

Dirk Helbing *et al.*

The greatest bottleneck of ICT systems today is the difficulty in making sense and efficiently use the large amounts of data we generate.

## The Future ICT Knowledge Accelerator - Unleashing the Power of Information for a Sustainable Future

Sketch of an EU flagship initiative tackling global challenges for mankind in the 21st century



*We have explored the microcosmos and the universe, and have sent men to the moon. It turns out, however, that our knowledge of society is too limited to efficiently tackle the global challenges of humanity in the 21<sup>st</sup> century. Thus, it is timely to create an ICT Flagship to explore social life on Earth and everything it relates to.*

## Humanity is Facing Novel Challenges

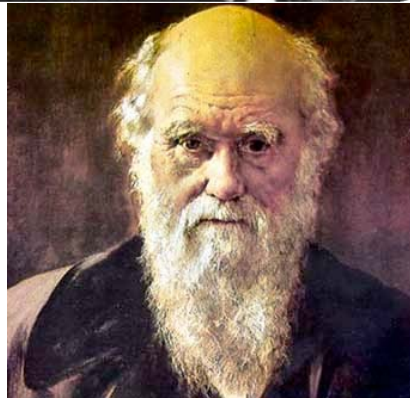
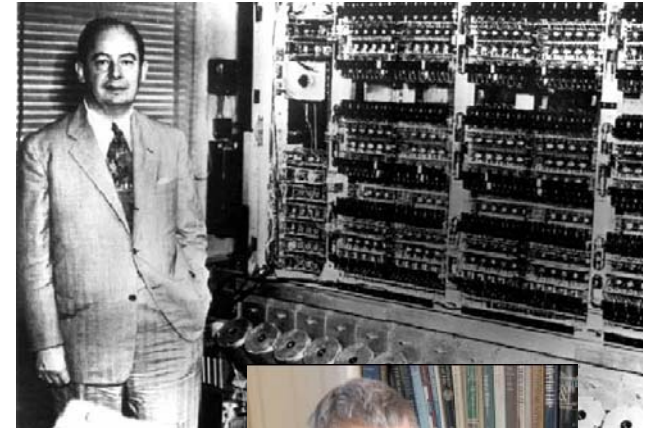
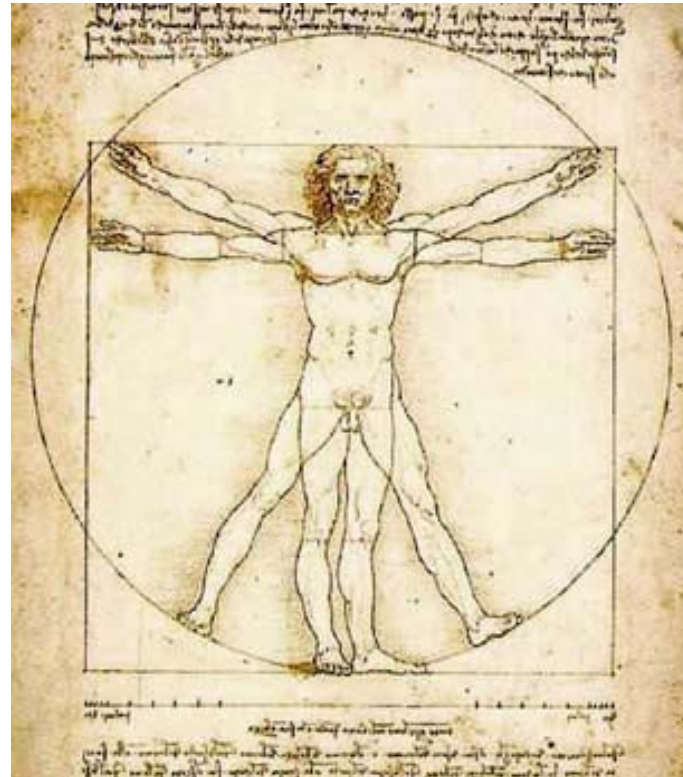
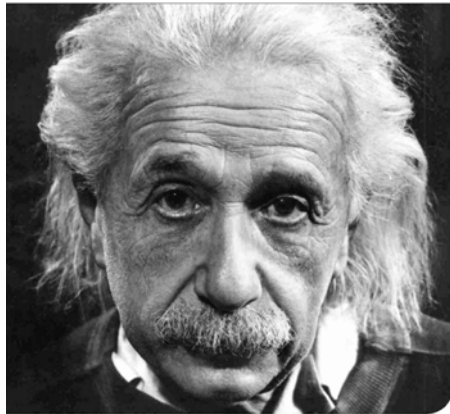
Lee C. Bollinger, president of Columbia University, formulated the issue as follows: “The forces affecting societies around the world ... are powerful and novel. The spread of global market systems ... are ... reshaping our world ..., raising profound questions. These questions call for the kinds of analyses and understandings that academic institutions are uniquely capable of providing. Too many policy failures are fundamentally failures of knowledge.”



## 10 Grand Socio-Economic Challenges

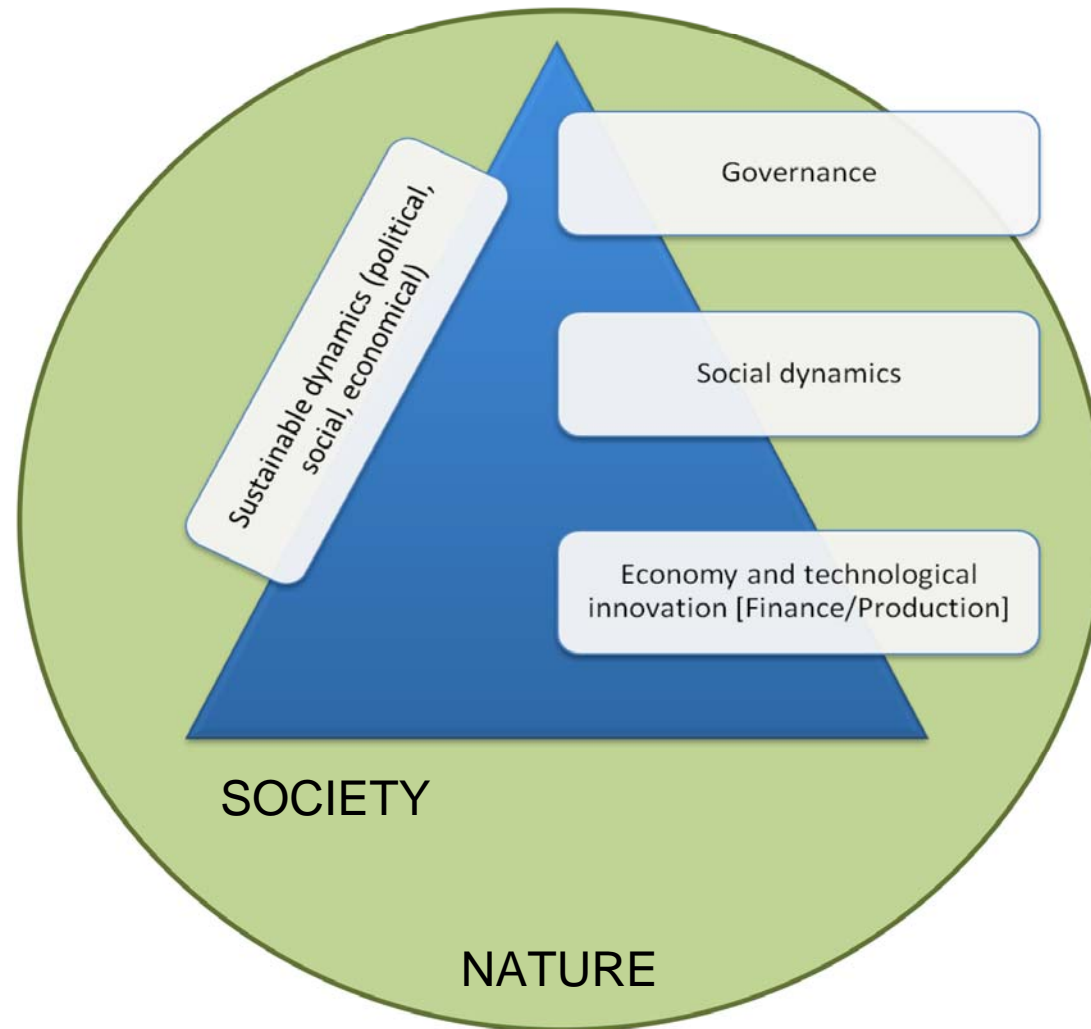
1. **Demographic change** of the population structure (change of birth rate, migration)
2. **Financial and economic stability** (trust, consumption and investments; government debts, taxation, and inflation/deflation; sustainability of social benefit systems...)
3. **Social, economic and political inclusion** (people of different gender, age, education, income, religion, culture, language, preferences,...; unemployment)
4. **Public health** (spreading of epidemics [flu, HIV], obesity, smoking, or healthy diets; incentives supporting food safety)
5. **Balance of power** (in a multi-polar world; also between individual and collective rights, political and company power; protection of pluralisms, individual freedom, and minorities...)
6. **Conflict** (terrorism, independence movements, social unrest, organized crime, war)
7. **Sustainability of communication and information systems** (education and inheritance of culture; cyber risks, violation of privacy, misuse of sensitive data, data deluge, spam, ...)
8. **Collective behavior and opinion dynamics** (social contagion, breakdown of trust, extremism, changing values, breakdown of cooperation, compliance, or solidarity)
9. **Institutional design** (over-regulation, compliance, corruption, balance between global and local, central and decentral, intellectual property rights,...)
10. **Sustainable use of resources and environment** (travel behavior, consumption habits, efficient use of energy and other resources, participation in recycling efforts)

## The Need of A Knowledge Accelerator



We need to create a **socio-economic knowledge accelerator** - a multi-disciplinary Apollo project for the social sciences, involving natural scientists and engineers

## Integrated, Systemic Approach of FuturICT



# Ambitions of FuturICT

## Fundamental ICT Challenges

- Exascale Computing and Living Earth Simulator
- Highly Decentralized and Peer-to-Peer Systems
- Zero-Delay Reality Mining
- Swarm Computing
- Social Computing
- Social Information Theory
- User-Oriented ICT Systems

## Applied ICT Challenges

- Data Collectors
- ICT-Empowered Systems Modeling
- Evaluating ICT Systems
- Reasoning ICT Systems
- Creative ICT Systems

## Impact of FuturICT

### Future Living

- Customized Information Services
- Innovation Accelerator
- Personalized Education
- Smart Cities, Transport, Traffic, Logistics
- Micro-Generation of Energy
- Safety and Security

### Towards Robust and Sustainable Systems

- Realistic Theory of Economic Systems
- Crisis Observatories
- Contingency Plans and Risk Management
- Managing Complexity and Institutional Design
- Integrative Design of A Sustainable Financial System and Economics
- Global Systems Dynamics

## Impact on Science, Industry, Business, Administration, Governance

- Science and Education:
  - Innovation accelerator
  - Personalized education
- Public Sector:
  - Healthcare (e.g. epidemics)
  - Security
  - Urban planning
- Business and Industry:
  - Supermarkets, department stores, retail business
  - Financial sector
  - Transport, traffic, logistics
  - Electrical micro-generation, renewable energy?
- Administration and Governance:
  - eGovernance
  - Coordination, participation, right mix of central and decentral control
- Consultancy?
  - Customized information services



## Completed Steps and On-Going Preparations for FuturICT

- Build-up of networked **multi-disciplinary community**
- Linking with **global system dynamics** and sustainability community (GSDP project)
- Identification of Grand Challenges, **Hilbert Program** for the socio-economic sciences
- Elaboration of suitable institutional settings (**Visioneer**):
  - Social data-mining and crises forecasting capacities
  - Innovation accelerator
  - Social simulation capacities
  - Integrative systems design centers

**Science AAAS nature**  
www.nature.com/nature Vol 460 | Issue no. 7256 | 6 August 2009

**A model approach**  
More development work is needed to help computer simulations inform economic policy.

**Economics needs a scientific revolution**  
Financial engineers have put too much faith in untested axioms and faulty models, says **Jean-Philippe Bouchaud**. To prevent economic havoc, that needs to change.

Vol 460/6 August 2009

**Connections**  
INTRODUCTION  
*We are caught in an inescapable network of mutuality. ... Whatever affects one directly, affects all indirectly.*  
—Martin Luther King Jr.

**The economy needs agent-based modelling**  
The leaders of the world are flying the economy by the seat of their pants, say **J. Doyne Farmer** and **Duncan Foley**. There is, however, a better way to help guide financial policies.

**Computational Social Science**  
SOCIAL SCIENCE  
David Lazer,<sup>1</sup> Alex Pentland,<sup>2</sup> Lada Adamic,<sup>3</sup> Sinan Aral,<sup>2,4</sup> Albert-László Barabási,<sup>5</sup> Devon Brewer,<sup>6</sup> Nicholas Christakis,<sup>1</sup> Noshir Contractor,<sup>7</sup> James Fowler,<sup>8</sup> Myron Gut Tony Jebara,<sup>9</sup> Gary King,<sup>1</sup> Michael Macy,<sup>10</sup> Deb Roy,<sup>2</sup> Marshall Van Alstyne<sup>2,11</sup>

**Economic Networks: The New Challenges**  
PERSPECTIVE  
Frank Schweitzer,<sup>1\*</sup> Giorgio Fagiolo,<sup>2</sup> Didier Sornette,<sup>1,3</sup> Alessandro Vespignani,<sup>6,7</sup> Douglas R. White<sup>8</sup>

**Meltdown modelling**  
Could agent-based computer models prevent another

**Ourselves and Our Interactions: The Ultimate Physics Problem?**  
NEWS  
In the field of complex socioeconomic systems, physicists and others are people almost as if they were interchangeable electrons. Can that decipher society and what ails it?

**Predicting the Behavior of Techno-Social Systems**  
PERSPECTIVE  
Alessandro Vespignani



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Department of Humanities and Social Sciences

Chair of Sociology, in particular  
of Modeling and Simulation

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Mr. George Soros

Zürich, 17 March 2010

Dear Mr. Soros,

Many leading scientists from various scientific fields, including Nobel Prize winners, have recently expressed their dissatisfaction with the state of economic theory, and it is obvious that new approaches are needed to address the fundamental and practical challenges of our financial, economic and social system. The criticisms of the pillars of classical economics are substantial and suggest that

- markets are not efficient by nature,
- economics can be driven far from equilibrium (as bubbles and crashes illustrate),
- the system behavior is dominated by interactions between the market participants and stakeholders, and hard to regulate,
- network interactions can change the behavior of markets dramatically, and
- science needs to be driven by empirical data, not just by the logic or beauty of theories.

This situation calls for concerted action and a largely multi-disciplinary approach. It has been proposed, for example, that one can gain valuable insights by comparing financial with eco-systems, in which extreme events can be the result of systemic instabilities. This approach relates to the theory of complex dynamical systems, considering randomness and strong interactions as fundamental features.

The financial crisis has not only created huge financial losses. It has damaged the economic system to an extent that several countries are at the verge of bankruptcy, and social systems have become dangerously vulnerable. The problems we have seen may just be the beginning of a larger crisis. The situation may totally get out of control, endangering social peace and cultural achievements.

It may, therefore, interest you that the European Union is currently creating scientific "Flagships" to address the grand challenges of the future. With a budget of 100 million EUR per year, over a period of ten years, they want to foster unprecedented scientific discoveries and radical innovation by transdisciplinary research. FuturICT, one of the initiatives applying for this program, aims at developing a realistic theory of economic systems and society, at creating computer simulations of global-scale systems, and at designing new concepts for a sustainable world. It will involve scientists from a large range of disciplines. Hundreds of experts in social simulation, economics, physics, sociology, mathematics, psychology, ecology, computer science, etc. would be working together to combine the best of human knowledge.

Herewith, we would like to invite you to be a galleon figure of this Flagship. The FuturICT flagship fits perfectly the goals of your **Institute of New Economic Thinking**. Joining forces could largely accelerate the required paradigm shifts and the development of solutions to the challenges humanity is facing.

Sincerely yours,

Dirk Helbing  
Economists: Mauro Callegati, Domenico Delli Gatti, Cars Hommes, Alan Kirman, Thomas Lux  
Econophysicists: Jean-Philippe Bouchaud, Doyne Farmer, Imre Kondor, Matteo Marsili, Yi-Cheng Zhang

**GEORGE SOROS**

March 30, 2010

To Whom It May Concern,

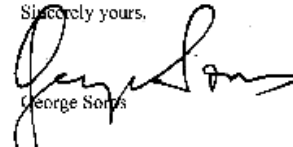
On behalf of the Institute for New Economic Thinking and Central European University I am writing to express strong interest in this scientific endeavor and in collaborating with the candidate flagship FuturICT and the team Professor Helbing is creating.

The Institute for New Economic Thinking (INET) [www.ineteconomics.org](http://www.ineteconomics.org) has been founded to foster and create new interdisciplinary ways to address social and economic problems. Applications of network theories to system evolution, political-economic interactions and psychologically sophisticated approaches to understanding system dynamics are just a few dimensions of exciting new research that our fellows will be working to develop.

Central European University, INET and a number of leading universities are working to establish a network of campus based joint venture institutes around the world to further invigorate our research agenda. The first of which, in conjunction with the Oxford Universities 21<sup>st</sup> Century School will begin to operate shortly. This interdisciplinary network will add further strength and depth of scholarship to the pursuit of new and deeper understanding of a myriad of social issues.

The team of scientists that Dr. Helbing has gathered together can, I believe, make a significant contribution to the understanding of the evolution and change in societies as they meet the formidable issues of governance, climate change, sustainable economic balance that we are all faced with in the coming decades. I look forward to CEU and INET joining with FuturICT to address these daunting challenges in the coming years.

Sincerely yours,



George Soros

Lord Robert May of Oxford: "Your letter to Soros puts the case admirably well, and I believe he may well be interested in such an initiative."

UCL DEPARTMENT OF MATHEMATICS



To: Wolfgang Boch  
Head of FET

23 March 2010

March 19, 2010

To Whom It May Concern

Re: FuturICT - Unleashing the Power of Information for a Sustainable Future

Dear Wolfgang,

As you know, GSD is very much concerned with identifying new techniques of ICT influenced mathematics that we require in order to assist policy makers with their decision making, particularly in the area of sustainability. GSD Partners have been informed, and indeed are informing, the proposal being put forward by Professor Helbing for his idea of a flagship. Although GSD is approaching its end, new ideas are now being fed into many different projects. It is bizarre that despite all the advanced mathematics available to us we are still not able to successfully model social interactions. It is this inability which lets scientific advisors down in their efforts to provide advice to politicians and others on the best way forward.

As Coordinator of the GSD project I firmly support this notion for a flagship and I know that my colleagues are also supportive. We feel that we have only just begun modelling and simulation can be brought together to inform an making both for governance and in business. Furthermore we have instigate and collect data that will help form the basis for new actions, much interested in this project.

Furthermore we recognise that the ideas being proposed go even further the FuturICT programme is truly both adventurous and challenge

Finally, the goals of FuturICT very neatly match not only my own but also of my colleagues here at UCL.

I am therefore very keen to work with Professor Helbing and will support this important project. I know that this attitude is already mirrored by other colleagues on our GSD database and I am sure that the others will be much aware of the particulars.

Yours sincerely

Steven Bishop  
Professor of Nonlinear Dynamics

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[www.ucl.ac.uk](http://www.ucl.ac.uk)

[www.globalsystemdynamics.eu](http://www.globalsystemdynamics.eu)

Physics of Socio-Economic Systems Division  
of the German Physical Society (DPG)  
The Wolfgang Boch  
Head of FET  
Zurich, March 18, 2010

Letter of Support for the Physics of Socio-Economic Systems Division

It is my pleasure to inform you that I have followed the Physics of Socio-Economic Systems Division about the FuturICT flagship initiative, as a result of our discussions, I am pleased to provide my support of the Division for the participation in this flagship initiative.

The Physics of Socio-Economic Systems Division has been established within the German Physical Society since 2007. Since then, we have held several workshops with many talks and poster presentations on various topics.

- financial markets and risk management,
- economic models and evolutionary game theory,
- traffic dynamics, urban and regional systems,
- social systems, opinion and group dynamics,
- networks from topology to dynamics, and
- systems of robots.

We often have joint sessions with the Physical Systems and Biological Physics Divisions. Furthermore, we often do have sessions on various data mining and social agent modeling, such. Next year, we will have a joint focus session with the Mathematical Physics Division.

One of our highlights each year is the Young Science Award for Robotics and Biomechanics, which is given annually to a young researcher who has made a significant contribution to the understanding of social or economic systems. The winners of the prize are chosen by the members of the Division. Due to its large recognition and the generally eminent projects, the prize has enjoyed a large success in public media.

Having started with about 20 members, the Physics of Socio-Economic Systems Division has grown to more than 200 members in less than 10 years and welcome members from all countries. Our success is due to the fact that our Physical Division is the result of the joint efforts of the members in the area of physics of socio-economic systems, but they remain to be the members of a community, through its regular meetings, workshops and workshops, the Division is an excellent model for the organization of scientific teams.

With our scientific organization in an academic view, a wide-scale freedom of its members in working in various fields of disciplines, such as biology, medicine, and computing sciences. This means that there is a strong interest in an interdisciplinary research and future partners in this area. I am sure that the commitment of the Physics of Socio-Economic Systems Division is a great asset for the project's flagship and one of the pillars to make it a great success.

Sincerely yours,

Dirk Helbing  
Chairman of the DPG Physics of Socio-Economic Systems Division  
[http://www.spe.ethz.ch/helbing/helbing/see\\_dhacking/verlaed](http://www.spe.ethz.ch/helbing/helbing/see_dhacking/verlaed)

RE: Candidate Flagship on "FuturICT: Unleashing the Power of Information for a Sustainable Future" EU Projects, FET Programme, Complexity Initiative

On behalf of the Management Committee and as President of the European Social Simulation Association (ESSA), I would like to express the strong interest of our community in this scientific initiative.

On one hand, this initiative is a clear evidence of the growing reputation of social simulation and its fertile interconnections with other scientific environments. When the computational social sciences link ICT with the social scientific disciplines, social simulation can bridge the gap with complexity science.

On the other hand, the candidate Flagship shows the strong applicability of social simulation. Nowadays, it would be short sighted to ignore the tools that ICT in general, and computer simulation in particular, can provide to anyone who is interested in understanding the evolution and change of societies.

There is no way to investigate the future without the powerful technology provided by ICT, because these technologies are a significant factor for change, and a major component of the future. ICT-enabled social sciences enables us to understand future developments of ICT and its contribution to society.

Taking advantage of a large network of prestigious institutions and highly reputed scientific communities, the Flagship has several merits.

Firstly, it tackles the most crucial issues that strongly affect the future growth and the quality of life in (r)ized societies.

Secondly, it creates a far-reaching interdisciplinary vision, requiring strong synergies among social, cognitive and computational sciences.

Thirdly, if one may use an oxymoron, it represents a solid vision. Highly ambitious in its goals, it stands on solid grounds. Implementing complex and evolving virtual societies is a daring task, on the other hand, can count upon a resource of models, theories, techniques and tools. Still in some basic ingredients (new theories and models, large-scale simulation platforms, databases and techniques, etc.) are already available, waiting to be incorporated into a consistent theoretical framework.

Fourthly, it would contribute to European competitiveness by providing novel means to maintain and develop its welfare tradition. Moreover, it will add to the merits of the Complexity Programme of the EU to provide the ways and means of such a competitive endeavour.

Finally, it is innovative, building on the frontiers of ICT and providing stimulating reasons to go further: using Bertrand Russell's words, it builds on the objective to "see in imagination the society that can be created".

Best wishes

Rosaria Conte  
President of ESSA  
<http://www.essa.eu.org/>

TRINITY COLLEGE  
UNIVERSITY OF DUBLIN

Professor Peter Richmond  
Tel +353 1 896 1676  
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Department of Physics  
Trinity College  
Dublin 2  
Ireland



To: **Whom may concern**  
Date: **13 April 2010**

31<sup>st</sup> March 2010

Re: **FUTurICT - Unleashing the Power of Information for a Sustainable Future**

To who it might concern,

As you may know, COST is very much concerned with establishing new networks in innovative areas of science and technology. Complex systems science has over the past few years been supported first by COST P10 Physics of Risk and currently by COST MP0801 Physics of conflict and cooperation. The aim of this latest action is to nurture and support researchers interested in applying methods of complex systems to social and economic systems. These concerted actions have partners from over 24 European member states and many of the partners have been informed, and indeed are informing, the proposal being put forward by Professor Helbing for his idea of a flagship. COST MP0801 will continue for another two years and we expect to help feed many new ideas into the Flagship project. In this way we shall provide a valuable link and input for key projects concerned with the application of new mathematics and physical ideas into the social and economic systems which are in sore need of new intellectual input.

As Coordinator of these COST Initiatives I firmly support this proposal for a flagship and I know that colleagues are also very supportive and will be very interested in the project. The ideas being proposed will take our activity forward in new and, at the moment unknown ways and we believe the FuturICT programme is truly both adventurous and challenging. The goals of FuturICT very neatly match the interests of all colleagues within COST.

Many if not most will be keen to work with Professor Helbing and collaborate on this important project and I am sure that the others will follow suit once they

We therefore strongly support this proposal:

Yours sincerely



**POLITECNICO DI TORINO**

To whom it may concern

As legal representative of the Politecnico di Torino, I hereby confirm our interest and willingness to participate and support the initiative "Candidate Flagship FuturICT", co-ordinated by Prof. Dirk Helbing, ETH Zurich, that will be submitted in response to the next call for proposals of the FEI-ICT Programme.

The action areas of the FuturICT Flagship are critically relevant to the main needs of our present and future society. In the area of the ICT, the focus of research and technology development has moved from the design of monolithic engineered systems to the design, integration, on-the-fly composition of distributed systems and the development of platforms for such systems. Public and private institutions, industries, commercial and public-sector organisations are increasingly aware that their software applications do not stand alone, but are part of a broad interconnected system.

Social interactions change and adapt to the multifaceted and interconnected effect of ambient intelligence. The challenge of this Flagship will be to establish guidelines, design rules and increase awareness to meet the increasing need to face with these new social paradigms.

Hence, we confirm our interest in co-operating actively to the preparation of the project proposal and then in successfully implementing and promoting the Project activities.

A cluster of Departments (Physics, Information and Communication Engineering, Transport and Civil Engineering) is jointly involved in the Flagship, collaborating with Professor Helbing and the other partners. The members of our team have long-standing skills in many areas of the ICT as for example Statistical Physics, Image Processing, Distributed Information and Communication Technologies, Information and Algorithmic Complexity, Building and Transport Engineering.

The people involved within our organisation are:

- Prof. Anna Carbone (anna.carbone@polito.it) Physics Department - Referent
- Prof. Enrico Maci (enrico.maci@polito.it) Convolver Engineering Department
- Prof. Marco Ajmone Marsan (marco.ajmone@polito.it) Electronic Engineering Department
- Prof. Cristina Promello (cristina.promello@polito.it) Transport Engineering Department
- Prof. Bernardino M. Chiaia (bernardino.chiaia@polito.it) Civil Engineering Department

Name and Position of Legal Representative  
Prof. Francesco Prommo  
RECTOR  
Torino, 12 April 2010

Professor Francesco Prommo  
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**The Complex Systems Society**

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Tel: +44 77 966 966 21

Prof Dirk Helbing  
ETH Zurich  
17<sup>th</sup> March 2010  
Dear Professor Helbing

**Complex Systems Society Support for the FuturICT Flagship Project**

I write on behalf of the Complex Systems Society to express our commitment to the proposed FuturICT Flagship Project. This proposal has our strongest support.

The Complex Systems Society was created in Europe through the ONCE-CS coordination action of the Future and Emerging Technology (FET) unit of the European Commission. Ten years ago FET had the vision to see that the emerging science of complex system would have a profound impact on every aspect of European Society, providing new ICT-enabled solutions to problems that traditional physical, biological, environmental and social science cannot solve by themselves. Complex systems is a synthesis that integrates the traditional sciences, adding new layers of understanding and enabling new technologies for exploitation in the private and public sectors. Through the support of the European Commission and national funding agencies, Europe has become a world leader in complex systems science. With a membership exceeding two thousand people, the Complex Systems Society is a large and heterogeneous community of scientists, entrepreneurs and policy makers developing and applying the new science.

The complex systems community believes that the FuturICT Flagship will be one of the most profound scientific initiatives of the twenty first century, and it will have a great impact in the short and long terms. The major challenges faced by humankind are complex systems problems - from adapting to climate change and its geo-socio-political-economic consequences, to providing reliable science to underpin global and national finances, to creating a new in-vivo biological science on which to base pharmaceutical and medical practice, to creating new methods to study epidemics of viral and socially induced illness, to producing the new theoretical understanding necessary for geopolitical and military stability in the face of the many global challenges that lie ahead. Humankind needs to integrate all its knowledge from all domains into new science able to address the new kinds of problem that emerge in our ever more connected world. The FuturICT programme is a unique opportunity for Europe to grasp the scientific initiative and create new science to enable it to survive and even thrive in the turbulent times that lie ahead.

We offer our full support to the FuturICT Flagship and we want to work with you to make this extraordinary vision become a reality. For scientists this is a once-in-a-lifetime opportunity to participate in a programme of revolutionary scientific discovery and unprecedented social innovation. The Complex Systems Society and its members are excited by the prospect of making a quantum leap in science and its applications through the visionary FuturICT Flagship project.

Assuring you of our full support, yours sincerely

Professor Jeffrey Johnson  
President



Prof. Dr. Carlo C. Jaeger

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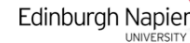
Potsdam, 24 March 2010

To Whom It May Concern

RE: Candidate Flagship on "FuturICT"  
EU Projects, FET Programme, Complexity Initiative

The GSDP - Global System Dynamics and Policy - network currently includes about 200 researchers interested in developing a research program for the study of global systems. We see great potential in the "FuturICT" initiative from this point of view.

An important example of global systems is given by the world economy. With regard to this system, the global financial crisis has raised the irritating question whether-and if so, why - the



March 28, 2010

To whom it may concern

**Support for the FuturICT Flagship Project**

Dear Professor Helbing:

On behalf of the PANORAMA (Pervasive Adaptation) Research Agenda Group within the Future and Emerging Technology (FET) unit of the European Commission, we write to express our strong support of the proposed FuturICT Flagship Project.

PerAda is a vibrant consortium of researchers, manifested in the FET FP7 PANORAMA coordination action, involving the leading Pervasive Adaptation research consortia ALLOW, ATTRACO, FRONTS, REFLECT, SOCIALNETS and SYMBRION, all concerned with technologies used in information and communication systems which are capable of autonomously adapting to highly dynamic user contexts. The development of future systems will increasingly require collaborative systems, involving complex interactions between people, intelligent objects and computers. The real challenge will be the constantly changing networked environment that can no longer be centrally controlled, or even completely understood, by the developer or user. To be successful especially in such highly dynamic environments, systems will have to adapt themselves, taking into account the emergent behaviour of the system. More than 650 renowned researchers in this area are coordinated by PANORAMA (see www.perada.eu).

Within PANORAMA, the Research Agenda Group is concerned with the identification of the most challenging frontiers of research in Pervasive Computing and Communications, supporting decision makers, stakeholders and policy makers within the Future and Emerging Technology (FET) unit of the EC, the leading authorities in academia and scientific research worldwide, and future-oriented industrial stakeholders in the ICT area in Europe and across continents.

Many of the grand research challenges identified by PANORAMA are coherent with what FuturICT attempts to address as the most profound scientific initiative in this century. After almost a whole century of ICT focussed on and centered around the individuals or groups of people, the FuturICT Flagship approach will open a whole new dimension of ICT at the level of societies, and eventually the whole human mankind. It is crucially important for an initiative that reaches out for the ultimate ICT frontiers, to find its underpinning not only in



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Prof Dirk Helbing  
ETH Zurich  
24<sup>th</sup> March 2010

Dear Prof Helbing,

**FET Flagship: FuturICT**

The Open University fully supports the proposed FuturICT Flagship and will do everything I can to make the project a success. The Design Complexity Group at the Open University has an international reputation for its research into the way complexity emerges on design and design embrace complex systems science. We hope to be able to contribute our expertise as the Flagship develops.

Also we will be pleased to contribute our well known expertise in education and distance learning to the project. With over forty years experience of educating millions of students in many countries the Open University will be able to provide programmes of education and support at the level the Flagship will require across many countries and institutions.

As you know the European ASSYST project based in my department is committed to supporting the FuturICT Flagship project, which we see as having the potential to be one of the most important scientific innovations of this century. We congratulate you for developing this exciting and innovative project. The ASSYST community strongly supports it.

The Open University will be also pleased to do whatever I can to help prepare and promote the FuturICT proposal through the efforts of ASSYST and my research group.

We wish you luck, yours sincerely

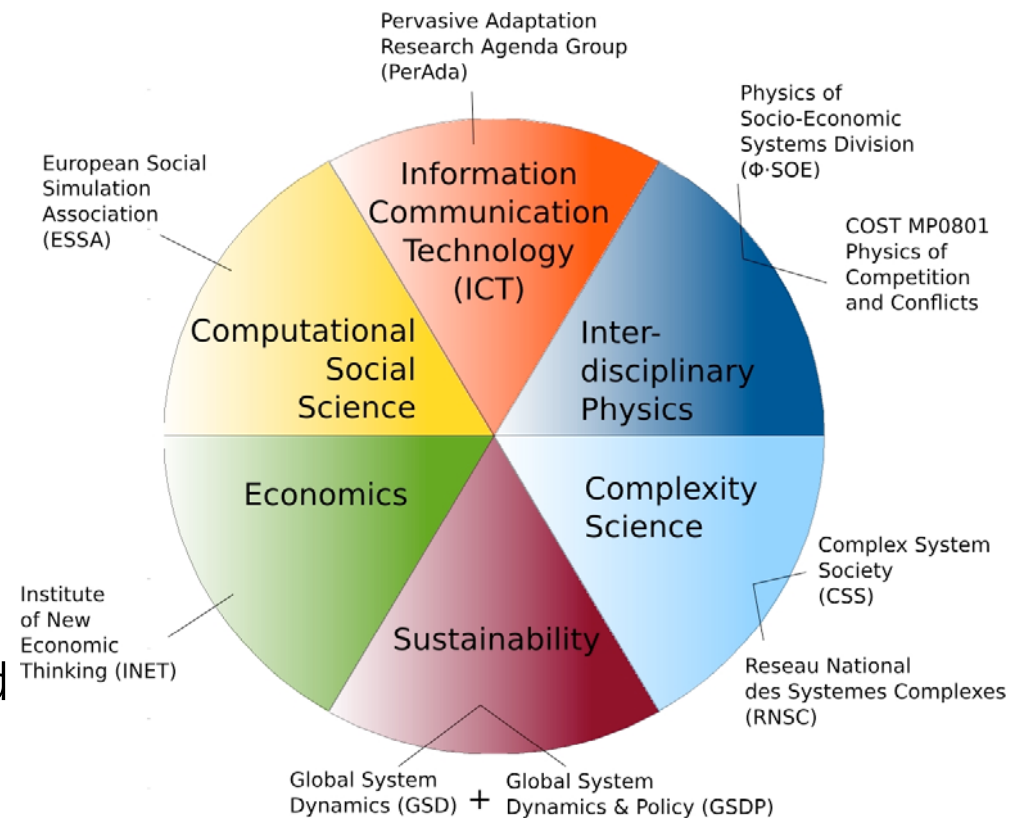
Jeffrey Johnson  
Professor of Complexity Science and Design  
Director of the European ASSYST Coordination Action Project

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## Plausibility of FuturICT

### Organizational Bodies

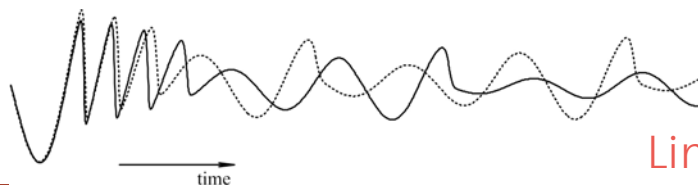
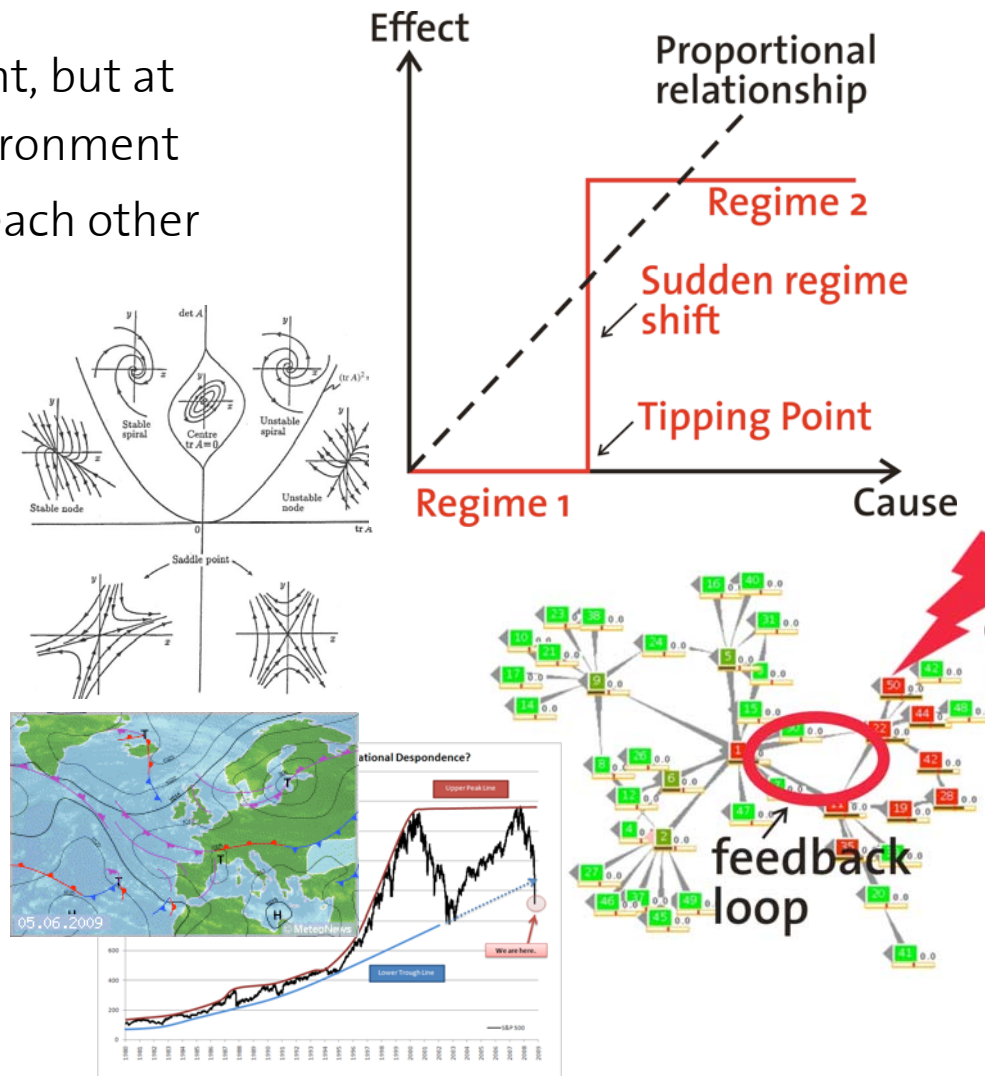
- PANORAMA/PerAda, ASSYST
- Complex Systems Society
- Institute of New Economic Thinking
- European Social Simulation Association
- Physics of Socio-Economic Systems Division of DPG
- COST Physics of Competition and Conflicts, Transport and Urban Development
- Global System Dynamics and Policy
- Open University, and many more



The FuturICT Knowledge Accelerator integrates the best of all relevant knowledge

# Techno-Social-Economic-Environmental Systems Are Complex

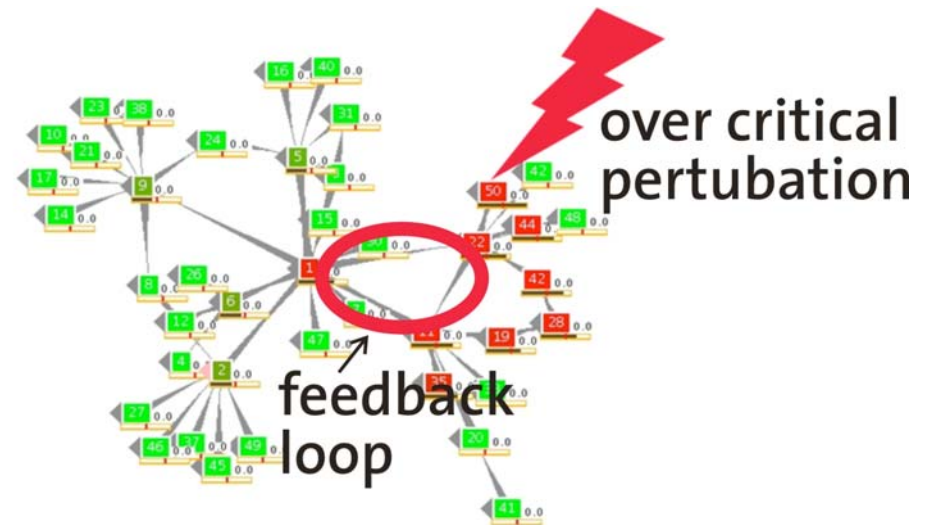
- Elements mutually adapt to each other
- They are influenced by their environment, but at the same time, they influence their environment
- Causes and effects not proportional to each other
- Unresponsive system or regime shifts
- Example: Sudden public opinion changes (collapse of GDR; pro vs. anti-war mood; public smoking ban; swiss banking secrecy; car sales)
- Network interactions are ubiquitous
  - Feedback loops, circuli vitiosi
  - Cascade spreading
  - Unwanted side effects



Limits of predictability: Chaos, turbulence, “butterfly effect”

## Cascade Spreading and Systemic Crises

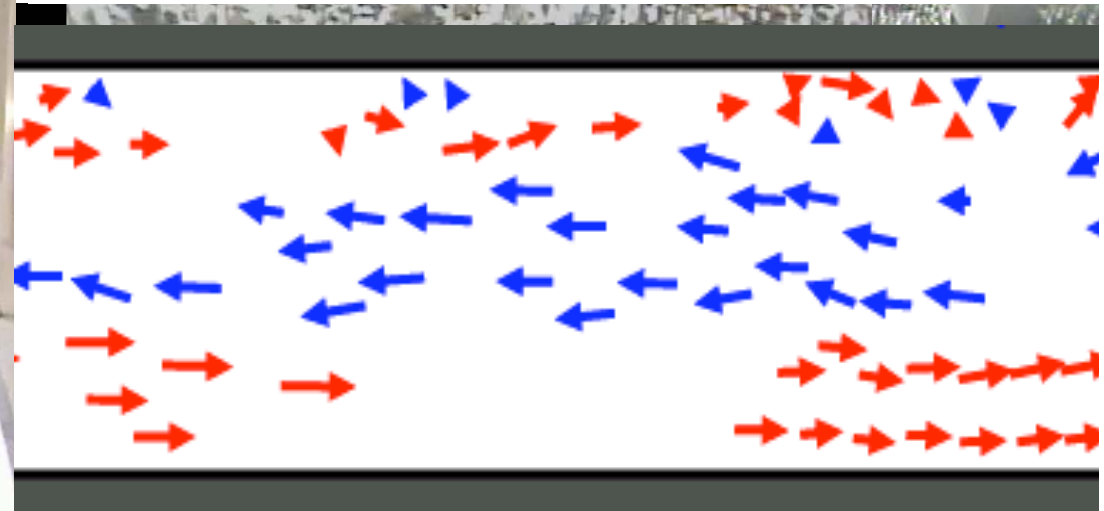
- Network interactions are ubiquitous
  - **Feedback loops**, circuli vitiosi
  - Unwanted side effects
- **Systemic malfunctions**, whenever the system state changes beyond a **critical threshold** („tipping point“)
- Often caused by massive cascading effects („domino effects“, „avalanche effects“)
- Triggered by overcritical perturbation or coincidence of failures
- **Examples:** Epidemic spreading, failure of interbank market, congestion spreading, blackout of electrical power system



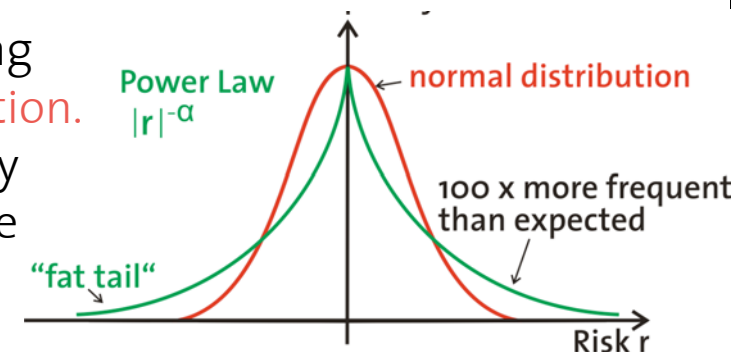
# Self-Organized Coordination and Its Breakdown in Complex Systems



Acts like Adam Smith's "invisible hand", but self-organized coordination may break down



Based on individual interactions, lanes of uniform walking directions **emerge** in pedestrian crowds by **self-organization**. This constitutes a „**macroscopic**“ **social structure**. Nobody orchestrates this collective behavior, and most people are not even aware of it. But **when challenged by extreme conditions**, **social order breaks down**.



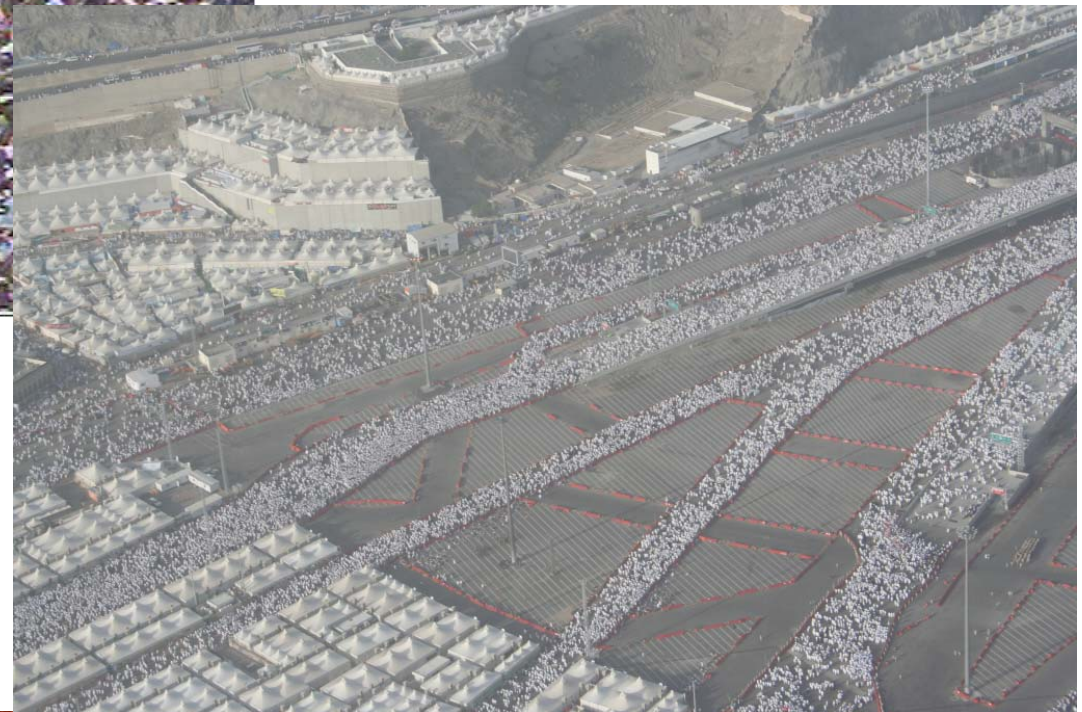


## The Change in Organization from 2006 to 2007

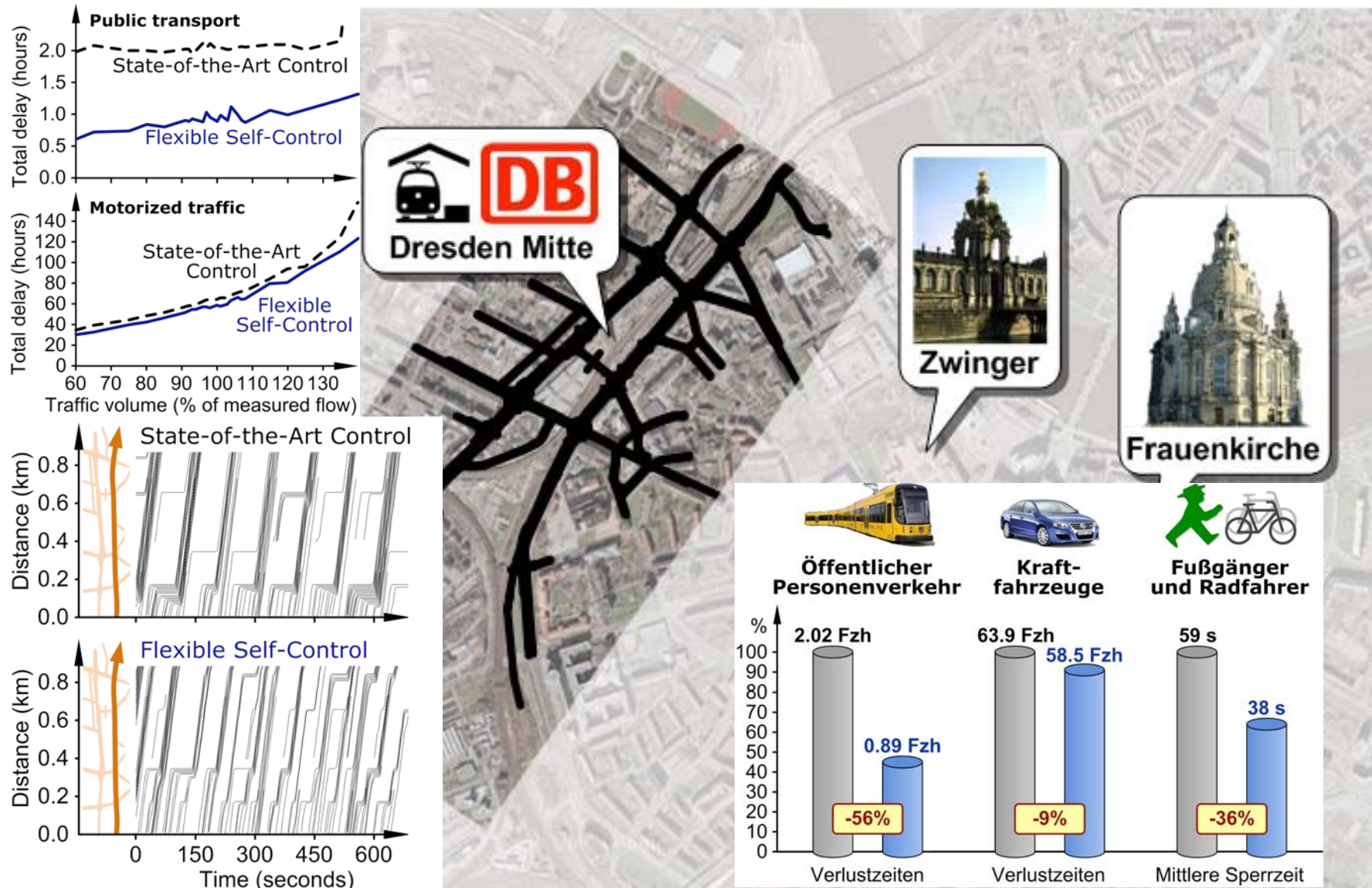


2006: Large accumulations, dense crowds, and long exposure times to intensive sun.

2007: **Unidirectional and smooth flows.** Pilgrims liked and supported the new organization.



# Self-Control of Urban Traffic: Environmental-Friendly without Pain

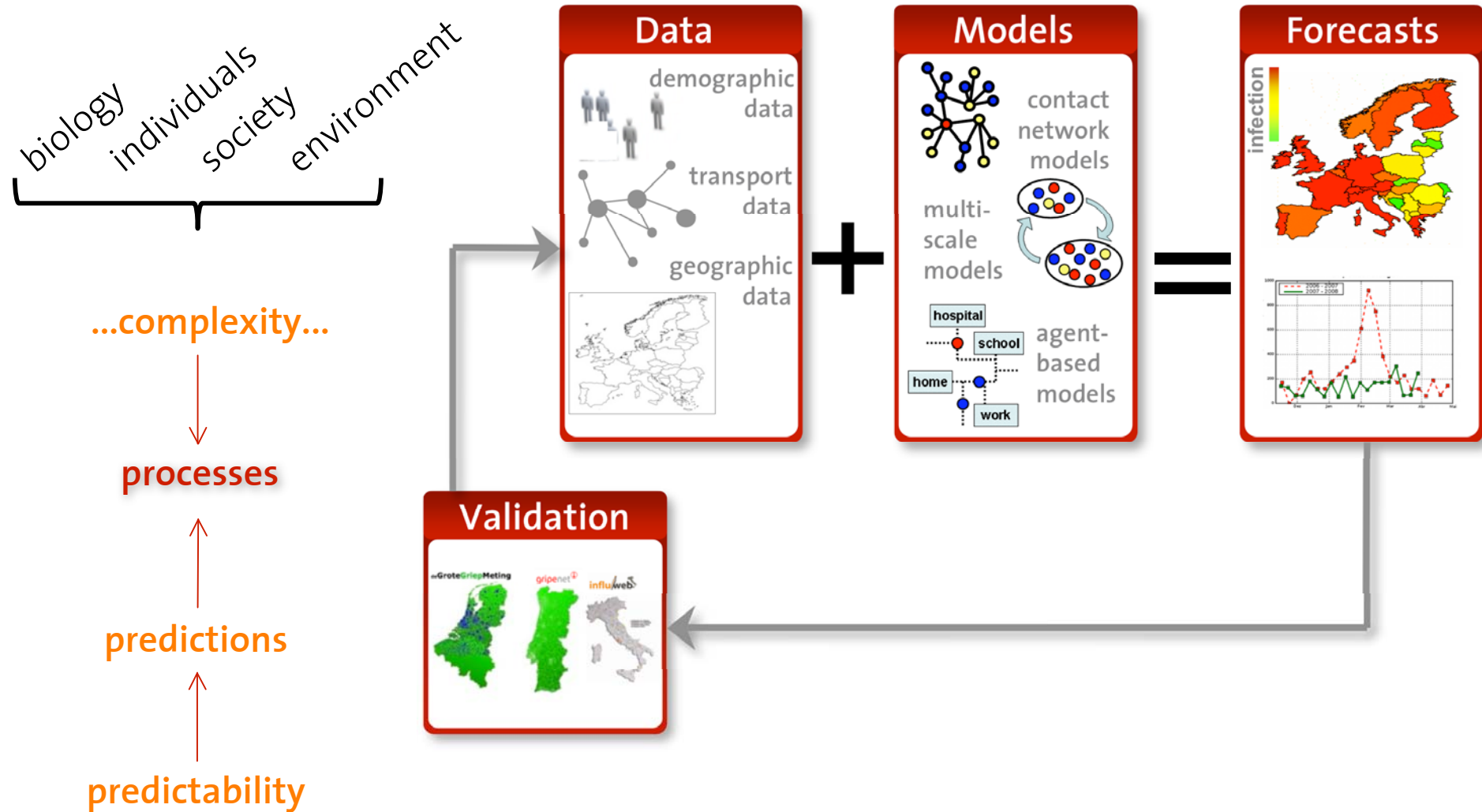


## Further Perspectives of Systems Design Utilizing Self-Organization



The way in which system elements interact can make a big difference!  
We can choose between breakdowns and capacity drops or stability and efficient flow

# Global-Scale Simulation of Socio-Economic-Environmental Systems

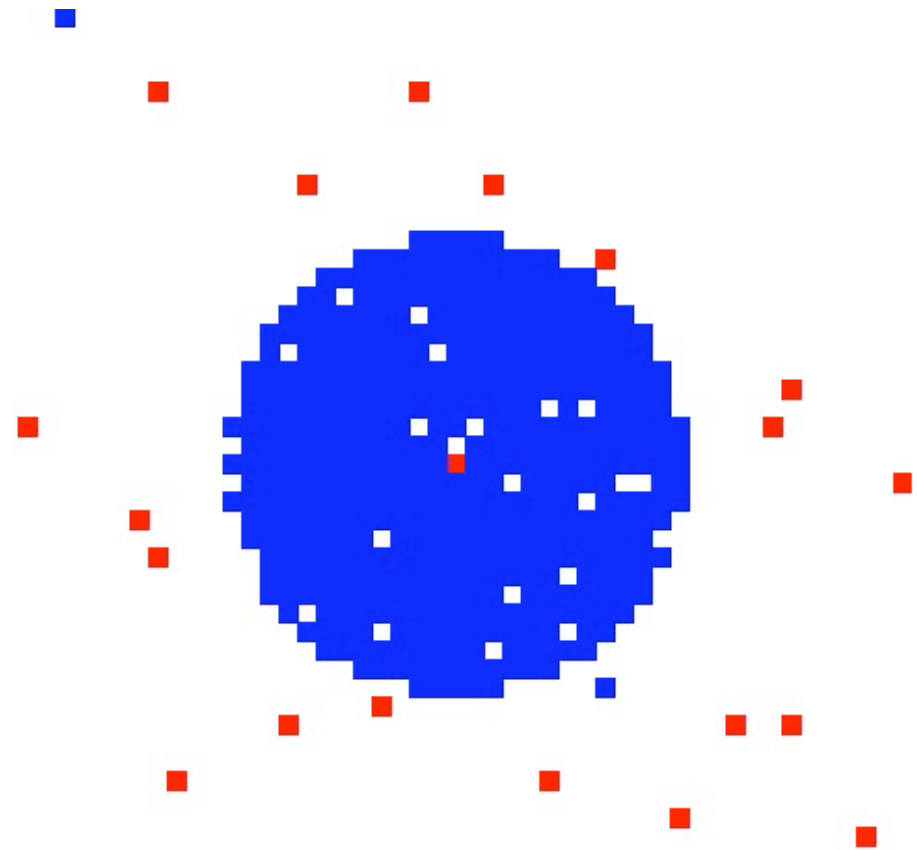
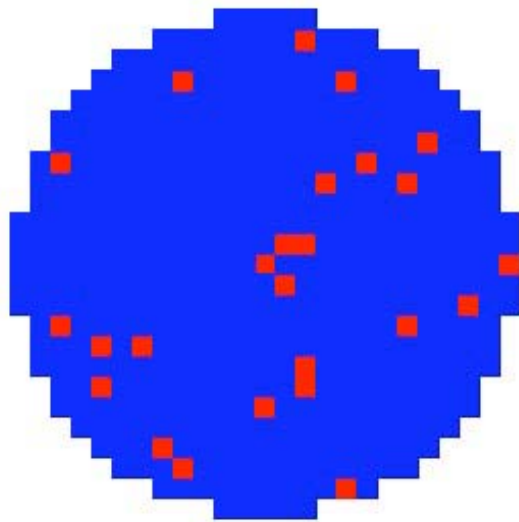


(thanks to Alex Vespignani)

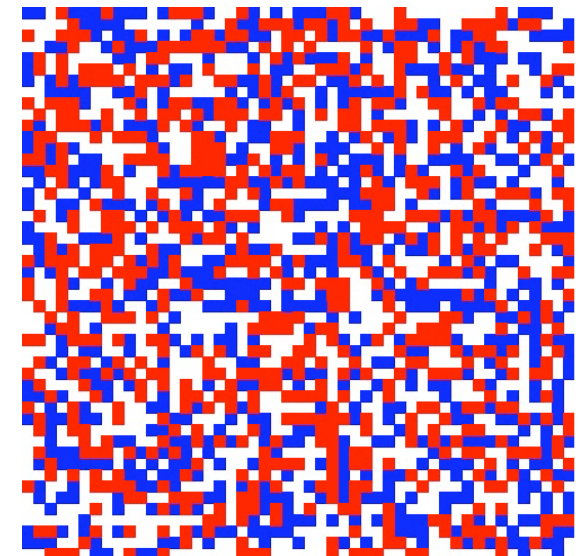
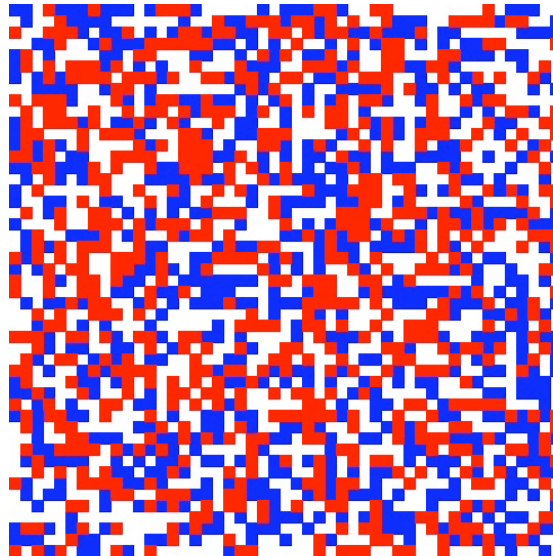
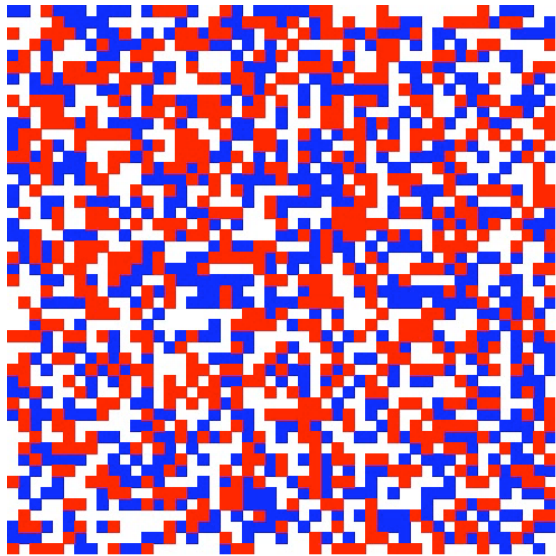
## Breakdown and Outbreak of Cooperation without and with Mobility

Red, yellow: defectors (cheaters)

Blue, green: cooperators



## Global Interactions Can Endanger Cooperation, Require Regulation

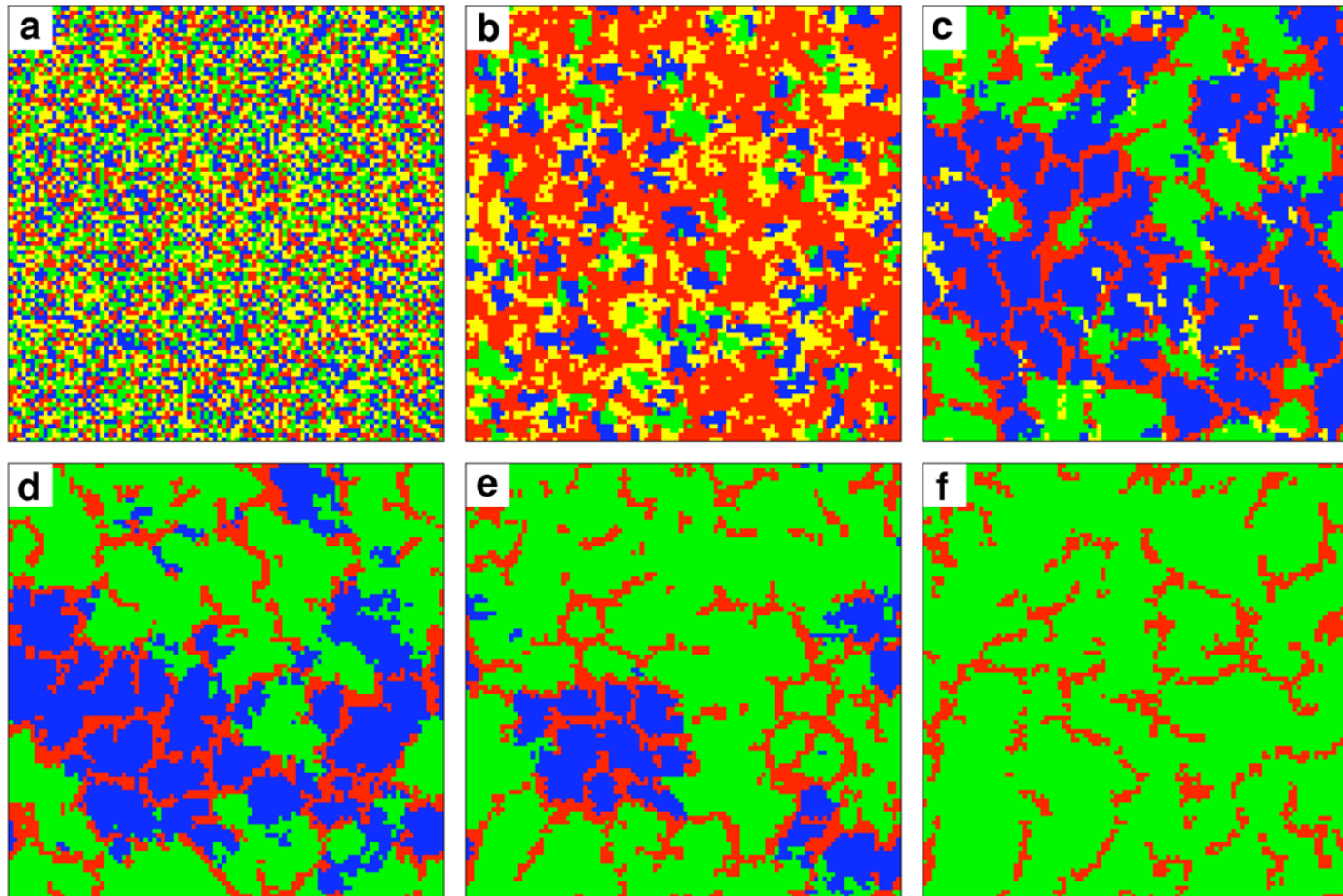


## Global Warming and the Spreading of Costly Punishment

- Imagine that **cooperators (C)** correspond to countries trying to meet the CO<sub>2</sub> emission standards of the Kyoto protocol, and **“moralists” (M)** to cooperative countries that additionally enforce the standards by international pressure (e.g. embargoes). **Defectors (D)** would correspond to those countries ignoring the Kyoto protocol, and **“immoralists” (I)** to countries failing to meet the Kyoto standards, but nevertheless imposing pressure on other countries to fulfil them.
- For well-mixed interactions, **defectors will be the winners** of the evolutionary competition among the strategies, i.e. all countries would finally fail to meet the emission standards (**“tragedy of the commons”**). The reason is that **cooperators** (**“second-order free-riders”**) spread at the cost of moralists, while requiring them for their own survival.

(See the work of Milinski et al.!)

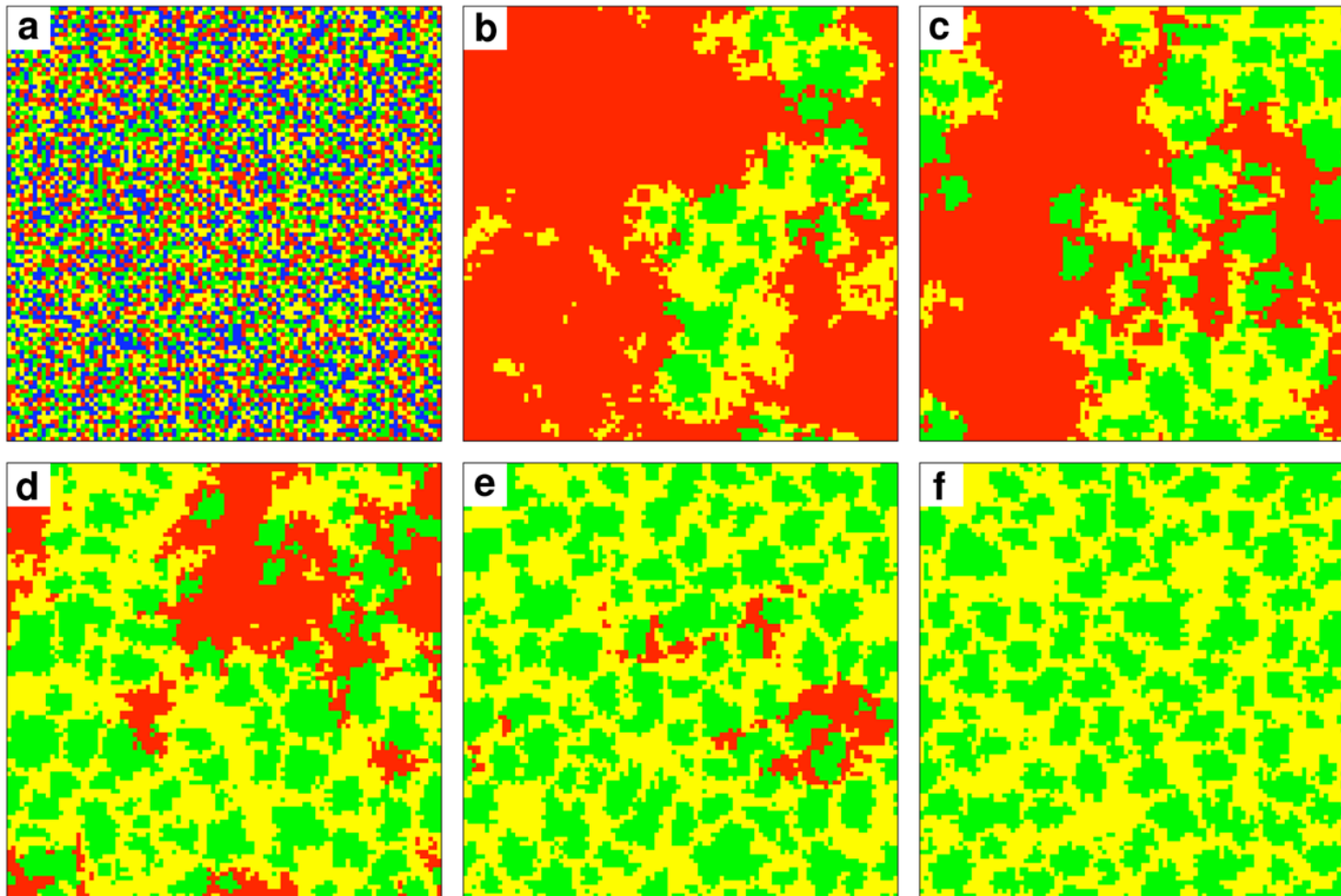
## How Second-Order Free-Riders Are Eliminated+Punishment Spreads



D = Defectors (Free-Riders), M = Moralists, I=Immoralists  
C = Non-punishing Cooperators (Second-Order Free-Riders)

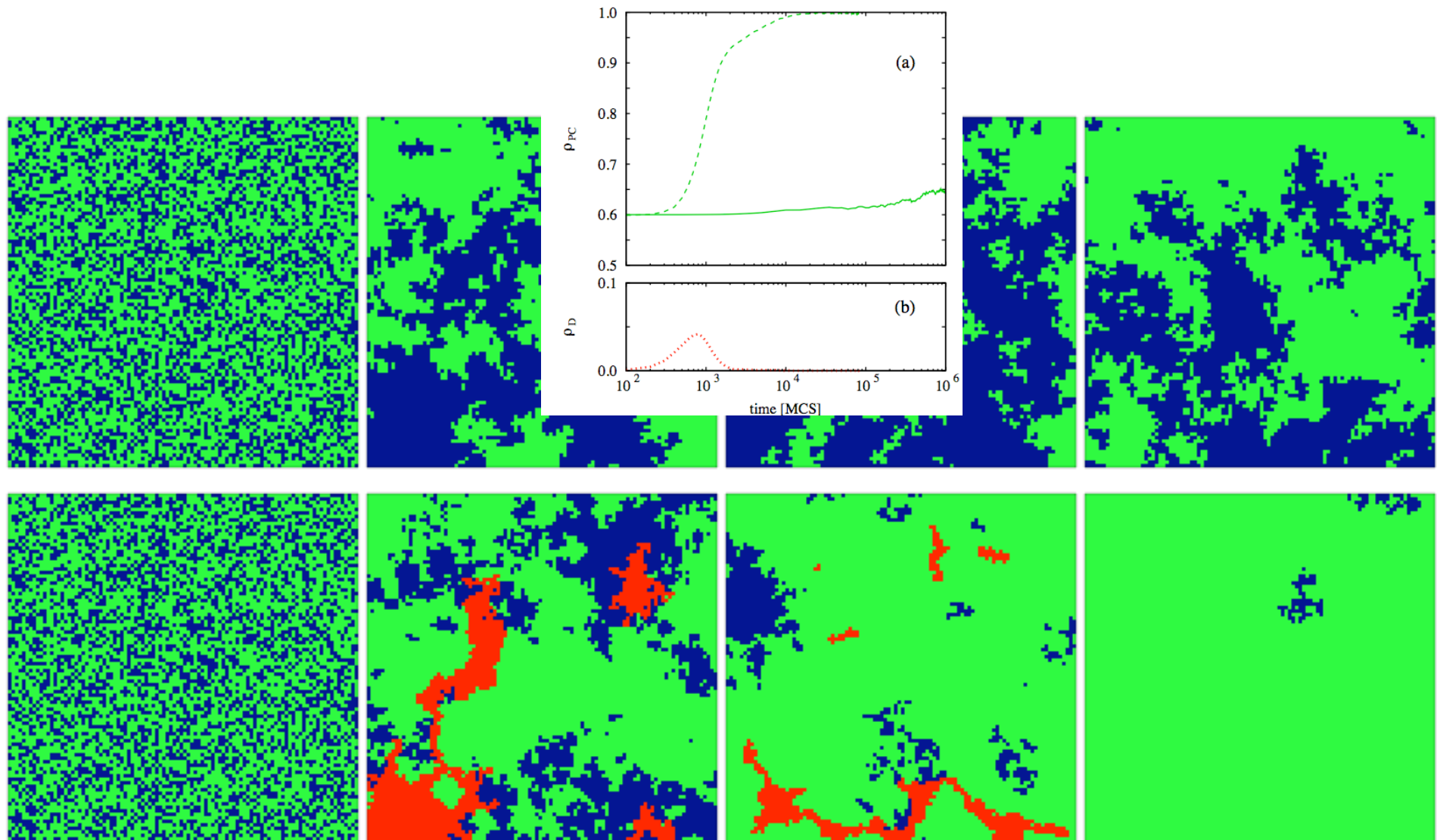


## Sometimes Moralists Succeed by “Unholy Collaborations”

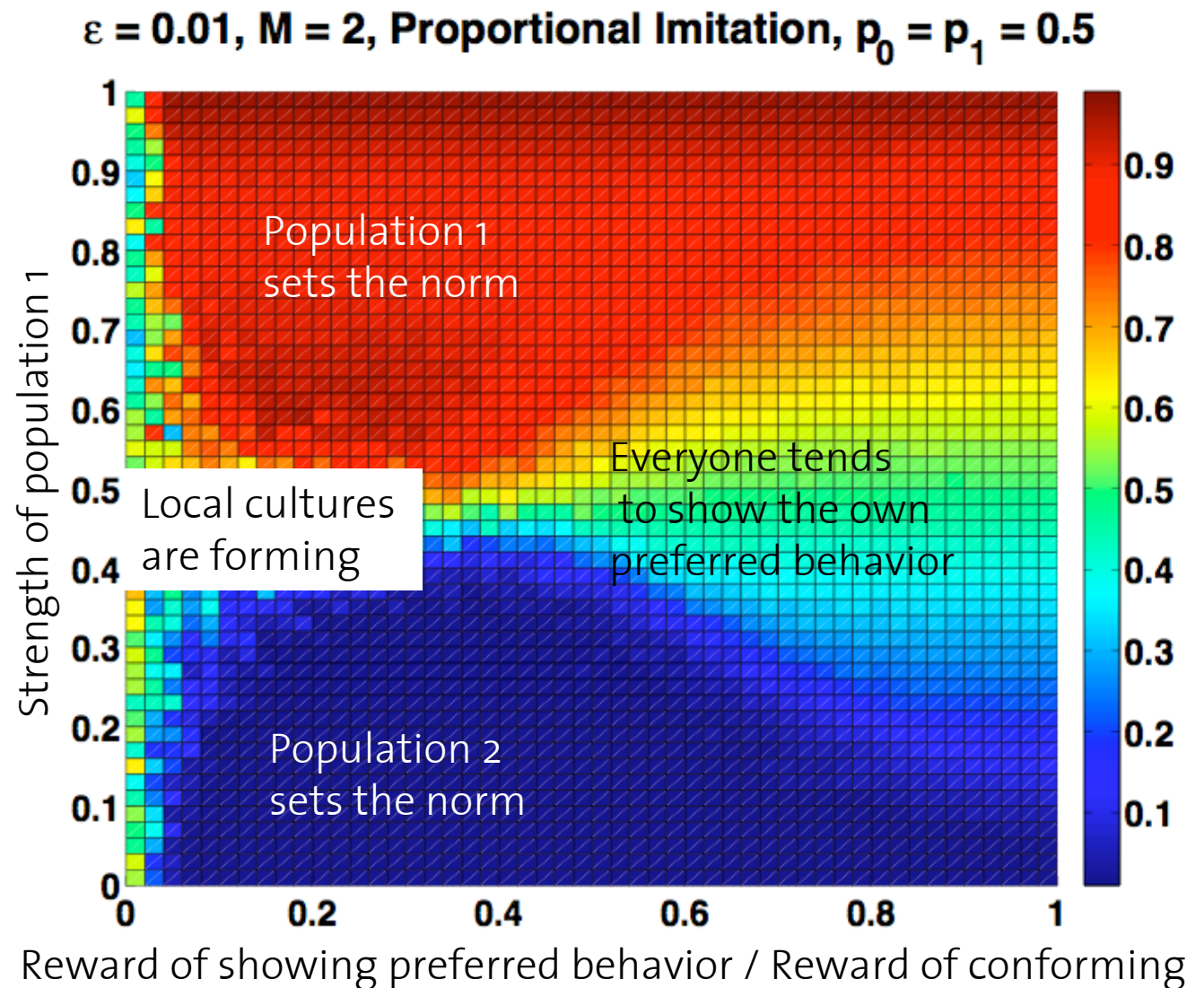
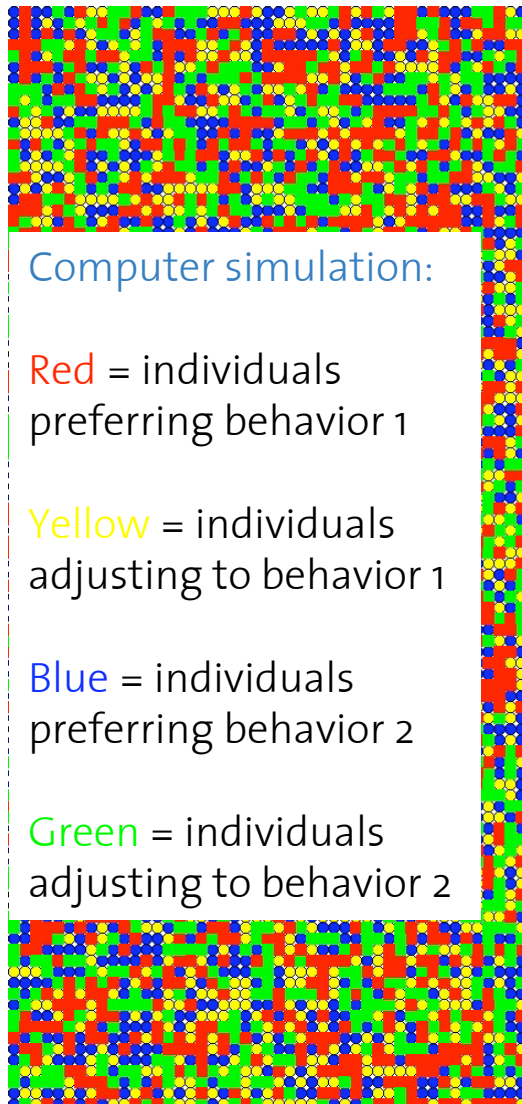


D = Defectors (Free-Riders), M = Moralists, I=Immoralists  
C = Non-punishing Cooperators (Second-Order Free-Riders)

## Lucifer's Positive Side Effect: When Defectors Promote Moralists

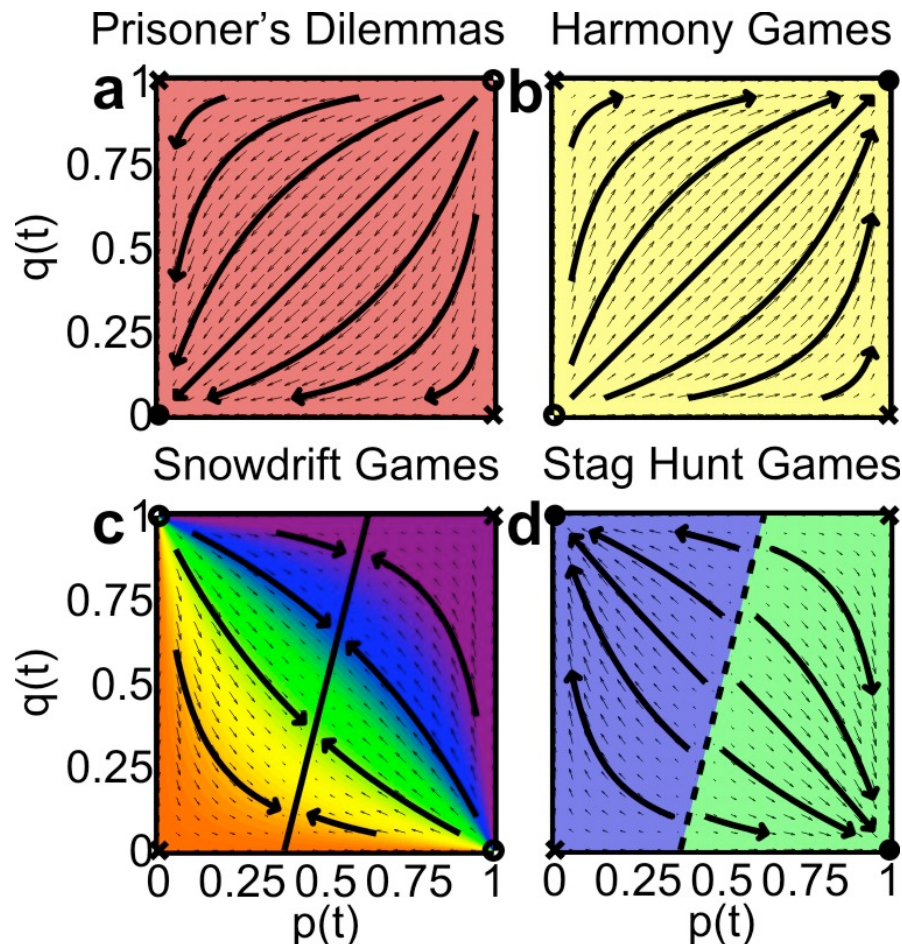


## Stabilizing Social Systems by the Emergence of Social Norms



## Possible Outcomes for Two Populations with Incompatible Interests

Breakdown  
of cooperation



Formation of  
subcultures

Polarization

Formation of shared  
behavioral norms

Only in the stag hunt game we find that both populations tend to use the same behavioral strategy, i.e. **a behavioral norm evolves!** The norm-creating mechanism is also important for the **evolution of language.**

*Global-scale social simulation is possible*

*We could understand the major steps of human cultural evolution*

*We could simulate possible futures*

*We can create new institutional designs*

*We can test policy options*



## A Quote from Josh Epstein (Brookings Institution)

“We are poised at the cusp of interacting epochal changes: ICT is propelling humanity into the age of global human connectivity; we are changing the global environment; we are peering into the human genome and unraveling the neurochemistry of human emotion and behavior. ICT is at once propelling these changes, but also permitting us to comprehend them. Planetary-scale computational modeling is now feasible, allowing the study of coupled transitions at multiple scales.

These epochal changes eclipse the turbulence of daily political affairs. And their complexity dwarfs the capacity of any individual's comprehension. Only a collective mind enabled by the ICT resources of our [the Flagship] consortium can undertake credible actionable forecasts embracing all of this, for the first time, in a rigorous replicable manner. And it is imperative that this admittedly bold step be taken: to envision - as comprehensively as the best minds and best ICT permit - how these epochal developments will interact over the next decade. The coupled socio-economic-environmental dynamics will [be] far from linear, far from equilibrium, and far from canonically rational. But they can be understood, and productively shaped, by the Flagship proposed here. It is an experiment we can't afford not to do.”