THE TOURIST'S DRIVES

GIS ORIENTED METHODS FOR ANALYSING TOURIST RECREATION COMPLEXES

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ABSTRACT

Tourism is a product of diverse composition. An increasing number of people pursue their own specific wishes and combine various products which may or may not be intended for tourists; they create their own individual holiday package. In order to determine how this trend of combining elements influences the use of (tourist) products in a region, it is necessary to gain insight into tourist time-space behaviour. Time, space and context are important domains for describing tourist time-space behaviour. People differ, situations constantly change and a particular interaction depends on the circumstances (personal and topological) in which it takes place. The analysis of tourist time-space behaviour might provide an explanation for this combinatory behaviour. This type of analysis requires specific personal data about time spent, places visited, routes chosen, information used, perception and motivation. Not only the visible tourist time-space pattern is important, but also the process involved.

To date, most researchers have attempted to analyse spatially related tourism data using statistical methods. The data structure needed for such a statistical analysis requires data for each period considered and for each possible location and road in a region. However, a maximum of only 1% of these data is likely to be significantly related to one person. Furthermore, the enormous size of the data set makes it difficult to uncover spatial relations. Geographical Information Systems (GIS) are capable of handling spatial relationships. Four main data groups can be distinguished:

(1) tourist related characteristics;
(2) perception of space and of activities undertaken, and observed time-space behaviour;
(3) spatial objects;
(4) specific (tourism) codes added to these objects.

The constructed tourist recreation complex can be understood as an interwoven structure of several different networks. None of these networks prevails or determines tourist behaviours exclusively. A methodology consisting of two steps is proposed for the analysis of tourist time-space behaviour:

(1) Survey the use of the physical environment by tourists, using exploratory

spatial data analysis techniques and dynamic visualisation. Determine clusters of product elements and a possible typology of tourist groups.

(2) Deduce, describe and analyse tourist recreation complexes using graph and network analysis techniques, and statistical methods. The individual network is based on products and product-clusters and tourist time-space behaviour in relation to the use of the environment and the tourist's perception of it. Execute pattern analysis using graph techniques and accessibility studies for the links and nodes in the network.

Data visualization is used to make patterns in scientific data visible. The application of dynamic cartography adds a new dimension to the visualization process: data can be interactively explored for errors and patterns. The Cartographic Data Visualizer for Time-Space data (CDV-TS) can be used to make a coherent analysis of the use of space, the time distribution and the context of time-space behaviour. GIS is an instrument which is particularly suited to the analysis of clearly limited physical elements. Current GIS software can be applied to obtain a static overview and to perform spatial analyses of the use of a region at a certain moment in a specific context. The storage of time-space data within the GIS data structure is more efficient than the data storage for a statistical application. However, the statistical uses of current GIS are limited to descriptive forms. A linkage between GIS and statistical software creates a powerful instrument. The current generation of commercial GIS software is not capable of dealing with time. Applications were developed to approximate this. A GIS has few network capabilities for supporting tourist time-space behaviour analyses. Network pattern recognition and comparison is not possible at all, and network indices cannot be calculated within a GIS. A newly developed morphologic pattern describer seems appropriate for comparing different constructed network patterns.

Two data sets were used to illustrate how the applications and approaches developed can describe a tourist recreation complex in a tourist region. The applications offer a wealth of opportunities for the interactive examination of time-space oriented data, and to search for different tourist combinations of products supplied. A main drawback of the applications is the amount of data that has to be processed.

Keywords: GIS, Time-Space Behaviour, Dynamic Visualization, Network Analysis

STELLINGEN

1 Een toeristisch recreatief complex is uiteen te leggen in verschillende typen van netwerken.

2 Het toepassen van exploratory spatial data analysis technieken levert een bijdrage aan het beoordelen en analyseren van tijd-ruimte gerelateerde gegevens.

3 De huidige GIS analyse technieken zijn direct geschikt voor de analyse van tijd-ruimte gerelateerde gegevens.

4 Het toepassen van animatie en multimedia mogelijkheden in de interpretatie fase van gegevens stelt hoge eisen aan de grafische weergave van een GIS-resultaat; de presentatie fase van een eindproduct wordt geïntegreerd in de analyse.

5 Bij onderzoek van toeristisch tijd-ruimte gedrag dient de toerist uitgerust te worden met een Global Positioning Systeem om snel en eenduidig de verplaatsingsgegevens te verzamelen en op te slaan.

6 In dit tijdperk heeft informatietechnologie een duidelijke rol in tijd-ruimte compressie. De zeer trage omschakeling van een commando gestuurde DOS omgeving naar een (ongeveer even oude) menu gestuurde schermafhandeling bewijst echter dat niet alles snel verandert.

7 In de 21^{e} eeuw dient de ruimtelijke ordening vervangen te worden door een tijd-ruimtelijke ordening; hierdoor kan ook aan het huidige VROM adagium 'onthaasting' een uitwerking worden gegeven.

8 De 'information superhighway' is niet slechts 1 'snelweg', maar bestaat uit zeer veel verbindingen en lijkt meer op een plattelandswegennet, waarop met verschillende (lage) snelheden gemanoeuvreerd kan worden.

9 Cyber-toerisme is de beste vorm van eco-toerisme.

10 Het verbieden van geweld en gewelddadige films op tv om hiermee de (jeugd-)criminaliteit op te lossen, geeft de televisie te veel eer en ontkent dat de jeugd veel andere prikkels tot geweld krijgt.

11 Het blijft verbazingwekkend dat mensen voor wie flexibiliteit zo'n beetje een tweede natuur is geworden en die bestaande verhoudingen het liefst willen veranderen .... steevast een ding willen houden zoals het is: de natuur. De eerste, de enige, de echte. Daar moet zelfs meer van hetzelfde bij, om het nog mooier te maken.
(S. Sanders, de Volkskrant 12/5/97)

12 De voortdurende verandering van de organisatie houdt alleen beleidsmedewerkers continu betrokken bij hun eigen vakgebied.

Wim van der Knaap
The Tourist's Drives
GIS oriented methods for analysing tourist recreation complexes.
Wageningen, 13 juni 1997

PREFACE

This thesis is the main result of a project that started in October 1993 and ended in July 1996. The project was funded by NWO, the Dutch Organisation for Scientific Research. It was one of the research projects within the FUTRO programme, established to support fundamental research on time-space dynamics in tourism and recreation. Departments from Wageningen Agricultural University (WAU), Eindhoven University of Technology and Tilburg University are participants in the FUTRO programme. During the research period I was also a part-time lecturer at the Department of Physical Planning and Rural Development at WAU.

The literature used in this thesis is mainly restricted to publications which appeared before the beginning of 1996, with the exception of some references from later in 1996. Developments have been extensive, especially concerning GIS, and much has been published recently. I made use of different networks which enabled me to arrive at the end of this thesis. These networks include that of family and friends with their moral and social support, the network of colleagues and fellow researchers at the department and in the University for their support and academic discussions, the network of various forms of technological support from people outside the department, and of course the technological infrastructure provided by the university computer network and the Internet.

During the research years my wife San and son Maurits made sure they organised and enjoyed as many 'field work' trips as possible, which made theory come alive. I would also like to thank all the other people involved in this thesis for their efforts: I will mention a few of them in particular. First of all I want to thank Adri Dietvorst and Ron van Lammeren, my two promotoren, for their stimulating discussions. Birgit Elands made a very important contribution with her discussion and evaluation of many steps in the research. Her contributions have been incorporated into several chapters. I had long discussions about networks and network applications with Frank van Langevelde. His ideas and contributions were most valuable, and formed the basis for Chapter 4. Jason Dykes of Leicester University gave important impetus to the visual analysis section by developing the special CDV-TS software for use with linear and point (area) oriented time-space data sets. Jason Dykes and Richard Hillman are gratefully acknowledged for their contributions which are partly incorporated in Chapter 5. Many others, too numerous to mention individually, made smaller but equally important contributions, for which I am very grateful: in particular those involved in the technical support for the applications and the CD-Rom content development.

The theory could not have been applied without the existence of the two data sets. The data from the Euregion were collected by Birgit Elands, and the ALMA organisation made it possible to collect part of this total data set. The data from the Nette Tal area were made available by Jan Philipsen. The National Physical Planning Agency also provided data from the Euregion on land use and main road structure.

During the final period of writing this thesis several colleagues offered me the opportunity to concentrate on the writing by taking over some of my teaching responsibilities; I acknowledge their support. I also want to thank Birgit, Frank and Janine for their final checking of the thesis. Sara van Otterloo Butler is acknowledged for correcting the syntax and spelling of the manuscript.

Wageningen, 25 April 1997 Wim van der Knaap

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YOU
ARE
HERE

1 INTRODUCTION

'There is nothing in nature that science cannot do better and more efficiently. Take the computer, for instance. It's a machine that can do all the work. No spare parts are necessary and hardly any handwork in a civilized world is required!'
The old man stopped between the trees, frowning his eyebrows.
'By Zazel!', he croaked astonished. 'What do they do in the city with all their leisure time?'
'I don't know', the scientist said. 'I'm no expert in that subject. I gave them the computer, so they don't have to work any more. And the rest, they have to find out for themselves.'
(Translated from: De Hupbloemerij. Marten Toonder, 1994).

1.1 Tourism in a Changing World

Tourists move around the world in search of opportunities for recreation. Some say they engage in these activities to escape from daily (working) life, others describe it as a quest for the true meaning of life. Whatever the reasons, their movements alter the landscape for others. Even the movement of just one tourist from one place to another has an impact on the landscape. Each activity undertaken by a tourist lasts a certain amount of time and has its own relevance. This raises many questions. Why is an activity undertaken? Is it important and if so for whom or for what? What conditions are necessary to make a particular movement possible? Are there alternatives? Are previous activities important? Who benefits from this movement, who suffers? How does perception determine a person's activities? This thesis focuses on applications that can be used to support the explanation of the tourist's drives and in particular on how the chosen physical drives, or paths, are related to the personal drives and choice opportunities.

The questions raised above are related to people's time-space behaviour and their motivations or drives. It is impossible (and probably unnecessary) to answer all these questions simultaneously, but for the purposes of planning and a better understanding of tourism, it is essential to answer as many of them as possible. In order to do this, we need to take a closer look at what is happening in our society, and at what generates these transformations. Various trends can be distinguished in Western society in general and more specifically in tourism, which influence our daily lives, our needs and wishes. Several of these trends are considered to influence the time-space behaviour of tourists. Four of these will be generally discussed in this Chapter. Visualization as a cultural phenomenon and compression of space and time are regarded by several authors as trends that influence Western society. The urge to escape from everyday life and technological developments are two trends which will be discussed in relation to tourism. These trends induce a growing desire for variety; tourists also demand a higher quality product.

Visualization as a cultural phenomenon

The continuous developments in cultural, demographic and economic processes are all reflected in spatial claims and transformations in and of the landscape. Clarke *et al.* (1994) and Johnston (1996) identify two significant cultural and economic developments: a strong shift to visual communication, interpretation and presentation, and secondly, the compression of space and time. The use of Internet clearly demonstrates these processes. People with access to the necessary technology can communicate and exchange information and data without having to take into account either geographical location or working hours; thousands of kilometres are crossed within seconds. This intercultural communication makes the use of universal symbols necessary, *e.g.* computer icons. The current visually oriented culture is reflected in the growth of video filming and photography. People search for 'clean' landscapes; they reject disturbing (modern) elements, such as a parking garage, a nuclear power plant, or large-scale infrastructure. This 'clean' landscape is remembered, its design and lay-out are important. Urry's Tourist Gaze (1990) clearly illustrates the visualization influences in tourism.

Time-space compression

The process of time-space compression plays an important role in our society with its strong visual and information orientation, where the geographical location of people seems to be of less and less importance. The use of airplanes clearly demonstrates this. The techniques available for visual communication, including the multi-media approach, open up opportunities (Negroponte, 1995). One of the essential aspects of any multi-media application is interaction. Virtual reality gives the user the sensation of actually being in the situation generated by the computer (Negroponte, 1995). The Internet has grown tremendously in recent years, especially the World Wide Web (WWW) facilities for accessing visual information. An increasing number of people use the Internet to gain access to or deliver information over the whole world. We are rapidly moving towards what could be described as an Information Society. If you are not linked up to the system you are considered to be out of date and out of touch, leading to a segregation of society.

In contrast with these two developments, the Dutch National Planning Agency (RPD, 1995) argues that people's attitudes have hardly changed; there is still considerable scepticism concerning the evolution of the virtual, digitally oriented human. As Guggenberger (1994) argues in his column in Die *Zeit*: '*People tend to look for tangible local experiences in response to the* information explosion and time-space compression.' Forester (1992) describes several examples which characterize this desire for tangible experiences and indicates why most of the extreme mega-trends predicted for the Information Society have not had as much social impact in the short term as was expected. Firstly, teleshopping is boring and limited compared with real shopping; friends are not encountered and products cannot be touched. Secondly, paper is still the main medium for communication; printers, faxes and photocopiers are heavily used machines. Telecommuting, Forester's third example, increases family conflicts; reasons for this include the inability to separate work from leisure, and increased feelings of loneliness and isolation. Meanwhile, people are bombarded by so many media messages that they actually absorb less and less. Although computers have infiltrated many areas of our social life, they have not transformed it radically. The automobile had little impact when it was first introduced; nevertheless it slowly changed Western society and is now an essential element of the society structure. A transformation process takes time to be assimilated into a society. After a critical initial phase, however, developments may be rapid and can create huge changes in society, and, as a result, in the spatial organization of the landscape.

Escapism

In addition to time-space compression and visual communication, Dietvorst (1996) describes two other (tourism oriented) influential trends: the desire to escape *from everyday life, and developments in technology*. These two trends will be discussed in relation to tourism. The time-space compression process makes the future less certain. Long-term decisions are no longer made. A reaction to this is that the modern consumer starts to look back to the familiar past (nostalgia). This urge to escape is considered to be the result of everyday life more and more dictated by the calendar (Lengkeek, 1994; Dietvorst, 1996). A contra-structure (world) is created in which special and often complicated activities and experiences are sought for pleasure and unique life experiences, but also pleasant surroundings with little or no risks are preferred (Lengkeek, 1994).

Technological developments

Modern technology makes it possible to meet the more specialized demands of a larger public. The growth of wild-water sports is an example. All these processes are also obvious in the vigorous growth and increasing economic importance of tourism and recreation (Dietvorst, 1994a and 1994b). The Dutch National Planning Agency (RPD) (1995) anticipates that technological developments may lead to a growing number of choice opportunities in terms of place, scale, spatial distribution and time schedules for people in the Netherlands. The physical and social attraction of locations and regions might become more important. An example of this expectation is the scenario called 'the caravan', in which a person becomes more and more a travelling human being; a permanent address becomes increasingly unlikely. The region in which daily activities take place will enlarge and thus create more mobility and movements by car. Activities become less dependent on distance, which also increases mobility. The leisure segment in the total (personal) timetable also expands. If the urge for mobility can be fulfilled by electronic means, car mobility might decrease. The combination of a shift towards more leisure time, growing mobility, and technological developments influence both the tourist's consumption processes and behaviour, as well as the popularity and use of a number of tourist destinations. Social and recreative values determine routes and stopping places (RPD, 1995).

In the long run, quality assessment of tourist products is essential for a region. The importance and size of a region increases as a result of decreasing distances, growing mobility, and technological developments. An airport is close by when there are good train connections or motorways, and improved access makes it easier to go to far away places. Different groups, with a continuously changing configuration of persons, populate the 'caravan' of moving people; each person has their own route, timetable and motivation (RPD, 1995). For each group, a combination of location and social attractions is important. During movements or at stopping places everybody enjoys the things that a specific place has to offer. Because of the increase in the amount of movements, more places in the world offer the same sort of facilities, thus recreating familiar surroundings (same operas at different locations, same hamburgers everywhere). Immigrants are no longer a special group, everybody has become a 'traveller'.

Diversity and quality

The time-space compression, the growth in visual communication, the desire for escape and technological developments all lead to transformations in and of the landscape. They also induce a growing desire for variety in activities offered. People are (made) more aware of the fact that there is more to experience; they can also do more in less time and in more places - compression of time and space. They can also choose from a broad range of activities, made possible by technological developments. These trends offer more opportunities for comparison and might make people more critical consumers. Increasingly they demand a product that satisfies their wishes and their personal circumstances. As a result, they also demand a higher quality product. In tourism, this quality is increasingly sought in terms of the way in which the various tourist product elements can be combined in relation to each other (Dietvorst, 1996). In order to be able to achieve a well tuned combination one needs to gain insight into the actual and potential demands of tourism. It is therefore crucial to determine whether there are relationships between the spatial context and the more individual tourist experiences. It is the tourist who combines available attractions and facilities, expressing them in a specific time-space behaviour. Dietvorst (1989, 1993a) has labelled the process of linking experiences the 'Tourist Recreation Complex', in which the whole is considered to be more attractive than the separate amenities.

Tourists make use of several locations and situations to integrate external influences on his decision-making process. These they then link to their own personal tourist recreation complex. Activity patterns in time and space are considered to be the result of the decision-making process, and are influenced by the perception and interpretation of the landscape and of opportunities offered. In addition, variables such as preference, motivation, age, weather, awareness space, constraints, etc., also influence the tourist in his time-space behaviour. In order to achieve a higher quality regional tourist product, it is necessary to analyse the construction of the tourist recreation complex. This requires that the important elements within this linking process and the expressed time-space behaviour be unravelled. The quality of the tourist recreation complex which is created determines the success of the holiday and thereby also a possible return visit to the region.

1.2 Time-Space Behaviour Analysis

Time-space behaviour analysis deals with human actions in space and over time. Two main (contrasting) concepts can be noted in the time-space behaviour approach (see Huigen, 1986; Blaas, 1989; Floor *et al.*, 1990; Beckers and Raaijmakers, 1991). One concerns the physicalist approach postulated by Hägerstrand (in Walmsley and Lewis, 1993; Dietvorst 1995a). The other concept involves the choice-oriented approach described by Chapin (1974) and others. The approach chosen by Hägerstrand and his followers is an appreciation of the biophysical, ecological and spatial realities that impose constraints on human activities (Thrift in: Carlstein *et al.*, 1978). These constraints are described as capability (such as physical and biological constraints), coupling (constraints of a social nature) and authority constraints (*e.g.* accessibility). Individuals are forced to pack their activities into specific time-space stacks. The constraint approach indicates the environmental constraints that determine the accessibility of a region. The 'constraint-oriented' approach contrasts with the 'choice-oriented' approach (Floor *et al.*, 1990).

In the choice-oriented approach, activities are considered to be a result of personal choices. According to Chapin, specific choices for concrete activities are influenced by motives and preferences, by time-space opportunities and time-space related contexts. A diary which describes activities undertaken, will give insight in the related time-space behaviour process. To determine time-space behaviour of tourists the choice-oriented approach will be taken as the leading approach. Based on a diary of activity-patterns, a relationship between facilities available and the use of space may be deduced. This can give insight into how a region is used.

The role of the spatial context in time-space behaviour can be illustrated by way of a newspaper metaphor (*cf.* Negroponte, 1995). Everybody who reads a newspaper (visits a region) consumes it in a different way. Some browse through it and scan the headlines; the tourist visits the main advertised and popular locations and attractions. Some read the paper from cover to cover (a tourist plans the whole holiday beforehand so as to visit every spot in the region). Others just pick out the articles they are interested in at that moment and read other articles later (the tourist determines each day or moment what the next activity will be). Everybody is led by headlines and photographs in the newspaper (likewise, the tourist is led by the structure or landscape elements of the spatial context). Everyone interprets and uses this information differently. The structure is the same but the experiences differ, depending on personal characteristics and possibilities.

As stated before, activity patterns in time-space behaviour are important for the reconstruction of a tourist recreation complex, with which the mutual relationships between the characteristics of the product elements and the general behaviour of tourists can be analysed. Different components can be noted: the tourist, tourist products (single products and whole regions, including the landscape), and time-space behaviour which connects the elements. The constructed tourist recreation complex, as described by Dietvorst (1989, 1993a), can be regarded as a comprehensive notion. To determine and analyse this complex at an individual and regional level, it is necessary to examine the characteristics of:

- ***the tourist***
- ***the tourist (oriented) products***
- ***the tourist time-space behaviour***

Data have to be collected in relation to specific tourism-related questions. Most of these data collected are concerned with characteristics of tourists or tourist products and are evaluated separately using statistical methods. To date, researchers have also endeavoured to make statistical analyses of data related to tourist time-space behaviour. This type of time-space behaviour analysis requires specific personal data about time spent, places visited, movements, routes chosen, information used, perception and motivation. Data are also required for each period considered (*e.g.* for every half or whole hour) and for each possible location and road in the region. For example, if you want to analyse twenty possible activities divided over six time segments (within a two day period) for fifteen locations, without even considering possible routes, the statistical data structure requires a total of 1,800 combinations. A maximum of only 1% of these data is likely to be significantly related to one person. The remaining 99% of the data will consist of zero values: for the locations (or roads) not visited, or for a person who spent more than one period at the same place. Furthermore, the enormous size of the data set makes it difficult, if not impossible, to uncover spatial relations (see, *e.g.* Bergmans *et al.*, 1994; Kolsté, 1996).

There seems no 'best' solution for this combinatorial explosion of data required. People differ, situations constantly change, and a specific interaction depends on personal and environmental circumstances in which the interaction takes place. The tourist time-space behaviour is guided by the interactions between the tourist and the physical surroundings. These include the influence of the tourist (the learning process, experience), and other persons and changes in the surroundings. Markers play an important role in the decision-making process of selecting activities (Elands, 1995). Markers represent and reproduce things deemed to be worthwhile seeing in our society. These markers refer to a sight and can be any piece of information about this sight. Tourists make use of signs and interpret them to fill their holiday with activities and to give it meaning.

In addition to statistical analysis, Geographical Information Systems (GIS) might be suitable for the analysis of at least the spatial component in the data of the time-space behaviour of tourists. Miller (1991) and Golledge *et al.* (1994) have done some modelling of time-space behaviour using GIS. Other time-space activity applications are limited to data representation, a 'snapshot' of the situation. At the moment GIS is mainly used to represent physical space (*e.g.* the landscape elements, road structure, height as static objects) and to examine relations between neighbouring objects. The inclusion of dynamic aspects such as time or changes, and interaction between the different 'objects', is still underdeveloped in GIS (*e.g.* Peuquet, 1994; Burrough and Frank, 1995).

1.3 The Aim of the Study

To date, the main applications of GIS are as a cartographic presentation medium and data storage instrument. GIS has not yet been widely used as a modelling and analysis instrument (Maguire, 1991), nor has it been applied more specifically for analytical purposes in research on Dutch recreation and tourism. (Dietvorst and Spee, 1991; Philipsen and Sijbrandij, 1994; Dietvorst, 1994a). The possibilities of using GIS to identify relationships between tourists, product elements and tourist time-space behaviour remain as yet unexplored. Miller (1991) states that 'the full potential of the time-space prism concept has not been realized in spatial analysis and planning. There is as yet no general and widely applicable procedure for deriving space-time prisms for empirical settings.' Miller explains this by indicating the problems that arise when attempting to analyse and present the necessary data with sufficient (geometric and topological) accuracy and when processing time-related data within current GIS.

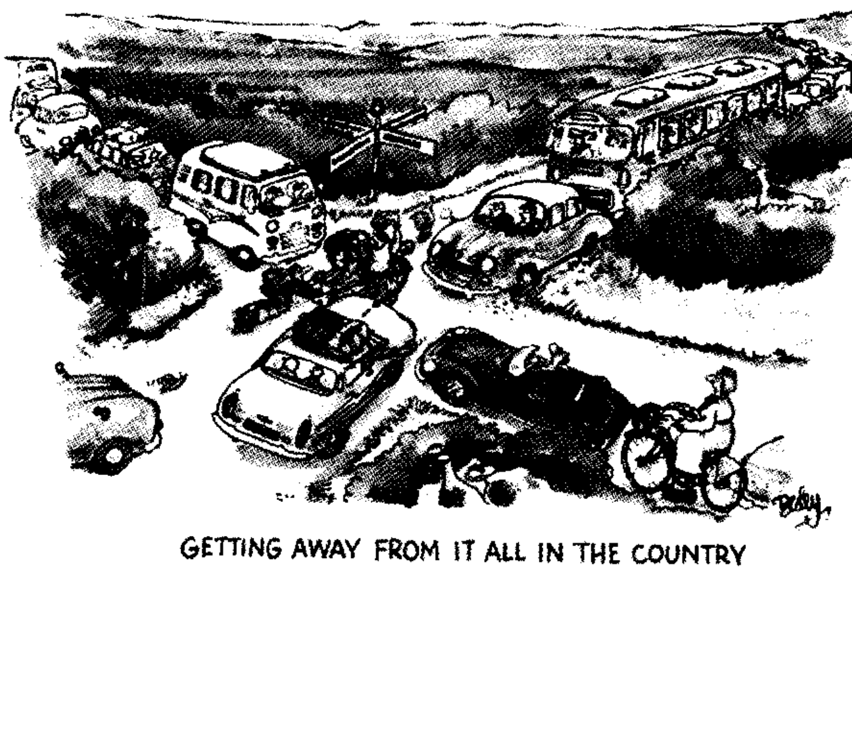
Interaction and linking (combining) are important elements in the time-space behaviour process of the tourist recreation complex. From the previous section, it can be concluded that current statistical software is not adequate for the identification and analysis of these elements which determine tourist recreation complexes. New approaches have to be sought whereby these elements can be integrated into the analysis of the tourist recreation complex.

The aim of the study can be described as:

To develop GIS applications and extensions that could contribute to improved insight into the many complex and mutual relations (such as those existing in time and space) between, on the one hand, the physical and social spatial features within the tourist recreation complex and, on the other hand, the social and cultural characteristics of the individual tourist.

1.4 Structure of this Thesis

To achieve this aim, more information on the characteristics of tourism and the tourist recreation complex is needed. This is introduced in Chapter 2. This chapter also includes a brief description of the application of a network approach to interpret the construction of a tourist recreation complex. Following this theoretical outline, Chapter 3 describes a methodological approach for the analysis of time-space data. Two main elements of this methodology are described in the subsequent chapters: general network analysis in Chapter 4 and dynamic cartography in Chapter 5. In Chapter 6, network construction and analysis is elaborated, focusing on tourism purposes. Two data sets are used to illustrate the methodology. The first data set consists of data gathered in the Nette Tal area (Germany) in May 1992 and a second set is from a survey conducted in April-May and July-August 1995 in the Euregion Maas-Rijn. A discussion of the methodology and an evaluation of the two examples are presented in Chapter 7. The thesis ends with several recommendations for future research, and some refinements.



GETTING AWAY FROM IT ALL IN THE COUNTRY

2 THEORETICAL FRAMEWORK

In digital life, it is becoming less important to be at a specific place at a specific moment .... many duties and activities will become disconnected from geography (Negroponte, 1995).

2.1 Introduction

The main research question of this study can be briefly described as: to what extent is it possible to use a Geographical Information System (GIS) for the analysis of time-space behaviour of tourists? Three aspects of this research question require elucidation prior to formulating several more detailed research questions. The aspects to be explored are: tourism, tourist time-space behaviour and the use of GIS. Tourism and time-space behaviour will be discussed from the perspective of the application of GIS as an instrument to elucidate geographically based research questions. In addition, GIS will be discussed from the perspective of how tourism and tourist behaviour can be understood.

In the next section, tourism is examined in more detail. Dietvorst (1993a, 1995b) proposes a transformation model related to supply and demand in recreation and tourism. This model describes a structure for comprehending and studying different processes in recreation and tourism. In the third section, notions of space, time and time-space will be explored so as to comprehend how time-space behaviour might be analysed. These two components, tourism and notion of time-space, form the basis for a description of the tourist recreation complex, leading to an insight into this concept (Section 2.4). This complex approach can be seen as an interwoven network structure in which different time and scale levels and typologies influence and guide each other. This idea is elaborated on in Section 2.5. The possibilities of GIS are the last aspect to be covered in this chapter on the theoretical framework, and will be briefly described in Section 2.6. Some important GIS details relating to tourism are explained in this section. Following the discussion on the theoretical framework proposed for the analysis of a tourist recreation complex, various more detailed research questions are put forward in the last section.

2.2 Tourism

2.2.1 The Tourism Transformation Model

Dietvorst (1993a, 1995b) describes a model for developing the tourist recreation product, which is based upon common aspects of supply and demand in recreation and tourism. He adds some essential dimensions to construct the model (Figure 1).

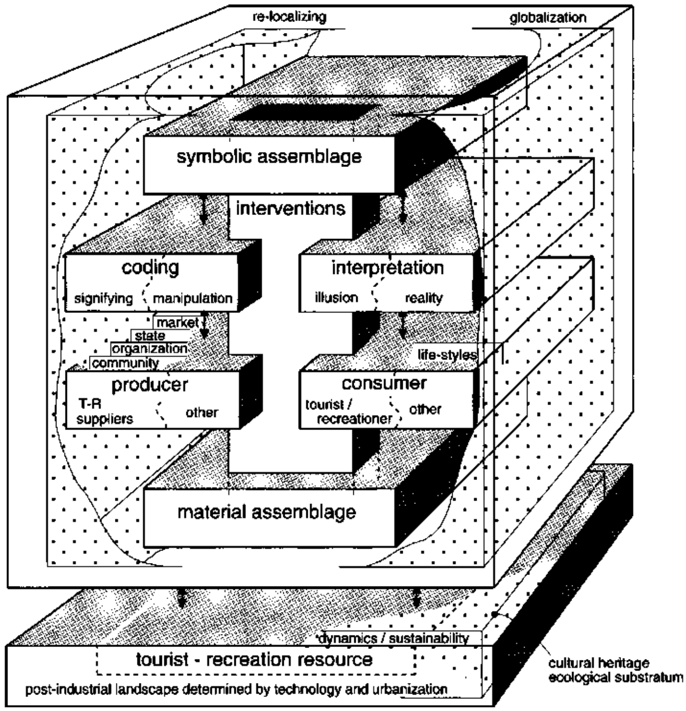


Figure 1 Transformation model of tourism and recreation (Dietvorst, 1995a)

The model represents the continuous transformation of the original resource as the result of different activities and interventions of producers and consumers. The resource forms the material and symbolic basis from which tourism is derived. This basis can consist, for example, of a specific landscape, a monumental building, or a local culture. The transformations result, intentionally or unintentionally, in a product suitable for tourism. Dietvorst (1995b) describes the term transformation as 'changes in form, appearance, quality or characteristic of something'. Continuous changes take place in the tourist-recreation resource production and consumption. All transformations of the resource have two dimensions in common: time and space. Time and space are not only consumed by tourists, but the resource also changes in spatial appearance over time. The notions of time and space will be elaborated in the next section.

First, the function of the interventions and resources within the transformation process is explained, followed by an explanation of the role of producers and consumers, and their material and symbolic assemblages. To understand each component, it is important to recognize the context of these components, the mechanisms that guide the transformation process (see also § 1.1). Relocalization and globalization are two examples of driving forces that guide the transformation process in contemporary society. The globalization process can be illustrated by the world-wide influences on our every-day life, *e.g.* it is normal to eat food prepared according to customs from different (far-away) countries and to listen to music from different cultures. In reaction to this globalization, there is a tendency to stress local aspects as important, to hold onto and develop values and habits related to the immediate surroundings. The relocalization process concerns the levels of local and regional identity, *i.e.*, how to adapt to and integrate regional and global developments and influences into local customs.

The main assumption in the transformation model is that people establish the transformation of the original physical and social space and consequently make space accessible for recreation and tourism. The scale factor is important for the analysis of the transformation processes. Of particular importance is the way tourist recreation development contributes to the creation of local and regional identity (Dietvorst, 1994a). The transformations have a symbolic nature and a material one; the image is important, as is the material product.

Resource

Resource refers to anything that can be used to create a tourist recreation product. The physical spatial structure of and lay-out in an area (such as landscape and cities) are important elements of a resource. In addition, the (local) social and cultural facade and the cultural heritage is expanding in significance for the tourist industry. Tourism uses resources that are also exploited by non-tourist activities or are generally available, *e.g.* landscape. Likewise, the tourist product is consumed by non-tourists. Moreover, tourism can create and destroy a resource. (Dietvorst, 1994a).

Intervention

The intervention component in the transformation process concerns actions external to tourism development itself which are needed to harmonise the demand and supply side within tourism. Planning, price regulations, and legislation are examples of these actions. These instruments can be used to guide tourism developments in the desired directions, by those who are in a position to stimulate these actions. The government and market members are the main participants in these interventions.

Producers

Producers transform a resource, such as landscape or the city, which is not intended for tourists in the first place. This is done through direct interference, *e.g.* by building facilities, transforming coastal landscapes into resorts or transforming historic buildings. Sometimes, a form of non-intervention is possible whereby public authorities restrict or forbid activities. A variety of public authorities, entrepreneurs, private organizations, and local communities are involved in this 'production'. The suppliers of the tourist recreation product act upon other producers and are subjected to the influence of activities of others in their region. The changing relationship between the state and the market exerts an influence upon the character and direction of tourist recreation development in an area.

Symbolic assemblage

The producers assemble and transform the material resource into a (new) tourist product. A specific coding is added to the transformed resource. The tourist recreation product is packaged, designed and assembled: a 'romantic' holiday in Paris is offered by a tour operator, 'adventurous' and 'fascinating' landscape can be enjoyed in the Amazon area, and so on. Often this is the real tourist recreation product (*i.e.* the illusion), a surplus value is created by which normal, everyday elements become 'special'. Not only the coding created is important, the (desired) interpretation of the coding and of the non-coded is also essential. These two aspects together form the symbolic assemblage.

Consumers

Consumers or visitors transform the physical structure of the region or the area visited through a certain interpretation of the product offered. Their motives, needs and preferences 'stimulated' through advertisements in newspapers, recommendations by friends and relatives, as well as former experiences and the weather, all influence the decision of whether or not to go on holiday, make a day trip, or visit a museum. This transformation or assemblage is indirect because the supplier reacts to the trends in the market, *i.e.* the behaviour of the visitor. The decision to go to a place results in a contribution to the transformation of the physical and social structures of the areas visited. Space consumption, crowding, the deterioration of the infrastructure and of historic monuments, and the disturbances to animal behaviour, are all forms of direct transformation of the original resource.

Material assemblage
During their stay in a specific city or area, tourists combine different locations and activities into a total day-out or holiday. Producers also combine different product elements into a new tourist product. This concrete combination can be characterized as the material assemblage. Tourists combine through behaviour in time and space. This time-space behaviour of tourists is in particular located on the consumer side of the transformation model. This aspect is the main focus of this thesis.

2.2.2 Conclusion

The tourist recreation complex is situated on the consumer side of the transformation model. The interpretation by the tourist of the symbolic assemblage drives the tourist to a material assemblage of resources: time-space behaviour. A first indication about what is needed to describe the three domains in a tourist recreation complex (tourist, tourist product and time-space behaviour in § 1.2) can be derived from the previously described model. The characteristics presented by no means form a complete list. Data about the tourist might describe social background, personal characteristics, preferences, motivations, interpretations, information used, means of transport and spatial location of the accommodation and places visited. For the tourist product, it is important to know about its spatial location, the landscape elements and the coding which is attributed to it.

To characterize time-space behaviour, it might be significant to recognize movements, motivations, objects visited, time and budget spending, product element clusters and weather conditions. The tourist-recreation complex which is created by each individual tourist, consists of the spatial and social combination which interacts with the landscape. A regional tourist opportunity structure might also be depicted by combining and abstracting the different individual tourist recreation complexes. In order to extend and elucidate this list of characteristics, a closer look at time, space and their intertwined relationship is necessary. This will be presented in the next section.

2.3 Space, Time and Time-Space

2.3.1 Space

The notion of space is discussed extensively by different authors (Harvey, 1989; Nunes, 1991; Lefebvre, 1991; Peuquet, 1994; Mark and Frank, 1995). The discussion continues as new concepts about space arise, such as cyberspace (see, *e.g.* Boelens, 1996; Poster, 1996). The notion of space is dependent on interpretation, usage and operation by every distinctive culture and society (Campari, 1991; Lefebvre, 1991; Campari and Frank, 1994; Mark *et al.*, 1995). A few western world oriented approaches will be highlighted here from a social and a geographical point of view.

Lefebvre (1991; p. 83) uses the notion of space to describe a set of relations between things, of which objects and products can be regarded as a subset. He denotes space as a precondition and a result of social superstructures; it is a product to be used (consumed) and it is also a means of production. He describes space as networks of exchange and flows of raw materials and energy, which design space and are determined by it. Lefebvre bases his ideas on a conceptual triad, which consists of spatial practices, representation of space and representational spaces. The spatial practices contain production and reproduction, as well as the particular locations and spatial sets characteristic of each social formation. Spatial practice assures continuity and some degree of cohesion; it can be observed, described and analysed. The representations of space are tied to the relationships of production, to the order that those relationships impose, and to knowledge, codes and signs. The representational spaces refer to autonomous social life, the intuitive side of humans and incentives.

These three dimensions act upon each other in society and environment, shaping and changing them. Harvey (1989, Ch. 13; after Lefebvre) identifies almost the same three dimensions: material spatial practices (experiences), representations of space (perception) and spaces of representation (imagination). Material space is created by the visible and tangible world around us. Representations of space include signs, codes, models, knowledge, terminology and definitions which make it possible to communicate about this world. Imaginary space includes the mental constructions of material space made by people.

While Lefebvre and Harvey have a social cultural approach to space and spatial relationships, geographers such as Gatrell and Nunes refer to more physical spatial relationships, the (objective) material objects as describers of space. Gatrell (1991) defines space as a relationship within a set of elements. He distinguishes two classes: metric and non-metric spaces. Nunes (1991) starts by describing the conception of space as a container or framework in which things exist. It exists even if empty. He continues by giving other views on space. One view is a mental category: space as a set of elements with their relationships; this mental space can be regarded as corresponding to the non-metric space of Gatrell or the space described by Lefebvre. All the different types of relationships create a variety of space-notions.

Nunes (1991) refers to Chapman (1977) for a more detailed specification of real world elements, which endow space with structure. Elements have characteristics that are determined by taxonomy (hierarchical ordering), morphology (form and structure), physiology (aspects of living things), ecology (relationships between living organisms and landscape), chorology (dispersion, spatial development and mutual relationships), chronology (time sequence), and composition (structure of elements). Topology (coherent collection of changing elements) can be added to this list. The scale of these characteristics which are both discrete and continuous, ranges from the level of atoms to that of galaxies and beyond, with no clear boundaries between levels. Thus the boundaries of an element are difficult to define. Philbrick (1991) and others refer to this as a relative approach of elements.

In this research, space is characterized as a physical condition for human activity and as the result of human action and interaction. Space is considered to be the mutual coherence of a collection of elements and the relationships between the elements, which are partly established by persons. A collection of elements forms the structure of a system and the collection of relationships generates the function within the system (after Nunes, 1991; Dietvorst, 1979). The object of this (geographical) study includes the physical space, its elements and its relationships, as well as the processes which evolve between the elements, influenced by the imaginative and the representative space of humans, within the sphere of tourism and tourist behaviour.

2.3.2 Time

The notion of time is intuitive. We use time and the notion of time in many ways in our daily lives (see, *e.g.* Peuquet, 1994; Frank, 1994). The use of a clock gives time a discrete (absolute) quality. We are able to use measurable portions of time in our material world to somehow organise our society. Perception of time and portions of time is, nevertheless, relative, *e.g.* waiting at the dentist for ten minutes clock time can seem like hours. The general time-notion depends on several specific characteristics. Some of these will be mentioned here, but the list is not exhaustive.

The level of aggregation which is under observation is important. For example, for a landscape, which we think of as changing very slowly, years or decades are a suitable level of aggregation; while for a particular activity which is undertaken hours or an even smaller unit will be more appropriate. In addition the question of who is observing and for what reason is significant. For example, a producer of a tourist product will use a time scale based on production processes, residents of an area might use their lifespan as a reference, whereas a geologist will not be content with a period of less than ten thousand years. Perception of and meaning attributed to time is a third characteristic: *e.g.* who takes part in what sort of activity, how is this perceived and under which circumstances. Historical context, experience of and knowledge about a situation or comparable situation at a specific location constitutes a fourth aspect. In tourism, discrete clock time is an important constraint in day to day (tourist) activities. However, perceived time also plays an important role in the way in which meaning is attached to the activities undertaken. The notions of both discrete and perceived time therefore need to be considered.

The notion of time is also connected to processes. Content and meaning of processes can change over time as a result of a new ordering or addition of elements. By freezing the continuous process at specific moments temporal patterns can be distinguished. The underlying dynamics of these temporal patterns are important because they represent the developments over time. Moreover, each element in the process and therefore in the corresponding temporal patterns, together with its relationships to other elements, has its own dynamics and meaning and depends on different components, such as group composition, location, moment of the day, perception of time and place, and cultural background.

Peuquet (1994) describes four main mathematical characterizations of a temporal pattern: steady state, oscillating, chaotic and random;
'Chaotic behaviour characteristically amplifies small uncertainties through time, allowing only relatively short-term predictability within an overall random pattern of occurrences. We also can use the term chaos to describe spatial distributions that are not completely irregular and unpredictable' (Peuquet, 1994) or show more regularity at a higher level. These time characterizations are similar to the spatial pattern distribution which Peuquet distinguishes: regular, clustered, chaotic or random. This similarity has, of course, to do with the intertwining of time and space and brings us to the context of time and space.

2.3.3 Time-Space Context

The character of time and space has been debated since the ancient Greeks. Representations of time and space have been historically divided into absolute and relative views. Peuquet (1994) argues: 'Absolute and relative views of space-time are complementary, not contradictory. The absolute view focuses on space-time as the subject matter. Objects are located within an unchanging geometry defined by a space-time matrix. The relative view, in contrast, focuses on objects as the subject matter. Space and time are measured as relationships between objects. Absolute space is thus objective: it assumes an immutable structure that is rigid, purely geometric, and serves as the backcloth upon which objects may or may not occur. Relative space is subjective: it assumes a flexible structure that is more topological in the sense that it is defined in terms of relationships between and among objects. In the relative view neither space nor time exists independently.' An absolute view involves measurement referring to some constant base, implying non-judgemental observations. The relative view involves interpretation of process and the flux of a changing pattern and process within specific subjective contexts.

To date, time and space have not generally been regarded as separate and absolute entities; in geography, time and space are indissolubly connected with each other (*e.g.* Haggett *et al.*, 1977; Harvey, 1989; Parkes and Thrift (in Langran, 1992); Peuquet, 1994). For example, space is constructed through processes, changes of elements and relationships that are established over time. If either time or space is regarded as an unchanging domain, only a (small) part of what is happening can be described and analysed. For example, if time is viewed as constant then we are dealing with a static situation, a snapshot of the use and interpretation of space at a specific moment. This snapshot can be regarded as a pattern. A pattern can be defined as: 'a number of ranked or combined data that gives insight in one way or another'. This pattern is the result of a process at a distinct moment in time, which has a specific meaning only for that moment.

The properties of time and space have many similarities and some important differences. In the so-called objective time-space view, everything everywhere progresses inexorably forward in time. Nothing can travel backward in time. In (the absolute) space, by contrast, we can travel backward and forward. 'Both space and time are continuous, yet for purposes of objective measurement they are conventionally broken into discrete units of uniform or variable length' (Peuquet, 1994).

When examining time-space related events or elements, another aspect which is important is the context in which the time-space activity can be set (see also, Bracken and Webster, 1990; Langran, 1992; Molenaar, 1993; Yuan, 1994). For instance, the socio-economic and cultural aspects in which time and space are perceived, used, changed and applied must be regarded. Demographic and composition aspects also specify this context aspect. Therefore, three domains should be considered when an event or element is to be evaluated:

1) Time
2) Space
3) Context

Time characterizes the process of change in place and context. Space refers to material space, a single element in this space located with coordinates in X, Y and Z. Context is also connected to representative space (*e.g.* for communication purposes) and mental space (imagination).

For each different domain, terminology and descriptions of situations are important and three features can be distinguished (*cf.* Molenaar, 1993; Yuan, 1994). The first feature relates to the time domain: the relevance and description of an element change in time for a user, and for each element, with a different speed. The second feature is the aim for which an element is examined: for which tasks will the information be used (*e.g.* monitoring or planning purposes). A third feature concerns users, their personal cultural background and their related profession. These users, and the professional group to which they belong, will have their own definition and perception of elements, which will also depend on the scale level at which the element is to be observed (*e.g.* a village as part of the countryside or the village and the surrounding area as a rural attraction).

2.3.4 Conclusion

Time-space activities can be regarded as being determined by time, space and context and the relationships between these three. Space forms the physical condition for human activity and is a result of human action, interaction and transformation. Absolute (clock) time forms a constraint on human activities, but simultaneously, perceived time can be totally different and is important for the meaning attached to these activities. Both space and time are very strongly connected with each other. Also, space and time cannot be viewed independently of the context in and from which space and time are applied and used. Three features of elements are important: relevance and description, aim and use. Having elucidated these domains, the process of how a tourist constructs a tourist recreation complex will be discussed in the next section. The way in which the tourist connects activities to each other through specific time-space behaviour, in combination with the tourist's interaction with the landscape, are considered to be two important elements in a tourist recreation complex.

2.4 The Tourist Recreation Complex

2.4.1 Introduction

Tourists do not use the various opportunities in an area at random. The various elements of the tourist recreation products on offer are combined according to knowledge, motives, images, preferences and actual opportunities (Dietvorst, 1989, 1995b). Tourists tend to combine several attractions and facilities during their holidays or day trips. These connected amenities as a whole are considered to be more attractive than each amenity on its own. To the visitor, the amenities appear related to each other; the amenities should also be near to each other (within a specific distance and time frame) in order to make their consumption possible. Dietvorst (1989, 1995b) labels these combinations of spatially related attractions and facilities a 'Tourist Recreation Complex'. The actual time-space behaviour of a tourist forms an expression of the tourist recreation complex. In a tourist region, a variety of tourist recreation complexes can be identified because each visitor links museums, restaurants, shopping facilities, theme parks, and so on in a unique way to form a coherent but spatially differentiated whole. Van der Heijden and Timmermans (1988) state that, for a total group of tourists, different opportunities, locations, and attractions are more important than a repetition of behaviour. They label this as variety seeking behaviour. The kind of activities chosen and locations visited might also vary for different tourist groups, *e.g.* young families or nature lovers. Each person will create its own specific complex.

The tourist recreation complex will first be discussed in relation to geographical field theory, which should give more insight into the complex concept (Dietvorst, 1995a) (§ 2.4.2). The tourist, as consumer, plays an important role in the complex development. A second aspect in the complex concept is the interaction between the tourist and the physical space that is expressed in time-space behaviour. Time-space behaviour and the related interaction process will be separately discussed in Sections 2.4.3 and 2.4.4.

2.4.2 The Tourist Recreation Complex in Relation to Geographical Field Theory

Dietvorst (1989, 1995b) describes a Tourist Recreation Complex as a system, an aggregate of product elements with their mutual relationships. These relationships are created through the time-space movements of tourists. A tourist region contains different individual Tourist Recreation Complexes or subsystems, consisting of aggregations of product elements, based on meaning attached to them by tourists. These aggregates have specific characteristics, determined by appearance or interpretation. A system can be defined as the following (*cf.* Dietvorst, 1979 and 1995a):

- a collection of elements, whose identity is determined by one or more characteristics;
- a collection of relationships between the designated elements;
- a collection of relationships between the elements and the environment of the system.

Dietvorst (1979, pp. 16/17) states that, for the description of the characteristics of a system, the concepts of structure and function are important components. Structure refers to the designated elements in a system. It can be defined by the character of the elements in the system. Function refers to the collection of relationships between the designated system elements. This phenomenon supports the maintenance of specific characteristics or conditions of the system. A relationship consists of a tangible flow between the system elements, which is either present or realised; examples are flows of commodities, persons, capital, information. They are not potential relationships but displayed relationships.

Geographical field theory can be used to analyse the internal dynamics of the Tourist Recreation Complex (Dietvorst, 1989, 1995a). The essence of geographical field theory for Berry (1968, pp. 421 in: Dietvorst, 1979) is the interdependency between structure and function: 'a mutual equilibration of spatial structure and spatial behaviour in a state of complex interdependency. Thus in the context of ongoing spatial processes behavioural changes may call forth structural changes as well as the converse'. The analysis of the actual use of the tourist recreation product in a region reveals the system mechanism. It helps to make the dynamics of a spatial element visible. A structure matrix and a function matrix can be used to trace the mutual connections (see Figure 2).

Structure

	Quality 1	*Quality 2*	*....*	*Quality y*
Element 1	*q*	*q*	*q*	*q*
Element 2	*q*	*q*	*q*	*q*
....	*q*	*q*	*q*	*q*
Element x	*q*	*q*	*q*	*q*

Function

	Element 1	*Element 2*	*....*	*Element x*
Element 1	-	*r*	*r*	*r*
Element 2	*r*	-	*r*	*r*
....	*r*	*r*	-	*r*
Element x	*r*	*r*	*r*	-

q = quality describer
r = relationship describer

Figure 2 Structure and function matrix as parts in a system description (cf. Dietvorst, 1979)

A tourist recreation complex can be conceptualised as a system. The different elements in an environment - the product elements, such as hotels, a marketplace or a museum, together with their applied coding and the tourist (consumer) - form the system elements (structure). The relationships between these elements (functions) are established by the individual tourists and their movements. These relationships become tangible as tourist flows, capital flows or information flows between places or regions. Time-space behaviour is the result of the created relationships (functions) between elements (structure) in a tourist recreation region. Time-space patterns are developed through the interaction between the tourist and the material space. This interaction is influenced by specific qualities of the tourist and by qualities from outside that influence the tourist. It is now time to take a closer look at how to deal with time-space behaviour, how it is accomplished and how it can be comprehended.

2.4.3 Time-Space Behaviour

The individual tourist creates a personal Tourist Recreation Complex by combining activities, drawn from a supply that is spread out over a region and that might have coding added to it. Several choice moments can be noted in each individual complex package. Each choice is followed by an interaction and activity in space and time. The noticeable time-space behaviour is regarded as the outcome of a conscious (cognitive psychological) decision-making process, which might be guided by unintentional influences, such as product coding or fear of open spaces or fear of height. Unconscious influences do not lead to a well-considered decision; they are the result of a direct reaction from 'internal stimuli'. These indirect influences will not be considered in this discussion of time-space behaviour, because it is difficult to evaluate their effects. Another study would be required to clarify the importance of these influences on time-space behaviour.

Choice process

Stemerding (1996, Ch 4) offers an overview of how leisure behaviour and the choice decision process might be understood. From this overview, the concept created by Timmermans (1982), which bears similarities to the notion developed by Lang (1987) in a different context, seems suitable for the elucidation of time-space behaviour. The concept provided attempts to explain the interaction between an actor and physical space. The latter is perceived through various senses (subjective filtering, perception) and transformed into a cognitive image with several choices. Information constraints, which determine awareness of choice options, play an important role in the subjective filtering of all available alternatives. In fact, the cognitive environment, or all perceived choice alternatives, is the outcome of a simple calculation: the physical space minus the alternatives not known as a result of information constraints (Stemerding, 1996). Each (known) situation is examined by combining the cognitive image with other subjective values, such as emotions (subjective weighting). Series of choices are created through this weighting-process, from which a definite choice is made, according to specific decision-making rules. A spatial interaction takes place, leading to time-space behaviour. Figure 3 illustrates the essence of this choice model.

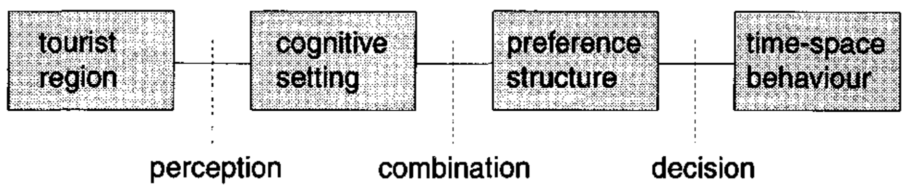


Figure 3 Essence of a choice model of (conscious) behaviour (cf. Timmermans (1982) and Stemerding (1996))

Aspects of time-space behaviour

Perception, combination and decision making guide the specific time-space behaviour of a tourist (Timmermans, 1982). These guiding factors are influenced by experience, by social-structuring elements of the actor, and by the physical space itself. Four aspects can be distinguished in time-space behaviour (after Thrift, 1977; Huigen, 1986; Lang, 1987; Van der Heijden and Timmermans, 1988; Freundschuh, 1992; De Vries and De Bruin, 1993):

1) substantial:
   type of activities that can be initiated, sort of attraction that has these activities, known activities (and how well), the necessary and legal means to fulfil these activities;
2) spatial:
   where the activities are realized and how perception of the physical environment and landscape opportunities influence the interaction between tourist and environment;

3) social:
   individual influence of the tourist - learning process, experience, motivation, values and standards, preferences, personal judgement - as well as influence of a group and the social environment;
4) temporal:
- changes in behaviour resulting from earlier choices: each activity follows on from an earlier one; the visitor and the location visited are (still) indivisible, a person cannot be in two places simultaneously; there are time constraints (during a day), each activity and movement demands time; there is a limited radius of action from any specific place within a specific amount of time; preferences and perception change over time: different activities are desirable on one day and over a period of days and they must also change over time; there is a learning process related to the acquisition of knowledge about an environment and a route, first there is only topological knowledge, later also metric knowledge (Freundschuh, 1991);
- changes in the tourist recreation product; rise, stabilisation and decline of the product, each phase with a unique meaning and symbolism. Each product and phase has its own dynamics (life-cycle, exhaustion of resources).

These four aspects are often translated in a few measurable components:
1) substantial:
   sort of activity performed, sort of means available;
2) spatial:
   where, which area is chosen, which routes are followed, how much space is covered;
3) social:
   with whom, individual or with a group (and what sort of group);
4) temporal:
   when, how often, how long, which sequence in time.

These components can be measured separately, but this neglects the mutual coherence. Furthermore, it does not provide a sufficient explanation of the demonstrated behaviour in relation to environment and previously made choices, the discovery of an area and the feedback to motivation and experience, of which both lead to a new preference structure and to changes in time-space behaviour. The coherence between components must also be considered in order to discover the structure of the tourist recreational complex.

Variety seeking and markers

Two identifiers can be mentioned that link the four components. These are related to time-space behaviour: a variety seeking tendency and the role markers play in the choice process. Van der Heijden and Timmermans (1988) assert, in their research on time-space behaviour by outdoor recreators in nature and recreation areas, that location and the possibilities offered by an area are important to the variety seeking process. Large areas are preferred as they might offer more possibilities. Dietvorst (1996) also describes the consumers' urge to variety with his example of aquatic recreation; not only are the possibilities and qualities of the waterway and surrounding areas important, but also the amenities for aquatic sports and general tourist recreation facilities.

The second identifier, which is regarded as important in time-space behaviour, is the role markers play in tourists' choice process (Elands, 1995; Brouwer and Elands, 1996). A marker refers to a sight and can be any piece of information about that sight. This information can refer directly to any characteristic of the sight, but most of the time it will indicate a symbolic meaning. Tourists interpret and make use of signs to fill their vacation with activities and give it meaning. The communication between the producers of sights and the visitors takes place through markers (Elands, 1995). Timing is of significance for markers: at home or at the holiday location (generating), during the travel (transit), or at the vacation accommodation or attraction (contiguous). Dietvorst (1995b) distinguishes three levels on which markers can be important: landscape, territory or element. Guidance takes place based on interpretation of physical spatial characteristics. Brouwer and Elands (1996) describe these markers as parts of the information which exists about an attraction. Most of the time, a tourist marker tells us how we can see, interpret and use an attraction. Markers continually reproduce the meaning which individuals and society give to elements that might be valuable to visit, to see. Needless to say, the value of a marker is determined by cultural and historical influences.

One important element in time-space behaviour is formed by markers in and of the landscape: the role of markers in the decision-making process, how the tourist anticipates these markers. The perception and interaction determine the behaviour of the tourist, as stated earlier (see also Figure 3). Therefore, in dealing with this interaction process in time-space behaviour, we can conclude that it would be useful to have a more detailed discussion about the interaction between a tourist and the surrounding landscape.

2.4.4 Tourist - Landscape Interaction

The tourist-landscape interaction process needs to be explored from a number of angles. Four perspectives will be examined, culled from work by a number of authors: the landscape, the tourist, the influence of external factors on the decision process, and the learning process related to the environment. The interaction between an individual and the surrounding landscape is described in detail by Coeterier (1987). Coeterier outlines several (landscape-oriented) features, which he regards as important in the human perception and appreciation of landscape. Lengkeek (1994) focuses on the tourist experiences within the landscape, when analysing tourist activities from the point of view of the perception and valuation of the tourist. Kwan (1995) offers another approach of the relation between an individual and the landscape. While Coeterier and Lengkeek use perception as the starting point, Kwan uses movement and activity scheduling to describe the interaction and the resulting behaviour; the unexpected element in the route selection process is a main issue in her approach. A fourth angle is offered by Car and Frank (1994), Freundschuh (1992), and Smyth (1992). They discuss how a person develops knowledge of the environment during a stay. These angles are elaborated upon below.

The landscape

Coeterier (1987) describes many dominant perception features, which can be distinguished in the person-landscape interaction. These are: unity, use, naturalness, management, historical character, spatial relations, soil, sensory perceptions and season. Coeterier asserts that these features are not unique, simple or independent characteristics of landscapes. Each feature is part of or overlaps with other features. Furthermore, the features do not remain static in the perception of the individual, but constantly change under the influence of knowledge and experience. This dynamic character also characterizes the mutual relationships between the features.

Luiks and Miedema (1992) modelled the Coeterier features in a Geographical Information System to analyse how the attraction of the landscape influences decisions of cyclists, who are cycling for pleasure. They also incorporated variety and beauty as features. Coeterier also mention other features in other studies: variety, prosperity (as a combination of management and soil characteristics), knowledge of the landscape, orientation possibilities, sphere, attraction, suitability of the landscape for specific mobility forms. Additional features can be applied such as safety, shelter, and comfort. All these features contribute to a general picture of the important elements in the interaction process. However, they are all rather qualitative features, and therefore difficult to process in the more quantitatively oriented GIS.

The tourist

Coeterier uses landscape as the inspiration source for the interaction analysis. Lengkeek (1994) puts the tourist first and uses the landscape to interpret the context of the tourist experience. He distinguishes three relevant values (p. 149): use, appreciation and attraction value. This categorization can be different for each tourist: an object with a high attraction value for tourist A might be more functional for tourist B. The same difference holds for meaning linked to a landscape element or activity. There is consensus on the description of most elements (*e.g.* a forest or an amusement park), but tourists' interpretations of them are entirely subjective (*e.g.* relaxing or letting off steam). This additional meaning seems more flexible and important for the tourist and thus for the related time-space behaviour. It would therefore seem to be important to find out what role this additional meaning plays in the perception, experience and use of a tourist region. Lengkeek (1994) describes this as tourist relevancy context.

According to Lengkeek (1994), van Keken *et al.* (1995) and Elands and Lengkeek (1996), Cohen offers a phenomenology of tourist experiences that can deal with this tourist relevancy setting. The five modes distinguished are all directed towards a journey in search of the real and authentic basis of life:

1) the recreational mode:
   experiences are aimed at leisure and relaxation; the landscape is more or less scenery; the travel group is important; the destination must be familiar.
2) the diversionary mode:
   experiences are necessary to escape every-day life, which causes stress and is boring; maybe elsewhere new and exiting things might happen.
3) the experiential mode:
   the home environment and experiences are regarded as limited, not the 'authentic life'; the tourist looks for landscapes with authenticity, but there is no identification with this authenticity.
4) the experimental mode:
   the tourist experiences are used to rediscover oneself, to encounter one's

own physical and mental limits; the exploration of inner authenticity.

5) the existential mode:
   experiences are sought with the aim of assimilating with another culture, the tourist's own life is not considered to be real.

Researchers, such as Van Keken *et al.* (1995), have tried to transform this approach into a typology. As with all typologies, the five modes distinguished by Cohen cannot be strictly separated. Each tourist might be placed in more than one mode; modes one to five are on a sort of continuum. This typology, however, offers a way in which tourist experiences and the context in which tourist activities must be judged, can be taken into account. The different values underlying the tourist experience and the way they are applied by each tourist, or tourist typology group, stresses the differences for each tourist-landscape interaction process. These differences have to be taken into account when creating the structure for the analysis of the tourist recreation complex.

The route selection process

In contrast to the approaches from a perception point of view, Kwan (1995) applies a more instrumental approach, not related to tourism but to route selection in everyday life. She uses activity scheduling as the exploratory basis to model time-space behaviour. Kwan distinguishes four angles:

a) Activities and their spatial effects:
   Routine and non-routine activities, fixed and flexible in time and space;
b) Different stages in activity scheduling:
   Pre-trip planning and en-route planning;
c) Multi-strategy adjustment:
   Interdependencies between trips in the time-space continuity; constraints on an individual's life path; rerouting in unexpected situations: 1) activity rescheduling; 2) consolidation of trips; 3) destination substitution;
d) Use of heuristics:
   It is a 'satisficing' behaviour rather than an optimizing or maximizing behaviour.

The last aspect in particular is related to behaviour and transportation modelling. Kwan (1995) notes several difficulties encountered when applying activity scheduling in transportation models. There is a limitation on the nature and amount of information (focused on realistic spatial information, such as location of facilities, or transport network) to be acquired, stored, processed and updated. Furthermore, it is not easy to specify a realistic traveller choice set; humans are not capable of evaluating and comparing a large number of alternatives in the objective environment. Only a selective amount of alternatives is needed and used. There is also a recursive character in the travel decision-making process; new decisions and ad hoc adjustments are often made as the traveller faces unexpected events during the execution of previously made decisions.

Kwan's approach to modelling time-space behaviour illustrates the unpredictable character of a route choice when other, external, aspects play a role. Markers in and of the landscape can have this kind of external influence on the decision process. Her approach offers a more dynamic view of time-space behaviour for dealing with tourist-landscape interactions.

The learning process

All the perception features distinguished are directed by the various elements located in physical space. It can be stated that each distinguishable element has a relationship with other elements and that it is itself also developing and changing. Some relationships between elements are hierarchical. In the analysis of the interaction between a tourist and the landscape this hierarchy may be important. Car and Frank (1994) highlight hierarchical spatial reasoning as the way in which human beings try to solve complex spatial tasks. A problem is divided into smaller parts that are then solved; many elements are quickly excluded from consideration, moving from top to bottom in the problem structure.

Car and Frank state that humans use an abstraction of geographical space organized in multiple levels. Each level contains only information necessary for the successful performance of a specific task. The amount of detail increases descending from the top to the lowest level. The example Car and Frank use to illustrate their approach is finding the way. They assert that finding a way occurs in small sub-networks; humans may divide a large road network into a hierarchy of smaller sub-networks. Smyth (1992) and Freundschuh (1992) offer a similar approach by describing how the action space of a person in road networks and landscape increases. First, the (networks in) local areas are discovered; these are comparable to the sub-networks of Car and Frank. Subsequently knowledge of the area increases, in more detail for the local area and more generally for the surrounding networks in which the local area is embedded. It can be concluded that the growing knowledge acquired while staying in or moving through an area will change the meaning and experiences for a tourist.

2.4.5 Conclusion

Each tourist links and combines different elements in a tourism region. The individual tourist recreation complex created is regarded as a system that consists of tourist product elements, the system elements, and the established relationships or function. Time-space behaviour is an expression, the outcome, of the relationships created between the elements. Different choice moments are important in the decision-making process involved in undertaking and enjoying activities. Physical space, the individual cognitive setting and preference arrangement, all lead to the final decision and the demonstrated time-space behaviour. Four measurable aspects can be distinguished in time-space behaviour: substantial, spatial, social and temporal. These separate aspects together with the cohesion between these aspects forms the tourist recreation complex. Two identifiers can be mentioned that are important for this cohesion: a tendency towards variety seeking and the role of markers in the decision-making process.

A special aspect of the cohesion is the interaction between the tourist and the landscape, how markers in the landscape influence the decision-making process, and thus the time-space behaviour. Many qualitative features of the landscape can be identified which give insight into how the landscape and its markers influence the choice process. The tourist experience is produced through three landscape values: use, meaning and attraction of the landscape. The tourist context is based on a journey in search of the real and authentic basis of life, which can be divided into five different Cohen modes. A third approach to the tourist-landscape interaction is the route selection process; unpredictable external influences guide the decision-making and selection process and give it a dynamic character. Another dynamic aspect is found in the growing knowledge of an area that the tourist accumulates. Several hierarchical levels can be distinguished in this learning process, each with its own amount of detail.

2.5 The Tourist Recreation Complex as a Network

2.5.1 Introduction

In the previous sections, different aspects related to the general research question were discussed. The tourist transformation model offers a framework for the better understanding of the relationships between supply and demand in tourism. Producer and consumer add their own coding to and perception of the tourist recreation product elements and movements. Space is characterized as a physical condition for human activity and a result of human action and interaction. The tourist space can be understood as mutual cohesion between different (tourist) elements and the relationships between these elements, which are partially established by tourists. Time contributes an historical perspective to the element, while the tourist has his own (perceived) time-table to consider. The tourist combines several attractions, facilities and movements to create a personal tourist recreation complex. Several choice moments can be recognized in this complex package. The interaction between the tourist and the physical space is expressed in the tourist time-space behaviour and can be analysed from several angles. In order to analyse the tourist recreation complex it is first necessary to analyse time-space behaviour, and therefore the different components of this behaviour. The hierarchical way in which humans try to solve spatial problems might offer a strategy for analysing the spatial component of the time-space behaviour of tourists.

The Tourist Recreation Complex was described as a system consisting of system elements and the relationships between these elements (function). This complex system can be depicted as a network. A network can be defined as existing of two or more nodes that are connected with each other (see, *e.g.* Haggett *et al.*, 1976; Selkirk, 1982; Ritsema van Eck, 1993). A network can be represented as an array of nodes and links that describes if nodes are connected to each other or not. A Tourist Recreation Complex can be characterized as having several locations (nodes) at which activities and perceptions take place, connected by any form of links, *e.g.* information sources, mentally, or through movements between locations. The nodes and links can be signified and organized in different ways, each leading to a specific network. Furthermore, it was suggested that the knowledge about the tourist region changes during a visit. The tourist awareness space will be small when first visiting a new area or region. The tourist is open to impulses from the environment and promotional information. This new information enlarges the awareness space of the tourist as do the activities undertaken, such as touring in the surroundings. These changes make the tourist less perceptive of an enlargement of the own awareness space due to signals from the landscape or promotional material. After a period (of days or weeks) during which the new information is embedded into the cognitive map of the tourist, new impulses can be incorporated. Therefore, it can be argued that the tourist recreation complex, and thus the corresponding network, will grow during a holiday, it will not be static.

2.5.2 The Network Approach

The Tourist Recreation Complex, interpreted as a network, cannot be compared to other networks such as a road-network. In a road-network, each link between two crossings is considered to be a separate connection, and is important for the total network. In a Tourist Recreation Complex-network, several of these road-links can form one connection for movement purposes or for environmental influences. Different types of networks can be distinguished in the Tourist Recreation Complex, depending on the way in which a network is approached. Several possible networks will be described here:

1) Physical network
   Landscape can be depicted as a network, see *e.g.* Cantwell and Forman (1993) or Cook and Van Lier (1994). Part of the landscape is formed by a road-network, links intended for movement; each link is limited by two nodes (a node at each possible intersection or crossing). Only roads, as line-elements, are important for this network.
2 Route network
   The road-network can be interpreted as a potential tourist movement network; at each intersection a new road can be chosen by the tourist. The actual roads followed by the tourists form the tourist route network. Each link is limited by two important choice moments, leaving or arriving at a special (desired or undesired) location or following a specific route. Each link in the route network can consist of several roads.
3) Tourist activity network
   A specific type of tourist network is a tourist activity network. In this network, the changes of location or activity form the nodes, and the links are straight lines, only used to connect the nodes. The activity pattern is of more importance than the roads followed.

4) Experience network

In addition to the network types with mainly physically oriented links, another type of link can be identified in a Tourist Recreation Complex. This link depends on activities undertaken by a tourist, and the way in which the tourist perceives them and gives them meaning. The links can include several physical links and nodes, but each link is limited by a change of meaning. This type of network can be defined as a tourist meaning or experience network. This experience network can be spatially related to the physical network, which is used to move around in the region is measured and interpreted in a totally different way. In addition to line-elements (roads), point and area elements are also important in this network. The landscape or the environment influences the perception, and thereby the experience and meaning, of an activity. The landscape can be described using point and area elements important to the tourist.

5) Information network

This network structure consists of information sources as nodes; the connection between the nodes is formed by the way in which the information is applied in the decision-making process concerning the initiation or continuation of an activity. Information sources can include local tourist information agencies, signposts along the road or specific landscape features. This type of network can be defined as an information network, in which spatial relationships with the physical network can also be depicted.

The last four network types are all influenced by previous knowledge or opportunities of an area, the learning process and personal characteristics. All these types of networks can be combined to form new networks. For each network type a different aspect of the time-space behaviour or of personal characteristics is applied. The different locations visited, including the activities and movements, can be depicted as nodes. The links between these nodes can be described as a route compiled by a tourist (or group of persons). The networks constructed may be based on choices, meaning (or experience), information, roads chosen or available time. A single network, consisting of routes with nodes, is part of a tourist recreation complex, an individual structure shaped in time, space and context. All the different networks generated together form an individual tourist recreation complex; these networks are interwoven and they influence each other. No single network dominates in determining the total tourist time-space behaviour. At any specific moment a number of nodes and links of one network determine a part of the time-space behaviour. This results in an individual tourist recreation complex.

The interaction between the physical spatial structure and the personal characteristics of the tourist leads to different individual perceptions that might be represented as networks and sequences (see Figure 4). Markers, in the surroundings or from promotional and information material, and the variety seeking behaviour of tourists influence the construction of these networks and sequences. All the individually created networks and the networks which can

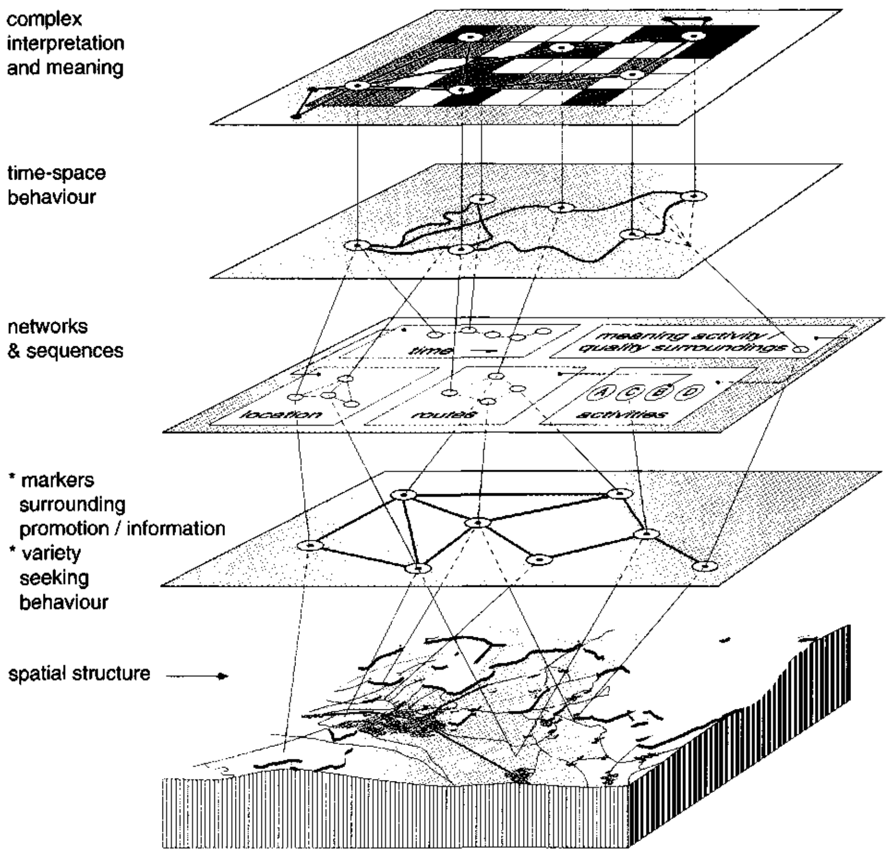


Figure 4 Interwoven network patterns and sequences which create a tourist recreation complex (after Elands, 1995, and Dietvorst and Hetsen, 1996)

be distinguished in the physical landscape, influence each other continuously. These networks form an interwoven structure. Out of these interwoven networks, a specific tourist route and time-space behaviour is established, resulting in an individual tourist complex.

The combination of various individual tourist complexes makes up a pattern in a region. This regional network is of more importance to the suppliers and planners of tourist recreation products. The regional network gives information about the size of the area used and how tourists make connections between the different locations and elements (landscape elements, facilities and products). Making a distinction between complexes at an individual level and at a regional level offers two analytical approaches. At the individual level, the analysis focuses on the nodes, links and the properties of the network elements, based on the meaning attached to these elements by each individual tourist. At the regional level, the analysis focuses on the meaning or function of the individual complexes (which were abstracted to networks at the regional level), the distribution and concentration of nodes and links, the cohesion in a region based on the different regional network patterns, the (possible or future) areas of conflict between different visitors or visitor groups that can be distinguished, and the opportunities offered in a region for the tourist. The individual tourist complex consists of different networks that are part of and created by the individual. A regional tourist complex consists of different individual tourist recreation complexes, which can be considered individual networks at a regional level (see Figure 5). At a

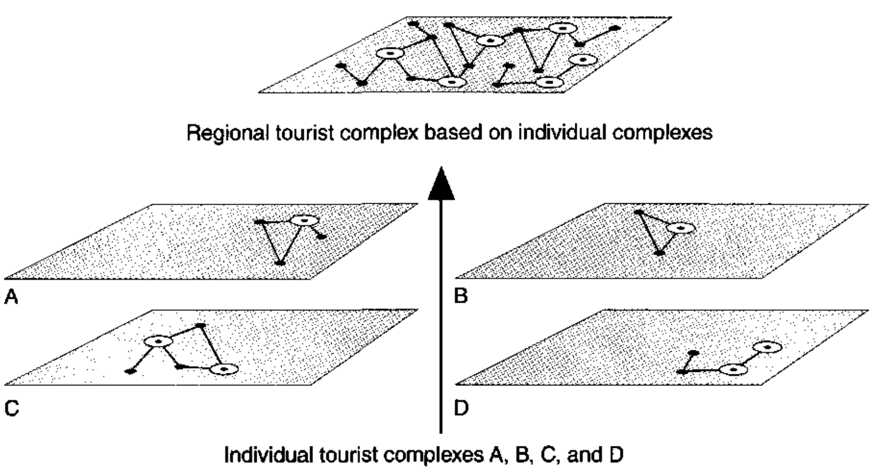


Figure 5 Regional tourist complexes consisting of different individual tourist complexes

regional level both diversity and cohesion of tourist product elements are important conditions for the stimulation and maintenance of the individual tourist recreation complexes and thus regional prosperity, opportunity structures and quality of tourism and recreation.

2.6 Geographical Information Systems

2.6.1 Introduction

The first two aspects of the general research question (see § 2.1), tourism and time-space behaviour, have now been sufficiently elucidated to continue with the third aspect, the use of Geographical Information Systems (GIS). This will be discussed briefly below and in more detail in Chapter 3. The abstraction of a tourist recreation complex to a system, consisting of interwoven networks, seems a promising approach for at least a partial clarification of tourist behaviour. Three domains were considered to be important for elements in the tourist recreation complex: space, time and context. These can be further described using the following brief characteristics:

- space: the geometry of the location in x, y (and z) coordinates (metric data) and topology: connectivity, relationship with other elements on the same or higher scale level, and contiguity;
- context: theme, quality, meaning and perception of the elements and activities;
- time: the historical determination of movement, geometry and context.

An appropriate way of dealing simultaneously with these characteristics can be an information system. In particular a Geographical Information System may be used to analyse the geometrical aspects of tourist time-space behaviour. We still need to ascertain how GIS might be used to deal with the time and context aspects. A general introduction to GIS is presented in § 2.6.2. Geographically related processes can be abstracted at three levels: conceptual, logical and implementation levels. The application of GIS involves three steps: collection, processing and presentation. These steps will be used to describe GIS in more detail. The usefulness of GIS for tourist time-space behaviour analysis will be examined in § 2.6.3.

2.6.2 *General Description of GIS*

There are many definitions and descriptions of Geographical Information Systems (GIS) in the literature. See, for example, the overview given by Maguire (1991), but other general GIS books also give a broad range of descriptions, *e.g.* Burrough, 1986; Goodchild and Kemp, 1990; Peuquet and Marble, 1990; Star and Estes, 1990; Scholten and Stilwell, 1990; Maguire *et al.*, 1991; Laurini and Thompson, 1992. These descriptions all deal with geo-referenced or spatial data. Standard (commercial) software or specific applications are available for dealing with this spatial data. They are all referred to as GIS.

Within GIS the real world and its elements are transformed and formalized into spatial data, which is then processed into information from which results are presented. Before the formalization process can be initiated, phenomena that are regarded as important have to be described using certain characteristics and it should also be indicated how these characteristics are related to each other. Eweg and Van Lammeren (1996) describe this level as the conceptual level. It consists of the construction of the data model, the designation of the problem(s), and the determination of the presentation forms. The next level, the formalization process, consists of the logical approach to the data, the way the data structure can be depicted in order to store data in a computer system, how the data have to be processed and the graphical means applied to present the results. The last level distinguished by Eweg and Van Lammeren is the implementation level, in which the data are stored in a data base, and analysis and presentation commands are processed.

At each level, the dealing with spatial data within GIS can be divided into three steps (*cf.* Maguire, 1991; Molenaar *et al.*, 1996):

1) data collection: determination, input, storage, and updating;
2) data processing: description and analysis of present situations and modelling for future situations, using data query, transformation and combination of data; this can be further separated into questions related to (*cf.* Maguire, 1991): location (what can be found at ...), condition (where is it ...), trend (what has changed ...), routing (what is the best way to ...), pattern (is there a pattern ...) and modelling (what if ...).
3) presentation in the form of maps, graphics and tables.

These levels and steps will be applied in the following chapters, in an attempt to characterize the tourist recreation complex construction using a GIS.

The three domains that were examined in order to assess the tourist recreation complex (time, geometry and context) cannot all be implemented in the same way within current GIS. One aspect has to be regarded as a constant, a second aspect may be varied within specific limits while the third aspect is assessed (Langran, 1992). An example may clarify this: a tourist day-out, as an object, is kept fixed in its meaning, while several places are visited and activities undertaken, and the time spent is registered. In this example time is assessed, but very often time is kept constant within GIS applications. This leads to a static representation of geographical data. The meaning, which is attributed to an object and to the mutual relationships between objects, is dependent upon the interpretation of that object and the scale of detail, as well as the context that is related to that moment in time.

The aim of this research is not to develop a new GIS for the analysis of data with a time and context domain. Existing literature on the topics of time, language and cultural aspects is relevant for its coverage of the time and context domain in general. See *e.g.* Langran (1992), and Worboys, Frank, Lakoff, Couclelis and Mark in: Mark and Frank (1991), Frank *et al.* (1995) and Campari and Frank (1995). This literature also seems also relevant for the future development of GIS, as it deals extensively with the role of time and context domains in the development of better instruments of analysis. For example, specific query structures for the analysis of ordinal temporal data or a more explicit query syntax are described. However, the aim of this study can be transposed into questions such as: How can a tourist recreation complex be conceptualized? How can time-space behavioural data be structured into a data model? How well do they fit into current GIS data structures? What might current GIS be able to offer in processing these data? What kind of applications need to be developed to support the analysis of time-space data? The possible uses of current GIS software need to be explored in terms of their suitability for dealing with collection, processing and presentation of data on tourist recreation complexes.

2.6.3 GIS and Tourist Recreation Complexes

In order to determine if and how current GIS software can deal with tourist recreation complexes it is necessary to conceptualize the tourist recreation complex in GIS terms. The tourist recreation complex was described (in § 2.2) as the spatial and social combination and linking, in interaction with landscape, by the individual tourist and for a tourism region as a whole. Tourist time-space behaviour was considered to be an expression of the tourist recreation complex. In Figure 2 (§ 2.4.2) the tourist recreation complex was characterized as a system with elements of structure and function. The landscape elements and the specific tourist recreation products were regarded as system elements. The interpretation of the landscape elements and the tourist time-space behaviour can be regarded as the functional elements, the relationships created between the landscape elements. The context in which these connections are made is established by the tourist and the activities undertaken. However, as the perception of space and activity is difficult to measure, an appreciation value might be appropriate to classify this.

Geographical data are currently stored in a vector or raster data structure. An object in a two-dimensional GIS is always an abstraction of a spatial element in reality. Within the two-dimensional vector data structure the object data are stored as a point, line or polygon object. In a three-dimensional representation the volume is added. In a raster data structure the data are stored in a (regular) cell pattern. It is argued that the tourist behaviour, and therefore the tourist recreation complex, must be explained using interwoven vector GIS-objects (point, line and area). None of the geographical elements, described as two-dimensional point, line and area objects, have exclusive significance for the tourist recreation complex and the exposed time-space behaviour. It seems that there is always a combination of different objects. In the tourist perception and interpretation some activities take place at point level while other activities are undertaken in an area. Point and area specifications can be regarded as scale-dependent. The route chosen can be represented by a line object. The following example illustrates why this interwoven approach is required: an accommodation or activity location can be perceived as (and thus represented by) a point object; driving, touring, walking to a new destination or enjoying the landscape is represented by a line object; walking in (a part of) a forest or town centre or landscape type can be represented by an area object or a line object, depending on the scale of observation. All these different (GIS) objects form the object 'tourist time-space behaviour'. This can be examined over a period of half a day, one or two days, or for the length of time of a holiday, a year or even longer. All the combinations, or constructed networks, together with the context from which the different aspects are perceived, form the individual tourist recreation complex.

2.7 Detailed Research Questions

In this chapter, different aspects of the tourist recreation complex have been discussed. Furthermore, some considerations on GIS were presented from the viewpoint of the analysis of a tourist recreation complex. Special attention was given to the tourist and the time-space behaviour as the expression of the tourist recreation complex.

Based on the various considerations, the aim of the research can now be specified in more detail. The questions arising are:

- How should a methodological framework be defined in order to acquire better insight into the tourist recreation complex, the relationships created between the tourism elements and the individual tourist?
- How should the various system elements and their relationships within a tourist recreation complex be approximated? Is it possible to regard the system of elements and their relationships as a network?
- How and how well does current GIS software handle the assumptions about time, space, context and networks? How do current GIS collection, processing and presentation modes handle the associated data and structures? Are extensions, from outside GIS, necessary to support the processing and presentation modes?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3 METHODOLOGICAL FRAMEWORK

Computerised visualization provides an artistic, creative, spatial analysis technology that may be extremely useful in a wide range of circumstances and applications. It retains the communication power of the map, but injects into this an element of dynamism (Openshaw et al., 1994).

3.1 Introduction

In the previous chapter, notions of time, space, time-space, tourism and tourist behaviour were discussed in relation to the analysis of a tourist recreation complex. A tourist recreation complex was considered to consist of system elements and relationships created between these elements. Tourist time-space behaviour was regarded as a spatial expression of this tourist recreation complex. The three important features or domains distinguished in a tourist recreation complex were: space, time and context. GIS, with its spatial analysis possibilities, was introduced as an instrument to store and analyse spatial elements with their created linkages as they occur with the described tourist time-space behaviour. Current GIS can be used to analyse and evaluate spatial features. However, to deal with time and context domains, approximations of these domains have to be made. The dynamics of time and individual perception, and the tourist's appreciation and interaction with the surroundings are difficult to model, either in a data or a processing model. It is argued that a methodology for determining tourist recreation complexes using the described time-space behaviour should take into account as equally as possible the three domains (space, time, context).

Three levels were distinguished to identify geographical processes in GIS: conceptual, logical and implementation levels (§ 2.6.1). All three levels are applied for the phases of data collection, data processing, and data presentation. In the data collection phase at the conceptual level, a data model is determined and constructed in which different variables and their relationships are assumed to describe reality. Within the data processing model one or more approaches are determined which are required to tackle stated questions. In the presentation phase the form of visualization of the results is chosen. These three phases will be described below, mainly for the conceptual level. The other two levels will also be touched upon, as they cannot be totally separated from the conceptual level. Firstly, GIS will be further elaborated from the perspective of the tourist recreation complex construction (§ 3.2). In the following section, the possibilities of using GIS for network analysis are described. In Section 3.4 a methodology for the analysis of tourist recreation complexes is proposed.

3.2 The Tourist Recreation Complex and GIS

3.2.1 GIS in general

We begin by elaborating the three GIS steps: collection, processing and presentation. This is in order to conceptualise the tourist recreation complex as geographical processes that can be dealt with in a GIS. The main principles of GIS will not be described here; there is recent extensive literature available (see § 2.6.2).

Collection
Several considerations are important when collecting data. To mention a few: the data model and data quality at the conceptual level, data type at the logical level, and data entry and data storage structure at the implementation level. It is still very easy within GIS-packages to (unintentionally) mix data of different scale, reliability and essence. A well defined data model and meta-information about the data can protect users from this possible pitfall.

A refinement can be made by considering the data model and data type, related to time and scale interval. Elements can be regarded as more or less fixed (static) elements in the spatial configuration of a landscape. Alternatively these can be regarded as dynamic (flexible) elements, such as coding of products, movement, intensity and mobility of persons in the landscape. Within GIS, the fixed elements can be stored as raster or vector objects, *e.g.* a tourism facility as point, a road as line and a forest as a polygon. At a lower scale level the raster or polygon object can again be composed of raster objects, or point, line and polygon objects, *e.g.* the paths in the forest (lines), specific old trees or picnic facilities (points) and areas of heather (polygons). Molenaar (1993) describes this as a special relationship between the contributing objects. To generate data on a higher scale level, generalisations, aggregations, or associations can be made using the geometry aspect (point, lines and polygons, or raster) and the theme aspect (Molenaar, 1993).

The shape of an element is determined by its history and context. Topological relationships exist between the elements. Furthermore, the scale on which an element is observed also determines the way in which the element will be described as an object. The associated metric data pinpoint the element at a specific physical location and moment, but the shape of the elements and the relationships between the elements can be transformed into another configuration as a result of human perception (cognitive mapping). The aggregation of elements from physical space can be defined by words such as unity, orientation possibilities, attraction, openness, shelter, etc. (*cf.* Coeterier and others).

Besides the perception of physical landscape elements, another type of product element can be noticed that may influence tourist time-space behaviour or generate an attraction by itself. This type of element is referred to as the dynamic element, and is also time and context dependent. These elements are determined by geometry and theme within specific time frames, *e.g.* a predefined tourist route, a parade, a cycle race, tourist traffic intensities on different roads at specific moments or aeroplane demonstrations over regions during specific hours. These (constructed) elements make use of existing physical elements, onto which the dynamic element is projected 'relatively'. Relative can be defined as being measured with respect to a starting point of a road or route over time or distance. For example, bicycle race organisers make use of existing road structure and landscape forms to create a spectacular event. They also code the different physical elements used, which enhances the attraction value and stimulates new visits. An example illustrating this is the way in which several mountains in France are envisioned; these are well-known to European cycling aficionados because of the coding added by the organisers and participants of the Tour de France cycle race. Transposing these dynamic tourist product elements into the data model creates some contradictions. Either the tourist is part of this dynamic element, (*e.g.* when touring in the countryside) or the tourist normally encounters these dynamic tourist product elements from only one or a few observation locations. The tourist routes followed might be linked to the road structure and landscape elements in so far as the physical elements are concerned. The dynamic elements in which the tourist does not participate actively, pinpoint an activity geometrically to a single location for that tourist. However, if tourist product elements also have to be taken into account, there has to be a sufficient describer for these dynamic elements that relates to the landscape elements.

At present each project evaluated with GIS, a spatial data base is generated in which each object has one specific attribute meaning, *e.g.* soil, vegetation or roads. Generally speaking, with the vector and raster data structures, there is one information layer at one scale level, describing one moment in time. Applying these separate layers for various purposes might create problems concerning data reliability and accuracy, data interpretation, overlap and missing data, differences in aggregation and generalization, data from different sources, etc. Frank (1992) gives a more extensive description of these problems. In the object-oriented approach (see *e.g.* Yeh and Viémont, 1992; Molenaar, 1993), the separation over different layers disappears. Objects can be defined by different features, each describing a special aspect and accuracy level. This definition of objects can be established in various ways, *e.g.* by inheritance or pointers. A hierarchical structure between objects is created. Car and Frank (1994) argue that current GIS is not yet suitable for dealing with hierarchical structures; the formalization of human representation of spatial knowledge is inadequate and insufficient for implementation purposes. The data model required must be capable of being divided into parts in the same way as a hierarchical problem can be split up.

Processing

In terms of data processing, four methods that might be useful for the analysis of data concerning tourist time-space behaviour can be mentioned (based on 3 methods described by Dietvorst, 1993b): principal component analysis, exploratory spatial data analysis, the application of graph theory, and network analysis. The first method, principal component analysis, can make a statistical exploration of data patterns to reveal 'visitor preference spaces'. This exploration results in combinations of elements visited. By comparing these patterns with visitor characteristics, more insight can be gained into existing tourist recreation complexes. Previous studies which have analysed time-space behaviour using statistics only (see Bergmans *et al.*, 1994; Dietvorst, 1995a; Kolsté, 1996) have proved to be of limited use as far as the analysis of the temporal and especially the spatial components are concerned.

An as yet relatively new method of querying and analysing data involves the use of exploratory spatial data analysis (ESDA) techniques (see, *e.g.* A.

Unwin *et al.*, 1992; Hazelhoff and Gunnink, 1992; Hearnshaw and D. Unwin, 1994; MacEachren and Taylor, 1994). ESDA applies spatial dispersion analysis and statistical processing in combination, thus analysing data from a spatial view and not only a statistical approach. For example, the REGARD software (A. Unwin *et al.*, 1994) has been specially developed for this type of analysis and uses dynamic linkage of windows, but it is only suitable for point data. A basic characteristic of the ESDA technique is that data viewing is considered a good method for understanding, isolating and describing patterns of spatial distribution. In addition to static representations provided by maps and other graphical displays, time can be simulated by animating the display, showing specific time frames one after the other in real time processing. This animation process can be described as dynamic cartography. This method of dynamic cartography can lead to new insights into the data (Dorling, 1992; Ganter, 1994; Dykes, 1996).

The third method uses graph theory to describe patterns that can be derived from tourist time-space behaviour. The nodes and links, which can be discerned in tourist behaviour, can represent the structure and function elements of a tourist recreation complex. Flows of tourists could be analysed to discover underlying hierarchical structures, which can be distinguished within the tourist recreation complexes. An origin-destination matrix can also be determined to represent the graph, and this matrix can reflect the prevailing structure of linkages and dominance.

The fourth method is the application of operations research. Operations research is often used in modelling the maximization or minimization of the effects of certain human decisions. A specific method in operations research is network analysis. In general, network analysis deals with the analysis of transport of persons, means or data, mostly related to shortest path analyses or measurable distance analyses, such as zoning, allocation and accessibility. Network analysis can be applied in combination with GIS to reveal spatial activity patterns. Ritsema van Eck (1993) has studied the usefulness of GIS techniques for network analysis in relation to socio-spatial analyses and the technical and practical aspects of the application of network analysis within GIS. He focuses especially on network analysis for transport purposes, applying shortest routes algorithms. These shortest routes algorithms seem inappropriate for tourist behaviour analysis, as the main objective of the tourist does not always seem to be to use the shortest route in distance or in the smallest time-frame possible or to visit as many amenities as possible during a day.

From the first and second methods, the data pattern exploration is selected. The third method provides the abstraction of the tourist recreation complex to graph structures. From the fourth method, the network analysis can be derived. These three elements, exploration, network analysis and graph application, can be combined to form a new data processing approach.

The processing of geographical data consists of querying, transforming and combining the data to obtain a description of the data, determine possible relationships, find explanations for these relationships and to model and evaluate current and future situations. As stated previously, current GIS represent a static view of physical space (or spatial structure) using spatial elements and their mutual relationships, a snapshot of the landscape (Peuquet, 1994). This static characteristic makes it possible to query and analyse the data easily. The dynamic aspects, such as time, the (vague or changing) boundaries of elements, or interaction through processes and organisations, cannot be directly processed within GIS. It is possible to more or less approximate these dynamics by creating several (static) layers, each representing a specific dynamic phase; *e.g.* by making a layer for each year, month or day from a specific area and then comparing these, differences over time can be represented.

For data in current GIS, the geometry of the physical space is only referred to. A reason for this limitation is that GIS has developed from cartography and therefore uses the two-dimensional reference (*e.g.* Nunes, 1991; Wood, 1994). The potentials for GIS analysis have not yet been sufficiently explored, nor have the linkages with other models been much applied (Maguire, 1991; Scholten and Openshaw, 1991; Peuquet, 1994; Burrough and Frank, 1995). Also, the linkages between GIS and external models (*e.g.* statistical packages) have not been adequately integrated. Data still have to be transferred from GIS to an external model or vice versa through interface programmes (*e.g.* Bailey, 1992; Bulens *et al.*, 1995; Van Deursen, 1995).

Presentation

Presentation of the data consist often of fine map visualizations, which scarcely correspond to the real world. These can conceal many mistakes and assumptions about the real world (Wood, 1994). Maps form the basis of GIS with its strong geometric link. Maps are used as the starting point (to collect data), as intermediate product (to store and process data) and as a presentation of the conclusions (Kraak, 1993). The 'cultural' context in which and from which objects are viewed is still not taken into account (Nunes, 1991; Mark *et al.*, 1995). Lefebvre (1991, pp. 85) raises the question of how many maps might be needed to deal exhaustively with a given space, to code and decode all its meanings and contents. We might be confronted with a sort of instant infinity. It is not only the codes (the map's legend, the conventional signs of map-making and map-reading) that are liable to change, but also the objects represented, the lens (context) through which they are viewed, and the scale used.

New opportunities for presentation arise in addition to the traditional (cartographic) map and other graphic presentations. Multi-media presentation can be seen as such a prospect, in which sounds of an area can be presented together with the map, or video presentations, in combination with interactive opportunities to provide tailor-made presentations. Within an area presented, newly modelled situations can be integrated to form an idea of the effects that proposed plans will have. Through these developments, the presentation aspect becomes more and more part of the processing phase. It becomes difficult to distinguish the end product from the analysis material. The end of the project is no longer only a traditional presentation of results. Throughout the processing phase, presentation might raise new discussion points, views and insights because of the way results can be shown.

Concluding remarks

In the tourist recreation complex construction, system elements and function have to be derived from landscape elements. These elements can be fixed and dynamic. They both have to be referenced within the GIS in conjunction with each other. Exploratory spatial data analysis offers an opportunity to analyse data in a dynamic way in order to discover patterns. Graph theory and network analysis might be helpful for processing data relating to tourist time-space behaviour. The current presentation of GIS analysis results consists mainly of static maps. These maps also offer new analysis material, thus moving the presentation phase up to form a part of the analysis phase. With interactive, or even multi-media map presentations, the boundary between these phases is even less obvious and offers new prospects for analysis.

3.2.2 GIS and Tourist Time-Space Behaviour

After first conceptualizing a geographical approach to the tourist recreation complex using GIS, this section will deal with tourist time-space behaviour as the observed expression of the tourist recreation complex. The three steps distinguished -collection, processing, and presentation- will again be used to elucidate how the observed behaviour might be transposed into GIS.

Collection: Input and Storage

Data are collected and stored within their own data structure depending on how and what part of the tourist time-space behaviour is analysed. Using

Table 1 Supply, demand and geographical elements, cf. Harvey (1989) and Dietvorst (1994b)

COMPONENT		SIGHT (point)	ROUTE (line)	REGION (area)
Supply side (landscape, producer)	material, physical space	attraction, sight, place	castle route, scenic route	hilly landscape, polder landscape
	coding	'romantic holiday'	'medieval living'	'struggle against the water'
Demand side (tourist)	perception / [illegible]	nostalgia	gazing, variety seeking	authentic experiences
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Harvey's ideas (1989) about space (material, perception and imagination) and Dietvorst's interpretation of these ideas (1994b) in developing a model for rural tourism, the transformation model and the tourist recreation complex concept can be distinguished over different geographical objects (see Table 1). The two components of tourism, supply (landscape and producer) and demand (actor), are strongly interwoven, and influence each other. Both components have their own constraints and each is affected by external constraints such as weather, road works or a (small) disaster. The supply side of a region is represented by the physical space (elements). These elements are extended by coding, some of them constructed by producers, others may be predetermined through culture. The demand side is represented by the time-space behaviour of the tourist, the way the visitor connects the different attractions with each other. For example, the interpretation of information and markers indirectly influences the behaviour of tourists.

The approximation of a tourist recreation complex introduced here can be transformed into a data model consisting of four main data groups to store the data related to tourist time-space behaviour. This data model is presented in Figure 6. For each data group external influences and changes determine the variables that might be part of such a group and the characteristics of these variables. In addition to these separate data groups, a specific independent classification of attributes can be made in order to cluster data on a higher, more abstract level, *e.g.* to cluster tourists according to their basic holiday motives (the Cohen modes) to cluster elements in the landscape to form a new (temporary) tourist product or tourist opportunity structure, or to create a specific regional coding.

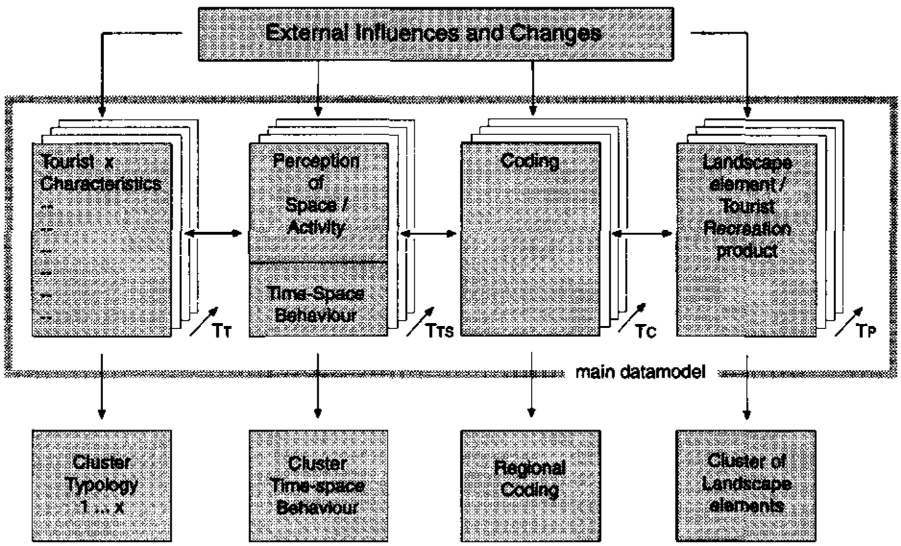


Figure 6 The data model for the main data groups that can be distinguished in a tourist recreation complex

The data groups also correspond with the components distinguished in Table 1. The supply side includes the data groups for landscape objects, tourist products and coding added. The demand side incorporates the data groups for the tourist, perception and time-space behaviour. The data group with the tourist characteristics consists of person-related data, such as age, social background, indication of accommodation, preferences, motivations, information used. The time-space behaviour, in the second data group of Figure 6, describes the relationships constructed between the elements, and consists of the movements, visits, time and budget spending as a result of appreciation (perception) of activities and space. Different aspects were distinguished (see § 2.4.3): substantial (sort of activity and means of transport), spatial (location, routes followed, size of area visited), social (with whom, individual or group), and temporal (when, how often, life phase of a product, speed at which an area is discovered). For the tourist recreation product (TR product) and the landscape elements, it is essential to know the spatial location, the context and coding added to the different elements.

Each data group (in Figure 6) has its own time scale (T_T, T_{TS}, T_C and T_P), in which significant developments take place. A tourist stays for a short time in an area, *e.g.* a week in which the own time-space behaviour is created (T_{TS}). The characteristics of the tourist also change (T_T), but most of them will not change during that holiday week. The life cycle of a tourist product or landscape element is normally not dependent on that week long visit of the tourist; it has to last for at least a few years (T_P). The coding added to the product can change more quickly if a producer thinks it is necessary (T_C).

The geometric and thematic data related to tourist characteristics, landscape elements, and tourist products can be gathered and stored in GIS data tables relatively easily (as point, line and area data), although it will still be a comprehensive task. For instance, the only way to currently collect and store data in GIS about tourist routes followed is to type in the route related data or digitize selected routes followed, if any correct information at all on the routes followed is available. The possibilities of Global Positioning Systems (GPS) are, at the moment, subject of research. The use of GPS might solve the problem of how to obtain a correct digital reproduction of the route followed; during travel, the data are digitally collected and stored through an automated procedure. The linkage to the digital road-network and tourist related data will be the next step.

Processing

The tourist related data can be stored in data tables for point, line and area components, and can be queried, transformed and combined separately, based on the data model. Through links between the data tables, it is possible to approach and process the data tables simultaneously. It is possible to query and display a specific location, *e.g*, who was there, which (known) journeys were made, what sort of time-table was used, what sort of locations were visited, how are these locations promoted, what are the relationships to other objects of the landscape or objects of the tourist products. Tourist time-space behaviour, viewed as interwoven point, line and area components, cannot be processed within most of the current (commercially) available GIS-software as one unity (see also Peuquet, 1994). Another disadvantage of current GIS is that only the geometric aspects can be dealt with; time and context domains must be transformed into specific structures and can then be partially analysed. For instance, to analyse time spent in a region, different 'snapshots' of the activities must be made over specific time units. These 'time-slices' can then be processed. The relationships between the different 'time-slices' are not directly available and a new slice must be generated by zooming between two 'time-slices'. Attention should also be payed to the context, meaning of activities and appreciation of the landscape, *e.g.* as elements of the time-space behaviour of a tourist. If data on time-space behaviour is to be modelled in GIS, the context elements must also be taken into account. Different layers of data and information within GIS might be useful for storing this data. These layers can represent the different meanings and values, but it must be possible to query these simultaneously with the related time and geometry data.

The approach of object-orientation, described by various others including Yeh and Viémont (1992) and Molenaar (1993), might provide a key to analysing time-space behaviour as a unity. They argue that the description of space is based on many objects and the relationships between them. Each object should contain data about knowledge of occurrence, topology, description, connectivity, edit-possibilities, symbolic values, time link and meaning, rules about priority, how interactions take place with other objects, location, which presentation requirements are important, when decay starts and the object no longer exists. With current GIS it is not yet possible to process such a huge amount of data and discover relationships. Nor is the hardware needed to process this huge amount of data available yet.

Presentation

Maps, graphics and tables are mainly used to present results of time-space research. The spatial representation of behaviour of different individuals or clusters of persons is still very limited. The path followed by one person can be illustrated using a so-called Hägerstrand scheme. Figure 7 offers an example of such a scheme.

It is very difficult to present activities and movements of several individuals using this scheme, especially when the individuals do not follow the same

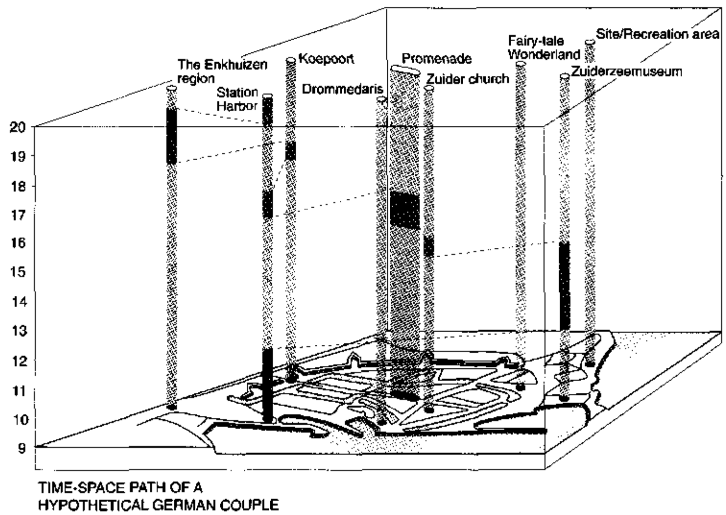


Figure 7 Example of a Hägerstrand scheme (Dietvorst, 1995b)

paths. However, it would be possible to illustrate an average for groups. Miller (1991) also uses the Hägerstrand scheme in a GIS-application, to describe the time-space behaviour of only one person. Where GIS is used to process and present spatial behaviour of an extensive group of tourists or a region, the amount of data involved will be enormous. Aggregation of persons, activities and behaviour should then be considered, to generate more specific conclusions. A different presentation form has to be applied.

A presentation technique which displays many data simultaneously might be found in the application of an intensity measure. An example would be the frequency of usage of a road network for different periods using different colours and/or line-sizes. An example of intensity of road-use is presented in Figure 8. Furthermore, the activities or tourist characteristics can be displayed in conjunction with this network presentation in a related table or diagram. A fine illustration of such a diagram is given by Jansen *et al.* (1996), see Figure 9. The main pattern in sequences of facilities visited is presented, not related to time. In the displayed diagram the starting point for 31% of the total amount of visitors of the Park is the Kröller Müller Museum. A small group leaves the Park after visiting this Museum, while the rest go to other facilities, mainly up to two or three consecutively before leaving.

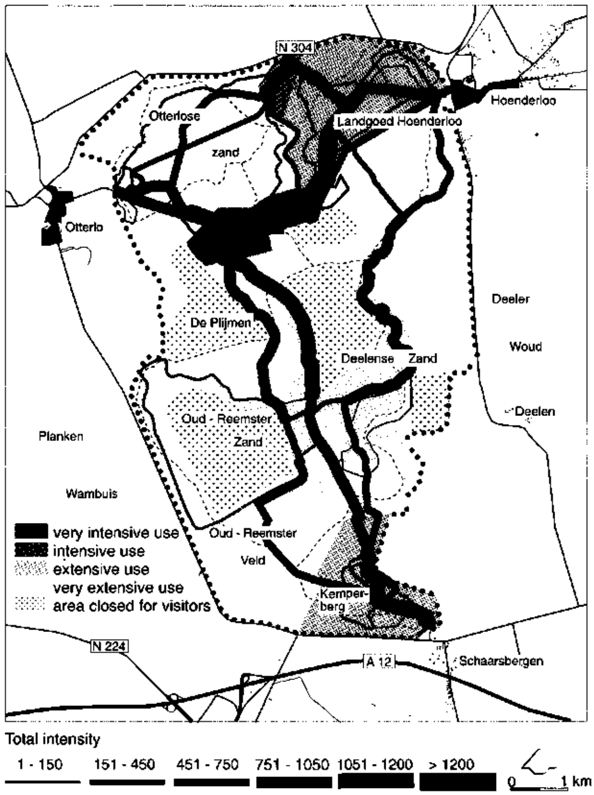


Figure 8 Example of a presentation of intensity of road-use in the 'Nationaal Park de Hoge Veluwe' (Jansen et al., 1996)

Presentations such as Figure 8 deal only with the spatial aspect of time-space behaviour, and not with time or context aspects. In Figure 9, there is no direct visual spatial aspect, only the sequence of activities can be derived. Examples of time or time-space related presentations can be found by Huigen (1986), Deurloo *et al.* (1991), and Jurgens (1992). Deurloo *et al.* and Jurgens offer examples in which the display of the distance covered is the main objective, see Figure 10 and Figure 11. Figure 10 displays the area that is covered when two different Euclidean distances are applied from a central point, the Opera in Amsterdam. In Figure 11, the distance covered from a central line (the highway) along existing roads is presented. This offers a more valid impression of which pre-defined points can be reached. In both figures, distance covered is used as a measure to display spatial accessibility.

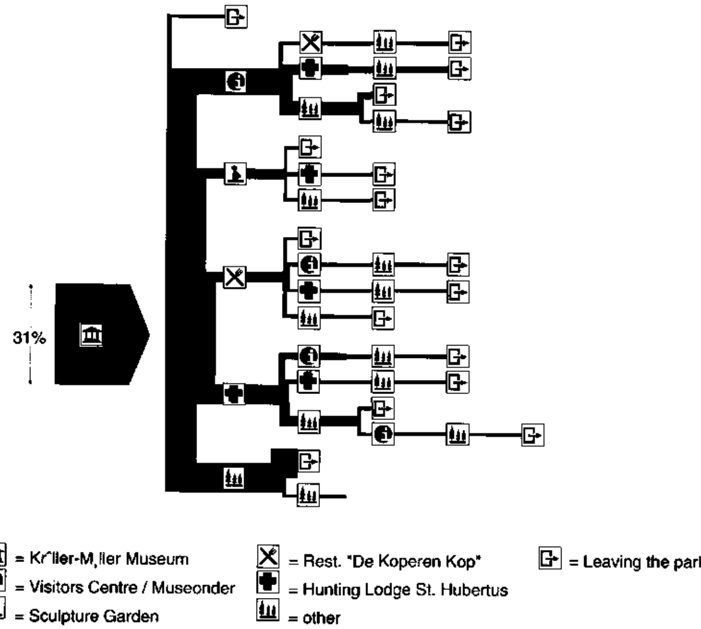
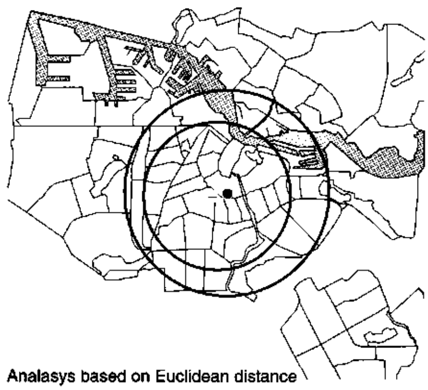


Figure 9 Example of a diagram presenting the sequence of facilities visited in the 'Nationaal Park de Hoge Veluwe' in the high season period (Jansen et al., 1996)

Time spent is also an aspect for display. Huigen (1986), and others, offers a diagram presentation of the percentages of time spent for several activities. Location is not important in this presentation (see Figure 12). Different activities can be undertaken simultaneously, as long as they are at the same location. Another presentation of a discriminating measure is given in Figure 13, in which the possible distance covered is presented, based on the spatial features that influence transport possibilities.

All these presentations give a specific view of time-space behaviour data and are derived from the data set by making selections. The results of a selection cannot be directly displayed. At the moment, different steps have to be followed to construct these maps and diagrams. To integrate and fully apply these presentations in the processing (or analysis) phase also, adaptions and changes have to be made. Furthermore, these presentations only provide a static 'snapshot' of a specific selection, no dynamics are involved.



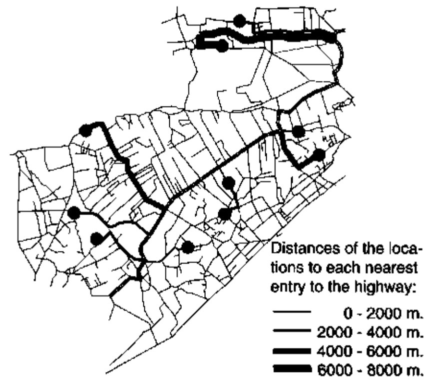
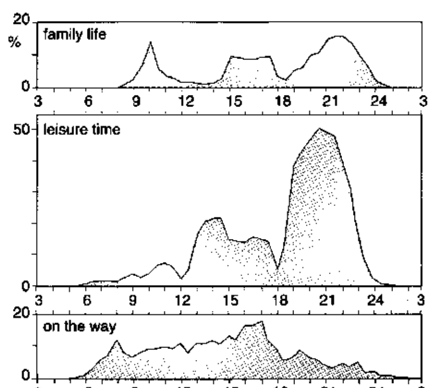


Figure 10 *Analysis based on Euclidean distance (Deurloo et al., 1991)*

Figure 11 *Reachable distance from highway (Jurgens, 1992)*



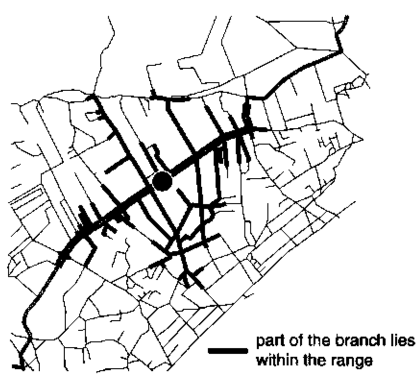


Figure 12 *Time spent on main activities during a day (Huigen, 1986)*

Figure 13 *Reachable locations within a specific range (Jurgens, 1992)*

Concluding remarks

The data model describing the contributing elements in a tourist recreation complex can be divided over four main data groups. Each data group has its own (absolute) time scale. The differences in meaning and time scales makes it difficult to implement and process all the related data together in a current GIS. It is impossible to incorporate the dynamics of time-related data in current GIS. New approaches, such as object oriented data structures, might offer better possibilities. Because these structures are not yet fully available in GIS, this approach is not further explored. Presentation of time-space behaviour data has until now mainly been restricted to data on the behaviour of one person to describe spatial use over time. To present data for a group of tourists, other techniques are useful, such as intensity maps or diagrams with sequences of facilities visited. The problem with all these presentations is that they are static and cannot be easily integrated in the analysis process, because of the time-consuming alterations and constructions of the presentations necessary.

3.3 Network Approaches in Current GIS

In Section 2.5, the interwoven network concept was introduced to analyse a tourist recreation complex. When applying this concept, it is necessary to examine the network analysis capabilities of current GIS. The collection of network data, and the processing and presentation potentials will be discussed generally. Special attention will be given to the possibilities of Arc/Info 7.0 and the related ArcView 2.0 software of ESRI, as ESRI is one of the current leading commercial GIS software producers.

Network Input and Storage

Different network types can be distinguished in the interwoven network concept, each with its own data model and data structure. For instance, the physical network consists of separate roads or road sections. The geometric data for each road have to be digitally stored as a line with a start and end node. A route can be constructed by selecting the contributing roads, and this information can be stored separately. In Arc/Info, the roads are stored as a line coverage, while the route information is stored in a separate route table, related to the line coverage. For each route, a special table is constructed in which each road segment followed is stored. This way of storing routes can be applied to store tourist time-space behaviour movements. Related information can be stored in separate tables.

If the network is composed of landscape elements, these have to be abstracted to point objects represented by nodes and put into the system as nodes; the links between the objects are the lines. The whole network construction can be stored the same way as a road network is stored. The same procedure can be applied if non-geographically located features are to be stored as network elements. An example is a non-geographical network diagram that connects time related elements with the (covered or Euclidean) distance from the accommodation. This specific type of network diagram will be elaborated later.

Network Processing

Current GIS can process networks to analyse shortest routes between several locations or to determine an optimal tour between locations to be visited. This processing focuses on minimising the shortest distances between locations and is useful if only economic considerations are important. Different publications deal with this shortest route analysis, see, *e.g.*, Haggett (1976), Selkirk (1982), Jurgens (1992), and Ritsema van Eck (1994). However, shortest route analysis does not seem to be suitable for characterizing networks as components within a tourist recreation complex; taking the shortest route between locations is not necessarily supposed to be the main objective of a tourist. All the networks, which can be distinguished as parts of the tourist recreation complex, must be characterized in such a way that it is possible to compare and evaluate different network shapes and network influences. In the literature, there are network describers available, see, *e.g.* Kansky (1963), Garrison and Marble (1965), Haggett *et al.* (1997), Selkirk (1982), Allen *et al.* (1993), Pooler (1995). These network describers will be discussed in more detail in Chapter 4.

The hierarchical network approach, proposed by Car and Frank (1994), diminishes the size of large, extended networks to more manageable proportions. The scale effects, including those which are a result of the growing awareness space, can be incorporated following a hierarchical division of the tourist recreation complex. It may be possible to apply network describers to characterize the contributing networks and to compare these, sometimes fragmented, network structures (van Langevelde *et al.*, in prep.).

data in an urban network. He suggests that data that vary over time can be displayed in several ways: animation, small multiples, and using a 'slide show' effect. Animation allows the analyst to see a series of slides in rapid succession. The data can be displayed using temporal variables such as duration, rate of change, order and phase (MacEachren, 1994). For instance, if the amount of information is large and changes occur frequently, it may be difficult to see the patterns unless the animation is slowed down to make patterns more visible. Tufte (1990) suggests that small multiples, or the simultaneous display of a range of small frames, often make the best visual representation, as this allows the analyst to compare frames rapidly. The disadvantage for computer cartography is, that this takes up screen space. Ganter (1994) uses the 'slide show' option in his analysis of urban traffic networks. Slides are created, which are actually time slices. These are aggregates of the number of vehicles passing a control point during a certain period. The analyst can control the pace of the slide show and move backwards and forwards in time to refresh short term memory, and pick out features to observe over subsequent frames. One of the drawbacks of his system, at the moment, is that it takes too much time to compose the different slides instantaneously.

Dynamic presentation of and alterations in network elements (*i.e.* the nodes and links) offer the user a framework for analysing the time-space related data set. The networks can be statically displayed within Arc/Info 7.0 and ArcView 2.0. The software presents a 'snapshot' of a situation. With modifications, it is even possible to generate a 'slide show' of selected frames of time slices. However, fast dynamic presentation depends on the computer system used and the organisation of the related data tables.

3.4 An Analysis Methodology

In the previous sections of this chapter, several possible uses of current GIS for the analysis of tourist recreation complexes were described. This complex notion was approximated by the construction of an interwoven network structure (see Figure 4), in which time, space and context were regarded as important domains. The transformation model (Figure 1) was turned into a data model, in which tourism related activities were distinguished as geographical objects (Table 1). The related data were divided among four groups of characteristics (Figure 6). In order to analyse the data, current GIS were examined on the basis of their capabilities for dealing with the described tourist recreation complex approach. These capabilities were not sufficient for dealing with the three domains of time, space and context in combination. A new methodology has to be derived.

Two phases can be distinguished to transform the scheme presented in Table 1, and Figure 4 and Figure 6 into an analysis methodology for a better understanding of the construction of individual and regional tourist networks, and thus the corresponding complexes. These two phases can be related to the GIS steps outlined in Section 2.6.2. The first phase involves the construction of the data model and includes the data collection (data input and storage). The second phase concerns the processing model. The GIS presentation step is incorporated into the processing phase. Screen-displayed or printed analysis results can also be presented graphically, especially when the outcomes are the result of GIS (-related) analyses. These results offer the opportunity to communicate accomplishments, without needing to pay any extra attention to presentation enhancements. However, developments such as animation and multi media, stress the presentation aspect substantially, which puts an extra burden on the user interface of a GIS(-related) tool.

The collection phase consists of setting up a data model and gathering the basic data on the spatial elements and their structure. The processing phase can be associated with the interpretation of the data. Peuquet (1994) identifies four modes of inquiry (exploration, explanation, prediction and planning) that can be helpful consecutive steps in the processing phase. In the first mode only the stored observational data are necessary. To describe and examine the causes of occurrences and their effects in the next three modes, storage of derived information (or higher level knowledge) regarding phenomenal relationships is also needed. In the analysis of the tourist recreation complex this necessary information can be derived from the different networks that can be distinguished.

The two phases for the proposed methodology can be further detailed. In the collection phase a distinction can be made between a data model and a data structure for both the supply and the demand sides. With the processing phase Peuquet's four modes of inquiry can be applied.

Collection:

- The supply side: create the geographical layer of information about the physical space at the appropriate level, *e.g.* a road network, location of accommodation and attractions, landscape describers (*e.g.* height, land use, water structure), predefined tourist routes, bicycle paths, etc. Add the coding constructed by the producers as tabular data for separate and clustered elements.
- The demand side: add the individual tourist routes, together with individual characteristics, constraints, interpretations and appreciations.

Processing:

- Exploration: gain overview of possible networks and sequences created by tourists in the physical environment, using exploratory spatial data analysis techniques and principal component analysis.
- Explanation: deduce, describe and analyse tourist recreation complexes using graph and network analysis techniques, and statistics. Determine clusters and networks of tourist product elements and a typology of tourist groups. The individual network is based on product (-clusters) and time-space behaviour in relation to the use of the environment and the tourist's perception of it. Execute pattern analysis with graph techniques and accessibility studies for the links and nodes in the network.
- Prediction and Planning: discover potential shifts in use and weaknesses in a region and the tourist products by monitoring behaviour and changes in regional networks.

The two phases of collection and processing are further elucidated below. The first two steps of the processing phase, exploration and part of the explanation mode, will be further elaborated in separate chapters of this thesis because of their complexity. The explanation mode will be restricted to graph and network analysis techniques to support the analysis of tourist recreation complexes. The analysis itself will be dealt with in a separate PhD thesis by Elands. As prediction and planning mode is also outside the scope of this thesis, this subject will be briefly mentioned and not further elaborated. The results of the analysis of the explanation mode are the basis for the prediction and planning process. Prediction of tourist behaviour in relation to the landscape and combined with a simultaneous attempt to alter tourist behaviour, offers a steering mechanism to guide developments in a desired direction and prevent possible conflicts between different land uses and tourist groups. Behaviour of persons in time and space is modelled in different ways in order to cope with the prediction process. Examples can be found in Huigen (1986), Golledge *et al.* (1994), Kwan (1995), Geertman and Ritsema van Eck (1995), Stemerding (1996), and many others.

Collection

The data collection phase is fairly straightforward. The different spatial landscape elements have to be digitized in geographical layers as point, line and area objects. The objects in each layer must contain the geographical position and the thematic descriptions of the elements, including the coding constructed by the producers per element. Several basic geographical objects can be clustered into new layers with other features, *e.g.* specific roads are grouped into a predefined tourist route, landscape elements are joined as special tourist landscape typologies, or new (regional) coding is constructed based on the coding of separate objects.

The individual tourist data can be gathered through questionnaires. Based on the data model, individual characteristics have to be determined divided over three sections: personal information, a diary section and an evaluation of each activity and of the day as a whole. Each answer on the questionnaire must be coded and stored in the computer. Furthermore, each individual is asked to sketch on a map the routes followed during a trip, what type of information source was used to make a decision, and how the trip was evaluated. These sketched routes also have to be processed. In Chapter 6, more attention will be paid to how the data input and storage phase is applied for two case studies.

Processing

The first step in the data processing focuses on the exploration of possible relations between the spatial pattern, different tourist characteristics and their time-space behaviour. One of the methods of revealing likely relationships is to 'let the data speak for themselves' (Gould, 1981 in: Peuquet, 1994) in the absence of preconceived notions. One way of achieving this is to apply dynamic visual means, animation and vary the values of characteristics related to links, tourists and activities. This method helps the researcher to organize thoughts and ideas and it stimulates the researcher to gain new insights and generate new ideas about the data and their relationships. Furthermore, it offers the analyst opportunities to identify mistakes made during data input, or strongly deviant data. Hypotheses on tourist behaviour and their interaction with the environment have to be constructed in order to analyse how tourists use the region. The animation of time-space behaviour data in combination with tourist characteristics will also give an impression of possible tourist recreation complexes. Scientific visualization techniques and dynamic cartography must be incorporated to support the exploration process, see, *e.g.* MacEachren and Taylor (1994) or Hearnshaw and Unwin (1994).

In the second step of the data processing, the assumptions formulated can be further described by applying graph techniques and network constructions. The results must be verified by statistics and geographically oriented tools. Network analysis can be applied after the networks have been created. These networks have to be determined and analysed in combination with landscape and tourist components. Graph describers and indices are suitable for describing networks and discovering a possible pattern. The use of space and the interaction between landscape elements and tourist behaviour can be examined by applying accessibility studies. These studies are an instrument for analysing the tourist's time-space prism at a certain moment in relation to the actual performed time-space behaviour: What could the tourist have done? What could the tourist be doing at the moment? What could the tourist be about to do?

Following the description of individual-related data, the clustering of individual data may form a second stage in the explanation phase. Principal component analysis can be used to divide the total data set into different groups, such as life-style groups or Cohen modes, based on tourist characteristics. Routes followed can be clustered based on, for example, roads chosen, interaction with the environment, or the quality of routes drawn on a map. The life-style groups and their matching time-space behaviour are then analysed spatially to determine their corresponding tourist recreation complexes and derive the regional tourist opportunity structures.

The place and person accessibility approaches (described in Section 3.3) are all strongly connected to the physical spatial structure. The spatial place accessibility can be analysed in two ways:

1) In terms of the locations of accommodation, attractions and sights as nodes projected on the road structure in relation to the different outlined routes. There are several ways in which GIS can deal with absolute and relative distances, such as buffer commands and shortest-route algorithms. This is a very straightforward analysis that can easily be made within various GIS that have route analysis capabilities, *e.g.* Arc/Info,

Genamap, and TransCad.

2) By considering the physical limitations of the landscape (surroundings, opportunities and area). Donnay and Ledent (1995) have developed a system for this type of accessibility study, using the raster data structure of Arc/Info. Not only is the accessibility of a road network computed per node, but also from any raster cell in the surrounding area according to its shortest weighted distance to the road network. Other forms of measurements can be applied as well as the metric distance. Geertman and Ritsema van Eck (1995) also described a method for the physical accessibility. They developed a potential accessibility module within the Genamap raster system. Both models might be suitable for examining the interaction between the landscape elements (including markers) and the tourist.


Bertje, old boy, you look so depressed....
don't worry, we'll help you get over it.
this is the most prettiest route in the whole area
did you see the little pigs, Bertje?
and the cows grazing peacefully
grrrr
at this time of the year the forest is breathtakingly beautiful
shall we stop so we can listen to the birds singing?
oh look, Bertje, isn't it just like a castle out of a fairy tale? hmm?
so, how are you doing now? you must be feeling much better, sureley?
think of all the beautiful spots we've shown you
didn't you see all those hedgehogs run over at the side of the road?!...
oh, how sad .....

4 NETWORKS

As disciplines engage with a connectionist approach, they also begin to discover the redundancy of their own disciplinary separation (Plant, 1996).

4.1 Introduction

In the theoretical framework described in Chapter 2, the tourist recreation complex was conceptualised as a system consisting of product elements and relationships or function between these different product elements. The relationships and elements were also described as links and nodes. The node s are the locations at which the visitor engages in an activity, perceives an inc entive, or makes a decision. The relationships between these nodes, links, are mainly established by tourist movements. These movements are guided by various aspects including the distance travelled, the qualities of the landscape, the tourist's perception of the environment and the activity, and information used; these qualifications can be assigned to the links. A network is created by linking the nodes.

Applying various approaches to the links and nodes, as described in Secti on 2.5, different networks can be created that make up the individual tourist complex (see Figure 4). At the individual tourist level, connectedness is apparent since the tourist always makes the connections, almost always returns to the same accommodation and can only create connected paths. At a regional level, tourism connectivity refers to the qualities of the amenities and the opportunities offered to the tourists. In order to analyse and enhance coherence in the regional opportunities, it is essential to combine the individual paths to form a regional tourist complex pattern. The various individual tourist complexes will not have to be connected when examined at a regional level. Non-connected regional networks are referred to as fragmentation in the regional opportunity structure.

Details of the (conceptual) data model and some parts of the data structure for estimating a tourist recreation complex were already outlined in the previous chapter. Furthermore, network analysis techniques were mentioned as processing opportunities to determine and describe the possible relationships. If network analysis is applied in the processing of the data, this will partly determine the data structure and data implementation. Therefore, it is necessary to examine more closely how networks might be applied and how they can be characterized. In this chapter, a short introduction on network analysis and connectivity is presented in Section 4.2, followed by an overview of three types of connectivity parameters for characterizing networks (§ 4.3). An evaluation of several features of the network parameters is made in Section 4.4. A discussion of the application of the parameters distinguished for analysing tourist time-space behaviour is offered in Section 4.5. Chapter 6 provides a more detailed description of the construction and determination of individual and regional networks, as a basis for their related complexes.

4.2 Network Analysis and Connectivity

In geographical research, several parameters are used to characterize connected networks (*e.g.* Taaffe and Gauthier, 1973; Lowe and Moryadas, 1975; Haggett *et al.*, 1977; Tinkler, 1977; Selkirk, 1982; Geertman and Ritsema van Eck, 1995). These studies explore the usefulness of network parameters based on the concepts of mathematical graph theory. In the last d ecades, these parameters have been applied to investigate the pattern of networks, and in particular, networks with a transportation function. However, these studies have not paid much attention to the spatial configuration of network elements nor to the notion of fragmentation for non-connected networks. This lack of attention may be caused by a combination of the following reasons:

- Some techniques are directly adopted from mathematics. Interpretation of the results of these techniques is not unambiguous. A lack of knowledge about the meaning and the properties of the network parameters exists.
- Combination of the results of network analysis with data from network function has had little attention, especially the relationships between geographical elements as locations for social events concerning the spatial configuration of the network elements. Spatial configuration refers to distance, extent, shape and juxtaposition of the network and its elements.
- Analyses are only focused on connected networks; mainly transportation networks from an economic perspective.

- Analysing large networks evokes practical problems due to their size and complexity, such as limited possibilities for storing, calculation and data presentation.

Three types of parameters for connectivity analysis for spatial planning will be evaluated: elementary parameters, matrix-based parameters and morphologic parameters. The parameter(s) to be applied should characterize the quality of networks in terms of the degree of connectivity of the whole network and of its elements. The parameter(s) must result in hypotheses concerning the relationships between pattern, function and change of networks. The rise of GIS is broadening the potential applications of network analysis, especially for large and complex networks. Three questions concerning the exploration of tourist complexes can be addressed:

(1) Which parameters characterize the connectivity of networks quantitatively; can they deal with spatial configuration, fragmentation and alteration of networks?
(2) What are the properties and meaning of the parameters from a tourism perspective?
(3) How can the network analysis be applied as a basis for spatial planning of tourist complexes dealing with spatial configuration and fragmentation?

The three types of parameters were enumerated using literature on network analysis using a topological or geometric approach. They are expanded with approaches for refined geometric matrix-based parameters and morphologic parameters. Van Langevelde *et al.* (in prep.) focus in detail on the correction of the matrix-based parameters, which provide opportunities to analyse connectivity concerning the spatial configuration of network elements and the fragmentation of networks. In this thesis, the parameter types are evaluated in the context of the application for tourism analysis.

4.3 Connectivity Parameters

4.3.1 Setting

For the quantitative assessment of connectivity, the graph theory is applied as a framework to analyse a set of spatial and functional relationships between geographical elements. Bertin (1983) states that in a network 'one can plot the figures on a plane which has no meaning, and then look for the arrangement which produces the minimum number of intersections, or the simplest figure'. This provides the most efficient representation for visual interpretation. All the

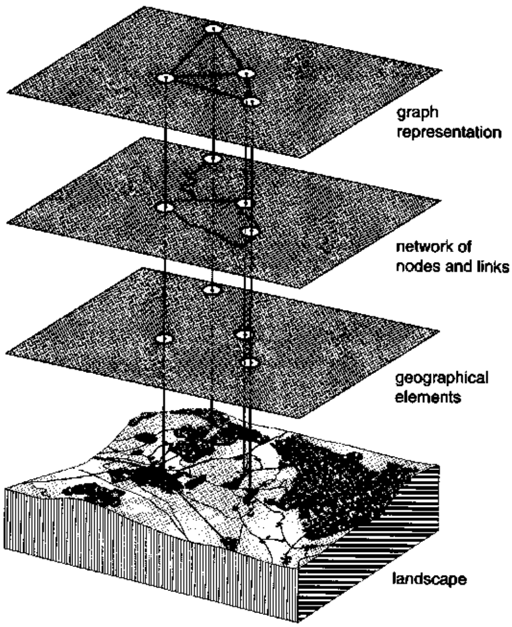


Figure 14 *Generation of a network from landscape and the abstraction to a graph (cf. Elands, 1995)*

different networks that can be distinguished in a tourist recreation complex, both at individual and regional scale, are established through linking of activities and using information. A network might be depicted as a specific pattern in a landscape that can be strictly defined, but which still remains its geometric relationships to this landscape. The network can be abstracted to a graph, which describes the observed system isolated from the background matrix. This is illustrated in Figure 14.

A graph $G(V,E)$ is defined by a finite set of vertices $(V(G) = (v_1, v_2, ..., v_n))$ and a finite set of edges $(E(G) = (e_1, e_2, ..., e_m))$. Basic notions of graph theory are widely available in the literature (*e.g.* Ore, 1963; Harary, 1969; Wilson, 1972; Christofides, 1975; Tutte, 1984; Dolan and Aldous, 1993). At the highest level of abstraction, an edge represents relationships of incidence between two vertices. This is referred to as the topological approach. The topological approach considers the cardinality (or length) of a path by the number of edges it has. The presence of the edges provides no information about spacing, meaning, or orientation of the set of vertices and edges, and does not correspond with the spatial configuration of the network.

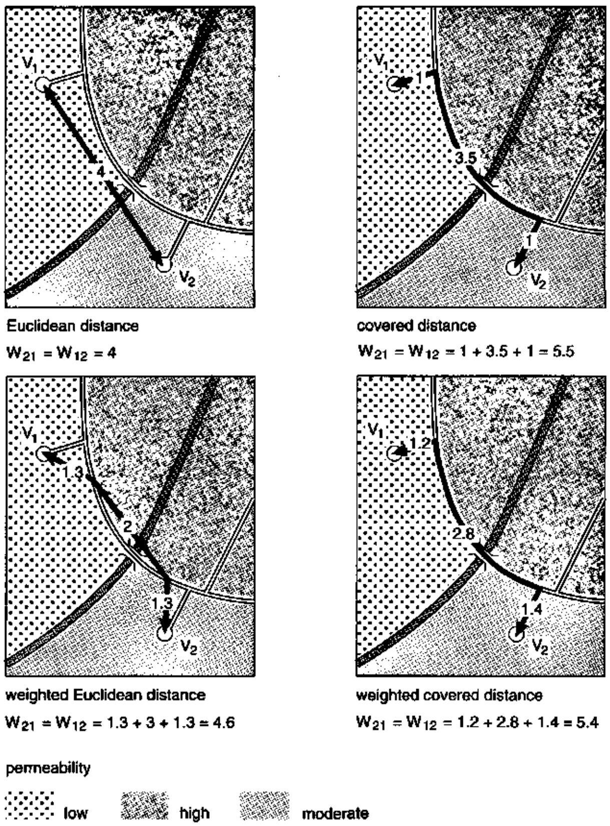


Figure 15 *Several distance definitions and ways of weighting network edges between pairs of vertices*

The geometric approach considers the length of a path, but differs within this approach in the definition of distance. It considers the spatial properties of networks. In many studies, it is necessary to use distance in terms of, *e.g.* the costs of movement, Euclidean distance or the time required to move between vertices. The length of edges between pairs of vertices v_i and v_j is numerically weighted with w_{ij}. The geometric approach distinguishes several ways of weighting edge length with w_{ij} (see Figure 15): Euclidean distance between vertices, covered distance by flows between vertices, and either Euclidean or covered distance weighted by the characteristics of the landscape. In tourist complexes, edges can be weighted in terms of experienced distance, attraction of different landscapes, scenery routes or attractions, sights and activities connected by the edges, and the information used. The weighted distance w_{ij} as permeability or conductance of the landscape, can be taken as an indicator of the relative difficulty or guidance for movements.

Three types of parameters to characterize networks and quantify connectivity are distinguished (Table 2). The first type consists of parameters based on ratios of the basic measurements of graphs for the complexity of the network as a whole. The second type deals with the relationships of network elements and the network as a whole based on numerical matrix methods. The third type is developed as a shape describer characterizing the morphology of the network and its elements. Two of the three types can be subdivided into parameters considering distance as defined either by the topological or the geometric approach.

Table 2 Parameters to characterize networks and to quantify connectivity

	Topological approach	Geometric approach
Elementary parameters		
Network	$G(V,E)$, $E(G)$, $V(G)$	w_{ij}
	α, β, γ, δ, μ	η, θ, ι, π
Matrix-based parameters		
Elements	C, A, D	P, S
Network	c^A, a^A, d^A	p^A, s^A
Morphologic parameters		
Configuration	shape and pattern describers	

4.3.2 Elementary Parameters

Parameters describing the whole network consider the degree of connectivity between all vertices and edges. $G(V,E)$, $E(G)$, $V(G)$ and w_{ij} are the basic measures for the parameters describing the structure of graphs (Kansky, 1963; Garrison and Marble, 1965; Taaffe and Gauthier, 1973; Haggett *et al.*, 1977; Selkirk, 1982). More information about how the elementary parameters are calculated can be found in Appendix 1. The simplest description of increasing network connectivity is the β-index: the ratio between the number of edges and vertices. The β-index differentiates simple topological structures (low β-value) from complicated structures (high β-value). The γ-index is the degree to which the network as a whole is connected. The connectivity of the network is evaluated by the γ-index in terms of the degree to which the network deviates from a non-connected graph and approximates a maximally connected one. Additional edges lead to increasing connectivity, and create a kind of circuitry. The number of independent circuits can be conceived as a measure of complexity. The cyclomatic number μ gives the observed number of independent circuits. The α-index is the degree to which circuits in a network are present. In the α-index, μ is related to the maximum number of circuits. The α-index characterizes the redundancy of connections in the network: the higher α, the greater the number of alternative paths. The extent of the graph in topological distance is the diameter δ of the graph. Large values of δ indicate extensive graphs. The indices α, β, γ, δ and μ are frequently used in geographical studies. One should bear in mind that these parameters are calculated differently, depending on whether they are used for planar or non-planar graphs.

Several geometric parameters exist, as discussed by Selkirk (1982). These parameters measure the spatial extent and mesh size of the network. The η-index considers the mean length of the edges. The θ-index measures the mean length of edges per vertex. The ι-index considers a weighting for each vertex to emphasize more central vertices. The π-index measures the network's branching. The η-, θ-, ι- and π-indices are valid for both planar and non-planar graphs. None of the elementary parameters are applicable for multi-graphs (with loops and multiple edges).

4.3.3 Matrix-based Parameters

The second group of network parameters considers the network elements and their position in the network. The graph representation of a given network is divergent due to different approaches of the network definition. Therefore, it is useful to store the information about the network in matrix form. Matrix algebra is used to define the various properties of graphs. An advantage of matrices is that they are able to contain both the topological and geometric structure of graphs. Moreover, in matrix analysis it is not necessary to distinguish between planar and non-planar graphs. The information about the graph and its elements can be abstracted to matrices. The relationships between vertices are recorded in the rows and columns of a square matrix of $n \times n$. Five types of matrices may be constructed to more fully understand the connectivity of elements in the graphs (*cf.* Taaffe and Gauthier, 1973; Christofides, 1975;

Haggett *et al.*, 1977; Tinkler, 1977): connectivity matrix *C*, accessibility matrix *A*, shortest path matrix *D*, weighted distance matrix *P* and shortest weighted path matrix *S*.

The connectivity matrix $C = (c_{ij})$ of a graph is defined as: $c_{ij} = 1$ if a direct connection from v_i to v_j exists in $G(V,E)$, and otherwise $c_{ij} = 0$. In the matrices discussed, the principal diagonal elements are zero: no loops or self-connections are distinguished. For non-directed graphs, the matrices are symmetric around the principal diagonal since all routes may be traced in either direction. For directed graphs (digraphs), the direction of the edges is defined. The rows of a matrix are identified as the set of origin vertices, and the columns as the set of destination vertices. The resulting matrix is non-symmetric. The connectivity matrix of non-directed graphs has the property that the sum of each row or column provides the degree vector $\underline{c} = (c_i)$ of a graph (Equation 1). Each row or column sum c_i is the degree of v_i corresponding to *C*. High values for c_i refer to the most connected vertices. In digraphs, the sum of each row results in a vector with the outdegree vector $\underline{c}^{out}$ and the sum of each column in the indegree vector $\underline{c}^{in}$ of the corresponding vertex v_i. The matrix-based parameters are elaborated for non-directed graphs. Further research should explore the character and the applications of the indegree and the outdegree.

$$c_i = \sum_{j=1}^{n} c_{ij} \tag{1}$$

The degree c_i is a simple measure and only quantifies adjacency. The degree of a vertex has limitations as a measure of connectivity. Indirect edges should also be taken into account. The connectivity matrix C can be used to measure the total accessibility of vertices. Therefore, accessibility is defined as the degree to which a vertex is directly and indirectly connected to the other vertices, *i.e.* a path exists between a pair of vertices that passes one or more intermediate edges. The number of direct and indirect connections between vertices can be measured by matrix multiplication.

The accessibility matrix $A = (a_{ij})$ is the sum of the connectivity matrix *C* and all matrices that enumerate indirect paths between vertices of the graph: $A = C + C^2 + C^3 + ... + C^\delta$, where δ is the diameter of the graph. The diagonal entries c^t_{ij} of C^t indicate the total number of paths of cardinality t_{ij} between v_i and v_j, and the off-diagonal entries indicate the total number of *t*-step routes between v_i and v_j. The vector $\underline{a}$ measures the total accessibility of vertices to the other vertices of the graph. High values of a_i correspond with a high degree of connectivity.

Matrix $D = (d_{ij})$ provides the shortest path distribution between vertices. For each t, matrix D_t results from producing matrix A. The power of each C^t-matrix is entered in the appropriate cell in matrix D : each cell d_{ij} in D^2 $(i \neq j)$ becomes 2 if $c^2_{ij} \neq 0$ in C^2 and $d_{ij} = 0$ in D^1. The elements in matrix D indicate the cardinality t_{ij} of the shortest paths between pairs of vertices. For connected networks, each vertex has one shortest path to each other vertex when $t = \delta$. In matrix D, the principal diagonal elements are zero. The vector $\underline{d}$ sums the cardinality of shortest paths connected to each vertex. The vertex v_i with the lowest d_i has the highest degree of connectivity. A derived measure is the associated number or König number: the maximum d_{ij} connected to v_i. Vertices with a low associated number have a high degree of connectivity. It is apparent that the largest associated number d_{ij} equals δ.

More refined measures are necessary when taking the geometric distance between vertices into account. The weighted distance w_{ij} is used to compute weighted-distance matrix P and shortest weighted path matrix S. The weighted-distance matrix $P = (p_{ij})$ of a graph is defined as: $p_{ij} = w_{ij}$ if a direct connection from v_i to v_j exists in G, and otherwise $p_{ij} = 0$. Matrix P is the geometric equivalent of matrix C : only direct edges count. The weighted length of direct edges of v_i provides a measure of the geometric proximity of neighbouring vertices v_j as a connectivity index. The vector $\underline{p}$ is not a simple summing of the rows or columns of P. The expectation is that low values p_i refer to v_i with a high degree of connectivity. However, if more than one edge is connected to v_i, p_i leads to misinterpretations. Therefore, it is stated that each p_i should be corrected for the number of connecting edges, *i.e.* the c_i (Van Langevelde *et al.*, in prep.). The corrected degree p'_i of v_i is computed by the ratio between the squared c_i and the p_i (Equation 2).

$$p'_i = \frac{p_i}{c_i^2} \qquad (2)$$

The lower the p'_i, the higher the connectivity of v_i. Figure 16 shows a comparison between different network patterns and an assessment of their connectivity based on matrices C and P. Several examples of correcting the p_i

are presented. It should be mentioned that comparisons between more complex network patterns are difficult to interpret in simple terms. In Figure 16

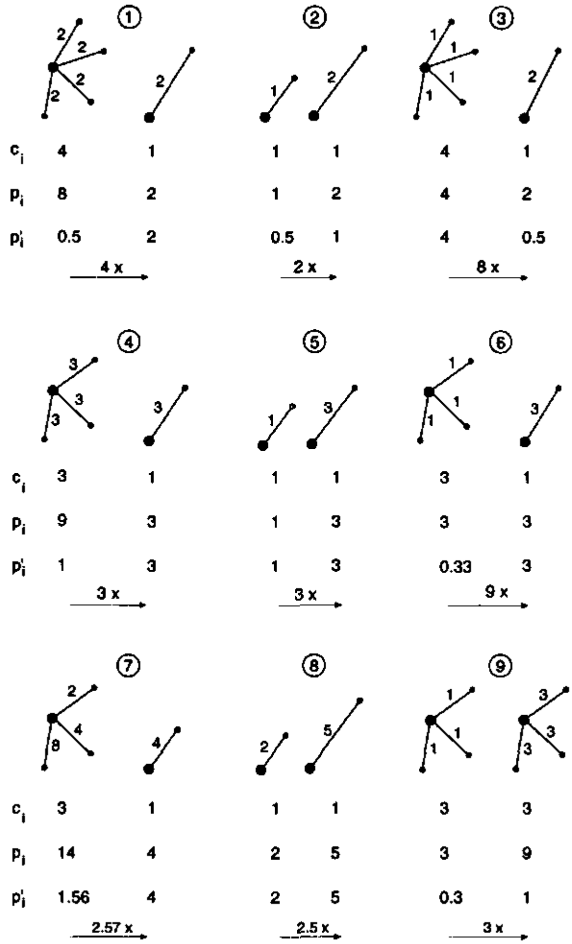


Figure 16 *Paired graph patterns illustrating the correction of degree p'_i*

the connectivity degree of the larger vertices is considered. It is assumed that a vertex connected to four edges of $w_{ij} = 2$ has a four times higher degree of connectivity than a vertex connected with one edge of $w_{ij} = 2$. The same reasoning applies for one vertex connected with one edge of $w_{ij} = 1$, which has a degree of connectivity that is twice that of a vertex connected with one edge of $w_{ij} = 2$.

Matrix *S* provides the shortest weighted paths between pairs of vertices.

Following the reasoning of shortest path matrix D, shortest weighted path matrix S can be determined based on P by following an adapted matrix-powering procedure. The calculation differs in two ways following matrix D (Taaffe and Gauthier, 1973; Tinkler, 1977). Instead of element-by-element multiplication of $(c_{ik} \times c_{kj})$, for matrix S a summation $(w_{ik} + w_{kj})$ is used. Secondly, instead of summing the results of the multiplication, the minimum value of the summation is determined and inserted in the appropriate cell of matrix S. The final level of calculation remains δ. Matrix S does not provide an exact approach but a heuristic approach for computing the shortest weighted paths. The assumption is that the shortest paths resulting from D approximate the routes for the shortest weighted paths of S. The elements of the vector $\underline{s}$ with the lowest sum of the shortest weighted paths represent vertices with a high degree of connectivity in the graph.

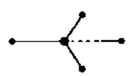
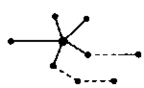
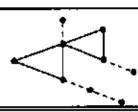
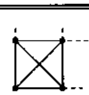
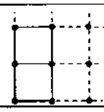
The c_i, a_i, d_i, p_i and s_i are indicators of how connected v_i is, and its overall influence in the network. The five matrices C, A, D, P and S measure three network characteristics:

1) the relative importance of elements in the network is determined by ranking the vector values of each matrix type to obtain a hierarchy considering dominant versus peripheral vertices;
2) the relative locational position of elements; the numerical vector values indicate spatial centrality versus isolation of v_i in the network configuration to determine the relative locational position of elements.
3) the degree of connectivity of the whole network; the sum of the vector corresponding to each matrix type provides an index of connectivity for the whole network. This sum is known as the dispersion of the network. It measures the total connectivity of all elements in the matrix.

An application of matrix algebra can be found in the space syntax approach. Space syntax is a technique that has been applied to analyse buildings, architectural plans, urban areas and urban plans (*e.g.* Hillier and Hanson, 1984; Hillier *et al.*, 1987). The aim is to describe different aspects of the relationships between the structure of man-made environments and social structure or events (Teklenburg *et al.*, 1993). For example, it can be used when considering the relationships between the structure of urban areas and movement patterns (of pedestrians). Space syntax in combination with graph theory can also be used for analysis of networks.

4.3.4 Morphologic Parameters

The morphologic approach in network analysis includes the recognition of network pattern types. A pattern type is a predefined graph or subgraph with a certain shape and number of vertices and edges. The shape of the network and the number and juxtaposition of the network elements determine the

pattern type nr	graph	specifications	
0		point	sat = 0 V(G) = 1 E(G) = 0
1		line	sat = 2 V(G) = 2 E(G) = 1
2		necklace	sat = 2 V(G) ≥ 3 E(G) = V(G)-1
3		dendrite	sat = 3 v 4 V(G) ≥ 4 E(G) = V(G)-1
4		spider	sat ≥ 5 V(G) ≥ 6 E(G) = V(G)-1
5		ring	sat = 0 V(G) ≥ 3 E(G) ≥ V(G) R(G) = 1
6		dendring	sat ≥ 1 V(G) ≥ 4 E(G) ≥ V(G) R(G) = 1
7		multiple ring	sat ≥ 0 V(G) ≥ 5 E(G) ≥ V(G)+1 R(G) ≥ 2
8		cross	sat ≥ 0 V(G) ≥ 4 E(G) ≥ V+3 R(G) ≥ 1
9		grid	sat ≥ 0 V(G) ≥ 6 E(G) ≥ V(G)+ (R(G) -1) R(G) ≥ 2

sat = number of satelites   E(G) = number of edges
V(G) = number of vertices   R(G) = number of rings

Figure 17   Morphologic graph patterns connectivity of the network. Regarding the network morphology (the location and the connectivity of the elements) several distinctive pattern types of vertices and edges can be identified within graphs. Each type is a unique arrangement of vertices and edges. Moreover, each specific pattern type may represent specific network functions. The pattern types distinguished may act as shape indices and syntax describers. Figure 17 presents a range from simple to more complex compositions of vertices and edges.

The most simple pattern type is a vertex with no edges, a point. The second pattern type is an edge between a pair of vertices. This type contains two satellite vertices. Satellites are end vertices with $c_i = 1$. A necklace is a path of edges with two satellites and more than two vertices. The dendritic pattern is a necklace with three or four satellites. Both necklace and dendritic patterns are typical for linear objects, representing roads, hedgerows or rivers. These types may contain a conduit for movement. The spider pattern indicates a central vertex surrounded by or connected to more than four vertices. A ring is an interconnected necklace pattern. Two types of rings can be distinguished: one ring and several connected rings both with or without satellites. The cross pattern is a specific ring. It contains alternative routes for movement. More complex units are delta and grid patterns. These two types contain repeating patterns. Vertices in such mesh patterns have approximately an equal connectivity value. No element in the mesh is connected enough to be a spider pattern type.

4.4 Evaluation of the Network Parameters

4.4.1 Introduction

Two main qualities are essential for a meaningful analysis, when applying these parameters: a simple calculation procedure and well-defined parameters for interpretation. The geographical basis of the networks implies a possible use of GIS to compute the parameters. The second aspect concerns knowledge about the properties and the meaning of the parameters. Three specific features are distinguished: spatial configuration, fragmentation and alteration of the network. Different spatial patterns might imply that the function of the network differs. Therefore, it is important that the parameters can deal with geometric distances, projected on the edges, shape and juxtaposition of the elements. The parameters should also consider the fragmented character of regional tourist complexes. The third feature concerns how well the parameter describes network changes. Is the parameter sensitive to (small) alterations in the network, as they occur in space and over time? This is essential for comparing changing networks and landscapes. Networks abstracted from a landscape are not static, rather they change when alterations occur in the landscape. It is useful to make these changes explicit by using models representing network parameters. In Table 3, an overview is presented of the evaluation of the properties of the network parameters.

Table 3 Overview of network parameter properties

	Determination		***Interpretation***		
	General	***GIS***	***Spatial config.***	***Fragmen-tation***	***Alteration***
Parameter types					
Topol. elementary	++	+	o	o	*
Geometr. elementary	++	+	*	o	*
Topol. matrix-based	+	-	o	o	*
Geometr. matrix-based	+	-	*	o	*
Morphologic	+	-	*	*	-

*++ very simple; + simple; * taken into account; o indifferent; - not applicable*
Topol. = Topological; Geometr. = Geometrical

4.4.2 Determination of the Network Parameters

All the parameters discussed are relatively simple to determine, some more than others. The topological elementary parameters only make use of *V(G)*, *E(G)* and *G(V,E)*. The geometric parameters contain a weighting of distance w_{ij}. The matrix-based parameters require more attention because of the matrix algebra. This has been well developed in graph theory. The morphologic parameters are decided upon by comparing them with predefined pattern types.

At present, GIS lacks functionalities for determining the different parameters. Arc/Info was used to examine if such functionalities already exist in a GIS or if they were easy to implement. The current network functionality in a GIS consists mainly of procedures for path finding, travelling-salesman problems and allocation, to create models of flow through connected networks (*e.g.* Lupien *et al.*, 1987; Jurgens, 1992; Ritsema van Eck, 1993; Geertman and Ritsema van Eck, 1995). The GIS does not have the tailor-made capability to characterize a network as a specific geographical object with its own characteristics, such as connectivity. This object approach could be compared with the concept of regions or routes, already applied in Arc/Info. The basic elements of a network (vertices, edges and distances) are already stored in the GIS. Therefore, the basic data needed to calculate the elementary and matrix-based parameters can be derived from the GIS data base. For the determination of w_{ij}, the shortest path algorithm is suitable. With specially developed software, *e.g.* programmed in Arc/Info Macro Language (AML), it is possible to derive the elementary network parameters. GIS appear not to be appropriate for matrix algebra. Although the matrix form resembles a regular grid pattern, it takes too much time to simulate matrix calculations with the offered grid functionality. A GIS grid pattern always has a geographical component, which is not related to matrix calculations. Therefore, it is better to develop a programme outside the GIS to do the matrix algebra and to store the results into the Arc/Info data base. With a complex query structure, a GIS might be capable to determine the morphologic pattern types. The basic elements are available in a GIS. This was not explored because of its complex character. At the moment, the human eye is still much quicker at determining a specific pattern type.

4.4.3 Interpretation of the Network Parameters

Spatial configuration

The elementary parameters provide global information about the network. However, they neglect the internal relationships of vertices and edges within a network, and (in a digraph) the direction of the edges. For different (connected) networks, the same values can be achieved. It is argued that the value of the topological elementary parameters (α, β, γ, μ and δ) remains the same for different patterns of networks that have the same values for $V(G)$, $E(G)$ and $G(V,E)$, but which are not topologically equivalent (*e.g.* Haggett *et al.*, 1977; Selkirk, 1982). They remain constant under isomorphic transformation. In the case of isomorphism, it may be useful to have some precise way of recognizing that the graphs are identical although they may be arranged differently and that their vertices and edges are structured in a different way (*e.g.* Haggett *et al.*, 1977; Selkirk, 1982). It is apparent that these parameters measure more or less the same and correlate mutually.

James *et al.* (1970) developed the *si*-index as an alternative topological measure to differentiate between networks that have the same topological elementary parameter values. This index is considered to be able to discriminate very sensitively within and between network patterns (Haggett *et al.*, 1977). The *si*-index uses the frequency distributions of shortest paths derived from matrix *D*. The topological elementary parameters also neglect the spatial configuration of the network. For the geometric elementary parameters, it holds that they are also less distinctive between network types, although the geometric approach gives some more information about the geometric pattern.

The matrix-based parameters describe both the elements and their position in the network (see Table 2). Since the topological matrix-based parameters measure connectivity of one vertex to all others based on the presence or absence of edges, it cannot be concluded that the topological centre of the network is the most spatially connected vertex. Since both *P* and *S* consider geometric distances, they estimate the relative locational position of vertices better than *C*, *A* and *D*. It is argued that the variation in vector values is sensitive to the spatial configuration of the network elements for *P* and *S*, to a lesser extent for *D*, and to a lesser extent for *C* and *A* (see Taafe and Gauthier, 1973; Van Langevelde *et al.*, in prep.).

A problem encountered in calculating the *A*-matrix is that, since the higher powers involve much larger numbers than the smaller powers, they consistently dominate the total accessibility sum. All edges between pairs of vertices, no matter how indirect, are regarded as equal in importance. The excessive weight of the higher power sums in *A* is contrary to expectations. In tourist complexes, increase in distance is expected to have a decreasing influence on the behaviour of tourists. A more realistic procedure would be to decrease the relative importance of indirect connections between vertices. A procedure suggested by Selkirk (1982) is to transform the multiplication by a scalar. The higher-powered matrices will be of diminishing importance in determining accessibility. However, the problem is how to determine an appropriate scalar value. Another issue with the calculation of matrix *A* is that several redundant paths are included in the powered matrices (Taaffe and Gauthier, 1973; Haggett *et al.*, 1977). The redundant paths indicate alternative routes between pairs of vertices in which one vertex occurs several times.

The morphologic parameters describe different patterns in a network. They do not describe the connectivity of a network as a whole. Moreover, they do not describe the internal relationships between vertices and edges, nor their relative locational position in the network. The distinguished morphologic pattern types only characterize the topological patterns in a network. A geometric approach can give a better understanding of the spatial configuration, the locational position, and of distances between vertices. A geometric distinction leads to more pattern types, *e.g.* a candelabra pattern (see Cantwell and Forman, 1993) can be defined as a geometric dendrite pattern. The amount of different pattern types can indicate the complexity of a network pattern.

Fragmentation

Only the elementary parameters are discussed for connected networks in the literature. For non-connected networks, the parameters do not represent fragmentation. In the calculation of α and μ, the number of subgraphs is taken into account, but these parameters do not appear to be very distinctive. The matrix-based parameters describe the relative importance and locational position of a vertex in a connected network. The matrix-based parameters C and P are not affected by fragmentation. The parameters A, D and S are only suitable for connected graphs, since they contain at least one path between each pair of vertices. The corresponding vectors $\underline{a}$, $\underline{d}$ and $\underline{s}$ are incorrect describers for non-connected graphs. A correction factor is proposed to deal with non-connected graphs for the parameters derived from D and S (Van Langevelde *et al.*, in prep.).

In non-connected graphs, the correction factor should first take into account the relative position of the vertex in its subgraph, the mean length of the edges in the subgraph, and the extent of the subgraph (*i.e.* the number of vertices in it). There is no correction factor for the parameter derived from matrix A, because of the calculation and interpretation problems already mentioned. The morphologic pattern types describe a connected subgraph or part of a graph. An additional feature should be used to describe fragmented networks, namely the geometric distances between the subgraphs.

Alteration

The elementary parameters are useful in comparing networks over time. The main use of α, β and γ has been in comparative studies of road and rail networks, particularly in countries where there are many geographical changes described, and in studies of the correlation with measures of economic or demographic characteristics (*e.g.* Garrison and Marble, 1965). The δ-index is a crude range measure, which is somewhat weak for comparing networks, since it is directly affected by the extent of the graph and inversely affected by its connectivity. For the matrix-based parameters, a change of the vector values is an indication of alterations in the network. However, the size of the network is not considered. The vector values are only valuable if the different networks contain the same number of vertices. The dispersion indices provide suitable parameters to describe network alteration, especially s^{Δ} and p'^{Δ}, where the spatial configuration is concerned. The sequence in the morphologic parameters describes independent situations in a network. Alteration in a network does not imply a modification from one specific pattern type to another: the pattern types distinguished are not in line with each other. By visually comparing the different patterns, it is possible to make statements about alterations in the network.

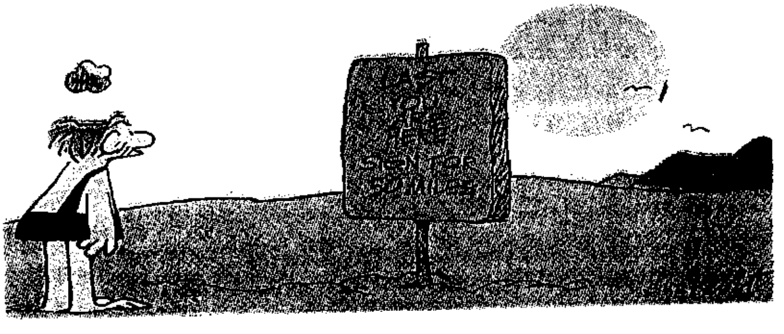
4.5 Discussion of the Network Parameters

The elementary and topological matrix-based network parameters are mainly used in geographical research to describe geographical and demographic changes. Other authors apply an economic approach, focusing on (low) costs and (shortest) travel distance in space and time. Moreover, all these network studies focus on flows in a connected network. The spatial configuration of the elements and the notion of fragmentation for non-connected networks are not considered. The topological relationships are the important topic for these studies. In tourism studies, network parameters and their interpretation are a neglected area. Three types of network parameters were discussed to characterize networks and quantify connectivity: the elementary, matrix-based, and morphological parameters (see also Table 2). To examine the function and accessibility of locations in relation to the rest of the network, graph theory provided a convenient means of measuring and recording the relative importance and locational position, and the alteration of these. For the parameters, the degree of connectivity is a function of the number of (direct and indirect) neighbouring vertices and the edge distance measured between the vertices. In the definition of distance, topological and geometric approaches were distinguished.

The connectivity parameters are shown to be strong in some areas, but weak in others. The elementary parameters indicate the connectivity of a connected network and describe alterations in the network. They can be calculated simply. However, they lack a clear relationship with the function of the network and its elements. The matrix-based parameters make use of this relationship since they account for the paths that facilitate flows. For these parameters, the vertex-edge relationships are the basis for determining the connectivity of the network and its elements. The weighting of the edges, according to the geometric approach with a certain distance definition, provided a more refined measurement to determine the connectivity degree of network elements, and therefore, to study network functions. The morphologic pattern types were suitable for characterizing the connectivity of the network. However, the determination and interpretation of extensive and complicated networks remain difficult.

From the tourism perspective, matrix calculations seem a useful technique for analysing potential paths and tourist opportunity structures in a region, especially, where non-geometric properties, such as scenery and information use, are to be explored in combination with transport networks and landscape characteristics. In addition, the matrix-based parameters should be elaborated to characterize directed graphs and graphs with multiple edges. The morphologic approach could deal with the description and analysis of tourist complexes. By analysing the different patterns, tourist behaviour might be predicted for other situations. These predictions could be integrated, to refine the analysis of the regional tourist opportunity structure. The role of the different locations in the tourist complexes might be analysed by the values in and out vectors of matrices derived from directed graphs. The elementary parameters were not applicable for the analysis of directed, non-planar tourist graphs. Therefore, Smith's postulation (1989) about the γ-index being appropriate for tourism studies, is not correct, at least for the description of tourist complexes.

Connectivity parameters can be used in different ways to analyse and design spatial interventions. However, for these contributions the discussion about network creation is essential. Questions about the character of vertices and edges and about the boundaries of the studied network should be addressed. In common with other measures of spatial structure (*e.g.* Teklenburg *et al.*, 1993), the connectivity parameters are sensitive the size of bounded network under study. Knowledge about the properties and meaning of network parameters is essential for questions about what, when and how they can be used, and for proper interpretation of results. Spatial configuration of network elements and fragmentation of the network have to be considered as important aspects for the analysis of connectivity of landscape networks.



5 DYNAMIC CARTOGRAPHY

We must not allow our technical choices to become delimited by the items on the 'menu bar' - the results of others' imaginations and agendas (Dorling, 1992).

5.1 Data Visualization

5.1.1 Introduction

The first step in the processing phase concerns the exploration of the collected data. This exploration can be accomplished going through the data set manually, looking at and examining the data. This option is feasible if the number of cases and the number of variables in the data set is small. Another option is to create different tables and overviews of selected variables and interpret these. A third choice is to make graphic representations of the data (*e.g.* diagrams) and to visualize hypothetical relations between the variables. When spatially related data are to be examined, these can be visualized by drawing maps to display the (aggregated) data. Scientists frequently model and observe their data and measurements using computer simulations and screen graphics. Visualization of data is the key approach when applying tables, diagrams and maps. The purpose of visualization is 'to make visible' the patterns hidden in tables of facts and figures or mathematical equations (Dorling, 1992). Considerable research effort has gone into achieving cartographic products, from which values can be read and patterns detected, for many different variables (Dykes, 1996). Much of the struggle in computer cartography has gone into making digital and algorithmic reproductions of traditional, manual cartography. Across the sciences, researchers are increasingly relying on visual representation of their data for analysis. However, the irregularity and volume of geographical data combining with the alternative focus of computer cartography have meant that a unified environment for geographical visualization has not been forthcoming (Dykes, 1996). Hillman (1995) offers a short overview of visualization in scientific computing and for cartographic purposes. The next two sections, about visualization and cartography, are adapted from Hillman.

5.1.2 Visualization

McCormick *et al.* (1987) published a report about Visualization in Scientific Computing or ViSC. In this report, ViSC is defined as: '... a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. .... Visualization embraces both image understanding and image synthesis. That is, visualization is a tool, both for interpreting image data fed into a computer, and for generating images from complex multi-dimensional data sets. It studies those mechanisms in humans and computers which allow them in concert to perceive, use and communicate visual information.'

This McCormick definition of ViSC focuses on the technology and computer aspects of ViSC. MacEachren *et al.* (1992) approach visualization more from the human side; they define it as: '.... first and foremost, an act of cognition. .... a human ability to develop mental images (often of relationships that have no visual form) together with the use of tools that can facilitate and augment this ability. Successful visualization tools allow our visual and cognitive processes to almost automatically focus on the patterns depicted rather on generating these patterns.'

Visvalingam (1994) applies the same type of differentiation when he makes the distinction between visualization as a mental process and visualization as a process of transformation. The mental process performs visual analysis as a method of inquiry for generating insight and for concept refinement. Visualization as a transformation process converts raw simulation data into an image which can be displayed. The goal of visualization should be to transform the data into a format amenable to understanding by the human perceptual system. Ganter (1994) adds to this that the human cognitive system, the parts of the mind that acquire, store and use information is competent at processing realistic graphics in real time, but not so good at processing information graphics that display qualitative and quantitative data. Ganter distinguishes three stages in the cognitive process. As visual information reaches the brain, it first goes into the perceptual buffer where it is stored, but not interpreted. Subsequently it goes into the short term memory, where specific features are assembled and symbols recognised. Then it goes into the long term memory, where the symbols are associated with concepts, and feedback is returned into the short term memory in the form of prompts for more information. The short term memory has a limited capacity to retain information, and so the facility for constant update is a major advantage of ViSC systems. In order for the long term memory to associate symbols with concepts efficiently, the graphics need to be carefully constructed.

The graphical variables proposed by Bertin (1983) provide a widely recognised and accepted set of guidelines for the display of qualitative and quantitative data using graphical representation. Bertin identified seven graphical variables: position, size, value, texture, hue, orientation and shape. These can be used to display different orders of information. For instance, in linear features, hue can be used to display nominal data, where different colours represent different classes of objects, such as rivers or roads. Size can display interval or ratio data, perhaps with the width of the line directly proportional to the value. These principles need to be incorporated into ViSC systems to facilitate cognition and optimise pattern recognition.

Although there are nuances in definition, the underlying philosophy of ViSC is that displaying visual representations of data assists in the processes of pattern recognition, generating ideas, and formulating hypotheses about the data. The relevance to cartographers is that a new set of computer tools exists, which allow multiple views of the same or related data to investigate spatial information. This has arrived at the same time as (or perhaps contributed to) an increased confidence in the use of images rather than numbers for describing geographical data (Dykes, 1994). This new toolkit allows the interrogation of maps and images for information, and the provision of many simultaneous views of the data set. These views can be linked dynamically so that related information can be identified in each view. Furthermore, a temporal dimension can be added to series and symbols. The toolkit will provide most efficient and effective visualization if it is able to make use of recognised cartographic techniques and follow the principles of Bertin's graphical variables. Information is collected from data by investigating, probing, transforming, and redisplaying images on the computer screen. This method of analysis provides at worst an overview of the data set, and at best insight from which new ideas about the data are developed and tested. The significance of cartography will be examined below before presenting new visualization techniques.

5.1.3 Cartography

Traditional cartography is seen as the presentation of an idea or view (Hillman, 1995). Static (paper) maps, the output of cartography, have been proven to be effective tools for scientific visualization, which can generate insight (Wood, 1994). Maps are used in this way for data storage and data communication. One has to consider that the map reader is always likely to extract something different or partly different from the cartographer's input (Wood, 1994). Wood describes this additional insight as 'unplanned increment'. A traditional map is an information source that might be hiding many unexpected patterns, which may provide insights. A single map used to illustrate something can be extremely effective; hundreds to look at can be bewildering.

In the last few years, changes in traditional cartography have become noticeable: data are stored in digital volumes and there is an ongoing discussion about the introduction of interactive and dynamic ways of visualization, using new technological possibilities (see *e.g.* MacEachren and Taylor, 1994; Hearnshaw and Unwin, 1994; Peuquet, 1994). New presentation methods and techniques are necessary to combine the increasing interest in visual communication, multimedia and the expanding digital volumes of data that have to be transformed into usable information. It is also necessary to look at the data in different ways (visually and statistically) to discern patterns and associations with no pre-formed hypotheses, by 'sifting-through' observations (Peuquet, 1994). As Taylor (1994) puts it: 'Cartographic cognition is a unique process as it involves the use of the brain in recognizing patterns and relationships in their spatial context. Whereas this cannot be easily replicated by GIS software with its essentially linear analytical processes, it can be considerably enhanced by cartographic visualization'.

Like a tourist, who uses perception and knowledge of the environment to plan trips, the researcher uses perception and cognition to interpret maps and visual images and data representations, with their extreme richness for conveying information. As Petch (1994) states: 'to generate hypotheses one must have a wide knowledge of things; the more we look at maps of different things and the more we deal with spatial phenomena the better we will become at recognising and interpreting them and developing the skills of spatial thinking'.

Cartography can be applied for two purposes, communication or cartographic visualization. For communication purposes, the optimal map is designed to communicate a specific message, to present an idea or view. With cartographic visualization, the message is unknown, there is no optimal map and the concern is the development of ideas. DiBiase (1990) incorporates literature from scientific visualization and exploratory data analysis to illustrate the role of maps in a research sequence. A distinction is made between maps used for private visual thinking and public visual communication. DiBiase sees visualization not as a new aspect of cartography but as a combination of four aspects of cartography: exploration, confirmation (on the visual thinking side of the research schema), synthesis and presentation (on the visual communication side). New emphasis is placed on each of the different roles. MacEachren (1994), however, argues that this redistribution of emphasis only acts to incorporate visualization under the heading of computerised cartography. He argues that within the realm of map use or cartography, there is a fundamental difference between visualization and communication, and visualization should be seen as an entity on its own. The additional factor that distinguishes visualization from other types of map use is the level of human-map interaction. This discussion will be further elaborated below.

5.1.4 Animation

Animation often can solve the dilemma between cartographic communication and visualization, but it can also compound it. Animating space is the process of panning (position), zooming (magnification) and focusing (resolution or generalization level) around and into a large two-dimensional static image (Dorling, 1992). Such a process is not normally considered cartographic; what justifies this as 'animation', is the speed and smoothness with which the image can be altered. What makes it useful, is the degree of control we can exert over the process. When animating time, the map is held still and the action is played out upon it; time rather than space changes the image. In this form of animation, movement is usually used to represent a function of time, mostly in the form of maps with changing colours instead of movements. However, humans are not good at recognizing objects that change colour alone.

The problem encountered when animating time with software is the brain's poor visual memory. We are good at registering continuous movement but we want to control it personally, *e.g.* by using various options such as rewinding, pausing, or fast-forwarding. Motion needs to be smooth and reasonably coordinated to be memorable (Dorling, 1992). To animate space, we need to freeze time; to animate time, it helps to freeze space. When we have acquired more than a dozen maps to show a process, assimilation becomes difficult. It is not possible to generate complex sequences in such a way that both overall and detailed views are represented. Interactive animation can ease this problem. One of the ironies of animation is that often the most effective way of seeing change over time is to avoid the use of time in order to show it. Comparison requires at least one simultaneous view. Animating space can allow detailed spatial investigation of a complex picture, which incorporates a temporal variable statically.

5.1.5 Conclusion

MacEachren *et al.* (1992) argue that changes in computer technology have made real-time interaction possible. Not only a technological difference in tools for representation, but a 'fundamental' difference in the nature of how analysts interact with those representations are important. They explain it as follows: 'The computer facilitates direct depiction of movement and change, multiple views of the same data, user interaction with maps, realism (through three-dimensional stereo views and other techniques), false realism (through fractal generation of landscapes), and the mixing of maps with other graphics, text, and sound. Geographical visualization using our growing array of computer technology allows visual thinking or map interaction to proceed in real time with cartographic displays presented as quickly as an analyst can think of the need for them.'

This exploring process of visualizing data can be labelled as dynamic visualization. Dynamic visualization of data sets can be very useful to explore large volumes of data and to formulate hypotheses. However, these hypotheses have to be tested, for instance using statistics. Complex time-space data, which are considered to be assembled from interwoven spatial and person-related components, might be very suitable for analysis using a dynamic cartography approach. Dykes (1996) claims that combining ViSC techniques with two dimensional cartography can provide a superb environment for investigating large and complex spatial data sets. Error or bias can be detected, an overview acquired, an understanding of the nature of the data developed, and should the need arise, analysis undertaken, results produced and knowledge gained. The individual attribute data have to be combined with the actual use of a region, the routes followed and area and locations visited. In addition, the different network abstractions, which can be derived from the actual data, can also be visualized and analysed dynamically.

5.2 Cartographic Data Visualization for Time-Space Data

5.2.1 General Description

The complex, irregular character of geographical data means that no integrated system exists which embraces the full range of visualization techniques available. GIS provide some capabilities found in ViSC systems, such as pseudo 3D viewing, point and click interrogations, control over classification, interactive colour schemes, abstract data transformations, and some linking of views (Dykes, 1996). However, the development of GIS from a quantitative setting has resulted in efforts being made to model spatial information in a complex data base from which numbers can be extracted and statistics computed. Cartographic considerations usually involve the replication of traditional maps and the production of high quality output with high precision as a static final product. Those who wish to employ aspects of ViSC in their analysis often have to use GIS first for geo-referencing and computing the necessary data. The following step is to export the data to visualization software to animate, transform, or fly by their data, or to dynamically link multiple maps and graphs of the data. One way of resolving the problem of different systems in the analysis process is for smoother and closer links to be shaped between software that manages and transforms spatial data and that which displays it, such as ArcView.

An alternative is to link display and data more fully in a data structure that revolves around graphical objects representing spatial elements and encapsulating spatial and attribute information. Dykes (1994) developed a system for this visual exploration of area-value data, the Cartographic Data Visualizer (CDV), in which he integrates ViSC techniques with computer cartography. The aim is to provide spatial scientists with a fully dynamic visual environment where questions can be asked and ideas developed. Besides visualization through maps, it is also possible to visualize network structures that can be abstracted from the data. For this purpose, Hillman (1995) developed the Graphic Network Visualizer (GNV). First, some details will be presented about the general Cartographic Data Visualizer system, followed by a general description of the CDV application for time-space data, the CDV-TS system. As a third system, the graphic network visualizer (GNV) will be introduced.

Cartographic Data Visualizer

The CDV software has been developed to visualize area valued data, specifically by producing multiple, linked, interactive cartographic views that can be interrogated and manipulated in real processing time. Variables are selected from a window, using scale bars. The main polygon map is initially shaded by the first initial variable(s) selected. The shading changes as the scale bar is moved. Different views of the variables can be produced by creating polygon maps, circle maps, and scatter plots, which can be coloured in many ways. Alternative variables and combinations of variables can be shaded instantly by moving the scale bars. Circles can be 'pushed' to the back of the window by clicking them to explore the detail of the pattern. All items can be interrogated by clicking with the cursor. The views are fully linked and dynamic. When an item is touched by the cursor in any view, the equivalent district is highlighted in the polygon map. Double clicking on an item results in items representing the same district being coloured in every view, so clusters can be investigated and insight can be gained into discrepancies.

Cartographic Data Visualizer for Time-Space data

To explore linear and area or point related time-space data, Dykes has made modifications to the CDV software system and created the Cartographic Data Visualizer for Time-Space analysis, the CDV-TS system. Different individual characteristics can be chosen from the window with the available attributes (Figure 18a[1]). Separate sections of the population can be distinguished, and their time-space behaviour can be visualized and assessed. By moving a scale bar or clicking the attribute buttons, the corresponding maps are instantly displayed, and time and attribute series can be produced and the data set analysed. In CDV-TS, a scale bar determines the time (Figure 18b). The line- and point- or area-related items are configured with size and colour combinations, depending on the number of individuals located on a route or in an area at the selected time (Figure 18c). Because of the character of this data exploration process, there is no explicit legend belonging to this sort of map. Only indications are considered to be useful, for example the brightness of the colour of a line that is connected to a specific characteristic, or the width of a

[1] *Additional information for Figure 18:*
(a) window with an overview of available individual characteristics; (b) time scale bar;
(c) time-space window: roads and areas in the Nette Tal park used by a selection of tourists between 9.00 and 17.00 hours; (d) window for the cartographic items: line-size, area-representation, colour, interval classes, map size.

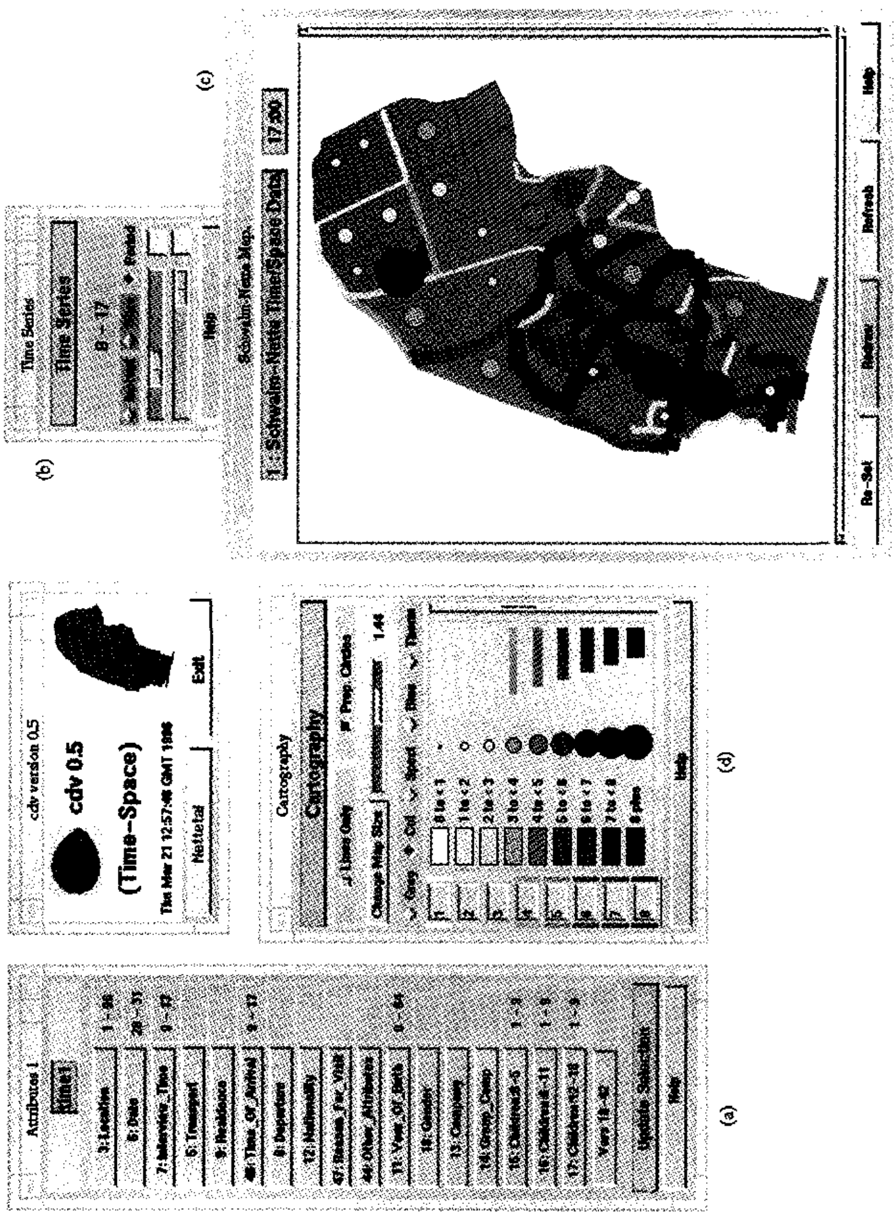


Figure 18 *Overview of windows used in the exploratory data analysis software CDV-TS*

line or a circle that gives an impression of the number of people at a given location (see Figure 18d). Researchers can vary the display and selection characteristics, as widgets have been created to vary the cartography variables and to restrict inclusion to individuals with specific characteristics.

The combined use of the different buttons and scale bars will produce an interactive 'movie', a series of time slices, of spatial behaviour during a selected period. Dynamically linked map views of different scales allow location within the area and individuals' characteristics to be compared with the distribution of tourist points of origin on a national map. Individuals (or group types) can be mapped as items with shape, colour, texture, and outline width conveying any of the personal attributes. It is also possible to link graphics such as histograms or scatter diagrams to the spatial data and to explore the spatial patterns through these graphics. The software has advantages over a time-series animation investigation, in that the user has total control over the speed and order of the sequence.

Graphic Network Visualizer

Bertin (1983) distinguishes a network from a diagram, when he states: 'In a diagram one begins by attributing a meaning to the planar dimensions, then one plots the correspondences (links)... In a network, one can plot the figures on a plane, which has no meaning, and then look for the arrangement which produces the minimum number of intersections, or the simplest figure. After this transformation the graphic will yield maximum efficiency.' Bertin suggests that it is necessary to pose and resolve most network problems graphically. Networks can have different shapes, such as linear, circular, tree, or regular shape. All these shapes may represent the same information. Efficiency in a network is encapsulated by minimising the number of meaningless intersections.

According to Hillman (1995), there are no simple procedures that would define the optimal arrangements of elements in a network for a given set of information. Therefore, he developed a software prototype system as an enlargement to the CDV-TS system, the Graphic Network Visualizer (GNV). In this system, the location visited and routes followed can be abstracted and visualized as a network. The complicated network can be represented as an abstraction of the actual data through a graph. Using an interactive construction, the graph can be reshaped by the user to produce a graphic without geometric relationships. The reshaping process offers a better understanding of the graphic structure and the relationships between network elements; a most efficient representation for visual interpretation can be created. The locations of attractions or places visited can be represented as nodes in the graph, and the routes followed are represented by links. By using of graphs, the confusion and cluttering caused by mapping the actual data is reduced.

The GNV system consists of several windows, see Figure 19[2]. The first window is the geographical map window (Figure 19a). This map shows the points visited and the routes followed. It can hold more information, such as road layout, country boundaries, rivers, etc. The second window (Figure 19b) offers the opportunity to select time-space characteristics, such as time period, date and activity number. In the third window, widgets are presented that allow the user to view individual characteristics of the data (Figure 19c). The fourth window offers the graph representation of the created selection of locations visited and routes followed (Figure 19d). There is a link between the geographical map and the graph representation, so that the selected graph node is also highlighted on the geographical map, and the various routes followed can similarly be seen when a link is selected. Furthermore, it is possible to examine nodes and links so that the location name is shown when selecting a node, and also the number of respondents using a link when selecting a link.

5.2.2 Description of Tcl/Tk software

The three described systems (CDV, CDV-TS and GNV) are all developed using the Tcl/Tk software toolkit. This toolkit offers graphical interface capabilities to support real-time visual spatial data analysis. 'Tcl' stands for Tool Command Language and offers programming structures within a window environment (Ousterhout, 1994). 'Tk' represents a X11 toolkit that defines familiar widgets such as buttons, labels, menus, and scale bars. The two can be linked to build widgets that issue commands and arrange them on screen. Commands and widget behaviour can be matched with particular mouse and cursor combinations. Such an environment, which permits interaction between screen and cursor, and screen objects, provides a basis upon which cartographic visualization can be developed, through altering the properties such as size, shape and colour, and through executing commands and procedures.

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[2] *Additional information for Figure 19:*
(a) Geographical or Context Map; (b) Time-space characteristics; (c) Overview of individual characteristics; (d) Graph representation of the constructed network.

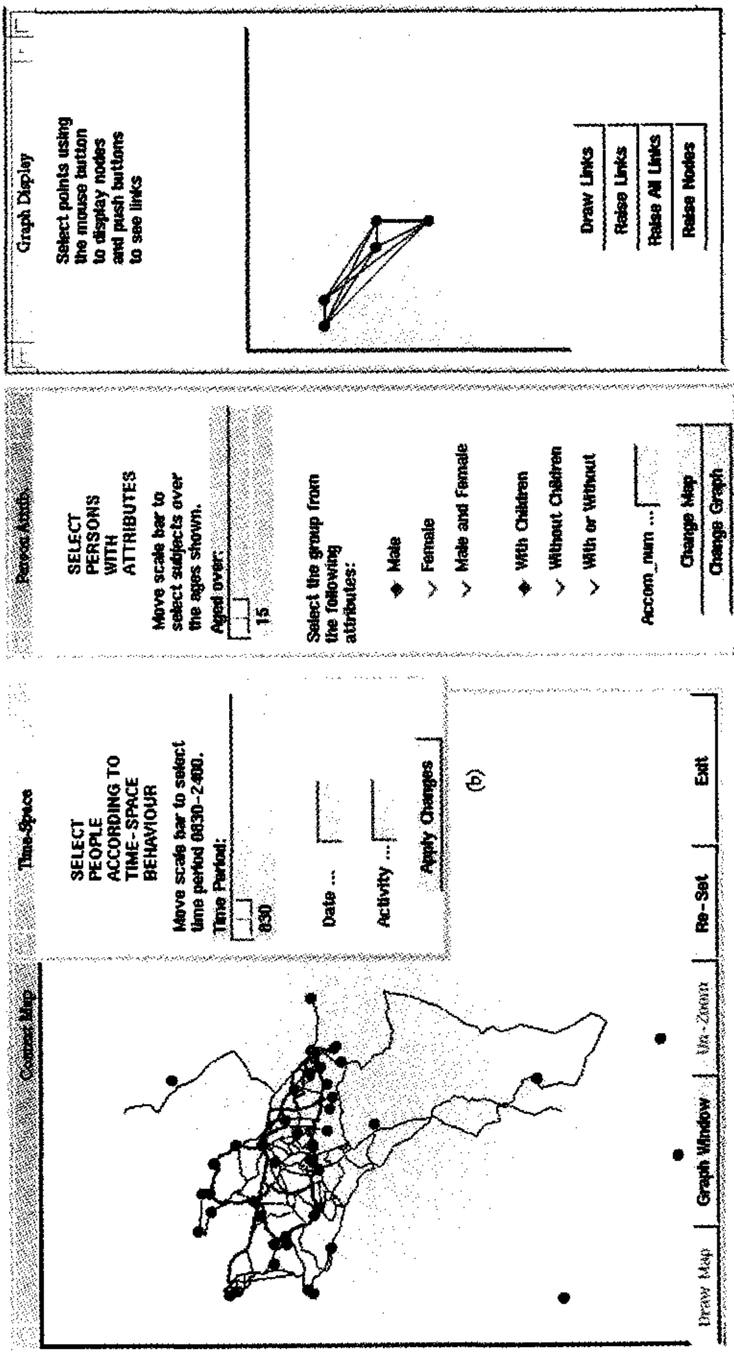


Figure 19 *Examples of windows from the Graphic Network Visualizer software*

First, some widget characteristics will be elucidated, followed by a paragraph about the interaction process.

Widget Characteristics

In Tcl/Tk, widgets are created by stating a widget type and a name. Widget characteristics, or options, are defined by declaring an option and its value. A simple example of widget communication is achieved by including the reconfiguration of one widget in another widget's command option. In addition to the familiar Graphic User Interface (GUI) widgets, Tcl/Tk has a canvas widget that provides a coordinate plane in which graphic items such as lines, arcs, ovals, polygons, text and images can be located. Like button widgets, canvas items also have characteristics that are defined as option-value pairs. For example, line items have options for width, smoothing technique, bitmap fill and colour, which permit cartographic symbolism. The items can be set to portray variable values, and dynamics, as items can be reconfigured or programmed to respond to other widgets or the cursor. As with buttons and other GUI widgets, canvas items can be reconfigured instantly in response to other widget activity. Thus, a polygon that forms a part of a choropleth map can change colour or texture if it is reclassified by a scale bar, or if a new variable is to be plotted within it. Many different views of data can be created with these features. For example, scatter plots are symbols located by attribute rather than geographical space, and proportional circle maps locate circles geographically with radius and other symbol options depending on particular variables.

Interaction

Interaction with canvas items is also possible, this is the binding option. Mouse movements over a canvas are linked to actions and can be used to interrogate maps for data. The result of binding is a map that displays information instantly for any zone when a cursor is moved over it. Binding can be used to perform more complex operations such as item reconfiguration or interrogation. Groups of items with a common attribute, or tag, can be reconfigured when any item with that tag is touched, if tags other than 'all' are specified as conditions to bind commands. This type of binding is useful for investigating symbols that have common attributes, and can be achieved between canvases or views. Maps or views can be linked by binding canvas items to a procedure that updates all items with a similar tag or ID across all views. This is a form of geographical brushing (MacDougal, 1992). Zones on a choropleth map can be linked with points on a scatter plot, or circles on a cartogram in this manner. Tcl/Tk canvases also incorporate facilities for instant scrolling and scaling, movements of items, transformations, destroying items and raising or lowering items within a canvas. Additionally, canvases can allow topological operations which includes finding the bounding box of an item, the closest item to a point, items that overlap a set of coordinates, or items within a certain distance of a point. All these simple, rudimentary commands can be put in series to create a sophisticated tool for visualizing spatial data. This sequence of commands has been put into practice for the CDV-TS and GNV systems. These two systems will be explained in more detail in the two following sections.

5.3 Cartographic Data Visualizer for Time-Space Data

Data required

The data model to analyse tourist time-space behaviour, as described in Chapter 3, consists of time, space and context related data. These main data domains were further specified over various data groups. To use the CDV-TS system, the data structure can be specified in data on personal characteristics, geographical data on locations, roads and areas, and data on the observed time-space behaviour. The data have to be organized and implemented within a special format in order to be used by the CDV-TS system. The geographical data need to have the same format as the export data tables produced by the Arc/Info ungenerate command. The person-related data have to be in a specific attribute format. For each person, the first line represents the values for the personal characteristics, while subsequent lines represent the time indication and arc- and area-numbers followed or visited; these form the time-space pattern per period.

Operation of the system

The CDV-TS system starts by opening the main windows (see Figure 18) and reading the related data. In the first selection, all the data are used. By moving the time-slider bar (Figure 18b), the related time-space data are visualized in the display window (Figure 18c). To make a selection out of the total data set, different attributes can be used, *e.g.* the tourist who came by bicycle or car, or a selection based on nationality, or on the group company (see Figure 20a). Each button in the attribute window hides several new selection options. When an attribute selection is made, the 'update selection' button creates an updated display of the related time-space data. The time-scale bar offers the oppor-

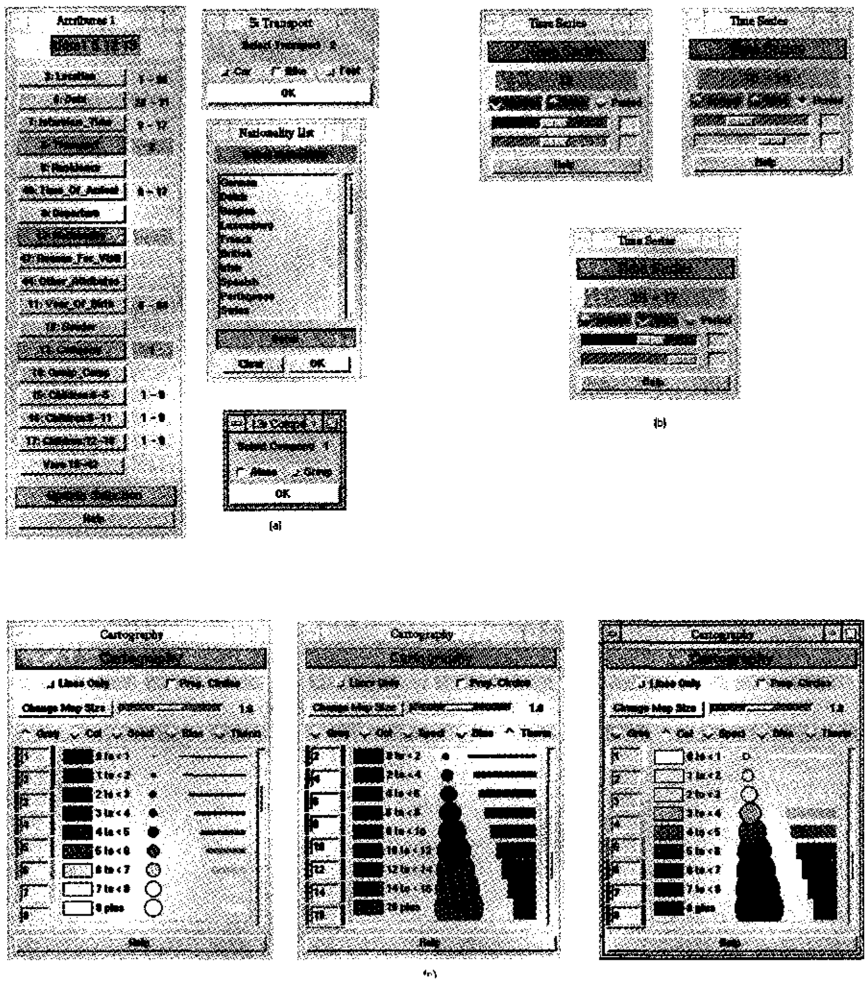


Figure 20 *Examples of CDV-TS features: (a) additional attributes; (b) time scale bar; (c) cartographic window*

tunity to change the time slices (see Figure 20b). The default is the instant option, for each hour a display of time-space data is shown. A second option is to select a period of the time, *e.g.* two or three hours, or a whole day. With this option the upper slider bar is kept at an initial time moment and the lower slider bar is moved until the period desired is created. The display window will alter in response and the accumulation in time, the intensity of the usage per line and area, is made visible. Figure 18c displays the time-space data during a whole day. With fixing the period, at four hours for example, the slice option can be used. The slice option generates a display in which data is presented for each time slice. An example would be to compare and analyse the time-space data for the morning and afternoon periods.

The cartographic window offers different options (Figure 20c). The line and area size can be altered by moving a scale bar up or down. The corresponding sizes are displayed in the window and the alterations are instantly visible in the display window. Another option is to alter the colour scale combinations. The grey scale is the default; other colour scales offered are a yellow-brown colour scale, a spectral colour scheme, a blue scale (light to dark - low to high), and a thermal scale (from blue to red). Depending on the selected variables, an appropriate colour scale can be selected. In the cartographic window, the classification is presented and can be altered. In the default setting, there are nine classes available. Each upper boundary of a class can be changed into a new value, which also instantly updates the map window. The system does not allow gaps between or overlap in the classes, adjustments have to start at the highest class. The value corresponding to the highest class is printed as proportional circles for the area presentation. This offers the user the possibility to change the highest class value to the displayed value.

Another utility offered by the CDV-TS system is the possibility to query individual lines and areas about the intensity of use in the map display window. By pointing at a specific line or area, a corresponding graphic presentation is displayed, which illustrate the usage per hour during the day for the current selection of attributes (see Figure 21d). When a new selection is made, the corresponding graphic will be displayed in a new colour in the graphic presentation. This offers the opportunity to compare time-space intensity per line segment for different attribute selections. The size of the graphic presentation can also be altered interactively. One of the last of the wide range of features in the CDV-TS system which deserves a mention, is the zoom capability. This option enables the user to examine a specific area more closely. In the general software window, the selected area is marked (see Figure 21e), so the user can always trace back which area has been zoomed in upon. Using the 'Reset' button will undo the zooming.

Evaluation

The CDV-TS system offers many analytic opportunities and options. The linkage between the different windows makes it possible to obtain an instant

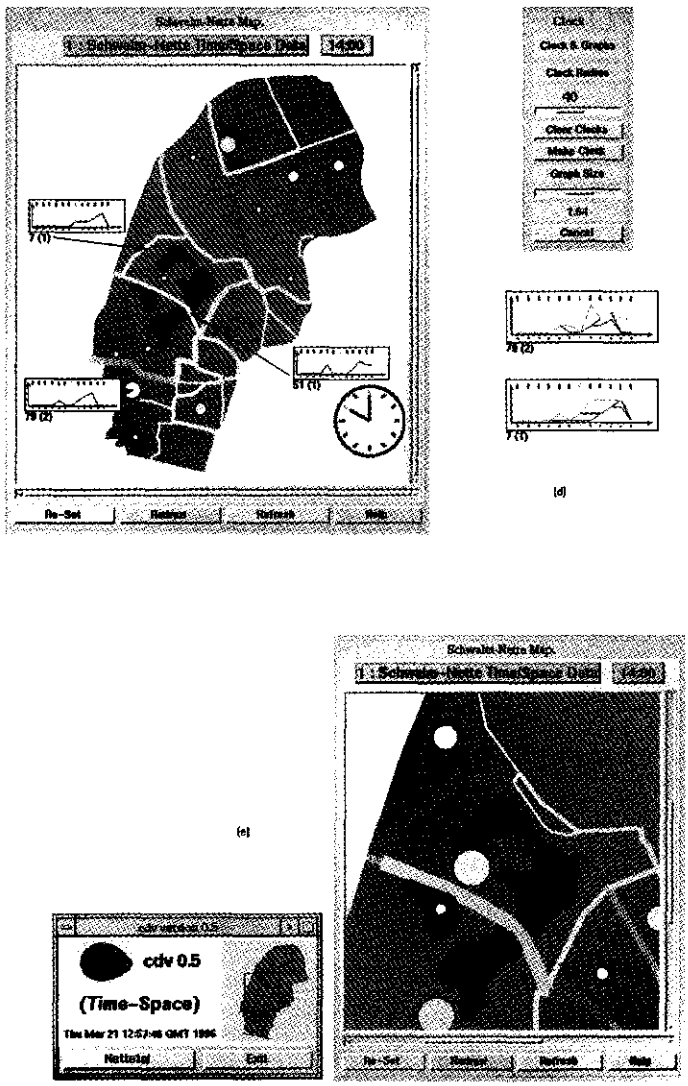


Figure 21 Examples of CDV-TS features: (d) query options of line and area; (e) zoom options of an area

update of the map on display. This makes it easy to examine time-space related data and to form hypotheses about behaviour and possible relationships between variables. This display of different selected combinations of variables might create better and new insights. The use of the time slider bar gives the analyst a good impression of how the region is used during a day. The user has total control over the speed and order of the selection sequence.

Dynamically linked map views of different scales allow analysis of location and characteristics of individuals. An interactive 'movie' of spatial behaviour is produced.

An option, which might be implemented into the system, is that information is displayed about the number of cases (persons) in the current selection and the total number of cases. This can be useful information if the map display has to be interpreted. The information is available in the system and therefore can be displayed without any problem. A second option that could be useful is the display of the modal split for a variable on demand. This is especially so when various options with a variable are available (*e.g.* reasons for a visit), as it offers the possibility to choose the most important ones.

A general warning must be added. The user must have the skills to manoeuvre within the overwhelming amount of choices and to apply the appropriate selections. The analyst must also know about the quality of the data and why and how the dynamically linked window system operates. Without any basic knowledge of time-space behaviour and its possible related interaction with landscape, there may be a risk of drawing wrong conclusions with this system. The system only offers an instrument to explore the data and to form hypotheses on the spatial distribution in an area. These constructed hypotheses then have to be tested.

5.4 Graphic Network Visualizer

Data required

For the prototype GNV system, only route line data and person-related data are required. If this is related to the data model, only the geometric describers of roads and routes and the describers on personal characteristics are applied. The route line data should be in the Arc/Info ungenerate format. Each route has to be described with the successive arcs followed. The general person-related characteristics have to be in a special format, together with the related time-space diary data.

Operation of the system

The main programme starts by reading in the different data tables. Next, the geographical map window is opened, the routes followed are displayed and five buttons are offered (see also the bottom of Figure 19a). Each button triggers a subprocess. The geographical map can also include other information, such as the actual road network, borders, rivers, landscape features; this has not yet been incorporated in the prototype. A second window displays the time-space attributes (see also Figure 19b). This window contains a time slider bar to select a specific period, and an entry box to enter a specific date and activity number. After clicking the 'Apply Changes' button, the new selection is visualized in the geographical map. The third window displays the personal attributes that can be selected (see also Figure 19c). In the prototype, this window only offers the variables for age, gender, whether the respondent has children, and the accommodation(-number) used. In the geographical map window, the graphic window button opens the graph network display of nodes and links (see also Figure 19d). Four options are offered in the graph display: draw links, raise links, raise all links and raise nodes. The first option (draw links) draws all possible links between all nodes in the network. Each time an item on the geographical map is selected or drawn, it is raised to the top of the window. The links that were actually used can be raised above the other links so that they can be seen clearly. This can also be done for the nodes.

There are four options offered to interrogate the geographical map and graph-linked environment. An entry of a point on the geographical map with the mouse cursor causes the node to be highlighted in the geographical map and the graph map, and the name of the location is displayed (Figure 22a). When the point is left, the node in the geographical map and graph map returns to its normal state and the name is erased. The same holds for nodes entered on the graph map: the corresponding node on the geographical map is either highlighted or put back in its normal state. The links on the graph map can also be highlighted and the corresponding routes visualized in the geographical map. The number of people using that link is displayed (Figure 22b). Furthermore, the graph window offers the possibility to change the position of a node and drags it to a new location to obtain another topological perspective of the constructed graph so that there are no any meaningless intersections (Figure 22c). A last option is the zoom facility offered, with which it is possible to take a closer look at a specific part of the area.

Evaluation

Although the Graphical Network Visualizer has so far only been developed as a prototype, it offers new insights; it supports the analysis of time-space behaviour and the interpretation of the behaviour into networks. It is especially

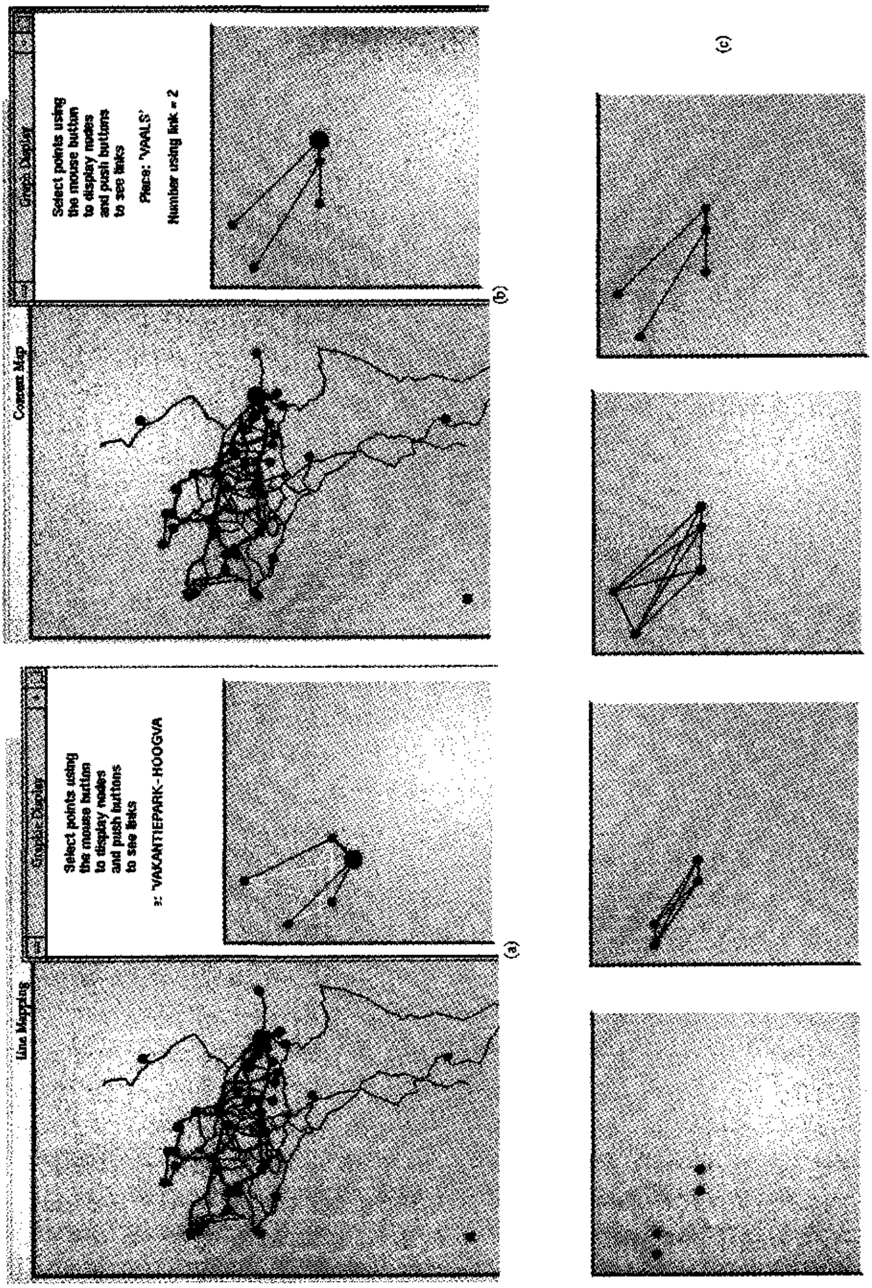
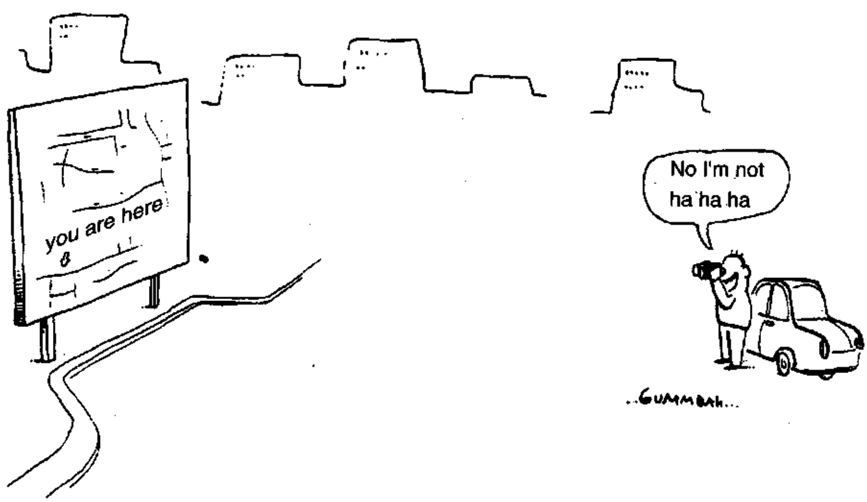


Figure 22 *Examples of GNV software features: (a) name of selected node; (b) number of users per link; (c) moving nodes*

the link between the use of the region, through locations and routes, and the abstraction of this into a graph which offers a strong instrument. The combined exploration makes it possible to perform an improved analysis. It allows the user to interact with the data, change variables and select different views in real processing time. The system also makes it possible to explore the data to identify an underlying hierarchy by using the graphic display of the constructed network. The layout of the network can be changed by moving nodes to reduce the number of meaningless intersections, and to provide the most efficient display. Hypotheses on the relationships can then be developed.

The geographical map provides an adequate, but limited basis for visualizing the spatial behaviour of tourists. There is no geographical reference, scale or legend presented. Nor is any other spatial environmental information displayed in the geographical map. These have to be added. The geographical map is useful for comparing actual routes and locations visited, but the nature of the data makes it difficult to display quantitatively how many respondents really went from one place to another, and what route they took. It simply provides nominal information on what locations were visited and what routes were followed. In the graph map, the direction between the nodes is not taken into account. The direction can be incorporated by applying two different colour segments for each direction. The length of the colour segment could show the number of people travelling in a particular direction, and the width of the line could be used to represent the total number travelling in both directions. Point statistics about time spent at a location can also be added to the system. The distribution of different variables in histograms could also be a major improvement for evaluating specific links and nodes.


you are here
No I'm not ha ha ha
..GUMMBAH...

6 CASE STUDIES

Increasingly we can get everywhere from anywhere, which means that everywhere is nowhere (Johnston, 1996).

6.1 Introduction

The previous chapters have been devoted to elucidating various conceptual aspects of the tourist recreation complex. Three domains were distinguished that are important in a tourist recreation complex: time, space and context. Furthermore, the complex consists of several types of interwoven networks. A data model has been presented that characterizes the tourist recreation complex. The data model, the data structure, and a processing model were described in previous chapters. A methodological process was also presented to support the analysis which should lead to a better understanding of the construction of individual tourist networks and thus the corresponding complexes. In Chapters 4 and 5, two methodological issues were examined in terms of their use in clarifying the tourist recreation complex. To describe several participating networks in the complex created, a morphologic approach was judged as a promising method. The Cartographic Data Visualizer for Time-Space data and the Graphic Network Visualizer software could offer ways of visualizing and determining coherence in a tourist region and the kind of networks patterns constructed.

After these theoretical explanations, it is time to determine if and how theory can be applied in the analysis of time-space related data. Data from two case study areas will be used for illustration. The data from the first study area, the Nette Tal area, were used as a pilot study to test the methodological opportunities of the described approach, the techniques and instruments, and to determine possible gaps and pitfalls. Based on the results from the Nette Tal survey, data from the second study area, the Euregion Maas-Rijn, were collected and processed. The two case study areas differ in area size, the amount of data collected, and the way time-space data were stored and processed. For the Nette Tal survey, only four days in 1992 were available for data collection. The Nette Tal area is a small area for which tourist characteristics and their corresponding time-space behaviour were recorded. For the much larger Euregion study area, two periods were examined, in the spring and summer of 1995. Landscape elements were taken into account and an attempt was made to determine possible relationships between the tourist perception of the landscape and activities undertaken. The GIS and GIS-oriented software, which were applied to store and process the data sets, were CDV-TS 0.5[3], GNV, Arc/Info 7.0.2 and ArcView 2.1, the latter two being representatives of currently available commercial GIS software.

This thesis will not offer an explanation of the results obtained for the study areas. In this chapter, only an exploratory and descriptive approach is offered to illustrate the proposed methodology, developed techniques and instruments. Some explanations of the analysis results from the Nette Tal data set had already been produced by students during their practical exercises with the data material. Results from the Euregion data set (*e.g.* the influence of specific landscape markers on routes followed and activities undertaken, the time-space behaviour of tourists in the Euregion Maas-Rijn, and possible relationships with specific tourist typologies) will be analysed and discussed in the PhD thesis by Elands (in prep.). Only examples are shown in this thesis, and some ideas about a possible interpretation are put forward.

The two case study areas are described in Section 6.2. The subsequent sections will focus on issues that arose. These issues include: Given the data model, what sort of data were obtained to describe time-space behaviour? Is the link between the time, context and spatial data of tourist behaviour strong enough to support an integrated analysis? How are the data implemented for tourist behaviour analysis? Does the exploration of the data offer ideas about the use of a tourist region? How are networks constructed and how do they describe tourist behaviour? Can a tourist opportunity structure be derived from the individual tourist networks which could assist planning and management purposes? All these issues are illustrated with results from the case studies. More of the applied software functionalities are illustrated on the CD-Rom supplement to this text: a selection from the two data sets is used to illustrate the potentials of the applications developed. The interactive conditions can

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[3] More information about the CDV-TS software can be found at the World Wide Web location (URL): http://www.geog.le.ac.uk/argus/ICA/J.Dykes

best be illustrated using a CD-Rom. Some black and white reproductions are included in this chapter.

6.2 Description of the Study Areas

6.2.1 Nette Tal

The Nette Tal study area is located in the north of the Schwalm-Nette Park in the German state North Rhine-Westphalia, just east of the Dutch border of northern Limburg, near Venlo (Figure 23). The Schwalm-Nette Park was

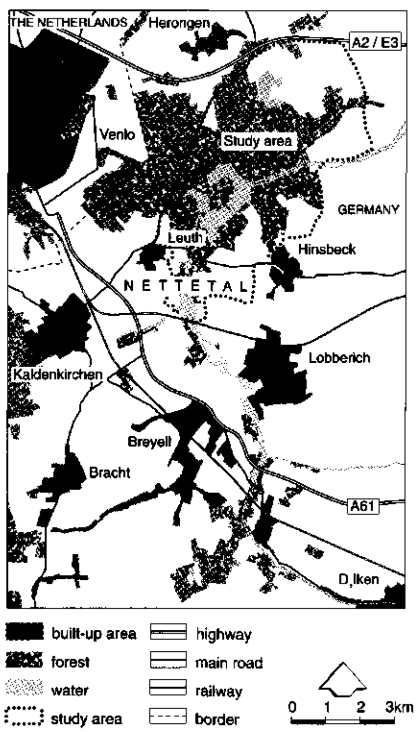


Figure 23 Study area located at the north side in the Schwalm-Nette Park

established to create day or weekend recreation opportunities for the people living nearby in natural surroundings. In the start-up period, in the early 1960s, the park area had a high population density with a relatively low percentage of forest, many small agricultural areas and a high road density. The small-scale structure of the park, combined with a relatively high population density and the agricultural character, made it impossible to reduce traffic movements quickly in favour of walking areas and areas with low noise levels, or for landscape preservation. Plans were made for conservation, preservation and development of the landscape (to so-called green-systems), to create parking facilities and routes for walkers, and to stimulate nature related recreation. The amount of accommodation offered for tourists also grew. However, camping, swimming and playground facilities have decreased in the last twenty years (Dahmen, 1985).

The Nette Tal study area is limited on the north side by the motorway A2/E3 and the village of Herongen, and on the south by the railway Lobberich-Venlo, the motorway A61 and the villages of Leuth, Hinsbeck and Lobberich. The size of the area is approximately 36 km^2, approximately nine by four kilometres. One of the oldest parts of the nature reserve park, the Krickenberger Seen, also has a castle, Schloß Krickenberger. Nine restaurants are situated in the Nette Tal area, and there are also many car parks. There are various walking routes set out in the forests. There are also ample swimming and rowing opportunities at the different lakes. The area is mainly visited by the local population, but it also attracts tourists from further afield.

6.2.2 Euregion Maas-Rijn

The second study area is located in the Euregion Maas-Rijn (Figure 24). The Euregion Maas-Rijn is the result of collaboration between the Belgium provinces Limburg and Liège, the southern part of the Dutch province Limburg, and the Aachen region in the German state North Rhine-Westphalia. The Euregion Maas-Rijn was set up to stimulate developments that cross the national borders. To achieve the goals set, many obstacles have to be surmounted (Brouwer and Elands, 1996), such as differences in governmental organisations and political approaches, language problems, and competition mechanisms. Brouwer and Elands (1996) argue that the existence of a national border influenced the physical spatial configuration of the landscape. For instance the landscape is considered to be more unspoilt and natural on the south side of the Dutch-Belgian border. In 1993 and 1994, the cities in the Euregion drew up a spatial development plan (D'Hondt, 1994; ICC MHAL, 1993 and 1994), in which sustainable development of the rural area in relation to tourism and nature is given priority. Cross-border walking paths and cycling paths are a first step towards achieving this objective.

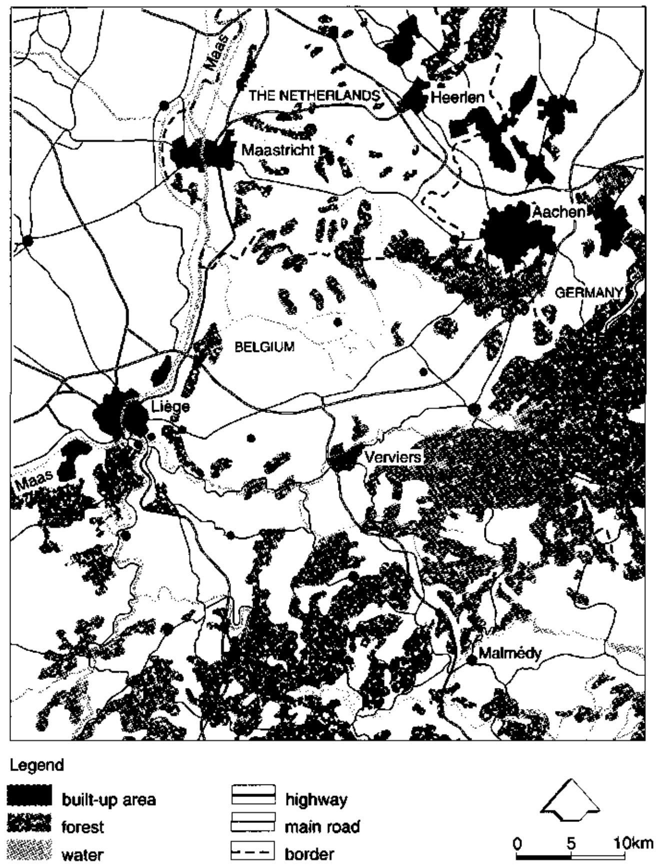


Figure 24 *The Euregion Maas-Rijn; the study area is located between the cities of Aachen, Maastricht, Liège and Malmedy*

A part of the Euregion Maas-Rijn was chosen as the project area for this study. The chosen area is much larger than the Nette Tal area, it covers approximately 2,400 km^2. In the north, the study area is bounded by the motorway A73 between Maastricht, Heerlen and Aachen. The river Maas, between Maastricht and Liège, forms the western boundary. The German Northwest Eifel region and the Belgian Haute Fagne district form the south and east sides of the study area. These last two areas are similar in landscape and tourist use. Nature conservation and education receive priority in these areas. An important region in the study area is the 'Park of the Three Nations', which consists of the Dutch region Heuvelland, the Flemish Voerstreek, the Walloon Pays de Herve and the Aacher Stadtwald. The high, slightly undulating plateaus, with dry valleys and brooks, old forests, thickets, lanes, springs, and streams, make the landscape attractive. Some plateaus are wide and deeply cut by small rivers, such as the Geul, the Gulp and the Berwinne. Wide panoramas are a feature, although in other parts the relief gives a relatively small-scale impression (Van Eck and Van Os, 1993). Another distinct area is the Belgian Ostkanton, part of the Walloon province of Liège with its German language and culture.

Heuvelland, the part in southern Dutch Limburg, has been a popular tourist region for almost a century and is therefore highly developed in terms of serving tourism. There are many and different types of accommodation available. The Belgian Voerstreek and the Pays de Herve are fairly undiscovered areas, especially by tourist product developers. In the Voerstreek the building of small-scale tourist facilities, stressing the historical character and traditional customs, has just begun (Brouwer and Elands, 1996). The emphasis on the romantic character of the landscape and the small traditional villages, where life still moves more slowly contrasts with the Heuvelland area. In the Heuvelland area, life moves forward at a faster pace, the landscape is more modern, and tourism has developed on a larger scale. The hilly landscape of the Heuvelland area always has been an attraction for Dutch tourists; it is the most hilly part of the Netherlands. For the Belgians, the landscape of the Voerstreek and the Pays de Herve is much more common, and therefore less attractive compared to the nearby Ardennes.

6.3 The Data Model and the Data Obtained

6.3.1 Introduction

In the data model for time-space behaviour, described in Section 3.2, four main data groups were distinguished: (1) tourist characteristics, (2) tourist perception and time-space behaviour, (3) product coding for tourism purposes, and (4) landscape elements and tourist products. For each data group measurable elements were designated, which are important in the construction of a Tourist Recreation Complex. The tourist related data entities are: locations visited, time spent, activities undertaken, roads followed, information used, appreciation/evaluation, and meaning. Some of these entities have a geographical reference. For other entities, a sequence is constructed, or they can be linked to entities with a geographical reference. When combining these entities more network-like patterns are created, and they can be analysed in combination with each other. An overview of the tourist related data entities and their combinations is presented in Table 4.

Table 4 Overview of tourist related entities, distinguished in a tourist recreation complex

Time: time spent as a sequence in a specified period (day, week, holiday)	*Combinations:*
Activity: sequence of separate or combined activities undertaken	*Time-Location: sequence of time spent at specific locations, on routes followed, or in areas visited*
Location: sequence of locations and areas visited	*Activity-Location: sequence of activities undertaken at specific locations, on routes followed or in areas visited*
Routes: routes followed in a region (= activity touring + go to locations)	*Time-Activity: sequence of time spent for each activity*
Meaning, Experience, Evaluation: features connected to time spent, activity undertaken, location visited	*Time-Location-Activity + Meaning and Information: tourist time-space behaviour, the coherence created between the different components*
Information: information obtained and used from the environment, brochures, information offices, social network; features connected to time spent, activity undertaken, location visited	

In addition to these tourist related data entities other geographical and non-geographical entities are important in the construction of the individual tourist complex: *e.g.* the road structure, the landscape and its elements, social networks, promotional activities from a producer or from a regional tourism organisation. Data gathered for all these entities from the Nette survey and Euregion surveys are compared with the proposed data model. The data collection methods for each study area are described first.

6.3.2 Nette Tal Data

For the Nette Tal area, time-space data were collected from 28 to 31 May 1992. Nearly 1,000 individuals were interviewed. Table 5 offers an overview of the distribution of the number and nationality of visitors interviewed each day. As each visitor (or group of persons) left the area, they were asked about some personal characteristics. Questions were also asked about their time-space movements: at what time they had entered the area, what roads had been taken, at which location a stop for more than ten minutes had been made, how long the stop had been and time of departure. It was an elementary type of questionnaire, focusing on some elements of behaviour in time and space. This limited approach was chosen mainly because it formed a part of a practical exercise for students. The interview period covered the hours between 9.00 and 18.00 and only focused on activities undertaken and movements made inside the Nette Tal study area. During the four interview days, the weather was warm and sunny.

Table 5 Overview of distribution of visitors interviewed in the Nette Tal, May 1992

Day	*Number*	*% D**	*% G**
28	*15*	*0*	*93*
29	*165*	*19*	*79*
30	*151*	*4*	*93*
31	*654*	*16*	*82*
Total	*985*	*14*	*83*

** D = Dutch visitor ; G = German visitor*

In a supplementary postal questionnaire, people were asked questions concerning the lay-out of the area, their reasons for undertaking recreational activities, and their daily occupations. Of the 985 persons interviewed, 680 sent back their postal questionnaires. In addition to the time-space data collection, mechanical and visual traffic counts were conducted at different locations to obtain an impression of the traffic movements, direction and modal split. The mechanical counts were conducted throughout the month of May, while visual counts were done on 28 May (Ascension day) between 9.00 and 18.00. The results of the visual counts are important for checking and adjusting the results from the mechanical counts. These corrected results can be applied in estimating the use of the Nette Tal during May and over the whole year.

6.3.3 Euregion Maas-Rijn Data

The main survey was carried out in the spring and summer of 1995. From the 800 questionnaires sent out 542 were returned. About 54% of the questionnaires were collected in spring, for the summer period about 46%. The weather conditions were stable throughout the spring and summer surveys. In both periods it was warm and sunny. 366 questionnaires (± 67%) were collected in the Netherlands and 176 (± 33%) in Belgium. The different accommodation types visited and the corresponding distribution are presented in Table 6.

The tourists were asked to fill in a questionnaire consisting of three parts.

The first part referred to personal characteristics. In the second part, tourists had to register their time-space behaviour in a diary. The third part was devoted to an evaluation of the day. For the diary part, the tourists were asked to report how a day had been spent, what activities had been undertaken (where and at what moment), what sort of information was used (*e.g.* map, guide or earlier visits), and how information had been obtained to plan a trip. They were also asked to give an evaluation score between one and ten for each activity. In a pilot survey conducted in October 1994, the tourists were asked to record their activities in fifteen minute blocks over three full days. In the spring and summer surveys of 1995, this was changed to every half hour for two days and only for the period between 8.00 and 24.00. In addition to keeping this diary, the tourists were asked to sketch the routes they had followed on a map. For the evaluation of the day, the tourists were given statements to judge, for example, whether it was an adventurous or boring day, a varied or monotonous day, or whether the environment was considered to be artificial or natural. In addition, the activity most appreciated had to be mentioned and the reasons for the choice stated.

Table 6 Categories of accommodation in the Euregion 1995 survey with percentages of Dutch and Belgian accommodations

Accommodation type	Number	%	% D*	% B*
Camp site	366	68	66	71
Holiday park	132	24	27	18
Apartments	38	7	6	9
Rest (hotel, B&B)	6	1	1	2
Total	542	100	100	100

* D = Dutch visitor ; B = Belgian visitor

6.3.4 Comparison

Comparing the methods for gathering the two data sets, several remarks are in order. The data for the Nette Tal area were gathered during a practical course for students. This put some limitations on the way the data were collected. Only a few days were available to do field work and to give the students some practice in gathering time-space related data. The students interviewed visitors leaving the area and asked them to reconstruct their time-space pattern in that area for that day. Furthermore, the Nette Tal data set refers to a fairly small demarcated area in which a limited amount of routes can be chosen. In contrast, the Euregion area is very large, with many roads, and a far wider choice of routes. In the Euregion survey, the tourists were asked to keep a diary for two days with no limitations to the areas visited. Surveys were carried out in spring and summer.

In addition to the limitations in area and period, the Nette Tal data set was also limited in the type of data gathered. In the Nette Tal survey there were no questions concerning an evaluation of the activities undertaken, nor an evaluation of the whole day, nor concerning information used. For the data model these characteristics were assumed to be important for the tourist recreation complex construction. Data on some personal characteristics, roads followed and locations visited, were gathered, whereas other tourist time-space oriented data were omitted. At the time, the data collected were deemed to be sufficient. In the Euregion study, more tourist-related characteristics were gathered, such as evaluation values. Several landscape typologies and tourist product elements were also assembled.

For the Nette Tal study, the students asked the people on the spot about their activities undertaken and the routes followed. The data describing the time-space behaviour show a fairly constant quality per student. This quality is, of course, influenced by the interviewee's memories of location and time. The tourists surveyed in the Euregion had to sketch the routes followed on a map. They were given a photocopy of topographical maps to sketch on. The quality of these sketches varies more than the routes sketched from the Nette Tal survey. Some people have difficulty reading topographical maps; others cannot remember the way they went or the exact routes taken; others did not want to draw the routes and only gave origins and destinations. Furthermore, the maps were not detailed enough to allow walkers to draw their routes chosen, whereas walkers are normally adept at map reading and can draw very detailed routes. The scale of the maps was more suitable for cyclists and car drivers.

Given the data model presented for the tourist recreation complex, it was difficult to gather all the attribute data required. For neither study area was the attribute data set complete. The Euregion data set came closer to the desired data model. The quality of the data must also be kept as constant as possible, *e.g.* routes followed should be sketched in by the interviewer.

6.4 Data Implementation

6.4.1 Introduction

After gathering the data, they had to be organised in a data structure, in such a way that they can be processed using statistical software (*e.g.* SPSS), the dynamic cartographic software products CDV-TS and GNV, and the Arc/Info and ArcView applications. The data implementations for the tourist characteristics and routes followed for the Nette Tal survey are described first. The Nette Tal data structure was developed before this thesis research was started. The data structure discussion is followed by a description of how the data had to be transformed to fit the proposed route data structure. Based on the Nette Tal experiences and the insights obtained into how tourist recreation complexes are created, a better structured data set could be obtained for the Euregion. This will be illustrated in the section following the explanation of the Nette Tal data implementation.

6.4.2 Nette Tal Data

The visitor characteristics and the related time-space data from the Nette Tal survey were stored in one Ascii file. A line with values for 483 variables was required for each visitor. This file was processed using the statistical software programme SPSS. The data from the postal questionnaire were put in a separate data file. An identifier was kept in both files to connect the corresponding data. For the 47 visitor characteristics the students coded the corresponding attribute values. They had sketched the routes followed and places and areas visited as part of their interview. They later transposed the roads taken into a sequence of road numbers. Activities such as crossing an area, or walking and driving over small or unpaved roads, especially in forest areas, were marked with an area number. Time was regarded as the main discriminating factor. Each whole hour of the day was taken separately, twenty three variables were reserved for location numbers and four variables for activities. Therefore, a maximum of twenty three roads or areas, and a maximum of four different activities, were allowed in one hour.

Activities undertaken at a point location or in an area were transposed into a location number and put at the end of the specific hour indication. The same method was applied with the routes followed: each road section number followed was put in sequence for that specific hour. If a route was followed for more than one hour, it was divided over the two adjacent hour blocks, depending on an assumed speed. In this way, the whole time-space behaviour of a visitor was reconstructed into location numbers. In order to process the data using statistical software, an enormous number of positions was necessary to store the data. Given the data structure, twenty three location positions and four activity positions were reserved for each hour. Furthermore, for each location variable a code for the transport mode was kept, which meant an additional twenty three positions.

In this thesis, a route data structure is proposed for storing tourist time-space oriented data. To test whether this data structure was sufficient for the Nette Tal data, a conversion process was applied. First, the different roads, areas and important locations were digitized and stored. The SPSS data file had to be separated into a table of data of tourist characteristics and a table of the time-space behaviour data. Difficulties were encountered when translating the time-space behaviour data coded for SPSS into the Arc/Info route data format. The Arc/Info route format requires a connection between line objects necessary to make up the route followed. In the SPSS data file, it was sufficient just to store the location numbers in sequence, either as a point visited, a road section followed or an area visited. For Arc/Info, it is important that the links between these numbers are in a route data format. Digitising only the roads made the main road structure available as a connected line structure. No connections were made between areas and roads or tourist attractions and roads.

These missing links were reconstructed as follows: determine if a link already exists between the positions of a point or area marker and halfway along the road that was used, either before or after the visit to that specific point or area location. If not, calculate the coordinates of the determined positions and create that link between these positions (see Figure 25A). Going through the thousand available interviews, and their related route numbers in the SPSS file, the routes were reconstructed to fit the route data structure of Arc/Info.

It transpired that the SPSS file with route information was not complete. Connection were missing between several road or area numbers. Sometimes, it was just a short road section that had to be added (Figure 25B), in other

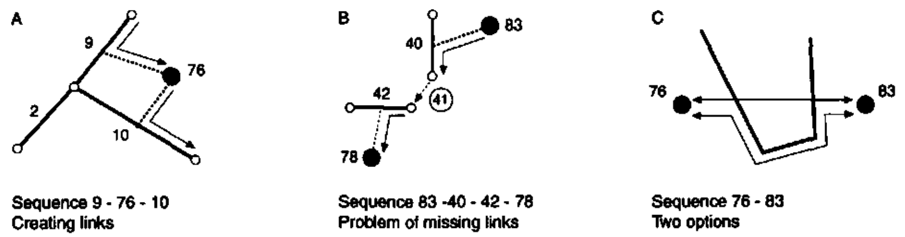


Figure 25 *Creating links, based on location and road numbers: (A) between a existing road and an area location; (B) using a existing road; (C) connecting two area locations*

cases more roads or area links had to be constructed (Figure 25C). Part of a route had to be reconstructed between two areas and two roads followed. Following the numbers supplied on the digital road network, a gap was noticed between the two road numbers or the two area locations. This was solved by applying the shortest path functionality between the two known sections. This path was then added to the reconstructed route. The corresponding mode of transport, which was also available in the SPSS file, was connected to each route section distinguished. Besides the reconstruction of the routes, the diary tables were reconstructed from the SPSS data file to form a new data table per hour.

The SPSS data file also had to be adapted for the CDV-TS software. The data structure for CDV-TS does not require a connected network unlike the route analysis module of Arc/Info. CDV-TS operates with the single road and area/location numbers per hour and determines the frequency for each given attribute selection and each distinguished period. The time-space related data (the numbers of the roads followed or areas or locations visited) must be available only for the hours in which movements are observed. The hours in which no movement has taken place are not taken into account. The attribute values describing tourist characteristics were stored in the data file for CDV-TS as a long row of numbers, divided by a space in a predefined sequence. A line of this data for each tourist is required before the lines of the corresponding time-space data.

If other tourist attributes have to be taken into account, part of the CDV-TS software that navigates the attribute window has to be altered. The current selection of attributes refers to the Nette Tal data set of 1992. In addition to the time-space behaviour data, geometric data of landscape elements (roads, tourist locations, and areas) is also necessary. For this geometric data the CDV-TS software requires the data structure resulting from the Arc/Info ungenerate command for the line and area objects.

6.4.3 Euregion Maas-Rijn Data

The data on the individual tourist characteristics from the Euregion Maas-Rijn survey were stored in three SPSS data files, so that they could be processed for statistical analysis. One data file contains the general tourist characteristics. A second file contains all the evaluation data and the third file contains the diary data, time spent, activities undertaken and locations visited. Duplicates of the data files were stored in the INFO data base, for processing with Arc/Info or ArcView. The tourist product elements, the road network, and information about some general landscape typologies were stored as a coverage in Arc/Info.

The routes followed, based on the maps sketched, were stored in the Arc/Info route data structure. First, all possible roads were digitized, as no suitable digital road map of the Euregion area was available in 1994. For a pilot survey, conducted in October 1994 for the Vaals-Epen region, the forest-paths and unpaved roads were also digitized. As a result, this part of the road network is highly dense. For the main survey in 1995, the minor roads, mainly the unimportant unpaved roads, were not digitized. During the pilot survey it became clear that it was impossible for people to reconstruct which specific unpaved road they had taken. Therefore, these roads were left out, which greatly reduced the amount of digitizing work. An Arc/Info Macro Language (AML) programme was developed to enter the routes sketched: after indicating crucial road junctions along the route followed, the GIS determined which roads were to be selected from the total road structure, by calculating the shortest path between the entered points. Each route entered was given a quality score, divided over four classes: 1) a (nearly) precise reproduction of the roads taken; 2) a very sketchy reproduction; 3) following a predefined route, such as the Mergelland route; 4) a route based only on the locations described in the diary and thus the shortest route between these locations. Besides the route information, the start time was also stored.

Three out of the four main data groups from the data model were filled with attribute data. The fourth data group, related to the product coding, can also be generated using the geometric information for the tourist products, road network and landscape information.

To create a data structure suitable for the CDV-TS programme, the route information per road section has to be related to the hour in which that particular road section was used in order. To accomplish this, an AML programme was developed. The programme makes use of the transport mode and the start and end time information, available from the diary data of each tourist. For each mode of transport, an assumption of the speed was applied in relation to the travelled distance. The time spent was calculated for each length of the road sections. For each road section a calculated start time was added. The data on section numbers and time was exported from the Arc/Info data base and translated to the required CDV-TS format using an interface programme. The geometric data for the line and area objects in the CDV-TS map window were exported using the Arc/Info ungenerate command.

The tourist attributes and their corresponding values can be easily exported from both the SPSS data files and the INFO data base. In CDV-TS however, the attribute window has to be adjusted to the attributes that were distinguished in the Euregion questionnaire.

6.4.4 Comparison

Implementing the data describing time-space behaviour proved to be dependent on the software systems applied. Each software system requires it own data structure. Although one data structure was proposed, derived from the main data model, it was impossible to keep the data in that structure. Different interfaces were necessary to convert the data from one system to the other. Errors were encountered and made when converting data.

The Nette Tal data were obtained for a small area in which a limited amount of roads can be chosen. The Euregion area is very large with many roads and locations. This difference in area size is reflected in the way the route data were initially approached and stored. The Nette Tal route data were transposed and stored in an SPSS data structure. The route data from the Euregion area were too numerous to store in the same way. The Euregion data set was stored in the Arc/Info route data format from the beginning. An initial attempt was made to process the Nette Tal data set (in 1993) using the

SPSS software and other specially developed programmes. However, it lacked a good user interface. The procedure for processing the data was standardized but not automated, and it took quite some time to see the time-space patterns in an area emerging after a specific selection. Therefore, this 1993 approach was not considered successful for the analysis of the time-space related data. The CDV-TS programme was especially developed for this thesis study to support the analysis of time-space related data, using the Nette Tal data set.

For the storage of the Euregion data set, Arc/Info was used for data input and storage. In succeeding phases, an attempt was made to convert the Nette Tal route data into the CDV-TS data format and the Arc/Info route data format and to convert the Euregion route data into the CDV-TS data format. The interface created to convert each data set revealed difficulties as a result of each specific data structure. For instance, in the Nette Tal route data, links for an easy conversion to the Arc/Info route data structure were often missing. The Euregion road data set was too large for the CDV-TS software. Many roads were digitised in detail. Road curves should be generalized to a more straight line. A road data set with many details, describing a large area, is difficult to handle with the current CDV-TS software; this is mainly a problem of computer memory availability.

Adding new attributes to the Arc/Info data set is no problem; this GIS software is partly dedicated to this kind of data base operations. To add a new attribute to the CDV-TS software, it is necessary to rewrite part of the software to allow the new attribute to be part of the attribute window. The CDV-TS software should have a more dedicated module that can generate attribute windows based on the attributes desired.

The time-space data structure of CDV-TS allows easy query and determination of different frequencies. The coherence between the data of road and area numbers, which make up a specific route, is based on the sequence of the numbers for each hour. It is a time-oriented route data structure. The Arc/Info software makes use of a network structure between roads and sections taken. A route can be approached in sequence and coherence; this is a geometric-oriented route data structure.

It is easy to put routes into the Arc/Info system with the AML application. It is more difficult to create a start data set for the CDV-TS software; all the road and area numbers have to be determined and stored in sequence and per period. If the time-space data is already available in Arc/Info, the interface application developed can be used to convert the data from one data structures to the other.

A constraint when abstracting the distinguished time-space behaviour components for the GIS Arc/Info is the different geographical objects for which the data have to be stored separately: the point, line and area objects. For specific queries, such as an activity-location combination, these combinations should be stored first as a unique object. Tourist time-space behaviour was regarded as a combination of the GIS objects (see also 2.6.2). A location visited is abstracted as a point or area feature, roads followed are line features. However, in the experience and meaning of the individual tourist, these elements are connected with each other and not regarded as separate elements. To tackle this problem for the time being, it is possible to abstract the point and area objects to a node in the line data structure, thus making it part of the routes (or lines) created, with specific characteristics added. By abstracting in this way, the analysis process can remain focused on line objects only.

6.5 Data Exploration

In the described analysis methodology, the first step in the data processing focuses on the exploration of possible relationships between landscape elements, different tourist characteristics and the demonstrated tourist time-space behaviour. It also became clear from earlier attempts to analyse the Nette Tal data set and other research (Bergmans *et al.*, 1994; Kolsté, 1996) that statistical software is not the most suitable instrument for revealing these relationships. To explore the Nette Tal data, software was developed in 1993 which could be used to determine intensities per hour for each road segment or area, for different tourist characteristics chosen by the researcher. The result consisted of many tables. For research purposes, the user had to combine and add up the different results from the tables and had to make a graphical display to obtain an impression of the use of the area. The applied data structure was sufficient for this approach, but the whole analysis path can be characterized as extremely laborious. Later in 1995, the CDV-TS software became available which smoothed out the analysis path sufficiently. The user can interactively select tourist attributes and the intensity of use in the areas and on the roads is displayed instantly on a corresponding map. However, to make the most of the opportunities the CDV-TS software offers, requires expertise from the user for the interpretation of the different views constructed.

The general handling of the CDV-TS programme was discussed in Section 5.3. To give an indication of the different possibilities two illustrations are presented here, see Figure 26 and Figure 27. By using the time slider bar

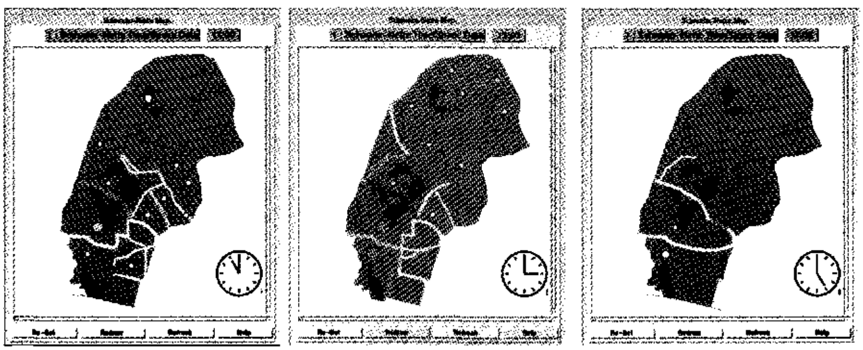


Figure 26 *Use of the Nette Tal area for different time moments for a specific tourist attribute selection*

to show several 'maps' related to different time series one after the other an impression of time-space behaviour is generated for specific groups of visitors. By executing the system with different variables and combinations of values, the researcher can gain insight into the data set and pinpoint deviating values for further examination. In Figure 26, views are presented of the use of the Nette Tal area at 11.00, 15.00 and 17.00. There is a clear difference in the parts used in the park. In the morning, the south side is visited, in the early afternoon the areas in the north are also populated. At the end of the day only a few main roads are used, probably to leave the area. In Figure 27, the differences between transport modes are illustrated. The first window gives an overview of how all the visitors use the area during the day. The use is reasonably spread out over the area. Looking at visitors who came by bicycle, they also use the total area, except for a few northern parts. These latter locations, however, are more popular with the visitors who came by car to the Nette Tal area. These visitors are also found more frequently on the main

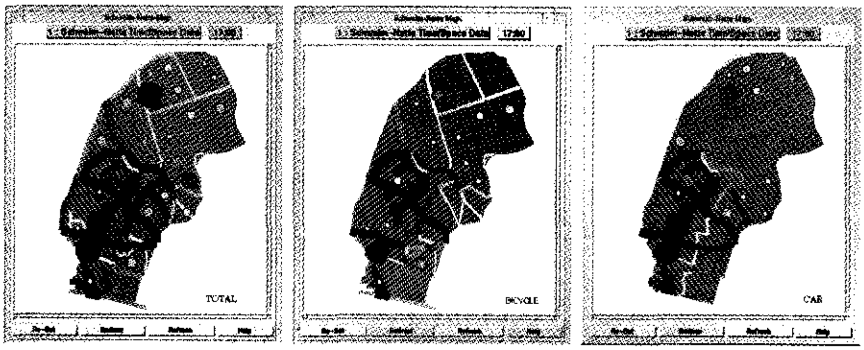


Figure 27 *Differences in intensity patterns in the Nette Tal area over a day from tourists using different modes of transport to visit the Nette Tal*

roads and at the several lakes than the bicycle users.

The main purpose of the first processing step in the proposed analysis methodology is to browse interactively through the data, in order to make different combinations of attribute values. CDV-TS offers this capability. Some of these are discussed and illustrated here, but more of the capabilities can be found on the accompanying CD-Rom. It is impossible to describe all the features of CDV-TS here as there are too many; also the amount of results that can be derived is enormous. The amount of results depends on the number of variables that can be evaluated. For instance, if there are values for fifty different tourist attributes available together with the related time-space data, then time-space patterns referring to all separate attributes can be examined as well as patterns which arise as a result of each possible combination between these attributes. It is up to the user to explore the data set and to discover possible relationships.

The next step was to determine whether Arc/Info and ArcView have the same exploratory capabilities as CDV-TS. The ArcView module, version 2.1, enables interactive presentation of route oriented data together with graphics and related geographical background maps (Figure 28). It is not yet possible to display time series continuously within the ArcView system, *i.e.* the instant display of alterations over time. A specific selection at a certain moment can be displayed as a snapshot (a static display). If a user wants a view over several separate periods, a selection has to be made first. Then it is neces-

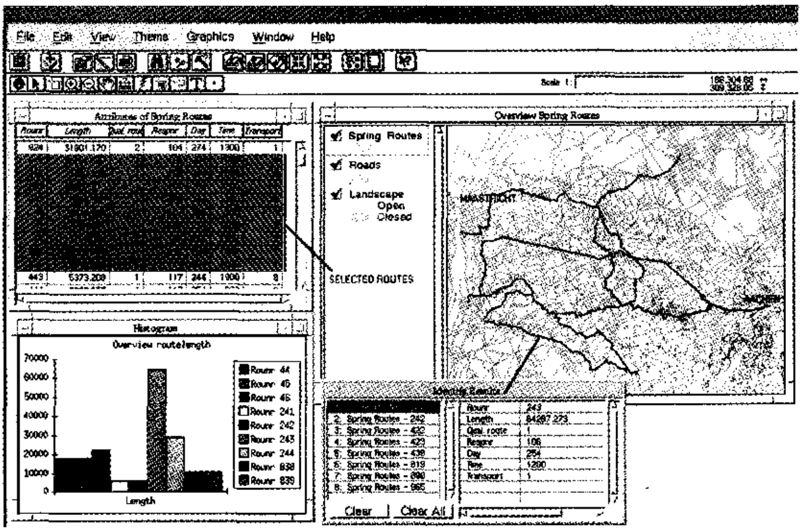


Figure 28 *Examples of interactive functionalities of Arcview 2.1 with route data from the spring survey for the Euregion (April/May 1995)*

sary to wait until the related tables have been searched for the desired selection, the frequencies determined, new relations have been established, and the different windows updated. It is assumed that this process is automated into a dedicated application, otherwise the user has to activate each distinguished step. To date, this method still takes too much time compared with the CDV-TS programme, especially when large data sets are involved. One possible suggestion would be to try to interface the CDV-TS software with the standard ArcView software to accomplish a continuous time series display of the data. The advantage of this construction is that the data base and data structure remain the same and that the CDV-TS programme can be run with the attribute selection of that moment.

When reconstructing route data from the Nette Tal data set into the Arc/Info route data structure, special attention had to be paid to the areas visited. It was not clear which roads and how many roads had been taken in these areas. Therefore, it was impossible to determine the route followed and the time spent in those areas, and assumptions had to be made. For the derived Arc/Info route format, the visits to these areas were abstracted to two straight lines, from one border (or road) to the centre of the area and from the centre of the area to another border (or road), see also Figure 25A. Where roads are taken in combination with the mode of transport, an indication has to be created of the necessary driving time in these areas.

With the Graphic Network Visualizer (GNV) prototype software it is possible to explore, construct, and alter network patterns derived from routes followed. These networks can be queried and the related routes displayed. However, the use of the software is restricted to data available for routes followed. If no routes are available for a certain tourist, the corresponding network cannot be generated. A quick impression of the networks created can be gained when the software is applied, see also Figure 22. Being a prototype, the software is not yet optimized for large data sets. For test purposes only a small selection of routes was used. When the total data set of the Euregion was used, the amount of time required to generate maps and networks was unacceptable. In combination with selections made using an ArcView application, the GNV software is suitable for displaying and characterizing the derived network pattern, and altering the shape of the network by moving the nodes around to obtain a better impression of the network pattern.

6.6 Network Construction and Interpretation

6.6.1 Introduction

The second step in the data processing, described in the methodology framework, focuses on the development and description of the observed relationships between the distinguished tourist time-space elements. It was assumed that these relationships and elements could be abstracted to several network structures. These networks consist of nodes and links, each with their own meaning and character. The shape of a network is judged to be important, but a network is also characterized by its spatial composition. The composition can be described in various ways, including the number of links per node, the distance between the nodes, the quality and meaning of nodes and links, the changes over time and season, and the juxtaposition of the nodes. During a stay in a region, almost all tourists create a closed network each day; these tourists always return to their accommodation. A link can be considered to be topological (only the connection is important) or geometrical (either Euclidian, covered or perceived distance). In Section 4.3, different morphologic types of network structures were presented.

Networks can be abstracted from a supply and demand perspective. A network described from a supply perspective consists mainly of the physical elements of a landscape, roads, attractions, facilities, accommodations, etc. This type of network abstraction is characterized as a physical network type. A tourist product network consists of the coding added to all the elements and the connections made by the producers or information suppliers between the (coded) elements. Networks from a demand perspective are created by the tourist: the roads taken, routes followed, locations visited, the perception and experiences added to the different attractions and facilities (landscape and local elements), the use of information and attraction values added, personal constraints, etc. This might offer a range of different network types depending on the characteristics added.

To explore the second processing step, the functionalities of GIS are evaluated to determine if GIS can be used to construct and classify these types of networks. First, the construction of the different network types will be examined. *In the following section the interpretation of network types is* elucidated. The various network abstractions will be examined mainly from a tourist perspective.

6.6.2 Network Construction

Route Network

From the tourist time-space behaviour data, the locations visited and roads taken are marked as two geographical elements, which can be stored and analysed using GIS. These elements together form the route network. To use the Arc/Info route capabilities, it is necessary to have a continuous path between the elements taken. Within Arc/Info, two tables are used to store route information: one table describes the total route and its characteristics, and the other table describes all the sections of the route. If these elements are known, the routes can be constructed and stored.

Location Network

Location networks are constructed by linking the geographical locations mentioned in the diary, and by abstracting routes taken. The start and end node in the network is the accommodation location. Each new location, point or area element visited or used, results in a Euclidean line, drawn to that location; the geographical position of that location is used as a node in the graph. If the routes followed are not available, the connections have to consist of Euclidean distances, alternatively abstractions of the covered distances can be applied. Six main categories of node locations are distinguished:

- accommodation;
- tourist facilities;
- in and around cities and villages inside a study area;
- forest areas and other non built-up areas;
- cities and villages outside the study area;
- passage points which generally aid the visualization of routes followed.

Figure 29 shows some examples of the appearance of these location networks in combination with a route network. Based on the locations visited

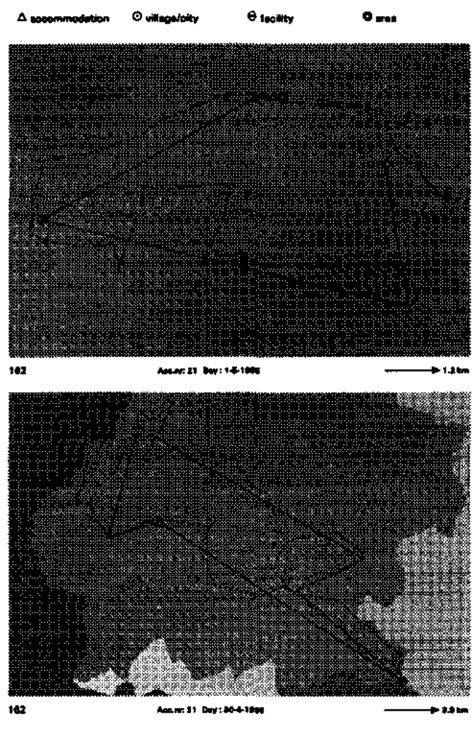


Figure 29 *Examples of representations of routes followed and its abstraction to a (Euclidean) graph*

and, if available, the routes followed, an abstraction is made to obtain a better impression of the use of the area and a description which can be used for comparative purposes. Several passage points were applied to give a visual idea of the routes followed. These can be placed at specific locations. These passage points are not marked with a symbol in the presentation. This type of network is more valuable, if the route descriptions are of ranging quality, see for instance the route descriptions available from the Euregion Maas-Rijn survey. By making abstractions of these route networks into a location network, the individual tourist network patterns can be better compared. Besides distance (Euclidean or covered) other measures can be connected to the links in a location network. Examples include meaning of (parts of) the route followed, or information used. To construct the location networks, a special software programme was created using the Arc/Info Macro Language (AML). This programme uses the diary tables in conjunction with the geometric locations and routes taken to construct a Euclidean network pattern per day for each tourist.

In order to prevent a situation where locations close to each other form a clump in the network pattern (*e.g.* in a forest area or city), new location numbers that represent several locations can be used. These new location numbers are aggregations of the contributing locations and are located more or less in the centre of the contributing locations.

A further abstraction of the tourist time-space behaviour networks can be created by moving the nodes around, as demonstrated in the GNV-prototype software (§ 5.2). Applying this software, the relation with a geographical location, described in X and Y coordinates, is totally ignored. Only the linkages and nodes (and their specific meaning) are important.

Time-Location Diagram

Combinations were made of time and location values in an attempt to understand the coherence between locations visited and time. These diagrams were constructed by plotting time as an X coordinate and the location number as a Y coordinate. A time-location line is obtained for each tourist. Within the GIS Arc/Info, it is possible to store the time-location sequence in the route data structure for each individual tourist. A node is placed at each position, defined by time and location. All these nodes are connected in sequence with a line, and the nodes and lines together are transformed into the route data structure. An example of the line display is presented in Figure 30. The individual time-location path of one day for one tourist is presented in the upper diagram. This diagram gives an impression of a day spent by an individual tourist. The type of locations visited can be derived. Each location type has its own range,

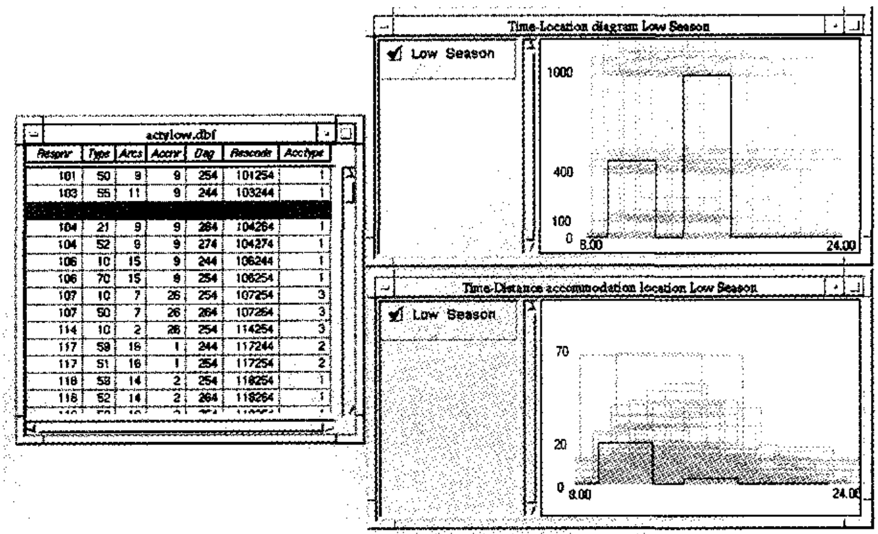


Figure 30 *Example of time-location and time-distance location diagrams for respondent 103 on 25 April 1995*

which is visible in the upper diagram. The accommodation locations (ranging from 1-99) are displayed at the bottom. The next horizontal greyer area represents tourist facility locations (numbered from 100 to 300). The third horizontal greyer area represents the cities and villages (numbered from 400 to 600). The following horizontal lines represent (forest) areas visited (numbered from 1000 to 1200). The uppermost horizontal lines represent the cities and villages outside the study area (numbered from 2000). When this diagram is displayed in combination with the geographical locations and landscape types on a related map, it is comparable with the Hägerstrand presentation (Figure 7). The difference is that the type of presentation shown in Figure 30 provides an opportunity to query the map, the diagram and the related tables in combination. New displays can be instantly generated.

By storing the time and location data in the route data structure, it is possible to query related locations over time or related time moments at specific locations. It is also possible to determine what has happened before or after a specific location was visited as well as before or after a particular moment of time. The same method can be applied for activity-time combinations and activity-location combinations.

Time-Distance Location Diagram

Another combination possibility is to use the distance between a location and the accommodation. This gives an impression of the distance range covered by each individual tourist. The distance between the accommodation and the location visited is put on the Y-axis of the graph. Time or activity code is put on the other axis depending on the type of relationship to be examined. This creates a time by distance-location diagram or an activity by distance-location diagram. The lower diagram in Figure 30 illustrates a time-distance combination for one tourist. A Euclidean distance between location and accommodation was calculated, but distance covered, if available as routes followed, can also be applied or a shortest distance using the road structure can be calculated.

6.6.3 Network Interpretation

Route Network

Within Arc/Info, there are ample opportunities to query the (connected) route data. A few examples of these queries are presented in Table 7. However, they do not consider the time and context aspects as an indivisible part of the (geographical) space aspect, because these are difficult to abstract and store into current GIS.

Table 7 Examples of GIS queries on available tourist route network data

- *selected routes or sections can be queried - who used these? - or the other way around - which tourists used what roads? -;*
- *determine frequencies of use per road section;*
- *relationships (overlays) between landscape and (selected) routes can be made, what sort of landscape is appreciated?, Are there any landscape elements that influence time-space behaviour?;*
- *what routes or paths are taken from a specific location (accommodation or attraction);*
- *what other routes could have been taken, given different constraints and considerations?, How easy is it to construct other routes?*

In order to gain an impression of the tourist use of the Euregion area in relation to the time-space behaviour, the routes followed are projected onto the road structure. A landscape map may be used as a background map to relate routes followed to specific landscape typologies. For each distinguishable road section, a use frequency is determined from the routes selected and this frequency is displayed using a specific line colour and line width for that road section. Different selections of tourist variables can be chosen to determine what routes, or road sections, were followed. For example, a selection of routes with a high quality, routes sketched well on a map, combined with the appraisal both of the day and of the route, can be overlayed with a landscape typology. This results in new displays, based on intensity of use, appreciation and landscape.

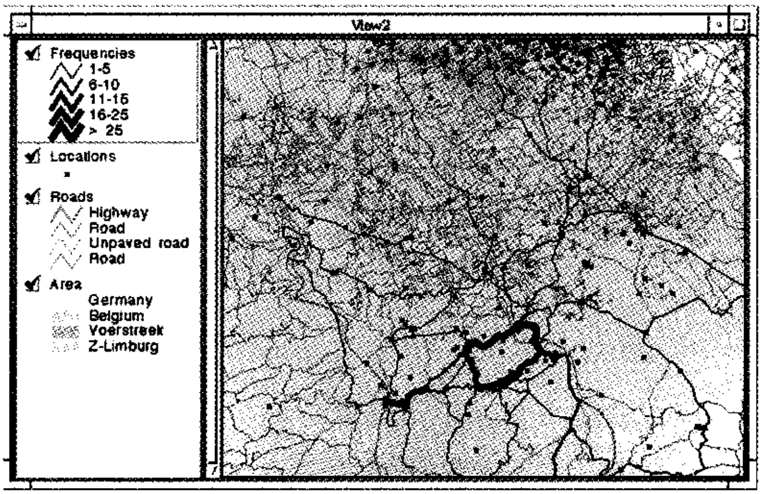


Figure 31 *The use frequency of roads chosen by tourists from accommodation 56, a camp site in Belgium*

A few examples of the intensity of use of the road network are presented in Figure 31 and Figure 32. Corresponding routes are presented for two different types of accommodation, a camp site in Belgium and a holiday park in the Netherlands. There are significant differences in use of the area: a strong local pattern for the Belgian location, with only a few longer trips to cities, such as Maastricht and Liège (Figure 31), and a more widespread pattern from the Dutch location, with several visits to various places further away (Figure 32).

Location Network

Different network patterns describing tourist behaviour were distinguished in Figure 17. These network typologies are especially useful for characterizing the location networks. If the tourist only stays at the accommodation, this is judged as a point pattern. If the tourist visits one location (or undertakes one

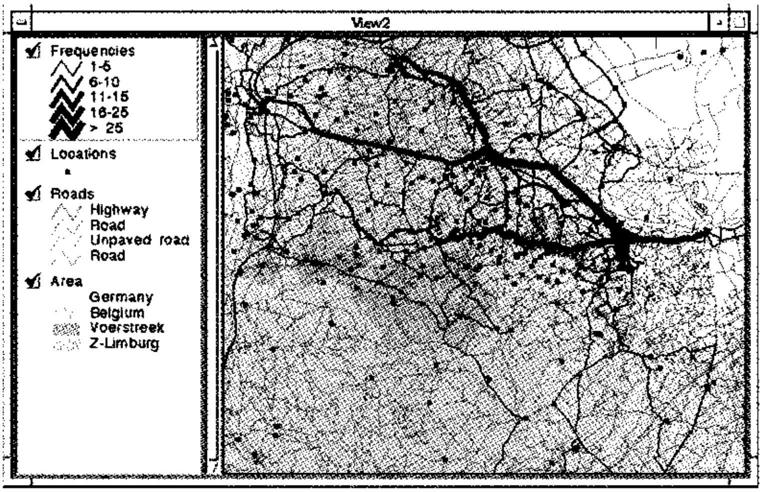


Figure 32 *The use frequency of roads chosen by tourists from accommodation 9, a holiday park in the Netherlands*

activity) outside the accommodation this is regarded a linear (line) pattern type. Visiting more than one location or undertaking several activities in sequence, before returning to the accommodation using the same path, is described as a necklace pattern type. By going to different locations and returning each time to the accommodation, a dendrite or spider pattern type is constructed, depending on the number of returns.

The line, necklace, dendrite and spider patterns all have linear characteristics. The same route (connection) is used to return. Choosing different paths as a connection, a ring pattern is created. The ring pattern can be encountered in various configurations: a single ring, a ring with one or more dendrites (or necklaces) connected to it (the dendring pattern), or multiple rings with possible dendrites connected. Touring in a region without visiting a specific attraction or location outside the circular route is judged as a single ring pattern. It is the same pattern as a necklace, but in the ring pattern the return path does not go over the same roads. With the dendring or multiple ring different 'side-paths' are made during the circular pattern before returning to the accommodation address, *e.g.* to visit a special location or attraction or to wander in a forest.

A factor related to network analysis is the differences in the meaning of a node. There are nodes in the different networks that are at the same geographical location, for example the accommodation location as a start and end node in each individual network. Although these nodes are spatially the same, they can have a different significance in each network. Other nodes might only be important in specific networks, *e.g.* an information sign or a characteristic landscape element in an information network. This leads to a more detailed set of the morphologic pattern types. In Figure 33, examples of a further specification of the dendrite and ring pattern types are presented. The accom-

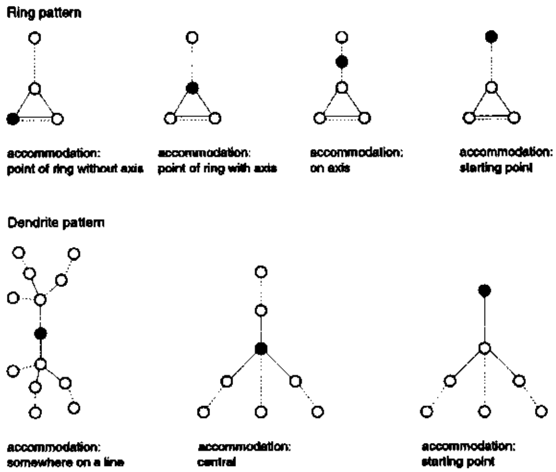


Figure 33 *Examples of the morphological pattern types ring and dendrite, in which the position of the accommodation is important*

modation is either located at the starting point from which different paths originate, or is located centrally in the constructed network type with or without one or more 'side-paths', or it can be located somewhere in between.

To determine what type of morphologic pattern each tourist has constructed during a day or over several days, a software programme was developed using the Arc/Info Macro Language (AML). A visual interpretation and characterization of the pattern can be made with this programme. First, the location network is presented, together with the different classified nodes and regions, and, if available, the routes followed. Figure 34 shows an example of this presentation. These presentations can be displayed on screen or made on paper, according to the user's wishes. After the pattern is displayed on screen, the programme asks the researcher to characterize the network with a morphologic pattern type number. This pattern judgement is then stored

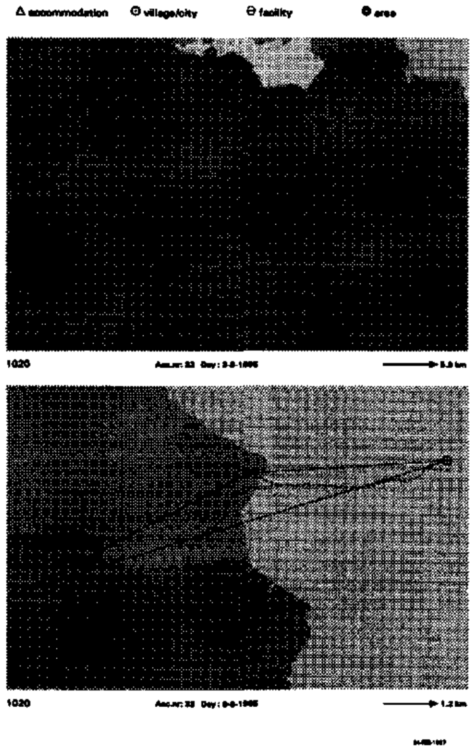


Figure 34 Example of a location network in combination with routes followed

for later analysis, together with information about the number of days and the accommodation location for which the pattern is constructed.

For each location network, the number, meaning, and contribution of the distinguished node categories (see § 6.6.2) can be evaluated. The distances, transport mode, and meaning derived from the tourist's evaluation, which can be added to the links, can also be considered. The time stayed at a location or the amount of different activities can indicate the importance of that location. The time of the day, the day in the holiday period, or the season in which the visit took place can also be taken into consideration to determine the relative importance of the node and link.

All the location networks constructed were typified for the Euregion data set, based on an adapted morphological pattern typology in which the position of the accommodation location was taken into account. Table 8 presents an overview of the distribution of network types for the general pattern typology (presented in Figure 17) and for the adapted specifications based on position of the accommodation location in the network (see Figure 33). The network

Table 8 Distribution of network patterns describing a tourist day, for the Euregion data set. The position of the accommodation location in the network is considered

Network Pattern	***Position of Accommodation Location***			
	Ignored	***Line start***	***Central***	***Ring point***
Line	*208*	*208*	-	-
Necklace	*98*	*29*	*69*	-
Dendrite	*13*	*5*	*8*	-
Ring	*178*	-	-	*178*
Dendring	*236*	*45*	*178*	*13*
Multiple ring	*131*	*1*	*84*	*46*
Total	*864*	*288*	*339*	*237*

Line Start : position of accommodation location is first point of a line network pattern.
Central : position of accommodation location is central in the network pattern from where different axes appear.
Ring Point : position of accommodation location is somewhere in the ring of a ring network pattern.

typology presented is made for each diary day, a day typology. It is also possible to create a typology based on the data available for each tourist, a tourist typology, or even per season. Given each typology, the distribution over each location network type distinguished can be determined. Comparisons can be made by relating Euclidean distances crossed to the metric distances of the routes followed. In addition to the distances between locations visited or passed, the links created can be based on other variables, such as information use or an appreciation value of activity, movement or landscape. This leads to another representation and interpretation of the network.

Time-Location Diagram

The diagrams created between separate variables, such as time and location number, or time and distance between locations visited and accommodation, are visualized and queried with the aid of the network programme of Arc/Info and ArcView. Figure 35 gives examples of these combinations: the time-space behaviour of tourists from accommodation location number 9 is displayed

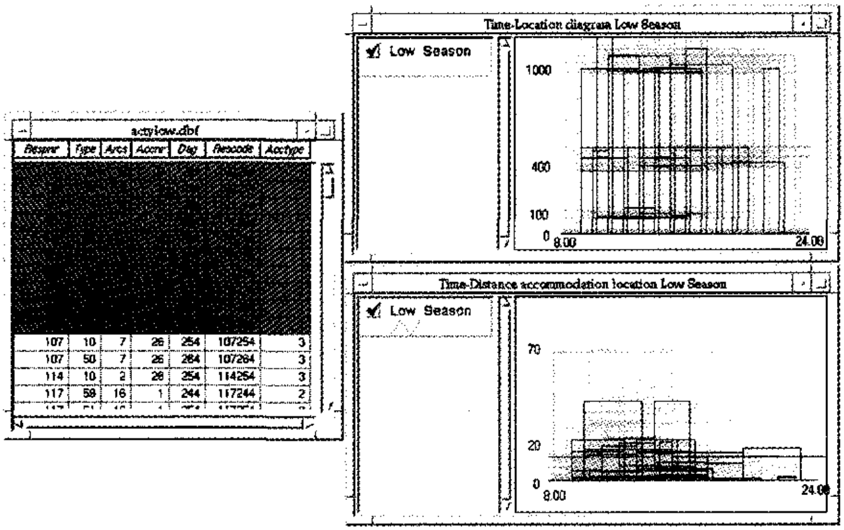


Figure 35 *Example of time-location and time-distance location diagrams for tourists from accommodation number 9*

between 8.00 and 24.00 on the X-axis. Differences in types of location visited during a day are presented in the upper diagram; in this figure the visits are mainly restricted to facility locations (numbered from 100 to 300) and cities or villages (numbered from 400 to 600). Most of the visits take place around 12. The (Euclidean) distance covered from the accommodation can also be seen (in the lower diagram). This indicates that most visits were made not too far away from the accommodation location (within 25 km), with a few exceptions.

The storage of the data for these diagrams in the route data model of Arc/Info offers the opportunity to query graphically the diagrams combined with the related tourist data tables. When links are established between the diagrams and the routes followed, these routes can also be incorporated into the analysis. Figure 35 illustrates how the diagram and the related tables can be queried to determine what relationships were created between several locations and activities and how these locations and activities were evaluated by the tourist.

Some Concluding Remarks

The diagrams, data tables, location networks and routes followed can be analysed separately or in combination with every possible relationship that might be thought of between variables in time, space and context. Figure 36 provides an example illustrating how time-distance diagrams are related to location networks and routes followed in order to determine the locations visited and distances covered. The storage of different combinations of

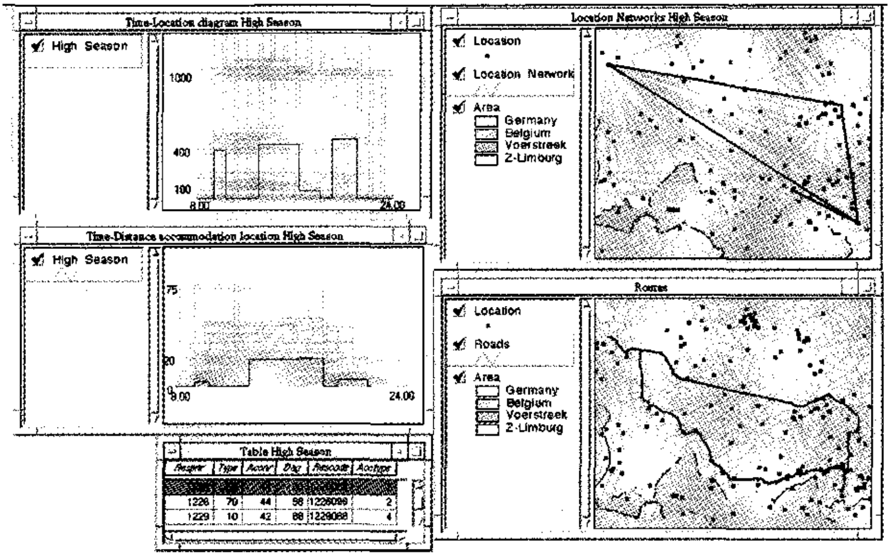


Figure 36 *Example of querying a combination of different networks: time-distance diagram, location network, route network*

variables in a route data format structure offers new opportunities to query time-space oriented data in relation to geographically oriented information. Instead of making a slide show of static presentations of specific intervals or making use of animation through a time variable, the Arc/Info route data construction makes it possible to have a two-way query of time-space related data. A query can be made by selecting one or several records from one of the data tables, or by querying one of the graphic views. It is fairly easy to determine what type of location which tourists visit after a particular location, how much time they spent at these other locations, what the corresponding appreciation value is, and the type of morphologic network pattern to which this selected location belongs. By linking up other data tables, *e.g.* on the accommodation type or a tourist typology, other selections can be made. The graphic query can have any shape, from a point to a many-sided polygon. The linkage established between the different data tables and graphic views offers the opportunity to determine the various relationships between space, time and context.

A disadvantage of ArcView, at least for software version 2.1, is its inability to display the linkages created between the different data tables and graphic views. It is up to the creator of an application to keep up, mostly on paper, with the linkages made. To date, it is not possible to derive the linkages created into a data table relation diagram, which can be used to determine what kind of linkages are made and thus what selections can be made. It would be very handy to have such a data table diagram available during analysis, especially when more complicated applications are used. It could function as a kind of guide and assist in indicating the various selection possibilities and the interpretation of the results. The relationships are already stored in the system, so it should be easy for the ArcView software developers to derive and display this information.

6.7 Tourist Opportunity Structure

Up to now the tourist recreation complex has been considered from an individual perspective. However, it is also possible to examine complexes from a regional perspective. A regional tourist network describes how a region is used by several tourists and how opportunities can be made available to the tourists. It gives an idea of the coherence of the regional tourist recreational products. The regional networks can be mainly regarded as supply-oriented networks, especially when the relationships with landscape and landscape elements are considered. A product supplier can have a perfect product, but if other products in the area are slowly deteriorating or no longer of interest, business will decline. These networks can also be typified as a regional tourist opportunity structure.

The regional network can be created by combining and clustering individual tourist complexes (see also 2.5 and Figure 5). The individual complexes constructed form the input for a regional level network. To declare each individual complex as a network on a regional level is not of much use, as it does not give insight into the use of a region as a whole and the interaction between landscape elements and tourists or tourist groups. It will not reveal a pattern. There is little chance that an individual path will change when it coincides with a path of another tourist at a specific location or vertex. In other words, the path of tourist A will hardly be influenced by tourist B at that location, unless they exchange information at that location about their earlier experiences. The diversity of individual tourist networks examined at a regional level usually results in a connected structure, whereby elements of different individual complexes are combined. There can be individual complexes that do not have connections to other individual complexes which make the regional network fragmented. If there are many such fragments, the producers have to worry about the regional coherence of their products, whether the regional tourist opportunity structure is still sound.

To examine the regional networks, the individual complexes can be generalized and aggregated to the regional level, using the thematic and geometry aspects of the point, line and polygon objects. Molenaar (1993) describes how to deal with the process of generalization and aggregation of objects. In addition to the generalization and aggregation of the tourist complexes, the product elements can also be associated into a cluster of tourist recreation products (Dietvorst, 1993b). These associations are more loosely coupled groups of objects. A cluster is a spatial concentration of tourist recreation product elements related to a common spatial characteristic. An example is the cluster 'beach': a spatial concentration of various product elements such as road infrastructure, restaurants, hotels, camp sites and mobile catering that are all located within one kilometre of the seafront. The coherence between a cluster of product elements differs from the coherence in a tourist recreation complex. In the product cluster, the product elements from several producers mostly do not cohere with each other. For tourist complexes the relationships are created through the meaning and experiences of the tourist and are therefore always coherent. The complex construction may coincide with the product cluster, but it might be totally different. The methodology described can help to discover whether there is regional coherence or a lack of coherence. Generalisation and aggregation of the object data can be applied to take the analysis a step further.

Generalisation

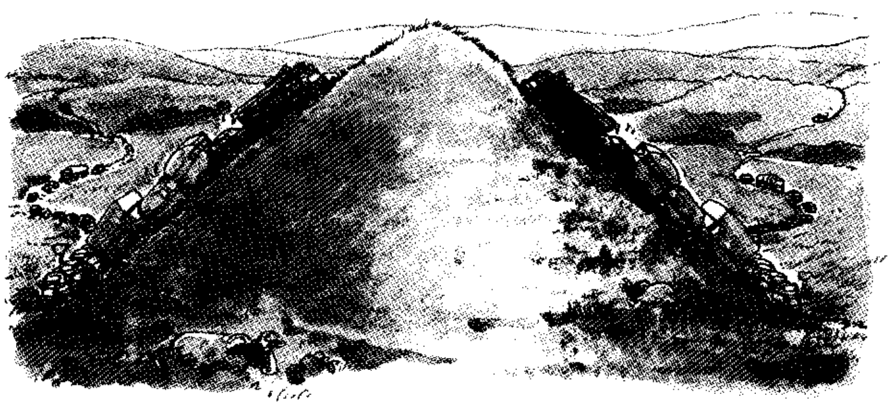
Generalisation is the process of joining separate classes to form new (super) classes; the thematic aspects of a geographical object (point, line or polygon) are important. To characterize joint individual networks as a pattern, a significance value, a threshold, must be met. If this value is not reached, based on, *e.g.* routes followed, then a generalization of activities to a higher abstraction level must be made until the required threshold is reached.

The first step in the generalisation process of determining a regional tourist opportunity structure, is to figure out how often two successive activities with a specific link are encountered. The next step is to determine how often combinations of more than two activities can be encountered, and how the most encountered combinations can be described in a network. If it is possible within the required threshold, a third step can be distinguished: the analysis of the meaning of links, such as distance, permeability, conductance and time. Distance can be measured in different ways (de Jong and Ritsema van Eck, 1994): global (Euclidian), covered (the path taken), economic (effort to reach a goal, *e.g.* time or money), perception (including social and psychological distance), and functional (distance is a function of the interaction: high interaction - low distance). The generalisation level reached depends partly on the number of individual networks. Where there is little individual data no generalization can be meaningfully processed.

Aggregation

Aggregation is the process of joining the geometric aspects of objects to new geometric objects. This process is guided according to the specific relative gap between the different stages in the aggregation process. First, the aggregation is accomplished using nearest neighbour analysis of the separate (parts of) routes, locations and related activities. Then an aggregation is established by joining the different objects distinguished to new objects.

An aggregation process starts when no network can be constructed through generalization within a specific threshold. Objects are joined following certain decision rules, *e.g.* locations or parts of routes that are close to each other and have an identical meaning or use. The newly formed objects (nodes and links) can be analysed as a network structure. If this is not satisfactory a new aggregation cycle can be started. The aggregating of routes that were not clearly sketched is an example. These routes were assigned a route quality two (see 6.4.3). The inaccuracy of these routes makes aggregation appropriate. It is possible to create so-called route corridors, which represent the uncertainty. For instance a corridor of 1 kilometre around the existing roads taken may be sufficient. Routes of quality two which fall within this corridor, can be aggregated together so that the corridor represents the route followed.



THE UNIQUE CHARACTER OF SCOTLAND'S ROAD NETWORK
CAN GIVE RISE TO PROBLEMS NOT ENCOUNTERED ELSEWHERE ...

7 DISCUSSION and CONCLUSIONS

Speed is the relation between some change that has to happen and time. So in some way it is a form of time efficiency. ... not always or maybe most of the time the goal is not important, it is the path to the result (E. Manzini, 1996).

7.1 Introduction

The main objective of the research is to develop GIS applications that could contribute to a (better) insight into the many complex and mutual relations which exist in time and space between, on the one hand, the physical and social spatial features within the tourist recreation complex and, on the other hand, the (individual) social cultural characteristics of the tourist. Several steps were taken in an attempt to clarify the objective and to determine how to obtain insight into the concept of a tourist recreation complex. The thesis began with an evaluation of theoretical approaches which could be of use for the elucidation of this concept. The second step was a further examination of GIS for the analysis of a tourist recreation complex. A network approach seemed a promising way to deal with the tourist recreation complex. Furthermore, new cartographic visualization techniques seemed to offer a potential way to explore data related to a tourist recreation complex.

These steps will be discussed in this chapter and evaluated in terms of their contribution to fulfilling the objectives of this thesis. The application of theoretical aspects will be discussed in Section 7.2, followed by a review of the potential of GIS for evaluating a tourist recreation complex (7.3). The network concept and approach, and cartographic visualization are evaluated in Section 7.4. Section 7.5 is devoted to a brief discussion of the application of the methodology developed to analyse data from two case study areas. The chapter closes with some recommendations for the further development of the proposed methodology.

7.2 The Theoretical Framework

Tourists move around a region, visit different attractions and undertake several activities during a stay in an area. To develop and sustain a sound tourist opportunity structure in a tourist region it is important to examine tourist behaviour. Time-space behaviour is an important but underestimated aspect of tourism research. Often only static analyses are made of visitor numbers and the demographic characteristics of tourists. These do not take into account the dynamic flows of tourist movements.

By moving around an area and linking various tourist activities, the tourist constructs a tourist recreation complex. Within this tourist recreation complex three domains are considered to be important: time, space and context. These three domains do not lend themselves to analysis using currently available statistical software, especially where the domains have to be analysed in coherence with each other. Too many combinations of variables are required to derive a statistically sound answer concerning possible relationships. A different analysis methodology is needed to support an approach where the time, space and context domains are integrated.

The tourist recreation complex is described as a system consisting of system elements and the relationships between these elements. This makes it possible to conceptualize the tourist recreation complex as an interwoven structure of several networks. Different types of networks are distinguished that contribute to the construction of a tourist recreation complex. None of these networks prevails or exclusively determines tourist behaviour.

The geometrical aspects of a tourist recreation complex can be examined using a GIS. A data model is derived that describes the salient characteristics of the tourist recreation complex and the relationships between them. The vector data structure best represents the different point, line and area objects distinguished in the observed tourist time-space behaviour. However, these GIS objects are interrelated; none of the objects is regarded as having exclusive significance for the tourist time-space behaviour.

7.3 GIS Opportunities

One of the questions arising from the main objective concerns the potential of GIS for analytical purposes. A tourist combines various components to form an individual tourist experience. This tourist recreation complex should be approached and analysed as far as possible as one object. However, from the point of view of a tourist product supplier, different elements are often regarded as being separate entities. For example, either a scenic castle route, or a forest trail, or a visit to an amusement park is promoted. Combinations of different product elements, created by a supplier, are rare.

GIS is an instrument which is particularly suitable for the analysis of clearly limited physical elements; these elements are easy to describe using geographical measures and can be clearly characterized. The fuzzy boundaries of time-space behaviour, where context is important, make it difficult, but not impossible, to process time-space data using a GIS. Current GIS software can be applied to obtain a static overview and to perform spatial analyses of the use of a region at a certain moment in a specific context.

Some of the existing functionalities of GIS are useful in the analysis process. The storage of time-space data within the GIS data structure is more efficient than the data storage for a statistical application. Only the routes followed have to be stored in the GIS; for statistical applications all roads have to be evaluated as a variable, or a predefined number of location variables per time unit have to be applied. However, the statistical possibilities of current GIS are limited to descriptive forms. A linkage between GIS and statistical software creates a powerful instrument, as in the case of the S-Plus statistical software combined with Arc/Info.

A GIS has hardly any network capabilities to support tourist time-space behaviour analyses. Network pattern recognition and comparison is not possible at all. Nor can network indices be calculated within a GIS. GIS can be used to determine the shortest route and calculate the optimal route between several locations, but these do not seem to be the most important objectives of tourists during their holiday.

Data visualization is used to make patterns in scientific data visible. The presentation module of a GIS for 'static' data display is helpful in the analysis.

Displays are made quickly and parameters can be changed easily. The application of dynamic cartography adds a new dimension to the visualization process: data can be interactively explored for errors and patterns.

To conceptualize and formalize the tourist recreation complex into a data model suitable for GIS handling and analysis, an analysis methodology was proposed. This methodology consists of several steps divided over two phases: data collection and data processing. Within the processing phase three modes were distinguished: exploration, explanation, and prediction and planning. The objective of this thesis limits the processing phase to the opportunities provided by the exploration mode and by the deduction and description part of the explanation mode. Network deduction and examination are considered to be important within these modes. The network characterization and the exploration through data visualization were further elaborated.

7.4 Network Characterization and Visualization

In applying the network concept it is necessary to determine how networks can be characterized. There are specific parameters available to characterize networks, especially concerning network connectivity. To determine the spatial configuration of a network, a new network evaluation parameter is introduced. The morphologic pattern describer seems appropriate to compare different constructed network patterns.

In network analysis one consideration is whether the order in which locations are linked by a tourist is important. Would another decision be made if an amenity were visited earlier or if a specific landmark had been spotted beforehand? The answer is probably yes, but this is difficult, if not impossible, to judge; a decision is usually influenced by the previous one made.

Visualization techniques and dynamic cartography are useful instrument for analysis. An application was developed in cooperation with the University of Leicester (UK), the Cartographic Data Visualizer for Time-Space data (CDV-TS), to determine the possibilities for combining visualization techniques and dynamic cartography. CDV-TS can be used to make a coherent analysis of the use of space, the time distribution, and the context of time-space behaviour. The user can choose the variables, either coherent or separate, to be examined. The interactive possibilities and visualization techniques within the CDV-TS software can be used in many ways to explore the data.

The current generation of commercial GIS software is incapable of dealing with the time domain. Applications were developed to approximate time. Two examples are time-location and time-distance to location diagrams. These diagrams can be examined interactively. It is possible to make an instant evaluation of the time-space paths before or after a selected period. The actual routes chosen (the distance covered) are displayed (to the extent that they are available) simultaneously with the visualization of the selections in the time-location diagrams. In addition to the abstractions of the time-location diagrams, it is possible to construct another view of the location networks. Hypotheses can be formulated about possible linkages between tourist activities, geographical elements and landscape typologies, constructed either by the tourist, the landscape or a producer of a tourist product.

7.5 Case Studies

Two data sets were used to illustrate how the applications and approaches developed can describe a tourist recreation complex in a tourist region. These data sets were applied to determine whether the proposed data model and process model could be made operational. Data were collected from almost 1,000 visitors to a nature reserve park in the Nette Tal in Germany, in May 1992; and from nearly 550 tourists in the Euregion Maas-Rijn, in April and August 1995. The Nette Tal data set was evaluated against the proposed data model. The results were applied for the construction of the Euregion data set.

The CDV-TS software proved to be a useful instrument for the interactive visualization of time-space related data in the case of the Nette Tal data. By selecting different attribute combinations, an overview can be generated quickly, giving insight into the use of a region at different moments in time. The user can instantly examine large data sets for mistakes or unusual values and assumptions. It is also possible to obtain a good impression of the data set and formulate hypotheses about relationships between variables. These hypotheses, however, have to be tested using statistical software. A number of applications were developed within the GIS Arc/Info and the related ArcView software to create several networks, to determine and describe the network characteristics and to present the network abstraction with time-space patterns.

The CDV-TS and the Arc/Info and ArcView applications, offer a wealth of opportunities for the interactive examination of time-space oriented data, and to search for different tourist combinations of products supplied. The user decides what attributes are combined or what relationships are explored. Time-location research can also be carried out using the Arc/Info and ArcView applications. Network abstraction of time-space behaviour can be generated, analysed and compared.

General remarks

For the successful analysis of time-space behaviour, a large amount of data on movements in time and space is needed. The kind of data needed requires much input from interviewees: *e.g.* map reading skills, sketching skills to draw the routes followed on a map, and diary keeping. Also, the processes of data input, data correction and fine tuning are very laborious.

Each application used (CDV-TS, Arc/Info, SPSS) has its own data structure. Data have to be stored in multiple data bases. If an alteration is made in one data base, adjustments have to be made in the other data bases as well. This forms a possible source for errors and can lead to data incoherence if alterations are not made in all the data bases. Ideally there should be one data base from which all the applications can derive the necessary data.

More detailed maps of smaller areas will be necessary to collect information from walkers, especially if large tourist regions are surveyed. Many walkers are skilled in map reading and can easily recollect routes taken. The maps used for the Euregion survey were not detailed enough for the purpose of walkers.

The main drawback of the application of GIS and Dynamic Cartography is the amount of data that has to be processed. One can hold surveys each month, but these have to be short in order to elicit enough response for a reliable result (people are on holiday). Problems arise with route data because many people have difficulties in sketching routes on a topographical map, or in recollecting the routes taken. Entering the data is also a very time-consuming operation. Where only a small number of routes is involved it may be easier to type in the roads chosen, as long as no analysis and presentation in combination with other roads is required. However, for analysis and presentation purposes, it is easier to have the road structure available in digitized form.

The quality of the route sketch is important in order to be able to draw meaningful conclusions. One solution to this problem might be to use Global Positioning Systems (GPS), whereby spatial data can be stored directly in a computer without requiring the tourist's recollection from memory. At the moment, this equipment requires too much technical knowledge to make it suitable for use by tourists; however, technical developments may make GPS more user friendly in the near future, and thus suitable for tourist time-space research. These are discussed further in Section 7.6.

7.6 Recommendations for Future Research

This study has offered new insights into the ways in which GIS can lend support to the analysis of tourist time-space behaviour. Several aspects of tourist behaviour and how to describe these aspects have been discussed. Some solutions have been suggested to tackle the topic of conceptualizing and formalizing the notion of the tourist recreation complex in such a way that GIS related techniques and instruments can be used. The result offers a by no means complete spectrum of all opportunities available. Furthermore, new research questions and topics arise from the results presented here. These include the conceptualization of the notion of the tourist recreation complex and tourist time-space behaviour into a data model, the technological opportunities and current application of techniques and instruments for the analysis of tourist time-space behaviour and the required data, and the means to sustain a better planning process. In this concluding section, several questions and issues related to these aspects will be highlighted.

Notion of the Tourist Recreation Complex

Outlining the time-space behaviour of tourists in relation to the landscape and tourist products was a useful first step in conceptualizing the creation of a tourist recreation complex. However, the influence of the landscape in a tourist region for the tourist choice process was not examined. It might be possible that specific landscape types influence tourist choice behaviour, either before going to or during a stay in a specific region. It seems difficult to quantify landscape perceptions in such a way that they could be taken into account in the analysis. It might be possible to tackle the problem by applying more landscape describers.

A second aspect of the construction of tourist recreation complexes concerns where and how the tourist gathers information to back up the decision-making process within time-space behaviour. Developments in the application of information technology, such as the commercialization of the Internet with World Wide Web applications, might substantially influence decisions concerning where to go and what places to visit, and thus lead to different tourist time-space behaviour. Text, graphics, video display and sound provide a range of possibilities for creating new images of a region and its amenities.

A third aspect in the formalization of tourist time-space behaviour is the sequence of activities. This sequence was supposed to be of no importance in constructing tourist recreation complexes. However, this assumption requires further exploration. The awareness space, the (spatial) knowledge of the area visited, influences the choices made and may influence the connections perceived between components.

Methodology and Network

The methodology presented gives rise to various other research questions. For instance, if patterns of behaviour can be described and interpreted, can these patterns be modelled for simulation programmes that would help tourists in deciding what places to visit, which activities to undertake, or to determine which routes can be taken? Can these simulation programmes be applied for planning purposes in tourism regions, to decide where new tourist locations can be developed and maintain coherence in observed patterns of tourist behaviour? Following on from these research questions, to what extent can GIS accessibility functionalities be used to simulate tourist behaviour? These are just a few new research issues that arise from the results of the methodology presented.

Regarding the network parameters, several other issues can be raised. These include the way in which resistance can be added to the links in a network, especially where there is a non-metric completion of these links, *e.g.* with information knowledge, an appreciation value, or typology of the landscape. Another issue not dealt with in this thesis, concerns the in and out values of c_i, d_i, p_i and s_i that were determined in the matrix calculations. These values were mentioned in the matrix based parameters for network description, but were not worked out. These in and out values, however, seem to form a promising describer for the role of locations in tourist recreation complexes and tourist behaviour, especially because there is so much information available about tourist behaviour within a region.

In the process of abstracting routes followed to links in location networks, 'passage points' were introduced as nodes. These nodes are functional for the abstraction of the touring activity of tourists. At present these points are located by hand, based on a visualization of the routes followed. However, since the geometries of the routes are available it must be possible to automate this abstraction process. Decision-making rules need to be formulated to determine where these passage points should be located geometrically. This constitutes perhaps a considerable challenge.

Regarding data one might wonder if it is possible to integrate the mental maps created of a tourism region into GIS analysis. During a stay in a region, tourists develop their own mental map of the region. Because this map plays an important role in the decision-making process, it should be part of the reconstruction of a tourist recreation complex. On the other hand, one might ask whether it is possible to approximate the mental maps of tourists, based on the information gathered from diaries and route descriptions.

Technological Developments

One technological development, which is related to data collection, is the application of Global Positioning Systems (GPS) in recording tourist time-space behaviour. Up to now this has been done in a time-consuming way by asking tourists to describe and sketch on a map the various roads taken and places visited during a day. Furthermore processing and checking the data are laborious tasks. In the near future it will be easy to use GPS to record spatial data, but it is not clear whether it will be possible to achieve interactive registration of appreciation and judgements at the same time? This information is considered to be valuable for reconstructing a tourist recreation complex because it represents part of the linkages made between the tourist product elements visited.

If the GPS option cannot yet be applied when reconstructing routes taken, another option might be suitable. It should be possible to reconstruct routes based on an indication of just a few important locations and roads obtained from diary data. Such an indication should consist of a few (main) road numbers and location identifiers. The routes can then be reconstructed by applying shortest route algorithms. The indication of importance depends on decisions made at specific locations and it relies totally on the tourist and what the tourist considers to be important. However, it will reduce the difficulties encountered in sketching roads followed on a map.

A second technological development that has to be taken into account concerns the prospects provided by video film and multimedia techniques. Can these techniques be applied in the analysis process to supplement dynamic cartography? The introduction of more dynamic elements in the analysis of movements might create even better insights into the many mutual relationships existing in time and space between, on the one hand, the physical and social spatial features within the tourist recreation complex and, on the other hand, the (individual) social and cultural characteristics of the tourist.

Furthermore, it must be possible to link the CDV-TS software to the ArcView data base. This would offer a more powerful instrument for processing time-space related data. The data base would remain coherent and no interfaces would be necessary. The user or data-analyst would be able to make use of the benefits of the two software systems in an integrated structure. This is a more technical research topic for the realm of computer programming.

The findings presented here are largely based on road structure, where many choices are available. This raises the question of to what extent the instruments developed will be of use in situations where these predefined paths are no longer available, *e.g.* for tourist activities in areas of water or desert. For instance, with the CDV-TS software, the use of a region at specific moments is partly indicated by the intensity per road segment or line object. Where no direct line objects are available, there might be still geometric locations that can be used, *e.g.* harbour locations, or line objects which have to be created.

Planning and Monitoring

A final question arising from the results of this thesis, concerns the potential for applying the methodology developed for monitoring and planning of tourist opportunity structures in a region. Do the formalization of the notion of the tourist recreation complex, the abstraction obtained from the tourist behaviour data and the evaluation offer enough starting-points for planning purposes? Dynamic Cartography is very useful for exploring spatial data sets. Therefore, it could also play a role in managing the regional development of a tourist recreational product and the development of a tourist opportunity structure. Using data from different years and months, the researcher can rapidly produce an impression of the changes in the use of the region. The CDV-TS instrument is also useful for planning purposes: How do different tourist groups use the region? How can conflicts be avoided by making changes in the landscape or by using information material? How can the stream of visitors be steered? A comparison between different regions can be made: How do tourists (or their representative subclass) behave and use the environment? It could also be a useful for creating a stronger regional tourist product where it is important to know how tourists combine separate elements and what is likely to happen if a component decays.

In addition to the prospects provided by CDV-TS software for monitoring purposes, the network parameters may also be suitable for more general application in the planning process. Various networks can be distinguished, related to different participants involved in (regional) development and planning. All these networks have to be characterized in order to be able to compare them and determine their meaning in a region for a specific participant. The parameters described and applied in this thesis might offer a basis for this typology of the networks.

The various applications described provide ample opportunities for use in tourist recreation product development. However, most of these applications require a large amount of data. Even where only general diary data describing the locations visited and time spent are available, a reasonable spatial impression of the use of a region and of the various product elements can already be obtained. If more data are available, such as specific person-related data, more detailed overviews and insights can be generated. If better data on routes followed can be obtained, either by using sketches on a map or applying GPS, even better analyses of the use of a region can be made.

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APPENDIX 1 Elementary parameters describing the whole network: index, bounds and interpretation

(*cf.* Kansky, 1963; Taaffe and Gauthier, 1973; Haggett *et al.*, 1977; Selkirk, 1982)

TOPOLOGICAL APPROACH

(1) α-index for planar graphs

$$\alpha = \frac{e - v + g}{2v - 5} \qquad 0 \leq \alpha \leq 1$$

α-index for non-planar graphs

$$\alpha = \frac{e - v + g}{\frac{1}{2}(v-1)(v-2)} \qquad 0 \leq \alpha \leq 1$$

$\alpha \times 100\%$	is an interpretation of the value as 'per cent redundancy'
$\alpha = 0$	indicates a ramified network or a (minimum-spanning) tree (0% redundancy)
$\alpha = 1$	indicates a completely connected network (100% redundancy)

(2) β-index for planar and non-planar graphs

$$\beta = \frac{e}{v}$$

$0 \leq \beta \leq \frac{1}{2}(v-1)$ (non-planar graphs)

$0 \leq \beta \leq 3$ (planar graphs)

$0 < \beta < 1$	indicates branching and non-connected networks
$\beta = 1$	the network has only one circuit
$1 < \beta < \frac{1}{2}(v-1)$	indicates complex networks

(3) γ-index for planar graphs

$$\gamma = \frac{e}{e^{max}} = \frac{e}{3(v-2)} \qquad 0 \leq \gamma \leq 1$$

γ-index for non-planar graphs

$$\gamma = \frac{e}{\frac{1}{2}v(v-1)} \qquad 0 \leq \gamma \leq 1$$

$\gamma \times 100\%$	is an interpretation of the value as 'per cent connectivity'
$\gamma = 0$	no node is connected to another node (0% connectivity)
$\gamma = 1$	indicates a completely connected network (100% connectivity)

(4) δ-index for planar and non-planar graphs

$$\delta = Max\,(\sum_{i=1}^{v}\sum_{j=1}^{v} d_{ij}) \qquad 1 \leq \delta \leq (v-1)$$

δ is the minimum numbers of edges between the two most distant vertices in the graph

(5) μ-index for planar and non-planar graphs

$$\mu = e - v + g$$

$0 \leq \mu \leq ½(v-1)(v-2)$	(non-planar graphs)
$0 \leq \mu \leq 2v-5$	(planar graphs $v > 3$)
$\mu = 0$	for branching networks and non-connected graphs

high values of μ indicate more complex networks

GEOMETRIC APPROACH

(6) η-index for planar and non-planar graphs

$$\eta = \frac{\sum_{i=1}^{e} w_i}{e} \qquad \eta \text{ is the average edge length}$$

(7) θ-index for planar and non-planar graphs

$$\theta = \frac{\sum_{i=1}^{e} w_i}{v} \qquad \theta \text{ is the average edge length per vertex}$$

(8) ι-index for planar and non-planar graphs

$$\iota = \frac{\sum_{i=1}^{e} w_i}{s_i v_i}$$

(9) π-index for planar and non-planar graphs

$$\pi = \frac{\sum_{i=1}^{e} w_i}{w_\delta}$$

low values of π indicate a linear network connecting all vertices
high values of π for more complete circuit networks

π is meaningless for non-connected networks

- e is the number of edges E(G)
- v is the number of vertices V(G)
- g is the number of subgraphs G(V,E) (connected graph $g = 1$)
- w_δ is the weighted distance of δ
- s_i is the scalar for determining the ι-index (c_i is used: the vertex degree following connectivity matrix C)

SAMENVATTING

De Wegen en Drijfveren van een Toerist;
GIS georiënteerde methodieken om toeristisch recreatieve complexen te analyseren.

Achtergrond

Toeristen ondernemen tijdens een vakantiedag veel verschillende activiteiten, zoals: opstaan en ontbijten, winkelen, terrasje pakken, even rond wandelen, lunchen, een attractie of pretpark of iets dergelijks bezoeken, daarna terug toerend met de auto of de fiets, uit eten, etc. Een hele reeks van verschillende mogelijkheden wordt zo aan elkaar geregen tot een eigen vakantiedag. Patronen zijn niet vast, meestal wordt er ter plekke iets bedacht. Elke activiteit heeft ook een bepaalde tijdsduur, vindt op specifieke locaties plaats en heeft een eigen waardering. Daarbij wordt elke activiteit op enigerlei wijze verbonden met de voorafgaande activiteiten en ervaringen. Dit koppelen van tijdsbesteding, ruimtegebruik en ervaringen is belangrijk. Dietvorst heeft dit combinatie-gedrag benoemd als toeristisch recreatief complex. Een integraal beeld over het combinatie-gedrag, het ruimtelijk keuzegedrag van en de waardering door toeristen tijdens hun vakantie, was tot nu niet goed te reconstrueren en te analyseren. Om de toeristenstromen beter te begrijpen, te sturen en te begeleiden, is het echter noodzakelijk om het gedrag van toeristen in tijd en ruimte te achterhalen.

Iedereen ontwikkelt en vergroot tijdens zijn vakantie een toeristisch recreatief complex. Het combinatie-gedrag bepaalt voor een groot deel het succes van een vakantie en derhalve ook het herhaal-bezoek in de regio. Drie domeinen zijn hierbij belangrijk: de ruimte, de tijd en de context waarin de activiteiten plaatsvinden. De onderliggende elementen bestaan uit:

1) de toerist en zijn karakteristieken,
2) de interpretatie van de omgeving en het vertoonde tijd-ruimte gedrag, en
3) het toeristisch recreatief product + aangebrachte coderingen, in samenhang met de elementen van het landschap.

Deze onderliggende elementen dienen vanuit de domeinen tijd, ruimte en context op verbinding, interactie en sturing te worden geanalyseerd. De ruimte-component wordt gevormd door locaties die bezocht worden, zoals steden, dorpen en attractielocaties, en uit gekozen wegen en gevolgde (toeristische) routes; hierdoor ontstaan toeristische route patronen. Onder de context-component is een aantal toerist gebonden aspecten te onderscheiden, zoals de ondernomen activiteit, met wie, de waardering en beleving van de activiteit, de attractiewaarde en het gebruik van informatie-bronnen hierbij. De tijds-component is inherent aanwezig bij beide andere componenten als een historische bepaling en als een hoeveelheid tijd die aan de verschillende onderdelen wordt besteed.

De verschillende elementen, zoals tijdsbesteding, waardering of voorzieningen-bezoek, werden tot nu toe apart onderzocht: vaak statistisch voor verschillende persoons-gebonden gegevens, of alleen het mogelijke ruimtegebruik via kortste route bepalingen of analyses van bereikbaarheid. Een analyse van tijd, ruimte en context gegevens via alleen een statistische weg schiet te kort door een grote hoeveelheid ballast die in de analyse geen functie vervult, maar door het statistische analyse systeem wel wordt vereist. Bij een statistisch verwerking dienen voor alle variabelen per case waarden bekend te zijn, wat vaak leidt tot veel nul-waarden. Wanneer daarbij ook de verschillende mogelijke wegen als ondergrond voor gevolgde routes wordt betrokken, wordt de omvang van de gegevens totaal onoverzichtelijk en zijn de gegevens niet meer statistisch te analyseren.

Een andere methode om tijd-ruimte gegevens te analyseren en presenteren heeft Hägerstrand ontwikkeld. Per tijdseenheid is ruimtelijk aangegeven waar een persoon zich bevindt. Nadelen hiervan zijn, dat er per toerist een dergelijk diagram ontwikkeld moet worden, dat het diagram bij meer personen al snel onoverzichtelijk wordt en dat het diagram niet geschikt is om snel in grote aantallen in samenhang te analyseren. Met de huidige Geografische Informatie Systemen (GIS) is in ieder geval een ruimtelijke analyse te maken; het is op dit moment nog een probleem om tijd dynamisch op te nemen in de analyse. Met name bij onderzoek naar het toeristisch tijd-ruimte gedrag blijkt de dynamiek van de tijd lastig via alleen huidige GIS-functionaliteiten op te lossen. Met het toepassen van GIS-georiënteerde systemen in combinatie met statistische software is een combinatie van verwerken (exploratie en explicatie van ruimtegebruik) en presenteren te bereiken, welke geschikt lijkt om het toeristisch tijd-ruimte gedrag te analyseren. Het gaat hier duidelijk niet over kortste route bepalingen tussen locaties of bereikbaarheid binnen een bepaalde afstand of tijd. Dergelijke overwegingen spelen tijdens een vakantie een veel minder belangrijke rol.

Methodologie
Het lijkt mogelijk om het toeristisch recreatief complex via een netwerk analogie te beschrijven. Hiermee zijn onderlinge relaties en verbindingen te karakteriseren. Toeristen creëren via het aanwenden van verschillende typen van netwerken een eigen specifiek toeristisch tijd-ruimte gedrag. Geen enkel netwerk bepaalt alleen het uiteindelijk waargenomen gedrag; de verschillende netwerken beïnvloeden elkaar continu.

Er is een aantal mogelijkheden opgesteld om tijd en context in samenhang met ruimtelijke informatie te beschrijven, verdeeld over twee stappen:

1) verzamelen en opslaan van gegevens:
   - van elementen van belang voor toeristisch recreatieve activiteiten, zoals het wegen-netwerk, accommodaties, locaties van attracties, landschapsbepalers, uitgezette toertochten, etc.
   - van toeristen, zoals de gevolgde routes, kenmerken van de toerist, beperkingen, waarderingen, etc.
2) verwerken van de gegevens via:
   - exploratie; verkrijgen van inzicht in de samenhang van mogelijke netwerken via exploratory spatial data analysis technieken;
   - explicatie; afleiden en beschrijven van mogelijke toeristische recreatieve complexen; bepalen van clusters en netwerken van toeristische producten; gebruiken van patroon beschrijvers en bereikbaarheid analyses om locaties en verbindingen te classificeren.
   - voorspelling en planning; ontdekken met behulp van de resultaten mogelijke ontwikkelingskansen, verschuivingen in gebruik, zwakke plekken in een gebied, mogelijke conflictpunten, en dergelijke.

De exploratieve en explicatieve fase van de verwerking van de gegevens zijn verder uitgewerkt.

De exploratieve fase kan plaats vinden via interactief visualiseren van tijdruimtegebruik met behulp van 'Cartographic Data Visualization for Time-Space data', het CDV-TS programma. Met het CDV-TS programma is via het selecteren van verschillende attribuut combinaties (of context beschrijvers) van gegevens direct een overzicht en inzicht te krijgen over het ruimtegebruik van de geselecteerde toeristen op verschillende tijdstippen en met verschillende karakteristieken. De gebruiker kan daarnaast grote data sets snel onderzoeken op fouten en vooroordelen. Ook kan snel bepaald worden wat de aard van de gegevens is en kunnen verschillende hypothesen geformuleerd worden.

De tweede fase, het verklaren van mogelijke verbanden tussen de gegevens, kan plaatsvinden via interactief onderzoeken van geconstrueerde netwerken over de samenhang tussen bijvoorbeeld tijd, activiteiten, informatiegebruik en waardering. Om deze samenhangen af te leiden en te beschrijven zijn ArcView applicaties ontwikkeld. In deze tweede fase van gegevens verwerking wordt een aantal GIS-functionaliteiten gecombineerd. Van de gevolgde routes per selectie is een frequentie overzicht te maken: hoeveel toeristen bevinden zich op welke tijdstippen op welke wegen of hoe is het ruimtegebruik van toeristen vanaf een kampeerplaats versus toeristen vanaf een bungalowpark. Bij deze toepassing is gedetailleerde informatie nodig over gevolgde routes, alle gevolgde wegen moeten bekend zijn. Het is echter ook mogelijk om op basis van alleen opgegeven bezochte locaties een zogenoemde locatie-netwerk te genereren, dat ook een indruk geeft over ruimtegebruik. Verschillende morfologische patronen zijn onderscheiden. Binnen de 9 basis-typen zijn varianten te maken, met name wat betreft de locatie van de accommodatie in het patroon. Bevindt deze zich aan het begin van een patroon of juist in het centrum of ergens tussen een aantal clusters van bezochte locaties in.

Om een directe tijd en context analyse te maken is een andere aanpak met de gegevens gevolgd. Als basis is het data structuur genomen waarin de route-gegevens worden opgeslagen in Arc/Info. Hiermee is het mogelijk om bepaalde patronen te analyseren, bijvoorbeeld wie zijn er allemaal op weg X en Y geweest op bepaalde tijdstippen en wat zijn hun vervolgtrajecten of voorafgaande trajecten geweest. Deze systematiek is ook toegepast op wat genoemd is tijd-locatie diagrammen. De ontwikkelde ArcView applicatie kan onder andere gegevens tussen tijd en locatienummer gebruiken. Deze gegevens zijn interactief te raadplegen. Via het grafisch selecteren van aanwezige gebruikers-variabelen wordt een beeld getoond van het gebruik van de ruimte en de verschillende ondernomen activiteiten in een bepaald tijdsbestek. Ook is het mogelijk om het in omgekeerde volgorde te analyseren: het voor- of natraject in het tijd-ruimte patroon wordt grafisch bevraagd, de bijbehorende tabelselectie wordt dan direct zichtbaar. Naast locatie-identifiers, zoals deze in het voorbeeld van de tijd-locatie diagrammen zijn opgeslagen is elke andere subset te gebruiken, zoals afstand tussen activiteit van de locatie en de accommodatie of waardering en tijd of waardering en locatie.

Conclusies

De ontwikkelde applicaties maken het mogelijk om een geïntegreerd inzicht in toeristisch tijd-ruimtegedrag te krijgen. Er kunnen verschillende profielen van toeristen worden onderzocht en gevisualiseerd. Met het resultaat kan er ingespeeld worden op capaciteitsproblemen (bv. op de infrastructuur) of de volgorde van bezoek aan of gebruik van toeristische (product) elementen. Met dit inzicht in het actuele gebruik en de waardering van de gebruikte onderdelen zijn specifieke doelstellingen voor een gebied te toetsen en ontstaat er duidelijkheid over knelpunten en eventuele toekomstige beheersproblemen, zoals een onderlinge afstemming tussen toeristische producten, achteruitgang van kwaliteit, onder- en overbezetting gedurende bepaalde tijdstippen, of sturing door landschappelijke elementen die niet direct als toeristisch product worden aangemerkt. Er is echter ook een probleem. De grote hoeveelheid gegevens die nodig is om het verplaatsing gedrag te beschrijven vormt een drempel. Verplaatsing, ofwel de onderliggende tijd-ruimte gegevens, zijn nu nog moeilijk te verzamelen en te verwerken. Mogelijk kan het toepassen van GPS (Global Positioning Systemen) hiervoor een oplossing bieden.

CURRICULUM VITAE

Wilhelmus Gerardus Maria van der Knaap was born on 24 July 1956 in Naaldwijk, the Netherlands. He obtained his Gymnasium ß diploma from the Canisius College, Nijmegen in 1975. From 1975 until 1983 he studied Land and Water Use Planning at the Wageningen Agricultural University (WAU), majoring in Physical Planning and Information Science. Part of his study was carried out at An Foras Forbartha Teoranta in Dublin, Ireland.

From 1984 to 1990 he worked as a research assistant at the Department of Land and Water Use of WAU. This period was mainly spent incorporating information technology into the curriculum, developing new teaching methods for computer supported education and counselling students. An important part of the curriculum development concerned the application of Geographic Information Systems (GIS) in land use planning. From 1990 until October 1993 he was a lecturer at the Department of Physical Planning and Rural Development of WAU. During this period his particular focus was on the possible uses of GIS in the planning process. From October 1993 he continued with this work for one day a week while conducting PhD research at the Centre for Recreation and Tourism Studies, WAU, between October 1993 and August 1996. He returned to full time teaching after finishing his PhD research and works at present in the Department of Environmental Sciences, within the Land Use Planning group and the Centre for Recreation and Tourism Studies, WAU.