

SERGIO ALBEVERIO
DENISE ANDREY
PAOLO GIORDANO
ALBERTO VANCHERI

Editors

The Dynamics of Complex Urban Systems

An Interdisciplinary Approach



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Sergio Albeverio · Denise Andrey
Paolo Giordano · Alberto Vancheri
(Editors)

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Professor Dr. Dr.h.c. Sergio Albeverio
Institute for Applied Mathematics
University of Bonn
Germany
albeverio@uni-bonn.de
and

Università della Svizzera Italiana
Accademia di Architettura
Via Canavée
6850 Mendrisio
Switzerland
salbeverio@arch.unisi.ch

Denise Andrey
Paolo Giordano
Dr. Alberto Vancheri

Università della Svizzera Italiana
Accademia di Architettura
Via Canavée
6850 Mendrisio
Switzerland

dandrey@arch.unisi.ch
pgiordano@arch.unisi.ch
avancheri@arch.unisi.ch

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The Dynamics of Complex Urban Systems



Preface

In recent years it has become increasingly clear that the dynamics of cities can be best captured by looking at them as complex systems governed by many degrees of freedom, interacting on different space and time scales in a non-linear fashion. The evolution of cities is shaped by internal factors, e.g. decisions taken by institutions and individuals, external causes (international economic context) and by social development. The underlying processes can be slow or fast, acting locally or globally. At a different level, both European cities and megacities are magnets for immigrants (e.g. countries, which have major economical and political problems), leading often to phenomena like marginalization or even ghettization and segregation. They are also hotbeds of economic, political and cultural activity, giving rise, among other things, to relocation and conversion of industries, revaluation of land, and development of new services. These phenomena as *qualitative* changes, are opposed to purely *quantitative* growth processes. They are far from being fully understood, nor they are captured in validated and complete urban models. For most of urban theory hitherto has been based on the assumption of slowly varying spatial and social structures. Only recently, these assumptions have been questioned, giving rise to models employing dissipative dynamics, stochastic cellular automata and multi-agent models, fractal geometry, and evolutionary change models, and to further mathematically oriented approaches. They are promising examples as to how the concepts and methods of mathematics, physics and, more generally natural science can be employed in order to achieve a deeper insight into some aspects of the complexity of urban processes.

One of the aims of the workshop *The Dynamics of Complex Urban Systems: an interdisciplinary Approach* which took place in Ascona (Switzerland), at the “Centro Monte Verità” from 4th to 6th November 2004 was to present and discuss some of these approaches developed by different communities, comparing them and trying to get as much as possible a synthetic overview.

This developed from the conviction that significant progress in the understanding of urban and territorial dynamics can be best achieved through a fruitful collaboration between natural science (physics, mathematics, computer science, biology, ...) and regional science (architecture, geography, city plannings, economics, sociology, ...) across traditional disciplines. Different models have to be investigated, which are adapted to various scales and aspects of urban growth. Theoretical but else experimental components are needed for reconstructing and forecasting change processes in cities.

The workshop was structured in 6 sessions characterized by the following key words:

- General dynamical models: urban growth, city evolution, pedestrian dynamics, self-organization, fractal geometry models, urban cluster dynamics, space syntax, continuum state cellular automata

- Models from economics and models for megacities: sustainable urban development, large-scale city formation, sociodynamics, econophysics, synergetics, applied geography
- Models from information science and data management: data mining, soft-computing methods, geo-referenced data, GIS, multi-agents models, artificial worlds, classical cellular automata, data availability
- Related mathematical and physical theories and models: stochastic processes, statistical mechanics, dynamical systems, diffusion, neural networks, power laws, phase transitions
- Models calibration/validation and forecasts: calibration of models' parameters, comparison between empirical data and simulations, optimization, forecasts of stochastic models for complex systems
- Dynamical models and case studies

The interconnections between the sessions turned out in the end to be very strong, which is of course good. This is the reason why for the proceedings we decided to present all contributions in alphabetic order, giving up in particular the division in sections. The contribution by **Michael Batty** was chosen however to open the book since it presents an extensive and deep chronological and conceptual overview of the developments of the urban land use-transportation models which occurred in the last 50 years in the context of current development. The contribution by **Allen, Strathern and Baldwin** presents new models of adaptative organization, which allow a better understanding for integrated views linking land-use changes to environmental and socio-economic and cultural factor. In particular these models stress the importance of adaptable emergent networks. The ontogeny of complex systems models is analyzed in the contribution by **Claes Andersson**, which also discuss the role and applicability of such models. The contribution by **Bazzani, Capriati et al.** investigates the citizen mobility in urban space, presenting an agent-based model for asystemic mobility determined by the "chronotopic areas". The model is also illustrated by a discussion of simulations on the campus of Milano Bicocca University. **Ulrike Beuck, Kai Nagel et al.** present the computational techniques needed for a multi-agent traffic simulation of a metropolitan region as Berlin. Simple behavioural mechanisms in spatial microsimulation models and their dynamic properties are explored by **Mark Birkin**, establishing links between microsimulations (in the contest of a British city), agent-based approaches and spatial interaction models. The difficult of the urban system complexity and the related analysis and forecast discussed by **Ivan Bleic, Armando Cecchini et al.**, who in particular try to cope also with the free behaviour of actors. A view of cities as evolutionary systems in random media with spatial emphasis on the intermittency phenomenon is presented in the contribution by **Leonid Bogachev**. The configurational approach to urban phenomena and its further developments are discussed by **Valerio Cutini**, whereas philosophical and methodological issues involved in validation and calibration of cellular automata based models of land use change are discussed in the contribution by **Guy Engelen and Roger White**, with illustrations from environmental studies in the Netherlands. Fractal geometry (context, fractal models, morphology and an overview

of results) for modeling of urban patterns is discussed by **Pierre Frankhauser**, with a special attention towards problems of urban sprawl. **Günther Haag** and **Jan Binder** discuss problems of modelling of patterns of a system of different sub-models (e.g. population, transport, production). The theory of the dynamical STASA-model and its application with the SCATTER project for the region of Stuttgart are particularly illustrated. **Erez Hatna** and **Ithzak Benenson** discuss the problem of the appropriateness of modelling urban processes by Markov processes. On the basis of laboratory experiments they argue for shared Markov processes for representing human urban development behaviour and for a basis for decision-making strategies. Three important aspects of self-organization in pedestrian and vehicle traffic are discussed by **Helbing, Johansson** and **Lämmer**. **Jeffrey Johnson** presents a general approach to multidimensional networks as models for complex (urban) systems. The problem of investigating land use transformations, in particular analysing the connections between political and socio-economical changes are discussed by **Silvana Lombardo** and **Massimiliano Petri** on the basis of field investigations in a territorial area of Albania. **Juval Portugali** presents a new structural-cognitive approach to urban simulation models, whereas **Denise Pumain** presents a multi-level model for socio-spatial dynamics of systems of cities and innovation processes. Large scale urban models and their possible renaissance are revisited by **Giovanni Rabino**, who stresses the necessity of joining the scientific and classical cultures in these studies. CityDev a multi-agent simulation of economic spatial dynamics in a poli-nucleated area is discussed by **Ferdinando Semboloni**, and illustrated by a case study in Firenze. The construction and application of continuum-valued cellular automata model for urban systems joined with a fuzzy decision process is presented by **Vancheri, Giordano** et al. In the contribution of **Damiàn Zanette**, Zipf's law relating cities sizes distribution is connected with the theory of multiplicative stochastic processes.

The volume ends with two poster session contributions by Tang Hui Yi and Lu Ming discussing the problems of modelling urban processes in China, in particular in view of their spatial features.

At this point we would like to thank all the speakers for their willingness to contribute to the great success of this conference by their lectures, the interesting discussion during the whole week of the workshop, as well as for delivering the promised manuscripts of their presentations.

We hope that by these proceedings the essential part of the contributions and a little of the stimulating atmosphere of the workshop can be made available for a wide audience.

The editors would like to express their gratitude to the organizers of the workshop professors Michael Batty, Volker Jentsch, Frank Schweitzer and Ferdinando Semboloni for the very stimulating discussions and their help in various stages of the preparation of the workshop and these Proceedings.

In particular the inspiring influence of the International Center of Complex systems (IZKS), University of Bonn, is gratefully acknowledged.

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Sergio Albeverio, Denise Andrey, Paolo Giordano and Alberto Vancheri
Spring 2007

Scientific Board

Albeverio Sergio, Prof. Dr. Dr.h.c
Institut für Angewandte Mathematik, Universität Bonn
Wegelerstrasse 6, 53115 Bonn
Germany
albeverio@uni-bonn.de

Batty Michael, Prof. Dr.
Centre for Advanced Spatial Analysis (CASA), University College London
1-19 Torrington Place, London WC1E 6BT
UK
m.batty@ucl.ac.uk

Jentsch Volker, PD Dr.
Interdisziplinäres Zentrum für Komplexe Systeme (IZKS), Universität Bonn
Meckenheimer Allee 176, 53115 Bonn
Germany
jentsch@uni-bonn.de

Schweitzer Frank, Prof. Dr. Dr.
Department of Management, Technology, and Economics (D-MTEC)
Swiss Federal Institute of Technology (ETH)
Zürichbergstrasse 18, 8092 Zürich
Switzerland
fschweitzer@eth.ch

Semboloni Ferdinando, Prof. Dr.
Dipartimento Urbanistica e Pianificazione del Territorio, Università di Firenze
Via Micheli 2, 50121 Firenze
Italy
semboloni@urba.arch.unifi.it

List of Contributors

Albeverio Sergio

Institut für Angewandte Mathematik, Universität Bonn
Wegelerstrasse 6, 53115 Bonn
Germany
albeverio@uni-bonn.de

Allen Peter M.

Complex Systems Management Centre, Cranfield School of Management
Cranfield University
Wharley End, Bedford MK43 OAL
UK
p.m.allen@cranfield.ac.uk

Andersson Claes

Department of Physical Resource Theory, Chalmers University of Technology
41296 Göteborg
Sweden
claes@mindmetric.com

Andrey Denise

Laboratory of Modelling and Applications of Complex Systems (MACS Lab)
Accademia di architettura, Università della svizzera italiana (USI)
Via Canavée 8, 6850 Mendrisio
Switzerland
dandrey@arch.unisi.ch

Baldwin James

Advanced Manufacturing Research Centre, Department of Mechanical
Engineering, University of Sheffield
Sheffield S1 3JD
UK

Balmer Michael

Institute for Transport Planning and Systems (IVT), ETH Zürich
ETH Hönggerberg, 8093 Zürich
Switzerland
balmer@ivt.baug.ethz.ch

Batty Michael

Centre for Advanced Spatial Analysis (CASA), University College London
1-19 Torrington Place, London WC1E 6BT
UK
m.batty@ucl.ac.uk

Bazzani Armando

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna
Via Irnerio 46, 40126 Bologna
Italy
armando.bazzani@unibo.it

Benenson Itzhak

ESLab, Porter School of Environmental Studies and Dept. of Geography and
Human Environment, University Tel Aviv
69978 Ramat-Aviv, Tel-Aviv
Israel
bennya@post.tau.ac.il

Beuck Ulrike

Transport Systems Planning and Transport Telematics (VSP), TU Berlin
Salzufer 17-19, 10587 Berlin
Germany
beuck@vsp.tu-berlin.de

Binder Jan

Steinbeis Transfer Centre Applied Systems Analysis (STASA),
Schönbergstrasse 15, 70599 Stuttgart
Germany

Birkin Mark

School of Geography, University of Leeds
Woodhouse Lane, Leeds LS2 9JT
UK
m.birkin@geography.leeds.ac.uk

Blecic Ivan

Laboratory of Analysis and Models for Planning, Dept. of Architecture and
Planning, University of Sassari
Palazzo Pou Salit, Piazza Duomo 6, 07041 Alghero (SS)
Italy
ivan@uniss.it

Bogachev Leonid

Department of Statistics, University of Leeds
Leeds LS2 9JT
UK
bogachev@maths.leeds.ac.uk

Capriotti Massimiliano

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna
Via Irnerio 46, 40126 Bologna
Italy

Cecchini Arnaldo

Laboratory of Analysis and Models for Planning, Dept. of Architecture and
Planning, University of Sassari
Palazzo Pou Salit, Piazza Duomo 6, 07041 Alghero (SS)
Italy
cecchini@uniss.it

Cutini Valerio

Dept. of Civil Engineering, University of Pisa
via Diotisalvi 2, 56126 Pisa
Italy
valerio.cutini@ing.unipi.it

Engelen Guy

Centre For Integrated Environmental Studies, Flemish Institute for Technologi-
cal Research (VITO)
Boeretang 200, 2400 Mol
Belgium
guy.engelen@vito.be

Frankhauser Pierre

ThéMA, UMR CNRS 6049, Université de Franche-Comté
32, Rue de Mégevand, 25030 Besançon CEDEX
France
pierre.frankhauser@univ-fcomte.fr

Giordano Paolo

Laboratory of Modelling and Applications of Complex Systems (MACS Lab),
Accademia di architettura, Università della svizzera italiana (USI)
Via Canavée 8, 6850 Mendrisio
Switzerland
pgiordano@arch.unisi.ch

Giorgini Bruno

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna
Via Irnerio 46, 40126 Bologna
Italy

Helbing Dirk

Institute for Economics and Traffic, Dresden University of Technology
Andreas-Schubert-Str. 23, 01062 Dresden
Germany
helbing1@vwi.tu-dresden.de

Haag Günter

Steinbeis Transfer Centre Applied Systems Analysis (STASA),
Schönbergstrasse 15, 70599 Stuttgart
Germany
haag@stasa.de

Hatna Erez

ESLab, Porter School of Environmental Studies and Dept. of Geography and
Human Environment, University Tel Aviv
69978 Ramat-Aviv, Tel-Aviv
Israel
erez51@post.tau.ac.il

Hui Yi Tang

Micro and Macro Architecture, School of Architecture
Harbin Institute of Technology
301 Building C Shengxin tai Sunny Green Garden, Huaihe Rd.
150056 Hangang (HeiLongJiang)
P.R.China
tanghuiyi@126.com

Johansson Anders

Institute for Economics and Traffic, Dresden University of Technology
Andreas-Schubert-Str. 23, 01062 Dresden
Germany

Johnson Jeffrey

Department of Design and Innovation, Faculty of Technology
The Open University
Walton Hall, Milton Keynes MK7 6AA,
UK
j.h.johnson@open.ac.uk

Lämmer Stefan

Institute for Economics and Traffic, Dresden University of Technology
Andreas-Schubert-Str. 23, 01062 Dresden
Germany

Lombardo Silvana

Laboratory of Territorial and Environmental System Engineering (LISTA),
Dept. of Civil Engineering, University of Pisa
via Diotisalvi 2, 56126 Pisa
Italy
s.lombardo@ing.unipi.it

Ming Lu

City Planning and Design Institute, School of Architecture
Harbin Institute of Technology
No. 66 West Da-zhi St., P.O.Box 1534, 150006 Harbin (HeiLongJiang)
P.R.China
hitlm@126.com

Melchiorre Giuseppina

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna
Via Irnerio 46, 40126 Bologna
Italy

Nagel Kai

Transport Systems Planning and Transport Telematics (VSP), TU Berlin
Salzufer 17-19, 10587 Berlin
Germany
nagel@vsp.tu-berlin.de

Petri Massimiliano

Department of Civil Engineering, University of Pisa
via Diotisalvi 2, 56126 Pisa
Italy
m.petri@ing.unipi.it

Portugali Juval

Environmental Simulation Laboratory (ESLab), Dept of Geography and the
Human Environment, Tel Aviv University
69978 Ramat-Aviv, Tel-Aviv
Israel
juval@post.tau.ca.il

Pumain Denise

UMR Géographie-cités, Université Paris I
13 rue du Four, 75 006 Paris
France
pumain@parisgeo.cnrs.fr

Rabino Giovanni A.

Department of Architecture and Planning (DiAP), Polytechnic of Milan
Piazza Leonardo da Vinci 32, 20132 Milan
Italy
giovanni.rabino@polimi.it

Rambaldi Sandro

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna
Via Irnerio 46, 40126 Bologna
Italy

Rieser Marcel

Transport Systems Planning and Transport Telematics (VSP), TU Berlin
Salzufer 17-19, 10587 Berlin
Germany
rieser@vsp.tu-berlin.de

Semboloni Ferdinando

Dipartimento Urbanistica e Pianificazione del Territorio, Università di Firenze
Via Micheli 2, 50121 Firenze
Italy
semboloni@urba.arch.unifi.it

Servizi Graziano

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna
Via Irnerio 46, 40126 Bologna
Italy

Strathern Mark

Complex Systems Management Centre, Cranfield School of Management
Cranfield University
Bedford MK43 0AL
England

Strippgen David

Transport Systems Planning and Transport Telematics (VSP), TU Berlin
Salzufer 17-19, 10587 Berlin
Germany
strippgen@vsp.tu-berlin.de

Trunfio Giuseppe A.

Laboratory of Analysis and Models for Planning, Dept. of Architecture and Planning, University of Sassari

Palazzo Pou Salit, Piazza Duomo 6, 07041 Alghero (SS)

Italy

trunfio@uniss.it

Turchetti Giorgio

Laboratory of Fisica della Città, Dept. of Physics, University of Bologna

Via Irnerio 46, 40126 Bologna

Italy

Vancheri Alberto

Laboratory of Modelling and Applications of Complex Systems (MACS Lab),
Accademia di architettura, Università della svizzera italiana (USI)

Via Canavée 8, 6850 Mendrisio

Switzerland

avancheri@arch.unisi.ch

White Roger

Department of Geography , Memorial University of Newfoundland

St. John's, NF A1B 3X9

Canada

roger@morgan.ucc.mun.ca

Zanette Damián Horacio

Consejo Nacional de Investigaciones Científicas y Técnicas

Centro Atómico Bariloche and Instituto Balseiro

Av. Bustillo 9500, 8400 Bariloche, Rio Negro

Argentina

zanette@cab.cnea.gov.ar

Table of Contents

Fifty Years of Urban Modeling: Macro-Statics to Micro-Dynamics <i>M. Batty</i>	1
Complexity: The Integrating Framework for Models of Urban and Regional Systems <i>P.M. Allen, M. Strathern, J. Baldwin</i>	21
Ontogeny and Ontology in Complex Systems Modeling <i>C. Andersson</i>	43
A Model for Asystematic Mobility in Urban Space <i>A. Bazzani, M. Capriotti, B. Giorgini, G. Melchiorre, S. Rambaldi, G. Servizi, G. Turchetti</i>	59
Preliminary Results of a Multi-Agent Traffic Simulation for Berlin <i>U. Beuck, M. Rieser, D. Strippgen, M. Balmer, K. Nagel</i>	75
Hybrid Geographical Models of Urban Spatial Structure and Behaviour <i>M. Birkin</i>	95
Two Complexities and a Few Models <i>I. Blecic, A. Cecchini, G.A. Trunfio</i>	111
Cities as Evolutionary Systems in Random Media <i>L. Bogachev</i>	143
Grilling the Grid: a Non-Ultimate (Nor Objective) Report on the Configurational Approach to Urban Phenomena <i>V. Cutini</i>	163
Validating and Calibrating Integrated Cellular Automata Based Models of Land Use Change <i>G. Engelen, R. White</i>	185
Fractal Geometry for Measuring and Modeling Urban Patterns <i>P. Frankhauser</i>	213
The Dynamics of Complex Urban Systems: Theory and Application of the STASA-Model within the Scatter Project <i>G. Haag, J. Binder</i>	245
Study of Urban Developers' Behavior in a Game Environment <i>E. Hatna, I. Benenson</i>	265
Self-Organization and Optimization of Pedestrian and Vehicle Traffic in Urban Environments <i>D. Helbing, A. Johansson, S. Lämmer</i>	287