Managing Safety of Heterogeneous Systems

Decisions under Uncertainties and Risks
Preface

The aim of the series of workshops on *Coping with Uncertainty (CwU)* organized since over a decade at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, has been to provide researchers and practitioners from different areas with an interdisciplinary forum for discussing various ways of effective dealing with uncertainties and risks in diverse areas, including environmental and social sciences, economics, policy making, management, and engineering. The workshops proved to be successful, especially in cross-disciplinary sharing methods, ideas, and open problems.

Science-based support for effective coping with uncertainties and risks in complex policy-making and engineering problems needs practical solutions for fundamentally new scientific problems that in turn require new concepts and tools. A key issue concerns a vast variety of practically irreducible uncertainties, including potential extreme events of high multidimensional consequences, which challenge traditional models, and thus require new concepts and analytical tools. Robust decisions for problems exposed to extreme events are essentially different from over-simplified decisions that ignore such events. Specifically, a proper treatment of extreme/rare events requires new paradigms of rational decisions, new performance indicators, and new spatio-temporal dimensions of heterogeneous interdependencies, including network externalities and risks.

Traditional scientific approaches usually rely on real observations and experiments. Yet no sufficient observations exist for new problems; “pure” experiments and “learning by doing” are dangerous, very expensive, and thus practically impossible. Moreover, the available historical observations are often contaminated by “experimentator,” i.e., past actions or policies. The complexity of new problems does not allow to achieve enough certainty, e.g., by increasing the resolution of models or by bringing in more links. Such problems require explicit treatment of uncertainties using “synthetic” information derived by integration of “hard” elements, including available data, results of possible experiments, and formal representations of scientific facts, as well as “soft” elements based on diverse representations of scenarios, and opinions of public, stakeholders, and experts.
However, even a best possible integration of all these factors results in assessments having poor estimates. Therefore, the science-based support for addressing the new class of problems summarized above needs to replace the traditional “deterministic predictions” analysis by new methods and tools for designing strategies that are robust against the involved uncertainties and risks, and is also suitable for effectively coping with new challenges, such as spatiotemporal heterogeneities, interdependencies, externalities, and endogenous (i.e., caused by possible future actions) risks.

Contributions to this volume are based on selected presentations at the CwU 2009 workshop. The workshop aimed at contributing to a better understanding between practitioners dealing with safety of complex heterogeneous systems under uncertainty, and scientists working on either corresponding modeling approaches, or on methods that can be adapted for improving the understanding and management of uncertainty. The focus of the CwU 2009 was on novel approaches to supporting robust decision making and design, especially when uncertainty is irreducible, consequences might be enormous, and the decision process involves stakeholders with diverse interests. Presentations dealt with open problems in this field, limitations of known approaches, novel methods and techniques, or lessons from applications of various approaches.

The workshop was organized at IIASA in December 2009, jointly by:

- International Institute for Applied Systems Analysis, Laxenburg, Austria, and
- Federal Armed Forces University Munich, Germany.

The scientific Program Committee included:

- Yuri Ermoliev, IIASA, Laxenburg (A),
- Marek Makowski, IIASA, Laxenburg (A),
- Kurt Marti, Federal Armed Forces University Munich (D), and
- Gerhard I. Schueller, University of Innsbruck (A).

This volume is composed of chapters based on selected contributions to the CwU 2009 workshop. The first chapter summarizes key issues related to supporting decision-making under uncertainties and risks, in particular for managing safety of heterogeneous systems. The other 17 chapters are organized into the following five parts:

1. *Decisions under systemic risks and uncertainties* discusses support of robust decisions involving threats generated by intelligent agents, and under lack of imprecise probabilities, as well as decision analysis through combining second-order belief distributions with qualitative statements, and an econometric model based on the max–min expected utility concept.

2. *Modeling uncertainties of heterogeneous systems* presents effective approaches to cope with diverse types heterogeneous systems, such as technological change under increasing returns and uncertainty, an agency problems, as well as sustainable agriculture, food security, socioeconomic risks, and water management.
3. *Uncertainty and optimization* deals with novel optimization methods for analysis of uncertainties; in particular in global optimization, fuzzy linear programming, and clustering of uncertain data.

4. *Analysis and optimization of technical systems and structures under stochastic uncertainty* discusses optimal open-loop feedback control of dynamic structural systems, and deals with problems in civil engineering and large spatial trusses.

5. *Analysis and optimization of economic systems under uncertainty* presents approaches to estimation and reduction of environmental impacts for sustainable agriculture, portfolio analysis of financial and insurance instruments, and pricing catastrophe bonds.

The organizers gratefully acknowledge the generous support IIASA provided for the workshop logistics, which enabled the participation of many researchers who otherwise could not have attended this meeting.

The editors express gratitude to all referees who have helped the authors to improve their contributions by providing constructive comments, in several cases on a short notice. We thank the authors for delivering their contributions that conformed to the substantive comments by the reviewers, and the technical guidelines that were necessary to prepare this volume with limited resources for technical edition. Furthermore, we thank Ms Suchitra Subramanian of the Integrated Modeling Environment (IME) Project at IIASA for her support in the preparation of this volume.

Finally, we thank the Springer-Verlag for including the Proceedings into the Springer Lecture Notes Series in *Economics and Mathematical Systems (LNEMS)*.

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Munich

Yuri Ermoliev
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