# Life and Motion of Socio-economic Units



GISDATA 8

Series Editors
Ian Masser and
François Salgé

Edited by
Andrew Frank,
Jonathan Raper and
Jean-Paul Cheylan

Frank, Andrew U., Jonathan Raper, and Jean-Paul Cheylan, eds. *Life and Motion of Socio-Economic Units*. Vol. 8, *Gisdata Series*. London: Taylor & Francis, 2001.

# Life and Motion of Socio-Economic Units

EDITORS

ANDREW U. FRANK, JONATHAN RAPER
AND
JEAN-PAUL CHEYLAN

GISDATA 8

SERIES EDITORS

I. MASSER and F. SALGÉ

EUROPEAN SCIENCE FOUNDATION
E S F

TAYLOR & FRANCIS
Founded 1798

First published 2001 by
Taylor & Francis
11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada
by Taylor & Francis
29 West 35th Street, New York, NY 1001

*Taylor & Francis is an imprint of the Taylor & Francis Group*



Printed and bound in Great Britain by
TJ International Ltd, Padstow, Cornwall



*Publisher's Note*

This book has been prepared from camera-ready copy provided by the authors.

*British Library Cataloguing in Publication Data*

A catalogue record for this book is available from the British Library

*Library of Congress Cataloging in Publication Data*

Life and motion of socio-economic units / Andrew Frank, Jonathan Raper and Jean-Paul Cheylan [editors].
p. cm. – (GISDATA; 8)
Includes bibliographical references and index.
1. Geographical informations systems. 2. Geographical perception.
I. Frank, Andrew U. II. Raper, Jonathan. III. Cheylan, Jean-Paul.
IV Series
G70.212.L52 2000
910'.285—dc 21 99-045691

ISBN 0-7484-0845-2

# TABLE OF CONTENTS

Over
is cor
Euroj
the fi
1992,
(MEC
geogr
press
clear
natio
that a
Th
origi
a sm
GIS
parti
urgei
Euro
resea
the e
impc
set t
1992
grou
geog
Tl
scier
Scie
20 E
man
are:

# The GIS Data Series

## Series Editors' Preface

Over the last few years there have been many signs that a European GIS community is coming into existence. This is particularly evident in the launch of the first of the European GIS (EGIS) conferences in Amsterdam in April 1990, the publication of the first issue of a GIS journal devoted to European issues (*GIS Europe*) in February 1992, the creation of a multipurpose European ground-related information network (MEGRIN) in June 1993, and the establishment of a European organisation for geographic information (EUROGI) in October 1993. Set in the context of increasing pressures towards greater European integration, these developments can be seen as a clear indication of the need to exploit the potential of a technology that can transcend national boundaries to deal with a wide range of social and environmental problems that are also increasingly seen as transcending the national boundaries within Europe.

The GISDATA scientific programme is very much part of such developments. Its origins go back to January 1991, when the European Science Foundation funded a small workshop at Davos in Switzerland to explore the need for a European level GIS research programme. Given the tendencies noted above it is not surprising that participants of this workshop felt very strongly that a programme of this kind was urgently needed to overcome the fragmentation of existing research efforts within Europe. They also argued that such a programme should concentrate on fundamental research and it should have a strong technology transfer component to facilitate the exchange of ideas and experience at a crucial stage in the development of an important new research field. Following this meeting a small coordinating group was set up to prepare more detailed proposals for a GIS scientific programme during 1992. A central element of these proposals was a research agenda of priority issues groups together under the headings of geographic databases, geographic databases, geographic data integration and social and environmental applications.

The GISDATA scientific programme was launched in January 1993. It is a four-year scientific programme of the Standing Committee of Social Sciences of the European Science Foundation. By the end of the programme more than 300 scientists from 20 European countries will have directly participated in GISDATA activities and many others will have utilised the networks built up as a result of them. Its objectives are:

- to enhance existing national research efforts and promote collaborative ventures overcoming European-wide limitations in geographic data integration, database design and social and environmental applications;
- to increase awareness of the political, cultural, organisational, technical and informational barriers to the increased utilisation and inter-operability of GIS in Europe;
- to promote the ethical use of integrated information systems, including GIS, which handle socio-economic data by respecting the legal restrictions on data privacy at the national and European levels;
- to facilitate the development of appropriate methodologies for GIS research at the European level;
- to produce output of high scientific value; and
- to build up a European network of researchers with particular emphasis on young researchers in the GIS field.

A key feature of the GISDATA programme is the series of specialist meetings that has been organised to discuss each of the issues outlined in the research agenda. The organisation of each of these meetings is in the hands of a small task force of leading European experts in the field. The aim of these meetings is to stimulate research networking at the European level on the issues involved and also to produce high quality output in the form of books, special issues of major journals and other materials.

With these considerations in mind, and in collaboration with Taylor & Francis, the GISDATA series has been established to provide a showcase for this work. It will present the products of selected specialist meetings in the form of edited volumes of specially commissioned studies. The basic objectives of the GISDATA series is to make the findings of these meetings accessible to as wide an audience as possible to facilitate the development of the GIS field as a whole.

For these reasons the work described in the series is likely to be of considerable importance in the context of the growing European GIS community. However, given that GIS is essentially a global technology most of the issues discussed in these volumes have their counterparts in research in other parts of the world. In fact there is already a strong UK dimension to the GISDATA programme as a result of the collaborative links that have been established with the National Center for Geographic Information and Analysis through the United States National Science Foundation. As a result it is felt that the subject matter contained in these volumes will make a significant contribution to global debates on geographic information systems research.

*Ian Masser*
*François Salgé*

# General Introduction

The world in which we live is permanently changing and these changes vary widely: some changes are extremely slow, nearly unnoticeable for us, for example, changes in climate or geology; others are rapid, like the movement of cars or wind. The objects changing are sometimes very large, sometimes very small (Gibson, 1979).

Nevertheless, most of the world is stable and with respect to this stable framework, we observe some elements change. In general, we seem to assume that we and most of our environment remain stable and few objects around us change. This is sometimes an illusion, as perceived changes are the effect of changes in our perception, in the classification or the observation of phenomena.

The interaction between objects have spatial and temporal ranges (Fraser, 1981): people interact with their environment centred around their places of living for 'three scores and ten' years. Glaciers interact with the region around them for thousands of years. A grass plant interacts with the plants and soil within a foot for a single year. Each science concentrates on some cluster of interaction, with a particular range of space or time in which the interaction of interests occurs (Morrison, 1982). For faster or slower interaction the larger or smaller processes create an environment which is relative to the process. It becomes then necessary to aggregate phenomena for a smaller or shorter interaction scale to bring them to the scale of interaction of the larger or smaller process. GIS—and to some degree geography in general—cross these scale boundaries and have to deal with the effects of aggregation, both in time and space.

People's interest in change in their environment is high. Many decisions are determined by change; often change is the more important signal than a static situation. The media report on change. Typically, politicians react to change with changes in the socio-administrative system. Planning observes changes in the environment and tries to stir them in a desired direction. Geography has evolved from a mostly descriptive attitude and concentrates on studying processes in space and time, i.e., changes, their causes and effects. The field of spatio-temporal processes in geographic space is a broad and rich field for scientific studies. Accurate data are necessary to back theories with actual observations. Even more data are necessary to describe changes.

Geographic Information Systems were designed to accurately collect, manage and render a description of the world around us (FIG Fédération Internationale des Géomètres, 1981). The current design of commercial GIS assumes the world as static and ignores processes that change the world. The GIS contains only the resulting, currently valid data—previous, historical data is lost. The changes in the world are captured in an update process. Updating is a practical problem; it is an administrative process built around the GIS, more as an afterthought.

The variable time is not included in current GIS, which store static snapshots of the world, following Sinton's general scheme for cartography: Time is fixed, Location is controlled and Theme is observed (Sinton, 1978). Often the time of the snapshot is not even well defined. This triad, which is imposed by technical limitations upon cartography, has been carried forward to the current commercial GIS.

This restriction of GIS to cartographic snapshots has reduced the technical problems in their design and in the challenge they pose to their users. But it has also reduced the potential of GIS to contribute to the solution of actual administrative, planning and scientific questions. It has also increased the difficulties to integrate GIS as a tool in administrative processes. GIS are not maps and are not restricted by the physical constraints of cartographic presentation. GIS could be used to collect time varying data, exploit it with respect to time and show the results graphically, only current commercially available systems are very much restricted. Several of the contributions develop this theme and May Yuan proposes a view of a GIS which has theme, space and time as equal partners (Chapter 15). We present here a continuous chain of arguments, from Jonathan Raper (Chapter 1), Jean-Paul Cheylan (Chapter 3) to Stuart Aitken (Chapter 13), which point to the impossibility to capture the social reality of a territory in the straightjacket of static Euclidean geometry, which can be linked to this remaining restriction inherited from cartography. To lift this restriction is possible today.

The field of spatio-temporal GIS is vast and the number of applications is enormous. Despite the importance ascribed to this field and the research efforts made in the past years, progress has been slim (Barrera *et al.*, 1991; NCGIA 1993; Egenhofer and Golledge, 1998). A first approach to introduce time into the GIS is to add to the two spatial dimensions current GIS handle, a third for the height and a fourth for time. Understanding time and space as a four-dimensional isotropic continuum has been very effective for physics and leads to substantial insight into the structure of matter and the smallest particles of which it consists. It is doubtful if a similar approach is usable in geography. Geographic space is not isotropic and movement in the plane is much different and experienced differently from a movement in the vertical. Unlike spatial dimensions, the arrow for time is fixed and processes progress from the past to the future and we cannot reverse this at will (Franck, Chapter 8); (Couclelis and Gale, 1986).

To make progress in research, it is often necessary to concentrate on a small part of a large problem. In this volume the focus is on socio-economic units, as a particular type of geographic object and their change in time. It is well understood that this is only one of several important research issues on the way to create a widely useful temporal geographic information system, but it is hoped that this focus will result in progress in particular questions.

The interaction of people with space can first be seen as a very direct one: people move around in space. This can be seen abstractly as the movement of points against a fixed frame.

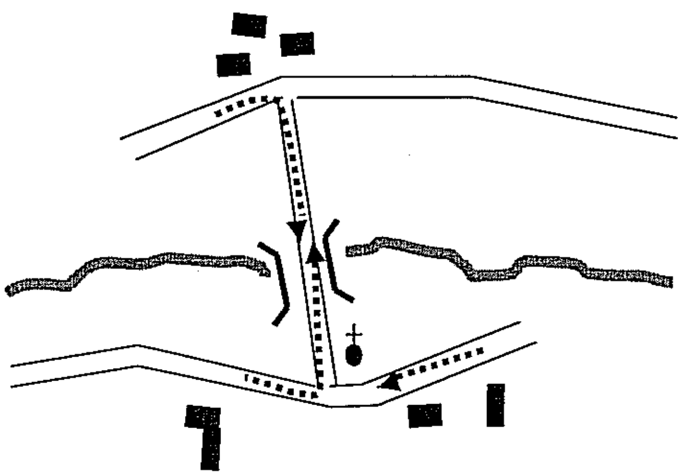

**Figure 1** Movement of points (vehicle)

But people also create by social processes larger areal units in space, for example, by the division of land into countries, which serve as fixed frames of reference for point movements. These areal units themselves change if sufficiently large time periods are considered.

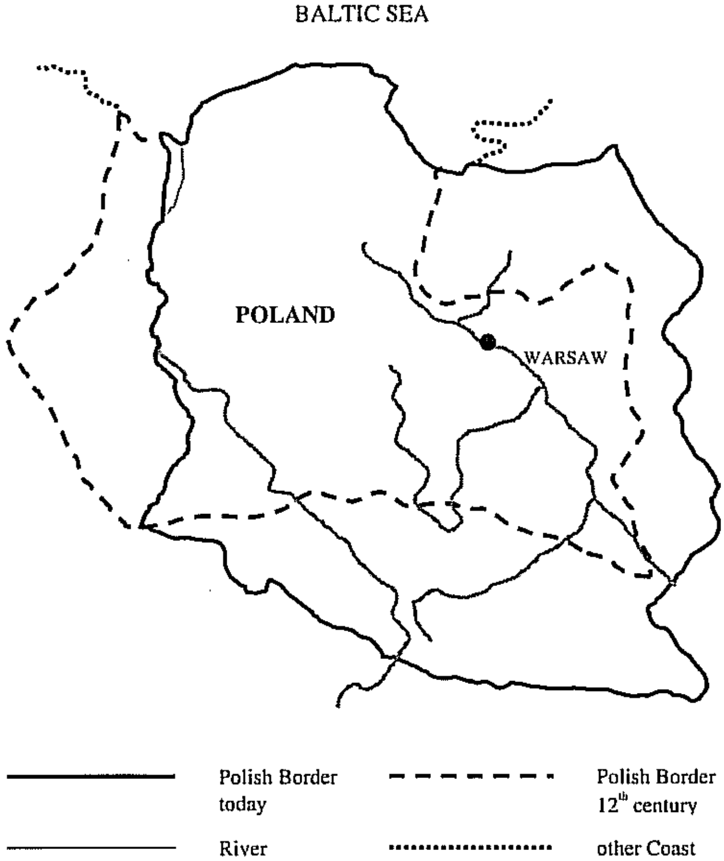


**Figure 2** Movement of area (country)

We have selected this second topic in the hope of

- opening a new topic of research, avoiding areas where already several competent research efforts are underway;
- defining the area well enough that productive detailed research can follow; and
- demonstrating that research results in this subfield have important practical applications.

Torsten Hägerstrand pioneered research in time geography addressing the first question. He traced the movement of individuals in space and time. He described the path of a person from home to work place in the morning and back to home in the evening and depicted it graphically as a path in three dimensions (the x–y plane of urban space and the time dimension as z). Generalised, time geography investigates the movement of one (or few) mobile elements in a space that is much larger than the elements, and the only thing that changes is the position of the elements in this space—everything else remains fixed in time. The town does not change (noticeably) during our travel, nor are changes in the elements moving considered. The conceptual framework is rich and widely applicable for studies in transportation and application of GIS to transportation problems. A currently important application of 'point movement' in geography and GIS is traffic, from systems to observe traffic volume, flow of individual cars to systems to advise drivers about optimal routes (Golledge, 1998).

This book concentrates on the second aspect of the human dimension of space and time in geography: the change of socially created large geographic objects, used to subdivide space for administrative and economic purposes. Social processes, mostly political, subdivide geographic space in delimited areas, some as large as a continent, some as small as a parcel of land owned by a person. These areas we call here spatial Socio-Economic Units. This social spatial framework is considered fixed for most of our activities, it is part of the fixed spatial framework against which we observe change—units like France, Washington D.C., and even parcels often remain unchanged for hundreds of years. Nevertheless, by careful observation, we find that these socio-economic units are occasionally changing and this framework is not as stable as we generally believe. Municipal boundaries change as the result of administrative reform; war leads to the appearance or disappearance of countries, etc.

The term 'spatial socio-economic' was selected to describe in most general terms spatial units that are the result of some social, cultural, economic, behavioural, etc. processes. There are many such processes and they follow their specific logic and produce different spatial units. The spatial socio-economic units most often considered are the reporting units for the national statistics and the political subdivisions, from communes, districts to countries. Many spatial socio-economic units consist of smaller units and are hierarchically aggregated—but particulars of the hierarchy problem are not within the scope of the effort reported here (for recent work on spatial hierarchies see Timpf, 1998). The prototypical spatial socio-economic unit has sharply defined and precisely known boundaries, but not all spatial socio-economic units follow this model: Aggregates of postal addresses for a common postal code are important, widely used spatial socio-economic units, but not in all countries do they represent delimited areas (Raper *et al.*, 1992); (Reis, Chapter 21). Other examples of socio-economic units with vague boundaries are the service areas—the area serviced by a particular school or hospital is often not precisely fixed and changes over time. Some socio-economic units seem to be more real and appear as objectively, often even physically existing: spatial socio-economic units are sometimes clearly marked in the world (national boundaries as an extreme case), influence other spatial processes (for example, the effects of urban planning zones) and have or become 'physical reality'. Others remain purely administrative and barely noticed by the general public, and some exist only in the perception of the local residents (for example, territories of gangs or sacred places). Despite their conceptual stability, such units slowly change.

This book tries to systematise this specific sub-area of spatio-temporal GIS: what are the elements that describe change to the socio-economic units in time. This requires asking general questions about the spatial socio-economic units themselves: what are their properties, how are they created, how do they change and disappear. The contributions in this volume are grouped in 5 parts, each having a particular focus.

Part 1 sets the stage and introduces the problem in abstract terms. It provides the intellectual framework to start an abstract discussion about the 'life and motion' of spatial socio-economic units, concentrating on their generic aspects and abstracting away the particulars of each special case. On this abstract level of discussion, Jonathan Raper initiates the discussion: spatial socio-economic units are human artifacts (Searle, 1984); (Berger and Luckmann, 1996), used for the collection of data with a life span, from creation to deletion. Spatial socio-economic units can also move in space over time. The second chapter by Andrew Frank differentiates types of change, separating changes in attribute properties from motion of the spatial socio-economic unit and catastrophic events ('life'), which create new spatial socio-economic units or make them disappear. Jean-Paul Cheylan further analyses the interaction between these changes and the final chapter by Marinos Kavouras links the abstract study of spatial socio-economic units with their use in administration and in particular planning.

Part 2 inquires in the philosophical background. Spatial socio-economic units are not physical objects and their properties are thus not as simple to comprehend as the red or green colour of an apple. It starts with an analysis by Carola Eschenbach of a seemingly simple query "How did the population of European capitals change during the last 100 years?", revealing the possible ontological commitments one could make and their effects on the results of the query. The chapter by Barry Smith reviews the metaphysical categories of Aristotle and concludes that spatial socio-economic units are not physical objects and share only few properties of these. From the investigation by Roberto Casati follows that spatial socio-economic units are more similar to shadows, which differentiate different parts of a region, without having a physical existence. But time is also not uniform and the chapter by Georg Franck points out four different uses of time—from a reversible physical time, to the irreversible biological clock, the experienced time with the exceptional point 'present' and two different measures for time in economics, which link space and time.

Part 3 reviews formal properties of a spatio-temporal GIS, starting with a review of the logical foundation by Michael Worboys and stressing three different views on space, time and theme—revisiting a fundamental law of cartography (Sinton, 1978) and applying it to the temporal GIS. Damir Medak contributes an analysis on a highly formalised level separating different 'lifestyles' for spatial socio-economic units. The remaining chapters consider the spatio-temporal database perspective: Therese Libourel investigates changes in the database schema, a point often forgotten, but of eminent importance for databases which should be used for long periods of time. Emmanuel Stephanakis and Timos Sellis link the abstract requirements to database implementation issues and query processing—the perspective on time in temporal databases can be abstracted to a sequence of transactions on which queries are possible.

Part 4 considers geographic applications. The chapter by Stuart Aitken is situated in the urban planning context and critically assesses the spatial socio-economic units, asking how they are created, by whom and to what end. The following chapter by Denis Gautier presents a complex application of a spatio-temporal GIS and the corresponding analysis to understand the evolution of a forest under different economic pressures. May Yuan further increases the links between space, theme and time with an example of service areas of supermarkets. Mauro Salvemini stresses how planning, especially city planning, implies a complex structure of the world where spatial objects of different nature interact with very different time scales. The evolution of land ownership and the legal rules, which guide a land registration system—a key example for a temporal GIS, is the subject of a highly formal treatment by Khaled Al-Taha.

The last part investigates the definition of spatial socio-economic units: Erik Stubkjær's chapter analyses in detail the interaction between changing the definitions of spatial socio-economic units and their collection—in a way reflecting the perspective of Libourel's review of the database schema. Stan Openshaw and Seraphim Alvanides then discuss the effects various aggregations of spatial socio-economic units have on the presentation of socio-economic data and then assess various methods for an optimal design of spatial socio-economic units. Mike Coombes and Stan Openshaw report on a practical project concerning a specific set of SSEUs in Britain, the so-called Travel-to-Work Areas, revealing changes in the size of spatial socio-economic units associated with longer journeys to work over the last decades. The chapter by Rui Pereira Reis deals with the actual decisions made in the creation of Portugal's new postcodes. The last chapter by Jostein Ryssevik reports on a pragmatic solution for a database of socio-economic data from the Norwegian census, which allows the approximate transformation of collected data to a selected set of spatial socio-economic units—adjusting for changes in their boundaries.

In conclusion, the volume presses for a stronger interaction between the social processes that create and change spatial socio-economic units, and the management and use of the data collected for them. The simplifying fiction that spatial socio-economic units are fixed, well defined areal units, which the static implementation of GIS today imply, considerably limits the use of GIS for the analysis of complex social interaction as it is necessary for, for example, urban planning. This view is an artifact from the cartographic tradition of GIS and must be replaced by a balanced triad of theme, space and time (Yuan, Chapter 15). The future GIS must provide data types for time varying objects, for example, spatial socio-economic units or moving objects (Erwig *et al.*, 1997), and relate them to forces which make them change and to abstract representations of change. This volume hopefully attempts to justify this need from a fundamental geographic analysis, but also from the practical needs—mostly felt in urban planning—and relates it to the formal mathematical treatment necessary for its realisation in future GIS software. The chapters here also indicate the relation of this research effort with the proper treatment of hierarchies and similar structures and scale in general—a currently active research area in GIS.

The theoretical analysis presented here should justify the development of GIS products by demonstrating their rich applicability and provide a theory for their implementation.

## ACKNOWLEDGEMENTS

This interdisciplinary study is the part of the GISDATA project, which was initiated by Ian Masser and François Salgé, and is financed by the European Science Foundation. Max Craglia administrated the project and pushed it forward along its slow and wearisome path from the initial idea to the printed book. Marinos Kavouras acted as the gracious host for the meeting in Nafplion, where most of the chapters in this volume were presented initially. Authors then revised their manuscript based on the discussion and we invited a small number of additional contributions to form this hopefully comprehensive volume. Last, but not least, Mag. Roswitha Markwart managed the preparation of the book manuscript at the Technical University in Vienna. We appreciate the numerous and various contributions of them all.

Andrew Frank
Jonathan Raper
Jean-Paul Cheylan

## REFERENCES

Barrera, R., Frank, A.U. and Al-Taha, K., 1991, Temporal relations in Geographic Information Systems: A workshop at the University of Maine. *SIGMOD Record*, **20** (3), pp. 85–91.

Berger, P.L. and Luckmann, T., 1996, *The Social Construction of Reality*, (New York: Doubleday).

Couclelis, H. and Gale, N., 1986, Space and spaces. *Geografiske Annaler* 68B, pp. 1–12.

Egenhofer, M.J. and Golledge, R.G., Eds, 1998, *Spatial and Temporal Reasoning in Geographic Information Systems*, (New York: Oxford University Press).

Gibson, J.J., 1979, *The Ecological Approach to Visual Perception*, (Boston: Houghton-Mifflin).

Erwig, M., Güting, R.H., Schneider, M. *et al.*, 1997, *Spatio-Temporal Data Types: An Approach to Modeling and Querying Moving Objects in Databases*. Report No. 224. (Hagen: FernUniversität).

FIG Fédération Internationale des Géomètres, Ed, 1981, *XVIe Congres International des Géomètres*. (Montreux, Switzerland).

Fraser, J.T., Ed., 1981, *The Voices of Time*, (Amherst: The University of Massachusetts Press).

Golledge, R.G., 1998, The relationship between GIS and disaggregate behavioral travel modeling. *Geographical Systems*, **5** (1–2), pp. 9–17.

Morrison, P., 1982, *Powers of Ten*, (San Francisco, CA: W.H. Freeman).

NCGIA, 1993, *Time in Geographic Space*. Report on I–10 Specialist Meeting, NCGIA.

Raper, J.F., Rhind, D. and Sheperd, J., 1992, *Postcodes—The New Geography*, (London: Longman).

Searle, J.R., 1984, *Minds, Brains and Science*, (Cambridge, MA: Harvard University Press).

Sinton, D., 1978, The inherent structure of information as a constraint to analysis: Mapped thematic data as a case study. In *Harvard Papers on Geographic Information Systems*, edited by Dutton, G. (Reading, MA: Addison-Wesley). Vol. 6.

Timpf, S., 1998, *Hierarchical Structures in Map Series*. Ph.D. thesis, Department of Geoinformation. (Vienna: Technical University Vienna).