PB 210-933

UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

INTERAGENCY REPORT USGS-227

BENEFITS FROM REMOTE SENSING DATA UTILIZATION IN URBAN PLANNING PROCESSES AND SYSTEM RECOMMENDATIONS
TR-6

by

Harry J. Mallon
and
Joan Y. Howard

January 1972

(NASA-CR-127496) BENEFITS FROM REMOTE SENSING DATA UTILIZATION IN URBAN PLANNING PROCESSES AND SYSTEM H.J. Mallon, et al (Metropolitan Washington Council of Governments) Jan. 1972 49 p CSCL 08G G3/13 N72-28348 Unclas 35483

Work performed by the Metropolitan Washington Council of Governments for the USGS Geographic Applications Program under USGS Contract No. 14-08-0001-12708, and for the National Aeronautics and Space Administration (NASA) under NASA Contract No.W-13318, Task No. 160-75-71-03.

This report will not be resubmitted to NTIS by NASA.

PRECEDING PAGE BLANK NOT FILMED

ABSTRACT

TITLE:	Benefits from Remote Sensing Data Utilization in Urban Planning Process and System Recommendations
AUTHORS:	Harry J. Mallon and Joan Y. Howard
SUBJECT:	An estimate of the benefits likely to accrue to the urban planning process in the Washington metropolitan area in comparison with traditional data collection techniques and discussion of remote sensing system requirements.
DATE:	January 1972
CONTRACTOR:	Metropolitan Washington Council of Governments
CONTRACT NUMBER:	14-08-0001-12708
SPONSORING AGENCY:	U.S. Geological Survey, U.S. Department of the Interior
NUMBER OF PAGES:	40
NUMBER OF TABLES:	4
ABSTRACT:	The benefits of utilizing remote sensor data in the urban planning process of the Metropolitan Washington Council of Governments are investigated, including an evaluation of sensor requirements, a description/comparison of costs, benefits, levels of accuracy, ease of attainment and frequency of update possible using sensor versus traditional data acquisition techniques.

BENEFITS FROM REMOTE SENSING DATA
UTILIZATION IN URBAN PLANNING PROCESSES
AND SYSTEM RECOMMENDATIONS

CONTENTS

LIST OF TABLES

1. INTRODUCTION

This study, one of a series of eight, has been prepared on the results of research of remote sensor applications to the planning program information needs of the Metropolitan Washington Council of Governments (MWCOG). The Project has been supported by the Geographic Applications Program of the U.S. Geological Survey.

Specific applications of remote sensing to the programs of the MWCOG have been discussed in previous reports. These have covered the following applications in various degrees of detail: land use, urban change detection, housing, transportation, natural features, thematic map up-date, sedimentation, pollution, regional photo research, training, and other uses. In particular, Technical Report No. 5, entitled, An Evaluation of Applications of Remote Sensing Data to Metropolitan Washington Council of Governments' Planning Requirements, discussed the above in a broad summary of tested and proposed remote sensing data uses.

This report is designed to expand that discussion by exploring further those specific programs of the Council of Governments for which remote sensors can supply data and by discussing whether it is technically feasible and economically justifiable to do so. By comparing costs and benefits of utilizing remote sensor data with traditional data acquisition techniques, this report hopes to indicate how and where remote sensing can make an important contribution to the activities of the Metropolitan Washington Council of Governments.

It is important to realize that more than cost comparisons alone be considered in decisions regarding remote sensing utilization.

Reduced costs, though significant, are only one way of measuring its contributions to the tasks of data acquisition; other factors and contributions must be considered. In general, there appear to be five possible areas of contributions which remote sensing could make to the data needs of the Council of Governments. These are:

1) more precise and therefore more useful data,
2) easier update and therefore better knowledge of change,
3) verification of current data base,
4) a source of data otherwise unavailable,
5) a less costly means of obtaining data.

We believe that any one of the first four contributions above might outweigh the cost considerations involved and be of sufficient justification for recommending acquisition and/or use of remote sensor data. This report points out where some of these contributions would be relevant within this region.

2. APPLICATIONS

A general summary of possible applications of remote sensing to regional planning needs was given in Table 1 shown in this Project's Technical Report No. 5, entitled, An Evalution of Applications of Remote Sensing Data to the Metropolitan Washington Council of Governments' Planning Requirements. That Table will provide the basis for discussion in this report and is accordingly reproduced (p.4).

Some of the applications listed in Table 1 would provide data that are not necessarily needed as direct inputs for COG programs, either because the data are obtainable by other means or because the information that remote sensing can provide may not necessarily be pertinent to specific and current tasks at hand.

For example, the geology and soils of the metropolitan area have previously been mapped. While the basic underlying geologic structures are less subject to change, the surficial characteristics are relatively more dynamic, and the available data on which are constantly changing. In addition, because of the growing urbanization of the region, more detailed data on soils, clay formations, sand and gravel deposits, soil erosion, slope surveys and so on are needed. To supplement ground surveys, a variety of remote sensors, including side-looking radar, could be utilized for data acquisition for updating purposes as well as for preparing more detailed geologic maps. The question though, is one of cost-effectiveness. Would it be cost-effective to plan remote sensing missions solely to support this type of information need? Obviously it would not, and certainly not to the Council of Govern-

TABLE I

LIST OF APPLICATIONS OF REMOTE SENSING TO REGIONAL URBAN PLANNING

Areas of Data of Interest to COG	Applications
Natural Features	Geology, soils, slope, flood plains, natural resource deposits, soil moisture.
Transportation	Traffic volume, patterns, movement, and routing, parking and terminal facilities, effect of safety improvements, siting, mapping, synoptic overview.
Land Use	Improvements of land use data in Council of Governments' parcel file, monitoring areas of change and special interest, updating of regional land use maps, historical growth, siting.
Flood	Flood plains, imperviousness, soil moisture, snow cover, runoff retention monitoring, surface water.
Sedimentation	Location and monitoring sources, transport mechanisms, deposition patterns.
Pollution	Monitor water pollution discharges, water temperature and turbidity, oil spills, and fish kills, study transport and deposition patterns, locate of air pollution sources, survey air pollution dispersion, study effluent characteristics, monitor treatment plants.

TABLE I

LIST OF APPLICATIONS OF REMOTE SENSING TO REGIONAL URBAN PLANNING

Areas of Data of Interest to COG	Applications
Housing	Identification of housing stock, location, type and structural character. Detection of environmental conditions suggesting quality and condition of housing and neighborhoods.
Miscellaneous	Siting, training, public safety, and aerial photographic availability.

ments. However, as a by-product or as an additional element in a larger coordinated data acquisition effort, the data obtained there may become cost-effective.

This would be the case for many of the applications discussed in this report. By themselves, they frequently do not justify the costs required to obtain the data. However, by coordinating data needs of several analytical programs, the costs of each may be sufficiently reduced to make the collection of data by remote sensing an efficient tool. This approach, of course, reinforces the concept of the cost-effectiveness of multi-disciplinary uses of remote sensing source information in area-wide applications.

In support of any single dimension of data need, the requirements and priority for the data must be the determinant and deciding factor in the acquisition and analysis of the remote sensing information. In such instances, the data required must not likely be available from any other sources and the need for it overriding. Such an example might be a synoptic overview of the entire region or city or county or other facet of the region's activity at any one point in time.

This section of the report continues the examination of those remote sensor applications in which members of the Council of Governments' staff expressed an interest as possible sources of data. It is designed to pinpoint better and more sharply the data which remote sensing could provide for various identified programs of COG.

Attention is now invited to Table 2 which provides in tabular arrangement, a series of applications interrelated with specific

TABLE 2

POSSIBLE BENEFICIAL USES OF REMOTE SENSOR DATA

Application	Program Applicable	Status of the Program	Importance of Data to the Program	Benefits of Using Remote Sensor Data	Current Data Source
1) Improvement of parcel file - locate and assign vacant land.	Improvement of data base	On-going	Would improve base upon which numerous MWCOG programs rest.	Provide improved data base. Verification of current data base.	Local public land records.
2) Regional land use mapping	Regional planning transportation planning	On-going	Basic input to program	Provides easier update. Visual presentation	Parcel file
3) Land use change mapping	Year 2000 Plan	On-going	Proved a visual picture of change and number of acres consumed by development each year. Would demonstrate how area is developing.	A type of data unavailable otherwise.	From local jurisdictions.
4) Update of regional map series	Most of MWCOG's programs	On-going	Provides input and visual display of several categories of data.	Provide easier updata and perhaps, therefore, less cost. Synoptic overview.	Aerial photography and field surveys.
5) Monitoring areas of special interest. a. areas of environment quality - designated areas of open space. b. floodplains c. steep slopes d. marshland	Open Space Program Regional Plan	On-going	Provide a means of following encroachment on these areas and possibly indicate need for further controls or action.	Would provide a relatively easy method of following change.	Not gathered as such on these areas.

TABLE 2

POSSIBLE BENEFICIAL USES OF REMOTE SENSOR DATA

Application	Program Applicable	Status of the Program	Importance of Data to the Program	Benefits of Using Remote Sensor Data	Current Data Source
6) Location of natural resources	Natural Features Study	Completed	Could provide additional knowledge on the location of resource deposits in the metropolitan area and thus, areas to leave undeveloped.	Provide data otherwise unavailable.	Geologic mapping
7) Mapping of additional geolofic features	Natural Features Sutdy	Completed	Could provide additional information on the geology of the area.	Provide data otherwise unavailable.	Geologic mapping.
8) Determine average speed over given transportation routes.	Maintaining levels of transportation service	On-going	Necessary input to program	Provide easier updata and possibly a less costly means of data collection.	Driving over the routes several times
9) Traffic behavior and patterns	Maintaining levels of transportation service	On-going	Would provide knowledge of behavior on which to base traffic controls.	Provide more precise data, data that is otherwise unavailable and possibly data at a reduced cost.	Not currently being collected
10) Turning movement counts at intersections	Maintaining levels of transportation service.	On-going	Supplementary input	Provide more precise data and possibly at a reduced cost.	Counting by several people at the intersection
11) Parking inventories. a. public parking (primarily outside of DC)	Maintaining levels of transportation service	Data for program currently unavailable	Data necessary for listed studies aimed at improving parking facilities.	Provide data otherwise unavailable.	Not currently gathered.

TABLE 2

POSSIBLE BENEFICIAL USES OF REMOTE SENSOR DATA

Application	Program Applicable	Status of the Program	Importance of Data to the Program	Benefits of Using Remote Sensor Data	Current Data Source
11) b. on-street parking c. shopping centers d. density mapping by time of day.					
12) Examination of terminal facilities	Maintaining levels of transportation planning	On-going	Provide data on efficiency of facilities	Possibly reduce costs by providing a synoptic overview.	Field surveys
13) Site selection	Solid-waste disposal; recreation and transportation planning	On-going	An occassional need of information for site selection.	A convenience if imagery is readily available	Variety of sources.
14) Locate and count new dwelling units	Origin-destination Study. Maintaining transportation service	On-going	Used to update origin-destination study as a basis for telephone interviews.	Possibly a less costly means of obtaining data. More accurate data.	Annual parcel file and possibly building permit file.
15) Determine floor space and building density, particularly of employment areas	Origin-destination	On-going	A primary input	Provide data which is currently difficult to obtain	Home Interview Survey

TABLE 2

POSSIBLE BENEFICIAL USES OF REMOTE SENSOR DATA

Application	Program Applicable	Status of the Program	Importance of Data to the Program	Benefits of Using Remote Sensor Data	Current Data Source
16) Measure impervious surface areas	Storm-Water Runoff Model	On-going	A specified input to the model	Provide a more precise and current means of obtaining data for specific task at hand.	Federal, State, or local studies, if applicable
17) Measurement of total length of gutters.	Storm-Water Runoff Model	On-going	A specified input to the model	Provide more precise data	Not currently gathered
18) Surface area of catchment basins	Storm Management Model	On-going	Provides input to model	Could provide more current data	Available from large scale topographic maps
19) Runoff retention monitoring	Storm-Water Runoff control	Future program	Could serve as an enforcement tool to control retention of runoff.	Provide data otherwise unavailable	Not currently gathered
20) Monitoring exposed soils	Sedimentation control	Future program	Could serve as an enforcement tool to control sedimentation	Provide data otherwise unavailable	Not currently gathered
21) Location of polluters	Estuary Model	On-going	Knowledge of pollutors is needed as an input. (The large polluters are, for the part, monitored on the ground.	Provide data otherwise unavailable. Pinpoint sources.	Registered pollutant sources. None on unidentified sources

TABLE 2

POSSIBLE BENEFICIAL USES OF REMOTE SENSOR DATA

Application	Program Applicable	Status of the Program	Importance of Data to the Program	Benefits of Using Remote Sensor Data	Current Data Source
22) Determining deposition patterns	Estuary Model	On-going	Provide additional information on the estuary.	Provide data otherwise unavailable	Not generally available
23) Monitor treatment plants	Insuring proper operation of treatment facilities	Future	Insuring proper operating of treatment facilities	Possibly provide less costly data.	Field checking
24) Air pollution mapping and monitoring	Pollution control	Future	Would provide data on dispersal of air pollution	Provide data difficult to obtain	Air sampling
25) Housing and Neighborhood quaility analysis	Housing stock	On-going	Need for identifying substandard housing	Possibly a less costly means of acquiring data	Census data
26) General region-wide planning and synoptic overview	All programs	On-going and future	Provides simultaneous data record of many interrelated activities within the region	Provides data otherwise not available	None

COG planning programs, their current status, data gaps, estimates of beneficial uses, and exisiting data acquisition sources. Some of the applications discussed in this report and listed in Table 2 would prove to be more valuable and pertinent to MWCOG's data needs than others. Some of these are discussed in the following.

The value of the first application mentioned in Table 2 — improvement of the COG parcel file — cannot be over emphasized. The parcel file as a data base provides information support for a wide variety of programs throughout COG, in particular the Empiric Activity Allocation Model which is used to forecast residential and employment locations for future years. Any menas of improving the data within the parcel file would serve to make the programs, which rely on it, more realistic and useful. The results of the remote sensor data inputs, especially with regard to land use, might also demonstrate to local jurisdictions how much their data bases need improvement and would encourage the argument of computerization of those data files which are still manual.

The regional land use map and land use change map, mentioned as items #2 and #3 in Table 2, would provide important inputs to regional and transportation planning programs as well as to visual pictures of the development of the region. A picture might be worth a thousand words, but it might also evoke a better understanding of the state of the region.

The contributions remote sensing can make to transportation planning studies are perhaps the more numerous. Some of the data are currently available by conventional survey means; however, by planning a coordinated remote sensing program, the costs may be sufficiently reduced to make remote sensing a cost-effective and often a more accurate means of data gathering, as will be discussed below. One area of data which is currently hard to obtain is vehicle parking information. Remote sensing can readily provide this information on parking both a long streets and in open parking lots. In addition, the synoptic overview of terminal facilities showing parking areas, interrelated routes and other facilities, and, if viewed sequentially, makes this kind of data source very attractive.

Item No. 15 in Table 2 is another important input to COG programs. Data on employment has been consistently difficult to obtain. The only consistent, comprehensive, and region-wide means of gathering the data has been the Home Interview Survey, which is costly and time consuming. By determining from remote sensing measurements, the amount of floor space devoted to commercial, industrial, government, and other land useage, employment figures based upon occupancy factors (employee per square foot ratios) could be estimated to provide the required data.

Measurement of the percent of impervious land, item #16, color infrared imagery has already proved successful, as has been discussed elsewhere during this project, particularly when done in conjunction with automated digital density scanning systems. This method relying upon an instrument which scans the different photo image densities between background and subject being analyzed is recommended for other similar uses.

A rather promising program, although presently not planned for, would be the monitoring of exposed soils (item #20 Table 2). The importance of controlling sediment runoff is not yet universally recognized, nor controlled, however, several local jurisdictions and the staff of COG are presently greatly concerned with the problem. The soil which continues to be washed into our waterways is both a waste of soil and a water pollutant. Monitoring with remote sensors could identify and keep track of areas where soils have been exposed. Jurisdictions with ordinances for limiting the periods of time that these areas are left exposed, could be readily supported by this type of information, graphically presented. Imagery could also be used to evaluate different watershed treatment techniques.

The data benefits and value provided by some of these examples of applications provide sufficient justification by themselves in the opinion of the authors, to use remote sensors for information gathering. Others, as mentioned previously would best be collected under a coordinated effort to make their utilization by remote sensors more feasible.

3. SENSOR REQUIREMENTS

The sensor requirements, scale and resolution needs, frequency of coverage, size of the area to be covered, altitude, focal lengths, etc., are the major factors determining the cost and the relative ease of acquiring remote sensing data. To illustrate in a consolidated listing, the technical requirements and specifications corresponding to the applications previously discussed, Table 3 has been prepared.

As will be evident from an examination of Table 3, there are many applications which share similar technical requirements and specifications and some others which are unique in their requirements. Common to most of the applications is the usefulness of black and white, color, and color infrared imagery, often at medium or small scales. This imagery, fortunately, is the most readily obtainable, since it is the type which most government agencies acquire for their own use, (the latter two in increasing amounts), and which aerial survey organizations are readily able to provide. Others, such as side-looking radar, thermal infrared, and multi-spectral imagery require special instrumentation and installations. Some of the applications, those with similar sensor and scale requirements, can be combined to develop workable flight plans addressed to meeting data requirements for other applications. Those data needs necessitating fairly large scale imagery, however, are generally limited to providing data for the specific application under investigation, and frequently involve "close-look" or relatively small geographic areas. Requirements for this type of sensor coverage, however, have frequently been based upon previous examination of smaller scale, larger area photo surveys.

Reference to the listings in Table 3, when used in conjunction with the applications listed in Table 2, should provide guidance and summary data for possible use for remote sensing mission planning purposes.

TABLE 3

TECHNICAL REQUIREMENTS

Applications	Desireable Sensors	Wavelength ** (microns- μ)	Scale *	Frequency of Coverage	Ease of Attainment and Interpretation
1) Improvement of parcel file	Black and White Color infrared Color	0.4 - 0.7	1:50,000	Annually	Imagery obtainable; interpretation and measurement time consuming.
2) Regional land use mapping	Black and White Color Infrared Color	0.4 - 0.7 0.5 - 1.0	1:300,000	Annually	Imagery obtainable interpretation and measurement time consuming.
3) Land use change mapping	Black and White Color infrared Color	0.4 - 0.7 0.5 - 1.0	1:100,000	Annually	Imagery obtainable; interpretation relatively rapid.
4) Update of regional map series	Black and White Color	0.4 - 0.5 0.4 - 0.7	1:100,000	Annually	Imagery obtainable; interpretation and measurement time consuming.
5) Monitoring areas of special interest			1:25,000 - 1:500,000	Annually	Imagery obtainable; interpretation relatively rapid.
a. open space	Black and White Color infrared	0.4 - 0.7 0.5 - 1.0			
b. flood plains	Black and White Color Infrared	0.4 - 0.7 0.5 - 1.0			
c. steep slopes	Black and White	0.4 - 0.7			
d. marshland	Black and White Color infrared Color Multispectral	0.4 - 0.7 0.5 - 1.0 0.4 - 0.7 0.4 - 1.0			

TABLE 3

TECHNICAL REQUIREMENTS

Applications	Desireable Sensors	Wavelength ** (microns - μ)	Scale *	Frequency of Coverage	Ease of Attainment and Interpretation
6) Location of natural resources	Black and White Color Color infrared Geophysical instruments (airborne and ground-based)	0.4 - 0.7 0.4 - 0.7 0.5 - 1.0	1:20,000 - 1:1,000,000	Infrequently	Imagery obtainable; special instrumentation not common in local applications. Interpretation by geologists.
7) Mapping additional geologic features	Black and White Color Color infrared Thermal infrared Side-looking radar	0.4 - 0.7 0.4 - 0.7 0.5 - 1.0 8 - 14 5 - 100 cm.	1:20,000 - 1:1,000,000	Infrequently	Scale and format of sensor not always compatible with other sensors interpretation by geologists.
8) Determine average speed over given routes	Black and White	0.4 - 0.7	1:10,000 - 1:15,000	Every 5 years	Imagery obtainable, interpretation fairly straight forward.
9) Traffic behavior and patterns	Black and White Color Thermal infrared	0.4 - 0.7 0.4 - 0.7 8 - 14	1:10,000	As needed	Time lapse imagery. Interpretation could be aided by automated counting.
10) Turning movement Counts at intersections	Black and White Color	0.4 - 0.7 0.4 - 0.7	1:20,000	As needed	Imagery readily obtained counting fairly

TABLE 3

TECHNICAL REQUIREMENTS

Applications	Desireable Sensors	Wavelength ** (microns - μ)	Scale *	Frequency of Coverage	Ease of Attainment and Interpretation
11) Parking inventories a) public parking b) on-street parking c) shopping centers	Black and White Color	0.4 - 0.7 0.4 - 0.7	1:30,000	At different times of the day - once a quarter	Imagery and interpretation readily obtained
12) Examination of terminal facilities	Black and White	0.4 - 0.7	1:30,000	Semi-annually	Imagery and interpretation readily obtained
13) Site location	Black and White Color	0.4 - 0.7 0.4 - 0.7	Variable	As required	Make use of available imagery
14) Location and count of new dwelling units	Black and White	0.4 - 0.7	1:100,000	Annually	Imagery obtainable; interpretation fairly rapid.
15) Determine floor space and building density	Black and White	0.4 - 0.7	1:25,000	Annually	Imagery obrainable; interpretation and measurement would require training in techniques.
16) Measure impervious surface areas	Black and white Color infrared	0.4 - 0.7 0.5 - 1.0	1:50,000	Once	Easily obtained and measured

TABLE 3

TECHNICAL REQUIREMENTS

Applications	Desireable Sensors	Wavelength ** (microns - μ)	Scale *	Frequency of Coverage	Ease of Attainment and Interpretation
17) Length of gutters	Black and White	0.4 - 0.7	1:50,000	Once	Easily obtained and measured
18) Surface area of catchment reservoirs	Black and White Color infrared Side-looking radar	0.4 - 0.7 0.5 - 1.0 5 - 100 cm.	1:50,000	Once	Easily obtained and measured Training needed for SLAR interpretation
19) Run-off retention monitoring	Black and White Black and White IR	0.4 - 0.7 0.4 - 0.9	1:20,000	As required	"Spot"coverage for monitorship
20) Monitoring exposed soils	Black and White	0.4 - 0.7	1:50,000- 1:100,000	Monthly or bimonthly	Imagery obtainable, interpretation rapid.
21) Location of polluters	Black and White Color infrared Multispectral Thermal IR	0.4 - 0.7 0.5 - 1.0 0.4 - 1.0 8 - 14	1:30,000- 1:1,000,000	As required	Variety of imagery needed; identification and location not difficult.
22) Determining deposition pattern	Black and White Color Multispectral	0.4 - 0.7 0.4 - 0.7 0.4 - 1.0	1:15,000- 1:1,000,000	As required	Timing of data acquisition critical (turbulence undesirable). Instrumented imagery analysis desireable.
23) Monitor treatment plants	Black and White Color Infrared Multispectral	0.4 - 0.7 0.5 - 1.0 0.4 - 1.0	1:10,000	As required	"Spot" coverage desired. Requires correlation with local ground data.

TABLE 3

TECHNICAL REQUIREMENTS

Applications	Desireable Sensors	Wavelength** (microns-μ)	Scale *	Frequency of Coverage	Ease of Attainment and Interpretation
24) Air pollution monitoring and mapping	Black and White Color Multispectral	0.4 - 0.7 0.4 - 0.7 0.4 - 1.0	1:75,000 - 1:1,000,000	As required	Imagery available. Instrumental imagery analysis desireable.
25) Housing and neighborhood condition	Black and White Color infrared Color	0.4 - 0.7 0.5 - 1.0 0.4 - 0.7	1:4,000	Annually	Large scale imagery nneded; analysis based upon indirect indicators.
26) General region-wide planning and synoptic overview	Multispectral	0.4 - 1.0	1:1,000,000	Maximum every 18 days; minimum annually	Imagery to be available from NASA Earth Resources Technology Satellite (ERTS-A) and Pre-ERTS high-altitude aircraft programs.

* Scale values for any imagery analysis are, of course, variable, and are task and experience oriented. Differing scales, larger and snaller, in nearly all cases could be adequate for analysis - image contrast, resolution, and subject activity all considered.

** Wavelengths are given in microns (μ). One micron equals 10^{-4} cm.

4. COST-BENEFIT COMPARISONS

There are several types of costs involved in gathering data with remote sensors, which are perhaps somewhat different than those of other means of collecting data. Primarily, they include the cost of imagery acquisition and of imagery interpretation and analysis. The last usually involves putting the data in a form compatible with other information systems.

The cost of imagery acquisition for the user can vary widely since there are two sources regularly engaged in gathering it; public and private. The federal government flies or contracts for a great deal of domestic aerial photographic imagery for its own uses and is often able to supply this imagery to individuals or organizations at relatively low costs or, in certain circumstances, at no cost.

It has been estimated that it costs the U.S. Department of Agriculture and the U.S. Geological Survey Map Information Office an average of between $2.00 - 4.00 per square mile to contract to have imagery flown at about 1:20,000. The imagery is available to the public at $1.75 per 9x9 inch black and white photo print. This amounts to only about $.22 per square mile to the individual purchaser. In contrast to this, local private companies which fly photographic missions on contract to government or other private organizations usually make these photographs available to the general public after they have served their initial purposes. Prices generally run from $10.00 to $15.00 per print for the same size and type photo (9x9 inches) on black and white paper). Both sources operate sliding price scales which favor quantity purchases.

Under special and controlled circumstances certain U.S. Government imagery could be made available to the Metropolitan Washington Council of Governments without charge. For example, imagery flown under the auspices of the NASA Earth Resources Aircraft Program is provided for specific investigators who are conducting specific scientific and technical research on imagery and natural resource relationships. These photo missions are flown by a variety of aircraft within the NASA program with sophisticated imaging and data recording instrumentation abroad. The missions are approved after a lengthly, yet orderly, review and justification process, and upon accomplishment, require systematic and periodic reporting to NASA and the supporting scientific disciplines as to progress of the research and the results obtained. Aircraft flown imagery may also be obtained under similarly controlled conditions from the U.S. Geological Survey. In this instance, the contractural arrangements between the U.S.G.S. and the MWCOG provided, on a loan basis, photographic coverage of much of this region for performance of work on this current project.

Imagery from the Earth Resources Technological Satellite Program (ERTS-A) would also be available either directly from NASA or through the U.S. Geological Survey EROS Program. This imagery would be made available providing similar mutually supporting and specific work arrangements (contractural or otherwise) are in effect. Otherwise this imagery would become subsequently available on a purchase basis through the U.S.G.S. EROS Program. Data availability and cost data related to that program are still in process of development. All efforts therefore during the early phase of MWCOG's investigations of remote sensing applicability data should be made to maximize the availability of data through these sources, recognizing the necessity that user research efforts be oriented largely in the direction of eventual earth resources satellite data applications (ERTS-A and follow-on systems). The aircraft imagery; however, will be generally of medium to small scale, though of extremely high quality. The ERTS-A imagery will be of very small scale, but will have enlargement capabilities.

The imagery available for public sale at the U.S. Department of Agriculture and the Map Information Office of the U.S.G.S. is of high quality and of variable scales, much at 1:20,000. It is readily available, and could be used for supplemental analytical purposes. The National Oceanographic and Atmospheric Administration also flies larger scale imagery for its charting programs and other requirements. This source also makes its photography available to the public at prices similar to those of the two above mentioned agencies. These data could also be utilized for specific analytical purposes.

Large scale imagery for specific analytical tasks would most likely have to be obtained from private commercial aerial photographic firms, unless the required data were not available from the above sources. The costs would vary from firm to firm, and of course, are dependent upon the size of the area to be covered, the scale of the imagery, and the types of aircraft and sensors used. The costs per square mile generally are reduced as the size of the area to be surveyed increases. However, as the required scale increases, say from 1:2400 to 1:1200 (it would be necessary to fly at half the altitude with the same camera aboard) the cost could more than double since the number of photographs taken would substantially increase . Flying costs are variable and, as stated, are negotiable. For example, one series of photo missions flown on a contract basis by a local aerial survey organization would cost roughly $10 per square mile for a total of 200,000 square miles. Another aerial survey type project covering about 400 square miles in the local area at a scale of 1:12,000 would cost an estimated $3000-$4000. Still another set of figures provide a yardstick for a different and smaller task. A mission covering about 50 different sites of interest within the metropolitan area flown with a 9X9 inch frame camera would cost an estimated $1800 (black and white prints). Assuming the flight was flown at 10,000 feet, using a 6" focal length lens (scale of 1:20,000), the cost would factor out to be about five dollars per square mile. When color or color infrared films are flown, the costs of film processing and reproduction will be somewhat higher than for the black and white film. For many applications discussed in this report, information requirements may adequately be met by black and white imagery. In the specialized cases where unique reflectance characteristics are needed, say to monitor pollutants or vegetative variations, color, color infrared and other sensors are recommended.

In order to gather information, for example, on vehicle traffic turning movements at intersections, the current procedure is to have people placed at the intersections to count the turning vehicles.

The number of counters used varies with the size of the intersection. It could vary to one per lane, although the usual number is between two and four. An average would probably be 2 - 4 man-hours per intersection at a cost of $8.00 - $20.00 per intersection.

To acquire these data from the air, a helicopter could be employed to hover over the intersections under investigation. The current costs of using a two-passenger helicopter on an hourly basis vary from $85 to $95 per hour. Daily, weekly, and monthly rates are also available with decreasing hourly costs. Using the per hour cost, and if imagery were obtained from a single helicopter on a two-hour mission hovering simultaneously over 4 - 10 intersections (the number based on the complexity of the intersection) this method of acquiring the data would be on par with the conventional ground-based method. Using an RC-8 camera with a 6" focal length lens and hovering at a 6000' altitude, would cover an area of better than 3 square miles of city blocks on one frame of 9X9 inch photography. Advantages include being more exact and providing a permanent record of the data. Additional charges would include the costs of a camera and film processing. Therefore, it would seem appropriate to plan for optimizing a balanced mix of areas, numbers of intersections or other activity points to be covered to make this application cost-effective.

A primary cost of acquiring data by remote sensors, at least for the Council of Governments, would be in the interpretation of the imagery. This would of course vary from application to application because of the different types of data and analysis needed.

In some cases, it involves merely measurement or counting of items being analyzed, such as buildings, cars, the percent of impervious surface areas, or traffic movements at intersections, and so on. For others, the interpretation requires more detailed and intuitive analysis and involves, for example, identification of land use or condition of a neighborhood. Since this latter type of interpretation requires the most detailed analysis - it being inventory work in nature - it is generally the most time consuming. Another type of interpretation is analysis of change, which is basically a comparison of two sets of time-separated imagery, and therefore, is relatively more rapid. Still another is identification of pollutant sources and flow. This also is relatively rapid.

Because of the differences in interpretation time among different applications and work tasks involved and the fact that little concrete analytical work data is available on them, it is difficult to be too specific about man-hour costs. In a general way, Table 3 presents some data on relative interpretation ease and corresponding time requirements. The bulk of anticipated imagery analysis and interpretations on MWCOG tasks is judged to be of a manual nature, however, in several instances, these skills may be measureably augmented and accelerated by automated techniques.

To present some idea of interpretation costs, at least for one or two limited applications, some man-hour data on task-oriented imagery analysis within this project are available and might be useful. A photo image-derived land use identification analysis, which involved categorization of land useage from medium scale imagery (1:14,000 - 1:50,000), measurement of the areas of land use, and comparison of the findings with data from the MWCOG parcel file and the Census required about 430 man-hours of work. This involved a detailed inventorying of land use within 18 census tracts comprising an aggregate area of 46,521 acres or about 73 square miles in metropolitan portions of Virginia. Considering the analysts' salaries for the work period, a cost of about $50 per square mile may be derived. Since this was an initial and experimental program, and also because the measurements were all done manually, this cost figure is undoubtably high, and would be subject to improvement on a regular work routine basis. A land use change analysis was also undertaken as part of the project and the figures for this task were somewhat different. On a similar basis, by comparing area analyzed and analyst's salary, it was estimated that by extrapolation, 1000-1500 man hours would be needed to identify and measure change in the Washington metropolitan area (excluding Prince William and Loudoun counties). This estimate amounted to about $2.80 - $4.30 per square mile. Out-of-pocket costs for imagery acquisition are not included because the photography was provided on loan by the Government to conduct this research.

The data from the remote sensing analysis in the land use study is believed to represent an example of a cost-effective application. While basic detailed land use inventorying represents a relatively time consuming analytical operation, the value of the data obtained, with its uniform and large area coverage, is such that it either supplements and corrects existing data or else is not available from other sources. In addition, the graphic character of the source material readily lends itself to standardized pictorial, publishable presentations.

Cost comparisons which this report would discuss next are those pertaining to applications whose benefits suggest a reduction of the cost of gathering the data. Unfortunately specific cost figures are not readily available for all of the applications either for current data collection methods or by remote sensing interpretation. However, an attempt will be made to discuss the likelihood of cost savings for some of these applications.

Aerial photography and field surveys are currently used to update the Council of Governments' regional map series and it is hoped that they continue to be. However, cost-saving may be realized in the future by using synoptic small scale imagery from the ERTS-A and follow-on subsequent satellite programs. Not only would fewer photographs be required by the coverage, which will be quite frequent, but repetetive data will be provided to update the series more often. By using satellite imagery, for large area surveys and change and growth detection, the costs of acquiring the imagery should be relatively small. These factors, particularly the increased frequency of regional coverage, would make the surveys more effective.

Transportation surveys are an area where remote sensing can probably provide several cost savings. The possibility of using helicopter photography for gathering intersection turning counts has been previously discussed in this report, but other traffic behavior studies would also possibly benefit from remote sensing information.

In regard to terminal facility studies, it seems likely that remote sensing can provide data at reduced costs. The current method of collecting data on the use and efficiency of a terminal, such as Washington National Airport, is to undertake a field survey, of the facility. This invariably involves a large man hour expenditure. By taking periodic, or even single photographs of a terminal facility at some stipulated time, remote sensing can provide similar data. (A set of stereo pairs flown by local survey organizations) Such imagery would cost about $130. Another approach, if current photo coverage were not vital to the survey, would involve imagery obtained, possibly on a loan basis (if available) or by appropriate low cost purchase from government sources. The major investment would, in this instance, represent image analysis time for counting vehicles, which would be relatively rapid.

Measuring vehicle traffic speeds along specific routes during rush- hour traffic is presently accomplished by placing survey vehicles in the traffic streams. Acquiring this type of data by remote sensing may possibly not be cost-effective unless it were possible to plan to survey several other traffic activities at the same time.

Locating new dwelling units in the region is a task which remote sensing can readily accomplish with considerable accuracy. In fact, it is an extension of land use change analysis, but the interpretation would take less time. The imagery analysis costs would probably be on a par with the change analysis data ($2 - $4 per square mile). Additional analysis time would be required to relate the new housing units to some locational reference base - such as a grid coordinate system or street address as currently used in the MWCOG parcel file. These addresses would be needed for compatibility with similar data from local record sources as well as for follow-up addressing requirements for postal interview studies.

Monitoring the outflow and/or operating status of treatment plants in the region on a regular interjurisdictional surveillance basis by aircraft-borne remote sensors, would probably not prove to be sufficiently cost-effective for any one single regional organization to absorb the costs. There are about 10 water treatment plants and about 75 sewage treatment plants at various locations within the approximately 2400 square miles of the region. Large scale imagery (1:15,000 or better) would be best suited for status monitoring with a frequent coverage schedule. Since government imagery would probably not be available on this basis, and since the scale and resolution requirements would probably preclude ERTS-A data use (at least initially until the full capabilities of the multispectral imagery has been assessed - the frequency cycle would be ideal, though not random), the chances are that acquisition of commercially flown photography would have to be considered. As was described earlier, a selection of some fifty sites within the region could be flown commercially for $1800 to $2400, respectively, with black and white or color infrared film. Of the 85 combined water and sewage treatment plants, a selection of fifty could be made on a priority basis to design a pattern of changing coverage to insure that once-over coverage of all 85 on some acceptable frequency basis. An alternative approach would be to combine the coverage requirements with other applications having similar technical requirements, thus increasing the overall data content per mission. Two such additional applications might be water run-off retention monitorship and housing and neighborhood quality investigations. By itself, except for specific small-area imagery, monitoring of run-off retention areas on a region-wide basis might not be cost-effective either. At the present time, only Montgomery County has roof-ponding regulations, so, should combined data acquisition be planned, the only treatment plants that would be monitored in that context would be those in Montgomery County. As still another approach, such a data acquisition effort could be operated on a contingency or "as required" basis for random checking, neighborhood surveys, and/or for coverage of spills, overflows, outfalls, etc. as they would occur. Initially this might prove to the the best local way to do this kind of a job. Even from a casual view of the many different types of information need, it must be increasingly evident that one single, sure way to acquire as much imagery on as many activities as possible in such a region as this, is through the medium of frequent, large area synoptic coverage with acceptable subject resolution.

Some of the applications mentioned in this report are cost-effective since they can draw their data from imagery currently available at the Metropolitan Washington Council of Governments or readily obtainable from other sources. Interpretation would require merely measurements of lengths or areas of the particular category of interest, or counts of specific objects. These measurements could be performed manually or with the aid of automated measurement techniques. The applications referred to here would include measurement of impervious surface areas, length of curbing or gutters, and surface areas of catchment reservoirs, all of which are important inputs to the Storm Water Management Model. Others support current data needs for transportation planning studies, and for identifying new activities, events, or for monitoring other visible regional phenomona.

As this section of the report has indicated, cost, as well as the cost-effectiveness of the applications vary widely. For some, remote sensing can provide less expensive data than conventional data collection methods, while for others remote sensing data is more costly. However, as was pointed out in the Introduction of this report, cost alone is not necessarily the determining factor in assessing the effectiveness of these applications of remote sensing. As in any data systems analysis, the practicability of using remote sensors to gather urban planning data is basically determined by a combination of the costs required and the specific benefits to be derived.

5. CONCLUSIONS and RECOMMENDATIONS

The conclusions of this study basically constitute a series of recommendations for the use of remote sensing data to aid the MWCOG's data collection and analysis tasks. Naturally, as has been seen, some of the proposed applications of remote sensing provide more useful data or more cost-effective data than others. The relative merits of each of the applications developed and presented in this report are summarized in Table 4. Each application has been accorded an index number (on a 1 to 5 scale) of relative importance for possible use.

Of course, several of these applications can be derived from analysis of the same set of imagery, and it is suggested that this approach be used whenever possible. Combining programs would contribute to a reduction of the final unit costs of obtaining the data. Careful mission planning should insure that multi-informational data needs of such an organization as the MWCOG be adequately and economically planned for.

It is also suggested that the MWCOG maintain its current relationships with the Geographic Applications and the EROS Programs of the U.S. Geological Survey and also with NASA. Furthermore, as additional experience is gained and more cost data are compiled, it will be possible to demonstrate more completely those expected and additional areas of remote sensor application. From this experience it should also be possible to make further recommendations for continuing the research for developing operational applications, thus warranting a gradual routinization of planning and budgeting for remote sensing data use in the Metropolitan Washington

Council of Governments regular planning programs.

TABLE 4

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

APPLICATION	CONCLUSIONS and RECOMMENDATIONS	IMPORTANCE INDEX *
1) Improvement of parcel file	Recommended for initiation now. The importance of the data provided outweighs the costs.	1
2) Regional land use mapping	Recommended for now and repeated coverage in future years. Relatively inexpensive. Possibility for use of USGS prepared map should be investigated.	2
3) Land use change mapping	Recommended annually to indicate development of the region, graphic presentation. Could be utilized between available land use maps. Relatively inexpensive.	2
4) Update of regional map series	Merely provide an expansion and improvement of current usage of aerial photography.	2
5) Monitoring areas of special interest	Can be undertaken in conjunction with land use change mapping.	2
6) Location of natural resources	Suggested as a byproduct of any other planned regional flight to provide data otherwise unavailable.	5
7) Mapping additional geologic features	Suggested for incorporation into an existing small scale flight plan.	5
8) Determine average speed over given routes	Not recommended	5

TABLE 4

APPLICATION	CONCLUSIONS AND RECOMMENDATIONS	IMPORTANCE INDEX *
9) Traffic behavior and patterns	Would provide quality and quanity of data not provided by conventional means.	1
10) Turning movements at intersections	Provides data at a reduced cost	2
11) Parking inventories	Provides data otherwise unavailable	2
12) Examination of terminal facilities	Costs are relatively low regardless of where imagery is acquired. Use of available imagery is suggested.	2
13) Site Selection	A convenience provided by available imagery.	NA
14) Location and count of new dwelling units	Can provide the needed data source or be used as check on conventional data depending on the accuracy of conventional data.	2
15) Determine floor space and building density particularly of employment areas.	Can provide important employment data which is currently difficult to obtain.	1
16) Measure impervious surface areas	Provides data otherwise unavailable easily and cheaply. Use of automated measurement system suggested.	1
17) Length of gutters	Data is extractable easily and cheaply.	1
18) Surface area of catchment basins	Inexpensive means of acquiring the data when imagery is readily available.	4
19) Runoff retention monitoring	Cost is probably too high to warrant gathering the data.	5
20) Monitoring exposed soils	Could become a workable program with data reasonably inexpensive. Possible use of repetative ERTS or pre-ERTS imagery.	1

TABLE 4

APPLICATION	CONCLUSIONS and RECOMMENDATIONS	IMPORTANCE INDEX *
21) Location of polluters	Would provide increased knowledge on pollution and identify unregistered pollutors.	1
22) Determine deposition patterns	Would provide increased knowledge deposition mechanisms and patterns otherwise unavailable.	2
23) Monitor treatment plants	Cost is probably too high to warrant gathering the data.	5
24) Air pollution monitoring and mapping	Would provide data otherwise unavailable.	3
25) Housing and neighborhood quality analysis	For use as a stand-by system when data is needed on a particular area - which is difficult to survey.	5
26) General region-wide planning and synoptic overview	Would provide complete coverage of the metropolitan Washington region approximately every three weeks.	1

* 1 Highly recommended; 2 Recommended; 3 Suggested 4 Inclusion with existing project; 5 Warranted in special circumstances or rely on other agencies for analysis.

6. REFERENCES.

1. Air Photographics, Inc., Silver Spring, Md., January 1972, Private communication.

2. Buhr, J.H., et al, 1967, A Nationwide Study of Freeway Merging Operations, Texas Transportation Institute, Texas A & M University, College Station, Texas.

3. Helicopter and Airplane Services Corp., Gaithersburg, Md., January 1972, Private communication.

4. Howard, J.Y., 1971, Determination of Land Use Change with the Use of Aerial Photography, Metropolitan Washington Council of Governments, prepared under terms of Contract No. 14-08-0001-12708 for Geographic Applications Program, U.S. Geological Survey.

5. Johnson, C.W. and Mullens, R.H., II, 1970, A Practical Method for the Collection and Analysis of Housing and Urban Environment Data, An Application of Color Infrared Photography, prepared under a grant from DHUD under the provisions of Title I of the Housing Act of 1949, as amended, Los Angeles Community Analysis Bureau.

6. Mallon, H.J. and Howard, J.Y., 1971, Land Use Determination by Remote Sensor Analysis, Metropolitan Washington Council of Governments, prepared under terms of Contract No. 14-08-0001-12708 for Geographic Applications Program, U.S. Geological Survey.

7. Mallon, H.J. and Howard, J.Y., 1971, An Examination of Applications of Remote Sensing Data to Metropolitan Washington Council of Governments' Planning Requirements, prepared under terms of Contract No. 14-08-0001-12708 for Geographic Applications Program, U.S. Geological Survey.

8. Manual of Photographic Interpretation, American Society of Photogrammetry, 1960, pp 772-775.

9. Manual of Photogrammetry, American Society of Photogrammetry, Third Edition, 1966.

10. Muir, A.H. and Sattinger, I.J., 1968, Methods of Feasibility and Economic Analysis of Remote Sensing Applications, Proceedings of the 5th Symposium on Remote Sensing of the Environment, Institute of Science and Technology, University of Michigan, May 16-18, 1968.

11. Prochaska, J.M., 1969, The Applications of Remote Sensing in the Urban Environment, Proceedings of the 35th Annual Meeting, American Society of Photogrammetry, Washington, D.C., March 9-14, 1969, pp246-246i.

12. Reconnaissance Reference Manual, 1969, McDonnell Douglas Reconnaissance Laboratory.

13. Wilson, E., 1969, Sensor Detection Capabilities Study, prepared by U.S. Geological Survey for NASA under Contract No. W-12570, Task No. 160-75-01-31-10, Geological Survey Circular 616.

14. Wobber, F.J., 1969, Aerial and Orbital Images in Urban Environment Studies, Parts I and II, Photographic Applications in Science and Technology and Medicine, pp 21-27, 33-39.

BIBLIOGRAPHIC DATA SHEET

1. Report No. USGS-DO-72-Ø17

2.

3. Recipient's Accession No.

4. Title and Subtitle

Benefits from Remote Sensing Data Utilization in Urban Planning Processes and System Recommendations

5. Report Date: January 1972

6.

7. Author(s)

Harry J. Mallon and Joan Y. Howard

8. Performing Organization Rept. No.: IR-USGS-227

9. Performing Organization Name and Address

U.S. Geological Survey
Geographic Applications Program
Washington, D. C. 2Ø242

10. Project/Task/Work Unit No.: 16Ø-75-71-Ø3

11. Contract/Grant No.: NASA W-13318; USGS 14-Ø8-ØØØ1-127Ø8

12. Sponsoring Organization Name and Address

National Aeronautics and Space Administration
Washington, D.C. 2Ø546

13. Type of Report & Period Covered: Final Report

14.

15. Supplementary Notes

Prepared by Metropolitan Washington Council of Governments for USGS Geographic Applications Program under USGS contract no. 14-Ø8-ØØØ1-127Ø8

16. Abstracts

The benefits of utilizing remote sensor data in the urban planning process of the Metropolitan Washington Council of Governments are investigated, including an evaluation of sensor requirements, a description/comparison of costs, benefits, levels of accuracy, ease of attainment and frequency of update possible using sensor versus traditional data acquisition techniques.

17. Key Words and Document Analysis. 17a. Descriptors

Urban planning, Remote sensing, Benefit cost analysis, Data acquisition, Data processing

This is the DRA CR# 127474 W 8-3-72

17b. Identifiers/Open-Ended Terms

Metropolitan Washington Council of Governments

17c. COSATI Field/Group 13 B

18. Distribution Statement	19. Security Class (This Report)	21. No. of Pages
Unclassified - Unlimited	UNCLASSIFIED	45
	20. Security Class. (This Page)	22. Price
	UNCLASSIFIED	