An Operational Planning Information System for Small Communities

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The wealth of data collected on the urban area by many people for a multiplicity of purposes has led to an inefficient, disorganized utilization of resources for data handling. Until recently, most of the information collected has been gathered by a specific group for a specific purpose. This information was not usable by other than the primary data recipient because of its narrow definitions and specific characteristics. Provided herein is a system whereby data that are collected only once are usable by all segments of the urban environment. Universally compatible definitions, aggregation units, and procedures are described. Computer programs were developed to handle the data for the system. The Environmental Data Storage and Retrieval System (EDSARS) will make a useful tool for all segments of the urban environment by putting all generally usable data in one place with one set of definitions and aggregated on one useful module, using one set of data handling procedures. The basic unit of data collection established was the parcel, thereby providing a high degree of flexibility in data aggregation. The conceptual development of information theory as it applies to urban data systems is first explored. The actual conceptual development of EDSARS is explained next, followed by the operational procedures needed to utilize the EDSARS system.

• FUNDAMENTAL to the planning process is the development of alternative plans, which are given to the decision-maker for action. These plans develop as a result of thorough analysis of proper and sufficient data. Analyses are good as, but no better than, the data quality. The present trend seems to be to seek more symptomatic relationships, which implies more data variables. Today it appears almost natural for researchers to add variables to the correlation analysis to increase the amount of variability of the dependent variable that can be explained. In spite of the general knowledge of the costliness of data collection, more data are being collected by more people for more reasons than ever before.

The value of data for proper analysis is not being questioned. The critical point is the efficiency of the entire data system, not from the standpoint of an individual user but in terms of total system costs. Data are being collected on many aspects, from the individual's health to the number of trips he makes. In the past, most of this information was gathered by a specific agency for a specific use, each agency applying its own individualized definitions to the data. For example, definitions of land-use density range from trips generated per acre to persons per square foot of floor space. The definition always has depended upon the information user. This multiplicity of data defini-

Paper sponsored by Department of Urban Transportation Planning.

tions and uses results in a hodgepodge of data collected many times by many agencies, often without knowledge of each other's efforts (1).

Public agencies gather much of their data for normal operations; these data could be very useful to other agencies at little additional cost if only common definitions and parameters could be established. Without these common definitions and parameters, it is difficult for each agency to visualize the urban environment except in the perspective of its own narrowly defined information requirements.

Each urban area has developed a multiplicity of plans to channel its growth in a manner that is deemed best for the community as a whole. Just as the different agencies collect and use their own data, so do the various urban studies. Whereas a recreational or school plan may use much of the data collected in a transportation study, the differences in data definitions and aggregation units make the information nearly useless for any study other than the one for which the data were collected.

There are many segments of the urban environment that desire information about the community. Any company, organization, or group that presently wants data on the community must collect the information itself or accept the narrow definitions of the data now established by existing governmental groups or studies.

To facilitate the use of data by other than the primary information receiver, a set of universally compatible definitions is needed. This set of definitions is not impossible to develop if one attempts to direct the collection of "pure" data. The term "pure" simply means that the information should not be aggregated before collection. For instance, when square feet of space is collected, it should be recorded as square feet, not square feet per some other dimension. Information concerning square feet per employee may be useful to an industry, but a knowledge of square feet of building and the number of employees is much more useful for planning purposes and still serves the original purpose.

The data system that is described here is an attempt to develop a tool for urban decision-making that utilizes data from many sources and makes this information available to and usable by other sectors of the urban community.

THE SCOPE

The project described involved the development of an urban data system for an area of approximately 100,000 population. The Lafayette-West Lafayette area in Indiana was used to demonstrate the application of the developed system. In the Greater Lafayette area, the conduct of a land use and transportation study was under consideration. In anticipation of the development of these data, this planning information system was developed. The system, referred to as the Environmental Data Storage and Retrieval System (EDSARS), was to be much broader than the proposed study (2).

The first developmental problem was choosing the degree of sophistication needed for such a system. This involved choosing a particular level in a hierarchy of data system complexity. After the level of sophistication had been decided, the basic data collection and aggregation module was chosen. The data to be used were selected along with specific definitions for each item. The methodology for entering these data into the system was developed along with updating procedures to keep information current. A logical and easily used means of data storage and retrieval was developed to facilitate use of the system by a wide variety of people.

DESCRIPTION OF EDSARS

Level of Data Sophistication

The information used in EDSARS is taken from the data library level in data hierarchy. Banked data, another level in the information hierarchy, are organized into machine records but need not be functional or logical in format. Raw data make up the lowest level of data sophistication. These data are not machine digestable and therefore are not usable in an organized data system. The data library information is logical and functional in format and can be updated, searched, and retrieved; these requirements are essential for any urban data system.

Level of System Sophistication

The three levels of system sophistication vary in the complexity of models incorporated. The first level uses no models, the second uses specialized models, and the third uses simulation. EDSARS, which is an attempt to develop the initial phase of an urban data system, uses the first level of sophistication. The system contains tabulated data but no specialized or simulation models. It is felt that the model requirements will evolve from the users' demands on the data system. The addition of models to the system can be made within the present format; the data in the system will feed directly any models developed in the future.

The computer hardware that is incorporated also influences the level of system sophistication. EDSARS uses the CDC 6500 computer at Purdue University. The CDC 6500 is a general purpose computer, and the programming language is CHIPPEWA FORTRAN. The data system can be initialized and information retrieved or updated by merely submitting the correct program deck to the computer science center. The updating, retrieval, or initialization will be run just as any other job that is submitted to the computer. The information for EDSARS now is stored on tape. As the system is initialized and the amount of stored information grows, the incorporation of a "disk pack" will become feasible. A disk pack is a mountable disk storage device that enables random access of information. This direct access feature will save valuable computer time when the system searches large quantities of data.

The decisions on the level of system sophistication were the result of many factors. Models were not incorporated into the system because of the need for actual data to test the validity of a model. This project outlines the initialization of EDSARS without actually inserting real data. The amount of data needed to initialize the system makes initialization another entire project of at least 1 to 2 years in duration. Once the initialization is complete, the addition of models can be considered.

The decision to use the CDC 6500 computer was made in light of the hardware available. Purdue University now has an IBM 7094 computer that could handle a data system such as EDSARS. The 7094, however, is a second generation computer; this type of computer is now in the process of being phased out by many organizations, being replaced by a third generation computer such as the CDC 6500. Any work done in the future on data systems most probably will be done on the more advanced equipment such as the CDC 6500. The use of CHIPPEWA FORTRAN was the result of the authors' knowledge of the language and the efficient data-handling capabilities of the FORTRAN developed for the CDC system.

Data Module

The data module for EDSARS is the parcel. This aggregation module seems to be almost the universal choice of existing urban data systems. The parcel provides a flexible, multipurpose base from which to work. The data to be incorporated into an urban data system are easily keyed to the parcel. The tagging methods work well with the parcel module. The parcel forms a very useful aggregation unit in that it is the largest common denominator that can be used to build zones. Any zone in an urban area can be represented fairly accurately by a composite of parcels. This capability gives the system maximum flexibility in the designation of zones with a minimum number of data units.

The parcel in EDSARS is defined as all contiguous land under one ownership and one general land use. This definition closely parallels the parcel used in assessors' records. If two adjacent pieces of land are owned by the same person and used for the same purpose, they are listed as one parcel. If two adjacent parcels have different uses, they are listed as two parcels. This definition, being general, allows a certain measure of ambiguity in the designation of a parcel; the system has the ability, however, to join two or more parcels into one new parcel or to break one parcel into two or more parcels. This capability of redefining parcels allows the system to establish its own equilibrium as the data are used and reevaluated.

A special definition of the parcel is used when rights-of-way are coded. Each street segment and utility right-of-way is coded just as any other parcel. A street or right-of-way is broken into block-long segments if the block length is 500 feet or less; if the block length is longer than 500 feet, the block is broken into segments of 500 feet or less. An intersection is taken as a street parcel. The parcel boundaries are defined as the right-of-way lines for the street segments. An example of an area divided into parcels is shown in Figure 1.

Data Tagging Methods

EDSARS uses both the name and location methods of tagging data. The name tag is the street address of a building or empty parcel. The street number, name, and type (e.g., drive, street, lane, etc.) all are noted in the name tag of the parcel or building. For rural areas the street number is replaced by the rural route number, and the street name is replaced by "Rural Route." The name method of tagging gives the system the capability of locating data for the user on a basis that is familiar to all segments of the urban environment. Street addresses are universally known and understood and, therefore, enable all potential users to be familiar with at least one retrieval method.

Street segments are coded by the street name and the number (in hundreds) of most of the houses on the street segment. A segment along a street called Main Street in which house numbers go from 100 to 225 would be coded as 100B Main Street, which means the 100 block of Main Street. This code gives the benefits of the name tag to street segments as well as individual parcels and buildings.

The location tag utilized by EDSARS is a rectangular grid coordinate system, which is superimposed over the entire development area. The grid coordinate uses 1 foot as the basic unit. The parcels and street lengths are tagged by the coordinates of their approximate centroid. The actual digitizing of the coordinates is accomplished by an automatic coordinate digitizer. By the use of a location tag, internal logic is added to the data in EDSARS. The coordinates facilitate the retrieval of data on an areal basis. Data for certain geographical segments of the development area can be retrieved directly with the use of the coordinates, and density computations become immediately possible.

Rectangular grid coordinates provide another very useful capability. A zone, such as a census tract or transportation zone, can be represented by the grid coordinates of its boundary. This is accomplished by representing the zone by a series of triangles and digitizing the coordinates of the vertices. By representing zones in this way, a dictionary of zone names and grid coordinates is developed. When any information is desired on a zonal basis, the coordinates of the zone are read, and each parcel is tested to establish whether it lies within the zone in question. The information for each parcel within the zone is retrieved and aggregated, thereby giving information on the desired zonal basis. Figure 2 shows a zone broken into triangles for coding.

To coordinate the actual data incorporated into the system and the tags for each parcel, a dictionary with the parcel number, building number, and street address (or block number for street segments) is developed. Another file coordinating each parcel number and grid coordinate then is initialized. The actual data are stored in conjunction with a parcel number. The data are related to the name and location tags through the parcel number-building number-street address dictionary and the parcel number-grid coordinate dictionary. The parcel number is merely a unique number of one to six digits given to each parcel. The numbers need not be consecutive or have any

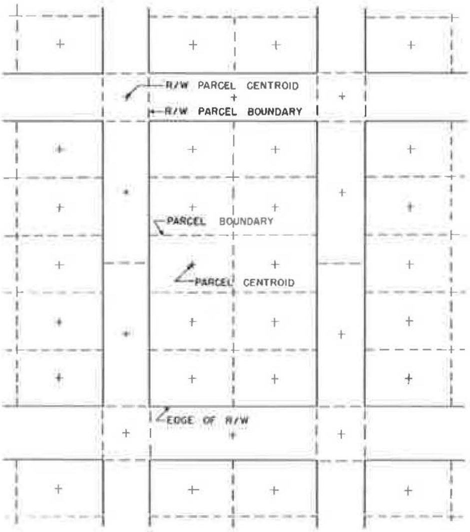


Figure 1. Separating an area into parcels for data coding.

logical order. The only requirement is that each parcel have only one number.

Data Dimensions

The definition of land use developed by the Metropolitan Washington Council of Governments was used in determining the data needed to define the different areas of land use. Data were examined in the light of how well they defined the following (3):

1. Type of activity
2. Type of structure
3. Type of land use
4. Intensity of use
5. Aesthetic qualities
6. Restrictions on use
7. Nuisance characteristics
8. Economic functions

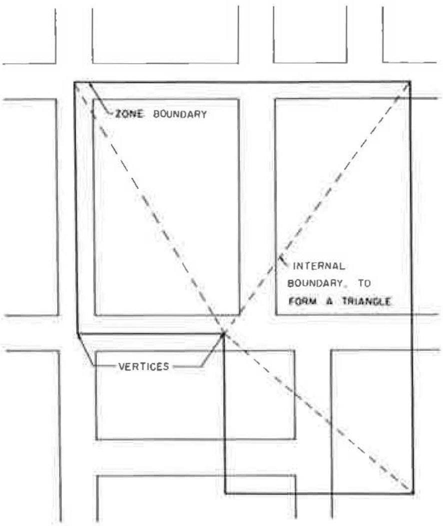


Figure 2. Zone divided into triangles for data coding.

To completely describe the urban environment, the information on each parcel is arranged into three categories.

1. Parcel information—information on the parcel itself, including dimensions, restrictions, zoning, and use.
2. Building information—information on each building on a parcel, including age, value, type of construction, condition, and size.
3. Establishment information—specific information on each unit within a building such as a business, a dwelling unit, etc., including space use, number of employees, number of residents, age of residents, and number of vehicles.

Information relating to these categories is collected by local studies and surveys such as those conducted by the Louisville Metropolitan Comprehensive Transportation and Development Program (4 through 18). The categories contain the following data items:

Parcel information

1. Land use
2. Ownership
3. Frontage
4. Area
5. Year of subdivision
6. Assessed value of land
7. Easement
8. Landmark
9. Neighborhood characteristics
10. Land appearance
11. Number of structures
12. Year of zoning change
13. Zoning
14. Zone change request number
15. Variance number
16. Comprehensive plan use
17. Utilities
18. Parking spaces
19. Loading area
20. Assessed value of improvements
21. Total assessed value
22. Sale date
23. Sale price
24. Nuisances

(The following data are collected for street segment parcels.)

25. Intersection
26. Length of segment
27. Right-of-way width
28. Pavement width
29. Functional class
30. Structural composition
31. Percent grade
32. Average daily traffic
33. Number of accidents
34. Traffic control signs and signals
35. Speed limit

36. Curb parking regulations
37. Curb type
38. Sidewalks
39. Number of lanes
40. Loading zone
41. Bus route
42. School route
43. Access control
44. Condition

Building information

1. Year built
2. Type of construction
3. Type of structure
4. Building condition
5. Year of latest building permit
6. Cumulative cost of building permits
7. Number of floors
8. Total floor area
9. Basement
10. First floor area
11. Number of dwelling units
12. Building setback
13. Required setback
14. Rehabilitation cost
15. Type of building code violations
16. Number of building code violations
17. Number of establishments

Establishment information

1. Space use
2. Total number of employees
3. First floor area
4. Total floor areas
5. Number of rooms for rent
6. Number of residents by sex and age group
7. Family income
8. Vehicles owned
9. Police calls
10. Fire calls
11. Welfare payment
12. Number of communicable diseases
13. Type of communicable diseases
14. Rent

Each data item that was entered into the system was judged to be important to the planning community, able to be updated, and relatively easy to collect. Data that were too expensive to collect or not updatable were not incorporated into the system.

OPERATION OF EDSARS

Data File Characteristics

The data in EDSARS are in four files. The first data file contains parcel numbers and parcel grid coordinates. Each parcel is given a unique number to identify it as a data entity; this number is correlated to the grid coordinates of the approximate parcel centroid by the parcel number-grid coordinate file. The second data file contains the parcel number and building number and street address of each building in the system. In the case of a parcel with no building, the building number is listed as zero. Each building is given a unique number on a parcel and coordinated to the correct address by the parcel number-building number-street address file. The third data file contains the parcel number and all general data on that parcel. The data for each parcel are correlated to the street address and grid coordinate via the parcel number. The fourth data file contains zone names and the coordinates of the zone boundary.

These four data files make up the data storage portion of EDSARS. The actual data are stored on tape and can be manipulated by a set of package programs. The first set of programs initializes the system by reading cards and writing the information on tape. The second set of programs incorporates more data items when they become available. The third set of programs reads the data tape and writes on paper. This set of programs checks the other program sets and gives a complete list of all data in the system. The fourth set of programs updates the values of data items in the system when current information becomes available. The fifth and final set of programs retrieves information from the system for special user purposes. The following is an explanation of the package programs and procedures for using them in EDSARS.

General Program Information

Each of the programs discussed below manipulates the data in EDSARS. When data cards are read into the system, a card with "7, 8, and 9" punched in column one must follow the main body of the program and precede the actual data cards. When general data cards are read the last card should have a "99" in columns seven and eight. This indicates end-of-data to the system. The last data card in the zone-grid coordinate file, the parcel number-building number-street address file; and the parcel number-grid coordinate file should be blank to indicate end-of-data to the system. The last data card is followed by a card with "6, 7, 8, and 9" punched in column one. This indicates end-of-program to the computer. If no data cards are used in a program, the "6, 7, 8, and 9" card immediately follows the main body of the program.

Data File Initialization

Parcel Number-Grid Coordinate File—The initialization of the parcel number-grid coordinate file occurs first. To initialize this file, a coordinate digitizer is used (2). An accurate base map of the entire development area is placed on the digitizer, and a point 1,000 feet south and 1,000 feet west of the southwestern corner of the development area is set as point 0,0. Key points on the base map are digitized. The digitizer gives readings in inches, and these readings are converted to feet; the conversion depends upon the scale of the map used.

The key points digitized are the intersections of street centerlines. The key points located on the base map are digitized on the more accurate maps, and the coordinates of these key points serve as reference coordinates for the digitizing of all parcels.

Each map to be digitized, other than the base map, is first broken into parcels and approximate centroids located as shown in Figure 1. Consecutive parcel numbers are written on the map for each parcel. The map is placed on the digitizer, and its key point located (for coordinate conversion to the base system); then each parcel centroid can be digitized. The digitizer will punch the parcel number and the grid coordinates on an IBM card that can be fed into the computer for coordinate conversion.

The data cards for actual initialization of this data file are read into the system via the "Initialize Parcel Number-Grid Coordinate File" program. The data cards for this file should have the format shown in Figure 3. This figure also can serve as a sample coding sheet. The parcel number is placed in columns one to six. The x coordinate is placed in columns eight to 13 and the y coordinate in columns 15 to 20. When more information becomes available, a program titled "Read More Information for the Parcel Number-Grid Coordinate File" is used. This data file locates all the parcels in the development area and coordinates the parcel location to a particular parcel number. This number is the identifying tag in the system used to locate all data that pertain to this particular parcel.

Parcel Number-Building Number-Address File—The parcel number-building number-address file is initialized by putting the parcel number in columns one to six and the building number in columns 20 and 21. The street or rural route number is placed in columns 22 to 27. If the parcel is a street segment, the block number is placed in columns 20 to 26, with a "B" in column 27 to indicate "street block." All these numbers should be right justified. Columns 30 to 69 contain the street name or "Rural Route." The name should start in column 30 and be punched on the card just as it appears in the town directory, with one column between each word in the name. The type of street is coded in columns 70 to 72. Format for this file card is shown in Figure 3. When more information becomes available, a program titled "Read More Information for the Parcel Number-Building Number-Address File" is used. This file coordinates each building, vacant parcel, and block segment with a particular address in the development area.

General Data File—The file for general data is initialized after each parcel in the development area has been given a unique number. The format for general data cards is shown in Figure 4; this figure also can serve as a sample coding sheet. The 01 card is

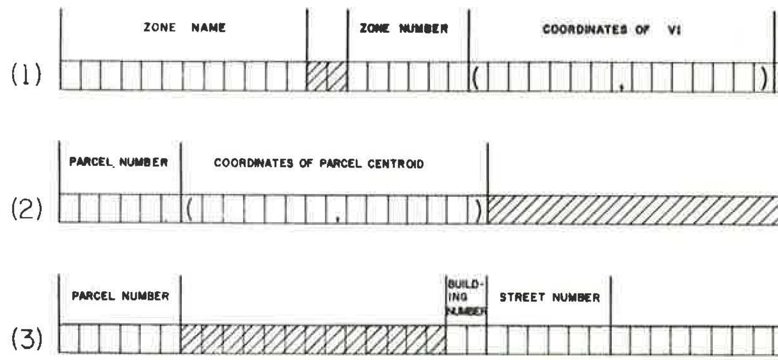


Figure 3. Format of (1) zone name-grid coordinate card; (2) parcel number-grid coordinat

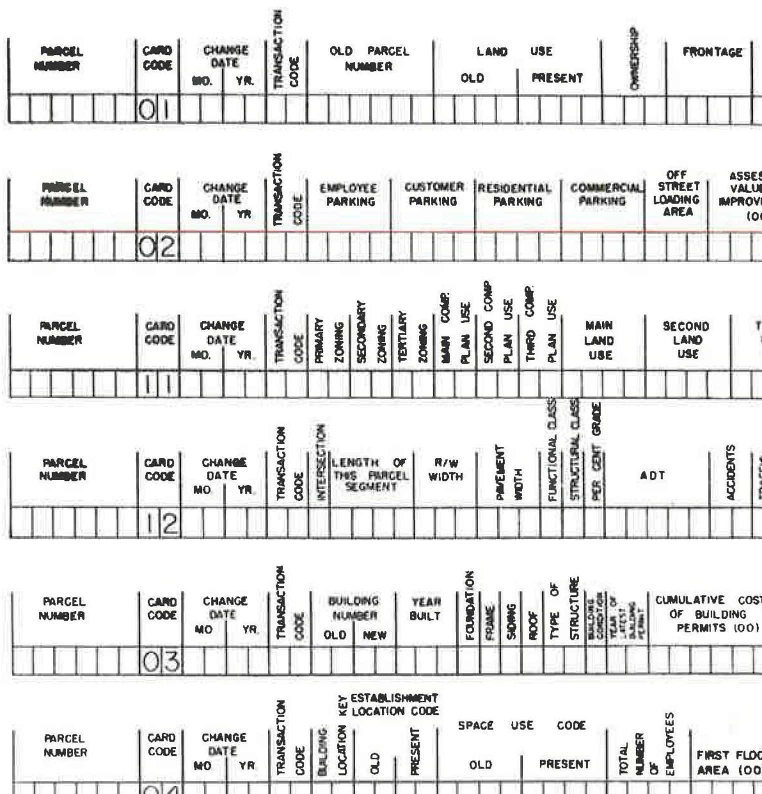
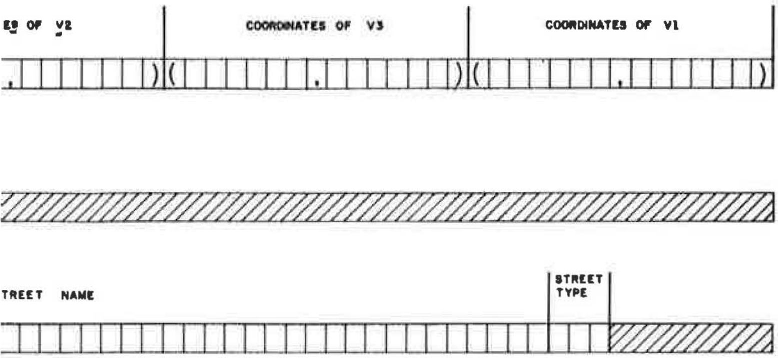
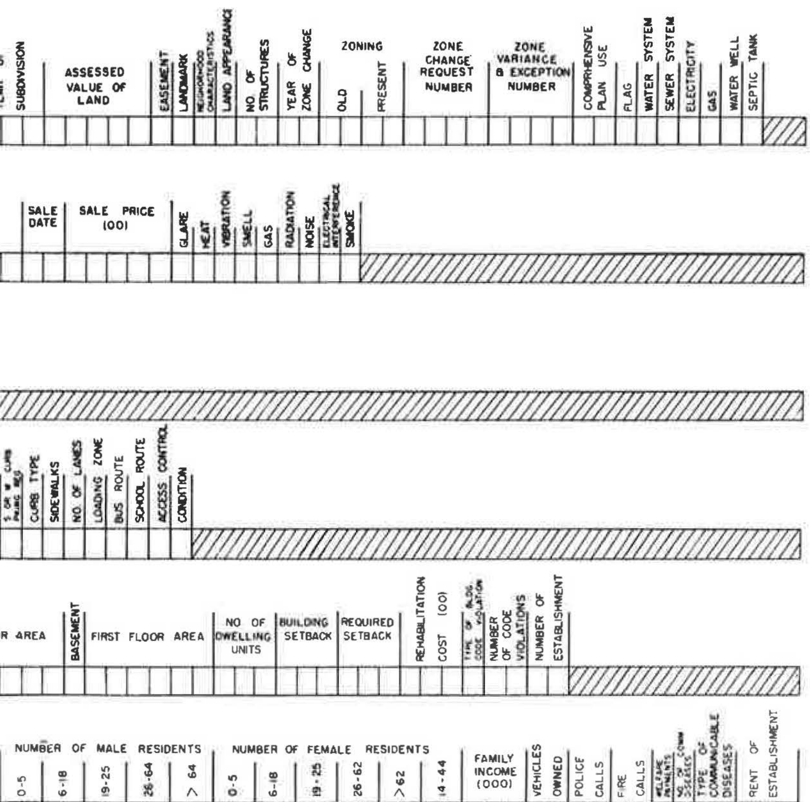


Figure 4. Format of general data cards.



arcel number-building number-address card.



used for every parcel in the development area. The 02 card is used when the parcel has a use other than right-of-way. A 12 card is used in place of the 02 card when a parcel has a right-of-way. If the parcel has multiple land uses or zoning or comprehensive land uses, an 11 card is used to supplement the 01 and 02 cards. Each building on a parcel is represented by the information on the 03 card, and each establishment (dwelling unit, business, office, etc.) in a building is represented by an 04 card. The information in the general data file is broken into three categories. The first category is land-use information and is represented by the 01, 02 or 12, and 11 cards; the second category is building information, which is represented on the 03 card; and the third category is establishment information, which is represented on the 04 card.

Each data item in the system is given a specific name that can be used to refer to the particular item.

Each building on a parcel is given a number to uniquely identify it; if four buildings exist on one parcel, they would be numbered one to four. Each establishment within a building is also given a unique number to identify it. Building numbers start at one in each separate parcel; establishment numbers start at one in each separate building. A program titled "Initialize the General Data File" initializes this data file by reading data cards and writing the information on tape and paper as a check. The program "Read More Information for the General Data File" reads in more information as it becomes available.

Zone-Grid Coordinate File—The last file to be initiated is the zone-grid coordinate file. To define a zone, its boundary is located in the development area by the grid coordinate system. The zone is broken into triangles, and the grid coordinates of each of the three vertices are coded on data cards. An example of a zone broken into triangles is shown in Figure 2. The card format is shown in Figure 3. The coordinates of the vertices are placed on the data card as follows. The vertices are numbered one to three; point one is coded first, followed by point two, point three, and point one again. The first and last coordinates must be the same in order to close the triangle. The identifying zone name is placed in columns one to 12 and the zone number in columns 15 to 20. The coordinates of the vertices are placed in columns 22 to 80 in the format shown in Figure 3. The zone name starts in column one. The zone number and grid coordinates are right-justified. The program "Initialize the Zone Name-Grid Coordinate File" initializes this file by reading data cards and writing the data on tape and then on paper as a check. To read more information into the system as it becomes available, the program "Read More Information for the Zone-Grid Coordinate File" is used. It should be noted that this file can contain as many zonal systems as required by the users. Census tracts, transportation zones, school zones, etc., are all examples of possible zonal systems that could be incorporated into this file. The inclusion of a particular zonal system is dependent upon the potential use of its parcel aggregation.

Read Programs

There is a general class of programs in EDSARS that will read the data file tape and print the information on paper. These programs should be used after reading in more data or updating the system to check the accuracy of the tape file. These programs also can be used to obtain a complete list of all information on the tape. These read programs will read the parcel number-grid coordinate file and print a complete list of the file; read the parcel number-building number-address file and print a complete list of the tape; read the general data file and print a complete list; and read the zone-grid coordinate file and print a complete list of this information.

Update Programs

To change or update any information in the system, a set of update programs has been developed to replace the old information by using the initializing programs to make a tape file of the new information. This new information file and the original file then are used to initialize a new tape file with all of the new information incorporated in it.

All the update programs require that the new data cards be identical to the original in format. The new cards should be complete—all information that is not changed still should be punched on the update card. The new information is punched on the new card in the same format and these cards are used to form the update file. Any data card that has no data changed need not be entered into the update file, but any card that has any piece of information changed must be completely repunched with all the new and unchanged information.

Retention of Old Data Files

Data files represent current data for a certain period of time. The comparison of data files for different time periods can yield useful information on trends that exist in the development area. It is felt that files should be updated at least once a year. These yearly files should be retained for at least 5 years. The final decision on this policy is, of course, up to the initializing agency.

RETRIEVAL PROGRAMS

To retrieve information from the data files for special purposes, there are programs in EDSARS that give specific information for special purposes of the user. The following programs were designed to be general in their characteristics so that specific user needs could be satisfied. The programs available in the system are designed to retrieve

1. A list of y and x;
2. The sum of y for a specific x;
3. A list of y for a specific x;
4. x for specific parcel numbers;
5. A parcel number and building number for a specific address; and
6. A list of parcel numbers for a specific zone.

CONCLUSIONS

The following conclusions about EDSARS and its potential can be made:

1. EDSARS should facilitate efficient and economical handling of planning data for an area of about 100,000 population.
2. The utilization of a general purpose computer and general purpose programming languages should make EDSARS available to most metropolitan areas in the United States.
3. The concept of a unified data system is the most important contribution of EDSARS.
4. The data proposed for EDSARS are the most usable and easily obtainable information available to the urban area.
5. The incorporation of a flexible method of representing zones by their location is essential to an efficient urban data system such as EDSARS.
6. The information for an urban data system should be in four separate files so that one file can be updated and improved without disturbing the other files.
7. Zone names and boundary locations should comprise one file; parcel numbers and parcel location should comprise another file; parcel numbers, building numbers, and street address should comprise the third file; and the fourth file should be made up of general data.
8. The best unit for data collection is the parcel.
9. The data system should be flexible so that improvements can be made as the system is used and technology increases.
10. The streets and rights-of-way should be represented as special parcels to ensure full territorial and informational coverage.
11. All data incorporated should be potentially useful and updatable.
12. Utilization of applicable theory and practical experience of existing data systems is needed to develop a useful, efficient, and improved data system.

The concepts represented by these conclusions, tied together in an urban data system such as EDSARS, give the planning community and the urban environment as a whole a flexible and useful tool. The EDSARS system should make more information available to more people at a much lower cost and with much less effort.

ACKNOWLEDGMENTS

It is important to acknowledge that the conceptual technique for retrieving information on a zonal basis through the use of coordinates was developed at the University of Washington by Mr. Robert B. Dial. The details of the EDSARS system, including initialization, update, and retrieval programs; codes; and complete descriptions are available in a report completed at Purdue University (2). Copies are available at the cost of reproduction. This project was funded by the Public Health Service through the Environmental Health Institute of Purdue University.

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