Cartographic and Design Work for a Comprehensive Origin-Destination Survey

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●COMPREHENSIVE origin and destination (O-D) studies such as the Pittsburgh Area Transportation Study (PATS) are still relatively new; consequently many of the problems confronting these studies are new also. Maps, charts and related items required for the collection, processing, analysis and presentation of the Study's data have a direct bearing on many of these problems. Although one study's requirements may differ slightly from those of another, the experience gained at PATS may prove generally helpful toward a solution to many difficult situations.

This paper is presented, then, in a twofold manner. First, an account is given of the methods and procedures found suitable for the Cartography and Design (C&D) Division of the Pittsburgh Area Transportation Study. Second, there are suggestions throughout the paper on additional procedures for perfecting the methods used at PATS.

At PATS, it is the responsibility of the C&D Division to: provide maps, manuals, visual aids, and forms for data collection and to assist in the land-use measurement; establish a complete system of geographic identification, to be used for the collection, coding and analysis of study data; prepare a series of maps for the arterial and mass transit inventories and assignments; visually present the data collected and projected; illustrate, edit, collate, have printed and distribute all study publications; and establish and maintain a technical library.

The organization of the C&D division and each of these general responsibilites is discussed and the total contribution that can be made to an O&D study by an effective C&D division is summarized.

ORGANIZING AND ESTABLISHING THE C&D DIVISION

The number of personnel needed in the C&D division will vary according to the size and scope of the study. However, basically, the organization of most comprehensive O&D studies is similar. For example, no matter how large a study's area is, the methods and procedures followed in the division are fundamentally the same. Consequently, the basic personnel requirements of the C&D division do not change to a great extent in any given study.

There are three key positions that make up the nucleus of the PATS C&D Division. They are: the cartographer, a graphic designer, and an editor-librarian. It is the cartographer's responsibility to set up and supervise the drafting of all maps required by the study. The cartographer should also be familiar with photogrammetry so that he can give technical assistance for the land-use measurements and highway location planning. The job of the graphic-designer is to lay out and prepare all forms, displays, illustrations and publications needed for the proper functioning of the study. Both of the aforementioned positions are of equal importance and the selection of personnel to fill the jobs is very important. It would be a great asset to the division and the study if experienced O&D personnel could be recruited for any of these key positions. Although neither must be a college graduate, extensive training and experience in each of the fields is essential. There are some experience requirements that would be helpful to either or both of the persons filling the positions. They are: experience in supervision, technical writing, photocopy work, printing, negative stripping and other related procedures. The C&D supervisior should be selected from either the cartographer or the graphic designer, depending on schooling, experience and ability. The editor-librarian is responsible for the editing of all publications turned out by the study.

The editor-librarian must also be familiar with basic printing procedures and must be capable of setting up and typing originals for printing by xerox or other direct methods. Also, it will be his (or her) responsibility to build up and maintain a technical library for the study's use. In a small study, the public relations may also be handled by the editor-librarian. (In a larger study, the public relations may have to be handled as a separate operation.) The editor-librarian must have a college background with a major in English or the equivalent in editorial experience.

Because the tasks assigned the C&D division vary greatly, personnel versatility is very important. For this reason, care must be taken when selecting employees. It is far better to select a person with a well-rounded background than a "specialist" in any of the fields.

All three of these positions should be filled early in the study. The cartographer should be the first of the three hired and must begin his job before field work starts. This is necessary for preparation of the required data collection maps. Soon after, so that forms and manuals may be prepared, the graphic designer and the editor-librarian positions must be filled.

The division's supporting personnel should consist of cartographic draftsmen, illustrators, and clerical help. Where feasible, it would be to a study's advantage to have its own photographer (copy camera), printer, and related equipment.

After recruiting the personnel necessary for proper function of the C&D division, a brief but intensive training program must be conducted. The instructions should include a thorough explanation of the purpose and procedures of an O&D study. A review of manuals and reports on similar studies could be helpful. Also, to enable a better understanding of reproduction and printing procedures, a tour of at least one local printing house is encouraged. Time should also be taken to familiarize the division's personnel with the topography of the area under study. In addition, training must cover all phases of the study's internal procedures, inasmuch as, the C&D division is a supporting unit for all other sections.

In conclusiion, it may be said that the more familiar the division's personnel are with the goal of the study and the methods necessary to attain this goal the more efficiently the C&D section will operate.

PREPARATION FOR DATA COLLECTION

The most important pre-field duty of the C&D division is to obtain a complete set of maps covering the area under study. The scale of the maps should be a minimum of 1 in. = 800 ft, to allow completeness of detail without cluttering the maps to any great extent. Due to the large map scale required for adequate coverage, a series of maps will generally be necessary to represent the complete study area. The maps should distinguish and name: (a) existing expressways, roads, streets, and alleys; (b) streams, rivers, and lakes; (c) railroad lines; (d) civil divisions; (e) cemeteries and major parks; (f) bridges, tunnels, etc.; and (g) local place names (other than civil divisions). The following details are also worth mentioning: (a) A map numbering system should be incorporated for control purposes. (b) The map sheets should be standardized at a good workable size. (c) A geographic identification system (grid coordinate system) should be included. (d) Contour lines, representing relief, are not necessary for the purpose of O&D work.

Although streets are not drawn at scale, it is helpful to the field listers and home interviewers to show alley widths at a smaller scale than major streets.

Field listers, as referred to in this paper, are the persons who manually account for all parcels of land within the study area, and classify each parcel into its particular land use. The field lister also obtains the street address of each building within the area. The data is collected by block and geographically identified by the block's grid coordinate values. From this list, samples are selected for home interviewing.

Home interviewers are the persons who make personal contact with the sample households and obtain the trip information required for the O&D study. Another aid in the interpretation of map detail is the representation of hard surface roads by solid lines and dirt roads by broken lines.

In addition to the study's map coverage there is a definite need for complete aerial coverage at a minimum scale of 1 in. = 800 ft. These aerials are necessary for proper land-use measurements. If insurance maps are used for these measurements, in all probability there will not be complete study area coverage. Therefore, the aerial photos may be used to supplement these measurements. The aerials are also useful as an aid in highway location planning, as well as for use in updating, checking, and/or drafting the series of maps required for the study's field work. When obtaining these enlarged aerials, it would be helpful to acquire a set of stereo matched prints and a complete set of single-weight photographs to be used in making an aerial mosaic of the study area.

The major circumstance influencing the procedure to be followed in acquiring maps and aerial photographs is availability from local sources. If satisfactory materials cannot be obtained locally, other courses of action must be taken. (It is unlikely that the survey will have at its disposal the equipment necessary for adequate aerial coverage. Therefore, it will be taken for granted that the aerials must be acquired from their government sources or a private concern.)

The first alternative is for the C&D division to draft the maps needed. Due to the detail required for adequate mapping of the study area, a great amount of drafting work is necessary, creating a need for additional draftsmen prior to the study's field work. But, inasmuch as a tighter control can be maintained when the mapping is done internally, a very good series of maps can be produced. Following is a suggested procedure for preparing a series of maps suitable for the work of an O&D study.

The first step is to obtain the black color separations for the USGS 7½- by 7½-ft quadrangles covering the area under study. (Also, a complete set of colored USGS topographic quadrangles at the same scale should be acquired.) Using the black separations, reproduce a Cronaflex print of each of the quadrangles. (Cronaflex is a trade name for a polyester base material which has the following desirable characteristics: sensitized for photographic process; durable, matte surface for ink work; very stable, thus very important in the mapping field.) Next draft onto the Cronaflex prints (using the colored topographic quadrangles as a base) all of the drainage within each quadrangle. (For clarity use the standard stream symbol.) This procedure will be followed on each quadrangle throughout the study area.

Then, add onto the Cronaflex prints a grid coordinate system to be used for geographic identification. After determining the axis of the grid system (usually at the area's central business district), the north-south line should run parallel to the nearest set of longitude marks on the Cronaflex prints. The east-west axis line should then be drawn perpendicular to the north-south line. From these axis lines plot out, in ½-mi increments, a complete grid coordinate system. Great care must be taken when plotting these grid lines from one sheet to another so that a uniform coordinate system may be realized.

An exception to this method is a study area with a predominantly "checkerboard" street network. The grid system in this case may be orientated to correspond with the street pattern. A slight deviation of the grid system from north will not affect the accuracy of the geographic identification. However, the degree of deviation from north must be noted.

The foregoing will result in a complete set of maps (1in. = 2,000ft USGS quadrangles) on Cronaflex film containing much of the detail needed for the data collection map series. Before proceeding any further, the drafting scale must be determined. This scale is governed by the aerial photograph enlargements. If, for instance, the enlarged aerials are at the scale of 1in. = 400 ft, then the Cronaflex prints would be photographically enlarged to that scale. A similar scale for both the aerials and the maps is necessary so that the photographs may be used for updating purposes. Also, because the maps, and not the aerials, will contain the geographic identification system, the maps must be used for control purposes when measuring the land uses from the aerial photographs. To facilitate this correlation between map and aerial, the Cronaflex prints are laid out for sheet size comparable to the aerial enlargements. (There is a five time enlargment required to obtain the map's desired scale 1 in. = 2,000 ft to 1 in. = 400 ft.)

Because the line weight of the map's detail at this enlarged scale is distorted to some extent, redrafting is necessary. Before the tracing can begin, a considerable amount of detail must be added to the enlarged maps. First, the maps should be overlaid on the aerials and the street network updated. Besides the addition of streets to the maps, a vast amount of supporting information must also be obtained. For instance, all available street maps from throughout the study area should be used to identify the streets represented on the maps. Also, all civil division boundary changes must be noted and made on the enlarged maps. When this updating is completed and thoroughly checked, the maps may be drafted in final form. The maps should contain all of the map detail as listed in the beginning of this section. (PATS required 60 maps at the scale of 1 in. = 400 ft for complete coverage of the study's 450-sq mi area.)

If the C&D division is not in a position to prepare the map series itself, a second alternative is to let the preparation of the maps out on bid. It is essential, when the contract is drawn up, that the person responsible for the C&D division assist in the writing of the required specifications. In most cases the company preparing the maps will also be in a position to supply the aerial photographs required by the study. If the preparation of the maps is contracted out, the C&D supervisor should have the prime responsibility for establishing liaison as well as insuring that adequate maps are prepared.

Whichever procedure is followed in obtaining the map series, it is imperative that the maps be as complete and accurate as possible and contain all of the data necessary for proper geographic orientation. Obtaining these maps and aerial photographs must be one of the first activities of the study. It is imperative that ample time be given for completion of the map series before the study begins field operations.

An additional check on the accuracy of the map series can be carried out during the field listing process. The field personnel should be instructed to verify all streets and street names. Any corrections or additions found by the field listers should be noted and forwarded to the C&D division for entry on the map originals. By following this procedure, the study can insure a more accurate map to be distributed for land-use measurement and home interviewing.

Geographic Identification

Before any of the study's data collection phases can begin, a complete system of geographic identification must be incorporated into the map. There are two major requirements of this system: first, it must express an easily understood relationship between the data obtained and its geographic location; and second, it must permit the application of data processing for rapid geographic summarization.

As previously stated, a plane-coordinate grid system is superimposed onto the Cronaflex prints (USGS quandrangles) and subsequently enlarged and drafted at 1 in. = 400 ft. This ½-mi grid system is the basis of all geographic identification. That is, all of the units of area used for data collection and summarization are related directly or indirectly ½-mi grid network. Following is a brief outline of a geographic identification system suitable for a comprehensive O&D study (Fig. 1).

The Block

The smallest unit of area used for data collection is the block, similar in size and shape to the common census block. It is identified by the coordinate values of the block's geographic center. The blocks are determined first on the 1 in. = 400 ft base maps. Their size is determined, somewhat by the development of the area. For example, where population is dense, the blocks are small; in the more rural areas, the block's area is generally larger. Where feasible, the block is bounded by actual on-the-ground features, such as roads, streams, railroads, paths, power line rights-of-way, or other terrain features. During the block layout procedure, the 1 in. = 400 ft aerials must be referred to constantly. Where terrain features are absent, an imaginary line must be drawn to limit the block size. These arbitrary lines must begin and end at a definite spot on the map and be easily identifiable on the ground (such as road intersections, sharp bends, etc.).

When practical, an attempt to relate census blocks with the study's blocks is recommended. This possibility should be kept in mind and the census blocks referred to

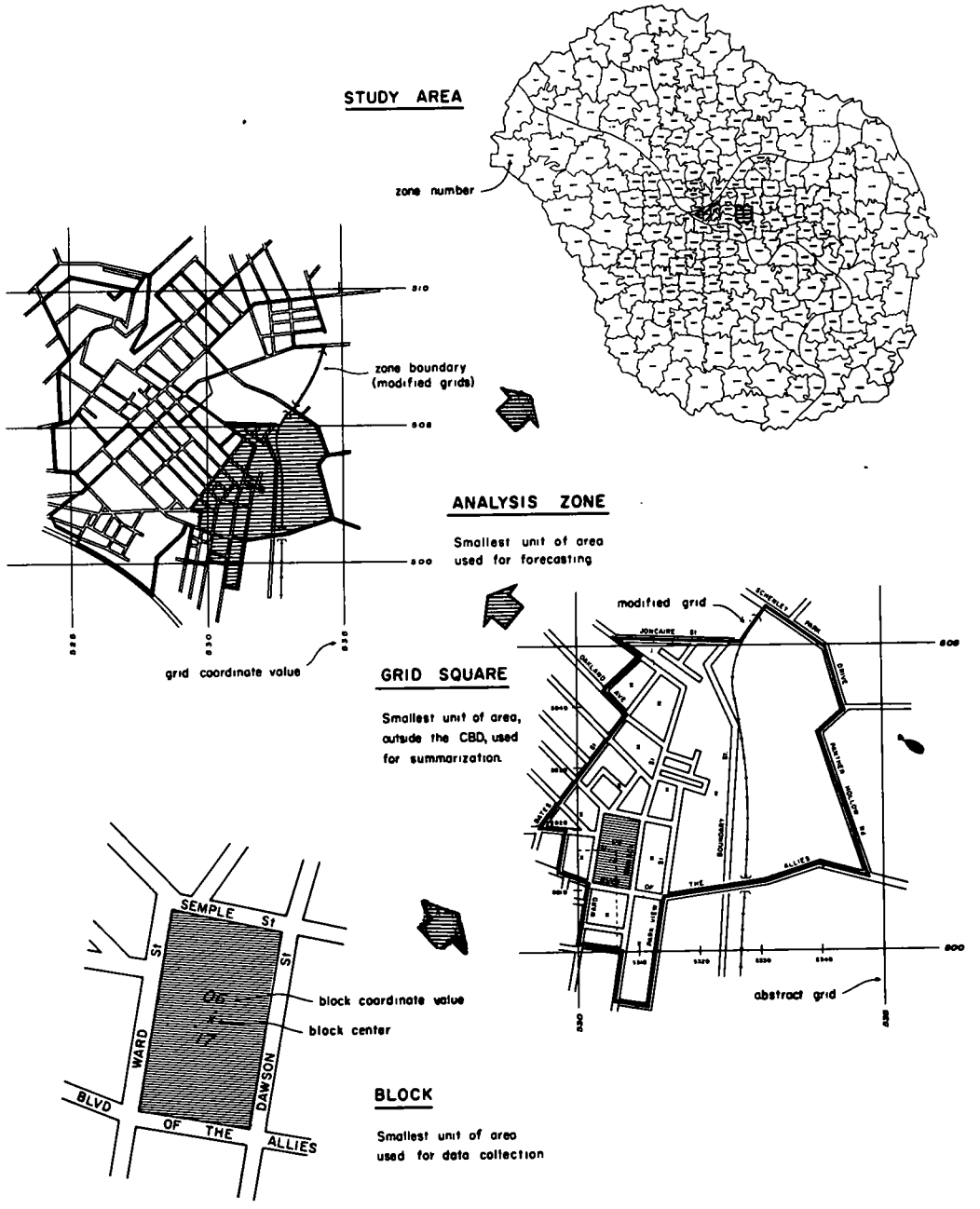

Figure 1. PATS' geographic identification progression.

when determining the study's block boundaries. By following this procedure an easy correlation can be made between study findings and census information. This method will necessitate an additional master deck of machine processing cards containing the study's block geographic identification and its census block counterpart. (This master deck will not interfere with the normal function of the block as used by the study, but will be used for the checking and updating of population, dwelling unit and related information.)

The Grid Square (Superimposed Grid)

To summarize the data collected during the study, a larger unit of area should be used. For this purpose the "grid square" is incorporated. The grid square is formed by the intersection of the ½-mi grid network, resulting in uniform ¼-sq mi areas. The grids are identifiable by assigned numerical "X" and "Y" grid coordinate values. As previously stated, the block is identified by its geographic center. Assigned to each grid square are all of the blocks whose centers fall within the superimposed grid's lines. Due to the dissimilarity between the superimposed grid and the block boundaries, a "modified grid" is required for reconciliation of areas. The modified grid is bounded by the perimeter of the block grouping and is geographically identified by the coordinate value of the superimposed grid from which it was formed (Fig. 1).

At PATS (with the exception of the central business district, where data is summarized by block) all information obtained during the data collection phase was summarized by grid square (modified grid). Thus, it was imperative that an adequate geographic identification system be used. For all intents and purposes, the system outlined was found satisfactory.

Forms

Another major function of the C&D division, particularly in the early stages of the O&D study, is the designing, drafting, and printing of forms. Although this may seem rather trivial contrasted with many of the division's other duties, it is of great importance to the collection, processing and controlling of the study's data that the forms be prepared correctly. It is a good practice for the person requesting the form to prepare a sketch of its contents, after which the actual designing is accomplished in conjunction with the C&D division's personnel. (A source used many times as a guide in the preparation of forms is the Bureau of Public Roads standard home interview form.) This cooperation is essential to insure that the maximum amount of usefulness be obtained from a form. With a thorough understanding of its purpose, the graphic designer can prepare a form suitable to the study's needs. Following are some suggestions for preparing the study's forms (especially adaptable to the home-interview-type forms).

1. Design form to minimize the amount of writing that must be done by the interviewer. That is, where possible, design the form so that a check or circle may be used to answer questions, rather than written answers.
2. Where writing is essential, allow adequate room so that the words need not be cramped.
3. On forms that contain areas for coding, as well as the recording of data, the coding block can be made more prominent by shading the block's area. This is accomplished during the photographic process with a 10 or 15 percent of black screen.
4. Shade areas in the body of the form that do not require the recording of any written data.
5. Draft form at a scale larger than that intended for the finished printed form, to insure a neater looking form.

Although the actual content of a form is the responsibility of the person or division requesting its preparation, there are some details that are many times overlooked. Following are some suggested methods of improving the efficiency of the form.

1. Where practical, squares should be provided on interviewing forms so that all of the coding required may be done directly on the form. That is, the coders (a coder is the person responsible for translating the written information obtained from the interview into a code suitable for machine processing) should work on the same forms used by the interviewer.
2. When the code used for an answer to a form's question is the same as the answer itself, the form should be designed so that the interviewers can enter the answer directly into the coding block. This will eliminate unnecessary work by the coder. (Example: "Number of cars owned?" Answer: "2". The "2" should then be placed by the interviewers directly into the coding block provided for that question.)

3. Much of the information obtained during interviewing has only a limited number of possible replies; for example, "mode of travel," "type of parking," and "trip purpose." The possible answers to each of these questions should be listed in a convenient place on the form along with their assigned codes. The interviewer may then use this listing as a guide for recording answers to the question.

Manuals

Manuals covering office procedure, field listing, home interviewing, roadside interviewing, and land-use measurements must be prepared before the field work begins. The coding manual, although not needed for field work, should be prepared as soon as possible following the other manuals. It is not the C&D division's responsibility to write these manuals, although they may assist in some of the technical sections concerning map reading or related information. The division should set up a standard format to be followed in preparing the manuals and should prepare the required illustrations.

Miscellaneous

Along with the particular projects mentioned, there are numerous minor duties that must be completed by the C&D section. First, the division must acquire all available maps of minor civil divisions within the study area. Also, if possible, postal route maps should be obtained from post offices throughout the area. These maps can be used as an aid in preparing the map series needed for data collection, and can be used as reference for local zoning ordinances and land use. In addition, during the early stages of the study, local agencies can be approached for maps containing information pertinent to the study area.

Also included during this phase of the study is the setting up of the library. Reference material useful to all phases of the study should be obtained, indexed and filed.

PREPARATION FOR CODING AND ANALYSIS

Coding Requirements

After the data collection phase of the study is under way, the C&D division duties include the preparation of source data for the coding procedures. A study's analysis will be inadequate unless trip ends can be precisely located. Therefore, there is a great need for accurate coding guides which geographically locate the trip end possibilities. It should be the duty of the C&D division to assist in the preparation and checking of all such guides.

At PATS, there were five coding guides: the trip generator file, local place name guide, street guide, intersection guide, and adjacent area guide. The procedures followed in obtaining the required guides were found satisfactory; therefore, these methods are described. First, to compile the trip generator file and local place name list, the study's grid coordinate system was plotted on a set of USGS topographic quadrangles of the study area. (Local place names as referred to here pertain to those areas other than civil divisions known by school districts, predominant geographic feature, old "stand-by" names, etc.) Next, for the generator file, the names of as many large trip generators as possible were obtained. Each generator was then located on the USGS sheets and assigned its grid coordinate value. A similar method was used for the geographic identification of the local place name coding guide. When these lists were completed, they were then turned over to the machine processing division and an alphabetical listing of each guide was then printed.

The street guide was initially processed from field lists by the machine methods division of PATS. These lists contained all street names by the lowest-highest address in each block within the study area. It should be the C&D section's duty to verify all streets from the data collection map series.

The street intersection guide was prepared in an effort to pinpoint trips in rural areas. For example, if the interviewer could not obtain a suitable address or location for a trip, he was instructed to get the road names of the nearest intersection. Therefore, to code trip ends such as this, a street intersection guide was prepared. The

guide geographically identified all street intersections by both streets involved. Although the list is prepared by the machine processing division, the C&D section must verify each intersection, thus insuring an accurate means of assigning trip ends that might otherwise be lost.

In order to allow adequate accountability of trip information beyond the immediate study area and to create a buffer zone for future predictions, an adjacent area surrounding the study's cordon line was plotted. Detailed maps, such as the 1 in. = 400 ft data collection maps, were not needed in this area. Instead, the 1 in. = 2,000 ft USGS quadrangles were used for adjacent areas coverage, and the grid coordinate system was extended to take in this area. In this way, a means of geographic identification was possible. An adjacent area coding guide was then prepared. In this guide, each civil division was assigned the grid coordinate values of the "superimposed grid" located at its geographic center. Also, to assist coding, all place names within each civil division in the adjacent area were assigned the grid coordinates for that civil division. (For coding purposes, all trip ends in the adjacent area were coded to these civil divisions.)

The C&D division may also help the coding procedure by preparing coding conversion tables and large coding charts, (for example, small tables converting normal time to the military numerical system—5:30 PM to 1730; also, coding progress charts).

Analysis Requirements

The block, the superimposed grid and the modified grid have been described. The block is the unit of area used for the collection of data, the modified grid is used for summarization (being formed from blocks and identified by its superimposed grid counterpart). Now for more general analysis, it becomes necessary to enlarge the units of area.

The system used at PATS to define "zones" and the reasoning behind this system will be described, because the criteria followed could be used as a guide for any given area.

The analysis zones within the study area were set up to provide workable units of area for the anlaysis of collected data and the forecast of future population and land use. Zones are composed of one or more modified grids and vary in size from approximately ¼-sq mi in the CBD to 4½ sq mi in the more rural areas. The variation in zone size is, in part, an attempt to equalize trip ends. Other factors pertinent to the selection of zone boundaries are: the extent of the arterial network, the degree of urbanization, continuity of the area, and the existence of topographic barriers.

The zones were first plotted on boards containing PATS' arterial street new-work system on an overlay of the 7½- x 7½-ft USGS quadrangles. (The making of the USGS boards and plotting of the arterial system on them are explained in the next section.) Clear acetate was placed over the USGS topographic maps which, in addition to the arterial system overlay, also contained the superimposed grid and a modified grid overlay. Because the grouping of the modified grids into analysis zones is somewhat of a trial and error procedure, the initial plotting of the zones was done with grease pencil on the clear acetate. As stated, there are certain factors that control the zone size and these factors must be taken into consideration when plotting the zones. Some of the factors previously mentioned may be found in part or in whole on the USGS 7½- x 7½-ft quadrangles themselves. For example, the topographic barriers are quite evident on these maps. When additional base data are used in conjunction with the USGS maps, some of the other factors, such as the degree of urbanization and the continuity of the area, are apparent. The extent of the arterial system, which is already plotted on the maps, is readily accessible. Another point to take into consideration is the zonal loading node. (The zone loading node is the single point at which trips to and from the zone enter or leave the arterial network in the traffic assignment process.) All major arterial intersections are considered potential loading nodes; therefore zones to some degree are so constructed that their centroids are located near a major intersection. The remaining factor, and one of the most important, is the problem of equalizing trip ends. A valuable asset to have when considering this important point is a "tab map" (to be explained in detail later) containing the number of trip ends in each modified grid (grid square).

Although satisfying all of these criteria is generally impossible, each must be taken into consideration when selecting the grouping of modified grids which make up the zones. In Figure 1 the growth of a zone from block to modified grid and finally to analysis zone can be seen. When a satisfactory series of analysis zones had been set up at PATS, the modified grids' coordinate values within each zone were listed and punched into cards for machine processing. A tabulation was prepared and checked back against the original zone layout for completeness. The zones were then numbered consecutively from the CBD in a clockwise manner within ring and sector.

Analysis zones were also carried out beyond the study area and into the adjacent area but were formed on the basis of less detailed inspection. These zone boundaries were formed by incorporating the Pennsylvania Department of Highways' statewide coding system. However, because the civil divisions were used for assigning trip data in the adjacent area, the zone boundaries could have been formed to correspond with the civil division boundaries. (Because the adjacent area zones were large at PATS, grouping of the civil divisions would have been necessary in most cases.) By using these civil division boundaries, a tighter control of the trip data would have been possible. Also, estimates of population distribution and land use would have been simplified a great deal.

For broader and more general analysis, there was prepared a system of "rings," concentric about the central business district, and "sectors," or wedges with the small ends focused at the CBD. Generally speaking, where two ring lines and two sector lines encompass an area, a "district" is created.

Rings are plotted in time-distance increments starting at the CBD and ending at the study's cordon line. Primary rings are first plotted in uniform progression from the CBD. But, since all units of area used for analysis must be related to allow machine summarization, the zone boundaries nearest the plotted ring lines are followed. At PATS there were eight such rings within the study area, numbered from 0, in the CBD, to 7 at the perimeter of the study area. All of the adjacent area surrounding the cordon line was considered ring 8, everything beyond was assigned to ring 9.

The sectors at PATS were first plotted in roughly at a 45-deg angle from the CBD and aligned so that each of the three river valleys was straddled by the sector's boundaries. This procedure was followed in an attempt to group types of land uses and environments into sectors. Again, the zones nearest the plotted sector lines were used for the actual sector boundaries. The PATS study area is split up into a total of eight sectors. These sectors are continued beyond the study's and adjacent area's extremities and carried throughout the United States, Canada and Mexico.

And analysis district is created by the intersection of two ring and two sector lines. Due to the construction of the rings and sectors, it is only reasonable that the area of the districts will enlarge as the distance from the CBD increases. Since the requirements for the district are similar to that of the analysis zone, great care must be exercised in plotting each ring and sector. When these controls (for the forming of zones) are considered during the selection of the ring and sector, the initial uniformity of trip ends and land use (urban and otherwise) is not lost.

PREPARATION OF ARTERIAL AND MASS TRANSIT ASSIGNMENT MAPS

As the trip maps needed for the highway and mass transit trip assignments are virtually the same, only the procedures followed in preparing adequate maps for the highway assignments is described. In the following paragraphs, the methods used at PATS to prepare this map series will be explained, beginning with the origin of the highway system.

For the purpose of selecting an adequate highway network, a complete set of $7\frac{1}{2}$- x $7\frac{1}{2}$-ft USGS topographic quadrangles covering the study area and the adjacent area was obtained. These USGS maps were then mounted in pairs on heavy-duty cardboard and the predetermined superimposed grid was plotted onto the maps exactly as it is on the data collection map. Each board was then numbered for indexing and covered with matte acetate and protective clear acetate overlays. (The clear acetate was also used for preliminary layouts in grease pencil.) The matte acetate was used for a more

permanent record of the arterial network plotted. Although these boards were primarily used for the network layout, they had many other uses, as for example, the plotting of the analysis zones described in the preceding section.

The USGS boards were, at this stage, then turned over to the traffic engineering division for plotting of the highway network. While the arterial system was being laid out by the traffic engineering division, the C&D division began preparing the maps needed for the assignment series. First, the black separations of the 7½- x 7½-ft quadrangles were acquired from the United States Geological Survey, after which a film negative print of each of the sheets was reproduced. The negatives were then matched together (east to west) forming three strips covering the study area. (Strips, as referred to in this part, are the USGS 7½- x 7½-ft quadrangles matched side by side, covering the study area from east to west with one 7½-ft quadrangle north to south. Three such strips covered the PATS area.) The negative strips were then screened and a contract Cronaflex print reproduced from each of the strips. The screening procedure subdues the image of the USGS map's detail so that the more pertinent information, such as the arterial street network and the study's analysis zones (added later by the C&D division personnel), stands out on the finished product. This subdued area is referred to as the supporting detail of the assignment maps.

When the arterial street network was examined, it was decided that the area surrounding the CBD was much too congested for an adequate posting of assignment results. Therefore, this portion of the study area was photographically enlarged and placed on a separate Cronaflex print. Although this enlargement was sufficient for the area surrounding the CBD, it still was not detailed sufficiently for the CBD itself. Consequently, a still larger scale map was required for the area. In all, three separate map scales were used for the PATS traffic assignment series: first, basic USGS strips at the scale of 1 in. = 2,000 ft; second, the enlarged area surrounding the CBD at the scale of 1 in. = 1,000 ft; and third, the CBD itself at the scale of 1 in. = 500 ft. A separate Cronaflex strip was also prepared with line diagrams of the expressway interchanges to illustrate the complex coding of the interchanges required for traffic assignment problems.

When the aforementioned procedures were completed, the C&D division had five map strips showing the supporting detail within the study area. Three contained the USGS black plate at scale, one consisted of both the enlarged maps of the central portion of the study area, and one contained the expressway interchanges.

A point worth emphasizing is that the supporting detail should be printed on the reverse side of the Cronaflex strips. This allows changes and additions to be made on the first side without distorting the supporting detail on the back. Also, when contacting additional Cronaflex prints, a sharper image is achieved. The importance of this method will become more evident in later parts of the discussion.

When all of the maps containing the supporting detail were completed, the arterial network was added to the Cronaflex strips, using the prepared USGS boards as a guide. When plotting of the arterials was finished, black and white prints were reproduced and delivered to the traffic engineering division to be used in making the arterial street inventory. On completion of the inventory, all additions and corrections to this highway network were noted and submitted to the C&D division for revision of the Cronaflex strips. Then reproducible sepia prints were made from the Cronaflex strips. Pertinent arterial inventory data could be added to the sepias, and black and white prints reproduced when needed. This completed the mapping needed for the arterial inventory; however, there is additional information that must be posted on the Cronaflex strips before the set of assignment maps is adequate.

Sometime between the selection of the arterial network and the completion of the network's inventory, the analysis zones should be defined. (For the method followed, see the section on, "Preparation for Coding and Analysis.")

At this point, all of the basic detail needed to set up the assignment maps was available. There is a complete set of Cronaflex strips (with the USGS map information screened and printed on the back) of the study area, including the existing highway network (drawn in ink on the front side). Also, the analysis zones were completed and posted on USGS board overlays. These zones were then added to Cronaflex strips for use in

the assignment coding. Inasmuch as the zones, like the USGS map detail, will not change with each new assignment, they were drafted on the back of the Cronaflex prints and black and white prints made. The traffic engineering division devised a numerical identification system (node numbers) for all arterial intersections on these prints which were then returned to the C&D division. After editing, the node number and symbol for each intersection were added to the Cronaflex strips.

Although a major portion of the Study's planning effort concentrates on traffic movement within the study area, consideration was also given to the adjacent area. A simplification of the type of map needed for traffic assignments was used. All that was required was a single line drawing, showing the arterial network, the arterial intersection identifications, and analysis zones. The scale of this adjacent area map was much smaller than the study area map, thus enabling the complete adjacent area to be shown on one map.

Before future traffic assignments can be made, there is a trial and error period used to test different methods of assigning traffic on the original arterial street system (revising the computer program as necessary). Using this procedure, the results of the different methods may be checked back against known ground counts, as obtained by the arterial inventory (or, if interchanges have been calculated by computer, checking back against known interchanges). Once an adequate program is devised, there is a need for additional sets of assignments to test various arterial and expressway proposals. To eliminate the need for preparing a new set of maps for each assignment, the following procedure is recommended: reproduce auto-positives (on Cronaflex prints) of the complete set of assignment maps containing the existing highway network. These should then be filed. The original Cronaflex strips (containing the arterials and their intersection identification on the front side in ink, and the zones and USGS maps' detail on the back) were used for the next assignment and each additional assignment thereafter. On black and white prints of the original strips, the traffic engineering division can make the necessary highway changes and highway proposals. The new arterial intersections formed may then be identified, checked, and coded into the highway system. These changes can be made on the original Cronaflex prints and a sepia print reproduced. The sepia print may then be labeled and filed as a permanent record of that particular assignment. Also, black and white prints can be made for posting the assignment results.

For the next assignment and each assignment thereafter, until an adequate highway system is decided on, the mapping procedures will be the same as the ones previously outlined. That is, the highway changes required for each new assignment should be made on prints of the previous assignment, and the change made on the original Cronaflex prints. Each time the original Cronaflex prints are changed, a sepia print should be made and filed as a record of the highway system used for that assignment.

The great difference in cost is the reason for using sepia prints in place of Cronaflex prints for immediate assignments. However, the sepia prints are not very durable. Therefore, for the definite arterial networks (first and last assignments) the Cronaflex prints are preferable. Also, the Cronaflex prints are much more suitable for corrections and additions, because the initial arterial roads set up by the study can be altered and added to without any distortion or mutilation of the zones and supporting data on the back.

From time to time there is a need to display the assignment results. This need is most evident in the early stages and for the late stages of the trip assignment phase. While the maps described fulfill the purpose for which they are intended, any attempt to display the entire study area at one time would prove very difficult. To overcome this difficulty, the strips were photographically reduced to a desirable scale and joined into a composite map. From this, a Cronaflex map was reproduced (and subsequently black and white prints), on which a color coding system was used to display the assignment results.

A properly prepared series of assignment maps is of the utmost importance to a comprehensive O&D study. Assigned trips to proposed plans represent the culmination of many months of data collection, forecasting, and planning. These results are therefore of vital interest to both study staff and sponsoring agencies and deserve the best

presentation possible. It is felt, at PATS, that the method outlined will satisfy all the requirements of an adequate series of assignment maps.

PRESENTATION OF STUDY DATA

During the life of a comprehensive O&D study, a vast amount of information is obtained. It is the C&D division's duty to graphically present this data in an accurate and concise manner. Not only is the pictorial representation of data an aid to the study's planners, but it is also an important public relations factor. In many cases, a person's initial opinion of the study (gained through personal contact or through publications) is the most lasting. People, although they will not admit it, do attempt to tell a book by its cover. Consequently, to favorably impress the visitor or reader, graphic illustrations must be presented in an attractive manner. Along with attractiveness, the information must be accurately displayed by the simplest method possible.

There are two primary means of presenting the study's data. One is the permanent display housed at the study's office. These displays may be used for presentation at lectures, conventions, and the like. They are also used by study personnel and other interested agencies for analytical purposes. The second method of graphically presenting information is through written technical reports, monthly publications, and the study's final report.

The following sections outline the procedures followed by the PATS' C&D division in completing some of the more important displays. Also noted is the use of these displays as illustrations in publications.

Base Map

The PATS' base map can be defined as a picture of the study area, showing selected study data and geographic features necessary for orientation. On this base, all data collected and all future predictions may be visually presented. In this way, there is formed a clear and definite pattern to assist in final analysis.

The base map is composed of ten separate overlays, five of which represent the following major geographical features: the PATS' arterial road network; civil divisions; civil division names; drainage; and major railroads and airports. The remaining overlays present the imaginary boundaries that were set up for the collection and analysis of data and include: ½-mi grid coordinate system; modified grid; analysis zones; districts; and cordon and screenline stations.

Although these two types of detail had different origins, the process of compilation was similar. Each item was laid out on a suitable reference map. A preliminary check was made for completeness and accuracy. The next step was to trace the items separately on overlays registered to one another. Each overlay was then reduced photographically to the working scale of 1 in. = 1 mi. The reductions were drafted in ink on a polyester base drafting film. After the drafting work was finished, each item was thoroughly checked for completeness, accuracy, and neatness. As work was concluded on the individual features, they were compared to one another for perfect registration of detail.

For most analysis and display purposes PATS used the base map at a scale of 1 in. = 2 mi. To facilitate the availability of the required base map combination, all overlays were reduced to this scale and filed in negative form. Each overlay was reproduced in line and screened form, so that the item of importance to the user would stand out (line) on a background (screened) of related information. Also a few composites were prepared in anticipation of maps needed for analysis. From this pool of overlays and composites, most of the study's reference maps could be prepared without any additional drafting.

To explain further, an example would be a user interested primarily in the arterial road network. He would want to associate the network with the ½-mi grid, the civil divisions, and the drainage. The arterial road network would be printed in line form, the ½-mi grid in line form, and the civil divisions and drainage in halftone. This would give the user the arterial road network, with which he is working, and the ½-mi grid; the background, providing orientation, would be the civil divisions and the drainage.

To accomplish this, each of the four overlays must be combined photographically to a single reproducible from which prints can be made.

In addition to the overlays, specialized overlays were also prepared as requested. For example, an index of the aerial photograph coverage was drafted as well as a mass transit system overlay.

For presentation of data in the PATS' final report, a simplification of the base map was required. The map is a composite of many of the base map overlays and contains the minimum amount of detail required for proper orientation.

Another phase of the base map series at PATS was the preparation of a CBD map. This map contains all streets within the CBD with overlays defining its arterial streets, blocks, analysis zones, and census blocks.

Tab Map Display

Tab Map.—A tab map, as prepared by PATS, may be defined as a geographic table. In reality, it is a gridded roll of tabulation paper containing data collected or projected by the study, originating in the machine processing division. The grids printed on the tabulation paper are set up to correspond with the superimposed grid coordinate system

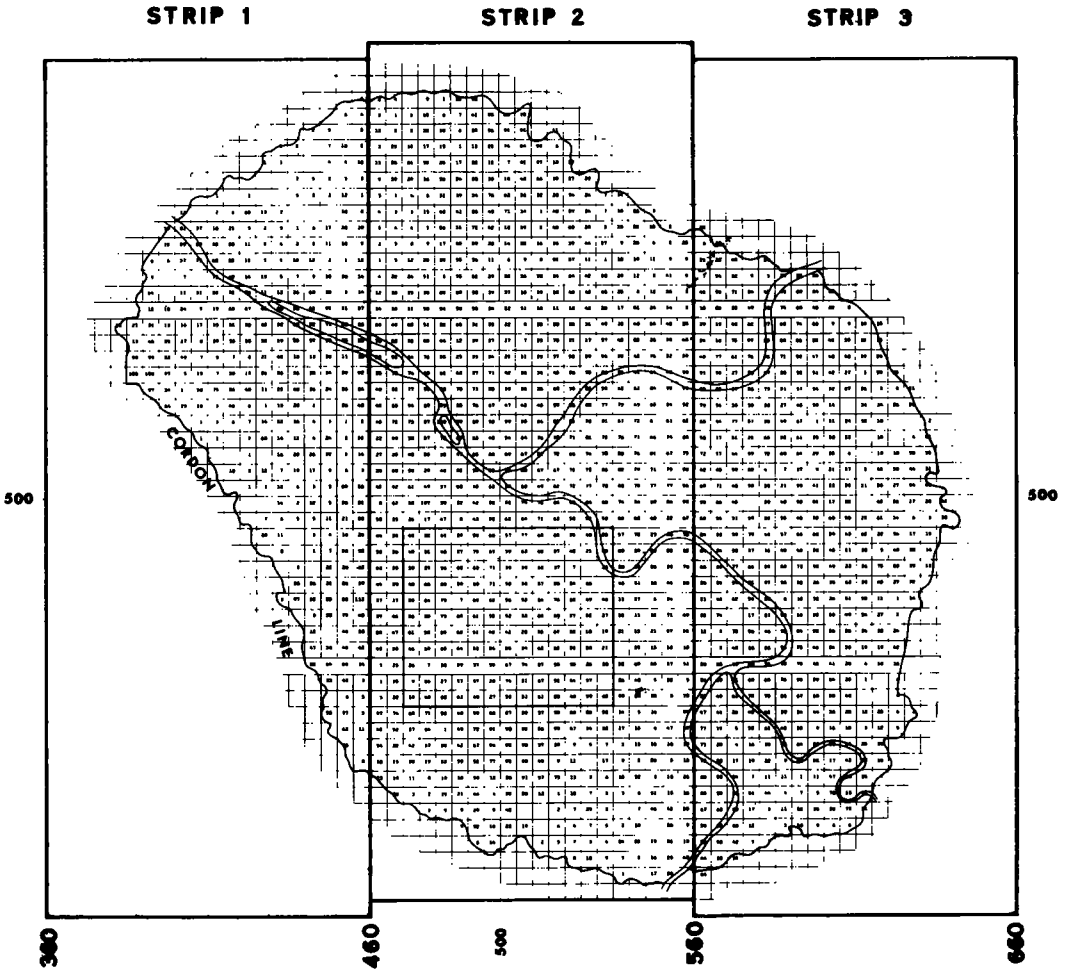

Figure 2. Layout of machine-printed tab map. The Study's cordon line and rivers were added to this reduction to clarify the relationship between the study area and the tab map.

used for geographic identification. The information to be printed on the maps is on punched cards and arranged in such order that the data pertaining to a particular grid square (modified grid) is printed in a ½ in. square representing that grid on the tab map. The ½-mi grid is the smallest unit of area summarized for the printing of the tab map. These maps break the study area's 1,692 grids into three strips (Fig. 2) at the scale of 1 in. = 1 mi.

Although the grid square is the basic unit of area used for presenting data collected, it becomes necessary to decrease the number of geographic units for the study's forecasting, therefore, the analysis zones are used. To present this projected data in tab map form, the same machine procedure is used, with the exception that only one grid out of each zone is used for printing information pertaining to the whole zone, this grid being the geographic center of the zone, whenever possible. (For a description of how analysis zones are formed, see the section on "Analysis".)

When the three strips making up the maps, either the zone or grid type have been printed and checked for accuracy by the machine processing division, they are turned over to the C&D division. After the three sections have been stripped together and all of the X and Y coordinates labeled, an appropriate title is put on each map, and the data is then reviewed (Fig. 2).

Although all the tab maps printed at PATS are important as reference material, the tab maps thought to be most useful were reduced from 1 in. = 1 mi to 1 in = 2 mi and prints reproduced. To facilitate reading of the grided tabulations, they are used with transparent overlays of the PATS' base map. In this way pertinent information may be readily correlated with civil divisions, the PATS' arterial system, or the PATS' analysis zones.

Presenting the data on tab maps with different overlays is sufficient for reference purposes, but is ineffective for over-all effect and legibility. It is practically impossible to look at a group of maps, each containing hundreds of grids, with anywhere from one to five digits printed in each grid, and try to form a complete picture. This is the major factor that necessitated the presentation of PATS' data in display form. Here the old saying "One picture is worth a thousand words" (or digits in this case) was never more true.

In choosing the data to be presented, several factors are to be considered. First, the data should be comprehensive enough to contribute to the general idea the study wishes to convey. Another consideration is the analytical value and appearance of the finished display weighed against the cost of producing it. With a decision based on these two points, the process used for data presentation was the problem next at hand.

At PATS two methods of displaying the data printed on the tab map were employed. By the first method, a model was built with the values in each ¼- sq mi area (grid square) represented by the height of wooden sticks. The data best presented in this manner was trip information. The second method used was the isoline map. This type of display is compiled by enclosing areas (grid squares) of similar values. Both of these methods are explained in detail in the following paragraphs.

Trip Models.—Inasmuch as the data to be shown was reduced to the standard display scale of 1 in. = 2 mi, each ½-in. grid became ¼-in. square. Consequently, wooden sticks ¼-in. square were used. From these strips, 7,000 wooden blocks were cut in ⅛-in. increments, in sizes ranging to 4 in. in height.

The procedure followed in making all models whose data are summarized by grid square is exactly the same. For this reason, the process used in preparing the model shown in Figure 3 will be explained.

The reduced tab map, "Mass Transit Trip Destinations" (by ¼ sq mi), was scanned to set up a suitable scale that would best point out the concentration of mass transit trip destinations within the study area. The vertical scale decided on was 1,500 trips per ⅛ in. of vertical height. A conversion table was then prepared using this increment range. For example, all grids with values between 1,000 and 2,249 were rated 1,500 trips (⅛ in.); likewise, all grids with trips ranging from 2,250 to 3,750 were rated 3,000 trips (¼ in.), etc. With the conversion table as a guide, the reduced tab map was gone over very carefully and each grid that fell within one of the values was

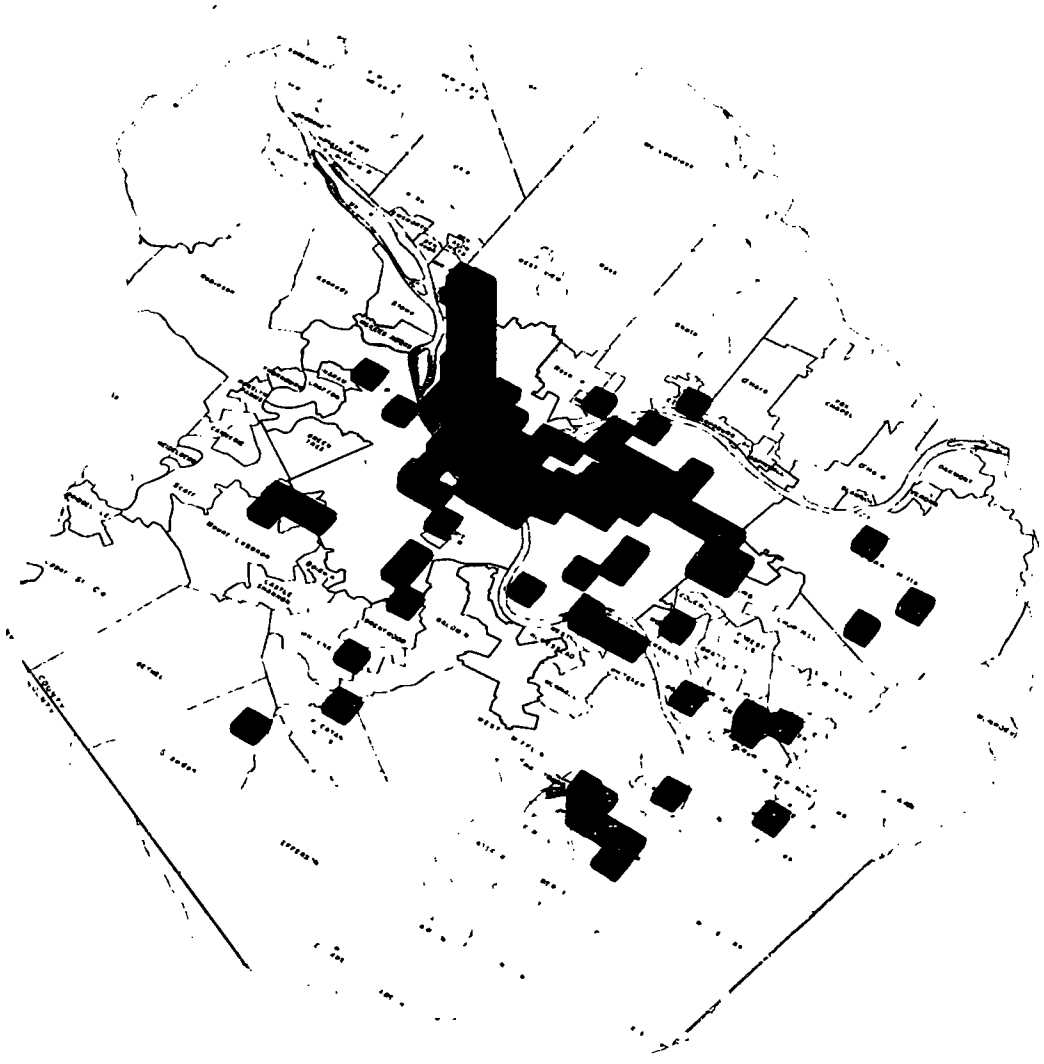

Figure 3. Typical model depicting mass transit trip destinations, by $\frac{1}{4}$-sq mi grid.

marked. When this step was completed, a transparent base map overlay (the same kind that will be used in the final display) was aligned on the tab map and the proper size wooden blocks were placed on the grids they represented. For example, all ¼-in. blocks were placed on the grids that fell within the range of the 3,000 trip value. Whenever the blocks were adjacent to one another, they were glued together, but not to the overlay. On completion of the positioning of the blocks, a very careful check was made to asure that each grid was represented by the proper size block. After all adjustments were made, the blocks were painted and varnished. (If the models are to be photographed, do not varnish the sticks until after the photographs have been taken.)

A photoprint of the same type of map that was used to set the wooden blocks on was then mounted on an 18-in square board, and the study area was tinted in. Next, the blocks were transferred from the overlay to the photoprint and glued down. It was necessary to exercise great care in this process, so that there would be no geographic distortion of the work trips represented by the blocks. This was the major reason for using the same map for both the tab map overlay and the photoprint used for the display. To complete the model, the title, legend, and border were then added, and as a protective measure, the model was covered with a plastic dome.

At PATS, the preparation of the models used to represent the study's trip forecasting is similar to the method previously described. There is, however, one major difference between these two models. The difference lies in the preparation of the base map on which wooden sticks are positioned for display. The base map contains, in addition to the civil divisions, all of the analysis zone boundaries. This is necessary because the wooden sticks, in most cases, represent an area much larger than the stick is square. (In the case of the models summarized by grid, the wooden sticks, which are ¼ in. square, are exactly the same size as the grid square they represent.) Also, because the area being defined is larger, a stick may be used to represent current trip data in the same zone with a stick representing the projected trips; thus the relationship between present and forecasted trips may be better compared.

Besides these displays representing data pertaining to the study area as a whole, models were also constructed representing Pittsburgh's CBD trip destinations and floor area data. In the CBD, data was summarized by block in place of grid, therefore, the models were prepared directly from table print-outs and not from tab maps. The preparation of the wooden sticks was similar to that of the study area models.

The completed trip models at PATS are used by the study for three different purposes. First, they are used by the study personnel and other interested agencies for general reference and analysis. Second, the models are photographed and presented as illustrations for the final report. The third way the models are used at PATS is for public relations purposes. They are displayed at conventions and meetings outside the study to familiarize other agencies and public with the study's functions and findings.

Isoline Maps.—In the case of the isoline maps, as with the trip models, the data to be displayed are printed out on a tab map and reduced to 1 in. = 2 mi. (The word "isoline" simply means a line of equal value and the compilation of an isoline map may be described as similar to the "logical contouring" of relief features. The isoline map as used here, however, is compiled by enclosing areas of similar values rather than connecting an infinite number of equal-value points.) The information printed in the tab map's grid square (or superimposed grid) is first "color coded" by grouping the data on the map into logical value ranges. Then the color given each abstract grid is transferred to its modified grid counterpart on another map. This transformation is necessary because of the variation between the superimposed and modified grids and results in better orientation of the information and the area which it represents. After checking, the color-coded modified grid map is overlaid with a drafting film containing a base map for final drafting. The perimeter of each color grouping is then traced. This type of isoline is used at PATS to represent the percentage of a modified grid used for a particular land use.

For presentation of data relating directly to population, another step is incorporated. By visual reference to actual population concentrations, the perimeter of each grouping is shaped somewhat, instead of simply following the modified grid boundary. (Similar shaping is done at the major rivers and prominent terrain features on all isoline maps.) This method conveys a more realistic picture of the distribution of population, car ownership, residential density, etc.

This type of isolining requires individual interpolation; therefore, it is doubtful that two persons would ever draw the same isoline map. However, the difference in interpretation may be lessened somewhat by the addition of more reference matter. At PATS, to attain greater accuracy and a more realistic picture, an overlay containing all large plots of used land (other than residential) and the vacant unusable areas was prepared. This overlay was used in conjunction with each of the color-coded modified grid maps for forming the isolines representing data relating to population.

A properly prepared isoline map is a valuable contribution to a study's analytical ability. Also, it provides an excellent means by which an area's land use and population characteristics may be defined.

Trip Desire Line Maps

A complex problem in every O&D survey has always been the presentation of trip

desire data. For the data to be a useful tool to the analyst, it must be presented in such a manner that it can be read and understood. One graphic method of displaying trip desire data would be to plot every trip by hand. This method requires many man-hours of labor and the finished product would not be easy to read and understand. Several methods have been used to reduce this problem to manageable terms. Probably the most commonly used method has been to group trip ends by zones and display the volume of interzonal trips by varying width bands. This method shows grouped trip desire lines. Another method which has been developed and is used by several agencies is to compute the direction each trip moves on a grid, punch a card, for each grid square traversed by the trip as it moves from origin to destination, summarize the cards, and make a tab print-out (tab map). This print-out can then be taken to the drafting table and isolined, producing a trip desire density chart.

All of these methods have one bad characteristic—the amount of man-hours and machine time necessary to complete the display. Early in 1958, the Chicago Area Transportation Study, in conjunction with the Armour Research Foundation of Chicago, developed a machine that will help to solve the problems associated with the presentation of trip desire data. Called the Cartographatron, (1), this machine is an unbelievably swift X-Y plotter.

The Cartographatron process involves three steps. Step one involves converting the original punched card deck for each survey to magnetic tapes. Step two is the actual operation of the machine in which the records taken from the tapes are converted to light traces, and recorded on a photographic plate. This plate acts as a memory or summarizing device. Step three involves the photographic plate, which is removed from the camera and developed. The negative can, by use of a densitometer, be electronically split to find the range of densities depicted by the data. This information can then be used by the photo lab to "slice" the negative into high contrast prints of different densities, which, in turn, can be drafted to form an isoline map. This method produces possibly the truest trip isoline that can be made, because the density patterns depicted in this manner are products of a mechanical application and not of human judgment.

If isoline maps are not desired, the negative is simply combined photographically with an overlay of the civil division map (for orientation) and printed to form a display. The machine can also be wired to show only origin of trips or destination of trips for particular trip purposes.

To estimate the amount of man-hours necessary to plot each origin and destination for an entire study area is next to impossible; to group trip ends by zones and plot them that way would take several months. However, the Cartographatron can, after the tapes are made, run a complete display in less than four hours. Thus, with approximately 4,000,000 combinations from one complete trip file and because of the speed at which they can be put in readable form, the analyst has many more desire line maps in highly selective forms.

Growth Map

A growth map may be described as a pictorial way of expressing progressive development in a certain area. Still another description might be that, in essence, it is much like looking at a cross-section of a large tree that shows its growth pattern in the annual rings. The growth map compiled by PATS, for example, shows the development of the Pittsburgh area from 1760 to 1958.

The major source of historical maps required for plotting the growth map was the Carnegie Library of Pittsburgh. Any source that might contain information on the placement of population for a particular year was closely examined. All maps that were found and thought to be of value were then traced exactly as printed in the source. Showing as much detail as possible at this stage proved to be a great help later when the different maps were collated. There was an abundance of material available on the growth of Pittsburgh proper; however, very little data were to be found on the area now known as metropolitan Pittsburgh.

Other sources were then sought for more recent maps showing population trends.

The United States Geological Survey (USGS) quadrangle, dated 1904, and a map showing development, dated 1930, were obtained—the latter from the Allegheny County Planning Commission. For the most recent information on development, the PATS' aerial mosaic was used. This was made from photos dated 1958.

After the basic data was compiled, it was analyzed so that an accurate picture of growth could be presented. Certain maps were discarded due to insufficient information or because they were dated too close together to show a noticeable difference in growth. After analysis, the following maps were chosen for final use: 1760, 1795, 1830, 1875, 1910, 1930, and 1958.

The 1904 USGS map was used as a basis for compiling the collected data inasmuch as much of the street network at that time corresponds with that of today. Roads, along with rivers, streams, railroads, and general contour of the land, constituted very good reference points for the plotting of the newer developments. At the same time, the 1904 base map helped in the location and plotting of the older settlements.

The 1904 map was then overlaid and, starting with the earliest date, each growth year was drawn in isoline form. After the growth map was drafted in final form, it was photographically reduced for use in PATS' final report. The original was used as a permanent display.

The growth map, besides being a display and illustration in the final report, will serve other functions. It may be helpful, for instance, in the prediction of future development in commercial, industrial, and residential areas. The map may also be used for analysis in conjunction with the area's economic status. Aside from these reasons, there will be even more uses for the growth map, because knowledge of what has happened in the past is a great factor in predicting what is to happen in the future.

Aerial Mosaic

An aerial mosaic provides a more complete and concise picture of a study's area than any other means of visual presentation. Although it cannot be used for exacting measurements, it is an excellent source for general references during all phases of the study. The mosaic will contain all existing topography at the beginning of the study. This is important for two reasons: First, it is very doubtful that there will be any map available containing all recent developments throughout the study area. This is extremely important for pin-pointing locations for land use and large trip generators. The mosaic will also afford a permanent record of the study area as it existed during, or immediately before, the data collection phase. Besides being valuable as a reference tool, the aerial mosaic is a very impressive permanent display.

Terrain Model

A terrain model (a three-dimensional map) of the study area is definitely an interesting display. The value of the terrain model as an aid in the study's planning procedure is dependent on the terrain features dominant in the area. In Pittsburgh, where the terrain is quite irregular, a model of this type was found necessary to properly grasp the actual lay of the land for traffic planning.

If the terrain model is decided to be an asset to the study, a method of obtaining it must be decided on. There are two procedures that might be followed. First, the model could be made by study personnel; second, the preparation of the model can be contracted. The construction of an accurate model is a very tedious operation requiring tools not common to a drafting room. For this reason, it is very unlikely that the C&D division would attempt to build the terrain model. Therefore, the second method is more desirable. If the building of the model is let out on contract, the amount of detail shown on the map is dependent directly on the amount of money allotted for construction. Regardless of the amount of detail on the model, there are certain basics that are common to any model that might be made. For instance, the model should be constructed of a lightweight durable material that is capable of maintaining its shape. Also, consideration should be given to the possibility of updating the model's detail (new roads, developments, etc.). That is, the model's original detail should be set up so that additions can be made by the study's personnel or, if done outside the study, at a minimum of expense.

Miscellaneous Displays

At PATS, it is felt that by varying the method of displaying study data a more effective over-all result may be achieved. For this reason, in addition to the displays mentioned in the preceding sections, numerous other displays will be constructed by the C&D division. To date, PATS has prepared approximately twenty displays by methods other than those previously described. These include such items as "Data Collection Stations," "Rapid Transit Proposals in the Pittsburgh Area," "Centroids of Selected PATS Data," "Station to Station Thru Trips," "CBD Accumulations of Persons and Vehicles," "Study Progress Chart," "Study Organization Chart," "Traffic Flow Map," and many more.

Illustrations for Publications

Due to the complicated nature of the data and the constant use of statistics, graphic illustrations are necessary to support the text of study publications. Well-planned illustrations assist the author in telling his story and provide additional interest for the reader.

At PATS the type of illustrations used in publications, except the final report, consist namely of charts, graphs and simple maps. Due to the expense involved most of these illustrations are printed in black and white. However, if the information or area defected appears to be congested, then a colored overlay is added to clarify the situation. When overlays are used, extreme care must be taken to insure proper registration during the drafting and printing process.

Although neatness and accuracy are essential for all illustrations, a little more effort should be exerted when preparing the final report's maps and figures. Each illustration should be thought out carefully and the end product visualized before it is drafted. Where possible, especially for the final reports graphs, a standard base is desirable. For example, at PATS most of the graphs are to be printed at a 3- x 3.3-in. size. To standardize the line weights of each of these illustrations, a base graph containing the borders and three horizontal lines was drafted at 10 in. x 11 in. (to arrive at the desirable printing size, a reduction of 30 percent of the original's size is needed). This base graph (containing five equal spaces from top to bottom) was then overlaid and the required lines representing given information were drafted. The overlay was then registered to the base graph. When an additional color was necessary, another overlay was drafted and registered to the first two. In the next step, all of the overlays and base graph were photographically reduced to the printing size on film negative prints. The original base graph was then used for all similar illustrations and the same procedure was followed, except that only the overlays were reduced. The one reduced base graph will be used with all illustrations of this type.

Also, to facilitate orientation of the isoline maps, the same base map is used for all illustrations depicting information by the isoline method.

The previously described trip models are also used as illustrations for the PATS' final report as well as in this publication. The models selected are photographed and a halftoned film negative reproduced at the desired size. The halftoned negative is then used for printing the model.

In general, a good rule to follow when preparing illustrations for any publications is that a completed illustration with suitable caption should be self-explanatory. In other words, it should not be necessary to describe the figures in the text. Each illustration must be an aid to the author and not another point to be explained.

Summary

Certain displays have been described in detail, whereas others have only been mentioned. It is the opinion at PATS that the displays described in detail are of the type that will probably be used by other agencies conducting a comprehensive O&D study. The displays mentioned as "other displays," are equally important, but methods and procedures used to produce them may vary greatly from one study to another. Usefulness versus cost is a major factor in determining what data will be displayed. The

decision on the method of display that would best present a particular type of data should be the responsibility of the C&D division, subject to approval of the study director.

Space necessary for display purposes was acquired by using the PATS' conference room. This served a dual purpose. First, the displays are readily available for committee discussions and, second, when the committees are not meeting, the room is used to receive visitors.

The importance of good displays and illustrations cannot be over-emphasized. Collecting, coding, summarizing and analyzing data requires the expenditure of a vast amount of money and labor. Attractive, well-planned and prepared displays and illustrations lend themselves to the justification of these expenditures. They also compliment the efficiency of the study organization.

PUBLICATIONS AND LIBRARY

The publications prepared by the Pittsburgh Area Transportation Study are the only contact many persons or organizations have with the Study; therefore, their preparation is a vital part of the Study's operation. A great amount of interest is created by PATS' procedures, as they represent a relatively new approach to the O&D study. PATS' findings have also been found useful by local agencies because of their application to the surrounding area. By reporting the Study's facts and figures through publications, it is hoped that the method suggested and the data presented may aid other interested agencies.

The printed matter will fall into one of the following two categories: that information which assists the study personnel in the completion of their duties; and that information which reports the findings of the study. In preparing publications for the first category, the main concern is to present the information clearly, as these are manuals of procedure. Manuals used at PATS were the Land Use, the Home Interview, the Truck and Taxi Interview, the Home Interview Office Procedures, the Coding and Roadside Interview. The text should be prepared by the division requiring the manual. The C&D section must then edit, prepare illustrations, collate, and prepare the text for printing. Although manuals need not be elaborately printed, they should have a durable cover, so that they will hold up under the constant use they will receive. The second category consists of publications designed to report the study's findings, as well as the procedure followed to arrive at these conclusions. At PATS there were four types of publications prepared for this purpose: the Research Letter, Interim Technical Reports, Technical Papers, and the Study's Final Report. Following is a description of each publication.

Research Letter

This is a publication of general Study information prepared and distributed monthly to interested agencies. Because most of the articles are written by Study personnel soon after completion of that phase of the study described, an excellent, simplified account of the methods followed is recorded. (For more detailed accounts of individual phases, the Study prepares Technical Papers.)

At PATS the C&D division set up style specifications to insure the uniformity of each Research Letter. The division's editor-librarian was responsible for editing and preparing the copy for printing and on completion of the printing, the editor-librarian also handled distribution. All illustrations required for the articles were prepared by the C&D section in cooperation with the author.

The Research Letters prepared by PATS have met with favorable response and, at the present time, approximately 250 copies are distributed monthly.

Interim Technical Reports

When information was considered (by the Study) important enough to warrant special attention, the data was presented in an Interim Technical Report. The content of these reports was less general than the Researvh Letter; therefore, the distribution was limited to persons interested in the particular subject covered.

The C&D division is responsible for editing, illustrating, printing, and distribution of these reports. At the present time, PATS has prepared four Interim Technical Reports, with about as many more in sight.

Technical Papers

The Technical Papers, as prepared by PATS, are used as background for the Study's Final Report, and to record many of the Study's more complicated methods and procedures for analysis. Distributing these papers before or with the Final Report eliminates a considerable amount of explanation that would otherwise be necessary in the text of the report.

There are a total of thirteen Technical Papers, to date, and more to come as needed.

Final Report

The Final Report will consist of two volumes. The first volume is concerned only with conditions as they were during the data collection phase of the Study. The second volume will present the Study's 1980 forecast of Study conditions as well as its recommendations for an integrated transportation system (transit and highways).

In the latter part of the Study, the preparation of the Final Report is the C&D division's most important function.

Due to its importance, a considerable amount of planning is required. Technical problems concerning the Final Report should be taken into consideration early in the study.

Prior to the printing of the Final Report, a proof copy of each chapter is distributed to the Study's supporting agencies for approval. This proof copy is prepared by the Study before a printer is contacted, to eliminate the need for distributing galley proofs (which are run for editing purposes by the printer preparing the report). Moreover, if a proof copy is prepared as each chapter is completed, one part can be written while another is distributed for approval. If galley proofs were used, the writing of the report would have to be finished (due to contract difficulties) before it could go to the printer. The printer then would set the type and run galley proofs, after which the completed report would have to be distributed for approval and rewrite. In all probability the whole report would then have to be typeset again; consuming a great amount of time and money.

Library

A technical library was established at PATS soon after the start of the Study. The books and periodicals collected by the library are to be used by staff members as reference material and also as a means of keeping up to date on current developments in fields related to the O&D study.

The editor-librarian is responsible for ordering the publications requested by PATS' staff and for cataloguing this material when it is received. At PATS, library material is grouped on shelves, alphabetically, according to general subject classification. A card file is also kept, containing the appropriate information for each publication, and cross-indexed by author, title and subject. Reports ordered for staff members included results of other O&D studies, procedural manuals, statistical compilations, economic studies, planning reports, and technical periodicals. The librarian also requests that PATS' name be placed on the mailing list of agencies related to the transportation and planning fields.

To save the typing time that would be required if a separate order were prepared for all new acquisitions, an order letter and a thank-you card were printed, with a copy of the order being kept on file for control and reference.

An additional library function is a newspaper clipping service. Articles on traffic plans or changes, mass transit, land use, and area development are put into scrapbooks and circulated among members of the Study staff. New publications are also routed to interested Study employees and, at intervals, library acquisition lists are compiled and distributed.

CONCLUSION

This report has described the organization and the methods used to discharge the duties and responsibilities of the C&D division at the Pittsburgh Area Transportation Study. Also included throughout the text are suggestions which the authors feel would improve some of the methods and procedures. Although some point or points may not be applicable to every study area and study group, generally the contents of this paper could be used as a reference by those agencies about to engage in O&D work.

During the study phases of data collection, coding and analysis, the C&D division aids and assists all other study divisions by supplying the "graphic tools" necessary for the completion of their tasks. These tools must be designed to cause or allow the data to be recorded with accuracy and dispatch.

After data is collected, coded, summarized and analyzed, it becomes the duty of the C&D division to transform this data so that the findings of the study can be clearly and explicitly conveyed to the study's sponsoring agencies and other interested parties.

So that these duties and responsibilities can be performed in the best interest of all concerned and the objectives of the study prosper thereby, thoughtful consideration must be given to the establishment and organization of the C&D division when the study is being formed. Lack of proper planning and foresight can seriously hamper the effectiveness of this division. The role of the C&D division in a comprehensive O&D study must not be underestimated or slighted. A well-organized division, adequately staffed with qualified, responsible personnel is a definite and necessary asset to the study.

REFERENCE

1. Carroll, J.D., Jr., and Jones, G.P., "Interpretation of Desire Line Charts Made on a Cartographatron." HRB Bull. 253 (1960).