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Scientific Support for the Decision Making in the Security Sector

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Editorial

The main objective of the present conference was to bring together specialists from diverse areas that would make them a part of the think tank of the future security elite of Europe. The main purpose of the organizers was to invite people with mathematical, computer and information sciences specialization who would have in the future the chance to contribute actively to the security topics. The conference was thought to play the role of a round table where specialists with technical background were invited to meet specialists in security so that the stimulating atmosphere could make them think in the perspective of security issues, and eventually attract them to new security projects in the future. Thus the present proceedings reflect the initial state of this dialogue between specialists in security and specialists in mathematics, computer and information sciences. Respectively, the papers included in this volume are naturally subdivided into four parts showing the wide future perspective for synthesis between science and security:

1. Planning for Security
2. Mathematical, Computer and Information Sciences Methods for Security
3. Environmental Security
4. Dynamic Optimization for Security.

* * *

Today's security environment is characterized by deep uncertainty. Threats are being posed not only by adversary (political) forces but may also come from natural challenges (be it energy, water, ecology or whatever). The types of operations that our civil security and military forces find themselves in today comprise a wide variety of tasks. The success criteria for these operations are a *safe/secure* environment for local population and stable conditions for state building rather than *hit-kill* ratio's against adversaries – the criteria are soft and the many actors involved may have divergent if not opposing objectives. And where actors intentionally share common objectives, they come from different cultural and organizational backgrounds, and their systems and modus operandi (doctrine) have loose or no connectivity.

Under these complex and uncertain conditions *decision making* is a challenging process. It is complex both for the long term planning process (concerned with the capabilities required from the own "security forces") and for the operational planning process (concerned with how to best operate with the "security forces" available today). How to model today and future worlds and how to bring together the various organizations that have to make contributions to the security now and then is the subject of the papers that are presented in Part 1 of the volume.

Key element in the support to the Decision Making in the security sector is the understanding of models and modeling. **K. Niemeyer** lays the basis for a *Theory of Models,* where he conceptualizes the understanding of the environment (perception), the ambitions as of how to (re-)direct that environment (motivation) and then how to manipulate the environment into that desired direction (anticipation). He claims that the systematic formulation of a model theory and further work in this area will provide a considerable im-

provement of understanding the intelligent behavior of humans and the decision making processes of higher level human organizations including advanced constructs of information technology like simulation models and decision support tools.

From this theory onwards **S. Malerud** provides a *framework to cope with uncertainty and complexity*. This starts with how to deduce good and relevant criteria to judge whether operations have been successful, and whether they are on track according to the mission objectives. Decision making related to this kind of operations usually involves more than one decision criterion, and explicit approaches to cope with uncertainty are required. His framework combines elements of Problem structuring methods (PSM) such as Soft Systems Methodology (SSM) – to discuss and agree on which problems to address, elements of scenario planning – to cope with uncertainties, value modeling and multi-criteria analysis – to evaluate and prioritize decision alternatives.

In his paper **R. Willems** expands on the importance of *scenario development and analysis* in support of long term defense planning. Not only defense force capabilities must be much more adaptive and flexible than was required before, but also the planning and the decision making about which systems and doctrine to be implemented, requires a much more flexible approach then ever before. He presents a systematic approach and a discussion on *how* the development of scenarios (to create plausible future worlds) and scenario-analyses (to guide today's ambitions and requirements setting to cope flexibly with such futures) may support this planning process.

One of the key elements to consider in the planning process is *technology*. **M. Rademaker** elaborates in his paper on the role of technology and the potential (operational) impact that technology developments may have. With a special interest in the so-called *disruptive technologies* (technology developments that may change the game in just one or two generations and consequently may have a high impact on current and future capabilities) he proposes a gaming method to assess possible technology effectiveness. Bringing together the strategic planners' world with that of operational planners and of the technology and research & development community he seeks an assessment of the doctrinal potential of technology developments, hence guidance as of where and how to seek priorities in technology investments and to anticipate for new doctrinal concepts and changes.

While the previous papers are in support of the long(er) term planning processes, **V. Shalamanov** addresses *computer assisted exercises* to bring together national and international stakeholders. He concentrates on [preparing for] emergency planning where civil and military organizations are co-operating, but his approach is equally valid for intervention, stabilization and reconstruction operations abroad. A prerequisite for success is the understanding of cultural and organizational differences that the various players will bring with them including their respective supporting models and analysis facilities. Shalamanov recommends a *proxy organization* to provide the basis for an integrated computer assisted exercise environment. In such environment both the development of new concepts, the experimentation with new systems and the implementation in standing organizations can be tested in a close cooperation between administrations, academia and industry. Basis for his recommendations are recent experiences in emergency management exercises that were held in Bulgaria in 2006.

The paper of T. Tagarev and **B. Mednikarov** presents a framework for capability-based planning and capability development in the security sector, and examines a particular application in the area of maritime sovereignty. The approach is based on centralized planning of the capabilities for protection of maritime sovereignty and agency-based development of these capabilities. The authors propose a process that links objectives, ambitions, planning scenarios, tasks, required capabilities, and planning risks and examine major decision support requirements to capability planning for maritime sovereignty.

In the paper presented by **Z. Minchev**, scenario development for Computer Assisted eXercises (CAX) is analyzed. The focus is on the greatest challenge – the consideration of terrorist attacks representation, modeling and simulation, where the information uncertainty is too high. An *ad hoc* created methodology and tool for scenario development is presented and based on the application of Expert Systems, Intuitionistic Fuzzy Sets and random numbers, implementation in a real CAX system. A software, named "I-SCIP" has been already successfully experimented in a real CAX – EU TACOM SEE 2006 (conducted in July 2006 in Bulgaria) as a part of the Joint Training Simulation & Analysis Center in Civil-Military Emergency Planning/Response (JTSAC – CMEP) – Analytical Center. Additionally, this program is planned to be a part of the contribution of Center of Excellence in Operational Analyses (CoE-OA) in NATO RTO MSG-049 project.

The paper of **V. Shemaiev** and O. Velychko is addressing the issues of scenario simulation for the state military security maintenance on a systematic basis. The method of processes simulation is offered in the framework of the methodology of cognitive simulation. The verification of the offered method is done on a training exercise. The important result of a cognitive simulation is definition of scripts of actions which approach (with other things being equal) a situation to a desirable target condition. In this aspect the solution of a management problem has a practical sense. The further decomposition of the received script of the situation development allows to receive quantitative solutions. The further direction of researches in the given area is simulation interaction of subjects of military security.

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It has become nowadays an obvious truth that any further essential progress in security is impossible without attracting the most recent advances in the area of natural sciences, and especially the newest developments in both pure and applied mathematics, computer and information sciences. One has to mention some of the areas which were represented at the Workshop, as pattern recognition theory, signal and image processing, compression and recognition, computer/geometric design and representation of images, communications and networks, etc.

Correct decision making in the security sector mainly depends on information, received from multiple sources. The paper by **K. Alexiev** and I. Nikolova contains an analysis of the fusion theory literature in the last years. The main objective is to provide an overview of the latest state-of-the art techniques for data and information fusion and to reveal the topics, on which the scientific society's efforts are nowadays concentrated. The authors also attempt to outline the most important and interesting topics for research in the field in the next few years.

The paper by **N. Atreas** and **C. Karanikas** emphasizes the role of approximation theory for fast pattern recognition. The authors build a new fingerprint function on the set of all words of length N written in an alphabet, which then they approximate by an appropriate hash function in order to reduce its computational complexity. In the paper of **C. Karanikas** and coauthors N. Atreas, A. Bakalakos, P. Polychronidou another aspects of recognition are addressed; namely, they propose a number of methods for fast exact and non-exact string matching, pattern recognition, and grammar detection, which may be applied to strings of symbolic information, e.g., biological data, biometric data, intelligence information, or any other form of information.

The paper *Database Structure for Radiation Incidents and for Treatment of Affected People* by **N. Kirov**, J. Djounova and K. Kirov describes an effort to create a national database of

radiation incidents in Bulgaria. It is designed for the National Center for Radiobiology and Radiation Protection. The purpose of the database is to store specific description of radiation incidents and to trace the effects on the health of the people affected by the incident.

In the paper of **O. Kounchev** and **H. Render** some aspects of representation of geometric data is considered which are important from the point of view of efficiency and design of the data; in particular they consider a generalization of the famous Bernstein-Bezier representations and curves in the case of exponential models. Their methods are efficient especially in the case of data which arise from processes with an exponential background. The results presented form a basis for developing new tools for efficient multidimensional signal representation, manipulation, and control.

O. Kounchev (with **H. Render** and K. Gumenerov) consider some new methods for forecasting of time series are the framework of the Global systems dynamics. The idea is to attract tools that have found wide use in the financial industry, and may facilitate the forecasting of future critical states of the global system of human-societal dynamics.

The paper presented by **S. Nikolov** (with coauthors T.D. Dixon, J.J. Lewis, C.N. Canagarajah, D.R. Bull, T. Troscianko and J. Noyes) tackles decision making from the perspective of image processing. The authors study how different multi-modality fused image or video displays affect visual information perception, interpretation, and decision making. The presented results include findings about the way these displays affect rapid decision making with very short display times, target tracking in multi-sensor visible and IR surveillance videos, and multi-sensor image segmentation.

A. Tsankov focused on analysis of computer networks for crises management as complex systems which consist of stationary and mobile management centers, exchanging information via different communication channels. Crises management networks should have ability for sharing its resources differentially between various users and applications according to prior defined criteria or for supporting with high degree the Quality of Services (QoS) of network traffic from different users and applications. It is shown that the proposed method for QoS management of network traffic is an effective solution of the formulated problems. A further goal of the paper is the thorough research of interactions between two stages of network management and formulation of dependencies which will allow effective reconfiguration of QoS parameters in cases when changes in network environment are needed.

The paper by **H. Ugail** and E. Elyan addresses the issue of the 3D data representations for biometric data; this is an important aspect of security, in particular for public spaces where it is important to have face identification/authentication in a timely fashion. Such data require to be represented using a handful of key facial parameters which can be identified for efficient storage and verification.

* * *

Environmental Security has become a very important issue in nowadays security sector. The relation between the environment and the security of humans has been the object of much research and the subject of many publications in recent decades but it is only recently becoming an important focus of international environmental policy. A recent comprehensive overview of the environmental security field observes that the environment is the most transnational of transnational issues, and its security is an important dimension of peace, national security, and human rights that is just now being understood. Environmental security is central to national security, comprising the dynamics and interconnec-

tions among the natural resource base, the social fabric of the state, and the economic engine for local and regional stability.

The papers of **R. San José** (with coauthors), **Z. Zlatev** and of **K. Georgiev** are devoted to air pollution problems. **R. San José** (J.L. Pérez, J.L. Morant and R.M. González) presented a paper considering an Operational Air Quality Forecasting System for industrial plants, urban and regional areas. The analyzed system is called OPANA (OPerational Atmospheric Numerical model for urban and regional Areas), that is an evolution and result of more than 10 years of research on sophisticated state-of-the-art numerical air quality modeling systems and the implementation on state-of-the-art computer platforms. The OPANA tool is operating on different industrial plants in the south of Madrid area and also over urban areas such as Madrid (Spain), Leicester City (U.K.), Las Palmas de Gran Canaria (Canary Islands, Spain). A complex emission model (EMIMO) developed by the authors' team in UPM (Spain) to provide accurate hourly and high spatial resolution (1 km) pollution emission data at global level is also described. The results show that these tools can provide reliable and robust information to authorities and industrial managers to control – in forecasting mode – the air quality in the surrounding areas of the industrial plant or to forecast the air quality in whole city or region.

The paper of **Z. Zlatev** presents large-scale air pollution models which can successfully be used to design reliable strategies to control the pollution levels. The author points out that the decision about what kind of *measures* are to be taken is made after many runs of the available mathematical models with different scenarios. The questions of the reliability of the model results and the choice of a sufficiently large set of scenarios are discussed. The conclusions are illustrated by results obtained in several comprehensive environmental studies.

K. Georgiev presents model studies of sulfate and sulfur dioxide in the atmosphere and comparison with real life data. The model used in this study is a three dimensional global chemistry Transport Model. Comparisons of the model's output results with measurements for sulphate and sulphur dioxide reported by the EMEP (scientifically based and policy driven program for international co-operation to solve transboundary air pollution problems) stations over the territory of Europe are presented.

The papers presented by **T. Vardanian, Ch. Hakopian** and **B. Mnatsakanyan** (with K. Aghababyan) deal with the issue of forecasting natural hazardous phenomena – earthquakes, floods, mudslides caused by mountainous rivers' overflows, etc. In the first two papers it is pointed out that today's science can not forecast some of these phenomena well enough, let alone preventing them. Since the causes for some of the considered phenomena are man-made, they argue that record keeping and detailed classification of the various natural disasters can improve our ability to resist them and to better manage the consequences from them. In the third paper several methods for calculating maximal river flows are compared.

* * *

Real life processes develop within their own timeframe, and the ability to react to a dynamically changing situation is important for the decision makers responsible to confront a developing crisis. Dynamical optimization techniques, optimal control among them, were present in some of the talks at the Workshop. In some of the presented models, assuming that a precise forecast for the dynamics of the crisis exists, it is possible to find the solution *a priori*. In other models the response to a developing crisis is regularly updated on the basis of the regularly incoming information about its dynamics.

In the paper of **R. Gabasov** and **F. Kirillova** the authors develop a novel approach to the optimal synthesis problem. Their approach is based on a new parameterization of optimal controls and fast algorithms of correcting optimal open-loop solutions in real time. They investigate the basic problems of classical regulation theory and provide up-to-date optimization methods producing the solution in real time, which employs the advances of computer technologies. The results represent the achievements of the Minsk group on optimal control and applications. In the paper several important examples on control (regulation) problems, stabilization by bounded controls, damping oscillations and on pendulum control are presented.

A. Kalinin and J. Grudo consider the time-optimal problem for a nonlinear singularly perturbed system with a bounded multidimensional control. The authors study an algorithm for the construction of asymptotic approximation to the solution. The algorithm employs solutions to two unperturbed optimal control problems of lesser dimension than the original problem.

Methods of computational graph theory for studying and modelling of the critical infrastructure were presented by **E. Kelevedjiev**. The theoretical model proposed and an experimental computer interactive implementation are designed for predicting the critical states of a large flow network system. Linear programming technique is used to find solutions in multi-stage in time and multi-criteria optimization of the involved graph flow problem. Due to the ability of interactive re-computing with different sets of input and control data, an expert using the proposed implementation can perform adequate decision making. Real numerical experiments are made for two main cases: modeling of an existing water supplying system for the upper part of the Iskar river basin near Sofia, Bulgaria (with two main scenarios- normal operation and situation of a water shortage) and calculations for the high-voltage transmission network in Bulgaria for which operation behavior is modeled to minimize shortages at some type of critical accidents.

The paper of **Ts. Tsachev** presents deterministic models of evacuation activities. The models differ in the assumptions on how the authorities control the transport flows. The continuous time models are in the form of optimal control problems. The discrete time model reduces to a linear programming problem. It is pointed out that further research is needed to determine the specific form of some of the functions, assumed known in two of the models. These functions describe how individual decisions, e.g. whether to leave the evacuated area or stay at home, are affected by other people's behavior or by the media.

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The reader may find additional information about the program, the lectures delivered, and the participants, at the website of the Workshop http://www.math.bas.bg/or/NATO_ARW/.

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The Editors, April 5, 2007
The Hague and Sofia

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(see the website of the conference http://www.math.bas.bg/or/NATO_ARW)

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