A GEOGRAPHIC AND CARTOGRAPHIC PROGRAM FOR THE 1980 CENSUS

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INTRODUCTION

Within the Census Bureau, the Geography Division has responsibility for the development and implementation of all geographic activities necessary to meet the requirements of Census Bureau programs. This includes the preparation of maps--more than a quarter of a million in total--needed by census enumerators during the conduct of the decennial census of population and housing; the development of geographic classification schemes, and geoprocessing and geocoding systems covering both economic and demographic census activities; the delineation of statistical areas for which the Bureau publishes survey and census data such as census tracts, census county divisions, "unincorporated places" and urbanized areas; the development and implementation of the GBF/DIME System (i.e., the Geographic Base (DIME) Files and the Metropolitan Map Series) to include all SMSA's designated by the Office of Management and Budget, and the extension of the system to provide for the geographic classification of decennial and economic census data; and the preparation of publication maps identifying statistical and political boundaries as well as maps displaying (in color) in thematic form data collected in the censuses.

The value of census data is directly related to the ability of the Census Bureau to classify data geographically. The total population of the U.S. (203,211,926 as of the time of the 1970 census) is an interesting number -- but not really useful. For the user, the important questions are where is the population located (What is its distribution?), how does a particular area relate to adjoining areas, to itself at an earlier time, and what are the characteristics of the population for the specific geographic area involved?

It is the job of the Geography Division to assign correct geographic identifications to the data provided from the major economic and demographic censuses conducted periodically by the Bureau of the Census. It is no small task. For example, between July 1, 1975 and June 30, 1980, the many geographic programs of the Bureau will probably entail the expenditure of more than 50 million dollars for cartographic operations, computer processes (including geoprocessing and geocoding) photographic and reproduction requirements, field surveys, development and maintenance of the GBF/DIME System and other Address Coding Guides, and, of course, the necessary accompanying administrative, professional and technical direction and clerical operations.

BACKGROUND

Thirty-five years ago the functions of the Geography Division of the Census Bureau were primarily those of map collection and map annotation. One description of the Division's activities in 1940 referred to its map holdings as being equivalent to 7 railroad box cars full of maps. These maps were used to delineate the approximately 250,000 administrative areas (enumeration districts) required for a door-to-door nationwide enumeration. The maps, as always, not only had to be up to date and accurate if the results of the census were to be correct, but since very few maps depict all of the political, statistical, and administrative boundaries that must be observed in a decennial census, the basic set of maps had to be manually enhanced by trained cartographers.

The mapping for these areas required that accurate boundary information be obtained for 3,070 counties, more than 48,000 minor civil divisions, more than 16,000 incorporated places, 435 congressional districts, and wards in cities of 10,000 population or larger. In addition, since census data were published for the several types of statistical areas delineated by the Geography Division, maps showing these boundaries had to be prepared also. And, of course, in addition to "input" maps (i.e., enumeration maps) there also had to be "output" maps, and a series of thematic and planimetric maps were prepared to accompany the published results of the census.

The basic elements of the mapping requirement still exist. The major difference is that since the 1940's much has happened to increase the importance of geography in respect to census data. One of the most important was the series of U.S. Supreme Court rulings commonly referred to as the "one man, one vote" decisions. The Court held that each congressional district and later each State legislative district, within a State must have substantially the same population-with the official population being determined to be that reported in a national census. The implementation of these decisions had the effect of requiring the census to report population counts for more and smaller areas than ever before specifically for use by State legislatures (or the courts) as the fundamental building blocks for defining legislative or congressional districts.

The "one man, one vote" dictum was not the only change which occurred during the 1960's and early 1970's that mandated the use of census data. The various laws which provided for "Revenue Sharing" establish Census Bureau data and Census Bureau geography as one of the basics upon which the funding entitlements of State and local governments are to be calculated. Although the specific requirements of these laws are not relevant to this paper, a listing of some (there are many others) of the legislation which requires use of Census Geography is of interest.

(1) The Federal-Aid Highway Act of 1973 (Public Law 93-87)

(2) The Housing and Community Development Act of 1974 (Public Law 93-383)

(3) The State and Local Fiscal Assistance Act of 1972 (Public Law 92-512)

(4) The Disaster Relief Act of 1974 (Public Law 93-288)

(5) Comprehensive Employment and Training Act of 1973 (Public Law 92-203)

(6) The National Mass Transportation Assistance Act of 1974 (Public Law 93-503)

In addition, numerous administrative guidelines refer to census defined geography because it offers an easy means of establishing the areal basis for the program at hand. These include environmental impact statements which use census tracts as a surrogate for neighborhoods and the use of census tracts as reporting units for welfare data. And most recently, local government economic and resource allocation programs and planning activities have brought a demand for census data for "locally defined areas" not heretofore considered a part of census geography. Thus, the Geography Division's program for 1980 is designed not only to meet the enumeration and tabulation needs of the Census Bureau, but is geared also to respond to the requirement of "outside" users. And this is as it should be if census products are to serve the statistical needs of the Nation.

MAP ACQUISITION

One of the basic activities of the geography division is the acquisition of accurate geographic information. We obtain from the major public map making agencies such as the United State Geological Survey, Defense Mapping Agency, Bureau of Land Management, and the State Highway Departments a continuous flow of up-to-date mappings. We also receive current maps from regional planning agencies, councils of government, and local agencies of government. In addition, we are now undertaking a comprehensive review of our complete file of map holdings to identify areas where better quality and more up-to-date maps are required and will seek new sources of maps for these areas.

But, as you know, no mapping program, no matter how comprehensive, can keep pace with the dynamics of growth and change. In the past we attempted to solve this problem by waiting until near the end of the decade to acquire the maps for the census and thus obtain the most recent maps available. This "end-of-decade" system met its end with the 1960 census as it was unable to meet current program needs. Useful Address Coding Guides and GBF/DIME-Files (more about these later) demand current maps. And, obviously, revenue sharing allocations cannot be tied to the mapping needs of census programs which occur once every 10 years.

To help meet Bureau needs in this area, the Geography Division has developed two major programs. These are the Metropolitan Map Series and the Boundary and Annexation Survey programs.

THE METROPOLITAN MAP SERIES (MMS)

Prior to 1960, major problems were encountered in the mapping of metropolitan areas as the only maps available consisted of a melange of place and county maps of varying scales and widely varying quality. Often place boundaries appearing on separate maps would not agree and the location of conjoint corporate boundaries would vary depending upon the particular place map being used. Streets continuing between communities would not match. The need for a standardized series of census maps could no longer be denied and the development of the Metropolitan Map Series (MMS) began.

MMS maps, which use a basic scale of 1" = 1600', are derived from the USGS quadrangle maps. The quads are divided in half along their east-west axis and from each half-quad a final map sheet 18x24 inches (45x60 centimeters) in size is produced which covers an area approximately five by seven miles (8.0 by 12.9 kilometers). (For areas of little urban density, multiples of the USGS quads are used to produce maps at scales of 1"=3200' and 1"=6400'.)

Over 3,500 MMS maps covering some 110,000 square miles (285,300 square kilometers) were prepared for 1970. As of today 500 additional MMS map sheets have been completed and 2,500 more are in various stages of preparation. The eventual goal of the program calls for preparation and maintenance of a total of some 14,000 MMS maps.

THE BOUNDARY AND ANNEXATION SURVEY

The need for maintaining an up-to-date file of municipal boundaries on a continuing basis resulted in the Bureau's inaugurating on January 1, 1971, the first of its now annual Boundary and Annexation Surveys. This Survey is designed to monitor changes in boundaries for all incorporated places of 2,500 or more population as well as identifying all new incorporations, mergers and disincorporations, regardless of the size of the place involved.

In addition to serving the needs of Census Bureau programs, one of the purposes served by the Boundary and Annexation Survey is the measuring of changes in population which take place as a result of annexation activity as such changes may affect the revenue sharing funding entitlements for the place concerned. Similarly, information on new incorporations, disincorporations, mergers and/or consolidations of political entities, and municipalities annexing into adjoining counties, impacts not only upon the General Revenue Sharing Program but other Federally funded and state funded programs as well.

At the time of the 1970 census, there were nearly 5,300 incorporated places of 2,500 or more inhabitants in the United States with a total population of more than 121.7 million. In the last 4 years, these places have reported over 23,600 annexations; 329 detachments and 61 other types of boundary changes.

Based on estimates provided to us by the local governments concerned, these annexation actions indicate that over 3,500 square miles of land and over 1,500,000 persons have been added to cities of 2,500 or more inhabitants since 1970. During this same period, 321 new municipalities have come into being, 61 municipalities have dissolved and 23 mergers or consolidations of cities have taken place. Extrapolated to 1980, these represent changes of considerable significance and magnitude.

Many more communities exist with populations under 2,500 persons than over - and all of these must be enumerated in a census. Therefore, in January 1977, a major expension of the Boundary and Annexation Survey will take place in preparation for the 1980 census. All incorporated places, regardless of size, will be included in the program so that accurate and current boundary maps can be obtained for all places. In total, approximately 12,000 places will be added resulting in more than 18,000 places being surveyed annually.

DELINEATION OF STATISTICAL AREAS

Supplementing "legally" defined areas are the statistical areas for which the Bureau also provides data. As defined by the Geography Division, they are the following:

(1) Census Tracts: Census tracts, which were first used in the 1910 census, are the most numerous of the statistical areas. (Approximately 37,000 have been delineated to date.) They are established by local committees (whose memberships embrace a wide spectrum of data users) following Census Bureau specifications. On the average, tracts are designed to contain about 4,000 persons so that small geographic area analysis can be provided. Basic to the tract program is the relative permanence of tract boundaries so as to make possible measurement of changes taking place over time for identifiable sub-city level geographic areas. Some tract changes must and do occur to keep pace with changes in a city's growth and spatial organization, but insofar as possible this is accomplished by splitting existing tracts into two or more parts rather than changing their boundaries.

The census tract program centers on metropolitan areas and it is our goal to completely tract all new SMSA's, new areas added to existing SMSA's, plus as many of the potential 1980 SMSA's as possible, by late 1976. In addition, we will conduct a review of the existing tracts for their continued utility as statistical units. All of this work is being carried out with the wholehearted (and welcomed) cooperation of the Census Statistical Areas Committees (formerly the Census Tract Committees.) The work involved is considerable; we anticipate that 40,000 or more tracts will be defined and mapped for the 1980 census.

Further, as part of the Bureau's continuing effort to provide users with more and better information, we have recently requested the Census Statistical Areas Committees to supplement their historic role of establishing and maintaining census tracts also assisting the Bureau in meeting the demands being placed on it for more comprehensive delineations of small area geography. Among these is the development of standardized groupings of tracts for which aggregate statistical data not now available for sub-city areas--such as data from the 1977 Economic Censuses--could be tabulated by the Bureau. Such standardized tract groupings may meet a variety of local needs not now served by census statistics.

(2) Census County Division (CCD's): In 21 states where the minor civil divisions (usually townships) had proved to be unsatisfactory data reporting units either because of frequent (sometimes yearly) boundary changes or because they were neither used nor recognized locally, census county divisions have been established. In many ways these serve as the rural equivalents of census tracts and are based upon market or service areas, delineated around identifiable centers of population within each county. CCD's are established with local cooperation and formal approval of the Governor's Office for the State concerned.

To date, 7,068 CCD's have been defined. More are anticipated for 1980 and work is, in fact, now underway to establish CCD's in the States of Maryland, Virginia, North Carolina and South Dakota which have recently expressed an interest in the Bureau's CCD program. CCD's are defined in conjunction with the tract program and (where possible) in SMSA's and other counties with tracts, CCD's are composed of groups of whole tracts. To some extent the functions of CCD's and tracts are overlapping and the CCD program is being reviewed with the thought of possibly utilizing in tracted areas aggregated tract information, as described above, instead of defining CCD's. Consideration is also being given to providing more statistical data for CCD's, particularly, for those of substantial population.

(3) Unincorporated Places: In many areas of the Nation, relatively large groups of people reside in communities which are identifiable by name and recognized locally even though they do not have any legal status. Locally, they represent important centers of population which have much the same characteristics as municipalities of similar size. As a means of identifying the populations of these areas, and publishing statistical data for them, the Bureau early developed the concept of "unincorporated" places. The communities so designated are those with a population of 1,000 or more (5,000 or more within urbanized areas) and a population density generally in excess of 1,000 persons per square mile.

The "statistical" boundaries for these places are delimited by State Highway Departments, by the Census Statistical Areas Committees, and by local agencies of government in accordance with Bureau developed specifications. It is not always easy to identify these population clusters and in the hope that improvements in their detection will result, research is currently underway to determine whether they can be successfully identified by satellite imagery. If so, this would provide, for the first time, a uniform method of locating all "unincorporated" places, nationwide.

Once unincorporated areas have been delimited and named, no distinctions exist between them and legally defined places as regards either the enumeration of the census or the tabulation of the collected statistics. As with incorporated communities, unincorporated places with populations of 2,500 or more are classified as urban, those below 2,500 as rural. Unincorporated places also meet the test of being "census defined places" as called for in various pieces of Federal legislation and are also places of record for the purposes of defining SMSA's and urbanized areas.

Interest has also been expressed in the possibility of defining unincorporated places down to populations of 500 rather than 1,000 and the Bureau is looking into this possibility. Costs, rather than technical considerations may be the deciding factor.

(4) Urbanized Areas: The fourth statistical area defined by the Bureau is the urbanized area. In general terms, an urbanized area consists of the central city of an SMSA and surrounding contiguous territory which has a population density in excess of 1,000 persons per square mile. The original purpose for this concept was to provide a means for more accurately and realistically defining the urban populations

which exist around the central cities of the SMSA's, as well as to obtain more accurate measures of the extent of urbanization for individual areas. Since that time, the urbanized area concept and the populations of urbanized areas have been recognized in Federal legislation as a means of determining funding eligibility, identifying the source of the funding, and for calculating the amount of the funding entitlement.

Although the specifications for defining an urbanized area are too lengthy to be included here, they involve dividing the territory surrounding central cities into very small geographic areas and examining each one to determine whether it meets the criteria for inclusion in an urbanized area. In 1970, more than 30,000 such reviews were undertaken and unless improvements in technology can be made, even more areas will need to be defined for review in 1980.

To improve the methodology for defining urbanized areas, research is being undertaken by the Bureau and NASA jointly to explore the use of LANDSAT multispectral data for this purpose. Briefly discribed, we are attempting to define the approximate limits of an urbanized area from remotely sensed reflectance characteristics of the urban landscape and thus limit, substantially, the number of small geographic areas that would otherwise need to be mapped and reviewed - with considerable gains in efficiency, economy, and timeliness.

LOCAL GEOGRAPHIC NEEDS

The traditional geographic classifications provided by the Census Bureau, State, county, place, SMSA, census tract, urbanized area, unincorporated place, etc., may not be sufficient to meet the needs of State and local governments in the 1980's. For example, bills have been introduced in the Congress which would require the Census Bureau to provide data by election district (provided that States delineate election districts 3 years in advance of the 1980 census and follow Census Bureau specifications requiring the boundaries to observe visible physical features).

Similar interests have been expressed as regards data for school districts, planning districts, health areas, and other locally defined areas, each of which, by and large, demands a unique set of boundaries. The extent to which all of these needs can be met is as yet unknown. But it seems fairly certain that showing all the boundaries on a single map produces a clutter of overlapping polygons which cannot be followed by an enumerator and makes the map impossible to use as an enumeration control. We believe we have solved the problem in urbanized areas through the use of the Geographic Base (DIME) Files (GBF/DIME). We are examining the possibility of utilizing radio navigation techniques (LORAN-C) as a possible solution to the problem in rural areas.

THE GBF/DIME SYSTEM

As I have noted earlier, the geographic accuracy of any census is a function of the accuracy of the mapping and geographic classification (geocoding) operations. In door-to-door enumeration areas, the operation is relatively straightforward. Give the enumerator an accurate map, check to make sure the limits shown on the map are being followed on the ground by the enumerator, and establish procedures to guarantee that all questionnaires obtained by that enumerator are geocoded to the correct geography. But what do you do when there are no enumerators? When the enumeration of a substantial portion of the Nation's population is carried out by mail? The answers led to the development of entirely new geoprocessing techniques. Mail enumeration (which covered some 60 percent of the U.S. population in 1970) was utilized in those areas wherein each housing unit could be uniquely identified through its address (i.e., street name and house number) as all such addresses can be precisely located geographically. The tool which made possible the precise location and thus the geographic classification of street addresses was the GBF/DIME-File.

Essentially, a GBF/DIME-File is a computerized description of the street and non-street features of the Metropolitan Maps supplemented by (1) an inventory of the address ranges between the street intersections, and (2) a set of geocodes which describe the geographic location (state, county, congressional district, municipality, census tract, census block, etc.) of each address range. Once every address range was identified geographically, the next step was the development of computer techniques which could match the address of each of the individual housing units included in the decennial census mail enumeration areas to the corresponding address ranges of the GBF/DIME-Files. Thus, for every mail address, a complete set of geographic classification codes could be accurately determined.

The GBF/DIME-File can be described very simply. However, because extreme accuracy was called for (errors in either the address range or geographic code assignments could create major errors of geographic classification) the preparation of the file was an extremely laborious undertaking. To help guarantee the accuracy of the file, local agencies of government were called upon by the Census Bureau to review, correct, and update the information content of the GBF/DIME-File as it applied to their particular geographic area.

It need not be said, of course, that the Metropolitan Maps and GBF/DIME-Files as they were prepared for the 1970 census, if left unchanged, would be completely out-of-date and unuseable by 1980. The dynamics of city growth and socio-economic change rapidly modify street patterns and political and statistical boundaries. To avoid this obsolescence, local agencies of government (primarily councils of government and regional planning agencies) are once again participating with the Census Bureau in a program designed to Correct, Update, and Extend (the CUE Program) the coverage of both the Metropolitan Maps and the GBF/DIME-Files. At the present time, the CUE program is ongoing in approximately 180 SMSA's. The eventual goal of the program is to establish an up-to-date GBF/DIME System in all SMSA's (currently numbering 276) throughout the Nation.

Beyond Census Bureau requirements, local agencies have their own interest in the CUE Program. The Geographic Base (DIME) File provides a "framework" through which address relatable data which have been too voluminous or geographically complex to analyze, can now be organized and mapped and thus made usable and understandable to those in decision and policy making positions. Current local uses being made of the GBF/DIME System capabilities include analysis of the spatial distribution of criminal activity, transit planning, distribution of building permits, car pool planning, and

distribution of school children by school of attendance, among others. Future uses of the GBF/DIME System are limited only by the imagination of the user.

I am pleased to note at this point that the Census Bureau is now able to assist local agencies of government financially as they participate with the Bureau in the development and update of the GBF/DIME System. Through the use of Joint Statistical Agreements approximately $900,000 will be available during this fiscal year to help local agencies meet the costs of Bureau mandated GBF/DIME/CUE activities. More will be available in succeeding years.

PUBLICATION MAPPINGS

One of the important outputs of the Census Bureau are the thematic maps which illustrate the highlights of the census' statistical product. Some of these maps accompany the published census reports. Others, such as the GE-50 series, are large, wall-size maps, printed in color and suitable for classroom instruction and display purposes.

We have not, in the past, produced as many publication maps as we wished simply because the time and cost restraints were prohibitive. The future, however, looks brighter because we now believe that these restraints have been largely overcome through new mapping techniques which the Geography Division has pioneered. Basically, the system employs micrographics with the map outputs being produced under computer control. We use micrographic techniques to produce 35mm open window negatives from which, after enlargement, full color or black and white maps can be produced. Essentially, our system combines the rapid and accurate manipulations of a computer with the traditional photo processing techniques common to most cartographic work. This capability has allowed us to quickly meet requests for specific maps to illustrate the spatial relationships of complex data. Some of the maps we have been producing show the relationships between two variables on the same map through the use of a 16 color matrix. The 1969 Census of Agriculture Graphics Summary, and the new series of 1970 Census Urban Atlases are current examples of our product. The 1980 census will see the first full use of this capability.

I would be remiss not to add that many local governments are also automating their mapping outputs and by utilizing the network (coordinate) features of the GBF/DIME-File are able to display the spatial relationships of local data distributions.

NEW HORIZONS

A geographic processing concept that is now being researched by the Geography Division involves the arrangement of the basic census data files in geographic coordinate sequence. Such an arrangement would, in effect, permit the individual census records to be embedded in a geographically unrestricted data base from which data for any defined geographic area (whether defined by the Census Bureau or by a local agency of government) could be aggregated. The entry key into the data base would be longitude-latitude coordinates and (within the constraints required to guarantee the confidentiality of individual census data) tabulations could be provided for any area which could be described in a longitude-latitude coordinate system.

In metropolitan areas, the GBF/DIME-File -- since it includes coordinates for every street intersection -- provides the basis for an automated and accurate means of defining any desired geographic area. Outside the area of GBF/DIME coverage we are, as noted earlier, testing the utility and practicality of the Coast Guard LORAN-C system to provide geographic coordinates for each block in rural towns and for each housing unit in the rural countryside.

We have demonstrated that we can locate the position of a housing unit in a rural setting through the use of LORAN to within 120 feet of its actual location with only a 1% chance that the unit is actually located further away. I should, of course, quickly add that coordinate identification is only part of the answer. A LORAN system would also require the development of digitized boundary files for the smallest geographic area for which census data is tabulated. Not the easiest of undertakings. But the Geography Division has just acquired a large scale interactive digitizing and coordinate editing system for its GBF/DIME program. This same equipment can also be used to develop the more extensive digitized inputs needed for geographically ordered files.

It is not likely that LORAN-C techniques will become operational in time to meet the massive production requirements of the 1980 census. But we do expect, as a part of the census, to be able to test the system in real time and in a real environment. Coordinate identification systems may in the long run prove to be the only feasible technique for meeting data requirements for areas not identified through the standard hierarchical arrangements of census geography, such as school districts, neighborhoods, watersheds, proposed legislative districts, planning areas and the others referred to earlier.

SUMMARY

I have attempted to provide a brief overview of the increasingly complex world of census geography. We now routinely provide services and capabilities that were neither required nor asked for in the past. But in reality, our work has just begun. We look forward to being able to provide better census geography and we would like you to help us. Your ideas, comments, and suggestions as to how we can best meet our goals are more than welcome and will be of benefit to all.