USES AND LIMITATIONS OF AERIAL PHOTOGRAPHY IN URBAN ANALYSIS AND PLANNING*

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ABSTRACT

This report presents an item-by-item tabulation, for the major components of Urban Analysis, of the uses and limitations of aerial photography. Its development should provide a guide to city and county administrators and photogrammetric engineers alike in planning surveys based on aerial photography and should encourage the more extensive use of aerial survey methods in day-to-day administration.

Illustrated are various civilian experiences with major problems in city and county administration and planning, and with civil defense preparation in Montgomery County, Maryland, a suburban county in the Metropolitan Area of Washington, D. C.

URBAN planning, in textbook terms, is an orderly process of organizing or altering the physical plant of the city to meet changing economic and social needs of the community, and guiding its future growth and development.

In practice however, urban planning has become a race to catch up with the post World War II phenomenon of rapid growth and spreading out of cities; an expansion motivated primarily by the desire for individual home owership and a place in the sun, and by the more general use of the automobile. In the wake of this construction activity has come a tremendous increase in demand for urban services and utilities.

The expansion of facilities to meet this demand has generally been slower than the growth of new housing, commercial, and industrial areas. In turn, each expansion of facilities has encouraged new growth and still greater demands for community services and utilities in a constantly expanding cycle.

In meeting these situations the aerial survey has demonstrated a remarkable capability for assembling the area basis for evaluation of planning problems, with simplicity, speed and economy. Such a survey provides a means for overcoming the high cost and slowness of conventional ground survey and statistical sampling, for developing simple methods of integrating a great volume of statistical data, and for presenting information quickly so as to maintain public interest in planning projects.

Only slightly additional cost is entailed in projecting the use of aerial photography from mapping to analysis and planning.

In each of three main aspects of urban study indicated in Figure 1 the application of aerial survey permits:

In mapping—A complete inventory of the physical features of the urban area; the topography of its site and surrounding area, the drainage pattern, built-up and open areas, the road pattern and other means of communication, and the location and identification of individual installations.

In analysis—The classification of the features of the urban area as land-use patterns of function, structure-type, and built-up area density, so as to characterize the population distribution, industry, commerce, community services and facilities, and the movement of people and goods.

In planning—The relating of engineering standards to land-use features, in order to plan the size, capacity and location of facilities, and to estimate the amount of work entailed in preparation of site.

In the mapping aspect, the speed, ease, and economy of aerial survey needs no elaboration.

In the planning aspect too, the practicability of aerial survey is being recognized in a greater degree, particularly with regard to large-scale survey. An English firm reports aerial surveys of railroad yards at scales of approximately 1:500 for relocation of track and other facilities. A firm in New York reports its use of large-scale aerial survey in planning a comprehensive county-wide sewerage system in recently "Suburbanized" Nassau County,

* This is a part of the Panel on Photo Interpretation held on March 8, 1955 during the Society's Annual Meeting.

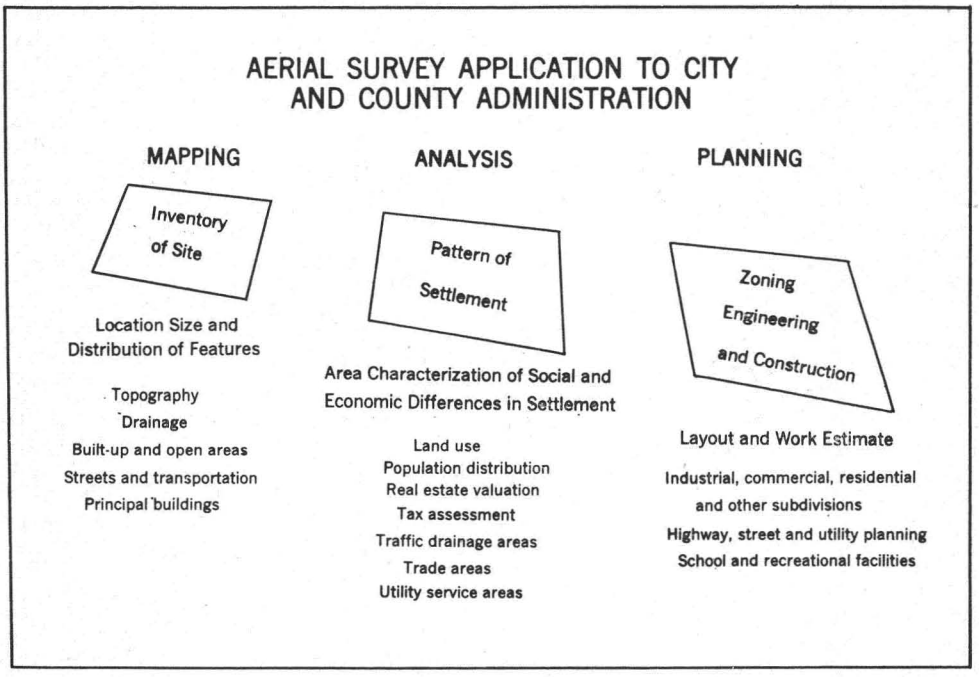


FIG. 1

an area of rapid outgrowth from New York City. Another firm performs slope studies in the layout of housing subdivisions, for location of streets, house lots, water, sewerage, and gas lines, and for estimating the quantities of earth to be moved in preparation of home sites.

On the other hand, the application of aerial survey to the analytic aspects which span the broad range between mapping and planning, has lagged far behind because adequate techniques have not been developed for studying aerial photography of social and economic factors which underly engineering considerations.

The development and testing of such methods, the object of this investigation, indicate that techniques for measuring social and economic factors by their expression in the use of the land affords simplicity and economy equal to that of mapping, for purposes of urban planning and administration.

A case in point is that of a well-known and highly esteemed economic analyst who is currently having difficulty in getting the report of his survey accepted by a local county government, in part because the survey took two years to complete, and many of the specific issues it sought to solve have since become merged with newer problems. For his part, this analyst, in a recent newspaper interview, has contended that he lost money on the survey.

In contrast, consider the case of the city of Rockville, a suburban town in the Metropolitan Area of Washington, D. C., which agreed to act as a test area for various applications of aerial survey to urban planning and administration problems. These were outlined at the last Annual Meeting of this Society.* During the following year many surprising events have taken place.

The City of Rockville won a highly-coveted All-American City award for its effective planning program and the progressive attitude of its citizens. During this past year, the issue of a small nucleus of old inhabitants versus the large mass of newcomers was decisively settled in an election; the "reform" group, largely the newcomers, won by 83% of the total vote. The results of the election were predictable as can be readily determined in the photomosaic of the town, Figure 3, page 426, June 1954 issue of this JOURNAL.

* Published in the June 1954 issue of PHOTOGRAMMETRIC ENGINEERING.

Three choices for future development of the city were presented in that report:

1) becoming submerged as a dormitory satellite of Washington, D. C.,
2) developing as a regional shopping center,
3) developing as an area of light manufacturing industry.

The choice decided upon was that of a regional shopping center with some light industry.

The development plan for Rockville which has been unfolding since this choice, has acted as a catalyst to fuse various factions together and to form an attractive community with an aggressive civic spirit. New petitions for residential, commercial and industrial construction permits indicate that the population which grew 400 per cent between 1946 and 1954 can be expected to double again by 1960, with consequent increase in land values, business activities and job opportunity.

The heart of this development program is an annual aerial survey which will serve a variety of planning needs and keep pace with the rapid growth of the city.

In general, urban analytic studies for civilian purposes are undertaken to consider such problems as the determination of service areas in relation to residential, industrial, commercial and other requirements for utilities; trading areas for existing and potential shopping areas; traffic drainage sheds for planning roads; population density and differentiation for planning school districts and location of recreational facilities.

The basis of the analytic study is the assembly of statistical data which are considered characteristic of the areas to which they apply; such characteristics may be population per acre, automobiles per block, income per household, and many others. Considerable information is obtainable from tax and utility receipts and other regularly organized data.

Sampling surveys are generally employed for data not regularly collected. The traditional method is the random sampling over a wide area in order to determine differences between areas, to mark their limits, and to establish a body of statistical data for each area. Because of the high cost, large samplings cannot be undertaken at frequent intervals. A recent survey of a large regional shopping center was based on a random sampling of 5,000 households taken over a wide area some four years earlier, in a locality which has since doubled in population and is now largely urban in character. This type of survey may be likened to the reconstruction of the size, shape, and use of a building from piecemeal exploration of its many individual parts. Even more important than the question of recency is the fact that a random sampling procedure is mainly a check of existing buying habits and is not of itself a measure of the potential buying power of an area, the primary object of the trade area determination.

On the other hand, an aerial survey in conjunction with sampling techniques, provides a means for directing a concentrated house-to-house canvass of selected sample areas for data applicable to similar areas throughout the city. Statistical data of great accuracy and ready application to engineering planning can be obtained with fewer canvasses, less complicated statistical exercises, and fewer extrapolations and assumptions than with random sampling.

Aerial photographs provide first, an over-all view of the city, from which differentiation of the land-use pattern is made. Then in conjunction with available published information, similar areas are classified. From each classification, representative areas are selected for detailed ground survey.

In the case of trade-area study, the limits of area are established on the basis of accessibility by automotive travel to the point of interest. Usually 5, 10, 15 minutes of driving time represent the limits of attraction to neighborhood, community or regional shopping centers. This is determined by ground check. Within these time zones, sample areas are selected from aerial photographs for house-to-house canvass. Other areas of like type are then spot checked for consistency with the sample areas. Details of this application were published in the June 1954 issue of PHOTOGRAMMETRIC ENGINEERING.

A similar approach is being tested for a study of many problems of civil defense in conjunction with Civil Defense officials in Montgomery County, a suburban area adjacent to Washington, D. C. Current civil defense policy considers the mass evacuation of urban populations from probable target areas to widely dispersed reception centers safe from blast, fire, and

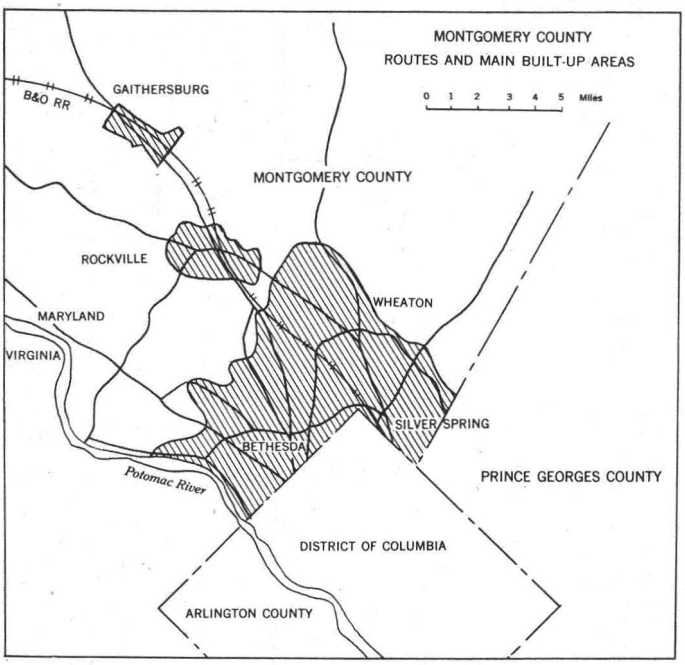


FIG. 2

radio-active fall-out. As the technology of atomic warfare advances, the problems of evacuation grow more and more complex. Neither precedent, excepting a few limited evacuation exercises, nor appropriate statistical data are available upon which a concrete course of action can be based.

In Montgomery County, civil defense planning has had to change three times in the past six months. Until recently the county (see Figure 2) was considered relatively safe from atomic bombs, and planning was concerned with reception of possible evacuees from Washington. With new data on the Hydrogen Bomb it became necessary to plan the evacuation of built-up areas adjoining Washington. As a result of more recent data on radio-active fall-out, drastic modifications in the evacuation plan are now required, dependent on weather and wind conditions.

In such situations the versatility of the aerial survey offers means of developing data of reasonable accuracy and direct application to evacuation planning, and provides the flexibility required to meet changes in policy.

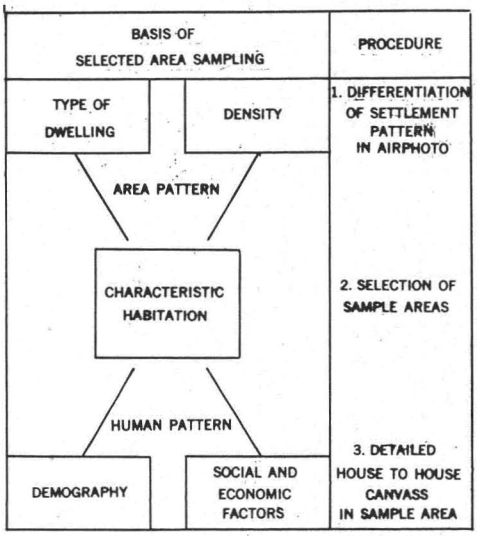
Two basic considerations for evacuation are readily developed from aerial photography:

1. Determination of areas capable of evacuation by private vehicles, and areas requiring support of public transportation.
2. Analysis of route location and capacity for handling expected traffic loads.

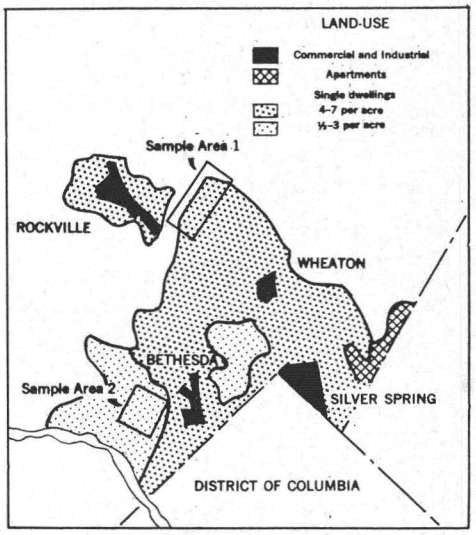
The method developed for determining the capability of areas for evacuation without aid of public transport comprises first, a land-use analysis to determine areas of like type to be used in selecting sample areas, Figure 3.

In Montgomery County single dwellings predominate. In areas of single dwellings the family automobile forms the principal means of transportation to work. The problem has been to determine the number of vehicles which remain in each area for use of daytime home population. In a selected sample area comprising 700 homes (Sample Area 1, Figure 4), a house-to-house canvass was made with the cooperation of the local citizens association. The number of invalids, school and preschool children, and the number of days the family car remained at home was determined. The survey indicated that due to car pooling arrangments, sufficient vehicles remain in the area for evacuation of the daytime non-school population, but that no great surplus of car capacity is available. With careful planning the en-

APPLICATION OF AERIAL PHOTOGRAPHY TO AREA SAMPLING
FOR SOCIAL AND ECONOMIC DATA RELATED TO URBAN PLANNING



HABITATION: A JUXTAPOSITION OF HUMAN AND AREA RELATIONS



GENERAL LAND-USE PATTERN AND AREAS SELECTED FOR SAMPLING

FIG. 3

tire non-school home population could be evacuated. Spot checking in like areas showed substantially the same situation. In view of these results detailed sampling of Sample Area 2—an area averaging better than two cars per house—was not considered necessary.

This program dovetails with the present policy of evacuating school children directly from schools under teacher supervision. Because many children are normally transported over long distances it would be impracticable to send them home first. Instead, the home population would proceed to predesignated centers where they could be reunited with their children. Applying this sampling on a county-wide basis, the expected traffic load can be determined from counting the houses in aerial photographs.

Route location and capacity for handling expected traffic loads are critical factors in evacuation planning. As can be seen on the map (Figure 2), the number of main roads suitable for evacuation is limited. The problem is mainly to even out the flow of traffic and to secure maximum use of side streets and secondary roads.

Initially, evacuation planning considered the movement out from the target area in all directions. With problems of fall-out, evacuation planning has had to consider movement only in those directions affording maximum safety, as indicated by wind and weather forecasts.

To determine how such traffic would flow we proceed from the viewpoint that in general each individual will seek the shortest time-route to a main road leading away from the center of the city.

A pattern of movement is assembled by studying the road system in aerial photographs. Between diverging main routes a dividing line is drawn representing the traffic drainage shed for each main route.

Within each shed the potential traffic load is related to the capacity of the main road, and the adequacy of the route is assessed. Further study of the street pattern indicates potential bottleneck points and supplementary routes, as well as where emergency traffic controls would be required.

Using aerial photographs, varying combinations of traffic flow can be studied in relation to the several evacuation plans which may be necessary on the basis of weather conditions.

New aerial photography is being presently obtained for the main built-up areas adjoining Washington. This will serve many urban planning needs including that of Civil Defense, and provide the means

for keeping abreast of rapid growth and even more rapid change.

Discussion of Mr. Witenstein's Paper

QUESTION: How can you predict damage resulting from an attack?

MR. WITENSTEIN: The damage depends upon the wind as well as the area. So there is no way to predetermine it. For instance, regarding the fire susceptibility of buildings, there would be the question of fuel content of the building, the density of construction, the type of occupancy of a tract; all of these determine fire susceptibility. There are many unknown factors which enter into the determination of firestorm areas; these make it a most difficult problem in the estimation of damage.

QUESTION: In this business of photographing Rockville, were you able to some extent to predict what the vote would be on reorganizing the county?

MR. WITENSTEIN: No. But I will say that in this case the vote coincided with the delineation of the area that had taken place prior to the election. Actually our estimate of what would be the attitude of people in the area was the basis upon which one party in the campaign fought the issue; apparently it worked.

QUESTION: Do you mean that the people in the newer houses were the ones that would vote for it?

MR. WITENSTEIN: Yes. The implication is that some psychological and physical aspects come together in the housing type, the settlement type that can be seen in the photograph. There is an expression both of the sociological and economic factors which developed in that particular settlement in the first place; by reasoning back from the settlement type, we can arrive at many estimates and conclusions for this sort of planning.

QUESTION: Outside of the city limits of Rockville, what advantage has the aerial photograph over the road map, in your planning for civil defense evacuation?

MR. WITENSTEIN: This civil defense evacuation to which I refer is a county-wide activity in which Rockville is just one small portion. As regards using road maps and the aerial photographs, the advantage of the photo is that all of the details are in the photo, while the map is a selection of details usually somewhat out of date. Events are moving fast in areas like Montgomery County. The maps are fine, because they present information which is not always obtained from aerial photos but the aerial photo is also neces-

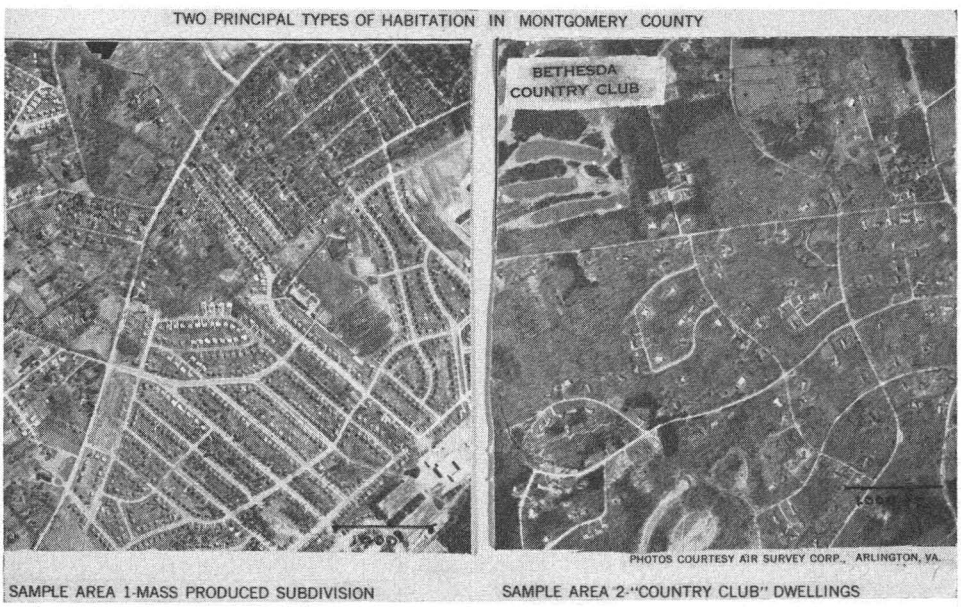


FIG. 4

sary in conjunction with the maps. The aerial photo is needed because it gives the latest possible information. Naturally, the aerial photography has to be of recent date. It will then clear up details and perhaps indicate the number of vehicles which can be expected on any particular road.

QUESTION: Do you recommend mosaics for this purpose?

MR. WITENSTEIN: Yes sir. The mosaic is the means of getting the over-all view of the area.

QUESTION: Suppose that in a given area you have a drainage pattern for traffic for civil defense and for some reason it is blocked. Can a plan be prepared automatically which will be followed immediately, without the destruction you speak of?

MR. WITENSTEIN: The automatic plan was discussed by me with the Chief of Police for the State of Massachusetts, at a recent civil defense school conference. He said the only kind of planning that the police can expect to carry out during a civil defense emergency is to take care of fellows that are smaller than themselves. All that can be done in the way of civil defense planning is an attempt to estimate what will be the probable course of action of the individual without supervision. That would indicate points at which maximum bottlenecks might occur. I think you are referring to potential bottlenecks which can be studied thoroughly from the air. Other factors may come into account which can not be indicated by interpretation, such as the number of vehicles breaking down and causing a jam at any given point. I don't know what one can do about this, but in planning one might try to understand the general or potential flow of traffic under any given set of circumstances. The aerial photograph can be used for that purpose.

QUESTION: Has civil defense a detailed plan for evacuating Montgomery County? It so, has it taken into consideration the flow of traffic, say from Baltimore if that was also a target site, and merging with the north-going traffic from Montgomery County?

MR. WITENSTEIN: There are, of course, many intangibles. While it would be helpful to have a real situation presented for study, no one wants such a situation to occur if only to provide an opportunity to test the plan. It is possible we will have no warning at all. Assuming there is some sort of warning—and that is the only basis on which any kind of plan can be developed—it is thought that we will have three to four hours' warning. The idea is to evacuate all the cities, because we don't know which city will be the target. General evacuation is the only precaution that can be taken. There would be traffic from Baltimore and Washington merging in Montgomery County an hour after the evacuation starts. This would take place away from the populated areas and would be a state police problem rather than an urban civilian defense problem.