

"The Mathematics of Public Security 2" (MAPUSE 2)

November 19th-20th, 2007



INSTITUT FÜR HÖHERE STUDIEN
INSTITUTE FOR ADVANCED STUDIES
Vienna

November 19th: *Institute for Advanced Studies (IHS)*

<http://www.ihs.ac.at/>

Austria, A-1060 Vienna, Stumpergasse 56



Austrian Academy of Sciences
Österreichische Akademie der Wissenschaften

November 20th: *Austrian Academy of Sciences (ÖAW)*

<http://www.oeaw.ac.at/>

Austria, A-1010 Vienna, Dr. Ignaz Seipel-Platz 2

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edited by

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List of Speakers/Authors (In Alphabetical Order)

Doris Behrens	<i>University of Klagenfurt</i>
<u>Bernard Brooks</u>	<i>Rochester Institute of Technology</i>
Tilman Brück	<i>DIW Berlin</i>
<u>Roswitha Bultmann</u>	<i>Vienna University of Technology</i>
<u>Jonathan P. Caulkins</u>	<i>Carnegie Mellon University in Qatar & Heinz School</i>
<u>Gerardo Chowell</u>	<i>Arizona State University</i>
Joao Ricardo Faria	<i>Nottingham Trent University</i>
Gustav Feichtinger	<i>Vienna University of Technology</i>
Robert Feyer	<i>Siemens Vienna</i>
Dieter Grass	<i>Vienna University of Technology</i>
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<u>Andreas Karcher</u>	<i>Federal Armed Forces University Munich</i>
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<u>Ulrike Leopold-Wildburger</u>	<i>University of Graz</i>
<u>Stefan Pickl</u>	<i>Federal Armed Forces University Munich</i>
<u>Friedrich Schneider</u>	<i>Johannes Kepler University of Linz</i>
Gernot Tragler	<i>Vienna University of Technology</i>
<u>Tsvetomir Tsachev</u>	<i>Bulgarian Academy of Sciences</i>
Firdaus Udwadia	<i>University of Southern California</i>
<u>Peter Waldmann</u>	<i>University of Augsburg</i>

Program

November 19th



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9:00: Registration starts

9:30 – 9:45: Bernhard Felderer (Director, IHS): Opening

9:45 – 10:30: Doris Behrens, Jonathan P. Caulkins, Gustav Feichtinger, Dieter Grass, and Gernot Tragler: "Modeling Strategic Interactions in Counterterrorist Operations"

10:30 – 11:15: Bernard Brooks: "Mathematical Models of Rumour Propagation"

11:15 – 11:45: Coffee Break

11:45 – 12:30: Gerardo Chowell: "Patterns of disease transmissibility and measures of the impact of epidemic outbreaks: The case of influenza and foot and mouth disease outbreaks"

12:30 – 14:00: Lunch Break

14:00 – 14:45: Alfred Greiner: Presents and discusses the paper "A Dynamical Model of Terrorism" by Firdaus Udwadia, George Leitmann, and Luca Lambertini

14:45 – 15:30: Roswitha Bultmann, Jonathan P. Caulkins, Gustav Feichtinger, Dieter Grass, and Gernot Tragler: "On the optimal timing of counter-terror measures"

15:30 – 16:00: Coffee Break

16:00 – 16:45: Robert Feyer, Ulrike Leopold-Wildburger, and Stefan Pickl: "The Influence of Social Values in Co operation"

Program

November 20th



Austrian Academy of Sciences
Österreichische Akademie der Wissenschaften

Austrian Academy of Sciences (ÖAW)

<http://www.oew.ac.at/>

Austria, A-1010 Vienna, Dr. Ignaz Seipel-Platz 2

10:30 – 11:15: Joao Ricardo Faria: "A Time Consistent Anti-Terror Legislation"

11:15 – 12:00: Andreas Karcher and Tobias Lehmann: "Decision Support in Security relevant Applications – Intelligent Agents based on Ontology enabled Knowledge Models"

12:00 – 13:30: Lunch Break

13:30 – 14:15: Friedrich Schneider and Tilman Brück: "A survey on economics of security with particular focus on the economic analysis of terrorism and anti-terror policies and on the interplay between costs of terrorism and anti-terror measures"

14:15 – 15:00: Peter Waldmann: "Terrorism as a symbolic strategy"

15:00 – 15:30: Coffee Break

15:30 – 16:15: Stefan Pickl: "Crisis Management and Risk Assessment within Intelligent Secure Systems as Challenges of Operations Research"

16:15 – 17:00: Tsvetomir Tsachev: "Mathematical Models for Force Planning"

18:00: Dinner at *Harry's Time*

<http://www.harrys-time.at/>

Titles and Abstracts

(In Alphabetical Order of Speakers)

Bernard Brooks

“Mathematical Models of Rumour Propagation”

Understanding rumour and information flow in situations of high anxiety and uncertainty is critical. Disaster rumours such as occurred in the aftermath of Katrina in New Orleans hampered rescue efforts and threatened public safety. Health rumours encourage African Americans in Chicago to avoid cancer screening. Rumours that American soldiers distribute pornography to Iraqi children solidify the mistrust and hatred that decimates any feelings of safety or wellbeing both in Iraq and the world over.

Our interdisciplinary team of mathematicians, social psychologists and computer scientists has embarked on a multi-year effort to understand how beliefs in rumours propagate across social networks. The diverse nature of our research group has resulted in mathematical models with empirically calibrated parameters. A summary of our models will be presented. These models include a generalized SIR style model of rumour as epidemic, rumour as a dynamical system flowing over various network topologies and computer assisted panel studies (CAPS) which are used to calibrate the models' parameters.

Roswitha Bultmann, Jonathan P. Caulkins, Gustav Feichtinger, Dieter Grass, and Gernot Tragler

“On the optimal timing of counter-terror measures”

To strike back after terrorist attacks governments can choose strategies from two abstract categories: “fire” and “water” strategies. “Water” strategies are intelligence-driven, very specific and targeted, e.g. “surgical” operations against individuals who are known with very high confidence to be terrorists. “Fire” strategies, on the other hand, involve tactics that may cause considerable collateral damage or inconvenience to innocent third parties, e.g. aerial bombing of residential neighbourhoods. Thus, “fire,” even though being cheaper and easier to apply than “water,” may have the undesirable side-effect of stimulating recruitment rates. To reduce the negative effects of unspecific counter-terror measures, the government could choose to delay the use of these strategies right after the terrorist attack, gather information about the attackers instead and then use this information to make the “fire” strategy more effective. So, additionally to finding the best mix of both “fire” and “water” strategies, we use multi-stage optimal control theory to try to answer the question how long the government should delay the use of “fire” strategies.

Doris Behrens, Jonathan P. Caulkins, Gustav Feichtinger, Dieter Grass, and Gernot Tragler

"Modeling Strategic Interactions in Counterterrorist Operations"

Counterterrorism includes defensive tactics (e.g., target hardening and disaster response), post-attack investigative tactics, and offensive tactics that seek to arrest, kill, or incapacitate terrorists before they strike. Offensive tactics can work to the extent that they draw down a scarce pool of trained and willing attackers; they can fail to the extent that they engender a backlash that stimulates additional recruitment. This talk reviews a variety of optimal control formulations that explore various perspectives on this possibility that counter-terror operations might be something of a "double-edged sword". Given how little is understood (at least in the open literature) about the dynamics of terrorist recruitment, these stylized models cannot reach definitive conclusions, but they do usefully frame and sharpen the issue. Furthermore, they yield a number of interesting mathematical results (notably pertaining to DNS threshold separating different basins of attraction) and also highlight the potential benefits of incorporating epidemic modeling methods from mathematical biosciences into analysis of the dynamic evolution of terrorist organizations.

Gerardo Chowell

"Patterns of disease transmissibility and measures of the impact of epidemic outbreaks:

The case of influenza and foot and mouth disease outbreaks"

Mathematical, modeling and statistical approaches are used to identify signature features of past epidemic outbreaks. The potential value of these methods in the context of real time epidemic outbreaks surveillance are explored using data from two historical outbreaks: the 1918-19 influenza pandemic and the 2001 foot-and-mouth disease epidemic in South America. We use these methods in the development of theoretical data-driven models. These test-bed models are used to address, for example, the role of surveillance against the threat associated with the deliberate releases of infectious pathogens.

Methods for the reconstruction of epidemic transmission trees are used to carry out some of the quantitative analyzes. These trees are used to estimate the risk of disease outbreaks in real time and, consequently, their potential use for early population-level disease detection.

The 1918-19 influenza pandemic, the most devastating natural event of the past century, has been linked to the deaths of between 20 and 100 millions deaths worldwide. We discuss the results of our analysis, using epidemic data from the cities of Geneva and San Francisco and a high-

resolution dataset from England and Wales in the study of flu transmission patterns.

Data on influenza associated deaths during the fall and winter waves of the 1918-19 pandemic in England and Wales are analyzed at two levels of spatial resolution (305 administrative units and 62 counties). Transmissibility is estimated using geographic-specific reproduction numbers derived from simple SEIR (susceptible-exposed-infectious-removed) single outbreak models. The role of potential mechanisms, including cross immunity and behavioural changes, on declines in transmissibility and death rates (as the outbreak moved from its fall to its winter wave) are explored. It turns out, for example, that death rates in cities and towns were 30-40% higher on the average than in rural areas and that urban death rates did not vary significantly with population size albeit large variations were identified across rural settings.

The analysis of the 2001 foot-and-mouth disease epidemic in Uruguay (South American) uses a county-based meta-population model. Disease dynamics and control efforts are explored using this spatially explicit model. The model recovers documented two-mode epidemic outbreak patterns. The model is used to assess the role of control interventions including movement restrictions and a mass vaccination campaign on current and future foot and mouth outbreaks.

References:

G. Chowell, A. L. Rivas, N. W. Hengartner, J. M. Hyman, C. Castillo-Chavez. The role of spatial mixing in the spread of foot-and-mouth disease. *Prev. Vet. Med.* 73, 297-314 (2006).

G. Chowell, H. Nishiura, L.M.A. Bettencourt. Comparative estimation of the reproduction number for pandemic influenza from daily case notification data. *J R Soc Interface* 4, 155-166 (2007)

G. Chowell, C. E. Ammon, N. W. Hengartner, J. M. Hyman. Transmission dynamics of the great influenza pandemic of 1918 in Geneva, Switzerland: Assessing the effects of hypothetical interventions. *J. Theor. Biol.* 241(2), 193-204 (2006)

G. Chowell, L.M.A. Bettencourt, N.P.A.S. Johnson, W.J. Alonso, C. Viboud. The 1918-19 influenza pandemic in England and Wales: Spatial patterns of transmissibility and mortality impact (in review).

Joao Ricardo Faria

"A Time Consistent Anti-Terror Legislation"

This paper examines in a Stackelberg differential game how an optimal time consistent anti-terror legislation is set considering security benefits, freedom costs and the strategic behavior of terrorists and government. In the steady state equilibrium, the legislation ignores freedom costs and only considers security issues, and tougher legislation and law enforcement cause further terrorist attacks.

Alfred Greiner:

Discussion of Paper
"A Dynamical Model of Terrorism"
by

Firdaus Udwadia, George Leitmann, and Luca Lambertini

This paper develops a dynamical model of terrorism. We consider the population in a given region as being made up of three primary components: terrorists, those susceptible to both terrorist and pacifist propaganda, and nonsusceptibles, or pacifists. The dynamical behavior of these three populations is studied using a model that incorporates the effects of both direct military/police intervention to reduce the terrorist population, and nonviolent, persuasive intervention to influence the susceptibles to become pacifists. The paper proposes a new paradigm for studying terrorism, and looks at the long-term dynamical evolution in time of these three population components when such interventions are carried out. Many important features—some intuitive, others not nearly so—of the nature of terrorism emerge from the dynamical model proposed, and they lead to several important policy implications for the management of terrorism. The different circumstances in which nonviolent intervention and/or military/police intervention may be beneficial, and the specific conditions under which each mode of intervention, or a combination of both, may be useful, are obtained. The novelty of the model presented herein is that it deals with the *time evolution* of terrorist activity. It appears to be one of the few models that can be tested, evaluated, and improved upon, through the use of actual field data.

Andreas Karcher and Tobias Lehmann

"Decision Support in Security relevant Applications – Intelligent Agents based on Ontology enabled Knowledge Models"

The new kind of multinational and cross agency operations with different military, governmental and non-governmental key players in more and more complex and not fully describable environments faces planners and decision makers with an new dimension of system complexity. An appropriate situational awareness and a joint understanding is a prerequisite for planning and decision making. Ontologies based on Semantic Web Technologies and formal models of the underlying concepts and relationships are the fundament for Virtual Knowledge Bases that integrate the different information sources into a common and joint picture of the relevant szenario. Intelligents Agents built upon this Ontology enabled Knowledge Bases are then able to help the decision makers in finding appropriate answers to complex questions. The presentation shall give an overview on a Framework for integrated and knowledge based decision support and will show examples of how intelligent agents built upon artificial intelligence methods and calculus can support gaining better situational awareness and planning in complex effects based operations.

Robert Feyer, Ulrike Leopold-Wildburger, and Stefan Pickl

“The Influence of Social Values in Cooperation”

This paper deals with the topic of cooperation among economic agents in a repeated game with unknown length. There is still little empirical evidence why and under which conditions people co-operate at all in situations such as the prisoner’s dilemma game. There is extensive literature on the theory of infinitely repeated games and also a large number of explanations for cooperative behaviour. Experimental evidence on the question how future features will affect the behaviour is rare and the classification of the participants into social and selfish types is new in this context.

The present study examines the influence of pre-existing individual differences in social value orientations measured by the outcomes to oneself and others according to the ring measure by McClintock, 1978. We run an experiment in the lab and we are able to figure out the high percentage at cooperation in a PDG in which the length of the game is unknown to the players and the fact that cooperation is significantly dependent on the type of the subjects’ social value orientation. The current research examines the roles of pre-existing personality differences in social value orientation (i.e., pro-social vs. pro-self orientation). The experiment conducted in Graz/Austria, it was found that people with pro-social orientations demonstrated significantly more cooperation within the PDG.

Stefan Pickl

“Crisis Management and Risk Assessment within Intelligent Secure Systems as Challenges of Operations Research”

Security, power management, catastrophic terrorism and terror attack on energy systems are examples of emerging areas for risk assessment within complex resource systems. Operations Research techniques like the computation of an optimal sensor placement can guarantee an efficient detection of destruction within such networks. Furthermore, online algorithms allow power management schemes to schedule resources and to save resources without full knowledge of future demands and possible threats. In the area of computational intelligence and algorithmic game theory, agents are in varying degrees of collaboration and competition, and questions about optimal decisions and organisational behaviour within energy markets arise. The study of combinatorial structures gives insight into complex interactions of such agents on the internet and international relations. Within those processes, in information security, investigations into efficient algorithms for secure dissemination of information, cyberforensics, and prevention of cybercrime are in great demand. A new form of terrorism poses a major challenge in search and rescue operations as well as in a risk assessment within such complex energy systems and its critical infrastructure. An introduction and survey about this challenging topic will be presented.

Friedrich Schneider and Tilman Brück

“A survey on economics of security with particular focus on the economic analysis of terrorism and anti-terror policies and on the interplay between costs of terrorism and anti-terror measures”

One important feature of the new global terrorism is its objective of harming the twin processes of economic growth in developed countries and of globalization in general. Terrorism therefore has an important economic dimension, for example, by reducing bilateral trade flows and annual direct foreign investment inflows, by causing a negative relative performance of stocks and by damaging the tourist industry, thus, causing a huge loss of income in the affected country. Yet, the fight against terrorism also has strong economic consequences, for example by affecting the ease of travel or trade, by targeting insurance regulations or by dampening consumers' and firms' expectations.

This survey provides an in-depth analysis of existing research on the economic analysis of terrorism and counter-terrorist measures.¹

¹ However, most countries are not yet sufficiently prepared to intellectually meet this new type of research. Its capacity for economic analysis and policy making in this field is still weak, especially in

Moreover, our survey presents the existing research and knowledge on the inter-relation between economy and security – with a particular focus on terrorism - in a comprehensive manner. It incorporates an analysis of the level of knowledge about the causal chains between security respectively insecurity and economy to show how the former translate themselves into the latter. Relevant knowledge on the interaction between the costs distribution of both terrorism and anti-terrorism measures are identified as well.

Since our survey concentrates on the impacts and dynamic effects of terrorism in the short- to long-run it will not provide a detailed analysis of the literature on the origins and causes of terrorism as such, it will consider drivers and determinants of terrorism in so far as it is important to provide insights into the dynamics between security measures and terrorist events in the long run. Further, as this survey focuses on perspectives and methodologies from the discipline of economics, it largely excludes non-economic literature on terrorism. However, it should be noted that this non-economic literature is not only extensive but should be seen as complementary to the economics literature not least as it covers some issues and aspects which have so far been overlooked by economists. In other words, economics contributes to the study of terrorism with important tools, yet it is not sufficient to understand all the complexities of the security-insecurity nexus as here a number of books and papers have been published.²

In the following chapter 2 some basic features (definitions, data sources, and methodological considerations) are discussed. Chapter 3 deals with the economies of insecurity or the economic effects of terrorism analysing micro and macro impacts as well as across section. Consequently chapter 4 deals with the economic effects of anti-terrorism policy. Chapter 5 summarizes the knowledge of the interaction of actors of insecurity and security. Finally, in chapter 6 a summary and some (policy) recommendations are given.

comparison with the United States. This is a result from several factors: first, the large geographical dispersion of economic research capacity on terrorism and anti-terror policy plays a role; second, experts are spread across many different sub-disciplines in economics, which often do not communicate with each other. Third, many authors publishing books and articles in the field of economics of security usually work on other themes and simply lend their expertise to the analysis of terror-related economic phenomena on a temporary basis, thus making experts on economics of security a very transient phenomenon. Still the economic literature on terrorism has made remarkable inroads (Frey 2004; Brück 2006; Enders and Sandler 2006) building on already available research, which had previously not received much attention. Nevertheless, despite of remarkable progress, different areas of research remain insufficiently integrated and various aspects still need to be studied in depth (Ilussa and Tavares 2006).

² See e.g. Landes (1978), Enders and Sandler (1991, 1993, 1995, 2000, 2006) and others.

Tsvetomir Tsachev

“Mathematical Models for Force Planning”

Several models for long term planning of the forces in the national security sector will be presented. All models are in the form of an optimization problem. The planning is based on a predetermined set of scenarios and is driven by the aim to acquire the appropriate levels of capabilities in order to minimize or neutralize the negative effects of these scenarios.

Peter Waldmann

“Terrorism as a symbolic strategy”

My principal thesis is that terrorism is not a case of instrumental but of symbolic violence, of violence as a means of communication. Terrorism can be considered as an extreme form of what in our days is often described as asymmetrical warfare. Terrorist groups are quite weak. Generally they lack the necessary resources (in terms of personal, weapons etc.) to attack their enemy openly and directly. That is the main reason why they go underground and use violence as a kind of signal or "message". That means at the same time that terrorism is an indirect strategy. When violence is employed in a direct , instrumental way, generally there are only two conflict parties, confronting one another and fighting against one another. Compared with that, in cases of symbolic violence three parties or groups are involved: Those who employ violence (the terrorists), the victims who suffer from the violent act, and the broad public which is the real target group of the terrorist act or "message". Terrorist messages will rise the more attention, the more surprising and cruel they are and the more they constitute a contrast to every day life. An explosion in Bogota or Bombay where violent conflicts are something very usual will not meet with the same interest by the media and the broad public as a bomb which is exploding for instance in Stockholm or Vienna. For this reason terrorists prefer as a stage for their spectacular attacks the democratic societies of the west. Within the broad public which is intended to listen to the terrorists' message we can roughly distinguish two groups: The terrorists' enemies whom they want to frighten and to provoke to an overreaction on one side, and the terrorists' supposed sympathisers whom they wish to encourage and win over for their project on the other. Summing up the idea exposed here I would define terrorism as a strategy which consists in shocking attacks against a political order from the underground. These attacks pursue the aim of spreading fear and insecurity among the enemies of the terrorists, but at the same time to produce sympathy and the will to support the terrorists among their supposed friends.

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