URBAN TRANSPORTATION LAND USE PLANNING AND MODEL CONSTRUCTION BY USING MACHINE PROCESSED REMOTESENSOR DATA

PREPARED

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I. PREFACE

The urban transportation phenomenon is a complex integrity in its space, time, and scope. The machine processed remote sensor data used in the classification of land use on the regional wide area has been extensive in recent years. A survey of these classification methods and their results is exposed on this paper. Main stress is placed on their suitability of the recognition and interpretation of the urban land use features. All of the findings indicate that works are continuing on methods of improving performance of each method. Results of these experiments to date demonstrate that producing land use maps of a large scale by machine processing of satellite scanner data is feasible by keeping land use classes fairly broad, a conspicuous level of accuracy is attained despite of the relatively coarse resolution and the inherent complexities of man made environment. Considering the urban growth as a dynamic and everlasting refinement process and its mass data-based characteristics, one might consider the use of machine processed remote sensor data as a convenient and efficient tool for handling these data and their problems associated with every phase of the urban transportation planning. Essential tool is the study of a temporal series of satellite passes for the purpose of monitoring and detecting change. Important products would be precise measurement of incremental growth of subdivision housing, commercial, and transportation uses as a means to update the urban planning program and to path with the ever changing needs of our urban environment.

Urban transportation land use models can be classified into two broad categories: The casual model and the causal model. Models known as EMPIRIC model (ref. 1), ACTIVITY model (ref. 2) are casual models. Basically they are derived from observations and analyses of urban land use and activity phenomenons. They use many statistical inference equations to extend their study scope. Further, they made their predictions to the near future. Models known as GRAVITY model (ref. 3), LOWRY model (ref. 4) are derived from induction of the real world phenomenon. They use a set of mathematical formula and certain constraints and some characteristic parameters to make their predictions. On this report, a computer solution to the lowry model designed by me is attached. An analysis of the result is accompanied with it.

From the description of lowry model, it is seen that further works by Batty (1972) (ref. 5), Goldner (1971) (ref. 6), and Masser (1971) (ref. 7) are resulted in better forecasting to the future trends of urban land use development.

All of these models have a common characteristic. That is, they need a up-to-date data as input to the forecasting requirement. As nowedays, all over the world, with growing populations and their associated effects on the enviroment, we are subject to more pressing needs of these data constantly than before.

II. URBAN TRANSPORTATION PLANNING AND INFORMATION SYSTEMS:

An urban transportation planning process begins with statement of transportation problems and problem domains. The remaining processes are identification of objects and constrains of the proposed transportation system, model construction, data collection, model prediction, setting of levels, use of models, decision among alternatives, implementation, and final operation and maintenance of system.

The information system is one of the great synthesizing concepts of our time. It denotes the purposeful organization of information. It may encompass both qualitative and quantitative data. Transportation information systems may involve information collection, handling, processing, storage, and retrieval for planning, construction, maintenance, and operation.

An information system is a collection of technical people, procedures, computer hardware, computer software, and a data base organized to develop the information required to support the functions of the parent organization and/or allied organizations. It is important to note that'information system' and 'data processing system' have quite different denotations. data processing system refers specifically to the computer hardware and software (E.G. computer programs). Information systems includes not only a data processing system, but also the data base and complete personel organization for a particular information function. The focus here will be on the data base needed for urban transportation planning.

Data base plays a major role in transportation planning. Since urban transportation planning is based in parts on its demonstrated abilities to simulate urban systems in computer. Such demonstration require vast quantities of measurements of land use, human travel behavior, and other urban characteristics. These meansurements cost money.

III. URBAN LAND USE INVENTORY

(1) Objectives

Most of the transportation oriented land use surveys have tried to serve four basic objectives:

a. To provide a land use base from which trip distribution factors and trip generation factors can be derived. (

reg. 1:dickey chapter 6).

b. To provide necessary data for coordinating transportation facilities with their users (drivers, operators).

c. To provide a 'universe' of dwelling units from which a sample can be drawn for the home interview phase of the travel survey.

d. To provide data useful for the day-to-day planning activities of city, county, and state government.

A wide range of land use studies to acquire basic data on land characteristics and the activities that occupy land includes. (ref. 8:chapin):

a. Land use survey.

b. Vacant land use survey.

c. Flood damage prevention survey.

d. Environment survey.

e. Cost-revenue survey.

f. Land-value survey.

g. Studies of the aesthetic features of the urban area.

h. Studies of public attitudes and preferences regarding land use.

i. Studies of activity systems.

(2) Classification of land uses

In 1971 a classification system for use with remote sensor data has been prepared by interior-agency steering commitee on land use information and classification of U.S.A.. Under leadership sponsored and provided by NASA and EROS program (ref. 10).

Governed by some guidelines, two levels of classifications are developed. They are:

Level I:

1. Urban and built up.
2. Transportation, communications, and utilities.
3. Farming (agriculture).
4. Grassland (grazing).
5. Forest land (forestry).
6. Extractive.
7. Water.
8. Marshland.
9. Tundra.
10. Barren land.
11. Permanent snow fields.

Level II:

1. Urban and built-up.
    a. Residential.
    b. Commercial (trade).
    C. industrial (manufacturing).
    d. Services

e. Recreational.

f. Transportation.

g. Other.

2. Transportation, communications, and utilities (no subcategories proposed).
3. Framing (agriculture).
   a. Cropland.
   b. Pasture.
   c. Orchards, vine yards, horticultural areas.
4. Grassland (grazing, rangeland), (no subcategories).
5. Forest land (forestry), (no subcategories).
6. Extractive (mining and quarrying), (no subcategories).
7. Fishing (no subcategories).
8. Water.
   a. Lakes.
   b. Streams.
   c. Ponds.
   d. Reservoirs.
9. Low activity land.
   a. Marshland.
   b. Tundra.
   c. Barren land.
   d. Permanent snow fields.

In application area, several researchers have indicated success at generating selected data for the III and IV level from satellite imagery. That will depends on the local users to move nearly fit their specific needs and is encouraging.

(3) Land Use Survey

Land use surveys are classified in two ways: Firstly, by whether or not dwellings and other places must be entered. Secondly, by whether or not data must be computer readable.

The second classification relates to the way the land use data are recorded in the field. The older method is to record the data directly on the maps or airphotos. It is best suited to a map storage system. During the last decades, especially in the large scale transportation land use studies, the method known as 'field listing' is undergone great usages. It is suited to a punch card storage system. Today, the machine processing satellite data transforms 'pixel' (resolution picture or element) into gray leveled imagery points. It can be obtained, handled, processed, storaged, and retrievaled periodically in an accurate and cost-effective manner.

(4) Presentation of Land Use Data

The results of the land use survey may be summarized in either map form or statistically. Traditionally, land use data have been presented in the form of land use map. This shows land use by general category of use, that is, residential, commercial, industrial, institutional, parks and recreation, transportation and utilities, agriculture and water.

Recently, land use maps have increasingly been based upon print outs of data processed on a grid cell basis by computer. These require that a draftsman prepare an overlay of principle streets for orientation; hence, they eliminate the time comsuming task of transcribing from data base to the overlay. The amount of land given to urban uses is always summarized in terms of percentages for the developed part of the city, the fringe areas, and planning area of the survey.

The use of aerial photography or satellite is effective for updating and correcting information from maps. It can be used to discern new streets, street extension, and any other land developments that may have occured in the period between the print out of the map and the taking of the aerial photography. For more detailed discussion on land use presentation by the computer see ref. 1: Chapter 7.

IV. SATELLITE MISSION FOR LAND USE SURVEY

Since the launch of the Earth Resources Technology Satellite-#1 (ERTS-1) on 1972, our earth environments have been subject to the multispectral scanner periodically (exactly 18 days). The machine processing of satellite data has a resolution point of about 57 x 79M and a gray level radial, range from o to 127. Each satellite scence has been recorded when the satellite is passing over the ground and it covered an area of about 185 x 185KM.

For the land use mapping purpose, many of the satellite goal had been to attempt to delineate with maximum accuracy as many functional land use classes as possible. The term functional is emphasized as it pertain to the usage of land, and not to naturally occuring land cover. Further, these functional land uses are selected to correspond as closely as possible to classes which are widely accepted and used by those in the planning and land management community. In short, spectral characteristics must be transformed into meaningful, acceptable, land use classes.

One of the satellite objects has been to determine the limits of inferring land uses from spectral information alone. The objective was selected by relizing that some urban planners argue that intensive, accurate land use determination from remote-sensed imagery of any sort is impossible and that the plotting of such discrete uses as retail, office, and many multi-family residential units are possible only with parcel-wise data secured from ground sources. Nevertheless, the characteristics of machine processed satellite data as applied to urban planning is progressing with great strides. The combination of the satellite borne scanner and machine processing provides a different tool than either conventional air-photo interpretation or surface and statistical unit mapping.

The advantages are,

1. High speed processing.
2. Frequently obtained new data.
3. Unbiased and uniformly repetitive classification.
4. Production of large scale map at relatively low cost.
5. The inherent digitizing of land use data retrievable in any form or combinations of forms.

The disadvantages are,

1. The inability of the system to discriminate with consistent success between functionally dissimilar but spectrally similar land uses.
2. The impossibility of detecting parcel ownership.
3. Generalization by resolution element: At 80M resolution element the complexity of the urban landscape can not be shown fully.
4. Identifications depend on vegetation vary seasonally.
5. Uncontrollable incidence of cloud cover.

Studies of land use classification by Machine Processing of ERTS-1 Multispectral Data.

The land use classification by machine processing of ERTS-1 multispectral data had been applied at many study areas (regions). For example:

1. San Francisco Bay Area (1972).
2. Marion County, Indiana (Sept. 30, 1972).
3. Portions of the Lower Rio Grande Valley of Texas (July 26, 1972).
4. Chesapeare Bay, Washington D.C. Area (1972).
5. Great Lake Basin, Great Lake Area (April 15, 1972).

For briefly, I Discuss two of the most related study areas to my subject.

(1) San Francisco Bay Area Study (ref. 11, 2A-7)

The study area is a large segment of the San Francisco-Oakland and San Jose urbanized areas. Basically, it uses a photo-interpretation procedure to solve problems of the spectral similarity of functionally different land uses and land covers.

Classification was achieved by grouping 28 spectral classes into 11 functional classes. A reliability analysis was checked by comparing computer results to contemporaneous high-altitude color air photographs on a pixel-by pixel basis. The results have shown with high performance from among the grossness of the data and the complexity of the urban landscape (fig.1).

The method employed requires the preliminary step of delimiting the urbanized area; subsequent groupings of urban land uses lie inside the boundary line and rural groupings are outside the line. A procedure was followed which adapted the census bureau's rules for urbanized area delimitation to a one-quarter kilometer grid system. The example uses a one kilometer cell generation. Kilometer squares were given UTM (Universal Transverse Mercator) addresses (or projections) and the corresponding computer coordinates were then entered into the computer and delimited on the print out. Two seperate groupings of the 28 cluster classes, one urban one rural, were then printed out. Manual cut-and-paste techniques were then used to make a single map (fig. 2a, 2b).

Upon superimposing the photo (1E. aerial photograph) over the computer map on the Zoom Transfer Scope, the question was asked for each pixel if the real land use match that given by the classifier. Score was kept and the results presented in table 1.

The introduction of the kilometer grids also provide a basic for aggregating land uses by a standard aerial unit. Table 2 illustrates for a typical few kilometers and for the average of 250 square kilometers the percentages of each land use for the area around San Jose. The figure of

62% for residental uses compares favorably with the 63.4% for the same area as measured by planimeter from air-photo interpreted uses in the work of the Geographic Applications Program's Census Cities Project.

Table 1. Reliability Test of Land Use Classification

Functional Land Use Class	% Correct
commercial-industrial	82.7
residential	84.6
parking lots	77.8
unimproved open space (bare)	94.2
improved open space (irrigated)	97.1

Table 2. Land Use Aggregations by Kilometer Squares for a Segment of the San Jose, California Area

		% of land use							
UTM Grid Designation	Commercial Industrial	Mobile Homes	Parking Lots	Res.[1]	Bare	Tree	Irrig[2]	Water	Thresh Old
135-603	32.5	1.7	1.7	59.0	4.3	0.9	0.0	0.0	0.0
134-590	12.1	1.3	11.2	72.3	0.4	1.8	0.9	0.0	0.0
134-591	9.8	0.0	14.7	72.3	0.0	0.9	1.3	0.0	0.0
134-592	13.3	0.5	9.0	75.7	0.0	0.0	1.4	0.0	0.9
134-593	18.8	0.4	14.7	62.1	0.0	3.1	0.4	0.0	0.4
134-594	32.1	6.7	33.5	13.8	0.0	1.3	11.6	0.0	0.9
134-595	42.9	4.5	18.3	27.7	3.6	0.0	1.8	0.0	1.3
:	:	:	:	:	:	:	:	:	:
Average for 250KM[2]	12.9	1.3	8.2	62.0	4.5	6.2	2.2	0.2	2.5

1. Residential.

2. Irrigation.

The precise determination of characteristics of land use obtained by using a pixel-to pixel basis were analyzed to determine the best grouping of the spectral classes into functional classes. A total of 11 categories (8 for urban, 3 for rural) were selected and presented in table 3.

Table 3. Functional Land Use Classes Employed on Computer Maps

	Functional Land Use	Spectral Classes Comprised
Urban	commercial	1,2,3,14
	mobil homes	5
	residential	6,9,10,13,15,16,17,18,19,20,21
	parking lots	8,22
	unimproved open space (bare)	11
	improved open space (irrigated)	12
	unimproved open space (with trees)	23,24,25,26,28,29,30
	water	27
Rural	grazing and cropland	1,2,3,5,6,8,9,10,11,12,13,14, 15,16,17,18,19,20,21,22,23
	tree covered	24,25,26,28,29,30
	water	27

(2) Marion County Study (Ref. 11, 2A-23)

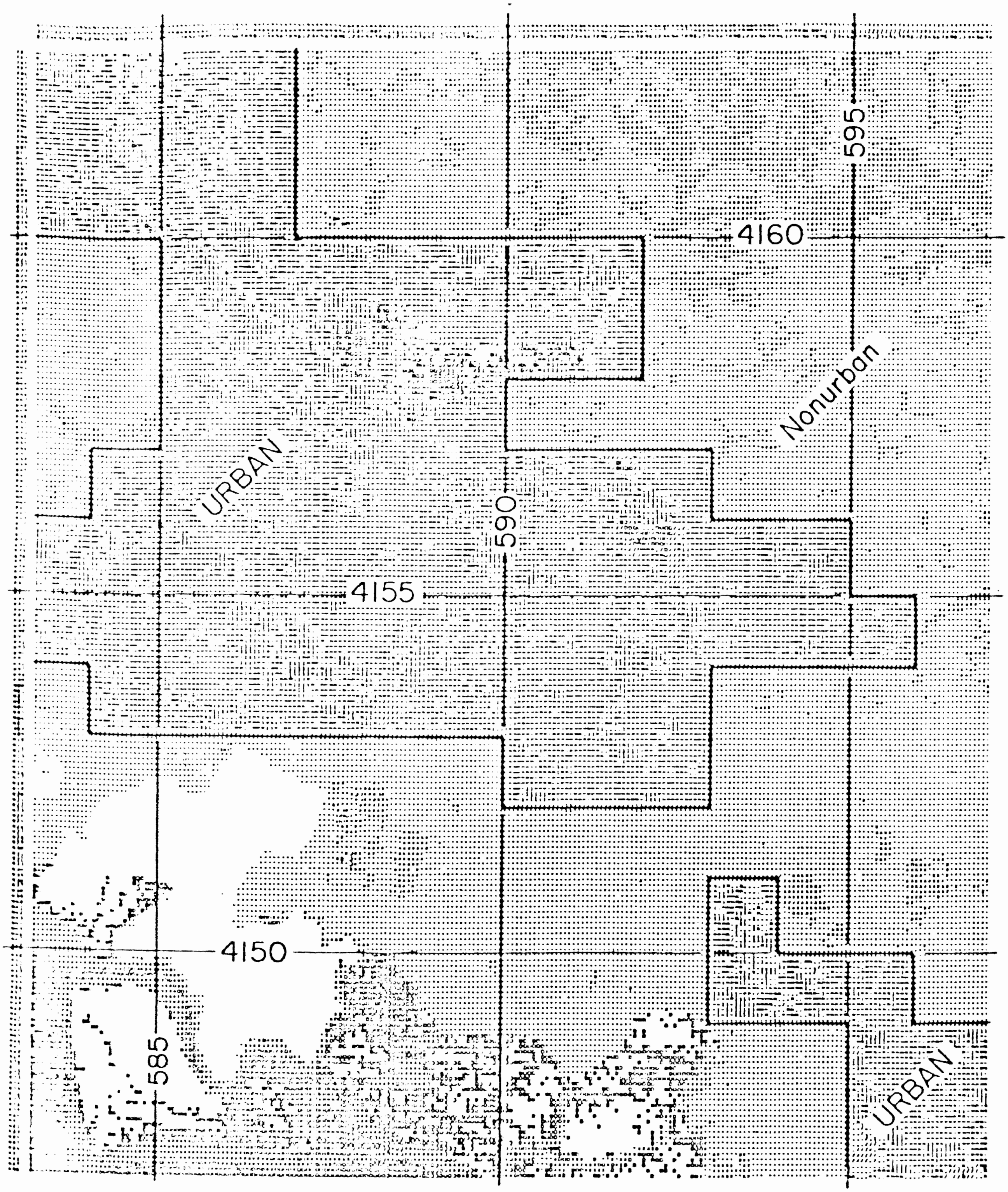


Figure 1. Computer-Classified Land-use Map of the Fremont Area, California. Map is derived from scanner digital tapes of ERTS-1 scene 1003-18175, 26 July 1972. It demonstrates use of separate classifications for Urban and Nonurban. Classification uses LARSYS pattern recognition algorithms, and was produced at Purdue University, Laboratory for Applications of Remote Sensing (LARS). Urban area is defined by one-kilometer UTM grid cell (zone 10) from USGS Census Cities ERTS experiment 1970 land-use map and NASA aircraft photography. Land use areas are aggregated by class and kilometer grid cell. Each pixel represent 0.465 hectares (1.1 acre). Urban classes: Commercial-Industrial (1); Mobile Homes (V); Residential (M); Parking Lots (·); Unimproved Open Space, Bare (-); Unimproved Open Space, Trees (/); Improved Open Space-Irrigated (+); Water (0). Nonurban: Grazing and Cropland ('); Trees (X); Water (0). Large unclassified areas (blank) are salt evaporation ponds.

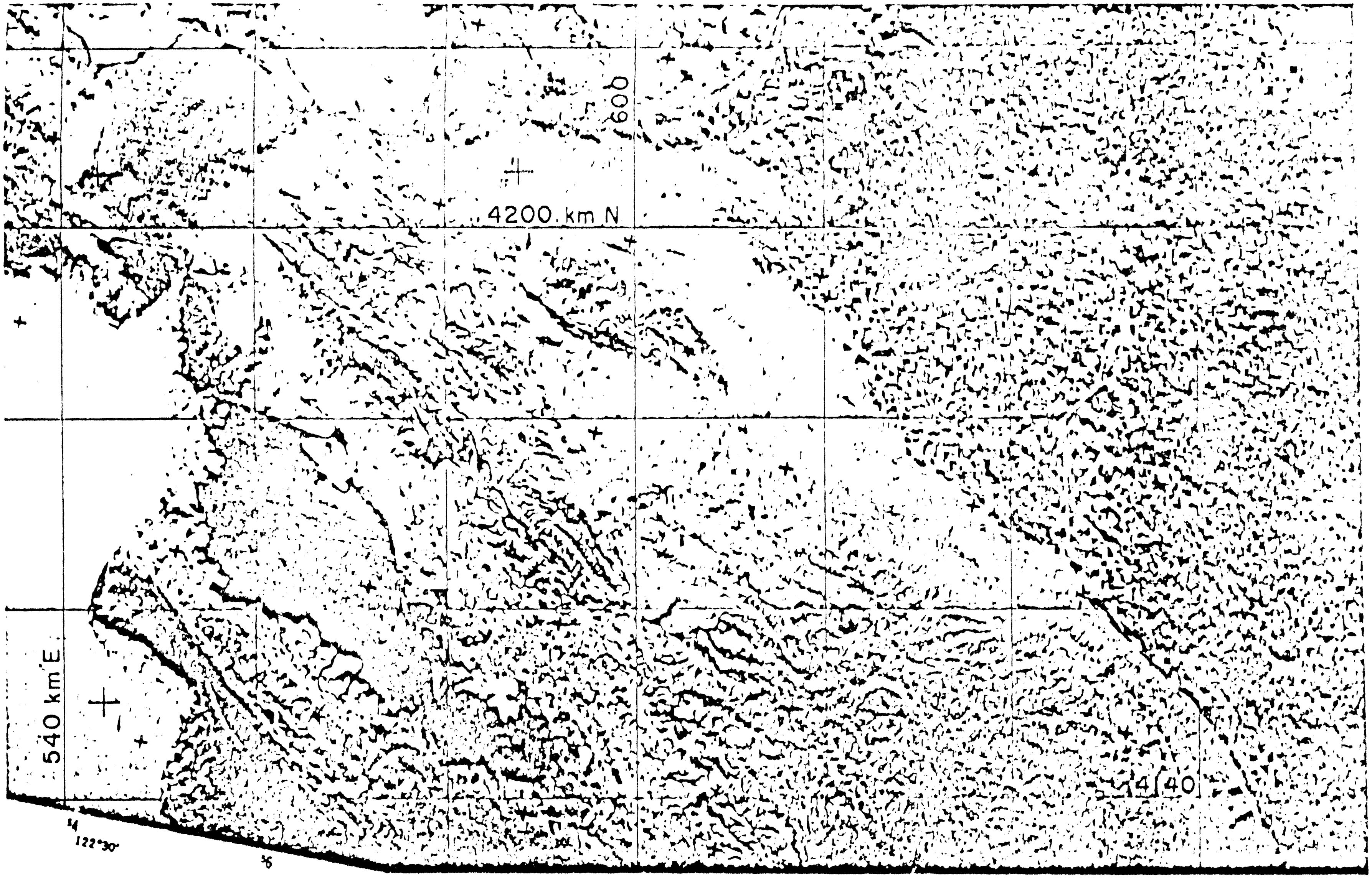


Figure 2a. Portion of ERTS-1 RBV View, San Francisco Bay Region. View is from Band 3 (red), frame 1003-18175, 26 July 1972, three days after launch. This is same view for which digital data from the four-channel multispectral scanner (MSS) are used to classify land use by computer-aided techniques (Figure 2b). Twenty-kilometer UTM grid (zone 10) and thirty-minute geographic grid fitted by U.S. Geological Survey. Position of grids meet Federal map accuracy standards. Fog and San Francisco Bay at left (west); San Joaquin Valley and large irrigated fields at right; Hayward and Freemont areas at southeast side of San Francisco Bay.

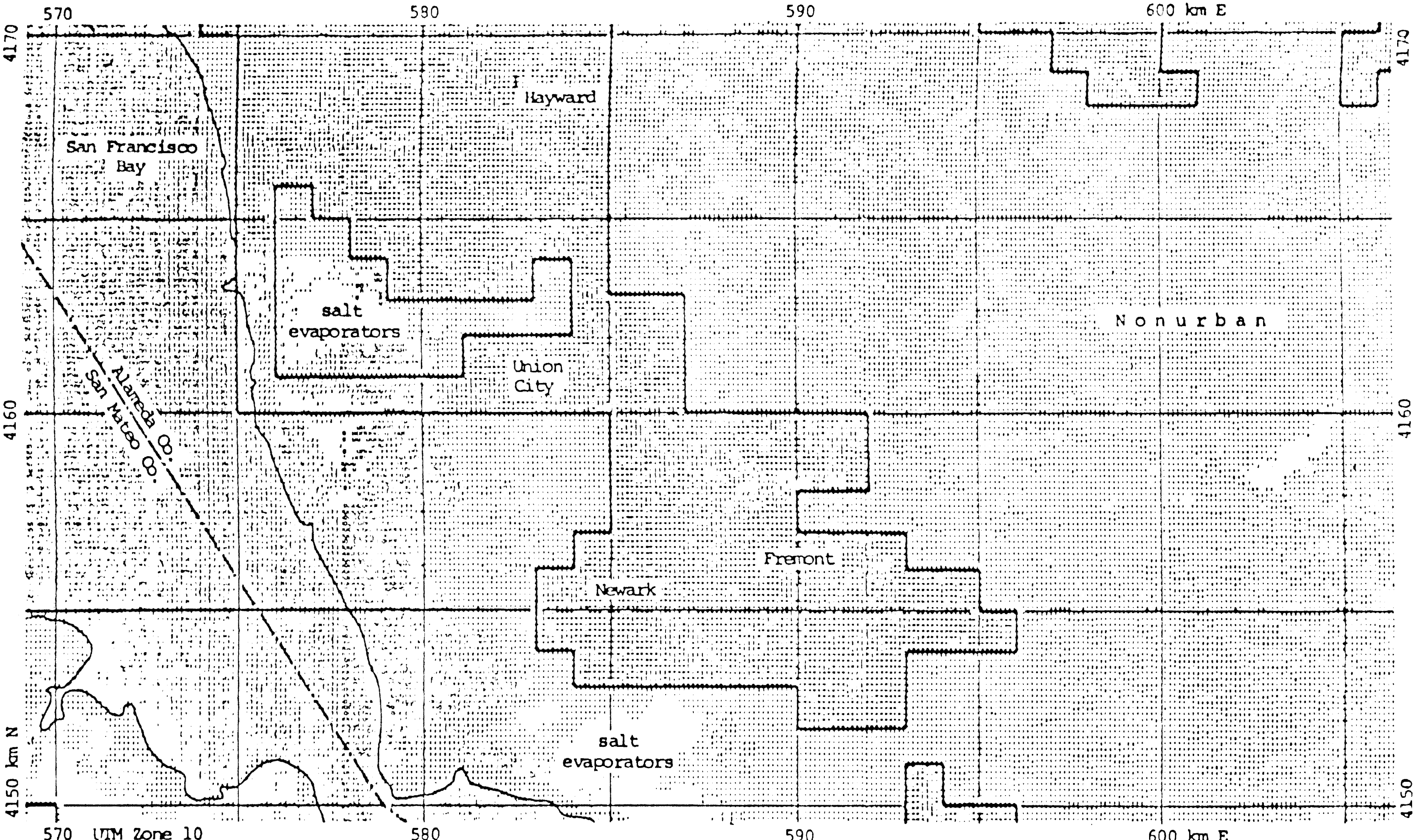


Figure 6b. Portion of computer-classified land use map of San Francisco Bay Region. Map is derived from ERTS-1 scanner digital data, frame 1003-18175, 26 July 1972. Classification, by Purdue/LARS, uses eight Urban classes, and three Nonurban classes (Figures 4 and 5). Urban area, defined by one-kilometer UTM grid (Zone 10), is from USGS Census Cities ERTS experiment and NASA aircraft photography. The grid facilitates comparison with corresponding ERTS-1 RBV scene (Figure 6a). Map is produced at 1:48,000 by classifying every other pixel in every other scan line. About 6500 square kilometers (or just under one-tenth of one percent of U.S. land area) were classified on LARS IBM 360-67 in about thirty minutes' computer time. Aggregation of areas by land use class and kilometer grid square can also be generated. It may soon be operationally and economically feasible to compile manuscript land use maps for large areas by this method, using additional Nonurban classes. Then edit and adapt to more conventional functional classes. Perhaps, draw use boundaries by conventional cartography or computer graphic methods, and publish maps at 1:50,000 to 1:250,000. Area measurement and land use change data by grid cell, or user jurisdiction area, would be valuable by-products. (-Ellefsen, Swain, and Wray, Figure 6b)

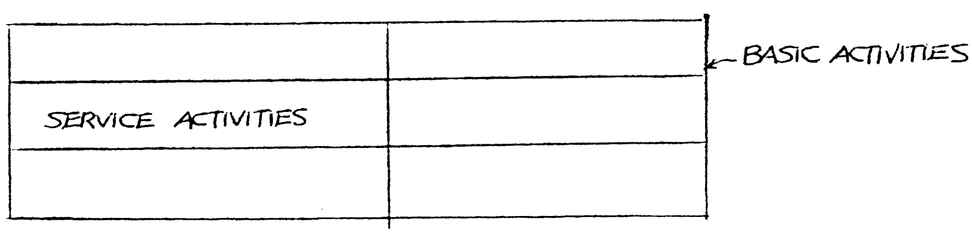
While many urban land uses exhibit spectrally seperable characteristics, permitting. Accurate identification through application of classifier, other important land use do not. For example, some older residential area have been confused with grassy area or agricultural area. The objectives in this study were to investigate further the spectral characteristics of these 'problem' areas. The hypothesis tested was that whether areas of misclassification could be identified by numerical (spectral) characteristics other than single spectral class. Parameters such as mean, range, standard deviation, and correlation coefficients were they key components of the investigation.

The resulting cluster map of marion county gaue important dues to the spectral classes of urban land cover phenomenon. Samples were extracted by rectangular training form and were located for the following land uses:

1. Single family residential.
2. Multi-family residential.
3. Grassy (open) areas.
4. Trees.
5. Commercial/Industrial.
6. Cloud.
7. Cloud shadow
8. Water.

sequences of externally derived estimates of changes in population or economic activity on the spatial organization of a region or urban area.

The lowry model makes two basic assumptions about the factors governing the location of activities in regions and urban areas. First, it is assumed that an individual choice of residential location is directly influenced by the location of his place of work. Second, it is assumed that economic activities (like employments or trips) can be divided into two categories on the basis of their locational requirement. They are basic activities where their location within the area is determined by factors outside the scope of the model, or as service activities (derived activities) where their location is seen to be largely a function of the distribution of population.



On the basis of these assumptions, the distribution of population and service employment can be predicted from a given distribution of basic employment by means of an iterative process. In this process the distribution of resident workers is first chlculated from the distribution of basic employment by means of an atiraction constrained gravity model (a kind of single constrained gravity model, see ref. 3). Then the estimetes of resident workers are multiplied by the activity rate to convert them into residential population. Given this estimate, the destination of service trips made by the residential population can be calculated by means of production constrained gravity model (a kind of single constrained gravity model too, see ref. 3), and converted into employment estimates by multiplying them by th ratio of service jobs to total population.

The second iteration begins using the distribution of service employments (or trips) calculated in the first cycle as the input to the attraction constrained gravity model instead of the distribution of basic employment. This essentially further distribute residential population and service employment for each iteration after iteration 2.

In this way a series of calculations is repeated until an equilibrium is reached which is generally after 4 or 5 iterations.

The general process of lowry model can be described by a series of equations begining with the attraction constrained gravity model which is used to find the distribution of residences of workers:

$$T_{ij}=B_j D_j W_i d_{ij}^{-\alpha} \qquad (1)$$

where $$B_j=1/(\sum_i W_i d_{ij}^{-\alpha}) \qquad (2)$$

and $\Sigma T_{ij}=D_j$ (3)

T_{ij}: The number of trips made by residents in zone i to work in zone j.

D_j: The number of jobs in zine j. In the first iteration this will represent basic employment and in subsequent iterations it will represent progressively diminishing increments of service employment.

W_i: Some measure of the attractiveness of zone i as a residential location.

$d_{ij}^{-\alpha}$: The distance between zone i and zone j, expressed in terms of the predetermined function (or constant) α.

The number of resident workers living in zine i (C_i) can be calculate by summing up the distribution of trips:

$$C_i=\sum_j T_{ij} \qquad (4)$$

This can be converted to resident population (O_i) by reference to an activity rate:

$$O_i=C_i/AR \qquad (5)$$

Where AR is the activity rate expressing total employment as a proportion of total population (IE. E_T/P)

From the distribution of residential population, the distribution of service trips can be calculated by a production constrained gravity model:

$$T_{ij}=A_iO_iWW_jd_{ij}^{-\alpha} \qquad (6)$$

where $A_i = 1/(\sum_j WW_j d_{ij}^{-\alpha})$ (7)

and $\sum_j T_{ij} = O_i$ (8)

T_{ij}: The number of service trips made by residents in zone i to services in zine j.

O_i: The residential population of zine i.

WW_j: Some measure of the attractiveness of zone j as a service center.

$d_{ij}^{-\alpha}$: The distance between zone i and zone j expressed in terms of a predetermined function (or constant) α.

The total number of service trips made to zone j(S_j) can be calculated by summing up the distribution of trips:

$$S_j = \sum_i T_{ij} \quad (9)$$

This figure can be converted to an estimate of service employment (D_{ij}) by reference to the population service ratio:

$$D_{ij} = S_j(PSR) \quad (10)$$

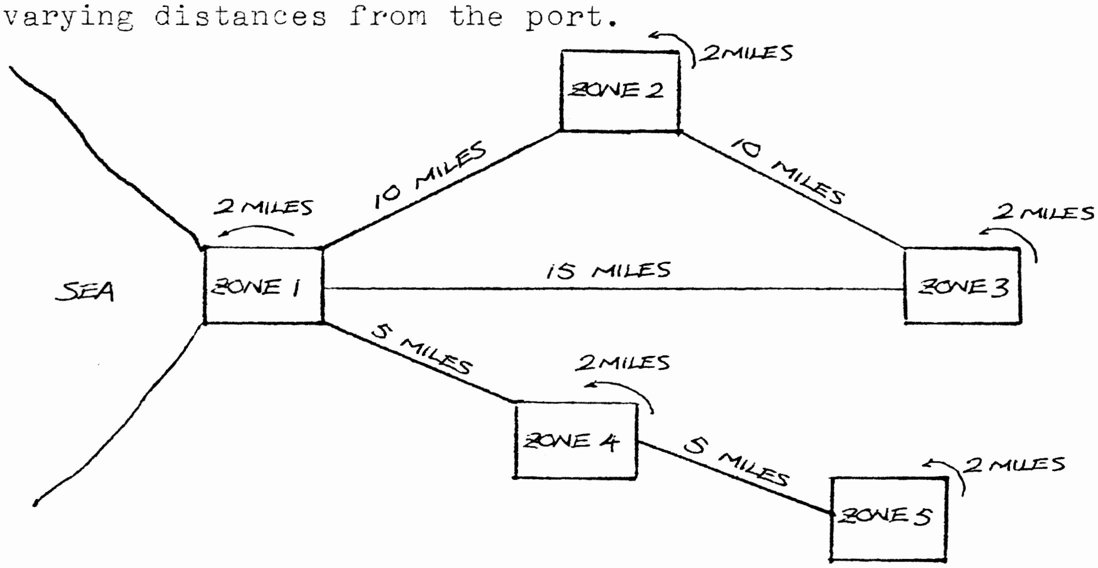
D_{ij}: The estimate of service employment made to zone j at the first iteration.

PSR: The ratio which express service employment as a proportion of the total population (IE, E_s/P)

The estimate of service employment forms the input to EQ.(1) in the first step of the second cycle of calculations.

The general principal underlying this model is illustrated by a five zone example for a region with a population of

10,000 and a labor force of 5,000 of whom one third are employed in jobs classified as basic in terms of their location. The example concerns a seaport (zone 1) which is the location of the 1,000 basic jobs in the region and four other zones representing areas for development at varying distances from the port.



It is assumed that the average distance traveled within each zone is 2 miles. An internal distance matrix can be derived from the above network.

		TO ZONE					
		1	2	3	4	5	
From	1	2Miles	10 Miles	15 Miles	5 Miles	10 Miles	=42 Miles
Zone	2	10	2	10	15	20	=57
	3	15	10	2	20	25	=72
	4	5	15	20	2	5	=47
	5	10	20	25	5	2	=62

The attractiveness of each of these zones for residential development (W_i) in this example is expressed by a measure of land area:

ZONE	LAND AREA (SQUARE MILES)
1	10
2	12
3	12
4	10
5	15

The attractiveness of each of these zones for service employment in this example (W_j) is expressed by a measure of existing service floor area:

ZONE	FLOOR AREA (1000 SQUARE FEET)
1	5
2	2
3	1
4	10
5	2

The overall activity rate will be 0.3 (IE. 3000/10000) and the population service ratio 0.2 (IE.(3000-1000)/10000). With this information, together with the assumption of used in both gravity model is Z.

A computer program for this model is constructed to solve this problem. An analysis is also contained on the last few seperate sheets. By using a new AR value, AR = 0.4, the last few seperate sheets are compared by a table list below.

	POPULATION DISTRIBUTION			SERVICE EMPLOYMENT DISTRIBUTION		
	AR=0.4			PSR=0.2		
ZONE	Others No Change	WW_3=1→5 Others No Change	α =2→1 Others No Change	Others No Change	WW_3=1→5 Others No Change	α =2→1 Others No Change
1	2961	2940	1799	465	455	287
2	281	269	615	56	50	87
3	127	185	413	23	49	40
4	1156	1138	1216	392	384	495
5	475	468	957	64	62	91
TOTAL	5000	5000	5000	1000	1000	1000

Note: When AR = o, PSR = 0, then total percentage of basic employment will be (0.4-0.2)(100%)=20%, so the total population will be (1000)/20%=5000

The results of these studies give some indication of how models of this type might respond to change situations. The impact of the five fold increase in floor space in zone 3 is reflected in a doubling of service employment and a fifty percent increase in the residential population in this zone. A change in the work trip (α from 2→1) benefits those residential zones whose travel distance is more far away. Zone 3 possesses the most far travel behavior. Its service employment is nearly two fold increase. And its population is nearly 3.5 times increase.

VI. URBAN LAND USE PLANNING AND MODEL USAGE BY USING REMOTE SENSOR DATA

Traditionally, aerial photography had been used extensively on both reconnaissance phase and the final location survey phase of the transportation route survey processes (ref. 9, ch. 8).

For reconnaissance purpose, an air photo base map is produced, usually to a scale of 1 inch = 200 feet, with 2-5 feet counter intervals. For final location survey purpose, usually a scale of not less than 1 inch = 100 feet is used.

Today, with the advancement of satellite remotely sensed data processing technique, many reconnaissance work originally made by air photograph can largely be substituted by satellite without loss of exactness. Sometimes, it can create better judgements than air photography owing to its large scale and unbiased repetitive classification abilities.

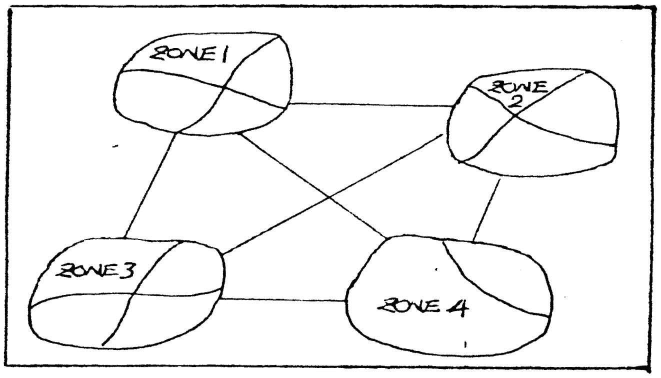
When used in regional planning, the satellite processed data (imagery or picture or digitized computer output) is used to devermine land uses such as cropland, pasture, lake, stream, baren land, marsh land, mountain area, urban area, rural area, etc., without too much difficulty as we have mentioned on above already.

For planning purpose, given a region, we can further divide them into five kinds of developmental land uses as:

1. Developed area (urban, fringe).
2. Underdevelope area (rural).
3. Undevelope area (cropland, pasture, property (both public or private), boundary area).
4. Waste land (barren land, floodway, marsh land).
5. Unreached area (mountain, highland).

From regional planning view point, the first three land uses: developed, underdevelope, and undeveloped area, will be considered for usage most frequently.

If a region planning is grouped into this classification category, we can construct the aerial constrints, like the zonal area, resources, water supply, etc., for each zone within this study region.



HYPOTHETIC STUDY REGION

zonal variables:
area, resources,
water supply, population,
employment,......

These aerial constraints (a spatial organization) can be used as a prediction of the growth factor(s) for each zone. The growth factors can be a reflection (function) of population, employment, resources, or optimal water supply, etc.

The model is subsequently used, by using the existing information regarding population, employment and a measure of some distance parameters (factors such as α), to evaluate the future growth of each zone within this region. If the eveluation will not conform to the aerial constraints of each zone, a revised evaluation, by changing some forecasting parameter values, is again put into the original model for a renew evaluation. The process is repeated over and over until an optimal solution is obtained.

A regional-wide problem is not easy to be handled by just evaluate its model results owing to the complexities of urban or regional phenomenon. But a model is as necessary an important and convenient tool as the social and economic considerations of some local activities. Otherwise, many model forecasting parameters are goodreflections of the social and economic phenomenon implicity! Model forecasting and model planning when adequately used, will always make good judgements.

VII CONCLUSION

Even for the advantages of satellite used in land use classification and urban planning reconnaisance purposes, the importance of aerial photography cannot be overlooked.

Aerial photography is a powerful tool used in the extensive and detailed location survey phase of transportation route decisions to produce. Base maps along the preliminary ~~augnment~~. alignment.

From the above discussion, several ways we can expect for the satellite application on land use classification will be:

1. Better resolution abilities.
2. Improve ability to seperate functional dissimilar but spectrally similar land uses.
3. Use infrared imagery scanner to elimate weather considerations.

in order to create better recognition of our earth land cover from the planning viewpoint.

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```
C      MAIN PROGRAM
       DIMENSION A(5,5),DD(5),W(5),WW(5),TOT1(5),TOT2(5),TOT3(5,5,5),
      1TOT4(5,5,5),O(5),P(5),Q(5),R(5),S(5,5),T(5,5),OUT1(5,5),OUT2(5,5),
      2OUT3(5,5),OUT4(5),OUT5(5),OUT6(5,5),OUT7(5,5),OUT8(5),OUT9(5,5),
      3OUT10(5),OUT11(5),OUT12(5),OUT13(5),OUT14(5)
       INTEGER Z
       WRITE(6,801)
       READ(5,*) M,Z,SL,G,GG
       WRITE(6,802)
       DO 111 I=1,5
       READ(5,*) A(I,1),A(I,2),A(I,3),A(I,4),A(I,5)
 111   CONTINUE
       WRITE(6,803)
       READ(5,*) DD(1),DD(2),DD(3),DD(4),DD(5)
       WRITE(6,804)
       READ(5,*) W(1),W(2),W(3),W(4),W(5)
       WRITE(6,805)
       READ(5,*) WW(1),WW(2),WW(3),WW(4),WW(5)
       CALL LOWRY(M,Z,SL,DD,W,WW,A,TOT1,TOT2,TOT3,TOT4,G,GG,O,P,Q,
      1R,S,T,TTL1,TTL2,OUT1,OUT2,OUT3,OUT4,OUT5,OUT6,OUT7,OUT8,OUT9,
      2OUT10,OUT11,OUT12,OUT13,OUT14)
C      OUTPUT OF RESIDENTIAL POPULATION ON EACH ITERATION
       DO 20 IX=1,Z
       WRITE(6,30) IX
       WRITE(6,806)
       WRITE(6,807)
       DO 40 I=1,M
       WRITE(6,45) I,(TOT3(I,J,IX),J=1,M),OUT2(I,IX),OUT1(I,IX)
 40    CONTINUE
       WRITE(6,50) (OUT3(J,IX),J=1,M),OUT4(IX),OUT5(IX)
       WRITE(6,808)
       WRITE(6,810)
       DO 72 I=1,M
       WRITE(6,300) I,(TOT4(I,J,IX),J=1,M),OUT6(I,IX)
 72    CONTINUE
       WRITE(6,70) (OUT7(J,IX),J=1,M),OUT8(IX)
       WRITE(6,75) (OUT9(J,IX),J=1,M),OUT10(IX)
 20    CONTINUE
       WRITE(6,814)
       WRITE(6,80)
       WRITE(6,811)
       WRITE(6,812)
       WRITE(6,810)
       DO 10 I=1,M
       WRITE(6,100) I,(OUT1(I,J),J=1,Z),OUT11(I)
 10    CONTINUE
       WRITE(6,200) (OUT12(I),I=1,Z),TTL1
       WRITE(6,813)
       WRITE(6,812)
       WRITE(6,810)
```

```
      DO 400 I=1,M
      WRITE(6,100) I,(OUT7(I,J),J=1,Z),OUT13(I)
400   CONTINUE
      WRITE(6,200) (OUT14(I),I=1,Z),TTL2
30    FORMAT('0',24H                 ITERATION      ,I12/)
801   FORMAT(5X,'ENTER M Z SL G GG')
802   FORMAT(5X,'ENTER A(I TO J)')
803   FORMAT(5X,'ENTER DD(I)')
804   FORMAT(5X,'ENTER W(I)')
805   FORMAT(5X,'ENTER WW(I)')
806   FORMAT('  ITERATION OF RESIDENT POPULATION')
807   FORMAT('      ZONE                   1',
     1'          2          3          4          ',
     2'5        TOTAL  RES')
808   FORMAT('  ITERATION OF SERVICE EMPLOYMENT')
810   FORMAT('      ZONE                   1',
     1'          2          3          4          ',
     2'5       TOTAL )
811   FORMAT('  TOTAL BASIC EMPLOYMENT AT EACH ITERATION')
812   FORMAT('                                 ITERATION NUMBER')
813   FORMAT('  TOTAL SERVICE EMPLOYMENT AT EACH ITERATION')
45    FORMAT('/',I7,9X,7F8.2)
50    FORMAT('0',16HBASIC EMPLOYMENT, 7F8.2,//)
814   FORMAT('                                                                 ')
70    FORMAT('0',18HTOTAL SERVICE TRIP,6F8.2)
75    FORMAT('0',18HSERVICE EMPLOYMENT,6F8.2//)
100   FORMAT('0',10X,I7,6F8.2)
200   FORMAT('0',7H TOTAL ,6F8.2//)
300   FORMAT('0',I7,10X,6F8.2)
80    FORMAT('1')
      STOP
      END
C
C
      SUBROUTINE LOWRY(MS,ZS,SLL,DDS,WS,WWS,Y,TOS1,TOS2,TOS3,TOS4,
     1GG,GGG,A,B,D,F,E,SLOPE,TTOL1,TTOL2,T1,T2,T3,T4,T5,T6,T7,T8,T9,
     2T10,T11,T12,T13,T14)
      DIMENSION Y(MS,MS),DDS(MS),WS(MS),WWS(MS),TOS1(MS),TOS2(MS),
     1TOS3(MS,MS,MS),TOS4(MS,MS,MS),A(MS),B(MS),D(MS),F(MS),E(MS,MS),
     2SLOPE(MS,MS),T1(MS,MS),T2(MS,MS),T3(MS,MS),T4(MS),T5(MS),
     3T6(MS,MS),T7(MS,MS),T8(MS),T9(MS,MS),T10(MS),T11(MS),T12(MS),
     4T13(MS),T14(MS)
      INTEGER ZS
      DO 1 I=1,MS
      DO 11 J=1,MS
      SLOPE(I,J)=1./Y(I,J)**SLL
11    CONTINUE
1     CONTINUE
      DO 31 J=1,MS
      B(J)=0.0
      DO 36 I=1,MS
      B(J)=B(J)+WS(I)*SLOPE(I,J)
```

```
36    CONTINUE
      B(J)=1./B(J)
31    CONTINUE
      DO 37 J=1,MS
      D(J)=DDS(J)
37    CONTINUE
      CC=GG/(GS-GGS)
      DO 131 IX=1,ZS
      DO 41 I=1,MS
      TOS1(I)=0.0
      TOS2(I)=0.0
      DO 42 J=1,MS
      TOS3(I,J,IX)=0.0
      TOS4(I,J,IX)=0.0
42    CONTINUE
41    CONTINUE
      DO 60 J=1,MS
      IF(IX.EQ.ZS)  D(J)=D(J)*CC
      TOS2(J)=TOS2(J)+D(J)
60    CONTINUE
      DO 61 I=1,MS
      P(I)=0.0
      DO 71 J=1,MS
      E(I,J)=B(J)*D(J)*WS(I)*SLOPE(I,J)
      TOS3(I,J,IX)=TOS3(I,J,IX)+E(I,J)
      P(I)=P(I)+E(I,J)
71    CONTINUE
61    CONTINUE
      DO 81 I=1,MS
      P(I)=P(I)/GS
      TOS1(I)=TOS1(I)+P(I)
      T1(I,IX)=TOS1(I)
      T2(I,IX)=T1(I,IX)*GS
81    CONTINUE
      DO 65 J=1,MS
      T3(J,IX)=0.0
      DO 70 I=1,MS
      T3(J,IX)=T3(J,IX)+TOS3(I,J,IX)
70    CONTINUE
65    CONTINUE
      T4(IX)=0.0
      DO 77 J=1,MS
      T4(IX)=T4(IX)+T3(J,IX)
77    CONTINUE
      T5(IX)=T4(IX)/GS
C
      DO 86 I=1,MS
      A(I)=0.0
      DO 92 J=1,MS
      A(I)=A(I)+WWS(J)*SLOPE(I,J)
```

```
 92     CONTINUE
        A(I)=1./A(I)
 86      CONTINUE
C
        DO 91 I=1,MS
        DO 101 J=1,MS
        E(I,J)=A(I)*F(I)*WWS(J)*SLOPE(I,J)
        TOS4(I,J,IX)=TOS4(I,J,IX)+E(I,J)
 101    CONTINUE
 91     CONTINUE
C
        DO 111 J=1,MS
        D(J)=0.0
        DO 121 I=1,MS
        D(J)=D(J)+E(I,J)
        T7(J,IX)=D(J)
        T9(J,IX)=T7(J,IX)*GGS
 121    CONTINUE
        D(J)=D(J)*GGS
 111    CONTINUE
C
        DO 120 I=1,MS
        T6(I,IX)=0.0
        DO 130 J=1,MS
        T6(I,IX)=T6(I,IX)+TOS4(I,J,IX)
 130    CONTINUE
 120    CONTINUE
        T8(IX)=0.0
        DO 140 I=1,MS
        T8(IX)=T8(IX)+T6(I,IX)
 140    CONTINUE
        T10(IX)=T8(IX)*GGS
 131    CONTINUE
C
        DO 145 I=1,MS
        T11(I)=0.0
        DO 155 J=1,ZS
        T11(I)=T11(I)+T1(I,J)
 155    CONTINUE
 145    CONTINUE
        DO 160 J=1,ZS
        T12(J)=0.0
        DO 170 I=1,MS
        T12(J)=T12(J)+T1(I,J)
 170    CONTINUE
 160    CONTINUE
        TTOL1=0.0
        DO 180 J=1,ZS
        TTOL1=TTOL1+T12(J)
 180    CONTINUE
```

```
RUN
01 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MAIN
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = LOWRY
*  NO DIAGNOSTICS GENERATED
    *STATISTICS*  NO DIAGNOSTICS THIS STEP :
```

DATA:

ZONE NO. (Z) : 5

ITERATION NO. (M) : 5

α (SL) : 2

AR (G) : 0.3

PSR (GG) : 0.2

```
     ENTER M Z SL G GG
?
?
?
?
   5,5,2,.3,.2
     ENTER A(I TO J)
?
   2,10,15,5,10
?
   10,2,10,15,20
?
   15,10,2,20,25
?
   5,15,20,2,5,
?
   10,20,25,5,2
     ENTER DD(I)
?
1000,0,0,0,0
     ENTER W(I)
?
   10,12,12,10,15
     ENTER WW(I)
?
   5,2,1,10,2
```

ITERATION 1

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	775.59	0.0	0.0	0.0	0.0	775.59	2585.31
2	37.23	0.0	0.0	0.0	0.0	37.23	124.10
3	16.55	0.0	0.0	0.0	0.0	16.55	55.15
4	124.10	0.0	0.0	0.0	0.0	124.10	413.65
5	46.54	0.0	0.0	0.0	0.0	46.54	155.12
BASIC EMPLOYMENT	1000.00	0.0	0.0	0.0	0.0	1000.00	3333.33

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	1907.20	30.52	6.78	610.30	30.52	2585.32
2	10.18	101.81	2.04	9.05	1.02	124.10
3	3.83	3.44	43.03	4.30	0.55	55.15
4	29.64	1.32	0.37	370.47	11.86	413.65
5	8.11	0.81	0.26	64.86	81.08	155.12
TOTAL SERVICE TRIP	1958.95	137.90	52.48	1058.97	125.02	3333.33
SERVICE EMPLOYMENT	391.79	27.58	10.50	211.80	25.00	666.67

ITERATION 2

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	303.87	0.84	0.13	23.64	0.58	329.07	1096.91
2	14.59	25.06	0.39	3.15	0.17	43.36	144.54
3	6.48	1.00	9.80	1.77	0.11	19.17	63.89
4	48.62	0.37	0.08	147.77	2.33	199.16	663.88
5	18.23	0.31	0.08	35.46	21.81	75.90	252.99
BASIC EMPLOYMENT	391.79	27.58	10.50	211.80	25.00	666.67	2222.22

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	809.20	12.95	2.88	258.94	12.95	1096.91
2	11.86	118.58	2.37	10.54	1.19	144.54
3	4.43	3.99	49.85	4.99	0.64	63.89
4	47.57	2.11	0.57	594.58	19.05	663.88
5	13.22	1.32	0.42	105.79	132.23	252.99
TOTAL SERVICE TRIP	886.28	138.95	56.12	974.84	166.05	2222.22
SERVICE EMPLOYMENT	177.26	27.79	11.22	194.97	33.21	444.44

ITERATION 3

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	137.48	0.84	0.16	21.76	0.77	161.01	536.70
2	6.60	25.25	0.42	2.70	0.23	35.40	118.00
3	2.93	1.01	10.48	1.63	0.15	16.20	54.01
4	22.00	0.37	0.07	136.02	3.07	161.57	538.57
5	8.25	0.32	0.08	32.65	28.96	70.26	234.17
BASIC EMPLOYMENT	177.26	27.79	11.22	194.97	33.21	444.44	1481.48

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	395.93	6.33	1.41	126.70	6.33	536.70
2	9.60	96.81	1.94	8.61	0.97	118.00
3	3.75	3.37	42.14	4.21	0.54	54.01
4	30.59	1.72	0.48	490.33	15.44	538.57
5	12.24	1.22	0.39	97.93	122.41	234.19
TOTAL SERVICE TRIP	460.18	109.46	46.35	719.77	145.67	1481.48
SERVICE EMPLOYMENT	92.04	21.89	9.27	143.96	29.14	296.29

ITERATION 4

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	71.38	0.66	0.13	16.07	0.68	88.92	296.41
2	3.43	19.89	0.35	2.14	0.20	26.01	86.69
3	1.52	0.80	8.66	1.21	0.13	12.31	41.03
4	11.42	0.29	0.07	100.44	2.71	114.94	383.12
5	4.28	0.25	0.07	24.10	25.42	54.12	180.40
BASIC EMPLOYMENT	92.04	21.89	9.27	143.96	29.14	296.29	987.65

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	218.66	3.50	0.78	69.97	3.50	296.41
2	7.11	71.13	1.42	6.32	0.71	86.69
3	2.85	2.56	32.01	3.20	0.41	41.03
4	27.45	1.22	0.34	343.12	10.98	383.12
5	9.43	0.94	0.30	75.43	94.29	180.40
TOTAL SERVICE TRIP	265.56	79.35	34.86	498.05	109.89	987.65
SERVICE EMPLOYMENT	53.10	15.87	6.97	99.61	21.98	197.53

ITERATION 5

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	123.55	1.44	0.29	33.36	1.53	160.17	533.91
2	5.93	43.26	0.78	4.45	0.46	54.87	182.91
3	2.64	1.73	19.52	2.50	0.29	26.69	88.96
4	19.77	0.64	0.16	208.49	6.13	235.19	783.98
5	7.41	0.54	0.16	50.04	57.51	115.66	385.53
BASIC EMPLOYMENT	159.30	47.61	20.91	278.83	65.94	592.59	1975.29

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	393.87	6.30	1.46	126.04	6.30	533.91
2	15.01	150.07	3.00	13.34	1.50	182.91
3	6.17	5.55	69.41	6.94	0.89	88.96
4	56.17	2.50	0.70	702.14	22.47	783.98
5	20.15	2.02	0.64	161.21	201.51	385.53
TOTAL SERVICE TRIP	491.37	166.43	75.15	1009.67	232.67	1975.29
SERVICE EMPLOYMENT	98.27	33.29	15.03	201.93	46.53	395.06

TOTAL BASIC EMPLOYMENT AT EACH ITERATION

	ITERATION NUMBER					
ZONE	1	2	3	4	5	TOTAL
1	2585.31	1096.91	536.70	296.41	533.91	5049.25
2	124.10	144.54	118.00	86.69	182.91	656.25
3	55.15	63.89	54.01	41.03	88.96	303.04
4	413.65	663.88	538.57	383.12	783.98	2783.20
5	155.12	252.99	234.19	180.40	385.53	1208.24
TOTAL	3333.33	2222.22	1481.48	987.65	1975.29	9999.96

TOTAL SERVICE EMPLOYMENT AT EACH ITERATION

	ITERATION NUMBER					
ZONE	1	2	3	4	5	TOTAL
1	1958.95	888.28	460.18	265.50	491.37	812.46
2	137.70	133.95	107.46	79.35	166.43	126.42
3	52.48	56.12	46.35	34.86	75.15	52.99
4	1058.99	974.84	719.79	498.03	1009.67	851.27
5	125.02	166.03	145.69	109.89	232.67	155.86
TOTAL	666.67	444.44	296.29	197.53	395.06	1999.99

```
RUN
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MAIN
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = LOWRY
*  NO DIAGNOSTICS GENERATED
    *STATISTICS*  NO DIAGNOSTICS THIS STEP :
```

SENSITIVITY ANALYSIS :

WHEN AR CHANGE FROM 0.3→0.4

```
    ENTER N Z SL G GG
?
?
   5,5,2,.4,.2
    ENTER A(I TO J)
?
   2,10,15,5,10
?
   10,2,10,15,20
?
   15,10,2,20,25
?
   5,15,20,2,5
?
   10,20,25,5,2
    ENTER DD(I)
?
   1000,0,0,0,0
    ENTER W(I)
?
   10,12,12,10,15
    ENTER WW(I)
?
   5,2,1,10,2
```

ITERATION 1

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	775.59	0.0	0.0	0.0	0.0	775.59	1938.99
2	37.23	0.0	0.0	0.0	0.0	37.23	93.07
3	16.55	0.0	0.0	0.0	0.0	16.55	41.37
4	124.10	0.0	0.0	0.0	0.0	124.10	310.24
5	46.54	0.0	0.0	0.0	0.0	46.54	116.34
BASIC EMPLOYMENT	1000.00	0.0	0.0	0.0	0.0	1000.00	2500.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	1430.40	22.89	5.09	457.73	22.89	1938.99
2	7.64	76.36	1.53	6.79	0.76	93.07
3	2.87	2.58	32.27	3.23	0.41	41.37
4	22.23	0.99	0.28	277.85	8.89	310.24
5	6.08	0.61	0.19	48.65	60.81	116.34
TOTAL SERVICE TRIP	1469.21	103.42	39.36	794.24	93.76	2500.00
SERVICE EMPLOYMENT	293.84	20.68	7.87	158.85	18.75	500.00

ITERATION 2

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	227.90	0.63	0.11	17.73	0.44	246.81	617.01
2	10.94	18.79	0.29	2.36	0.13	32.52	81.30
3	4.86	0.75	7.35	1.33	0.08	14.38	35.94
4	36.46	0.28	0.06	110.82	1.74	149.37	373.43
5	13.67	0.23	0.06	26.60	16.36	56.92	142.31
BASIC EMPLOYMENT	293.84	20.68	7.87	158.85	18.75	500.00	1250.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	455.18	7.28	1.62	145.66	7.28	617.01
2	6.67	66.70	1.33	5.93	0.67	81.30
3	2.49	2.24	28.04	2.80	0.36	35.94
4	26.76	1.19	0.33	334.45	10.70	373.43
5	7.44	0.74	0.24	59.51	74.38	142.31
TOTAL SERVICE TRIP	498.53	78.16	31.57	548.34	93.39	1250.00
SERVICE EMPLOYMENT	99.71	15.63	6.31	109.67	18.68	250.00

ITERATION 3

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	77.33	0.47	0.09	12.24	0.43	90.57	226.42
2	3.71	14.20	0.24	1.63	0.13	19.91	49.78
3	1.65	0.57	5.89	0.92	0.08	9.11	22.78
4	12.37	0.21	0.05	76.51	1.74	90.88	227.21
5	4.64	0.18	0.05	18.36	16.29	39.52	98.80
BASIC EMPLOYMENT	99.71	15.63	6.31	109.67	18.68	250.00	625.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	167.03	2.67	0.59	53.45	2.67	226.42
2	4.08	40.84	0.82	3.63	0.41	49.78
3	1.58	1.42	17.78	1.78	0.23	22.78
4	16.28	0.72	0.20	203.49	6.51	227.21
5	5.16	0.52	0.17	41.31	51.64	98.80
TOTAL SERVICE TRIP	194.14	46.18	19.56	303.66	61.46	625.00
SERVICE EMPLOYMENT	38.83	9.24	3.91	60.73	12.29	125.00

ITERATION 4

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	30.11	0.28	0.05	6.78	0.29	37.51	93.79
2	1.45	8.39	0.15	0.90	0.09	10.97	27.43
3	0.64	0.34	3.65	0.51	0.05	5.19	12.98
4	4.82	0.12	0.03	42.37	1.14	48.49	121.22
5	1.81	0.10	0.03	10.17	10.72	22.83	57.08
BASIC EMPLOYMENT	38.83	9.24	3.91	60.73	12.29	125.00	312.50

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	69.19	1.11	0.25	22.14	1.11	93.79
2	2.25	22.50	0.45	2.00	0.23	27.43
3	0.90	0.81	10.13	1.01	0.13	12.98
4	8.69	0.39	0.11	108.57	3.47	121.22
5	2.98	0.30	0.10	23.87	29.84	57.08
TOTAL SERVICE TRIP	84.01	25.11	11.03	157.59	34.77	312.50
SERVICE EMPLOYMENT	16.80	5.02	2.21	31.52	6.95	62.50

ITERATION 5

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	26.06	0.30	0.06	7.04	0.32	33.79	84.47
2	1.25	9.12	0.16	0.94	0.10	11.58	28.94
3	0.56	0.36	4.12	0.53	0.06	5.63	14.07
4	4.17	0.14	0.03	43.98	1.29	49.61	124.03
5	1.56	0.11	0.03	10.55	12.13	24.40	60.99
BASIC EMPLOYMENT	33.60	10.04	4.41	63.03	13.91	125.00	312.50

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	62.31	1.00	0.22	19.94	1.00	84.47
2	2.37	23.74	0.47	2.11	0.24	28.94
3	0.78	0.88	10.98	1.10	0.14	14.07
4	8.89	0.39	0.11	111.08	3.55	124.03
5	3.19	0.32	0.10	25.50	31.88	60.99
TOTAL SERVICE TRIP	77.74	26.33	11.89	159.73	36.81	312.50
SERVICE EMPLOYMENT	15.55	5.27	2.38	31.95	7.36	62.50

TOTAL BASIC EMPLOYMENT AT EACH ITERATION

ITERATION NUMBER

ZONE	1	2	3	4	5	TOTAL
1	1938.99	617.01	226.42	93.79	84.47	2960.67
2	73.07	81.30	49.78	27.43	28.94	280.53
3	41.37	35.94	22.78	12.98	14.07	127.14
4	310.24	373.43	227.21	121.22	124.03	1156.13
5	116.34	142.31	98.80	57.08	60.99	475.52
TOTAL	2500.00	1250.00	625.00	312.50	312.50	4999.98

TOTAL SERVICE EMPLOYMENT AT EACH ITERATION

ITERATION NUMBER

ZONE	1	2	3	4	5	TOTAL
1	1469.21	498.53	194.14	84.01	77.74	464.73
2	103.42	78.16	46.18	25.11	26.33	55.84
3	39.36	31.57	19.56	11.03	11.89	22.68
4	794.24	548.34	303.66	157.59	159.73	392.71
5	93.76	93.39	61.46	34.77	36.81	64.04
TOTAL	500.00	250.00	125.00	62.50	62.50	1000.00

E

```
RUN
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MAIN
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = LOWRY
*  NO DIAGNOSTICS GENERATED
    *STATISTICS*  NO DIAGNOSTICS THIS STEP :
```

SENSITIVITY ANALYSIS :

WHEN AR CHANGE FROM 0.3 → 0.4

AND WW_3 : 1 → 5

```
    ENTER M Z SL G GG
?
?
   5,5,2,.4,.2
    ENTER A(I TO J)
?
   2,10,15,5,10
?
   10,2,10,15,20
?
   15,10,2,20,25
?
   5,15,20,2,5
?
   10,20,25,5,2
    ENTER DD(I)
?
   1000,0,0,0,0
    ENTER W(I)
?
   10,12,12,10,15
    ENTER WW(I)
?
   5,2,5,10,2
```

ITERATION 1

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	775.59	0.0	0.0	0.0	0.0	775.59	1938.99
2	37.23	0.0	0.0	0.0	0.0	37.23	93.07
3	16.55	0.0	0.0	0.0	0.0	16.55	41.37
4	124.10	0.0	0.0	0.0	0.0	124.10	310.24
5	46.54	0.0	0.0	0.0	0.0	46.54	116.34
BASIC EMPLOYMENT	1000.00	0.0	0.0	0.0	0.0	1000.00	2500.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	1415.55	22.65	25.17	452.98	22.65	1938.99
2	7.17	71.65	7.17	6.37	0.72	93.07
3	0.70	0.63	39.16	0.78	0.10	41.37
4	22.15	0.98	1.38	276.86	8.86	310.24
5	6.04	0.60	0.97	48.32	60.40	116.34
TOTAL SERVICE TRIP	1451.60	96.52	73.84	785.31	92.73	2500.00
SERVICE EMPLOYMENT	290.32	19.30	14.77	157.06	18.55	500.00

ITERATION 2

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	225.17	0.58	0.20	17.53	0.43	243.92	609.81
2	10.81	17.54	0.55	2.34	0.13	31.37	78.41
3	4.80	0.70	13.79	1.31	0.08	20.69	51.73
4	36.03	0.26	0.11	109.58	1.73	147.71	369.26
5	13.51	0.22	0.11	26.30	16.18	56.32	140.79
BASIC EMPLOYMENT	290.32	19.30	14.77	157.06	18.55	500.00	1250.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	445.19	7.12	7.91	142.46	7.12	609.81
2	6.04	60.37	6.04	5.37	0.60	78.41
3	0.87	0.78	48.97	0.98	0.13	51.73
4	26.36	1.17	1.65	329.54	10.55	369.26
5	7.31	0.73	1.17	58.48	73.10	140.79
TOTAL SERVICE TRIP	485.77	70.18	65.74	536.82	91.50	1250.00
SERVICE EMPLOYMENT	97.15	14.04	13.15	107.36	18.30	250.00

ITERATION 3

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	75.35	0.43	0.16	11.98	0.43	88.37	220.92
2	3.62	12.75	0.49	1.60	0.13	18.59	46.46
3	1.61	0.51	12.27	0.90	0.08	15.37	38.43
4	12.06	0.19	0.10	74.91	1.70	88.96	222.39
5	4.52	0.16	0.10	17.98	15.96	38.72	96.79
BASIC EMPLOYMENT	97.15	14.04	13.15	107.36	18.30	250.00	625.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	161.28	2.58	2.87	51.61	2.58	220.92
2	3.58	35.77	3.58	3.18	0.36	46.46
3	0.65	0.58	36.38	0.73	0.09	38.43
4	15.88	0.71	0.99	198.46	6.35	222.39
5	5.03	0.50	0.80	40.21	50.26	96.79
TOTAL SERVICE TRIP	186.41	40.14	44.62	294.19	59.64	625.00
SERVICE EMPLOYMENT	37.28	8.03	8.92	58.84	11.93	125.00

ITERATION 4

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	28.92	0.24	0.12	6.57	0.28	36.13	90.32
2	1.39	7.29	0.33	0.88	0.08	9.97	24.94
3	0.62	0.29	8.35	0.49	0.05	9.79	24.46
4	4.63	0.11	0.07	41.05	1.11	46.96	117.41
5	1.73	0.09	0.07	9.85	10.40	22.15	55.37
BASIC EMPLOYMENT	37.28	8.03	8.92	58.84	11.93	125.00	312.50

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	65.94	1.05	1.17	21.10	1.05	90.32
2	1.92	19.20	1.92	1.71	0.19	24.94
3	0.41	0.37	23.16	0.46	0.06	24.46
4	8.38	0.37	0.52	104.78	3.35	117.41
5	2.87	0.29	0.46	23.00	28.75	55.37
TOTAL SERVICE TRIP	79.53	21.28	27.24	151.04	33.41	312.50
SERVICE EMPLOYMENT	15.91	4.26	5.45	30.21	6.68	62.50

```
RUN
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MAIN
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = LOWRY
*  NO DIAGNOSTICS GENERATED
    *STATISTICS*  NO DIAGNOSTICS THIS STEP :
```

SENSITIVITY ANALYSIS:

WHEN AR : 0.3 → 0.4

AND α : 2 → 1

```
    ENTER M Z SL C OG
?
?
   5,5,1,.4,.2
    ENTER A(I TO J)
?
 1^  2,10,15,5,10
?
   10,2,10,15,20
?
   15,10,2,20,25
?
   5,15,20,2,5
?
   10,20,25,5,2
    ENTER DD(I)
?
   1000,0,0,0,0
    ENTER W(I)
?
   10,12,12,10,15
    ENTER WW(I)
?
   5,2,1,10,2
```

ITERATION 1

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	476.19	0.0	0.0	0.0	0.0	476.19	1190.48
2	114.29	0.0	0.0	0.0	0.0	114.29	285.71
3	76.19	0.0	0.0	0.0	0.0	76.19	190.48
4	190.48	0.0	0.0	0.0	0.0	190.48	476.19
5	142.86	0.0	0.0	0.0	0.0	142.86	357.14
BASIC EMPLOYMENT	1000.00	0.0	0.0	0.0	0.0	1000.00	2500.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	599.23	47.94	15.98	479.39	47.94	1190.47
2	60.36	120.72	12.07	80.48	12.07	285.71
3	39.35	23.61	59.03	59.03	9.45	190.48
4	72.33	9.04	3.62	361.66	28.93	476.19
5	49.06	9.81	3.92	196.23	98.12	357.14
TOTAL SERVICE TRIP	820.34	211.73	94.63	1176.80	196.51	2500.00
SERVICE EMPLOYMENT	164.07	42.35	18.93	235.36	39.30	500.00

ITERATION 2

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	78.13	4.40	1.41	41.29	3.39	128.62	321.56
2	18.75	26.42	2.53	16.52	2.04	66.26	165.64
3	12.50	5.28	12.66	12.39	1.63	44.46	111.16
4	31.25	2.94	1.06	103.23	6.79	145.26	363.14
5	23.44	3.30	1.27	61.94	25.45	115.40	288.49
BASIC EMPLOYMENT	164.07	42.35	18.92	235.36	39.30	500.00	1250.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	161.86	12.95	4.32	129.49	12.95	321.56
2	34.99	69.99	7.00	46.66	7.00	165.64
3	22.97	13.78	34.45	34.45	5.51	111.16
4	55.16	7.35	2.76	275.80	22.06	363.14
5	39.63	7.93	3.17	158.51	79.26	288.49
TOTAL SERVICE TRIP	314.61	112.00	51.69	644.91	126.78	1250.00
SERVICE EMPLOYMENT	62.92	22.40	10.34	128.98	25.36	250.00

ITERATION 3

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	29.96	2.33	0.77	22.63	2.19	57.88	144.70
2	7.19	13.98	1.38	9.05	1.31	32.92	82.29
3	4.79	2.80	6.92	6.79	1.05	22.35	55.87
4	11.99	1.55	0.56	56.57	4.36	75.07	187.66
5	8.99	1.75	0.69	33.94	16.42	61.79	154.48
BASIC EMPLOYMENT	62.92	22.40	10.34	128.98	25.36	250.00	625.00

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	72.83	5.83	1.94	58.27	5.83	144.70
2	17.38	34.77	3.48	23.18	3.48	82.29
3	11.54	6.93	17.31	17.31	2.77	55.87
4	28.51	3.80	1.43	142.53	11.40	187.66
5	21.22	4.24	1.70	84.88	42.44	154.48
TOTAL SERVICE TRIP	151.49	55.57	25.86	326.17	65.92	625.00
SERVICE EMPLOYMENT	30.30	11.11	5.17	65.23	13.18	125.00

ITERATION 4

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	14.43	1.16	0.38	11.44	1.14	28.55	71.38
2	3.46	6.95	0.69	4.58	0.68	16.35	40.87
3	2.31	1.39	3.46	3.43	0.55	11.14	27.84
4	5.77	0.77	0.29	28.61	2.28	37.72	94.30
5	4.33	0.87	0.35	17.17	8.54	31.25	78.12
BASIC EMPLOYMENT	30.30	11.11	5.17	65.23	13.18	125.00	312.50

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	35.93	2.87	0.96	28.74	2.87	71.38
2	8.64	17.27	1.73	11.51	1.73	40.87
3	5.75	3.45	8.63	8.63	1.38	27.84
4	14.32	1.91	0.72	71.62	5.73	94.30
5	10.73	2.15	0.86	42.92	21.46	78.12
TOTAL SERVICE TRIP	75.37	27.65	12.89	163.42	33.17	312.50
SERVICE EMPLOYMENT	15.07	5.53	2.58	32.68	6.63	62.50

ITERATION 5

ITERATION OF RESIDENT POPULATION

ZONE	1	2	3	4	5	TOTAL	RES
1	14.36	1.15	0.38	11.47	1.15	28.50	71.26
2	3.45	6.90	0.69	4.59	0.69	16.31	40.78
3	2.30	1.38	3.45	3.44	0.55	11.12	27.79
4	5.74	0.77	0.29	28.67	2.29	37.76	94.40
5	4.31	0.86	0.34	17.20	8.59	31.31	78.27
BASIC EMPLOYMENT	30.15	11.06	5.15	65.37	13.27	125.00	312.50

ITERATION OF SERVICE EMPLOYMENT

ZONE	1	2	3	4	5	TOTAL
1	35.87	2.87	0.96	28.69	2.87	71.26
2	8.61	17.23	1.72	11.49	1.72	40.78
3	5.74	3.45	8.61	8.61	1.38	27.79
4	14.34	1.91	0.72	71.69	5.74	94.40
5	10.75	2.15	0.86	43.01	21.50	78.27
TOTAL SERVICE TRIP	75.32	27.61	12.87	163.50	33.21	312.50
SERVICE EMPLOYMENT	15.06	5.52	2.57	32.70	6.64	62.50

TOTAL BASIC EMPLOYMENT AT EACH ITERATION

	ITERATION NUMBER					
ZONE	1	2	3	4	5	TOTAL
1	1190.48	321.56	144.70	71.38	71.26	1799.36
2	285.71	165.64	82.29	40.87	40.78	615.29
3	190.48	111.16	55.87	27.84	27.79	413.13
4	476.19	363.14	187.66	94.30	94.40	1215.69
5	257.14	208.49	154.48	78.12	78.27	956.51
TOTAL	2500.00	1250.00	625.00	312.50	312.50	4999.98

TOTAL SERVICE EMPLOYMENT AT EACH ITERATION

	ITERATION NUMBER					
ZONE	1	2	3	4	5	TOTAL
1	820.34	314.61	151.49	75.37	75.32	287.42
2	211.73	112.00	55.57	27.65	27.61	86.91
3	94.63	51.69	25.86	12.89	12.87	39.59
4	1176.80	644.91	326.17	163.42	163.50	494.96
5	196.51	126.78	65.92	33.17	33.21	91.12
TOTAL	500.00	250.00	125.00	62.50	62.50	1000.00