.

Clarke-McNary Act
16 USC 567A

Agency Affected: Department of Agriculture

Date Passed: 29 August 1935

Data Collection
Statutory Requirement: The Secretary of Agriculture is authorized to acquire, in the name of the United States, forest lands to be managed by the states as state forests. This acquisition includes the mapping, examination, appraisal, and surveying of the forests.

Comments: Remote sensing could have a definite role in the preliminary mapping and surveying of prospective forest acquisitions. This statute does not mandate a particular level of activity, however.

Supplementary Information: Present program activity is estimated. Remote sensing requirements for appraisal and surveying of the forest are assumed to be fulfilled by the forest survey.

Demand Matrix Input: Present activity level requirements are assumed to be the same for the Forest Resources Act but a much smaller area.

The 1977 activity level indicates the supplementing of the present activity level with ERTS derived information.

Source: General information on the operation of the Forest Service.

National Wilderness Preservation System, 1964
P.L. 88-577

Agency Affected: Department of Agriculture; Forest Service

Data Collection
Statutory Requirement: The Secretary of Agriculture is required to file a map and legal description of each wilderness area with the Interior and Insular Affairs Committees of the United States Senate and the House of Representatives.

The Secretary of Agriculture must review as to its suitability or non-suitability for preservation as wilderness each area in the national forests classified on the effective date of this Act as primitive within ten years after the enactment of this Act.

Supplementary Information: The present program activity is assumed to follow the specific information and timetable requirements of the law. As indicated in the law, this program is administered by a number of agencies under the direction of the Secretary of Agriculture, the Chief Forester of the Forest Service, and the Secretary of the Interior. It is assumed that information used to implement this law was drawn from existing programs within the effected agencies. Some of this information is collected by remote sensing.

Demand Matrix Input: Present activity level indicates an estimated demand for information over a 10 year period for 5% of the U.S. per year.

The 1977 requirement indicates a continuation of the present program plus supplemental information provided by ERTS.

Source: Text of the legislation.

Rural Development Act of 1972
Bankhead-Jones Farm Tenant Act, As Amended
P.L. 92-419
7 USC 1010

Agency Affected: Department of Agriculture

Date Passed: 30 August 1972

Data Collection

Statutory Requirement: The Secretary of Agriculture is directed to carry out a land inventory and monitoring program to include, but not limited to, studies and surveys of erosion and sediment damages, flood plain identification, and utilization, land use changes and trends, and degradation of the environment resulting from improper use of soil, water and related resources. The Secretary shall issue at not less than 5-year intervals a land inventory report reflecting soil, water, and related resource conditions.

Supplementary Information: Present program activity is determined by the status of the Land Inventory and Monitoring Program (L.I.M.) of the Soil Conservation Service. This is a central data bank system for resource information used and collected by the USDA. A report must be filed on the items noted above once every five years. The present program in the planning stage with full operations is dependent upon funding from Congress. Present plans are to use any up-to-date source of information available and to collect raw data only when information is not available through other sources. Information gathered by most of the programs listed in Section A will be used.

Demand Matrix Input: The present program level reflects the need for land cover data to fulfill the once-every-five years requirement which is not operational at present.

The 1977 level reflects a continuation of the present program level plus an input by ERTS to keep the information updated.

Source: Meetings with the L.I.M. Program officials.

Agricultural Research Act
7 USC 427, 427i

Agency Affected: Department of Agriculture

Date Passed: 29 June 1935

Data Collection
Statutory Requirement: The Secretary of Agriculture is authorized and directed to conduct research relating to the conservation, development, and use of land, forest, and water resources for agricultural purposes, and other studies bearing on the agricultural industry of the United States.

Comments: As an instrument for the surveying and monitoring of land, forest, and water resources, remote sensing is applicable to the carrying out of the provisions of this law.

Supplementary Information: The present program activity is indicated by the activities of the Resource Development Economics Division of the Economic Research Service. A national land use inventory report entitled "Major Uses of Land and Water" is issued once every five years. Data for this report is collected on separate uses of land from various state and federal agencies to give an account of the entire land area. Some ASCS and other aerial photography is used for measuring changes in land use and for appraising use potentials and conservation needs. It is estimated that this activity will be replaced by the L.I.M. program.

Demand Matrix Input: The present activity level reflects the once-every-five years land use inventory.

The 1977 level indicates a continuation of the present program with the use of ERTS to provide seasonal updates.

Source: (1) Clawson, M. and Stewart, C.L., Land Use Information (Baltimore) The Johns Hopkins Press, 1965, Appendix B.

(2) Major Uses of Land in the United States - Summary for 1969 ERTS - Agri. Econ. Rept. #247.

Water Bank Act
16 USC 1301

Agency Affected: Department of Agriculture

Date Passed: 19 December 1970

Data Collection
Statutory Requirement: The Secretary of Agriculture is directed to formulate and carry out a continuous program to prevent the serious loss of wetlands, and to preserve, restore, and improve such lands. The Secretary shall have authority to enter into agreements with landowners and operators in wetlands areas in important migratory waterfowl nesting and breeding areas for the conservation of water on specified farm, ranch, or other wetlands identified in a conservation plan.

Comments: The identification of wetlands often entails mapping, where remote sensing can play a very significant role. In New Jersey, the implementation of a state wetlands law required a substantial aerial photograph and mapping effort.

Supplementary Information: The present program activity represents a continuing program to prevent the loss of wetlands by entering into agreements with landowners to conserve wetlands on their property. There is no periodic inventory of the wetlands; wetlands are mapped when an agreement is reached, and ASCS photography is used as a source of information.

Demand Matrix Input: The present activity level reflects estimated limited demand for ASCS photography.

The 1977 level reflects a continuation of the present program supplemented by ERTS to monitor and update the wetland areas.

Source: Conversation with Soil Conservation officials.

Geological Survey
43 USC 31

Agency Affected: Department of Interior, Geological Survey

Date Passed: 3 March 1879; 5 September 1962

Data Collection
Statutory Requirement: The Director of the Geological Survey shall have charge of the classification of the public lands and examination of the geological structure, mineral resources, and products of the country. The survey shall examine the geological structure, mineral resources, and products of the rest of the world where determined by the Secretary of the Interior to be in the national interest.

Comments: The authority provided by this Act is brief, yet quite broad in scope. Remote sensing clearly has an important role to play here.

Supplementary Information: This legislation is extremely broad, encompassing all of the Survey's programs. Program activities covered in this section are limited to the operational topographic mapping program and the R & D land use mapping programs. A land use mapping program called LUDA is expected to become operational next year with a goal of periodic mapping of the land cover of the United States. Both the topographic and land use mapping programs make extensive use of aerial photography.

Demand Matrix Input: The present activity level reflects the estimated aerial photography requirements of the topographic mapping program.

The 1977 level reflects the continued needs of the topographic mapping program which is expected by this time period and the requirements of an operational LUDA program. ERTS is expected to provide a significant input into the LUDA program especially in providing yearly updates.

Source: (1) Conversations with U.S.G.S. officials

(2) Congressional Appropriation Hearings on U.S.G.S. Programs.

Bureau of Land Management
43 USC 2

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed: 16 July 1946

Data Collection
Statutory Requirement: The Secretary of the Interior or his designate is empowered to perform all executive duties appertaining to the survey and sale of the public lands of the U.S.

Specificity: Very general. Does not direct that any particular surveys be done.

Comments: Enabling legislation.

Supplementary Information: Present program activity is estimated to be very limited in scope. It involves the surveying of public land and the preparation of cadastral maps. Aerial photography is used where base maps are nonexistent or out of date.

Demand Matrix Input: Present activity level represents a limited demand for aerial photography of a project-specific nature.

The 1977 level reflects a continuation of the present program with ERTS having no impact.

Source: General information on BLM programs.

Taylor Grazing Act
43 USC 315a

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed: 28 June 1934

Data Collection
Statutory Requirement: The Secretary of the Interior is directed to make provision for the protection, administration, regulation, and improvement of the grazing districts created under the authority of the Act, and is directed to do any and all things necessary to preserve the land from destruction and to provide for its orderly use. The Secretary is also authorized to continue the study of erosion and flood control.

Comments: Remote sensing is clearly relevant to the full carrying out of these provisions.

Supplementry Information: Although the present program does not involve an inventory of range land, several range condition and trend studies are conducted (with ground surveys) using random sampling and plot monitoring techniques. Aerial photography is used only as a base map where no maps exist.

Demand Matrix Input: The present program activity reflects the requirement of the ground surveys.

The 1977 level reflects an anticipated input by ERTS in monitoring range conditions to supplement the existing programs.

Source: Conversation with BLM - Division of Range personnel.

Taylor Grazing Act
43 USC 315f

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed: 28 June 1934

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized to examine and classify any lands withdrawn or reserved by Executive Orders 6910 and 6964, or within a grazing district, which are more valuable for agricultural crops than for forage crops or for any other use, and to open these lands to entry, selection, or location for disposal in accordance with such classification under applicable public land laws. These lands shall not be subject to disposition, settlement, or occupation until after the same have been classified and opened to entry, except for certain locations falling under mining laws.

Comments: This law requires the examination and classification of most lands falling under this provision. If the proposed National Resource Lands Management Act of 1973 is passed into law intact, the exemption of certain lands falling under mining laws will be dropped.

Remote sensing may be applicable to the provisions of this law.

For additional information see the Taylor Grazing Act (43 USC 315a).

Oregon and California Grant Lands
Land Use
43 USC 1181

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed: 28 August 1937

Data Collection
Statutory Requirement: The Secretary is authorized to classify and restore to homestead entry or purchase under certain provisions, any revested or reconveyed land of the Oregon and California Railroad and Coos Bay Wagon Road Grant Lands, which are more suitable for agricultural use than for use as forest, recreation, or other purposes.

Comments: Possible impact on remote sensing, magnitude almost certainly small.

Supplementary Information: The present program activity is assumed to be carried out under the range and forest management functions of the appropriate BLM management districts.

Demand Matrix Input: The present activity level is estimated to meet the general requirements of forest and range management.

The 1977 level reflects a possible input of ERTS to supplement the present program.

Source: Conversation with BLM officials.

Outdoor Recreation Act
P.L. 88-29
77 Stat. 49

Agency Affected: Department of the Interior, Bureau of Outdoor Recreation

Date Passed: 28 May 1963

Data Collection
Statutory Requirement: Secretary is authorized to:

- prepare and maintain a continuing inventory and evaluation of outdoor recreation needs and resources of the United States;

- prepare a system of outdoor recreation resources to assist in the effective and beneficial use and management of such resources.

Comments: Possibly relevant to remote sensing.

Supplementary Information: The present program is assumed to maintain a continuing inventory using information collected from any available sources. A comprehensive plan for outdoor recreation was issued in 1973. The level of remote sensing involvement is unknown.

Demand Matrix Input: The present activity level assumes a very broad requirement with data collected by ground survey.

The 1977 level reflects a continuation of the present program.

Source: General information on the Bureau of Outdoor Recreation.

Fish and Wildlife Act of 1956
16 USC 742

Agency Affected: Department of the Interior, Fish and Wildlife Service

Date Passed: 8 August 1956

Data Collection
Statutory Requirement: The Secretary shall conduct continuing investigations, prepare and disseminate information, and make periodical reports to the public, to the President, and to Congress, with respect to the following matters:

(2) The availability and abundance and the biological requirements of fish and wildlife resources.

(4) The collection and dissemination of statistics on commercial and sport fishing.

(5) The collection and dissemination of statistics on the nature and availability of wildlife, progress in acquisition of additional refuges and measures being taken to foster a coordinated program to encourage and develop wildlife values.

(7) Any other matters which in the judgment of the Secretary are of public interest in connection with any phases of fish and wildlife operations.

(f) The Secretary shall also

(4) take such steps as may be required for the development, advancement, management, conservation, and protection of the fisheries resources, and

(5) take such steps as amy be required for the development, management, advancement, conservation, and protection of wildlife resources through research, acquisition of refuge lands, development of existing facilities, and other means.

Comments: This law presents a broad mandate for the collection of a wide variety of natural resources information.

Supplementary Information: The present program is reflected by the activities of the Bureau of Sport Fisheries and Wildlife. At present inventories are conducted on an irregular basis as funding becomes available. A wetlands inventory was conducted in 1965 and is in the planning stage for approximately 1978. Aerial photography and surveys play a role in monitoring the wildlife resources.

Demand Matrix Input: The present program activity level indicates the general requirement of this broad program in which ground survey plays the major role with some input from aerial photography.

The 1977 level reflects an anticipated input by ERTS in addition to the present program activities.

Source: Conversation with Bureau of Sport Fisheries and Wildlife officials.

Federal Water Pollution Control Act of 1972
33 USC 1151
P.L. 92-500

Agency Affected: Environmental Protection Agency; Coast Guard

Date Passed: 18 October 1972

Data Collection
Statutory Requirements: One of the many provisions of this act calls for the establishment of an oil spill surveillance system designed to provide early notice of oil and other hazardous substances discharge. While nominally designating the President for this task, the Coast Guard has been selected to implement this provision.

On a more general level, Section 309 of the act prescribes a course of action for the EPA Administrator "whenever on the basis of information available to him" he finds any person in violation of certain of the laws provisions.

In addition, the Administrator of EPA is directed to

- conduct and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent ... of pollution; and to cooperate with other public and private groups in doing this.

- conduct public investigations concerning the pollution of any navigable waters

- establish, equip, and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters and ground waters and the continguous zone and the oceans; the Administrator shall, to the extent practicable, conduct such surveillance by utilizing the resources of NASA, NOAA, USGS, and USCG and shall report on this quality.

A proposed Administration amendment to this law would authorize the study of procedures and methods, including land use requirements, to control construction activity related sources of pollution, including run-off from the resultant facilities.

Specificity: The oil spill surveillance system called for by the law mandates a definite type of information gathering program. The language of the law is quite precise on this. The language is much less specific on the precise information-gathering requirements for other types of pollution.

Comments: The Coast Guard began their oil spill surveillance program in the summer of 1973. Surveillance is performed by six HU-16 aircraft which provide bi-weekly coverage of part of the U.S. coastal waterways and weekly coverage of the Great Lakes. The use of satellite surveillance is currently under investigation. The potential for satellite application in this program appears strong.

To the extent that satellite surveillance can detect other forms of water pollution such efforts should receive some impetus from this law, but the data-collection requirements are much less specific. With the success of ERTS sediment loading experiments and others, however, the provisions of this law may have more applicability to remote sensing.

Supplementary Information: The present program is very broad and information requirements are determined by the specific project needs. Remote sensing plays an active role.

Demand Matrix Input: The present activity level reflects the requirements of the oil spill surveillance program described above.

The 1977 level indicates a continuation of the present program supplemented by ERTS to reduce the area requirements for detailed information.

Source: Conversation with Environmental Protection Agency officials.

American-Mexican Chamizal
Convention Act of 1964
22 USC 277D-17

Agency Affected: Department of State

Date Passed: 29 April 1964

Data Collection
Statutory Requirement: The U.S. Commissioner of the International Boundary and Water Commission, United States and Mexico, is authorized to conduct technical and other investigations on flood control and water resources, among others.

Comments: Remote sensing should be generally applicable.

Supplementary Information: The present program level is estimated to apply to specific projects concerning water resources. It is assumed that remote sensing would apply to these projects.

Demand Matrix Input: The present activity level reflects the broad requirements needed to meet the various projects.

The 1977 level indicates a combination of the present program supplemented by ERTS.

Source: General information on water resource projects.

Fish and Wildlife Act of 1950
16 USC 760a

Agency Affected: Department of Commerce

Date Passed: 25 August 1950

Data Collection
Statutory Requirement: The Secretary of the Interior is directed to undertake a comprehensive continuing study of species of fish of the Atlantic coast, including bays, sounds, and tributaries, in order to recommend to the coastal states appropriate measures for the development and protection of such resources and their wisest utilization.

Comments: Remote sensing may be applicable.

Supplementary Information: The present program is administered by the National Marine Fisheries Service. The information requirements are related to the various types of studies being conducted in the coastal areas. Aerial photography is used in studying fish schools.

Demand Matrix Input: The present activity level reflects the numerous project requirements within the program.

The 1977 level indicates a continuation of the present program supplemented by ERTS.

Source: General information on the National Marine Fisheries Service.

Fish and Wildlife Act of 1949
16 USC 759

Agency Affected: Department of Commerce

Date Passed: 18 August 1949

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized to undertake a comprehensive and continuing study of the shad of the Atlantic Coast, to arrest the decline, increase the abundance, and promote the wisest utilization of shad resources.

Comments: Remote sensing may be applicable here.

Supplementary Information: The present program is administered by the National Marine Fisheries Service. The information requirements are related to the various types of studies being conducted in the coastal areas. Aerial photography is used in studying fish schools.

Demand Matrix Input: The present activity level reflects the numerous project requirements within the program.

The 1977 level indicates a continuation of the present program supplemented by ERTS.

Source: General information on the National Marine Fisheries Service.

Fish and Wildlife Act
16 USC 744

Agency Affected: Department of Commerce

Date Passed: 3 March 1887; 24 May 1950

Data Collection
Statutory Requirement: The Director of Fish and Wildlife Services shall make investigations of whether any and what diminution in the number of the food fishes of the coast and lakes of the United States has taken place; and, if so, to what causes the same is due, and also whether any and what protective, prohibitory, or precautionary measures should be adopted in the premises.

Comments: Application to remote sensing dependant upon its ability to detect fish populations and sources of fish stresses.

Supplementary Information: The present program is administered by the National Marine Fisheries Service. The information requirements are related to the various types of studies being conducted in the coastal areas. Aerial photography is used in studying fish schools.

Demand Matrix Input: The present activity level reflects the numerous project requirements within the program.

The 1977 level indicates a continuation of the present program supplemented by ERTS.

Source: General information on the National Marine Fisheries Service.

Fish and Wildlife Act of 1947
16 USC 758a

Agency Affected: Department of the Interior, Fish and Wildlife Service

Date Passed: 4 August 1947

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized to conduct studies to insure maximum development and utilization of the high seas fishery resources of the territories and island possessions of the U.S. in the tropical and sub-tropical Pacific Ocean and intervening areas.

Comments: Very general data collection mandate. Remote sensing may be relevant.

Supplementary Information: This legislation is not included in the matrix due to its lack of application to the continental U.S.

Water Resources Planning Act
42 USC 1962A-1
P.L. 89-30

Agency Affected: Departments of Interior; Agriculture; Health; Education, and Welfare; Federal Power Commission

Date Passed: 22 July 1965

Data Collection
Statutory Requirement: The Water Resources Council, created by this act, is directed to maintain a continuing study of the adequacy of water supplies necessary to meet the water requirements in each water resource region in the U.S.

The Council is also directed to study the relation of regional or river basin plans and programs to national requirements.

Specificity: Law mandates the collection of specific water supply data. The second requirement more indirectly calls for data collection through the determination of national requirements.

Comments: ERTS-1 hydrology experiments indicate feasibility of water supply determination by satellite.

Council is directed to prepare a water supply assessment at 22 year intervals.

Supplementary Information: The present program is reflected by the activities of the Water Resources Council. Information gathered for the biannual reports is assumed to be obtained from the various related programs of the sponsoring Departments with no raw data being collected by the Water Resources Council that would utilize aerial photography. Remote sensing is being used within some of the R & D projects funded.

Demand Matrix Input: The present activity represents the biannual report required by law.

The 1977 level indicates a continuation of the present program with a possible additional input from ERTS.

Source: General information on the Water Resources Council.

National Flood Insurance Act of 1968
42 USC 410L-2
P.L. 90-448, Title XIII

Agency Affected: Department of Housing and Urban Development

Date Passed: 1 August 1968

Data Collection
Statutory Requirement: The Secretary is authorized to:

- establish flood-risk zones in all flood plains, and to make estimates with respect to the rates of probable flood-caused loss for the various flood risk zones for each of these areas, before 1983.

- carry out studies and investigations with respect to the adequacy of state and local measures in flood-prone areas as to land-management and use, flood control, flood zoning, and flood damage prevention.

Comments: Remote sensing applicable to flood zone mapping and land use.

Supplementary Information: The present program is operated under the Federal Insurance Administration and has been supplemented by the Federal Disaster Protection Act of 1973, which requires localities to submit land use zoning plans for flood plains by July 1, 1975 or face the loss of Federal flood insurance. At present no update is required after plans are submitted and accepted. The method of data collection is left to each locality, and it is estimated that in some cases remote sensing is used.

Demand Matrix Input: The present activity level is based on the assumption that the July 1, 1975 deadline is to be met.

The 1977 level represents as estimated use of ERTS to monitor major floods in the U.S.

Source: Conversation with Federal Insurance Administration officials.

National Flood Insurance
42 USC 4102

Agency Affected: Department of Housing and Urban Development

Date Passed: August 1968

Data Collection
Statutory Requirement: The Secretary is authorized to carry out studies and investigations of the adequacy of state and local measures in flood-prone areas as to land management and use, flood control, flood zoning, and flood damage prevention.

Comments: Remote sensing should be useful for both studies and planning.

For additional information see the National Flood Insurance Act of 1968.

Housing Act of 1954, As Amended
P.L. 90-448, Title VI
40 USC 461

Agency Affected: Department of Housing and Urban Development

Date Passed: 1 August 1968

Data Collection
Statutory Requirement: The Secretary is authorized to provide technical assistance to local governmental planning agencies and by contract or otherwise, to make studies and publish information on related problems dealing with urban planning.

Comments: Remote sensing data may be pertinent.

Supplementary Information: The present program administers the Comprehensive Planning Assistance Grants. These grants are awarded by each district office with the specific requirements determined by each grant. This is a primary source of funding for land use mapping programs by state and local planning agencies. Remote sensing is used extensively in these programs.

Demand Matrix Input: The present activity level reflects the broad requirements of the program.

The 1977 level reflects a strong input by ERTS plus an increase in the present program level.

Source: Conversation with H.U.D. official and local development district officials in Tennessee.

Dam Safety Act of 1972
P.L. 92-367

Agency Affected: Army Corps of Engineers

Date Passed: 8 August 1972

Data Collection
Statutory Requirement: The Corps is directed to inspect all dams that are over 25 feet in height or impound over fifty acre - feet of water, with the exception of those dams that are less than six feet in height or that are impound less than fifteen acre - feet of water.

Comments: In many regions, particularly the Southeast and parts of the Midwest and West, the registry of dams is poor. Thus, to carrying out this law, the Corps had to search for unregistered dams. ERTS imagery has been useful in identifying water impoundments of as little as five acres. The location of these dams is a non-repetitive use of ERTS, but detection of future unregistered dams may still be mandated.

Supplementary Information: The present program activity is conducted through grants to the states with expected completion by 1975. At present no update is required, but future legislation is expected to require updating approximately once every five years. ERTS is being used in an operational program to update existing sources and to ensure completeness of coverage.

Demand Matrix Input: The present activity level assumes fifty states must be covered within two years with summer imagery necessary.

The 1977 level reflects anticipated requirements of once every five years update with extensive use of ERTS.

Source: Conversation with remote sensing section of the Army Corps of Engineers.

Watershed Protection and Flood
Protection Act, As Amended
16 USC 1001-1009

Agency Affected: Department of Agriculture; Army Corps of Engineers

Date Passed: 4 August 1954; 30 August 1972

Data Collection
Statutory Requirement: Upon suitable application of local organizations, the Department is authorized to conduct such investigations and surveys as may be necessary to prepare plans for flood prevention or the conservation, development, utilization, and disposal of water.

The Department is also authorized in cooperation with other federal, state, and local authorities to make investigations and surveys of the watersheds of rivers and other waterways as a basis for the development of coordinated programs.

Both the Army and Agriculture, when authorized by the House or Senate Public Works Committees, are authorized and directed to make joint investigations and surveys of U.S. watershed areas.

Comments: Very relevant to remote sensing.

Supplementary Information: The present program activities include a broad range of programs administered by the Department of Agriculture and the Army Corps of Engineers. Program requirements are dependent upon the specific requirements of each application. Remote sensing is utilized in this program.

Demand Matrix Input: Present activity level reflects the wide range of requirements of this program.

The 1977 level reflects a continuation of existing programs plus the use of ERTS for updating the studies once every five years.

Source: Conversation with Army Corps of Engineers officials.

Cooperative Agreements for Surveys and Investigations

33 USC 883e

Agency Affected: Department of the Army, Corps of Engineers

Date Passed: 6 August 1947

Data Collection
Statutory Requirement: The Director of the Corps is authorized to enter into cooperative agreements with state and local governments for surveying and mapping activities.

Comments: Remote sensing and earth resources satellites should be pertinent to these activities of the Corps. This statute merely provides authority, however, and does not mandate a particular program activity.

Supplementary Information: The present program activities are determined by the requirements of the agreements reached with the state. A research and development program is underway to compile environmental atlases for several states using remote sensing as a source of data.

> Demand Matrix Input: The present activity level reflects the wide range of requirements of this program.
>
> The 1977 level reflects a continuation of the existing program with the use of ERTS to update the studies once every five years.

Source: General information on Army Corps of Engineers activities.

Flood Control Act of 1960, As Amended
Title II, P.L. 86-645; 33 USC 709a

Agency Affected: Army Corps of Engineer

Date Passed: 14 July 1960

Data Collection
Statutory Requirement: The Corps is authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods, and general criteria for guidance in the use of flood plain areas; and to provide engineering advice to ameliorate flood hazards.

Specificity: Calls for particular kind of data collection.

Comments: $11,000,000 is set as the maximum annual expenditure of funds for this purpose. Remote sensing should be applicable.

Supplementary Information: The present program activities are estimated to cover the major floods occurring in the United States. The actual requirements are determined by the frequency and magnitude of major floods during a one year period.

Demand Matrix Input: The present activity level indicates an estimate of the number of major floods occurring in the U.S. during one year that require aerial coverage.

The 1977 level indicates an increase in the demand for this type of information for pusposes of land use planning in flood plains. It is anticipated that the input from ERTS could reduce the area requirements of the present system.

Source: General information on Army Corps of Engineers activities.

Section D-2

FEDERAL STATUTES FOR OTHER THAN LAND USE PLANNING PURPOSES

Soil Conservation Act
16 USC 590

Agency Affected: Department of Agriculture, Soil Conservation Service

Date Passed: 27 April 1935

Data Collection
Statutory Requirement: The Secretary of Agriculture is empowered to coordinate and direct all activities with relation to soil erosion and is authorized, from time to time, to conduct surveys, investigations, and research relating to the character of soil erosion and the preventive measures needed, to publish the results of any such surveys, investigating, or research, to disseminate information concerning such methods, and to conduct demonstrational projects in erosion-prone areas.

Specificity: Law calls for collection of particular type of natural resource data, but does not specify a frequency of collection.

Comments: Remote sensing appears applicable.

Supplementary Information: The present program is operated by the Soil Conservation Service. There is no established inventory program, but a sample inventory has been conducted for the last two decennial Conservation Needs Inventories. Present information is obtained from periodic reports from the S.C.S. county offices.

Demand Matrix Input: The present activity level represents the decennial input into the Conservation Needs Inventory.

The 1977 level reflects the anticipated demands of the L.I.M. program plus an annual monitoring capacity with ERTS.

Source: (1) National Inventory of Soil and Water Conservation

(2) Clawson, M. and Stewart, C.L., Land Use Information (Baltimore) The Johns Hopkins Press, 1965, Appendix D.

(3) Conversation with S.C.S. official.

Soil Survey Act
42 USC 3272

Agency Affected: Department of Agriculture

Date Passed: 7 September 1966

Data Collected
Statutory Requirement: The Secretary of Agriculture is directed to provide assistance in studies of soil classification and interpretation, and the furnishing of technical and other assistance needed for use of soil surveys, upon the request of a state or other public agency.

Comments: Remote sensing is capable of assisting in the carrying out of this statute.

Supplementary Information: The present program is engaged in the completion of soil maps by the Soil Conservation Service. Aerial photographs are used extensively for base maps and to delineate soil boundaries, thereby cutting the time required for field work. Imagery must be taken during early spring to show bare soil, and any available imagery taken within three years is used. Counties are resurveyed approximately once every 40 years.

Demand Matrix Input: The present activity level reflects present program requirements for spring imagery.

No change in the program is expected by 1977.

Source: Conversation with S.C.S. official.

Food and Agriculture Act of 1965
P.L. 89-321

Agency Affected: Department of Agriculture

Date Passed: 2 November 1965

Data Collection
Statutory Requirement: The Secretary of Agriculture is directed to determine the acreage of any agricultural commodity or land use on farms for which the knowledge of such acreage is necessary to determine compliance under any agricultural program. This determination is to be made prior to harvest if possible.

Specificity: By calling for acreage surveys, this bill mandates a specific kind of data to be compiled by Agriculture.

Comments: Upon development of suitable models for acreage determination, remote sensing may be very applicable to this law.

Supplementary Information: The present program is operated by the Agricultural Stabilization and Conservation Service. Crop acreage information is no longer used for enforcement of acreage allotments. Under this program, the ASCS obtains low altitude B & W aerial photography of each county every 6-8 years. This aerial photography is used extensively by a number of federal agencies.

Demand Matrix Input: The present activity level reflects the requirements of the aerial photography program for summer imagery.

The 1977 level reflects a continuation of the existing program with ERTS used to provide yearly updating of crop acreage.

Source: Conversation with ASCS officials.

Agricultural Adjustment Act of 1938
7 USC 1344

Agency Affected: Department of Agriculture

Date Passed: 16 February 1938

Data Collection
Statutory Requirement: The Secretary of Agriculture is directed to determine and proclaim a national acreage allotment for cotton whenever a national marketing quota is proclaimed under section 1342 of Title 7. The national acreage allotment for a given year is apportioned to the states on the basis of the acreage planted to cotton in the preceding five years. The allocation of a state's allotment to the counties is based upon a similar historical approach.

Comments: Remote sensing may be able to help in cotton acreage allotment determination by providing either a check on existing methods of determining cotton harvests or a more accurate and reliable alternative for the collection of this data.

Supplementary Information: The present program operates under the provisions of the Food and Agriculture Act of 1965 with yearly information obtained by mail surveys.

Demand Matrix Input: The present and 1977 activity levels reflect the requirements of the Food and Agriculture Act of 1965.

Source: Conversation with ASCS officials.

Agricultural Adjustment Act of 1938
7 USC 1358

Agency Affected: Department of Agriculture

Date Passed: 16 February 1938

Data Collection
Statutory Requirement: The Secretary of Agriculture is directed to proclaim the amount of the national marketing quota for peanuts between July and December of each calendar year for the crop produced in the succeeding calendar year. This quota is based upon the average quantity of peanuts harvested in the past five years, and other trends and factors.

Comments: Remote sensing may be able to assist the setting of the peanut marketing quota by providing more accurate estimates of peanut harvests.

Supplementary Information: The present program operates under the provisions of the Food and Agriculture Act of 1965 with yearly information obtained by mail surveys.

Demand Matrix Input: The present and 1977 activity levels reflect the requirements of the Food and Agriculture Act of 1965.

Source: Conversation with ASCS officials.

Statistical Reporting Service
7 USC 411a, b

Agency Affected: Department of Agriculture

Date Passed: 4 March 1909; 24 October 1962

Data Collection
Statutory Requirement: The monthly crop report, "which shall be gathered as far as practicable from practical farmers," shall contain statements of the conditions of crops by states, with the exception that estimates of apple production are to be confined to the commerical crop.

Comments: Remote sensing should be very useful in making crop estimates, especially as the technology evolves.

Supplementary Information: The present program collects monthly information on the condition of crops by mail survey and from periodic reports by the county agricultural agents. No remote sensing is presently being used.

Demand Matrix Input: The present program reflects the monthly reports required by law.

The 1977 level reflects a possible monthly input by ERTS allowing a reduction in the size of the present sampling program.

Source: Conversation with S.R.S. officials.

Agricultural Marketing Act of 1946, As Amended
7 USC 1622

Agency Affected: Department of Agriculture

Date Passed: 14 August 1946

Data Collection
Statutory Requirement: The Secretary of Agriculture is directed and authorized to collect, tabulate, and disseminate statistics on marketing agricultural products including, but not restricted to, statistics on market supplies, storage stocks, quality, and condition of such products in various positions in the marketing channel.

Comments: Data collection requirement is rather general, but remote sensing could play a role in ascertaining projected crop totals.

Supplementary Information: The present program is the same as that of the Statistical Reporting Service.

Cotton Act
7 USC 475, 476
P.L. 92-331

Agency Affected: Department of Agriculture

Date Passed: 30 June 1972

Data Collection
Statutory Requirement: The Secretary of Agriculture shall cause to be issued as of the first of each month during the cotton growing and harvesting season (from August to January inclusive) reports describing the condition and progress of the cotton crop and stating the probable number of bales which will be ginned.

The Secretary shall issue a report on or before the 12th day of July of each year showing by states and in total the estimated cotton acreage planted to be followed on or before the 12th day of August with an estimate of the acreage for harvest and on or before the 12th day of December with an estimate of the harvested acreage.

Comments: Law calls for a very precise kind of data and specifies the frequency with which it is to be issued. Remote sensing appears to offer a capability for meeting the mandated data collection.

Supplementary Information: The present program operates under the same procedures as the Statistical Reporting Service.

> Demand Matrix Input: The present activity level reflects the legislative requirement for monthly reports during 10 months of the year.
>
> The 1977 level reflects an anticipated improvement in the reporting time by utilizing ERTS.

Source: Conversation with S.R.S. officials.

Forest Pest Control Act
16 USC 594

Agency Affected: Department of Agriculture

Date Passed: 25 June 1947

Data Collection
Statutory Requirement: The Secretary of Agriculture is authorized either directly or in cooperation with other agencies or groups to conduct surveys on any forest lands to detect and appraise infestations of forest insect pests and tree diseases.

Comments: This law does not mandate action; where action is taken, remote sensing may be useful.

Supplementary Information: The present program is administered by the Forest Service at the district level. An annual aerial reconnaissance survey is conducted by some districts with ground surveys of infested areas made every 2-3 years, but no regular inventory program is in operation. At present, reconnaissance surveys annually cover 20% of the forest land.

> Demand Matrix Input: The present activity level indicates an estimated fifty aerial reconnaissance flights during one year.
>
> The 1977 level reflects an anticipated increase in demand due to more intense forest management practices with ERTS being used in a regional monthly monitoring capacity.

Source: Conversation with Forest Service officials.

Plant Disease and Pest Control
7 USC 147a

Agency Affected: Department of Agriculture

Date Passed: 21 September 1944

Data Collection
Statutory Requirement: The Secretary of Agriculture is authorized to carry out measures to eradicate or control insect pests, plant diseases, and nematodes.

Comments: Remote sensing may be applicable to this law if plant disease and insect pest signatures can be reliably determined.

Supplementary Information: The present program contains no regular inventory; information is obtained from periodic reports from county agricultural agents. A limited number of aerial surveys are conducted to monitor specific outbreaks.

Demand Matrix Input: The present activity level represents the estimated monthly reporting procedures during the growing season.

The 1977 level represents a continuation of the present procedure with a possible, but questionable, monthly monitoring input by ERTS.

Source: Conversation with Animal and Plant Health Inspection Service officials.

Geological Survey
43 USC 31

Agency Affected: Department of the Interior, Geological Survey

Date Passed: 3 March 1879; 5 September 1962

Data Collection
Statutory Requirement: The Director of the Geological Survey shall have charge of the classification of the public lands and examination of the geological structure, mineral resources, and products of the country. The survey shall examine the geological structure, mineral resources, and products of the rest of the world determined by the Secretary of the Interior to be in the national interest.

Comments: The authority provided by this Act is brief, yet quite broad in scope. Remote sensing clearly has an important role to play here.

Supplementary Information: The present program level covers geologic mapping within the U.S. by the Geological Survey in cooperation with the state geologic surveys. Once an area has been mapped, an update is conducted only to increase the accuracy of the map. When a survey is conducted, extensive use is made of any available aerial photography.

Demand Matrix Input: The present activity level reflects the extremely general requirements of this program and its ability to use any available photography.

The 1977 level indicates a continuation of the existing program supplemented by inputs from ERTS.

Source: General information on Geological Survey.

Extension of Co-operative
Work to Puerto Rico
43 USC 49

Agency Affected: Department of the Interior, Geological Survey

Date Passed: 17 June 1935

Data Collection
Statutory Requirement: The provisions of law authorizing the making of topographic and geological surveys relating to minerals and water resources by the Geological Survey are extended to include Puerto Rico as well.

Comments: General enabling legislation; no program activity level is specified. Remote sensing may be useful in particular applications.

Supplementary Information: The present program level operates under the same requirements as the Geological Survey's state geological mapping programs.

Demand Matrix Input: The present and 1977 levels are the same as the Geological Survey mapping program noted earlier.

Source: General information on Geological Survey.

Geological Survey
30 USC 641

<u>Agency Affected</u>: Department of the Interior, Geological Survey

<u>Date Passed</u>: 21 August 1958

<u>Data Collection</u>
<u>Statutory Requirement</u>: The Secretary of the Interior is authorized and directed to establish and maintain a program for exploration by private industry within the U.S. for such minerals, excluding organic fuels, as he shall designate, and to provide Federal financial assistance on a participating basis for that purpose.

<u>Comments</u>: Broadly pertinent to remote sensing.

<u>Supplementary Information</u>: The present program level covers a wide range of activities related to mineral exploration. Aerial photography is used extensively in this program. Specific requirements are determined by the individual project specifications.

<u>Demand Matrix Input</u>: The present activity level reflects the broad range of the project requirements.

The 1977 level indicates a continuation of the existing program with ERTS providing a significant supplementary input.

<u>Source</u>: General information on Geological Survey.

Coal Mine Fire Safety Act
P.L. 83-738
30 USC 553

Agency Affected: Department of the Interior, Bureau of Mines

Date Passed: 31 August 1954

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized to conduct surveys and research relating to the causes and extent of outcrop and underground fires in coal formations.

Comments: The data requirement of this law is general and nonmandatory. Outcrop may be observable by satellite; IR channel may be able to detect underground fires.

Supplementary Information: The present program level is determined by the number of fire control projects. Remote sensing, primarily with thermal infrared scanners, plays an important role in mapping the extent of these fires. The present program level is estimated.

Demand Matrix Input: The present activity level reflects the estimated number of fire control projects in existence.

The 1977 level indicates a continuation of the existing program.

Source: General information on the Bureau of Mines.

Wildlife Protection from Pollution
16 USC 665

Agency Affected: Department of the Interior, Fish and Wildlife Service, Bureau of Mines

Date Passed: 10 March 1934

Data Collection
Statutory Requirement: The Secretary is authorized to make such investigations as he deems necessary to determine the effects of domestic sewage, mine, petroleum, and industrial wastes, erosion silt, and other polluting substances on wildlife.

Comments: Very general non-mandatory data required.

Supplementary Information: The present program level is estimated. Requirements of the program are determined by the requirements of each research project. It is assumed that remote sensing will play an important role in determining the extent and source of pollution.

Demand Matrix Input: The present activity level reflects the broad range of requirements of the various research projects.

The 1977 level indicates a continuation of the present program supplemented by a possible input from ERTS.

Source: General information on Bureau of Sport Fisheries and Wildlife.

Water Resources Planning Act
Alaskan Water Resources
42 USC 1962D-12

Agency Affected: Department of the Interior

Date Passed: 9 August 1955

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized to make investigations of projects for the conservation, development, and utilization of the water resources of Alaska and to report on such investigations.

Comments: Remote sensing is useful here; no program activity level is specified.

Supplementary Information: The present program level is estimated. The actual program requirements will be determined by each specific project. Given the remoteness of Alaska, remote sensing is used extensively in these studied.

Demand Matrix Input: The present activity level is determined by the specific project requirements but is usually obtained during the summer.

The 1977 level indicates a continuation of the present program supplemented by ERTS imagery during the summer and winter.

Source: General information on water resources.

Federal Reclamation Law
43 USC 485g

Agency Affected: Department of the Interior, Bureau of Reclamation

Date Passed: 4 August 1939

Data Collection
Statutory Requirement: Those lands which have been, are, or may be included in any reclamation or irrigation project authorized by the Federal reclamation laws or operated and maintained by the Bureau of Reclamation for the reclamation of arid lands or other purposes must be reclassified at $\leq$ year intervals as to irrigability and productivity.

Comments: The law mandates specific types of data but not for an exact quantity of land. Frequency of data collection is low.

With the development of suitable models, land productivity and irrigability estimates could be aided or accomplished by remote sensing.

Supplementary Information: The present program does not follow the specific reporting requirements of the law. A continuing reporting program from the irrigation districts is used in which land that is being reclaimed or removed from irrigation is noted. Data collection is done by ground survey.

Demand Matrix Input: The present program activity level reflects the estimated general information reported to the Bureau of Reclamation.

The 1977 level reflects the anticipated inputs of ERTS to supplement the existing program.

Source: Conversations with Bureau of Reclamation officials.

Section D-3

FUTURE FEDERAL LEGISLATION RELATED TO LAND COVER INFORMATION

Land Use Polic, nd Planning
Assistance Ac. of 1973
S. 924; H.R. 4862

Agency Affected: Department of the Interior, the States

Date Passed: Still Pending

Data Collection
Statutory Requirement: The Secretary of the Interior may authorize program management grants if the State has developed a statewide land use planning process, including

- the establishment of a method for the compilation and revision of data related to inventorying areas of critical environmental concern, areas impacted by key facilities and development of land use of regional development

- the establishment of a method for the compilation and continuing revision of data related to population densities and trends, economic characteristics and projections, or environmental conditions and trends, and governmental service needs related to those areas reviewed.

The state land use planning agencies established in response to this law shall give priority to the development of an adequate data base for a statewide land use planning process using data available from existing sources wherever feasible.

The Secretary of the Interior, with the assistance of the National Advisory Board on Land Use Policy (established by this law), shall report to the President and the Congress biennial on land resources, uses of land, and the current and emerging problems of land use.

Comments: Calls for data collection on land use as a critical component of the law. Remote sensing has a great potential here.

Surface Mining Control and Reclamation Act of 1973 H.R. 11500

Agency Affected: Department of the Interior

Date Passed: NYP

Data Collection
Statutory Requirement: The Office of Surface Mining Reclamation and Enforcement is created, which office is directed to make inspections of surface mining and reclamation operations. The office is authorized to conduct and promote the coordination and acceleration of research, studies, surveys, experiments, and training in carrying out the provisions of the act.

Comments: Remote sensing, and ERTS in particular, should be useful for identifying old strip mined areas and for monitoring active strip mines and reclamation activities. According to Rogers et at*, on-site examination of mines is hindered by

- lack of adequate mine map coverage
- deeply eroded, non-existent, or blocked access roads
- lack of accurate or adequate records
- the great total size of the stripped area
- roadside reclamation planting that obscures adjacent barren land
- dated aerial photographic coverage

Thus, remote sensing could have an important role to play in the carrying out of the provisions of this bill.

* Rogers, W.H., Reed, L.E., and Pettyjohn, W.A., "Automated Strip-Mine and Reclamation Mapping from ERTS," Third ERTS Symposium, Washington, D.C., December 10-14, 1973

National Resource Lands
Management Act
S. 1041
H.R. 5441

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed: Still Pending

Data Collection
Statutory Requirement: The Secretary shall prepare and maintain on a continuing basis an inventory of all Bureau of Land Management - administered lands except the outer continental shelf, giving priority to areas of critical environmental concern. This inventory shall reflect changes in conditions and in identifications of resource values.

The Secretary shall develop, maintain, and when appropriate, revise land use plans for these lands with the land use plans of state and local governments and other federal agencies.

The Secretary is authorized to enter into contracts for the use of aircraft for airborne cadastral survey and fire protection operations of the Bureau of Land Management.

Comments: Calls for a large data collection effort on public lands. Frequency is not specified.

Remote sensing is applicable, especially for the survey and fire protection provision.

APPENDIX III

SUMMARY OF COST

1.0 Satellite System Cost

Cost data for the elements in a satellite system are given in Table 1 which has been adapted from reference 1 for a specific ERS configuration (designed mission configuration-3 in the referenced report). The mission configuration-3 will employ a spacecraft with capability similar to ERTS-1. It will carry two sensors, a Panchromatic Return Beam Vidicon and a Multi-spectral Scanner. In addition, this mission configuration will carry two wide band video tape recorders to provide global coverage. There will be two tracking and data acquisition stations and the data processing will be all digital.

The time phased investment and operations costs given in the referenced report for a five and one-half year operating period are shown in Table 1. Cost for each major hardware element are shown separately, together with NASA Civil Service Cost (computed as 6.6% of the annual total investment and operation costs). Based upon the data in Table 1, the time phased costs for a sixteen and one-half year program have been projected as shown in Table 2. In addition, cost projections were made for satellite systems employing two simultaneously active satellites in orbit and three simultaneously active satellites in orbit. Summary costs for a one, two and three

Table 1 Phased Program Costs* For Configuration 3 Over a Five Year Operating Period
Millions of 1973 Dollars

	1975	1976	1977	1978	1979	1980	1981	1982	TOTAL
INVESTMENT COST									
SPACECRAFT	2.7	10.7	10.8	10.7	2.0	2.0	0.5		39.4
PAYLOAD (Sensors)	5.6	11.4	2.8						19.8
Operations Control Center		2.4	1.6						4.0
Data Processing Facilities		3.4	2.2						5.6
Tracking and Data Acquisition System	0.3	6.7	6.6						13.6
LAUNCH VEHICLE			6.4		6.4		6.3		19.1
TOTAL INVESTMENT COST	8.6	34.6	30.4	10.7	8.4	2.0	6.8		101.5
OPERATIONS COST									
Operations Control Center			1.1	2.3	2.2	2.2	2.2	2.2	12.2
Data Processing Facilities			0.3	0.8	0.8	0.8	0.8	0.8	4.3
Tracking and Data Acquisition System			0.8	2.1	2.1	2.1	2.1	2.1	11.3
TOTAL OPERATIONS COST			2.2	5.2	5.1	5.1	5.1	5.1	27.8
TOTAL INVESTMENT & OPS	8.6	34.6	32.5	15.9	13.5	7.1	11.9	5.1	129.3
NASA CIVIL SERVICE COSTS	0.6	2.3	2.1	1.0	0.9	0.5	0.8	0.3	8.5
GRAND TOTAL	9.2	36.9	34.7	16.9	14.4	7.6	12.7	5.4	137.8

* Adopted from Earth Resources Survey (ERS) Operation System Study Final Report (reference 1).

Table 2 Phased Program Costs (1973 $M) for 1 Satellite

Years:	1975	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
Spacecraft	2.7	10.7	10.8	10.7	2.0	2.0	0.5														39.4
							2.7	10.7	10.8	10.7	2.0	2.0	0.5								39.4
													2.7	10.7	10.8	10.7	2.0	2.0	.5		39.4
Payload:	5.6	11.4	2.8				5.6	11.4	2.8				5.6	11.4	2.8						59.4
OCC		2.4	1.6																		4.0
DPF		3.4	2.2																		5.6
TDAS	0.3	6.7	6.6																		13.6
Launch Vehicle:			6.4		6.4		6.4		6.4		6.4		6.4		6.4		6.4		6.4		57.6
Total Investment: Costs	8.6	34.6	30.4	10.7	8.4	2.0	15.2	22.1	20.0	10.7	8.4	2.0	15.2	22.1	20.0	10.7	8.4	2.0	6.9		258
OCC			1.1	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2		
DPF			0.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
TDAS			0.8	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1		
Total Operations: Cost			2.2	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1		84
NASA Civil Service Costs:	0.6	2.3	2.1	1.0	0.9	0.5	1.4	2.6	2.1	1.0	0.9	0.5	1.4	2.6	2.1	1.0	0.9	0.5	0.8		26
Total Program: Costs	9.2	36.9	34.7	16.9	14.4	7.6	21.7	29.8	27.2	16.8	14.4	7.6	21.7	29.8	27.2	16.8	14.4	7.6	12.8		368

satellite system program extending over a sixteen and one-half year period are shown in Table 3.

Comparing Tables 2 and 1, it is seen that we assumed that the sixteen and one-half year program would involve three identical procurement cycles for spacecrafts and payloads, and launch vehicles are procured as required. In the cases of two satellite and three satellite systems, the values for these cost items were essentially scaled by 2 or 3, respectively. Operations costs for the one satellite system were simply extended from the values given in Table 1. For the two and three satellite systems, judgements were made concerning the extent to which the various components of cost would be impacted by two or three satellites orbiting at one time. Tables 4 and 5 present the cost estimates for the two and three satellite systems. The scaling factors that were assumed are provided in Table 6.

Table 3 Total* Program Costs (1977-1993) for Multi-Satellite System (1973 $M)

Number of Simultaneously Active Satellites	1	2	3
Investment Costs:	258	464	645
Operation Costs:	84	117	150
Civil Service Costs:	26	40	58
Total	368	621	853

*Exclusion of Data Processing Costs Which are Shown Separately in Tables 10 and 11 of the Appendix

Table 4 Phased Program Costs (1973 $M) for a 2 Satellite System

Year:	1975	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
Spacecraft:	4.4	18.4	18.6	18.4	4.0	4.0	1.0														68.8
							4.4	18.4	18.6	18.4	4.0	4.0	1.0								68.8
													4.4	18.4	18.6	18.4	4.0	4.0	1.0		68.8
Payload	11.2	22.8	5.6				11.2	22.8	5.6				11.2	22.8	5.6						118.8
OCC		2.4	1.6																		4.0
DPF		3.4	2.2																		5.6
TDAS	0.3	6.7	6.6																		13.6
Launch Vehicle:			12.8		12.8		12.8		12.8		12.8		12.8		12.8		12.8		12.8		115.2
Total Investment: Costs	15.9	53.7	47.4	18.4	16.8	4.0	29.4	41.2	37.0	18.4	16.8	4.0	29.4	41.2	37.0	18.4	16.8	4.0	13.8		493.6
OCC			1.6	3.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3		
DPF			0.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3		
TDAS			1.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5		
Total Operations: Cost			3.1	7.2	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1		116.8
NASA Civil Service Costs	1.1	3.7	3.5	1.9	1.6	0.7	2.5	3.4	3.1	1.9	1.6	0.7	2.5	3.4	3.1	1.9	1.6	0.7	1.4		40.3
Total Program: Costs	17.0	57.4	54.0	27.5	25.5	11.8	39.0	51.7	47.2	27.4	25.5	11.8	39.0	51.7	47.2	27.4	25.5	11.8	22.3		621

Table 5 Phased Program Costs (1973 $m) for a 3 Satellite System

Years:	1975	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
Spacecraft	4.1	24.1	24.1	24.1	6.0	6.0	1.5														90.2
							4.1	24.1	24.1	24.1	6.0	6.0	1.5								90.2
													4.1	24.1	24.1	24.1	6.0	6.0	1.5		90.2
Payload (Sensors);	16.8	34.2	8.4				16.8	34.2	8.4				16.8	34.2	8.4						178.2
OCC		2.4	1.6																		4.0
DPF		3.4	2.2																		5.6
TDAS	0.3	6.7	6.6																		13.6
Launch Vehicle:			19.2		19.2		19.2		19.2		19.2		19.2		19.2		19.2		19.2		172.8
Total Investment: Costs	21.4	70.8	62.4	24.1	25.2	6.0	41.6	58.3	52.0	24.1	25.2	6.0	41.6	58.3	52.0	24.1	25.2	6.0	20.7		645
OCC			2.2	4.5	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3		
DPF			0.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8		
TDAS			1.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		
Total Operations: Costs			3.9	9.3	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1		150
NASA Civil Service Cost	1.7	5.2	2.8	2.7	2.3	1.0	3.6	5.0	4.6	2.7	2.0	1.0	3.6	5.0	4.6	2.7	2.3	1.0	2.0		58
Total Program Cost	23.1	76.0	69.1	36.1	36.6	16.1	54.3	72.4	65.7	35.9	36.3	16.1	54.3	72.4	65.7	35.9	36.6	16.1	31.8		853

Table 6. Scaling Factors for Operations Costs	
Operations Cost Element	**Scaling Factor***
OCC	
Mission operations personnel	.1 N
Computer maintenance	.1 N
M&O personnel	.5 N
Expendables	N
Magnetic tape and paper	N
Orbit operations	.5 N
NDPF	
M&O staffing	.5 N
Engineering service contracts	.5 N
Expendables	N
TDAS	
Operations and maintenance	.1 N
Communications	N
Total Operations	.4 N

*To obtain incremental costs over the 1 Satellite case. For example, if the factor were .5 N, then for the 2 Satellite system the costs would be 1.5 that of the 1 Satellite system.

It must be emphasized that the satellite configuration used throughout this study is not the optimum configuration for a U.S. coverage mission. Nor did we undertake the task of attemping to define an optimum satellite configuration. Rather, the satellite system described in this report was selected for analysis because of the availability of definitive cost data from an earlier NASA study.* It may be argued that an optimum configuration satellite for a U.S. coverage mission may be of academic interest only since such a system would not necessarily be capable of providing global coverage. Nevertheless, it is

* See Reference 1 on page III-19

apparent that significant cost reductions can be achieved in the baseline satellite system used in this study while still providing a global coverage capability. In particular, the two wideband tape recorders in the baseline system appear to be the major life limiting factor of the projected 2 year satellite life time. It is believed that the lifetime of the satellite (without the tape recorders) and its sensor can be extended to 5 years by slight additional expenditure in the area of satellite investment cost for minor modifications to the altitude control system and orbit correction system. Global coverage capability which in the present baseline configuration is provided by two wideband tape recorders could be obtained by provision of additional satellite ground stations or by a system of 3 Tracking and Data Relay Satellites (TDRS). In addition, the baseline satellite system used in this study assumes orbital placement is accomplished by present day launch vehicles. In the 1980's, the Space Shuttle can be used for multiple placement (of two and three) five-year satellites with additional cost savings to be realized.

2.0 High Altitude Aircraft Costs

Cost data for the elements in a high altitude aircraft system are developed in the same manner as in the satellite system and are divided into the same cost categories: Investment Costs, Fixed Annual Costs, and Variable Annual Costs. The source document* for the cost data gives costs for a maximum of four aircraft; for the larger fleet sizes which are expected in an operational system,

* See Reference 2, page III-19

a linear relationship has been assumed between the cost and the number of aircrafts.

Table 7 is a detailed breakdown of the costs identified in the operation of an aircraft system. The assumed aircraft for this system is the U-2 since the coverage is maximized with respect to minimum investment costs compared to other possible aircraft (e.g., WB57, SR71). Maximum aircraft utilization is assumed to be 20 hours per week (1,000 hours/year), and the variable costs are based upong the actual aircraft utilization. The sensors assumed in this cost analysis are a five channel multispectral scanner and a six inch metric camera and are applicable to the automated data processing mode. The investment costs for a strict camera system are approximately two thirds of the listed scanner system costs.

Assumed in these costs is the existence of three bases for the aircraft: one main base, one remote base, and one staging base. Given the range of the U-2, the geographically ideal locations of these bases which would allow for the full coverage of the U.S. including Alaska, would be in Denver, Colorado; Dayton, Ohio; and the staging base in Alaska. With these base locations, the area of the entire U.S. (excluding Hawaii) is within the range of a U-2 for photographic coverage.

Table 8 presents a summary of the three components of the aircraft costs. Under the heading of Investment, it should be noted that the Initial Setup Costs, as the name implies, are one time charges and are phased in one year before the initiation of the operational system. The aircraft leasing cost is based upon

Table 7 Summary of U-2 Aircraft and Base Costs ($K)*					
		Number of U-2 Aircraft			
	Item	1	2	3	4
INVESTMENT					
Initial Setup Cost	Main Base	1005	1175	1390	1610
	Remote Base	870	1040	1255	1455
	Staging Base	870	1040	1255	1455
	Aircraft	200	400	600	800
	Sensor Procurement	240	480	720	960
	Modification	20	40	60	80
Annual Investment	Aircraft Lease	840	1680	2520	3360
FIXED ANNUAL COSTS	Main Base	105	105	105	105
	Remote Base	70	105	105	105
	Staging Base	NONE IDENTIFIED			
	Aircraft	NONE IDENTIFIED			
VARIABLE ANNUAL COST	Aircraft (Main Base)	1000	1700	2490	3165
	Aircraft (Remote Base)	1045	1820	2685	3460
	Sensor Spares	26	52	78	104
	Sensor Technicians	80	110	140	170

* Adopted from Aircraft Support Study for the Earth Resources Survey Operational System, Executive Summary, Satellite Complementary Systems (Reference 2).

TABLE 8 High Altitude Aircraft Total Costs (1973 $M)					
Number of U-2 (N)	1	2	3	4	Functional Relationship Between Cost and Number of U-2's
INVESTMENT					
Initial Setup Costs	3.205	4.175	5.280	6.360	2.153 + 1.052 x N
Aircraft Leasing	.840	1.680	2.520	3.360	+ .840 x N
FIXED ANNUAL COST	.175	.210	.210	.210	.210
VARIABLE ANNUAL COST	2.151	3.682	5.393	6.899	.570 + 1.583 x N*

a ten year life of both the aircraft and the sensor and is allocated to investment during every year of the operational system. The Variable Annual Costs are calculated on the basis of the actual utilization (N*) of the aircraft, to allow for the possibility of less than full use of the aircraft during any given year.

As increasing demand over the years can be expected in an operational system, it should also be expected that the initial setup will not be sufficient to accomodate the aircraft required in the later years. Such expansions in the bases and number of aircraft are assumed to be made in the year preceding the actual requirement for additional aircraft. Furthermore, given the ten year expected life of the aircraft, a re-setup and modification cost for the aircraft and sensor must be repeatedly incurred every ten years.

When an all aircraft system is utilized, a data processing facility must be established to process the information gathered from the high altitude aircraft and ground truth. The costs of such a facility for automatic data processing are: a setup cost of \$5.9M, and a fixed annual cost of \$0.8M. The corresponding costs for manual data processing are \$1.1M and \$.944M, respectively.

3.0 Ground Truth Costs

In the ground truth model we assume that all desired coverage will be contracted to a commercial firm on the basis of a per square mile of coverage. There are many factors governing such prices, and it is common that prices will vary seasonally, from firm to firm, and will be dependent upon such factors as desirability of the coverage, aircraft congestion, the urgency of demand, etc. Based upon the information given in References 3 and 4, and various experience with commercial aerial photographic firms, the average cost (in 1973 dollars) for information obtained at scale of 1:24,000 is estimated at \$6 per square mile. This cost includes the acquisition of photographic coverage and represents the total cost of the rented ground truth system.

In using an average figure we tacitly assume a lower bound on the amount of coverage as the costs per square mile for small areas increases rapidly as shown in Figure 2.

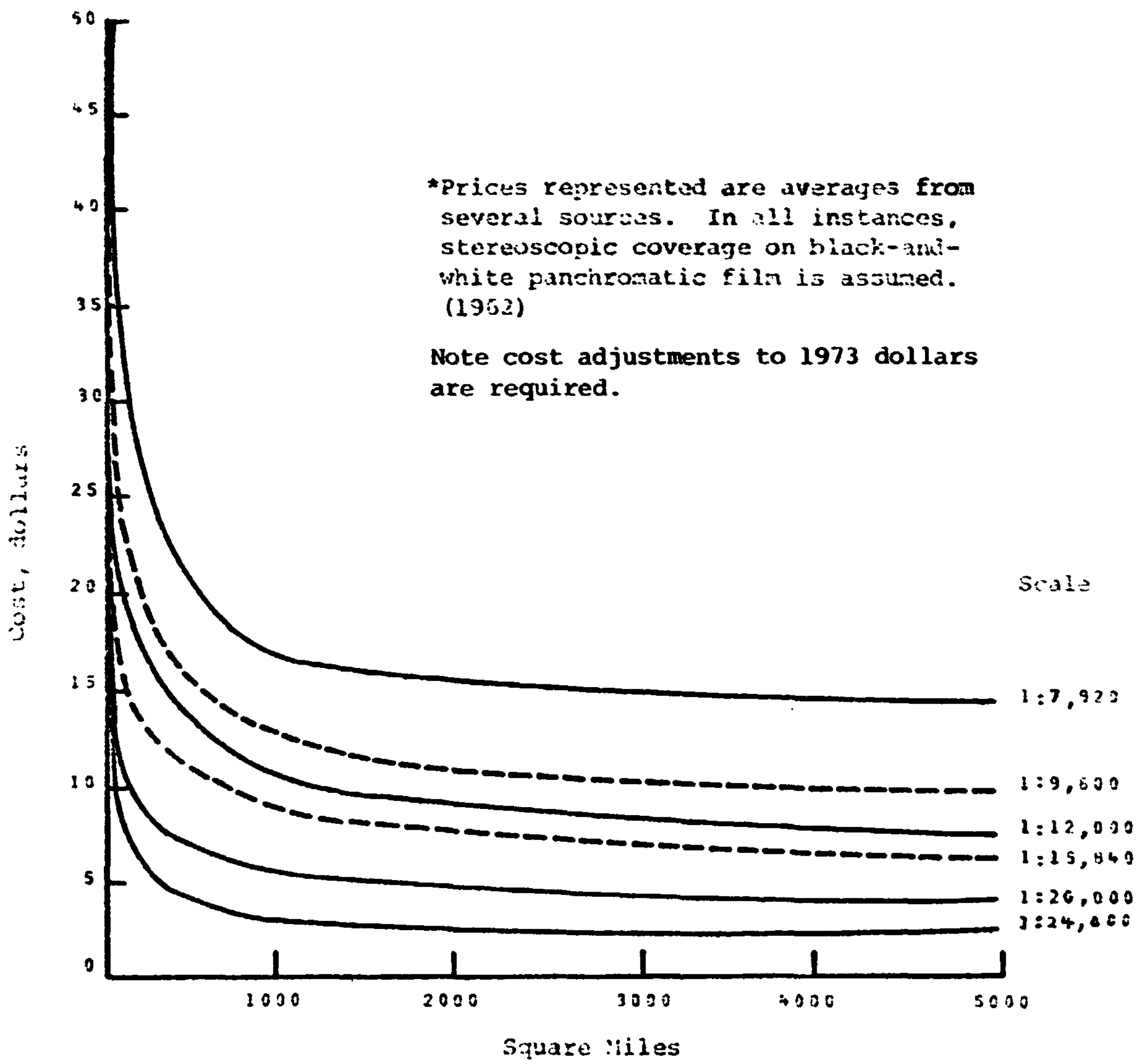

Figure 2 Approximate Cost Per Square Mile of Coverage, by Photo Scale for Low Altitude Aircraft*

4.0 Cost of Data Products

The cost of data products depends primarily upon the type of item which is requested, as simple photographic processing might suffice for applications in which bulk imagery has the highest utility, whereas rectification and interpretation into land cover categories might be required for other applications. Although the proposed land cover information system will be capable of satisfying both types of requests, the cost data presented here corresponds to the demand identified in this study as Level I, Level II, and Level III land cover information.

A major difference in cost is found between manual and automatic (digital) techniques. The sources of this difference are two: cost savings at equal capability, and increased capability; both are in favor of automated techniques. In the manual mode satellite is capable of Level I, high altitude aircraft Levels I and II, and ground truth Levels I, II, and III. In the automatic mode the satellite is capable of Levels I and II, high altitude aircraft Levels I, II and III, and ground truth in the mop up and sampling mode for Levels I, II, and III.

Table 9 presents the break down of the costs in manual interpretation by Level of detail and expected sensor. Table 11 presents the projected cost breakdown for automated interpretation by level of detail and expected sensor.

Table 9 Cost of Manual Production of Maps (Dollars per Square Mile)			
Cost Element	Level I[1] ERTS 1:500,000	Level II[2] H/A aircraft 1:125,000	Level III[3] GT 1:24,000
Imagery Cost (Film and Processing)	.00125	.0453	included in acquisition cost
Classification and Interpretation	.121	.939	5.78
Processing (Cartographic Costs)	.02	.625	2.86
TOTAL	.14	1.6	8.6

1. Based on purchase cost of one ERTS color composite print at $9.00/frame from the ERDS Data Center at Sioux Falls, S. D. The effective area of one ERTS frame is 7200 mi^2.

2. Based on purchase cost of one high altitude aircraft color transparency at $4.00/frame from the EROS Data Center at Sioux Falls, S. D. The effective coverage of one high altitude aircraft frame with 60% forwardlap and 30% sidelap is 88 mi^2.

3. Cost and time results generalized from the results reported by ERTS principle investigators (See references 5-9 on p.

Table 10 Projected[1] Cost of Digital Production of Maps (1973 Dollars per Square Mile)

Cost Element	Level I ERTS 1:500,000	Level II ERTS 1:125,000	Level III H/A aircraft
Imagery Cost[2] (Digital Tape)	.0023	.0023	.021
Rectification[3] Geometric and Radiometric	.002	.002	.027
Classification[4]	.04	.18	.83
Production			
Digital Maps[5]	.001	.002	.19
Photographic[6] (electron beam)	.005	.01	.54
Digital Tapes[2]	.0023	.0023	.021
TOTAL Digital Maps	.044	.186	1.07
TOTAL Photographic	.048	.194	1.42
TOTAL Digital Tapes	.0453	.186	.901

1. As the state of the art is rapidly advancing and current one-time costs are disproportionately high, projections of the component costs have been made which reflect the expected production mode cost of processing.

2. Based on commercial acquisition price of magnetic tapes plus the computer time necessary to copy the tapes.

3. Based on production mode figure cited by Ralph Bernstein in the Ninth International Symposium on Remote Sensing of Environment, Ann Arbor April 15-19, 1974.

4. Based on total cost (man hours, computer time) of the production of classified imagery using a table look-up approach. An order of magnitude decrease in computer-time could be possible through the utilization of a special purpose computer (MIDAS). A decrease in man hours could be possible through the utilization of an unsupervised classifier at the expense of additional computer time.

5. Based on the commercial cost of line printer output plus printing time.

6. Based on correspondence with Earth Resource Laboratory, NASA, Bay, St. Louis, Miss.

Although the major portions of the processing costs occur at the levels given in Tables 9 and 10, it should be recognized that the sensors can always collect less detail than their maximum. In this manner, an high altitude aircraft, which is capable of Level III in the automatic mode, can also acquire data at Levels I and II, and in the aircraft/ground combination, the high altitude aircraft is forced to acquire those data. Similarly, ground truth might be required to gather all Level II and Level III information as is the case in the satellite/ground manual interpretation mode where the satellite is capable of only Level I. In recognition of this upwards compatibility, Table 11 presents both the manual and the projected automatic processing costs for the three sensors, at all three levels of detail.

Table 11 Costs of Land Cover Information
(dollars per square mile)

	Manual			Automatic		
	Satellite	Aircraft	Ground	Satellite	Aircraft	Ground
Level I	.14	1.13	11.0	.048	.80	11.0
Level II	NC	1.60	12.5	.194	.97	12.5
Level III	NC	NC	14.6	NC	1.42	14.6

NC - The sensor is incapable of providing the required detail.

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APPENDIX IV

Selected Detailed Life Cycle Costs

In order to observe the complete effects of technology choices and demand variations, several computer runs of the model were made. Included in these runs was the assumption that the system initiation, that is the initial setup including procurement and modification of the sensors and their associated facilities, will begin in 1975 and that the operational demand will begin in 1977 and continue through 1993. The two year phase in period allows for the operational system to be ready in 1977.

The life cycle costs of the systems were computed in both the undiscounted base and discounted to 1974 at 10%. The discounted version lends insights into the total program costs while the undiscounted version illustrates the actual cost variations in year to year operations.

Each computer run is divided into two pages, each page having the same three components. The first page is the undiscounted costs, and the second is the discounted costs. The first component on each page is a summary of the total yearly costs in RDT&E, Investment, and Operations (activity level dependent and activity level independent). The next two components are the detailed breakdowns for these costs discributed to the satellite, high altitude aircraft, and ground truth systems.

For these analyses, we have assumed that all RDT&E spending has been completed before 1974 and that there will be no further RDT&E efforts for any of the sensors. The Investment costs correspond to both the initial setup costs of the facilities required to house and operate the sensors and the year to year charges to procure new satellites, aircraft leasing, etc. The activity level dependent costs are those which vary most directly with the level of activity of the sensor. These costs correspond to the maintenance, fueling, and personnel required to sustain the required utilization level. Included also in these costs are the interpretation and production costs required to provide the land cover information to the various users. The activity level independent costs are those which do not vary as a function of the utilization of the facility or of the sensors. They correspond to the cost required for the basic management of the facilities.

Presented along with each of the cost breakdowns is a description on the demand and technology for which the respective tables are created. By carefully examining the outputs, one is able to observe in the cost differences the effects of the system changes.

Life Cycle Costs to Provide

Land Cover Information for All

Federal User Demand - 1977

Manual Data Processing

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	16.93	0.00	0.00	16.93
1977	0.00	10.92	151.69	0.21	162.82
1978	0.00	10.92	119.04	0.21	130.17
1979	0.00	10.92	119.04	0.21	130.17
1980	0.00	10.92	119.04	0.21	130.17
1981	0.00	10.92	119.04	0.21	130.17
1982	0.00	10.92	152.63	0.21	163.76
1983	0.00	10.92	119.04	0.21	130.17
1984	0.00	10.92	119.04	0.21	130.17
1985	0.00	10.92	119.04	0.21	130.17
1986	.00	24.60	119.04	0.21	143.84
1987	0.00	10.92	152.63	0.21	163.76
1988	0.00	10.92	119.04	0.21	130.17
1989	0.00	10.92	119.04	0.21	130.17
1990	0.00	10.92	119.04	0.21	130.17
1991	0.00	10.92	119.04	0.21	130.17
1992	0.00	10.92	152.63	0.21	63.76
1993	0.00	10.92	119.04	0.21	130.17
	0.00	216.24	2157.05	3.5	2376.87

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	16.93	0.00
1977	0.00	0.00	0.00	0.00	10.92	0.00
1978	0.00	0.00	0.00	0.00	10.92	0.00
1979	0.00	0.00	0.00	0.00	10.92	0.00
1980	0.00	0.00	0.00	0.00	10.92	0.00
1981	0.00	0.00	0.00	0.00	10.92	0.00
1982	0.00	0.00	0.00	0.00	10.92	0.00
1983	0.00	0.00	0.00	0.00	10.92	0.00
1984	0.00	0.00	0.00	0.00	10.92	0.00
1985	0.00	0.00	0.00	0.00	10.92	0.00
1986	0.00	0.00	0.00	0.00	24.60	0.00
1987	0.00	0.00	0.00	0.00	10.92	0.00
1988	0.00	0.00	0.00	0.00	10.92	0.00
1989	0.00	0.00	0.00	0.00	10.92	0.00
1990	0.00	0.00	0.00	0.00	10.92	0.00
1991	0.00	0.00	0.00	0.00	10.92	0.00
1992	0.00	0.00	0.00	0.00	10.92	0.00
1993	0.00	0.00	0.00	0.00	10.92	0.00
	0.00	0.00	0.00	0.00	216.24	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	62.44	89.25	0.00	0.21	0.00
1978	0.00	63.38	55.65	0.00	0.21	0.00
1979	0.00	63.38	55.65	0.00	0.21	0.00
1980	0.00	63.38	55.65	0.00	0.21	0.00
1981	0.00	63.38	55.65	0.00	0.21	0.00
1982	0.00	63.38	89.25	0.00	0.21	0.00
1983	0.00	63.38	55.65	0.00	0.21	0.00
1984	0.00	63.38	55.65	0.00	0.21	0.00
1985	0.00	63.38	55.65	0.00	0.21	0.00
1986	0.00	63.38	55.65	0.00	0.21	0.00
1987	0.00	63.38	89.25	0.00	0.21	0.00
1988	0.00	63.38	55.65	0.00	0.21	0.00
1989	0.00	63.38	55.65	0.00	0.21	0.00
1990	0.00	63.38	55.65	0.00	0.21	0.00
1991	0.00	63.38	55.65	0.00	0.21	0.00
1992	0.00	63.38	89.25	0.00	0.21	0.00
1993	0.00	63.38	55.65	0.00	0.21	0.00
	0.00	******	******	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	13.99	0.00	0.00	13.99
1977	0.00	8.20	113.96	0.16	122.33
1978	0.00	7.46	81.30	0.14	88.91
1979	0.00	6.78	73.91	0.13	80.82
1980	0.00	6.16	67.19	0.12	73.48
1981	0.00	5.60	61.08	0.11	66.80
1982	0.00	5.09	71.26	0.10	76.39
1983	0.00	4.63	50.48	0.09	55.20
1984	0.00	4.21	45.89	0.08	50.18
1985	0.00	3.83	41.72	0.07	45.62
1986	0.00	7.84	37.93	0.07	45.83
1987	0.00	3.16	44.21	0.06	47.44
1988	0.00	2.88	31.35	0.06	34.28
1989	0.00	2.61	28.50	0.05	31.16
1990	0.00	2.38	25.91	0.05	28.33
1991	0.00	2.16	23.55	0.04	25.75
1992	0.00	1.96	27.45	0.04	29.45
1993	0.00	1.79	19.46	0.03	21.28
	0.00	90.74	845.11	1.39	937.24

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	13.99	0.00
1977	0.00	0.00	0.00	0.00	8.20	0.00
1978	0.00	0.00	0.00	0.00	7.46	0.00
1979	0.00	0.00	0.00	0.00	6.78	0.00
1980	0.00	0.00	0.00	0.00	6.16	0.00
1981	0.00	0.00	0.00	0.00	5.60	0.00
1982	0.00	0.00	0.00	0.00	5.09	0.00
1983	0.00	0.00	0.00	0.00	4.63	0.00
1984	0.00	0.00	0.00	0.00	4.21	0.00
1985	0.00	0.00	0.00	0.00	3.83	0.00
1986	0.00	0.00	0.00	0.00	7.84	0.00
1987	0.00	0.00	0.00	0.00	3.16	0.00
1988	0.00	0.00	0.00	0.00	2.88	0.00
1989	0.00	0.00	0.00	0.00	2.61	0.00
1990	0.00	0.00	0.00	0.00	2.38	0.00
1991	0.00	0.00	0.00	0.00	2.16	0.00
1992	0.00	0.00	0.00	0.00	1.96	0.00
1993	0.00	0.00	0.00	0.00	1.79	0.00
	0.00	0.00	0.00	0.00	90.74	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	46.91	67.05	0.00	0.16	0.00
1978	0.00	43.29	38.01	0.00	0.14	0.00
1979	0.00	37.36	34.55	0.00	0.13	0.00
1980	0.00	35.78	31.41	0.00	0.12	0.00
1981	0.00	32.53	28.56	0.00	0.11	0.00
1982	0.00	29.57	41.63	0.00	0.10	0.00
1983	0.00	26.88	23.60	0.00	0.09	0.00
1984	0.00	24.44	21.46	0.00	0.09	0.00
1985	0.00	22.22	19.51	[illegible]	0.07	0.00
1986	0.00	20.20	17.73	[illegible]	0.07	0.00
1987	0.00	[illegible]	25.85	0.00	0.06	0.00
1988	0.00	[illegible]	16.66	0.00	0.06	0.00
1989	0.00	[illegible]	13.32	0.00	0.05	0.00
1990	0.00	13.79	12.11	0.00	0.05	0.00
1991	0.00	12.54	11.01	0.00	0.04	0.00
1992	0.00	11.40	16.05	0.00	0.04	0.00
1993	0.00	10.36	9.10	0.00	0.03	0.00
	0.00	419.48	425.62	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	16.93	0.00	0.00	16.93
1977	0.00	10.92	179.27	0.21	190.40
1978	0.00	10.92	146.62	0.21	157.75
1979	0.00	10.92	146.62	0.21	157.75
1980	0.00	10.92	146.62	0.21	157.75
1981	0.00	10.92	146.62	0.21	157.75
1982	0.00	10.92	180.21	0.21	191.34
1983	0.00	10.92	146.62	0.21	157.75
1984	0.00	10.92	146.62	0.21	157.75
1985	0.00	10.92	146.62	0.21	157.75
1986	0.00	24.60	146.62	0.21	171.43
1987	0.00	10.92	180.21	0.21	191.34
1988	0.00	10.92	146.62	0.21	157.75
1989	0.00	10.92	146.62	0.21	157.75
1990	0.00	10.92	146.62	0.21	157.75
1991	0.00	10.92	146.62	0.21	157.75
1992	0.00	10.92	180.21	0.21	191.34
1993	0.00	10.92	146.62	0.21	157.75
	0.00	216.24	2626.00	3.57	2845.81

	RDT&E			INVESTMENT		
FISCAL YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	16.93	0.00
1977	0.00	0.00	0.00	0.00	10.92	0.00
1978	0.00	0.00	0.00	0.00	10.92	0.00
1979	0.00	0.00	0.00	0.00	10.92	0.00
1980	0.00	0.00	0.00	0.00	10.92	0.00
1981	0.00	0.00	0.00	0.00	10.92	0.00
1982	0.00	0.00	0.00	0.00	10.92	0.00
1983	0.00	0.00	0.00	0.00	10.92	0.00
1984	0.00	0.00	0.00	0.00	10.92	0.00
1985	0.00	0.00	0.00	0.00	10.92	0.00
1986	0.00	0.00	0.00	0.00	24.60	0.00
1987	0.00	0.00	0.00	0.00	10.92	0.00
1988	0.00	0.00	0.00	0.00	10.92	0.00
1989	0.00	0.00	0.00	0.00	10.92	0.00
1990	0.00	0.00	0.00	0.00	10.92	0.00
1991	0.00	0.00	0.00	0.00	10.92	0.00
1992	0.00	0.00	0.00	0.00	10.92	0.00
1993	0.00	0.00	0.00	0.00	10.92	0.00
	0.00	0.00	0.00	0.00	216.24	0.00

	ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT		
FISCAL YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	57.43	121.84	0.00	0.21	0.00
1978	0.00	58.37	88.25	0.00	0.21	0.00
1979	0.00	58.37	88.25	0.00	0.21	0.00
1980	0.00	58.37	88.25	0.00	0.21	0.00
1981	0.00	58.37	88.25	0.00	0.21	0.00
1982	0.00	58.37	121.84	0.00	0.21	0.00
1983	0.00	58.37	88.25	0.00	0.21	0.00
1984	0.00	58.37	88.25	0.00	0.21	0.00
1985	0.00	58.37	88.25	0.00	0.21	0.00
1986	0.00	58.37	88.25	0.00	0.21	0.00
1987	0.00	58.37	121.84	0.00	0.21	0.00
1988	0.00	58.37	88.25	0.00	0.21	0.00
1989	0.00	58.37	88.25	0.00	0.21	0.00
1990	0.00	58.37	88.25	0.00	0.21	0.00
1991	0.00	58.37	88.25	0.00	0.21	0.00
1992	0.00	58.37	121.84	0.00	0.21	0.00
1993	0.00	58.37	88.25	0.00	0.21	0.00
	0.00	991.41	******	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	13.99	0.00	0.00	13.99
1977	0.00	8.20	134.69	0.16	143.05
1978	0.00	7.46	100.14	0.14	107.75
1979	0.00	6.78	91.04	0.13	97.95
1980	0.00	6.16	82.76	0.12	89.05
1981	0.00	5.60	75.24	0.11	80.95
1982	0.00	5.09	84.07	0.10	89.26
1983	0.00	4.63	62.18	0.09	66.90
1984	0.00	4.21	56.53	0.08	60.82
1985	0.00	3.83	51.39	0.07	55.29
1986	0.00	7.84	46.72	0.07	54.62
1987	0.00	3.16	52.20	0.06	55.43
1988	0.00	2.88	38.61	0.06	41.54
1989	0.00	2.61	35.10	0.05	37.76
1990	0.00	2.38	31.91	0.05	34.33
1991	0.00	2.16	29.01	0.04	31.21
1992	0.00	1.96	32.41	0.04	34.41
1993	0.00	1.79	23.97	0.03	25.79
	0.00	90.74	1027.98	1.39	1120.11

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	13.99	0.00
1977	0.00	0.00	0.00	0.00	8.20	0.00
1978	0.00	0.00	0.00	0.00	7.46	0.00
1979	0.00	0.00	0.00	0.00	6.78	0.00
1980	0.00	0.00	0.00	0.00	6.16	0.00
1981	0.00	0.00	0.00	0.00	5.60	0.00
1982	0.00	0.00	0.00	0.00	5.09	0.00
1983	0.00	0.00	0.00	0.00	4.63	0.00
1984	0.00	0.00	0.00	0.00	4.21	0.00
1985	0.00	0.00	0.00	0.00	3.83	0.00
1986	0.00	0.00	0.00	0.00	7.84	0.00
1987	0.00	0.00	0.00	0.00	3.16	0.00
1988	0.00	0.00	0.00	0.00	2.88	0.00
1989	0.00	0.00	0.00	0.00	2.61	0.00
1990	0.00	0.00	0.00	0.00	2.38	0.00
1991	0.00	0.00	0.00	0.00	2.16	0.00
1992	0.00	0.00	0.00	0.00	1.96	0.00
1993	0.00	0.00	0.00	0.00	1.79	0.00
	0.00	0.00	0.00	0.00	90.74	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	43.15	91.54	0.00	0.16	0.00
1978	0.00	39.87	60.27	0.00	0.14	0.00
1979	0.00	36.25	54.79	0.00	0.13	0.00
1980	0.00	32.95	49.81	0.00	0.12	0.00
1981	0.00	29.96	45.29	0.00	0.11	0.00
1982	0.00	27.23	56.64	0.00	0.10	0.00
1983	0.00	24.76	37.43	0.00	0.09	0.00
1984	0.00	22.51	34.02	0.00	0.08	0.00
1985	0.00	20.46	30.93	0.00	0.07	0.00
1986	0.00	18.60	28.12	0.00	0.07	0.00
1987	0.00	16.91	35.29	0.00	0.06	0.00
1988	0.00	15.37	23.24	0.00	0.05	0.00
1989	0.00	13.97	21.13	0.00	0.05	0.00
1990	0.00	12.70	19.21	0.00	0.05	0.00
1991	0.00	11.55	17.46	0.00	0.04	0.00
1992	0.00	10.50	21.91	0.00	0.04	0.00
1993	0.00	9.54	14.43	0.00	0.03	0.00
	0.00	386.27	641.71	0.00	1.37	0.00

Life Cycle Costs to Provide
Land Cover Information for All
Federal User Demand - 1977

Automatic Data Processing

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	19.23	0.00	0.00	19.23
1977	0.00	13.12	80.02	0.21	93.35
1978	0.00	11.52	77.19	0.21	88.92
1979	0.00	10.92	77.19	0.21	88.32
1980	0.00	10.92	77.19	0.21	88.32
1981	0.00	10.92	77.19	0.21	88.32
1982	0.00	10.92	80.82	0.21	91.95
1983	0.00	10.92	77.19	0.21	88.32
1984	0.00	10.92	77.19	0.21	88.32
1985	0.00	10.92	77.19	0.21	88.32
1986	0.00	24.60	77.19	0.21	102.00
1987	0.00	10.92	80.82	0.21	91.95
1988	0.00	10.92	77.19	0.21	88.32
1989	0.00	10.92	77.19	0.21	88.32
1990	0.00	10.92	77.19	0.21	88.32
1991	0.00	10.92	77.19	0.21	88.32
1992	0.00	10.92	80.82	0.21	91.95
1993	0.00	10.92	77.19	0.21	88.32
	0.00	221.34	1325.96	3.57	1550.87

FISCAL		RDT&E			INVESTMENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	19.23	0.00
1977	0.00	0.00	0.00	0.00	13.12	0.00
1978	0.00	0.00	0.00	0.00	11.52	0.00
1979	0.00	0.00	0.00	0.00	10.92	0.00
1980	0.00	0.00	0.00	0.00	10.92	0.00
1981	0.00	0.00	0.00	0.00	10.92	0.00
1982	0.00	0.00	0.00	0.00	10.92	0.00
1983	0.00	0.00	0.00	0.00	10.92	0.00
1984	0.00	0.00	0.00	0.00	10.92	0.00
1985	0.00	0.00	0.00	0.00	10.92	0.00
1986	0.00	0.00	0.00	0.00	24.60	0.00
1987	0.00	0.00	0.00	0.00	10.92	0.00
1988	0.00	0.00	0.00	0.00	10.92	0.00
1989	0.00	0.00	0.00	0.00	10.92	0.00
1990	0.00	0.00	0.00	0.00	10.92	0.00
1991	0.00	0.00	0.00	0.00	10.92	0.00
1992	0.00	0.00	0.00	0.00	10.92	0.00
1993	0.00	0.00	0.00	0.00	10.92	0.00
	0.00	0.00	0.00	0.00	221.34	0.00

FISCAL		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	55.32	24.70	0.00	0.21	0.00
1978	0.00	50.27	26.92	0.00	0.21	0.00
1979	0.00	50.27	26.92	0.00	0.21	0.00
1980	0.00	50.27	26.92	0.00	0.21	0.00
1981	0.00	50.27	26.92	0.00	0.21	0.00
1982	0.00	56.12	24.70	0.00	0.21	0.00
1983	0.00	50.27	26.92	0.00	0.21	0.00
1984	0.00	50.27	26.92	0.00	0.21	0.00
1985	0.00	50.27	26.92	0.00	0.21	0.00
1986	0.00	50.27	26.92	0.00	0.21	0.00
1987	0.00	56.12	24.70	0.00	0.21	0.00
1988	0.00	50.27	26.92	0.00	0.21	0.00
1989	0.00	50.27	26.92	0.00	0.21	0.00
1990	0.00	50.27	26.92	0.00	0.21	0.00
1991	0.00	50.27	26.92	0.00	0.21	0.00
1992	0.00	56.12	24.70	0.00	0.21	0.00
1993	0.00	50.27	26.92	0.00	0.21	0.00
	0.00	877.19	[illegible]	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	15.89	0.00	0.00	15.89
1977	0.00	9.86	60.12	0.16	70.13
1978	0.00	7.87	52.72	0.14	60.73
1979	0.00	6.78	47.93	0.13	54.84
1980	0.00	6.16	43.57	0.12	49.86
1981	0.00	5.60	39.61	0.11	45.32
1982	0.00	5.09	37.70	0.10	42.89
1983	0.00	4.63	32.74	0.09	37.46
1984	0.00	4.21	29.76	0.08	34.05
1985	0.00	3.83	27.06	0.07	30.96
1986	0.00	7.84	24.60	0.07	32.50
1987	0.00	3.16	23.41	0.06	26.63
1988	0.00	2.86	20.33	0.06	23.26
1989	0.00	2.61	18.40	0.05	21.14
1990	0.00	2.38	16.80	0.05	19.22
1991	0.00	2.16	15.27	0.04	17.47
1992	0.00	1.96	14.56	0.04	16.54
1993	0.00	1.79	12.62	0.03	14.44
	0.00	94.70	517.25	1.39	613.34

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	15.89	0.00
1977	0.00	0.00	0.00	0.00	9.86	0.00
1978	0.00	0.00	0.00	0.00	7.87	0.00
1979	0.00	0.00	0.00	0.00	6.78	0.00
1980	0.00	0.00	0.00	0.00	6.16	0.00
1981	0.00	0.00	0.00	0.00	5.60	0.00
1982	0.00	0.00	0.00	0.00	5.09	0.00
1983	0.00	0.00	0.00	0.00	4.63	0.00
1984	0.00	0.00	0.00	0.00	4.21	0.00
1985	0.00	0.00	0.00	0.00	3.83	0.00
1986	0.00	0.00	0.00	0.00	7.84	0.00
1987	0.00	0.00	0.00	0.00	3.16	0.00
1988	0.00	0.00	0.00	0.00	2.88	0.00
1989	0.00	0.00	0.00	0.00	2.61	0.00
1990	0.00	0.00	0.00	0.00	2.38	0.00
1991	0.00	0.00	0.00	0.00	2.16	0.00
1992	0.00	0.00	0.00	0.00	1.96	0.00
1993	0.00	0.00	0.00	0.00	1.79	0.00
	0.00	0.00	0.00	0.00	94.70	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	41.56	18.56	0.00	0.16	0.00
1978	0.00	34.34	18.39	0.00	0.14	0.00
1979	0.00	31.21	16.72	0.00	0.13	0.00
1980	0.00	28.38	15.20	0.00	0.12	0.00
1981	0.00	25.80	13.81	0.00	0.11	0.00
1982	0.00	26.18	11.52	0.00	0.10	0.00
1983	0.00	21.32	11.42	0.00	0.09	0.00
1984	0.00	19.38	10.38	0.00	0.08	0.00
1985	0.00	17.62	9.44	0.00	0.07	0.00
1986	0.00	16.02	8.58	0.00	0.07	0.00
1987	0.00	16.26	7.15	0.00	0.06	0.00
1988	0.00	13.24	7.09	0.00	0.06	0.00
1989	0.00	12.03	6.44	0.00	0.05	0.00
1990	0.00	10.94	5.86	0.00	0.05	0.00
1991	0.00	9.95	5.33	0.00	0.04	0.00
1992	0.00	10.09	4.44	0.00	0.04	0.00
1993	0.00	8.22	4.40	0.00	0.03	0.00
	0.00	342.53	174.72	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	15.90	0.00	1.10	17.00
1976	0.00	67.42	0.00	3.70	71.12
1977	0.00	56.64	56.93	3.71	117.28
1978	0.00	27.64	57.41	2.11	87.16
1979	0.00	26.04	57.31	1.81	85.16
1980	0.00	13.24	57.31	0.91	71.46
1981	0.00	38.64	57.31	2.71	98.66
1982	0.00	50.44	60.93	3.61	114.98
1983	0.00	46.24	57.31	3.31	106.86
1984	0.00	27.64	57.31	2.11	87.06
1985	0.00	26.04	57.31	1.81	85.16
1986	0.00	24.81	57.31	0.91	83.03
1987	0.00	38.64	60.93	2.71	102.28
1988	0.00	50.44	57.31	3.61	111.36
1989	0.00	46.24	57.31	3.31	106.86
1990	0.00	27.64	57.31	2.11	87.06
1991	0.00	26.04	57.31	1.81	85.16
1992	0.00	13.24	60.93	0.91	75.08
1993	0.00	23.04	57.31	1.61	81.96
	0.00	645.98	984.87	43.87	1674.71

FISCAL YEAR	RDT&E SAT	HA	GT	INVESTMENT SAT	HA	GT
1975	0.00	0.00	0.00	15.90	0.00	0.00
1976	0.00	0.00	0.00	53.70	13.73	0.00
1977	0.00	0.00	0.00	47.40	9.24	0.00
1978	0.00	0.00	0.00	18.40	9.24	0.00
1979	0.00	0.00	0.00	16.80	9.24	0.00
1980	0.00	0.00	0.00	4.00	9.24	0.00
1981	0.00	0.00	0.00	29.40	9.24	0.00
1982	0.00	0.00	0.00	41.20	9.24	0.00
1983	0.00	0.00	0.00	37.00	9.24	0.00
1984	0.00	0.00	0.00	18.40	9.24	0.00
1985	0.00	0.00	0.00	16.80	9.24	0.00
1986	0.00	0.00	0.00	4.00	20.81	0.00
1987	0.00	0.00	0.00	29.40	9.24	0.00
1988	0.00	0.00	0.00	41.20	9.24	0.00
1989	0.00	0.00	0.00	37.00	9.24	0.00
1990	0.00	0.00	0.00	18.40	9.24	0.00
1991	0.00	0.00	0.00	16.80	9.24	0.00
1992	0.00	0.00	0.00	4.00	9.24	0.00
1993	0.00	0.00	0.00	13.80	9.24	0.00
	0.00	0.00	0.00	463.60	182.38	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	HA	GT	ACTIVITY LEVEL INDEPENDENT SAT	HA	GT
1975	0.00	0.00	0.00	1.10	0.00	0.00
1976	0.00	0.00	0.00	3.70	0.00	0.00
1977	6.59	32.28	18.05	3.50	0.21	0.00
1978	10.69	26.44	20.28	1.90	0.21	0.00
1979	10.59	26.44	20.28	1.60	0.21	0.00
1980	10.59	26.44	20.28	0.70	0.21	0.00
1981	10.59	26.44	20.28	2.50	0.21	0.00
1982	10.59	32.28	18.05	3.40	0.21	0.00
1983	10.59	26.44	20.28	3.10	0.21	0.00
1984	10.59	26.44	20.28	1.90	0.21	0.00
1985	10.59	26.44	20.28	1.60	0.21	0.00
1986	10.59	26.44	20.28	0.70	0.21	0.00
1987	10.59	32.28	18.05	2.50	0.21	0.00
1988	10.59	26.44	20.28	3.40	0.21	0.00
1989	10.59	26.44	20.28	3.10	0.21	0.00
1990	10.59	26.44	20.28	1.90	0.21	0.00
1991	10.59	26.44	20.28	1.60	0.21	0.00
1992	10.59	32.28	18.05	0.70	0.21	0.00
1993	10.59	26.44	20.28	1.40	0.21	0.00
	175.21	472.84	315.82	40.30	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	14.45	0.00	1.00	15.45
1976	0.00	55.72	0.00	3.06	58.78
1977	0.00	42.55	42.77	2.79	88.11
1978	0.00	18.88	39.21	1.44	59.53
1979	0.00	16.17	35.59	1.12	52.88
1980	0.00	7.47	32.35	0.51	40.34
1981	0.00	19.83	29.41	1.39	50.63
1982	0.00	23.53	28.42	1.68	53.64
1983	0.00	19.61	24.31	1.40	45.32
1984	0.00	10.66	22.10	0.81	33.57
1985	0.00	9.13	20.09	0.63	29.85
1986	0.00	7.91	18.26	0.29	26.46
1987	0.00	11.19	17.65	0.78	29.63
1988	0.00	13.28	15.09	0.95	29.32
1989	0.00	11.07	13.72	0.79	25.58
1990	0.00	6.02	12.47	0.46	18.95
1991	0.00	5.15	11.34	0.36	16.85
1992	0.00	2.38	10.96	0.16	13.50
1993	0.00	3.77	9.37	0.26	13.40
	0.00	298.77	383.11	19.91	701.79

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	14.45	0.00	0.00
1976	0.00	0.00	0.00	44.38	11.34	0.00
1977	0.00	0.00	0.00	35.61	6.94	0.00
1978	0.00	0.00	0.00	12.57	6.31	0.00
1979	0.00	0.00	0.00	10.43	5.74	0.00
1980	0.00	0.00	0.00	2.26	5.22	0.00
1981	0.00	0.00	0.00	15.09	4.74	0.00
1982	0.00	0.00	0.00	19.22	4.31	0.00
1983	0.00	0.00	0.00	15.69	3.92	0.00
1984	0.00	0.00	0.00	7.09	3.56	0.00
1985	0.00	0.00	0.00	5.89	3.24	0.00
1986	0.00	0.00	0.00	1.27	6.63	0.00
1987	0.00	0.00	0.00	8.52	2.68	0.00
1988	0.00	0.00	0.00	10.85	2.43	0.00
1989	0.00	0.00	0.00	8.86	2.21	0.00
1990	0.00	0.00	0.00	4.00	2.01	0.00
1991	0.00	0.00	0.00	3.32	1.83	0.00
1992	0.00	0.00	0.00	0.72	1.66	0.00
1993	0.00	0.00	0.00	2.26	1.51	0.00
	0.00	0.00	0.00	222.49	76.29	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.00	0.00	0.00
1976	0.00	0.00	0.00	3.06	0.00	0.00
1977	4.95	24.25	13.56	2.63	0.16	0.00
1978	7.30	18.06	13.85	1.30	0.14	0.00
1979	6.58	16.42	12.59	0.99	0.13	0.00
1980	5.98	14.92	11.45	0.40	0.12	0.00
1981	5.44	13.57	10.41	1.28	0.11	0.00
1982	4.94	15.06	8.42	1.59	0.10	0.00
1983	4.49	11.71	8.60	1.31	0.09	0.00
1984	4.08	10.19	7.82	0.73	0.08	0.00
1985	3.71	9.27	7.11	0.56	0.07	0.00
1986	3.38	8.42	6.46	0.72	0.07	0.00
1987	3.07	9.35	5.23	0.72	0.06	0.00
1988	2.79	6.96	5.34	0.90	0.06	0.00
1989	2.54	6.13	4.85	0.74	0.05	0.00
1990	2.31	5.75	4.41	0.41	0.05	0.00
1991	2.10	5.23	4.01	0.32	0.04	0.00
1992	1.91	5.81	3.25	0.13	0.04	0.00
1993	1.73	4.12	3.32	0.23	0.03	0.00
	67.30	185.13	130.67	18.52	1.39	0.00

REPRODUCIBILITY OF THE ORIGINAL PAGE IS [illegible]

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.0	0.00	0.00
1976	0.00	19.23	0.0	0.00	19.23
1977	0.00	13.12	111.8	0.21	125.18
1978	0.00	11.52	111.3	0.21	123.04
1979	0.00	10.92	111.3	0.21	122.44
1980	0.00	10.92	111.3	0.21	122.44
1981	0.00	10.92	111.3	0.21	122.44
1982	0.00	10.92	112.6	0.21	123.78
1983	0.00	10.92	111.3	0.21	122.44
1984	0.00	10.92	111.3	0.21	122.44
1985	0.00	10.92	111.3	0.21	122.44
1986	0.00	24.60	111.3	0.21	136.12
1987	0.00	10.92	112.6	0.21	123.78
1988	0.00	10.92	111.3	0.21	122.44
1989	0.00	10.92	111.3	0.21	122.44
1990	0.00	10.92	111.3	0.21	122.44
1991	0.00	10.92	111.3	0.21	122.44
1992	0.00	10.92	112.6	0.21	123.78
1993	0.00	10.92	111.3	0.21	122.44
	0.00	221.34	1896.8	3.57	2121.73

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	19.23	0.00
1977	0.00	0.00	0.00	0.00	13.12	0.00
1978	0.00	0.00	0.00	0.00	11.52	0.00
1979	0.00	0.00	0.00	0.00	10.92	0.00
1980	0.00	0.00	0.00	0.00	10.92	0.00
1981	0.00	0.00	0.00	0.00	10.92	0.00
1982	0.00	0.00	0.00	0.00	10.92	0.00
1983	0.00	0.00	0.00	0.00	10.92	0.00
1984	0.00	0.00	0.00	0.00	10.92	0.00
1985	0.00	0.00	0.00	0.00	10.92	0.00
1986	0.00	0.00	0.00	0.00	24.60	0.00
1987	0.00	0.00	0.00	0.00	10.92	0.00
1988	0.00	0.00	0.00	0.00	10.92	0.00
1989	0.00	0.00	0.00	0.00	10.92	0.00
1990	0.00	0.00	0.00	0.00	10.92	0.00
1991	0.00	0.00	0.00	0.00	10.92	0.00
1992	0.00	0.00	0.00	0.00	10.92	0.00
1993	0.00	0.00	0.00	0.00	10.92	0.00
	0.00	0.00	0.00	0.00	221.34	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	51.98	59.87	0.00	0.21	0.00
1978	0.00	46.64	64.67	0.00	0.21	0.00
1979	0.00	46.64	64.67	0.00	0.21	0.00
1980	0.00	46.64	64.67	0.00	0.21	0.00
1981	0.00	46.64	64.67	0.00	0.21	0.00
1982	0.00	52.78	59.87	0.00	0.21	0.00
1983	0.00	46.64	64.67	0.00	0.21	0.00
1984	0.00	46.64	64.67	0.00	0.21	0.00
1985	0.00	46.64	64.67	0.00	0.21	0.00
1986	0.00	46.64	64.67	0.00	0.21	0.00
1987	0.00	52.78	59.87	0.00	0.21	0.00
1988	0.00	46.64	64.67	0.00	0.21	0.00
1989	0.00	46.64	64.67	0.00	0.21	0.00
1990	0.00	46.64	64.67	0.00	0.21	0.00
1991	0.00	46.64	64.67	0.00	0.21	0.00
1992	0.00	52.78	59.87	0.00	0.21	0.00
1993	0.00	46.64	64.67	0.00	0.21	0.00
	0.00	[illegible]	[illegible]	0.00	3.57	0.00

PRODUCIBILITY OF THE ORI

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.0	0.00	0.00
1976	0.00	15.89	0.0	0.00	15.89
1977	0.00	9.86	84.0	0.16	94.05
1978	0.00	7.87	76.0	0.14	84.04
1979	0.00	6.78	69.1	0.13	76.02
1980	0.00	6.16	62.8	0.12	69.11
1981	0.00	5.60	57.1	0.11	62.83
1982	0.00	5.09	52.5	0.10	57.74
1983	0.00	4.63	47.2	0.09	51.93
1984	0.00	4.21	42.9	0.08	47.21
1985	0.00	3.83	39.0	0.07	42.91
1986	0.00	7.84	35.4	0.07	43.37
1987	0.00	3.16	32.6	0.06	35.85
1988	0.00	2.88	29.3	0.06	32.24
1989	0.00	2.61	26.6	0.05	29.31
1990	0.00	2.38	24.2	0.05	26.65
1991	0.00	2.16	22.0	0.04	24.22
1992	0.00	1.96	20.2	0.04	22.26
1993	0.00	1.79	18.2	0.03	20.02
	0.00	94.70	739.5	1.39	835.66

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	15.89	0.00
1977	0.00	0.00	0.00	0.00	9.86	0.00
1978	0.00	0.00	0.00	0.00	7.87	0.00
1979	0.00	0.00	0.00	0.00	6.78	0.00
1980	0.00	0.00	0.00	0.00	6.16	0.00
1981	0.00	0.00	0.00	0.00	5.60	0.00
1982	0.00	0.00	0.00	0.00	5.09	0.00
1983	0.00	0.00	0.00	0.00	4.63	0.00
1984	0.00	0.00	0.00	0.00	4.21	0.00
1985	0.00	0.00	0.00	0.00	3.83	0.00
1986	0.00	0.00	0.00	0.00	7.84	0.00
1987	0.00	0.00	0.00	0.00	3.16	0.00
1988	0.00	0.00	0.00	0.00	2.88	0.00
1989	0.00	0.00	0.00	0.00	2.61	0.00
1990	0.00	0.00	0.00	0.00	2.38	0.00
1991	0.00	0.00	0.00	0.00	2.16	0.00
1992	0.00	0.00	0.00	0.00	1.96	0.00
1993	0.00	0.00	0.00	0.00	1.79	0.00
	0.00	0.00	0.00	0.00	94.70	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	39.05	44.98	0.00	0.16	0.00
1978	0.00	31.86	44.17	0.00	0.14	0.00
1979	0.00	28.96	40.15	0.00	0.13	0.00
1980	0.00	26.33	36.50	0.00	0.12	0.00
1981	0.00	23.93	33.19	0.00	0.11	0.00
1982	0.00	24.62	27.93	0.00	0.10	0.00
1983	0.00	19.78	27.43	0.00	0.09	0.00
1984	0.00	17.98	24.93	0.00	0.08	0.00
1985	0.00	16.35	22.67	0.00	0.07	0.00
1986	0.00	14.86	20.61	0.00	0.07	0.00
1987	0.00	15.29	17.34	0.00	0.06	0.00
1988	0.00	12.28	17.03	0.00	0.06	0.00
1989	0.00	11.17	15.48	0.00	0.05	0.00
1990	0.00	10.15	14.07	0.00	0.05	0.00
1991	0.00	9.23	12.79	0.00	0.04	0.00
1992	0.00	9.49	10.77	0.00	0.04	0.00
1993	0.00	7.63	10.57	0.00	0.03	0.00
	0.00	318.95	420.62	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	15.90	0.00	1.10	17.00
1976	0.00	64.27	0.00	3.70	67.[illegible]
1977	0.00	54.12	83.51	3.71	141.34
1978	0.00	25.12	88.84	2.11	116.07
1979	0.00	23.52	88.74	1.81	114.07
1980	0.00	10.72	88.74	0.91	100.37
1981	0.00	36.12	88.74	2.71	127.57
1982	0.00	47.92	87.51	3.61	139.04
1983	0.00	43.72	88.74	3.31	135.77
1984	0.00	25.12	88.74	2.11	115.97
1985	0.00	23.52	88.74	1.81	114.07
1986	0.00	19.14	88.74	0.91	108.79
1987	0.00	36.12	87.51	2.71	126.34
1988	0.00	47.92	88.74	3.61	140.27
1989	0.00	43.72	88.74	3.31	135.77
1990	0.00	25.12	88.74	2.11	115.97
1991	0.00	23.52	88.74	1.81	114.07
1992	0.00	10.72	87.51	0.91	99.14
1993	0.00	20.52	88.74	1.61	110.87
	0.00	596.82	1499.80	43.87	2140.49

FISCAL		RDT&E			INVESTMENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	15.90	0.00	0.00
1976	0.00	0.00	0.00	53.70	10.57	0.00
1977	0.00	0.00	0.00	47.40	6.72	0.00
1978	0.00	0.00	0.00	18.40	6.72	0.00
1979	0.00	0.00	0.00	16.80	6.72	0.00
1980	0.00	0.00	0.00	4.00	6.72	0.00
1981	0.00	0.00	0.00	29.40	6.72	0.00
1982	0.00	0.00	0.00	41.20	6.72	0.00
1983	0.00	0.00	0.00	37.00	6.72	0.00
1984	0.00	0.00	0.00	18.40	6.72	0.00
1985	0.00	0.00	0.00	16.80	6.72	0.00
1986	0.00	0.00	0.00	4.00	15.14	0.00
1987	0.00	0.00	0.00	29.40	6.72	0.00
1988	0.00	0.00	0.00	41.20	6.72	0.00
1989	0.00	0.00	0.00	37.00	6.72	0.00
1990	0.00	0.00	0.00	18.40	6.72	0.00
1991	0.00	0.00	0.00	16.80	6.72	0.00
1992	0.00	0.00	0.00	4.00	6.72	0.00
1993	0.00	0.00	0.00	13.80	6.72	0.00
	0.00	0.00	0.00	463.60	133.22	0.00

FISCAL		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	1.10	0.00	0.00
1976	0.00	0.00	0.00	3.70	0.00	0.00
1977	6.27	26.02	51.22	3.50	0.21	0.00
1978	10.37	19.53	56.94	1.90	0.21	0.00
1979	10.27	19.53	58.94	1.60	0.21	0.00
1980	10.27	19.53	58.94	0.70	0.21	0.00
1981	10.27	19.53	58.94	2.50	0.21	0.00
1982	10.27	26.02	51.22	3.40	0.21	0.00
1983	10.27	19.53	58.94	3.10	0.21	0.00
1984	10.27	19.53	58.94	1.90	0.21	0.00
1985	10.27	19.53	58.94	1.60	0.21	0.00
1986	10.27	19.53	58.94	0.70	0.21	0.00
1987	10.27	26.02	51.22	2.50	0.21	0.00
1988	10.27	19.53	58.94	3.40	0.21	0.00
1989	10.27	19.53	58.94	3.10	0.21	0.00
1990	10.27	19.53	58.94	1.90	0.21	0.00
1991	10.27	19.53	58.94	1.60	0.21	0.00
1992	10.27	26.02	51.22	0.70	0.21	0.00
1993	10.27	19.53	58.94	1.40	0.21	0.00
	170.26	357.97	[illegible]	40.30	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	14.45	0.00	1.00	15.45
1976	0.00	53.11	0.00	3.06	56.17
1977	0.00	40.66	62.74	2.79	106.19
1978	0.00	17.16	60.68	1.44	79.28
1979	0.00	14.60	55.10	1.12	70.83
1980	0.00	6.05	50.09	0.51	56.66
1981	0.00	18.54	45.54	1.39	65.46
1982	0.00	22.35	40.82	1.68	64.86
1983	0.00	18.54	37.64	1.40	57.58
1984	0.00	9.68	34.21	0.81	44.71
1985	0.00	8.24	31.10	0.63	39.98
1986	0.00	6.10	28.28	0.29	34.66
1987	0.00	10.46	25.35	0.78	36.60
1988	0.00	12.62	23.37	0.95	36.94
1989	0.00	10.47	21.24	0.79	32.50
1990	0.00	5.47	19.31	0.46	25.24
1991	0.00	4.65	17.56	0.36	22.57
1992	0.00	1.93	15.74	0.16	17.83
1993	0.00	3.36	14.51	0.26	18.13
	0.00	278.45	583.29	19.91	881.65

FISCAL		RDT&E			INVESTMENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	14.45	0.00	0.00
1976	0.00	0.00	0.00	44.38	8.73	0.00
1977	0.00	0.00	0.00	35.61	5.05	0.00
1978	0.00	0.00	0.00	12.57	4.59	0.00
1979	0.00	0.00	0.00	10.43	4.17	0.00
1980	0.00	0.00	0.00	2.26	3.79	0.00
1981	0.00	0.00	0.00	15.09	3.45	0.00
1982	0.00	0.00	0.00	19.22	3.13	0.00
1983	0.00	0.00	0.00	15.69	2.85	0.00
1984	0.00	0.00	0.00	7.09	2.59	0.00
1985	0.00	0.00	0.00	5.89	2.36	0.00
1986	0.00	0.00	0.00	1.27	4.82	0.00
1987	0.00	0.00	0.00	8.52	1.95	0.00
1988	0.00	0.00	0.00	10.85	1.77	0.00
1989	0.00	0.00	0.00	8.86	1.61	0.00
1990	0.00	0.00	0.00	4.00	1.46	0.00
1991	0.00	0.00	0.00	3.32	1.33	0.00
1992	0.00	0.00	0.00	0.72	1.21	0.00
1993	0.00	0.00	0.00	2.26	1.10	0.00
	0.00	0.00	0.00	222.49	55.97	0.00

FISCAL		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	1.00	0.00	0.00
1976	0.00	0.00	0.00	3.06	0.00	0.00
1977	4.71	19.55	38.48	2.63	0.16	0.00
1978	7.09	13.34	40.26	1.30	0.14	0.00
1979	6.38	12.13	36.60	0.99	0.13	0.00
1980	5.80	11.0	33.27	0.40	0.12	0.00
1981	5.27	10.03	30.24	1.28	0.11	0.00
1982	4.79	12.14	23.89	1.59	0.10	0.00
1983	4.36	8.28	25.00	1.31	0.09	0.00
1984	3.96	7.53	22.72	0.73	0.08	0.00
1985	3.60	6.85	20.66	0.56	0.07	0.00
1986	3.27	6.22	18.78	0.22	0.07	0.00
1987	2.98	7.54	14.84	0.72	0.06	0.00
1988	2.71	5.14	15.52	0.90	0.06	0.00
1989	2.46	4.68	14.11	0.74	0.05	0.00
1990	2.23	4.25	12.83	0.41	0.05	0.00
1991	2.03	3.66	11.66	0.32	0.04	0.00
1992	1.85	4.68	9.21	0.13	0.04	0.00
1993	1.68	3.19	9.64	0.23	0.03	0.00
	65.17	140.42	377.69	18.52	1.39	0.00

Life Cycle Costs to Provide

Land Cover Information for

Projected Demand from All Sources

Projected Level II Demand:

1977 - 1993 Six times at 60 days

Automatic Data Processing

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	22.38	0.00	0.00	22.38
1977	0.00	15.64	107.50	0.21	123.35
1978	0.00	14.04	104.68	0.21	118.93
1979	0.00	13.44	104.68	0.21	118.33
1980	0.00	13.44	104.68	0.21	118.33
1981	0.00	13.44	104.68	0.21	118.33
1982	0.00	13.44	108.30	0.21	121.95
1983	0.00	13.44	104.68	0.21	118.3[illegible]
1984	0.00	13.44	104.68	0.21	118.33
1985	0.00	13.44	104.68	0.21	118.33
1986	0.00	30.27	104.68	0.21	135.16
1987	0.00	13.44	108.30	0.21	121.95
1988	0.00	13.44	104.68	0.21	118.33
1989	0.00	13.44	104.68	0.21	118.33
1990	0.00	13.44	104.68	0.21	118.33
1991	0.00	13.44	104.68	0.21	118.33
1992	0.00	13.44	108.30	0.21	121.95
1993	0.00	13.44	104.68	0.21	118.33
	0.00	270.50	1793.24	[illegible].57	2067.31

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	22.38	0.00
1977	0.00	0.00	0.00	0.00	15.64	0.00
1978	0.00	0.00	0.00	0.00	14.04	0.00
1979	0.00	0.00	0.00	0.00	13.44	0.00
1980	0.00	0.00	0.00	0.00	13.44	0.00
1981	0.00	0.00	0.00	0.00	13.44	0.00
1982	0.00	0.00	0.00	0.00	13.44	0.00
1983	0.00	0.00	0.00	0.00	13.44	0.00
1984	0.00	0.00	0.00	0.00	13.44	0.00
1985	0.00	0.00	0.00	0.00	13.44	0.00
1986	0.00	0.00	0.00	0.00	30.27	0.00
1987	0.00	0.00	0.00	0.00	13.44	0.00
1988	0.00	0.00	0.00	0.00	13.44	0.00
1989	0.00	0.00	0.00	0.00	13.44	0.00
1990	0.00	0.00	0.00	0.00	13.44	0.00
1991	0.00	0.00	0.00	0.00	13.44	0.00
1992	0.00	0.00	0.00	0.00	13.44	0.00
1993	0.00	0.00	0.00	0.00	13.44	0.00
	0.00	0.00	0.00	0.00	270.50	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	HA	GT	ACTIVITY LEVEL INDEPENDENT SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	68.09	39.41	0.00	0.21	0.00
1978	0.00	63.05	41.63	0.00	0.21	0.00
1979	0.00	63.05	41.63	0.00	0.21	0.00
1980	0.00	63.05	41.63	0.00	0.21	0.00
1981	0.00	63.05	41.63	0.00	0.21	0.00
1982	0.00	68.09	39.41	0.00	0.21	0.00
1983	0.00	63.05	41.63	0.00	0.21	0.00
1984	0.00	63.05	41.63	0.00	0.21	0.00
1985	0.00	63.05	41.63	0.00	0.21	0.00
1986	0.00	63.05	41.63	0.00	0.21	0.00
1987	0.00	68.09	39.41	0.00	0.21	0.00
1988	0.00	63.05	41.63	0.00	0.21	0.00
1989	0.00	63.05	41.63	0.00	0.21	0.00
1990	0.00	63.05	41.63	0.00	0.21	[illegible]
1991	0.00	63.05	41.63	0.00	0.21	[illegible]
1992	0.00	68.09	39.41	0.00	0.21	0.00
1993	0.00	63.05	41.63	0.00	0.21	[illegible]
	0.0[illegible]	[illegible]	[illegible]	0.00	[illegible].57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	18.50	0.00	0.00	18.50
1977	0.00	11.75	80.76	0.16	92.67
1978	0.00	9.59	71.50	0.14	81.23
1979	0.00	8.35	65.00	0.13	73.47
1980	0.00	7.59	59.09	0.12	66.79
1981	0.00	6.90	53.72	0.11	60.72
1982	0.00	6.27	50.52	0.10	56.89
1983	0.00	5.70	44.39	0.09	50.18
1984	0.00	5.19	40.37	0.08	45.62
1985	0.00	4.71	36.69	0.07	41.47
1986	0.00	9.65	33.35	0.07	43.07
1987	0.00	3.89	31.37	0.06	35.32
1988	0.00	3.54	27.57	0.06	31.16
1989	0.00	3.22	25.06	0.05	28.33
1990	0.00	2.92	22.78	0.05	25.75
1991	0.00	2.66	20.71	0.04	23.41
1992	0.00	2.42	19.48	0.04	21.93
1993	0.00	2.20	17.12	0.03	19.35
	0.00	115.02	699.47	1.39	815.03

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	18.50	0.00
1977	0.00	0.00	0.00	0.00	11.75	0.00
1978	0.00	0.00	0.00	0.00	9.59	0.00
1979	0.00	0.00	0.00	0.00	8.35	0.00
1980	0.00	0.00	0.00	0.00	7.59	0.00
1981	0.00	0.00	0.00	0.00	6.90	0.00
1982	0.00	0.00	0.00	0.00	6.27	0.00
1983	0.00	0.00	0.00	0.00	5.70	0.00
1984	0.00	0.00	0.00	0.00	5.18	0.00
1985	0.00	0.00	0.00	0.00	4.71	0.00
1986	0.00	0.00	0.00	0.00	9.65	0.00
1987	0.00	0.00	0.00	0.00	3.89	0.00
1988	0.00	0.00	0.00	0.00	3.54	0.00
1989	0.00	0.00	0.00	0.00	3.22	0.00
1990	0.00	0.00	0.00	0.00	2.92	0.00
1991	0.00	0.00	0.00	0.00	2.66	0.00
1992	0.00	0.00	0.00	0.00	2.42	0.00
1993	0.00	0.00	0.00	0.00	2.20	0.00
	0.00	0.00	0.00	0.00	115.02	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	51.16	29.61	0.00	0.16	0.00
1978	0.00	43.06	28.43	0.00	0.14	0.00
1979	0.00	39.15	25.85	0.00	0.13	0.00
1980	0.00	35.59	[illegible]	0.00	0.12	0.00
1981	0.00	32.35	21.36	0.00	0.11	0.00
1982	0.00	32.14	18.38	0.00	0.10	0.00
1983	0.00	[illegible]	[illegible]	0.00	0.09	0.00
1984	0.00	[illegible]	[illegible]	0.00	0.08	0.00
1985	0.00	[illegible]	[illegible]	0.00	0.07	0.00
1986	0.00	[illegible]	[illegible]	0.00	0.07	0.00
1987	0.00	[illegible]	[illegible]	0.00	0.06	0.00
1988	0.00	[illegible]	[illegible]	0.00	0.06	0.00
1989	0.00	[illegible]	9.97	0.00	0.05	0.00
1990	0.00	[illegible]	[illegible]	0.00	0.05	0.00
1991	0.00	[illegible]	[illegible]	0.00	0.04	0.00
1992	0.00	[illegible]	[illegible]	0.00	0.04	0.00
1993	0.00	[illegible]	[illegible]	0.00	0.03	0.00
	0.00	[illegible]	[illegible]	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	15.90	0.00	1.10	17.00
1976	0.00	69.53	0.00	3.70	73.23
1977	0.00	58.32	63.43	3.71	125.46
1978	0.00	29.32	63.91	2.11	95.34
1979	0.00	27.72	63.81	1.81	93.34
1980	0.00	14.92	63.81	0.91	79.64
1981	0.00	40.32	63.81	2.71	106.84
1982	0.00	52.12	67.43	3.61	123.16
1983	0.00	47.92	63.81	3.31	115.04
1984	0.00	29.32	63.81	2.11	95.24
1985	0.00	27.72	63.81	1.81	93.34
1986	0.00	28.60	63.81	0.91	93.32
1987	0.00	40.32	67.43	2.71	110.46
1988	0.00	52.12	63.81	3.61	119.54
1989	0.00	47.92	63.81	3.31	115.04
1990	0.00	29.32	63.81	2.11	95.24
1991	0.00	27.72	63.81	1.81	93.34
1992	0.00	14.92	67.43	0.91	83.26
1993	0.00	24.72	63.81	1.61	90.14
	0.00	678.74	1095.[illegible]	43.87	1817.99

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	15.90	0.00	0.00
1976	0.00	0.00	0.00	53.70	15.83	0.00
1977	0.00	0.00	0.00	47.40	10.92	0.00
1978	0.00	0.00	0.00	18.40	10.92	0.00
1979	0.00	0.00	0.00	16.80	10.92	0.00
1980	0.00	0.00	0.00	4.00	10.92	0.00
1981	0.00	0.00	0.00	29.40	10.92	0.00
1982	0.00	0.00	0.00	41.20	10.92	0.00
1983	0.00	0.00	0.00	37.00	10.92	0.00
1984	0.00	0.00	0.00	18.40	10.92	0.00
1985	0.00	0.00	0.00	16.80	10.92	0.00
1986	0.00	0.00	0.00	4.00	24.60	0.00
1987	0.00	0.00	0.00	29.40	10.92	0.00
1988	0.00	0.00	0.00	41.20	10.92	0.00
1989	0.00	0.00	0.00	37.00	10.92	0.00
1990	0.00	0.00	0.00	18.40	10.92	0.00
1991	0.00	0.00	0.00	16.80	10.92	0.00
1992	0.00	0.00	0.00	4.00	10.92	0.00
1993	0.00	0.00	0.00	13.60	10.92	0.00
	0.00	0.00	0.00	463.60	215.14	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.10	0.00	0.00
1976	0.00	0.00	0.00	3.70	0.00	0.00
1977	7.97	36.21	19.25	3.50	0.21	0.00
1978	12.07	30.37	21.47	1.90	0.21	0.00
1979	11.97	30.37	21.47	1.60	0.21	0.00
1980	11.97	30.37	21.47	0.70	0.21	0.00
1981	11.97	30.37	21.47	2.50	0.21	0.00
1982	11.97	36.21	19.25	3.40	0.21	0.00
1983	11.97	30.37	21.47	3.10	0.21	0.00
1984	11.97	30.37	21.47	1.90	0.21	0.00
1985	11.97	30.37	21.47	1.60	0.21	0.00
1986	11.97	30.37	21.47	0.70	0.21	0.00
1987	11.97	36.21	19.25	2.50	0.21	0.00
1988	11.97	30.37	21.47	3.40	0.21	0.00
1989	11.97	30.37	21.47	3.10	0.21	0.00
1990	11.97	30.37	21.47	1.90	0.21	0.00
1991	11.97	30.37	21.47	1.60	0.21	0.00
1992	11.97	36.21	19.25	0.70	0.21	0.00
1993	11.97	30.37	21.47	1.40	0.21	0.00
	199.62	579.65	350.1[illegible]	40.30	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS ROT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	14.45	0.00	1.00	15.45
1976	0.00	57.46	0.00	3.06	60.52
1977	0.00	43.82	47.65	2.79	94.26
1978	0.00	20.03	43.65	1.44	65.12
1979	0.00	17.21	39.65	1.12	57.96
1980	0.00	8.42	36.02	0.51	44.96
1981	.00	20.69	32.75	1.39	54.83
1982	0.00	24.31	31.46	1.68	57.45
1983	0.00	20.32	27.06	1.40	48.79
1984	0.00	11.30	24.60	0.81	36.72
1985	0.00	9.72	22.37	0.63	32.72
1986	0.00	9.11	20.33	0.29	29.73
1987	0.00	11.68	19.53	0.78	32.00
1988	0.00	13.72	16.66	0.95	31.48
1989	0.00	11.47	15.28	0.79	27.54
1990	0.00	6.38	13.89	0.46	20.73
1991	0.00	5.45	12.62	0.36	18.47
1992	0.00	2.58	12.13	0.16	14.97
1993	0.00	4.04	10.43	0.26	14.74
	0.00	312.32	426.26	19.91	758.43

FISCAL YEAR	ROT&E SAT	ROT&E HA	ROT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	14.45	0.00	0.00
1976	0.00	0.00	0.00	44.38	13.08	0.00
1977	0.00	0.00	0.00	35.61	8.20	0.00
1978	0.00	0.00	0.00	12.57	7.46	0.00
1979	0.00	0.00	0.00	10.43	6.78	0.00
1980	0.00	0.00	0.00	2.26	6.16	0.00
1981	0.00	0.00	0.00	15.09	5.60	0.00
1982	0.00	0.00	0.00	19.22	5.09	0.00
1983	0.00	0.00	0.00	15.69	4.63	0.00
1984	0.00	0.00	0.00	7.09	4.21	0.00
1985	0.00	0.00	0.00	5.89	3.83	0.00
1986	0.00	0.00	0.00	1.27	7.84	0.00
1987	0.00	0.00	0.00	8.52	3.16	0.00
1988	0.00	0.00	0.00	10.85	2.88	0.00
1989	0.00	0.00	0.00	8.86	2.61	0.00
1990	0.00	0.00	0.00	4.00	2.38	0.00
1991	0.00	0.00	0.00	3.32	2.16	0.00
1992	0.00	0.00	0.00	0.72	1.96	0.00
1993	0.00	0.00	0.00	2.26	1.79	0.00
	0.00	0.00	0.00	222.49	89.83	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.00	0.00	0.00
1976	0.00	0.00	0.00	3.06	0.00	0.00
1977	5.99	27.21	14.46	2.63	0.16	0.00
1978	8.25	20.74	14.66	1.30	0.14	0.00
1979	7.43	18.06	13.33	0.99	0.13	0.00
1980	6.76	17.14	12.12	0.40	0.12	0.00
1981	6.14	15.53	11.02	1.78	0.11	0.00
1982	5.59	16.89	8.98	1.59	0.10	0.00
1983	5.08	12.88	9.11	1.31	0.09	0.00
1984	4.62	11.71	8.78	0.73	0.08	0.00
1985	4.20	10.64	7.53	0.56	0.07	0.00
1986	3.81	9.66	6.84	0.22	0.07	0.00
1987	3.47	10.49	5.57	0.72	0.05	0.00
1988	3.15	8.03	5.65	0.90	0.06	0.00
1989	2.87	7.27	5.14	0.74	0.05	0.00
1990	2.61	6.61	4.67	0.41	0.05	0.00
1991	2.37	6.91	4.25	0.32	0.04	0.00
1992	2.15	6.91	3.46	0.13	0.04	0.00
1993	1.95	6.97	3.51	0.23	0.03	0.00
	76.41	211.19	130.59	18.52	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	22.38	0.00	0.00	22.38
1977	0.00	15.64	154.33	0.21	170.18
1978	0.00	14.04	153.79	0.21	168.04
1979	0.00	13.44	153.79	0.21	167.44
1980	0.00	13.44	153.79	0.21	167.44
1981	0.00	13.44	153.79	0.21	167.44
1982	0.00	13.44	155.13	0.21	168.78
1983	0.00	13.44	153.79	0.21	167.44
1984	0.00	13.44	153.79	0.21	167.44
1985	0.00	13.44	153.79	0.21	167.44
1986	0.00	30.27	153.79	0.21	184.27
1987	0.00	13.44	155.13	0.21	168.78
1988	0.00	13.44	153.79	0.21	167.44
1989	0.00	13.44	153.79	0.21	167.44
1990	0.00	13.44	153.79	0.21	167.44
1991	0.00	13.44	153.79	0.21	167.44
1992	0.00	13.44	155.13	0.21	168.78
1993	0.00	13.44	153.79	0.21	167.44
	0.00	270.50	2616.94	3.57	2893.01

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	22.38	0.00
1977	0.00	0.00	0.00	0.00	15.64	0.00
1978	0.00	0.00	0.00	0.00	14.04	0.00
1979	0.00	0.00	0.00	0.00	13.44	0.00
1980	0.00	0.00	0.00	0.00	13.44	0.00
1981	0.00	0.00	0.00	0.00	13.44	0.00
1982	0.00	0.00	0.00	0.00	13.44	0.00
1983	0.00	0.00	0.00	0.00	13.44	0.00
1984	0.00	0.00	0.00	0.00	13.44	0.00
1985	0.00	0.00	0.00	0.00	13.44	0.00
1986	0.00	0.00	0.00	0.00	30.27	0.00
1987	0.00	0.00	0.00	0.00	13.44	0.00
1988	0.00	0.00	0.00	0.00	13.44	0.00
1989	0.00	0.00	0.00	0.00	13.44	0.00
1990	0.00	0.00	0.00	0.00	13.44	0.00
1991	0.00	0.00	0.00	0.00	13.44	0.00
1992	0.00	0.00	0.00	0.00	13.44	0.00
1993	0.00	0.00	0.00	0.00	13.44	0.00
	0.00	0.00	0.00	0.00	270.50	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	63.21	91.12	0.00	0.21	0.00
1978	0.00	57.87	95.92	0.00	0.21	0.00
1979	0.00	57.87	95.92	0.00	0.21	0.00
1980	0.00	57.87	95.92	0.00	0.21	0.00
1981	0.00	57.87	95.92	0.00	0.21	0.00
1982	0.00	64.01	91.12	0.00	0.21	0.00
1983	0.00	57.87	95.92	0.00	0.21	0.00
1984	0.00	57.87	95.92	0.00	0.21	0.00
1985	0.00	57.87	95.92	0.00	0.21	0.00
1986	0.00	57.87	95.92	0.00	0.21	0.00
1987	0.00	64.01	91.12	0.00	0.21	0.00
1988	0.00	57.87	95.92	0.00	0.21	0.00
1989	0.00	57.87	95.92	0.00	0.21	0.00
1990	0.00	57.87	95.92	0.00	0.21	0.00
1991	0.00	57.87	95.92	0.00	0.21	0.00
1992	0.00	64.01	91.12	0.00	0.21	0.00
1993	0.00	57.87	95.92	0.00	0.21	0.00
	0.00	******	******	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS: RDT&E	NON-RECURRING COSTS: INVESTMENT	RECURRING COSTS: ACTIVITY LEVEL DEPENDENT	RECURRING COSTS: ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	18.50	0.00	0.00	18.50
1977	0.00	11.75	115.95	0.16	127.86
1978	0.00	9.59	105.04	0.14	114.77
1979	0.00	8.35	95.49	0.13	103.97
1980	0.00	7.59	86.81	0.12	94.51
1981	0.00	6.90	78.92	0.11	85.92
1982	0.00	6.27	72.37	0.10	78.74
1983	0.00	5.70	65.22	0.09	71.01
1984	0.00	5.18	59.29	0.08	64.55
1985	0.00	4.71	53.90	0.07	58.69
1986	0.00	9.65	49.00	0.07	58.71
1987	0.00	3.89	44.93	0.06	48.89
1988	0.00	3.54	40.50	0.06	44.09
1989	0.00	3.22	36.82	0.05	40.08
1990	0.00	2.92	33.47	0.05	36.44
1991	0.00	2.66	30.44	0.04	33.13
1992	0.00	2.42	27.90	0.04	30.36
1993	0.00	2.20	25.15	0.03	27.38
	0.00	115.02	1021.17	1.39	1137.59

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	18.50	0.00
1977	0.00	0.00	0.00	0.00	11.75	0.00
1978	0.00	0.00	0.00	0.00	9.59	0.00
1979	0.00	0.00	0.00	0.00	6.35	0.00
1980	0.00	0.00	0.00	0.00	7.59	0.00
1981	0.00	0.00	0.00	0.00	6.90	0.00
1982	0.00	0.00	0.00	0.00	6.27	0.00
1983	0.00	0.00	0.00	0.00	5.70	0.00
1984	0.00	0.00	0.00	0.00	5.18	0.00
1985	0.00	0.00	0.00	0.00	4.71	0.00
1986	0.00	0.00	0.00	0.00	9.65	0.00
1987	0.00	0.00	0.00	0.00	3.89	0.00
1988	0.00	0.00	0.00	0.00	3.54	0.00
1989	0.00	0.00	0.00	0.00	3.22	0.00
1990	0.00	0.00	0.00	0.00	2.92	0.00
1991	0.00	0.00	0.00	0.00	2.66	0.00
1992	0.00	0.00	0.00	0.00	2.42	0.00
1993	0.00	0.00	0.00	0.00	2.20	0.00
	0.00	0.00	0.00	0.00	115.02	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	47.49	69.46	0.00	0.16	0.00
1978	0.00	39.53	55.51	0.00	0.14	0.00
1979	0.00	35.93	59.56	0.00	0.13	0.00
1980	0.00	32.67	54.14	0.00	0.12	0.00
1981	0.00	29.70	49.22	0.00	0.11	0.00
1982	0.00	29.66	42.51	0.00	0.10	0.00
1983	0.00	24.54	40.68	0.00	0.09	0.00
1984	0.00	22.31	36.98	0.00	0.08	0.00
1985	0.00	20.28	33.62	0.00	0.07	0.00
1986	0.00	[illegible]	30.56	0.00	0.07	0.00
1987	0.00	[illegible]	26.39	0.00	0.06	0.00
1988	0.00	[illegible]	25.26	0.00	0.06	0.00
1989	0.00	[illegible]	22.96	0.00	0.05	0.00
1990	0.00	12.59	20.67	0.00	0.05	0.00
1991	0.00	11.45	18.99	0.00	0.04	0.00
1992	0.00	11.51	16.39	0.00	0.04	0.00
1993	0.00	9.66	15.60	0.00	0.03	0.00
	0.00	293.40	627.77	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 3 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	21.40	0.00	1.70	23.10
1976	0.00	82.42	0.00	5.20	87.62
1977	0.00	69.96	83.63	3.01	156.60
1978	0.00	31.66	90.27	2.91	124.84
1979	0.00	32.76	90.07	2.51	125.34
1980	0.00	13.56	90.07	1.21	104.84
1981	0.00	49.16	90.07	3.81	143.04
1982	0.00	65.86	88.83	5.21	159.90
1983	0.00	59.56	90.07	4.81	154.44
1984	0.00	31.66	90.07	2.91	124.64
1985	0.00	28.76	90.07	2.21	121.04
1986	0.00	23.03	90.07	1.21	114.31
1987	0.00	49.16	88.83	3.81	141.80
1988	0.00	65.86	90.07	5.21	161.14
1989	0.00	59.56	90.07	4.81	154.44
1990	0.00	31.66	90.07	2.91	124.64
1991	0.00	32.76	90.07	2.51	125.34
1992	0.00	13.56	88.83	1.21	103.60
1993	0.00	28.26	90.07	2.21	120.54
	0.00	790.61	1521.26	59.37	2371.24

FISCAL YEAR	RDT&E SAT	HA	GT	INVESTMENT SAT	HA	GT
1975	0.00	0.00	0.00	21.40	0.00	0.00
1976	0.00	0.00	0.00	70.80	11.62	0.00
1977	0.00	0.00	0.00	62.40	7.56	0.00
1978	0.00	0.00	0.00	24.10	7.56	0.00
1979	0.00	0.00	0.00	25.20	7.56	0.00
1980	0.00	0.00	0.00	6.00	7.56	0.00
1981	0.00	0.00	0.00	41.60	7.56	0.00
1982	0.00	0.00	0.00	58.30	7.56	0.00
1983	0.00	0.00	0.00	52.00	7.56	0.00
1984	0.00	0.00	0.00	24.10	7.56	0.00
1985	0.00	0.00	0.00	21.20	7.56	0.00
1986	0.00	0.00	0.00	6.00	17.03	0.00
1987	0.00	0.00	0.00	41.60	7.56	0.00
1988	0.00	0.00	0.00	58.30	7.56	0.00
1989	0.00	0.00	0.00	52.00	7.56	0.00
1990	0.00	0.00	0.00	24.10	7.56	0.00
1991	0.00	0.00	0.00	25.20	7.56	0.00
1992	0.00	0.00	0.00	6.00	7.56	0.00
1993	0.00	0.00	0.00	20.70	7.56	0.00
	0.00	0.00	0.00	641.00	149.61	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	HA	GT	ACTIVITY LEVEL INDEPENDENT SAT	HA	GT
1975	0.00	0.00	0.00	1.70	0.00	0.00
1976	0.00	0.00	0.00	5.20	0.00	0.00
1977	8.61	27.75	47.27	2.80	0.21	0.00
1978	14.01	21.27	54.99	2.70	0.21	0.00
1979	13.81	21.27	54.99	2.30	0.21	0.00
1980	13.81	21.27	54.99	1.00	0.21	0.00
1981	13.81	21.27	54.99	3.60	0.21	0.00
1982	13.81	27.75	47.27	5.00	0.21	0.00
1983	13.81	21.27	54.99	4.60	0.21	0.00
1984	13.81	21.27	54.99	2.70	0.21	0.00
1985	13.81	21.27	54.99	2.00	0.21	0.00
1986	13.81	21.27	54.99	1.00	0.21	0.00
1987	13.81	27.75	47.27	3.60	0.21	0.00
1988	13.81	21.27	54.99	5.00	0.21	0.00
1989	13.81	21.27	54.99	4.60	0.21	0.00
1990	13.81	21.27	54.99	2.70	0.21	0.00
1991	13.81	21.27	54.99	2.30	0.21	0.00
1992	13.81	27.75	47.27	1.00	0.21	0.00
1993	13.81	21.27	54.99	2.00	0.21	0.00
	229.74	387.51	904.01	55.60	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 3 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	19.45	0.00	1.55	21.00
1976	0.00	68.12	0.00	4.30	72.41
1977	0.00	52.56	62.83	2.26	117.66
1978	0.00	21.62	61.66	1.99	85.27
1979	0.00	20.34	55.93	1.56	77.83
1980	0.00	7.65	50.84	0.68	59.18
1981	0.00	25.23	46.22	1.96	73.40
1982	0.00	30.72	41.44	2.43	74.59
1983	0.00	25.26	38.20	2.04	65.50
1984	0.00	12.21	34.73	1.12	48.05
1985	0.00	10.08	31.57	0.77	42.42
1986	0.00	7.34	28.70	0.39	36.42
1987	0.00	14.24	25.73	1.10	41.07
1988	0.00	17.34	23.72	1.37	42.43
1989	0.00	14.26	21.56	1.15	36.97
1990	0.00	6.89	19.60	0.63	27.13
1991	0.00	6.48	17.82	0.59	24.80
1992	0.00	2.44	15.98	0.22	18.63
1993	0.00	4.62	14.73	0.36	19.71
	0.00	366.86	591.25	26.38	984.49

FISCAL		RDT&E			INVESTMENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	19.45	0.00	0.00
1976	0.00	0.00	0.00	58.51	9.60	0.00
1977	0.00	0.00	0.00	46.88	5.68	0.00
1978	0.00	0.00	0.00	16.46	5.16	0.00
1979	0.00	0.00	0.00	15.65	4.69	0.00
1980	0.00	0.00	0.00	3.39	4.27	0.00
1981	0.00	0.00	0.00	21.35	3.88	0.00
1982	0.00	0.00	0.00	27.20	3.53	0.00
1983	0.00	0.00	0.00	22.05	3.21	0.00
1984	0.00	0.00	0.00	9.29	2.91	0.00
1985	0.00	0.00	0.00	7.43	2.65	0.00
1986	0.00	0.00	0.00	1.91	5.43	0.00
1987	0.00	0.00	0.00	12.05	2.19	0.00
1988	0.00	0.00	0.00	15.35	1.99	0.00
1989	0.00	0.00	0.00	12.45	1.81	0.00
1990	0.00	0.00	0.00	5.24	1.65	0.00
1991	0.00	0.00	0.00	4.99	1.50	0.00
1992	0.00	0.00	0.00	1.08	1.36	0.00
1993	0.00	0.00	0.00	3.38	1.24	0.00
	0.00	0.00	0.00	304.12	62.74	0.00

FISCAL		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	1.55	0.00	0.00
1976	0.00	0.00	0.00	4.30	0.00	0.00
1977	6.47	20.85	35.52	2.10	0.16	0.00
1978	9.57	14.53	37.56	1.84	0.14	0.00
1979	8.57	13.21	34.15	1.43	0.13	0.00
1980	7.79	12.01	31.04	0.56	0.12	0.00
1981	7.09	10.91	28.22	1.85	0.11	0.00
1982	6.44	12.95	22.05	2.33	0.10	0.00
1983	5.86	9.02	23.32	1.95	0.09	0.00
1984	5.32	8.20	21.20	1.04	0.08	0.00
1985	4.84	7.45	19.28	0.70	0.07	0.00
1986	4.40	6.78	17.52	0.32	0.07	0.00
1987	4.00	8.04	13.69	1.04	0.06	0.00
1988	3.64	5.60	14.48	1.32	0.06	0.00
1989	3.31	5.09	13.17	1.10	0.05	0.00
1990	3.51	4.63	11.97	0.59	0.05	0.00
1991	2.73	4.21	10.88	0.46	0.04	0.00
1992	2.48	4.99	8.50	0.18	0.04	0.00
1993	2.26	3.48	8.99	0.33	0.03	0.00
	87.77	151.94	351.55	24.90	1.39	0.00

Life Cycle Costs to Provide

Land Cover Information for

Projected Demand from All Sources

Projected Level II Demand:

1977 - 1984 Six times at 60 days

1985 - 1993 Eight times at 45 days

Automatic Data Processing

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	22.38	0.00	0.00	22.38
1977	0.00	15.64	107.50	0.21	123.35
1978	0.00	13.74	104.68	0.21	118.63
1979	0.00	13.44	104.68	0.21	118.33
1980	0.00	13.44	104.68	0.21	118.33
1981	0.00	13.44	104.68	0.21	118.33
1982	0.00	13.44	108.30	0.21	121.95
1983	0.00	13.44	104.68	0.21	118.33
1984	0.00	15.54	104.68	0.21	120.44
1985	0.00	15.12	137.15	0.21	152.43
1986	0.00	31.95	137.15	0.21	169.32
1987	0.00	15.12	140.67	0.21	156.00
1988	0.00	15.12	137.15	0.21	152.48
1989	0.00	15.12	137.15	0.21	152.48
1990	0.00	15.12	137.15	0.21	152.48
1991	0.00	15.12	137.15	0.21	152.48
1992	0.00	15.12	140.67	0.21	156.00
1993	0.00	15.12	137.15	0.21	152.48
	0.00	287.42	2085.30	3.57	2376.29

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	22.38	0.00
1977	0.00	0.00	0.00	0.00	15.64	0.00
1978	0.00	0.00	0.00	0.00	13.74	0.00
1979	0.00	0.00	0.00	0.00	13.44	0.00
1980	0.00	0.00	0.00	0.00	13.44	0.00
1981	0.00	0.00	0.00	0.00	13.44	0.00
1982	0.00	0.00	0.00	0.00	13.44	0.00
1983	0.00	0.00	0.00	0.00	13.44	0.00
1984	0.00	0.00	0.00	0.00	15.54	0.00
1985	0.00	0.00	0.00	0.00	15.12	0.00
1986	0.00	0.00	0.00	0.00	31.95	0.00
1987	0.00	0.00	0.00	0.00	15.12	0.00
1988	0.00	0.00	0.00	0.00	15.12	0.00
1989	0.00	0.00	0.00	0.00	15.12	0.00
1990	0.00	0.00	0.00	0.00	15.12	0.00
1991	0.00	0.00	0.00	0.00	15.12	0.00
1992	0.00	0.00	0.00	0.00	15.12	0.00
1993	0.00	0.00	0.00	0.00	15.12	0.00
	0.00	0.00	0.00	0.00	287.42	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	68.09	39.41	0.00	0.21	0.00
1978	0.00	63.05	41.63	0.00	0.21	0.00
1979	0.00	63.05	41.63	0.00	0.21	0.00
1980	0.00	63.05	41.63	0.00	0.21	0.00
1981	0.00	63.05	41.63	0.00	0.21	0.00
1982	0.00	68.89	39.41	0.00	0.21	0.00
1983	0.00	63.05	41.63	0.00	0.21	0.00
1984	0.00	63.05	41.63	0.00	0.21	0.00
1985	0.00	75.30	61.85	0.00	0.21	0.00
1986	0.00	75.30	61.85	0.00	0.21	0.00
1987	0.00	81.04	59.63	0.00	0.21	0.00
1988	0.00	75.30	61.85	0.00	0.21	0.00
1989	0.00	75.30	61.85	0.00	0.21	0.00
1990	0.00	75.30	61.85	0.00	0.21	0.00
1991	0.00	75.30	61.85	0.00	0.21	0.00
1992	0.00	81.04	59.63	0.00	0.21	0.00
1993	0.00	75.30	61.85	0.00	0.21	0.00
	0.00	[illegible]	800.84	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	18.50	0.00	0.00	18.50
1977	0.00	11.75	80.76	0.16	92.67
1978	0.00	9.38	71.50	0.14	81.03
1979	0.00	8.35	65.00	0.13	73.47
1980	0.00	7.59	59.09	0.12	66.79
1981	0.00	6.90	53.72	0.11	60.72
1982	0.00	6.27	50.52	0.10	56.89
1983	0.00	5.70	44.39	0.09	50.18
1984	0.00	5.99	40.36	0.08	46.43
1985	0.00	5.30	48.07	0.07	53.44
1986	0.00	10.18	43.70	0.07	53.95
1987	0.00	4.38	40.75	0.06	45.19
1988	0.00	3.98	36.15	0.06	40.15
1989	0.00	3.62	32.83	0.05	36.50
1990	0.00	3.29	29.65	0.05	33.18
1991	0.00	2.99	27.14	0.04	30.17
1992	0.00	2.72	25.30	0.04	28.06
1993	0.00	2.47	22.43	0.03	24.93
	0.00	119.36	771.52	1.39	892.27

FISCAL YEAR	RDT&E SAT	HA	GT	INVESTMENT SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	18.50	0.00
1977	0.00	0.00	0.00	0.00	11.75	0.00
1978	0.00	0.00	0.00	0.00	9.38	0.00
1979	0.00	0.00	0.00	0.00	8.35	0.00
1980	0.00	0.00	0.00	0.00	7.59	0.00
1981	0.00	0.00	0.00	0.00	6.90	0.00
1982	0.00	0.00	0.00	0.00	6.27	0.00
1983	0.00	0.00	0.00	0.00	5.70	0.00
1984	0.00	0.00	0.00	0.00	5.99	0.00
1985	0.00	0.00	0.00	0.00	5.30	0.00
1986	0.00	0.00	0.00	0.00	10.18	0.00
1987	0.00	0.00	0.00	0.00	4.38	0.00
1988	0.00	0.00	0.00	0.00	3.98	0.00
1989	0.00	0.00	0.00	0.00	3.62	0.00
1990	0.00	0.00	0.00	0.00	3.29	0.00
1991	0.00	0.00	0.00	0.00	2.99	0.00
1992	0.00	0.00	0.00	0.00	2.72	0.00
1993	0.00	0.00	0.00	0.00	2.47	0.00
	0.00	0.00	0.00	0.00	119.36	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	HA	GT	ACTIVITY LEVEL INDEPENDENT SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	51.16	29.61	0.00	0.16	0.00
1978	0.00	43.06	28.43	0.00	0.14	0.00
1979	0.00	39.15	25.85	0.00	0.13	0.00
1980	0.00	35.59	23.50	0.00	0.12	0.00
1981	0.00	32.35	21.36	0.00	0.11	0.00
1982	0.00	32.14	18.38	0.00	0.10	0.00
1983	0.00	26.74	17.66	0.00	0.09	0.00
1984	0.00	24.31	16.05	0.00	0.08	0.00
1985	0.00	26.39	21.69	0.00	0.07	0.00
1986	0.00	23.99	19.71	0.00	0.07	0.00
1987	0.00	23.47	17.27	0.00	0.06	0.00
1988	0.00	19.83	16.29	0.00	0.06	0.00
1989	0.00	18.03	14.81	0.00	0.05	0.00
1990	0.00	16.39	13.46	0.00	0.05	0.00
1991	0.00	14.90	12.24	0.00	0.04	0.00
1992	0.00	14.58	10.72	0.00	0.04	0.00
1993	0.00	12.31	10.11	0.00	0.03	0.00
	0.00	[illegible]	311.14	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	15.90	0.00	1.10	17.00
1976	0.00	69.53	0.00	3.70	73.23
1977	0.00	58.32	63.43	3.71	125.46
1978	0.00	29.32	63.91	2.11	95.34
1979	0.00	27.72	63.81	1.81	93.34
1980	0.00	14.92	63.81	0.91	79.64
1981	0.00	40.32	63.81	2.71	106.84
1982	0.00	52.12	67.43	3.61	123.16
1983	0.00	47.92	63.81	3.31	115.04
1984	0.00	32.48	63.81	2.11	98.40
1985	0.00	30.24	77.57	1.81	109.62
1986	0.00	32.17	77.57	0.91	110.65
1987	0.00	43.68	81.19	2.71	127.58
1988	0.00	55.48	77.57	3.61	136.66
1989	0.00	51.28	77.57	3.31	132.16
1990	0.00	32.68	77.57	2.11	112.36
1991	0.00	31.08	77.57	1.81	110.46
1992	0.00	18.28	81.19	0.91	100.38
1993	0.00	28.08	77.57	1.61	107.26
	0.00	711.51	1219.22	43.87	1974.60

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	15.90	0.00	0.00
1976	0.00	0.00	0.00	53.70	15.83	0.00
1977	0.00	0.00	0.00	47.40	10.92	0.00
1978	0.00	0.00	0.00	18.40	10.92	0.00
1979	0.00	0.00	0.00	16.80	10.92	0.00
1980	0.00	0.00	0.00	4.00	10.92	0.00
1981	0.00	0.00	0.00	29.40	10.92	0.00
1982	0.00	0.00	0.00	41.20	10.92	0.00
1983	0.00	0.00	0.00	37.00	10.92	0.00
1984	0.00	0.00	0.00	18.40	14.08	0.00
1985	0.00	0.00	0.00	16.80	13.44	0.00
1986	0.00	0.00	0.00	4.00	28.17	0.00
1987	0.00	0.00	0.00	29.40	14.28	0.00
1988	0.00	0.00	0.00	41.20	14.28	0.00
1989	0.00	0.00	0.00	37.00	14.28	0.00
1990	0.00	0.00	0.00	18.40	14.28	0.00
1991	0.00	0.00	0.00	16.80	14.28	0.00
1992	0.00	0.00	0.00	4.00	14.28	0.00
1993	0.00	0.00	0.00	13.80	14.28	0.00
	0.00	0.00	0.00	463.60	247.91	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.10	0.00	0.00
1976	0.00	0.00	0.00	3.70	0.00	0.00
1977	7.97	36.21	19.25	3.50	0.21	0.00
1978	12.07	30.37	21.47	1.90	0.21	0.00
1979	11.97	30.37	21.47	1.60	0.21	0.00
1980	11.97	30.37	21.47	0.70	0.21	0.00
1981	11.97	30.37	21.47	2.50	0.21	0.00
1982	11.97	36.21	19.25	3.40	0.21	0.00
1983	11.97	30.37	21.47	3.10	0.21	0.00
1984	11.97	30.37	21.47	1.90	0.21	0.00
1985	13.23	39.60	24.74	1.60	0.21	0.00
1986	13.23	39.60	24.74	0.70	0.21	0.00
1987	13.23	45.44	22.52	2.50	0.21	0.00
1988	13.23	39.60	24.74	3.40	0.21	0.00
1989	13.23	39.60	24.74	3.10	0.21	0.00
1990	13.23	39.60	24.74	1.90	0.21	0.00
1991	13.23	39.60	24.74	1.60	0.21	0.00
1992	[illegible]	45.44	22.52	0.70	0.21	0.00
1993	13.23	39.60	24.74	1.40	0.21	0.00
	[illegible]	[illegible]	[illegible]	40.30	[illegible]	[illegible]

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	14.45	0.00	1.00	15.45
1976	0.00	57.46	0.00	3.06	60.52
1977	0.00	43.82	47.65	2.79	94.26
1978	0.00	20.03	43.65	1.44	65.12
1979	0.00	17.21	39.62	1.12	57.96
1980	0.00	8.42	36.02	0.51	44.96
1981	0.00	20.69	32.75	1.39	54.83
1982	0.00	24.31	31.46	1.68	57.45
1983	0.00	20.32	27.06	1.40	48.79
1984	0.00	12.52	24.60	0.81	37.94
1985	0.00	10.60	27.19	0.63	38.42
1986	0.00	10.25	24.72	0.29	35.26
1987	0.00	12.65	23.52	0.78	36.95
1988	0.00	14.61	20.43	0.95	35.99
1989	0.00	12.28	18.57	0.79	31.64
1990	0.00	7.11	16.88	0.46	24.45
1991	0.00	6.15	15.35	0.36	21.85
1992	0.00	3.29	14.60	0.16	18.05
1993	0.00	4.59	12.68	0.26	17.54
	0.00	320.77	456.75	19.91	797.43

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	14.45	0.00	0.00
1976	0.00	0.00	0.00	44.38	13.08	0.00
1977	0.00	0.00	0.00	35.61	8.20	0.00
1978	0.00	0.00	0.00	12.57	7.46	0.00
1979	0.00	0.00	0.00	10.43	6.78	0.00
1980	0.00	0.00	0.00	2.26	6.16	0.00
1981	0.00	0.00	0.00	15.09	5.60	0.00
1982	0.00	0.00	0.00	19.22	5.09	0.00
1983	0.00	0.00	0.00	15.69	4.63	0.00
1984	0.00	0.00	0.00	7.09	5.43	0.00
1985	0.00	0.00	0.00	5.89	4.71	0.00
1986	0.00	0.00	0.00	1.27	8.98	0.00
1987	0.00	0.00	0.00	8.52	4.14	0.00
1988	0.00	0.00	0.00	10.85	3.76	0.00
1989	0.00	0.00	0.00	8.86	3.42	0.00
1990	0.00	0.00	0.00	4.00	3.11	0.00
1991	0.00	0.00	0.00	3.32	2.83	0.00
1992	0.00	0.00	0.00	0.72	2.57	0.00
1993	0.00	0.00	0.00	2.26	2.33	0.00
	0.00	0.00	0.00	222.49	98.28	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.00	0.00	0.00
1976	0.00	0.00	0.00	3.06	0.00	0.00
1977	5.99	27.21	14.46	2.63	0.16	0.00
1978	8.25	20.74	14.66	1.30	0.14	0.00
1979	7.43	18.86	13.23	0.99	0.13	0.00
1980	6.76	17.14	13.12	[illegible]	0.12	0.00
1981	6.14	15.58	11.02	1.28	0.11	0.00
1982	5.59	16.09	8.98	1.59	0.10	0.00
1983	5.08	12.88	9.11	1.31	0.09	0.00
1984	4.62	11.71	8.28	0.73	0.08	0.00
1985	[illegible]	13.08	8.67	0.56	0.07	0.00
1986	4.22	12.62	7.88	0.22	0.07	0.00
1987	3.83	13.16	6.52	0.72	0.06	0.00
1988	3.48	10.43	6.51	0.90	0.06	0.00
1989	3.17	9.48	5.92	0.74	0.05	0.00
1990	2.88	8.62	5.38	0.41	0.05	0.00
1991	[illegible]	7.83	4.09	0.32	0.04	0.00
1992	[illegible]	8.17	4.55	0.13	0.04	0.00
1993	2.16	6.47	4.05	0.23	0.03	0.00
	[illegible]	241.68	145.65	18.52	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	22.38	0.00	0.00	22.38
1977	0.00	15.64	154.33	0.21	170.18
1978	0.00	13.74	153.79	0.21	167.74
1979	0.00	13.44	153.79	0.21	167.44
1980	0.00	13.44	153.79	0.21	167.44
1981	0.00	13.44	153.79	0.21	167.44
1982	0.00	13.44	155.13	0.21	168.78
1983	0.00	13.44	153.79	0.21	167.44
1984	0.00	15.54	153.79	0.21	169.54
1985	0.00	15.12	202.94	0.21	218.27
1986	0.00	31.95	202.94	0.21	235.10
1987	0.00	15.12	204.18	0.21	219.51
1988	0.00	15.12	202.94	0.21	218.27
1989	0.00	15.12	202.94	0.21	218.27
1990	0.00	15.12	202.94	0.21	218.27
1991	0.00	15.12	202.94	0.21	218.27
1992	0.00	15.12	204.18	0.21	219.51
1993	0.00	15.12	202.94	0.21	218.27
	0.00	287.42	3061.08	3.57	3352.07

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	22.38	0.00
1977	0.00	0.00	0.00	0.00	15.64	0.00
1978	0.00	0.00	0.00	0.00	13.74	0.00
1979	0.00	0.00	0.00	0.00	13.44	0.00
1980	0.00	0.00	0.00	0.00	13.44	0.00
1981	0.00	0.00	0.00	0.00	13.44	0.00
1982	0.00	0.00	0.00	0.00	13.44	0.00
1983	0.00	0.00	0.00	0.00	13.44	0.00
1984	0.00	0.00	0.00	0.00	15.54	0.00
1985	0.00	0.00	0.00	0.00	15.12	0.00
1986	0.00	0.00	0.00	0.00	31.95	0.00
1987	0.00	0.00	0.00	0.00	15.12	0.00
1988	0.00	0.00	0.00	0.00	15.12	0.00
1989	0.00	0.00	0.00	0.00	15.12	0.00
1990	0.00	0.00	0.00	0.00	15.12	0.00
1991	0.00	0.00	0.00	0.00	15.12	0.00
1992	0.00	0.00	0.00	0.00	15.12	0.00
1993	0.00	0.00	0.00	0.00	15.12	0.00
	0.00	0.00	0.00	0.00	287.42	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	63.21	91.12	0.00	0.21	0.00
1978	0.00	57.87	95.92	0.00	0.21	0.00
1979	0.00	57.87	95.92	0.00	0.21	0.00
1980	0.00	57.87	95.92	0.00	0.21	0.00
1981	0.00	57.87	95.92	0.00	0.21	0.00
1982	0.00	64.01	91.12	0.00	0.21	0.00
1983	0.00	57.87	95.92	0.00	0.21	0.00
1984	0.00	57.87	95.92	0.00	0.21	0.00
1985	0.00	68.42	134.52	0.00	0.21	0.00
1986	0.00	68.42	134.52	0.00	0.21	0.00
1987	0.00	74.46	129.72	0.00	0.21	0.00
1988	0.00	68.42	134.52	0.00	0.21	0.00
1989	0.00	68.42	134.52	0.00	0.21	0.00
1990	0.00	68.42	134.52	0.00	0.21	0.00
1991	0.00	68.42	134.52	0.00	0.21	0.00
1992	0.00	74.46	129.72	0.00	0.21	0.00
1993	0.00	68.42	134.52	0.00	0.21	0.00
	0.00	******	******	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	18.50	0.00	0.00	18.50
1977	0.00	11.75	115.95	0.16	127.86
1978	0.00	9.38	105.04	0.14	114.57
1979	0.00	8.35	95.49	0.13	103.97
1980	0.00	7.59	86.81	0.12	94.51
1981	0.00	6.90	78.92	0.11	85.92
1982	0.00	6.27	72.37	0.10	78.74
1983	0.00	5.70	65.22	0.09	71.01
1984	0.00	5.99	59.29	0.08	65.37
1985	0.00	5.30	71.13	0.07	76.50
1986	0.00	10.18	64.66	0.07	74.91
1987	0.00	4.38	59.14	0.06	63.58
1988	0.00	3.98	53.44	0.06	57.48
1989	0.00	3.62	48.58	0.05	52.25
1990	0.00	3.29	44.16	0.05	47.50
1991	0.00	2.99	40.15	0.04	43.18
1992	0.00	2.72	36.72	0.04	39.48
1993	0.00	2.47	33.18	0.03	35.69
	0.00	119.36	1130.28	1.39	1251.00

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	18.50	0.00
1977	0.00	0.00	0.00	0.00	11.75	0.00
1978	0.00	0.00	0.00	0.00	9.38	0.00
1979	0.00	0.00	[illegible]	0.00	8.35	0.00
1980	0.00	0.00	0.00	0.00	7.59	0.00
1981	0.00	0.00	0.00	0.00	6.90	0.00
1982	0.00	0.00	0.00	0.00	6.27	0.00
1983	0.00	0.00	0.00	0.00	5.70	0.00
1984	0.00	0.00	0.00	0.00	5.99	0.00
1985	0.00	0.00	0.00	0.00	5.30	0.00
1986	0.00	0.00	0.00	0.00	10.18	0.00
1987	0.00	0.00	0.00	0.00	4.38	0.00
1988	0.00	0.00	0.00	0.00	3.98	0.00
1989	0.00	0.00	0.00	0.00	3.62	0.00
1990	0.00	0.00	0.00	0.00	3.29	0.00
1991	0.00	0.00	0.00	0.00	2.99	0.00
1992	0.00	0.00	0.00	0.00	2.72	0.00
1993	0.00	0.00	0.00	0.00	2.47	0.00
	0.00	0.00	0.00	0.00	119.36	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	47.49	68.46	0.00	0.16	0.00
1978	0.00	39.53	65.51	0.00	0.14	0.00
1979	0.00	35.92	59.56	0.00	0.13	0.00
1980	0.00	32.67	54.14	0.00	0.12	0.00
1981	0.00	29.70	49.22	0.00	0.11	0.00
1982	0.00	29.86	42.51	0.00	0.10	0.00
1983	0.00	24.54	40.66	0.00	0.09	0.00
1984	0.00	22.34	36.98	0.00	0.08	0.00
1985	0.00	[illegible]	47.15	0.00	0.07	0.00
1986	0.00	21.86	42.86	.00	0.07	0.00
1987	0.00	[illegible]	37.57	0.00	0.06	0.00
1988	0.00	18.02	[illegible]	0.00	0.06	0.00
1989	0.00	16.38	32.20	0.00	0.05	0.00
1990	0.00	14.89	29.27	0.00	0.05	0.00
1991	0.00	13.54	26.61	0.00	0.04	0.00
1992	0.00	13.39	23.33	0.00	0.04	0.00
1993	0.00	11.19	21.99	0.00	0.03	0.00
	0.00	416.78	713.47	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 3 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	21.40	0.00	1.70	23.10
1976	0.00	82.42	0.00	5.20	87.62
1977	0.00	69.96	83.63	3.01	156.60
1978	0.00	31.66	90.27	2.91	124.84
1979	0.00	32.76	90.07	2.51	125.34
1980	0.00	13.56	90.07	1.21	104.84
1981	0.00	49.16	90.07	3.81	143.04
1982	0.00	65.86	88.83	5.21	159.90
1983	0.00	59.56	90.07	4.81	154.44
1984	0.00	33.76	90.07	2.91	126.75
1985	0.00	30.44	108.89	2.21	141.54
1986	0.00	25.76	108.89	1.21	135.86
1987	0.00	51.68	107.65	3.81	163.14
1988	0.00	68.38	108.89	5.21	182.48
1989	0.00	62.08	108.89	4.81	175.78
1990	0.00	34.18	108.89	2.91	145.98
1991	0.00	35.28	108.89	2.51	146.68
1992	0.00	16.08	107.65	1.21	124.94
1993	0.00	30.78	108.89	2.21	141.88
	0.00	814.76	1690.63	59.37	2564.76

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	21.40	0.00	0.00
1976	0.00	0.00	0.00	70.80	11.62	0.00
1977	0.00	0.00	0.00	62.40	7.56	0.00
1978	0.00	0.00	0.00	24.10	7.56	0.00
1979	0.00	0.00	0.00	25.20	7.56	0.00
1980	0.00	0.00	0.00	6.00	7.56	0.00
1981	0.00	0.00	0.00	41.60	7.56	0.00
1982	0.00	0.00	0.00	58.30	7.56	0.00
1983	0.00	0.00	0.00	52.60	7.56	0.00
1984	0.00	0.00	0.00	24.10	9.66	0.00
1985	0.00	0.00	0.00	21.20	9.24	0.00
1986	0.00	0.00	0.00	6.00	19.76	0.00
1987	0.00	0.00	0.00	41.60	10.08	0.00
1988	0.00	0.00	0.00	58.30	10.08	0.00
1989	0.00	0.00	0.00	52.00	10.08	0.00
1990	0.00	0.00	0.00	24.10	10.08	0.00
1991	0.00	0.00	0.00	25.20	10.08	0.00
1992	0.00	0.00	0.00	6.00	10.08	0.00
1993	0.00	0.00	0.00	20.70	10.08	0.00
	0.00	0.00	0.00	641.00	173.76	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.70	0.00	0.00
1976	0.00	0.00	0.00	5.20	0.00	0.00
1977	8.61	27.75	47.27	2.80	0.21	0.00
1978	14.01	21.27	54.99	2.70	0.21	0.00
1979	13.81	21.27	54.99	2.30	0.21	0.00
1980	13.81	21.27	54.99	1.00	0.21	0.00
1981	13.81	21.27	54.99	3.60	0.21	0.00
1982	13.81	27.75	47.27	5.00	0.21	0.00
1983	13.81	21.27	54.99	4.60	0.21	0.00
1984	13.81	21.27	54.99	2.70	0.21	0.00
1985	14.93	30.13	63.83	2.00	0.21	0.00
1986	14.93	30.13	63.83	1.00	0.21	0.00
1987	14.93	36.61	56.11	3.60	0.21	0.00
1988	14.93	30.13	63.83	5.00	0.21	0.00
1989	14.93	30.13	63.83	4.60	0.21	0.00
1990	14.93	30.13	63.83	2.70	0.21	0.00
1991	14.93	30.13	63.83	2.30	0.21	0.00
1992	14.93	36.61	56.11	1.00	0.21	0.00
1993	14.93	30.13	63.83	2.00	0.21	0.00
	[illegible]	[illegible]	[illegible]	55.80	3.[illegible]	0.00

C-4

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 3 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	19.45	0.00	1.55	21.00
1976	0.00	68.12	0.00	4.39	72.41
1977	0.00	52.56	62.83	2.26	117.66
1978	0.00	21.62	61.66	1.99	85.27
1979	0.00	20.34	55.93	1.56	77.83
1980	0.00	7.65	50.84	0.68	59.18
1981	0.00	25.23	46.22	1.96	73.40
1982	0.00	30.72	41.44	2.43	74.59
1983	0.00	25.26	38.20	2.04	65.50
1984	0.00	13.02	34.73	1.12	48.87
1985	0.00	10.67	38.17	0.77	49.61
1986	0.00	8.21	34.70	0.39	43.29
1987	0.00	14.97	31.18	1.10	47.25
1988	0.00	18.01	28.67	1.37	48.05
1989	0.00	14.86	26.07	1.15	42.08
1990	0.00	7.44	23.70	0.63	31.77
1991	0.00	6.98	21.54	0.50	29.02
1992	0.00	2.89	19.36	0.22	22.47
1993	0.00	5.03	17.80	0.36	23.20
	0.00	373.04	633.04	26.38	1032.45

FISCAL YEAR	RDT&E SAT	HA	GT	INVESTMENT SAT	HA	GT
1975	0.00	0.00	0.00	19.45	0.00	0.00
1976	0.00	0.00	0.00	58.51	9.60	0.00
1977	0.00	0.00	0.00	46.88	5.68	0.00
1978	0.00	0.00	0.00	16.46	5.16	0.00
1979	0.00	0.00	0.00	15.65	4.69	0.00
1980	0.00	0.00	0.00	3.39	4.27	0.00
1981	0.00	0.00	0.00	21.35	3.88	0.00
1982	0.00	0.00	0.00	27.20	3.53	0.00
1983	0.00	0.00	0.00	22.05	3.21	0.00
1984	0.00	0.00	0.00	9.29	3.73	0.00
1985	0.00	0.00	0.00	7.43	3.24	0.00
1986	0.00	0.00	0.00	1.91	6.30	0.00
1987	0.00	0.00	0.00	12.05	2.92	0.00
1988	0.00	0.00	0.00	15.35	2.65	0.00
1989	0.00	0.00	0.00	12.45	2.41	0.00
1990	0.00	0.00	0.00	5.24	2.19	0.00
1991	0.00	0.00	0.00	4.99	1.99	0.00
1992	0.00	0.00	0.00	1.08	1.81	0.00
1993	0.00	0.00	0.00	3.38	1.65	0.00
	0.00	0.00	0.00	304.12	68.92	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	HA	GT	ACTIVITY LEVEL INDEPENDENT SAT	HA	GT
1975	0.00	0.00	0.00	1.55	0.00	0.00
1976	0.00	0.00	0.00	4.30	0.00	0.00
1977	6.47	20.65	35.52	2.10	0.16	0.00
1978	9.57	14.53	37.56	1.84	0.14	0.00
1979	8.57	13.21	34.15	1.43	0.13	0.00
1980	7.79	12.91	31.04	0.56	0.12	0.00
1981	7.09	[illegible]	28.22	1.85	0.11	0.00
1982	6.44	12.95	22.05	2.33	0.10	0.00
1983	5.86	9.02	23.32	1.25	0.09	0.00
1984	5.32	8.20	21.20	1.04	0.08	0.00
1985	5.23	10.56	22.37	0.70	0.07	0.00
1986	4.76	9.60	20.34	0.32	0.07	0.00
1987	4.32	10.60	16.25	1.04	0.06	0.00
1988	3.93	7.33	16.01	[illegible]	0.06	0.00
1989	[illegible]	7.21	15.28	1.10	0.05	0.00
1990	[illegible]	6.56	[illegible]	[illegible]	[illegible]	0.00
1991	[illegible]	[illegible]	12.63	[illegible]	0.04	0.00
1992	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.00
1993	2.44	[illegible]	10.44	[illegible]	0.03	0.00
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00

Life Cycle Costs to Provide

Land Cover Information for

Projected Demand from All Sources

Projected Level II Demand:

1977 - 1980 Six times at 60 days

1981 - 1993 Eight times at 45 days

Automatic Data Processing

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	22.38	0.00	0.00	22.38
1977	0.00	15.64	107.50	0.21	123.35
1978	0.00	13.74	104.68	0.21	118.63
1979	0.00	13.44	104.68	0.21	118.33
1980	0.00	15.54	104.68	0.21	120.44
1981	0.00	15.12	137.16	0.21	152.48
1982	0.00	15.12	140.67	0.21	156.00
1983	0.00	15.12	137.16	0.21	152.48
1984	0.00	15.12	137.15	0.21	152.48
1985	0.00	15.12	137.15	0.21	152.48
1986	0.00	31.95	137.15	0.21	169.32
1987	0.00	15.12	140.67	0.21	156.00
1988	0.00	15.12	137.15	0.21	152.48
1989	0.00	15.12	137.15	0.21	152.48
1990	0.00	17.22	137.15	0.21	154.59
1991	0.00	15.12	137.15	0.21	152.48
1992	0.00	15.12	140.67	0.21	156.00
1993	0.00	15.12	137.16	0.21	152.48
	0.00	296.24	2215.09	3.57	2514.90

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	22.38	0.00
1977	0.00	0.00	0.00	0.00	15.64	0.00
1978	0.00	0.00	0.00	0.00	13.74	0.00
1979	0.00	0.00	0.00	0.00	13.44	0.00
1980	0.00	0.00	0.00	0.00	15.54	0.00
1981	0.00	0.00	0.00	0.00	15.12	0.00
1982	0.00	0.00	0.00	0.00	15.12	0.00
1983	0.00	0.00	0.00	0.00	15.12	0.00
1984	0.00	0.00	0.00	0.00	15.12	0.00
1985	0.00	0.00	0.00	0.00	15.12	0.00
1986	0.00	0.00	0.00	0.00	31.95	0.00
1987	0.00	0.00	0.00	0.00	15.12	0.00
1988	0.00	0.00	0.00	0.00	15.12	0.00
1989	0.00	0.00	0.00	0.00	15.12	0.00
1990	0.00	0.00	0.00	0.00	17.22	0.00
1991	0.00	0.00	0.00	0.00	15.12	0.00
1992	0.00	0.00	0.00	0.00	15.12	0.00
1993	0.00	0.00	0.00	0.00	15.12	0.00
	0.00	0.00	0.00	0.00	296.24	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	68.09	39.41	0.00	0.21	0.00
1978	0.00	63.05	41.63	0.00	0.21	0.00
1979	0.00	63.05	41.63	0.00	0.21	0.00
1980	0.00	63.05	41.63	0.00	0.21	0.00
1981	0.00	75.30	61.85	0.00	0.21	0.00
1982	0.00	81.04	59.63	0.00	0.21	0.00
1983	0.00	75.30	61.85	0.00	0.21	0.00
1984	0.00	75.30	61.85	0.00	0.21	0.00
1985	0.00	75.30	61.85	0.00	0.21	0.00
1986	0.00	75.30	61.85	0.00	0.21	0.00
1987	0.00	81.04	59.63	0.00	0.21	0.00
1988	0.00	75.30	61.85	0.00	0.21	0.00
1989	0.00	75.30	61.85	0.00	0.21	0.00
1990	0.00	75.30	61.85	0.00	0.21	0.00
1991	0.00	75.30	61.85	0.00	0.21	0.00
1992	0.00	81.04	59.63	0.00	0.21	0.00
1993	0.00	75.30	61.85	0.00	0.21	0.00
	0.00	******	961.73	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	18.50	0.00	0.00	18.50
1977	0.00	11.75	80.76	0.16	92.67
1978	0.00	9.38	71.50	0.14	81.03
1979	0.00	8.35	65.00	0.13	73.47
1980	0.00	8.77	59.09	0.12	67.98
1981	0.00	7.76	70.38	0.11	78.25
1982	0.00	7.05	65.62	0.10	72.77
1983	0.00	6.41	58.17	0.09	64.67
1984	0.00	5.83	52.88	0.08	58.79
1985	0.00	5.30	48.07	0.07	53.44
1986	0.00	10.18	43.70	0.07	53.95
1987	0.00	4.38	40.75	0.06	45.19
1988	0.00	3.98	36.15	0.06	40.15
1989	0.00	3.62	32.83	0.05	36.50
1990	0.00	3.75	29.85	0.05	33.64
1991	0.00	2.99	27.14	0.04	30.17
1992	0.00	2.72	25.30	0.04	28.06
1993	0.00	2.47	22.43	0.03	24.93
	0.00	123.20	829.58	1.39	954.17

		RDT&E			INVESTMENT	
FISCAL YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	18.50	0.00
1977	0.00	0.00	0.00	0.00	11.75	0.00
1978	0.00	0.00	0.00	0.00	9.39	0.00
1979	0.00	0.00	0.00	0.00	8.35	0.00
1980	0.00	0.00	0.00	0.00	8.77	0.00
1981	0.00	0.00	0.00	0.00	7.76	0.00
1982	0.00	0.00	0.00	0.00	7.05	0.00
1983	0.00	0.00	0.00	0.00	6.41	0.00
1984	0.00	0.00	0.00	0.00	5.83	0.00
1985	0.00	0.00	0.00	0.00	5.30	0.00
1986	0.00	0.00	0.00	0.00	10.18	0.00
1987	0.00	0.00	0.00	0.00	4.38	0.00
1988	0.00	0.00	0.00	0.00	3.98	0.00
1989	0.00	0.00	0.00	0.03	3.62	0.00
1990	0.00	0.00	0.00	0.00	3.75	0.00
1991	0.00	0.00	0.00	0.00	2.99	0.00
1992	0.00	0.00	0.00	0.00	2.72	0.00
1993	0.00	0.00	0.00	0.00	2.47	0.00
	0.00	-0.00	0.00	0.00	123.20	0.00

		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
FISCAL YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	51.16	29.61	0.00	0.16	0.00
1978	0.00	43.06	28.43	0.00	0.14	0.00
1979	0.00	39.15	25.85	0.00	0.13	0.00
1980	0.00	35.59	23.50	0.00	0.12	0.00
1981	0.00	38.64	31.74	0.00	0.11	0.00
1982	0.00	37.81	27.82	0.00	0.10	0.00
1983	0.00	31.93	26.23	0.00	0.09	0.00
1984	0.00	29.03	23.85	0.00	0.08	0.00
1985	0.00	26.39	21.68	0.00	0.07	0.00
1986	0.00	23.99	19.71	0.00	0.07	0.00
1987	0.00	23.47	17.27	0.00	0.06	0.00
1988	0.00	19.83	16.29	0.00	0.06	0.00
1989	0.00	18.03	14.81	0.00	0.05	0.00
1990	0.00	16.39	13.46	0.00	0.05	0.00
1991	0.00	14.90	12.74	0.00	0.04	0.00
1992	0.00	14.50	10.72	0.00	0.04	0.00
1993	0.00	12.31	10.11	0.00	0.03	0.00
	0.00	476.26	353.32	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

ENTER THE NUMBER OF THE FIRST YEAR

FISCAL YEAR	NON-RECURRING COSTS RDT&E	NON-RECURRING COSTS INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	RECURRING COSTS ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	15.90	0.00	1.10	17.00
1976	0.00	69.53	0.00	3.70	73.23
1977	0.00	58.32	63.43	3.71	125.46
1978	0.00	29.32	63.91	2.11	95.34
1979	0.00	27.72	63.81	1.81	93.34
1980	0.00	18.08	63.81	0.91	82.80
1981	0.00	43.89	77.57	2.71	124.18
1982	0.00	55.48	81.19	3.61	140.28
1983	0.00	51.28	77.57	3.31	132.16
1984	0.00	32.68	77.57	2.11	112.36
1985	0.00	31.08	77.57	1.81	110.46
1986	0.00	31.96	77.57	0.91	110.44
1987	0.00	43.68	81.19	2.71	127.58
1988	0.00	55.48	77.57	3.61	136.66
1989	0.00	51.28	77.57	3.31	132.16
1990	0.00	35.84	77.57	2.11	115.52
1991	0.00	32.13	77.57	1.81	111.52
1992	0.00	18.28	81.19	0.91	100.38
1993	0.00	28.08	77.57	1.61	107.26
	0.00	730.00	1274.26	43.87	2048.13

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	15.90	0.00	0.00
1976	0.00	0.00	0.00	53.70	15.83	0.00
1977	0.00	0.00	0.00	47.40	10.92	0.00
1978	0.00	0.00	0.00	18.40	10.92	0.00
1979	0.00	0.00	0.00	16.80	10.92	0.00
1980	0.00	0.00	0.00	4.00	14.08	0.00
1981	0.00	0.00	0.00	29.40	14.49	0.00
1982	0.00	0.00	0.00	41.20	14.28	0.00
1983	0.00	0.00	0.00	37.00	14.28	0.00
1984	0.00	0.00	0.00	18.40	14.28	0.00
1985	0.00	0.00	0.00	16.80	14.28	0.00
1986	0.00	0.00	0.00	4.00	27.96	0.00
1987	0.00	0.00	0.00	29.40	14.28	0.00
1988	0.00	0.00	0.00	41.20	14.28	0.00
1989	0.00	0.00	0.00	37.00	14.28	0.00
1990	0.00	0.00	0.00	18.40	17.44	0.00
1991	0.00	0.00	0.00	16.80	15.33	0.00
1992	0.00	0.00	0.00	4.00	14.28	0.00
1993	0.00	0.00	0.00	13.80	14.28	0.00
	0.00	0.00	0.00	463.60	266.40	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.10	0.00	0.00
1976	0.00	0.00	0.00	3.70	0.00	0.00
1977	7.97	36.21	19.25	3.50	0.21	0.00
1978	12.07	30.37	21.47	1.90	0.21	0.00
1979	11.97	30.37	21.47	1.60	0.21	0.00
1980	11.97	30.37	21.47	0.70	0.21	0.00
1981	13.23	39.60	24.74	2.50	0.21	0.00
1982	13.23	45.44	22.52	3.40	0.21	0.00
1983	13.23	39.60	24.74	3.10	0.21	0.00
1984	13.23	39.60	24.74	1.90	0.21	0.00
1985	13.23	39.60	24.74	1.60	0.21	0.00
1986	13.23	39.60	24.74	0.70	0.21	0.00
1987	13.23	45.44	22.52	2.50	0.21	0.00
1988	13.23	39.60	24.74	3.40	0.21	0.00
1989	13.23	39.60	24.74	3.10	0.21	0.00
1990	13.23	39.60	24.74	1.90	0.21	0.00
1991	13.23	39.60	24.74	1.60	0.21	0.00
1992	13.23	45.44	[illegible]	0.70	0.21	0.00
1993	[illegible]	[illegible]	[illegible]	1.40	0.21	0.00
	[illegible]	[illegible]	[illegible]	40.30	[illegible]	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 2 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-30%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	14.45	0.00	1.00	15.45
1976	0.00	57.46	0.00	3.06	60.52
1977	0.00	43.82	47.65	2.79	94.26
1978	0.00	20.03	43.65	1.44	65.12
1979	0.00	17.21	39.62	1.12	57.96
1980	0.00	10.20	36.02	0.51	46.74
1981	0.00	22.52	39.81	1.39	63.72
1982	0.00	25.88	37.87	1.68	65.44
1983	0.00	21.75	32.90	1.40	56.05
1984	0.00	12.60	29.91	0.81	43.32
1985	0.00	10.89	27.19	0.63	38.72
1986	0.00	10.18	24.72	0.29	35.19
1987	0.00	12.65	23.52	0.78	36.95
1988	0.00	14.61	20.43	0.95	35.99
1989	0.00	12.28	18.57	0.79	31.64
1990	0.00	7.80	16.88	0.46	25.14
1991	0.00	6.36	15.35	0.36	22.06
1992	0.00	3.29	14.60	0.16	18.05
1993	0.00	4.59	12.68	0.26	17.54
	0.00	328.57	481.37	19.91	829.86

FISCAL		RDT&E			INVESTMENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	14.45	0.00	0.00
1976	0.00	0.00	0.00	44.38	13.08	0.00
1977	0.00	0.00	0.00	35.61	8.20	0.00
1978	0.00	0.00	0.00	12.57	7.46	0.00
1979	0.00	0.00	0.00	10.43	6.78	0.00
1980	0.00	0.00	0.00	2.26	7.95	0.00
1981	0.00	0.00	0.00	15.09	7.44	0.00
1982	0.00	0.00	0.00	19.22	6.66	0.00
1983	0.00	0.00	0.00	15.69	6.06	0.00
1984	0.00	0.00	0.00	7.09	5.51	0.00
1985	0.00	0.00	0.00	5.89	5.01	0.00
1986	0.00	0.00	0.00	1.27	8.91	0.00
1987	0.00	0.00	0.00	8.52	4.14	0.00
1988	0.00	0.00	0.00	10.85	3.76	0.00
1989	0.00	0.00	0.00	8.86	3.42	0.00
1990	0.00	0.00	0.00	4.00	3.79	0.00
1991	0.00	0.00	0.00	3.32	3.03	0.00
1992	0.00	0.00	0.00	0.72	2.57	0.00
1993	0.00	0.00	0.00	2.26	2.33	0.00
	0.00	0.00	0.00	222.49	106.09	0.00

FISCAL		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	1.00	0.00	0.00
1976	0.00	0.00	0.00	3.06	0.00	0.00
1977	5.99	27.21	14.46	2.63	0.16	0.00
1978	8.25	20.74	14.66	1.30	0.14	0.00
1979	7.43	18.86	13.33	0.99	0.13	0.00
1980	6.76	17.14	12.12	0.40	0.12	0.00
1981	6.79	20.32	12.70	1.28	0.11	0.00
1982	6.17	21.20	10.50	1.59	0.10	0.00
1983	5.61	16.79	10.49	1.31	0.09	0.00
1984	5.10	15.27	9.54	0.73	0.08	0.00
1985	4.64	13.88	8.67	0.56	0.07	0.00
1986	4.22	12.62	7.68	0.22	0.07	0.00
1987	3.83	13.16	6.52	0.72	0.06	0.00
1988	3.48	10.43	6.51	0.90	0.06	0.00
1989	3.17	9.48	5.92	0.74	0.05	0.00
1990	2.80	8.62	5.38	0.41	0.05	0.00
1991	2.62	7.03	4.89	0.32	0.04	0.00
1992	2.38	8.17	4.05	0.13	0.04	0.00
1993	2.16	6.47	4.05	0.23	0.03	0.00
	81.48	248.20	151.70	18.52	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	22.38	0.00	0.00	22.38
1977	0.00	15.64	154.33	0.21	170.18
1978	0.00	13.74	153.79	0.21	167.74
1979	0.00	13.44	153.79	0.21	167.44
1980	0.00	15.54	153.79	0.21	169.54
1981	0.00	15.12	202.94	0.21	218.27
1982	0.00	15.12	204.18	0.21	219.51
1983	0.00	15.12	202.94	0.21	218.27
1984	0.00	15.12	202.94	0.21	218.27
1985	0.00	15.12	202.94	0.21	218.27
1986	0.00	31.95	202.94	0.21	235.10
1987	0.00	15.12	204.18	0.21	219.51
1988	0.00	15.12	202.94	0.21	218.27
1989	0.00	15.12	202.94	0.21	218.27
1990	0.00	17.22	202.94	0.21	220.37
1991	0.00	15.12	202.94	0.21	218.27
1992	0.00	15.12	204.18	0.21	219.51
1993	0.00	15.12	202.94	0.21	218.27
	0.00	296.24	3257.57	3.57	3557.38

FISCAL		RDT&E			INVESTMENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	22.38	0.00
1977	0.00	0.00	0.00	0.00	15.64	0.00
1978	0.00	0.00	0.00	0.00	13.74	0.00
1979	0.00	0.00	0.00	0.00	13.44	0.00
1980	0.00	0.00	0.00	0.00	15.54	0.00
1981	0.00	0.00	0.00	0.00	15.12	0.00
1982	0.00	0.00	0.00	0.00	15.12	0.00
1983	0.00	0.00	0.00	0.00	15.12	0.00
1984	0.00	0.00	0.00	0.00	15.12	0.00
1985	0.00	0.00	0.00	0.00	15.12	0.00
1986	0.00	0.00	0.00	0.00	31.95	0.00
1987	0.00	0.00	0.00	0.00	15.12	0.00
1988	0.00	0.00	0.00	0.00	15.12	0.00
1989	0.00	0.00	0.00	0.00	15.12	0.00
1990	0.00	0.00	0.00	0.00	17.22	0.00
1991	0.00	0.00	0.00	0.00	15.12	0.00
1992	0.00	0.00	0.00	0.00	15.12	0.00
1993	0.00	0.00	0.00	0.00	15.12	0.00
	0.00	0.00	0.00	0.00	296.24	0.00

FISCAL		ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT	
YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	63.21	91.12	0.00	0.21	0.00
1978	0.00	57.67	95.92	0.00	0.21	0.00
1979	0.00	57.87	95.92	0.00	0.21	0.00
1980	0.00	57.87	95.92	0.00	0.21	0.00
1981	0.00	68.42	134.52	0.00	0.21	0.00
1982	0.00	74.46	129.72	0.00	0.21	0.00
1983	0.00	68.42	134.52	0.00	0.21	0.00
1984	0.00	68.42	134.52	0.00	0.21	0.00
1985	0.00	68.42	134.52	0.00	0.21	0.00
1986	0.00	68.42	134.52	0.00	0.21	0.00
1987	0.00	74.46	129.72	0.00	0.21	0.00
1988	0.00	68.42	134.52	0.00	0.21	0.00
1989	0.00	68.42	134.52	0.00	0.21	0.00
1990	0.00	68.42	134.52	0.00	0.21	0.00
1991	0.00	68.42	134.52	0.00	0.21	0.00
1992	0.00	74.46	129.72	0.00	0.21	0.00
1993	0.00	68.42	134.52	0.00	0.21	0.00
	0.00	******	******	0.00	3.57	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS: RDT&E	NON-RECURRING COSTS: INVESTMENT	RECURRING COSTS: ACTIVITY LEVEL DEPENDENT	RECURRING COSTS: ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	0.00	0.00	0.00	0.00
1976	0.00	18.50	0.00	0.00	18.50
1977	0.00	11.75	115.95	0.16	127.86
1978	0.00	9.38	105.04	0.14	114.57
1979	0.00	8.35	95.49	0.13	103.97
1980	0.00	8.77	86.81	0.12	95.70
1981	0.00	7.76	104.14	0.11	112.00
1982	0.00	7.05	95.25	0.10	102.40
1983	0.00	6.41	86.06	0.09	92.57
1984	0.00	5.83	78.24	0.08	84.15
1985	0.00	5.30	71.13	0.07	76.50
1986	0.00	10.18	64.66	0.07	74.91
1987	0.00	4.38	59.14	0.06	63.58
1988	0.00	3.98	53.44	0.06	57.48
1989	0.00	3.62	48.58	0.05	52.25
1990	0.00	3.75	44.16	0.05	47.96
1991	0.00	2.99	40.15	0.04	43.18
1992	0.00	2.72	36.75	0.04	39.48
1993	0.00	2.47	33.18	0.03	35.69
	0.00	123.20	1218.14	1.39	1342.74

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	18.50	0.00
1977	0.00	0.00	0.00	0.00	11.75	0.00
1978	0.00	0.00	0.00	0.00	9.38	0.00
1979	0.00	0.00	0.00	0.00	8.35	0.00
1980	0.00	0.00	0.00	0.00	8.77	0.00
1981	0.00	0.00	0.00	0.00	7.76	0.00
1982	0.00	0.00	0.00	0.00	7.05	0.00
1983	0.00	0.00	0.00	0.00	6.41	0.00
1984	0.00	0.00	0.00	0.00	5.83	0.00
1985	0.00	0.00	0.00	0.00	5.30	0.00
1986	0.00	0.00	0.00	0.00	10.18	0.00
1987	0.00	0.00	0.00	0.00	4.38	0.00
1988	0.00	0.00	0.00	0.00	3.98	0.00
1989	0.00	0.00	0.00	0.00	3.62	0.00
1990	0.00	0.00	0.00	0.00	3.75	0.00
1991	0.00	0.00	0.00	0.00	2.99	0.00
1992	0.00	0.00	0.00	0.00	2.72	0.00
1993	0.00	0.00	0.00	0.00	2.47	0.00
	0.00	0.00	0.00	0.00	123.20	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	47.49	68.46	0.00	0.16	0.00
1978	0.00	39.53	65.51	0.00	0.14	0.00
1979	0.00	35.93	59.56	0.00	0.13	0.00
1980	0.00	32.67	54.14	0.00	0.12	0.00
1981	0.00	35.11	69.03	0.00	0.11	0.00
1982	0.00	34.74	60.51	0.00	0.10	0.00
1983	0.00	29.02	57.05	0.00	0.09	0.00
1984	0.00	26.38	51.86	0.00	0.08	0.00
1985	0.00	23.98	47.15	0.00	0.07	0.00
1986	0.00	21.80	42.86	0.00	0.07	0.00
1987	0.00	21.57	37.57	0.00	0.06	0.00
1988	0.00	18.02	35.42	0.00	0.06	0.00
1989	0.00	16.38	32.20	0.00	0.05	0.00
1990	0.00	14.89	29.27	0.00	0.05	0.00
1991	0.00	13.54	26.61	0.00	0.04	0.00
1992	0.00	13.39	23.33	0.00	0.04	0.00
1993	0.00	11.19	21.99	0.00	0.03	0.00
	0.00	435.61	702.53	0.00	1.39	0.00

LIFE CYCLE COSTS

MILLIONS OF UNDISCOUNTED 1973 DOLLARS
SYSTEM ALTERNATIVE -- 3 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

	NON-RECURRING COSTS		RECURRING COSTS		
FISCAL YEAR	RDT&E	INVESTMENT	ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	21.40	0.00	1.70	23.10
1976	0.00	82.42	0.00	5.20	87.62
1977	0.00	69.96	83.63	3.01	156.60
1978	0.00	31.66	90.27	2.91	124.84
1979	0.00	32.76	90.07	2.51	125.34
1980	0.00	15.66	90.07	1.21	106.95
1981	0.00	51.89	108.89	3.81	164.59
1982	0.00	68.38	107.65	5.21	181.24
1983	0.00	62.08	108.89	4.81	175.78
1984	0.00	34.18	108.89	2.91	145.98
1985	0.00	31.28	108.89	2.21	142.38
1986	0.00	25.55	108.89	1.21	135.65
1987	0.00	51.68	107.65	3.81	163.14
1988	0.00	68.38	108.89	5.21	182.48
1989	0.00	62.08	108.89	4.81	175.78
1990	0.00	36.28	108.89	2.91	148.08
1991	0.00	36.33	108.89	2.51	147.73
1992	0.00	16.08	107.65	1.21	124.94
1993	0.00	30.78	108.89	2.21	141.88
	0.00	828.84	1765.90	59.37	2654.11

	RDT&E			INVESTMENT		
FISCAL YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	21.40	0.00	0.00
1976	0.00	0.00	0.00	70.80	11.62	0.00
1977	0.00	0.00	0.00	62.40	7.56	0.00
1978	0.00	0.00	0.00	24.10	7.56	0.00
1979	0.00	0.00	0.00	25.20	7.56	0.00
1980	0.00	0.00	0.00	6.00	9.66	0.00
1981	0.00	0.00	0.00	41.60	10.29	0.00
1982	0.00	0.00	0.00	58.30	10.08	0.00
1983	0.00	0.00	0.00	52.00	10.08	0.00
1984	0.00	0.00	0.00	24.10	10.08	0.00
1985	0.00	0.00	0.00	21.20	10.08	0.00
1986	0.00	0.00	0.00	6.00	19.55	0.00
1987	0.00	0.00	0.00	41.60	10.08	0.00
1988	0.00	0.00	0.00	58.30	10.08	0.00
1989	0.00	0.00	0.00	52.00	10.00	0.00
1990	0.00	0.00	0.00	24.10	12.18	0.00
1991	0.00	0.00	0.00	25.20	11.13	0.00
1992	0.00	0.00	0.00	6.00	10.08	0.00
1993	0.00	0.00	0.00	20.70	10.08	0.00
	0.00	0.00	0.00	641.00	187.84	0.00

	ACTIVITY LEVEL DEPENDENT			ACTIVITY LEVEL INDEPENDENT		
FISCAL YEAR	SAT	HA	GT	SAT	HA	GT
1975	0.00	0.00	0.00	1.70	0.00	0.00
1976	0.00	0.00	0.00	5.20	0.00	0.00
1977	8.61	27.75	47.27	2.80	0.21	0.00
1978	14.01	21.27	54.99	2.70	0.21	0.00
1979	13.81	21.27	54.99	2.30	0.21	0.00
1980	13.81	21.27	54.99	1.00	0.21	0.00
1981	14.93	30.13	63.83	3.60	0.21	0.00
1982	14.93	36.61	56.11	5.00	0.21	0.00
1983	14.93	30.13	63.83	4.00	0.21	0.00
1984	14.93	30.13	63.83	2.70	0.21	0.00
1985	14.93	30.13	63.83	2.00	0.21	0.00
1986	14.93	30.13	63.83	1.00	0.21	0.00
1987	14.93	36.61	56.11	3.60	0.21	0.00
1988	14.93	30.13	63.83	5.00	0.21	0.00
1989	14.93	30.13	63.83	4.00	0.21	0.00
1990	14.93	30.13	63.83	2.70	0.21	0.00
1991	14.93	30.13	63.83	2.30	0.21	0.00
1992	14.93	36.61	56.11	1.00	0.21	0.00
1993	14.93	30.13	63.83	2.00	0.21	0.00
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00

LIFE CYCLE COSTS

MILLIONS OF 1973 DOLLARS DISCOUNTED TO 1974 AT 10%
SYSTEM ALTERNATIVE -- 3 SATELLITE/AIRCRAFT/GROUND
ALLOWABLE CLOUD COVER -- 0-10%

FISCAL YEAR	NON-RECURRING COSTS RDT&E	INVESTMENT	RECURRING COSTS ACTIVITY LEVEL DEPENDENT	ACTIVITY LEVEL INDEPENDENT	ANNUAL COSTS
1975	0.00	19.45	0.00	1.55	21.00
1976	0.00	68.12	0.00	4.30	72.41
1977	0.00	52.56	62.83	2.26	117.66
1978	0.00	21.62	61.66	1.99	85.27
1979	0.00	20.34	55.93	1.56	77.83
1980	0.00	8.84	50.84	0.68	60.37
1981	0.00	26.63	55.88	1.96	84.46
1982	0.00	31.90	50.22	2.43	84.55
1983	0.00	26.33	46.18	2.04	74.55
1984	0.00	13.18	41.98	1.12	56.28
1985	0.00	10.96	38.17	0.77	49.90
1986	0.00	8.14	34.70	0.39	43.22
1987	0.00	14.97	31.18	1.10	47.25
1988	0.00	18.01	28.67	1.37	48.05
1989	0.00	14.86	26.07	1.15	42.08
1990	0.00	7.90	23.70	0.63	32.23
1991	0.00	7.19	21.54	0.50	29.23
1992	0.00	2.8	19.36	0.22	22.47
1993	0.00	5.0[illegible]	17.80	0.36	23.20
	0.00	378.92	666.71	26.38	1072.01

FISCAL YEAR	RDT&E SAT	RDT&E HA	RDT&E GT	INVESTMENT SAT	INVESTMENT HA	INVESTMENT GT
1975	0.00	0.00	0.00	19.45	0.00	0.00
1976	0.00	0.00	0.00	58.51	9.60	0.00
1977	0.00	0.00	0.00	46.88	5.68	0.00
1978	0.00	0.00	0.00	16.46	5.16	0.00
1979	0.00	0.00	0.00	15.65	4.69	0.00
1980	0.00	0.00	0.00	3.39	5.46	0.00
1981	0.00	0.00	0.00	21.35	5.28	0.00
1982	0.00	0.00	0.00	27.20	4.70	0.00
1983	0.00	0.00	0.00	22.05	4.27	0.00
1984	0.00	0.00	0.00	9.29	3.89	0.00
1985	0.00	0.00	0.00	7.43	3.53	0.00
1986	0.00	0.00	0.00	1.91	6.23	0.00
1987	0.00	0.00	0.00	12.05	2.92	0.00
1988	0.00	0.00	0.00	15.35	2.65	0.00
1989	0.00	0.00	0.00	12.45	2.41	0.00
1990	0.00	0.00	0.00	5.24	2.65	0.00
1991	0.00	0.00	0.00	4.99	2.20	0.00
1992	0.00	0.00	0.00	1.08	1.81	0.00
1993	0.00	0.00	0.00	3.38	1.65	0.00
	0.00	0.00	0.00	304.12	74.81	0.00

FISCAL YEAR	ACTIVITY LEVEL DEPENDENT SAT	ACTIVITY LEVEL DEPENDENT HA	ACTIVITY LEVEL DEPENDENT GT	ACTIVITY LEVEL INDEPENDENT SAT	ACTIVITY LEVEL INDEPENDENT HA	ACTIVITY LEVEL INDEPENDENT GT
1975	0.00	0.00	0.00	1.55	0.00	0.00
1976	0.00	0.00	0.00	4.30	0.00	0.00
1977	6.47	20.85	35.52	2.10	0.16	0.00
1978	9.57	14.53	37.56	1.84	0.14	0.00
1979	8.57	13.21	34.15	1.43	0.13	0.00
1980	[illegible]	12.01	31.04	0.56	0.12	0.00
1981	7.06	15.46	32.76	1.85	0.11	0.00
1982	6.96	17.00	26.18	2.33	0.10	0.00
1983	6.32	12.70	27.07	1.95	0.09	0.00
1984	5.75	11.62	24.61	1.04	0.08	0.00
1985	5.23	10.56	22.37	0.70	0.07	0.00
1986	4.26	9.00	20.34	0.32	0.07	0.00
1987	4.37	10.60	[illegible]	1.04	0.06	0.00
1988	3.33	7.93	16.91	1.32	0.06	0.00
1989	3.57	7.21	15.28	1.10	0.05	0.00
1990	3.25	6.56	[illegible]	0.59	0.05	0.00
1991	[illegible]	5.56	[illegible]	0.46	0.04	0.00
1992	[illegible]	6.58	10.09	0.19	0.04	0.00
1993	2.08	[illegible]	10.99	0.33	0.03	0.00
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00