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# GIS AS A TOOL FOR ROAD AND TRANSPORTATION STATISTICS

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## I. INTRODUCTION

1. Geographical information systems (GIS) give an added value to different stages of the statistical process by optimising data collection, reducing the response burden and enriching statistics. As the examples below will show, this is made possible by standardizing and integrating data from different sources and by using internal and external registers. In this paper some (future) GIS applications in the field of traffic and transport statistics at Statistics Netherlands are described. As experience shows, it is possible to introduce GIS in an organization only through an integrated organizational approach.

## II. AN ORGANIZATION IN TRANSITION

2. At the beginning of 1995 Statistics Netherlands underwent a major organizational change. One of the aims of the reorganization was to lead Dutch official statistics into the next century by presenting the bureau as a modern information processing organization responding to the demands of users of statistical information. Within the Division of Integration and Presentation a unit was set up to introduce and promote the use of GIS as one of the tools for statistics production. The starting point is to create awareness at the bottom level as well as at the top level of the organization.

3. The planned activities are a) organizing mini-seminars for middle and higher management; b) publishing a two-monthly newsletter; c) pilot projects to give the organization a clear view of the potential benefits of GIS; d) the organization of a GIS expertise and knowledge centre; e) the maintenance of national and international contacts in the GIS field; and f) the maintenance of geographical base files.

## III. REGIONAL TRANSPORTATION STATISTICS

4. The increasing prosperity of the Dutch population has resulted in a sharp rise in the number and use of cars. Public concern about the environmental and socio-economic impact of traffic growth has created an urgent need for figures on mobility. The government needed these figures in order to take action; the use of cars was increasing much more rapidly than the use of other forms of transport, such as public transport. The national Mobility Survey provides data for different applications such as the evaluation of the traffic and transport policy, long-term plans on infrastructure and transport projects, traffic and transport models, and specific reports about issues like commuter traffic.

5. Detailed information on the infrastructure and its expansion is also available from the road statistics. In the meantime not only national government but also provincial and municipal authorities are aware of the importance of statistical data to support their policies.

## IV. NETWORK ANALYSIS

6. The data management and display functions of a GIS can be used to create, manage and analyse any network. This facilitates the use of network analysis in a variety of applications. Pathfinding is an additional method of viewing spatial relationships. Pathfinding procedures built into a GIS can be used to create highly realistic models of flow through these networks. The object of pathfinding is to determine the minimum-cost path through a network between an origin and a destination. The best path does not always mean the quickest. An optimum path considers all of the components of travel cost, those of travel along links as well as between links. Each component of the network must be assigned a travel cost that reflects both geometric and flow characteristics. These attributes in the database model the desirability of traversing each link.

7. One limitation of the GIS approach to network analysis is its assumption that a network maintains its original flow characteristics during an allocation or pathfinding session. An urban rush hour, with influential patterns of congestion is not easily modelled with a GIS. One should take into account, however, that in reality less optimal routes are also chosen.

8. The interactive session is the essence of the GIS approach to network analysis. Optimization techniques presume that their criteria are complete. These arrive at a solution without providing intermediate results that help a user comprehend the complex patterns of spatial interactions that occur within a network.

## V. THE MOBILITY SURVEY

9. The Mobility Survey started in 1978. The prevailing belief at the time that mobility patterns would change considerably and would be accompanied by infrastructural adjustments led to the urgent need at Statistics Netherlands for a survey on travelling habits. A few years ago the sample was considered to be too small to give adequate opinions on new issues. In coordination with the Ministry of Transport and Public Works the Mobility Survey was extended and adapted in 1994.

10. By extending the sample and by adapting the survey contents more reliable opinions about regional mobility patterns and the use of public transport can be given in future. The sample size was doubled to 60,000 households in 1994 and again to 120,000 households in 1995. The questionnaire covers personal details such as occupation, education and income, and records in detail individual journeys, including means of transport, motive and distance covered, for one whole day.

11. The use of a GIS for the Survey was investigated in a pilot project. One of the goals is the validation of the recorded distances. Several routes were determined with the ROUTE option in ArcInfo using a digital road network provided by the Ministry of Transport and Public Works. Information on length was linked to every road segment of the network model and the driving time for each road segment was calculated using observed actual speed values. One way streets were marked.

12. The starting- and end-point of each journey are only recorded at four-digit postal code level. First, centres of the four-digit postcode zones were determined using an internal address register with geographical grid co-ordinates. These zone centre co-ordinates were linked to the starting- and end-points. Then the zone centre location of every starting- and end-point was translated to the nearest node in the road network. This connection of the zones to the road network is not always accurate: the zone is linked through a single point, but the nearest linkage point to the road network might be on the other side of a river. In this model, an all-or-nothing allocation is used for the choice of routes. Routes were determined on the shortest distance and shortest travel time. At the moment, the recorded distances and those determined by GIS are being compared. The first impression is that the estimated distance travelled by a traveller is not very accurate.

13. The second goal was to assign travel movements to road segments. This is possible with ROUTE option because all the travelled arcs are recorded for every route. By relating these figures to the counting points of the Ministry of Transport and Public Works, Statistics Netherlands hopes to give more insight into the purpose of the trip made and the characteristics of the people who pass these points.

## VI. INFRASTRUCTURE

14. Every four years all the municipalities in the Netherlands (approximately 630) receive a questionnaire on their infrastructure. Questions cover road length, breakdown into urban/non-urban, metalled/non-metalled, and by width, cycle paths and cycle lanes of different categories, parking places and residential areas. Although a few municipalities use a land information system with a built-in statistical module, most municipalities find it difficult to complete the questionnaire. Non-response is about 5 % and the data on these municipalities are estimated. The most recent questionnaire was sent this year but we are looking at alternatives for the future.

15. The GIS unit will investigate to what extent the required data can be deduced from a base register of the Netherlands Topographical Agency. In 1997 a network of roads, part of a 1:10,000 digital map, will become available with figures to be updated annually. Because of the great amount of detail in the present questionnaire, it is already obvious that it will not be able to answer all the questions. For example, the base register does not contain figures on parking places and residential areas. But the advantage of reducing the response burden will probably be greater than the disadvantage of fewer data.

## VII. OTHER APPLICATIONS

16. The use of a digital road network is not restricted to regional statistics; another application is currently also being investigated. At the moment, survey sample addresses are allocated to interviewers based on postcode regions. Like pathfinding, allocation is a spatial analysis tool available in ArcInfo. Using the ALLOCATE command, links in the network can be assigned to centres based on available supply (maximum number of sample addresses to be visited) at the centres (interviewers) and the demand (sample addresses) associated with the links. The links are assigned to a centre along least-impedance paths. ALLOCATE enables the assignation of only a maximum number of sample addresses to be visited by an interviewer, not a minimum. If three interviewers live near each other, the person in the middle will be assigned too few addresses.

17. Solutions are being sought by clustering sample addresses or interviewers. An analysis using grid cells of 500 x 500 metres with information about the number of addresses and the possible number of sample addresses will be used as a base in the analysis. In the near future, a register of persons will replace the address register as a sampling frame for surveys.

## VIII. FUTURE DEVELOPMENTS

18. In the end of 1996 Statistics Netherlands has started to test the use of a Global Positioning System (GPS) for the Mobility Survey. The basic idea is to use very small GPS receivers to record the travelling habits of respondents. The only activities demanded from the respondent are to start the GIS equipment at the beginning of a journey, select the motive for the journey from a menu and to stop the GIS equipment when the destination is reached.

19. During the trip the GPS receiver will record locations and time during a pre-determined time interval. The recorded information can be downloaded through a modem at the end of a day The decreasing cost of electronic equipment in future will make it cost effective to utilize such equipment instead of the classical questionnaires. The first results were promising. However, the GIS equipment is still not user-friendly and is too big to be used on a large scale. The quality and quantity of the gathered information is promising. It is even possible to obtain information on traffic jams encountered during the journey and the way the respondent reacts on the situation.

20. We are convinced of the possibilities that GPS adds to GIS. In the future information of a higher quality can be processed which will result in better data, or smaller sample surveys.

## VIII. CONCLUSION

21. Statistics Netherlands has defined a new strategy for GIS, considering the organization as a ‘node on the electronic highway’. One important element of the strategy is the growing use of external registers instead of building and maintaining internal ones. This requires the standardization and harmonization of the input and output. The road networks and their statistical applications described above can serve as an example.

22. Input standardization not only means accepting internal statistical standards, but also acknowledging external standards. For example, a standard for geocoding makes it possible to link information from the person register to a road network using street names and house numbers. This could result in applications comparable with the TIGER system in the United States.

23. Using the 1:10,000 digital map road network standardizes the output of road statistics since the concepts are determined by the Netherlands Topographical Agency. The Netherlands Topographical Agency lays down the centre lines for the road network. The existing generalized road network of the Ministry of Transport and Public Works will be harmonized with these defined centre lines.

24. One of the products of Statistics Netherlands is the digital boundary of the census tracts and census districts. In 1994 these boundaries were harmonized with the municipality boundaries of the Netherlands Topographical Agency. As roads often form the boundaries of a census tract or district, these boundaries can be harmonized with the road network in the future.

25. The information harmonizing aspect of maps can be used for quality control. Visualization of geographical positioning (charts) combined with the administrative and statistical data can help to detect divergent and wrongly allocated data.