Principles for Determining Special Trip Generators

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Abstract — The article discusses the principles of the formation of the estimated transportation districts, taking into account special generators of movements that are understood as large objects of mass service of the population, in relation of which, the generation of visits is comparable to the generation of certain districts of the city. The conditions for the allocation of such generators in the special estimated transportation districts are considered. The methodology to form the initial data in relation to the estimated transportation districts using modern GIS technologies is described. The classification of the estimated transportation districts is presented.

Keywords — transport and urban planning, special trip generators, transportation zoning, transportation simulation.

I. INTRODUCTION

In modern practice, urban planning concepts have been developed to reduce transportation and environmental pressures, increase the safety of using transportation system, make streets and public spaces more attractive for living, and at the same time increase the efficiency of using urban areas.

Currently, Russia does not have national studies of trip generation rates for different land-use types and special trip generators, as is done in other countries [1,6,8,12,17,19,20]. IRNITU Transport Laboratory is studying methods of transport demand estimation and developing methods of urban transportation modeling including trip generation techniques [9-11,14,15,16,18].

A traffic analysis zone (TAZ) is an essential component of transport demand models [2-5,13]. For each of TAZ into which the city is divided, it is necessary to perform accumulation of socio-economic parameters, which involves mainly the analysis and processing of statistical data from different sources. The formation of zones and the determination of their boundaries largely affect the accuracy of transport forecasts [3,4].

The concept of TAZ is related to the concept of a special trip generator [7,8,19,20]. A special trip generator can be defined as an object or facility (like - large industry sites, large shopping centers universities, hospitals, airports, recreation facilities) that has unique characteristics of trip generation-destination and cannot be presented as a usual TAZ without losing some information needed for transport demand forecasting.

In this regard, several types of TAZ should be identified, including special trip generators. Therefore, it is necessary to formulate the principles and criteria for the division of zones into different types. The most important parameter is the volume of trip generation, which is defined as the number of trips to and from the object per unit of time per unit of one of the characteristics of the area (for example, the total number of trips during peak hours per 100 m² of sales area).

The principles for determining special generators are shown by the example of the Irkutsk transport model.

II. REVISION OF TRANSPORTATION ANALYSIS ZONES OF IRKUTSK TRANSPORT MODEL

The territory of the city of Irkutsk was divided into 96 TAZ (Fig. 1), in relation to which the correspondence matrix was calculated on the basis of population survey data, population data and places of employment.

After that, the functional use of the areas as a part of the estimated transportation districts was analyzed. To achieve this aim, the coding of objects that constitute transportation districts were proposed (Table 1).

The number of buildings and total area of the buildings is identified for different types of usage (i.e., related to different codes) in relation to each transportation district, based on the 2GIS geo-information data. The results of processing data of each object with the aim to distribute the area of all its floors between types of usage were entered into a model made up in the VISUM program. Figure 2 shows an example of entering such data along with a pre-prepared set of object parameters.
TABLE 1. Area use type (code) - type of objects

| No. | Description                           | List of Objects                                                                 |
|-----|---------------------------------------|---------------------------------------------------------------------------------|
| 1   | Residential                           | Residential complex, private housing                                          |
| 2   | Supermarkets, food markets            | Supermarket, food market, pharmacy                                             |
| 3   | Trade (non-food products)             | Goods, household appliances, shoes, flower shop, household goods, auto shop, jewelry store |
| 4   | Trade (furniture, construction materials) | Furniture, construction materials, windows                                    |
| 5   | Medicine                              | Hospital, dental clinic, polyclinic, veterinary clinic, health resort           |
| 6   | Kindergarten                          | Kindergarten, nursery, preschool education, extended education school, school   |
| 7   | Orphanage, boarding school           | Orphanage, boarding school                                                     |
| 8   | Education                             | Higher education institution, college, vocational school                        |
| 9   | Legal and bank services               | Bank, notary, insurance, court, post office, prosecutor's office               |
| 10  | Domestic services                     | Repair, tailoring, hairdresser, beauty salon, pawnshop, personal services      |
| 11  | Food services                         | Café, restaurant, coffee shop, canteen, bakery                                 |
| 12  | Leisure activities                    | Night club, bowling, cinema, bathhouse, billiard                               |
| 13  | Sport                                 | Sport complex, sport club, gym, swimming pool                                  |
| 14  | Garages                               | Garages, parking lots                                                          |
| 15  | Car service                           | Car service, car centre, car wash, tire fitting                                |
| 16  | Circus, theatre, cultural centre      | Circus, theatre, cultural centre, museum                                        |
| 17  | Stadium, park                         | Stadium, park, zoo                                                              |
| 18  | Library                               | Library                                                                         |
| 19  | Petrol station (AZS)                  | Petrol station (AZS)                                                            |
| 20  | Stores                                | Stores, household complex, greenhouse                                          |
| 21  | Administrative building               | Administrative building, engineering companies, business centres                |
| 22  | Church                                | Church, religious constructions                                                 |
| 23  | Constructions                         | Constructions                                                                   |
| 24  | ATMs                                  | ATMs, payment terminals (5 sq.m as recommended area)                            |
| 25  | Buildings under construction          | Buildings under reconstruction                                                  |
| 26  | Mall                                  | Trade centre, large (food and goods), trade – leisure centre                    |
| 27  | Civil Status Registration body (ZAGS) | Department of Internal Affairs (UVD), military registration and enlistment office |
| 28  | Police station                        |                                                                                  |
| 29  | Customs                               |                                                                                  |
| 30  | Fire station                          |                                                                                  |
| 31  | CHP plant                             |                                                                                  |
| 32  | Pension fund                          |                                                                                  |
| 33  | Railway station                       |                                                                                  |
| 34  | Airport                               |                                                                                  |
| 35  | Bus station                           |                                                                                  |
| 36  | Plant                                 |                                                                                  |
| 37  | Traffic control station               | Tram depot, trolleybus depot                                                    |
| 38  | Correctional facility                 |                                                                                  |

Fig. 1. Irkutsk transportation analysis zones

Fig. 2. Example of entering 2GIS geo-information data in VISUM transportation model

The data obtained as a result of the study were used to estimate the generation of visits to each building (object) separately. After that, total generation volumes of visits were obtained for each of the main estimated districts at evening rush hour.

\[
O_{PT,car \ i} = \sum_{k=1}^{m} S_{ik} G_{PT,car \ i} \tag{1}
\]

\[
D_{PT,car \ j} = \sum_{k=1}^{m} S_{jk} G_{PT,car \ j} \tag{2}
\]

\(O_{PT,car \ i}\) - total volume of correspondence departures from district \(i\) at rush hour; \(PT\) - public passenger transport; \(Car\) - individual vehicular transport; \(D_{PT,car \ j}\) - total volume of correspondence –arrivals at district \(j\) at rush hour; \(n\) - number of transportation districts, \(i, j = 1,2,\ldots,n; \ S_{ik}\) - total area of code \(k\) objects in the estimated transportation district \(i\) or \(j\); \(k = 1,2,\ldots,m; m\) - number of object types; \(G\) - specific generation, correspondence / h / 100 m².
It should be noted that this approach is universal, as it makes it possible to take into account special generators of the movements of city residents in the process of transport and urban planning and the assessment of transport demand. The obtained research data were applied to perform a cluster analysis of the main estimated transportation districts of Irkutsk (Fig. 3). As a result, according to the violation of the monotony of the function “distance of coupling - agglomeration step” (linkage distance - step), 6 clusters were identified, i.e. types of TAZ (Fig. 4):
1. zones with a high share of housing area;
2. zones with a moderate share of housing area;
3. zones with a low share of housing area;
4. zones of the central part of the city and business centers;
5. dormitory zones;
6. industrial zones.

In addition, an approach to the allocation of special transportation districts has been considered by the authors of this article. In accordance with it, it is necessary to identify large objects, the generation of visits to which is comparable to the generation of certain districts of the city, with their subsequent allocation into special estimated transportation districts. While testing this approach, two data sets were analyzed:

- hourly values of generation of travels of the main types of Irkutsk TAZs (transportation analysis zones);
- hourly values of hourly travel cost; attraction generation is concentrated in the central district of Irkutsk.

The center of Irkutsk is considered as an area of about 600 hectares, where a large number of various focus points of attraction are concentrated, including federal and municipal institutions, universities, various shops and supermarkets, theaters, restaurants, cafes, fast-food restaurants, entertainment centers, etc. Figure 5 shows the spatial distribution of all attractions in the center of Irkutsk, ranked by the route generation volume. It should be noted that, according to the results of the study, some of the focus points generate more than 500 private car trips per hour that confirms the feasibility of considering them as special trip generators to assess the demand for transport.
The results of the study are a continuation of a whole series of studies on transport and urban planning simulation performed at IRNITU. In general, development of database to assess transportation demand will be the objective of further research.

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