Biographical Sketch and Seminar Abstracts

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Keith W. Hipel is *University Professor* of Systems Design Engineering at the University of Waterloo where he is *Coordinator* of the Conflict Analysis Group. He is *President* of the Academy of Science within the Royal Society of Canada, *Senior Fellow* of the Centre for International Governance Innovation, *Fellow* of the Balsillie School of International Affairs, and *Past-Chair* of the Board of Governors of Renison University College. Keith thoroughly enjoys mentoring students and is a recipient of the *Distinguished Teacher Award*, *Faculty of Engineering Teaching Excellence Award*, and the *Award of Excellence in Graduate Supervision* from the University of Waterloo, as well as the *2011 Outstanding Engineering Educator Award* from IEEE Canada. His major research interests are the development of conflict resolution, multiple criteria decision analysis, time series analysis and other decision-making methodologies for addressing challenging interdisciplinary system of systems engineering problems lying at the confluence of society, technology and the environment, with applications in water resources management, hydrology, environmental engineering, energy, and sustainable development. Keith is the author or co-author of 4 books, 12 edited books, more than 280 journal papers, as well as many conference and encyclopedia articles. In recognition of his academic and professional accomplishments, Keith has received 48 awards and honors including being elected *Fellow* of the Institute of Electrical and Electronics Engineers (*FIEEE*), Royal Society of Canada (*FRSC*), Canadian Academy of Engineering (*FCAE*), American Society of Civil Engineers (*FASCE*), American Water Resources Association (*FAWRA*), International Council on Systems Engineering (*FINCOSE*), and Engineering Institute of Canada (*FEIC*). Keith is a recipient of the *Joseph G. Wohl Outstanding Career Award* from the IEEE Systems, Man and Cybernetics (SMC) Society, IEEE SMC *Norbert Wiener Award*, *Japan Society for the Promotion of Science (JSPS) Eminent Scientist Award*, and the *Sir John William Dawson Medal* from the RSC. He also received the designation of *Docteur Honoris Causa* from École Centrale de Lille, *Icko Iben Award* from AWRA, *Doctor Honoris Causa* from Obuda University, *Outstanding Contribution Award* from the IEEE SMC Society, *Most Active SMC Technical Committee Award*, *W.R. Boggess Award* from AWRA, and the *University of Waterloo Award for Excellence in Research*.

Keith has held a *Canada Council Killam Research Fellowship*, Monbusho Kyoto University Visiting Professor Position, Stanley Vineberg Memorial Visiting Professorship, Centre National de la Récherche Scientifique (*CNRS*) Research Fellowship, and JSPS Fellowships. Moreover, he is a Professional Engineer (*PEng*), recipient of the *Engineering Medal for Research and Development* from Professional Engineers Ontario, and *Co-Chair* of the Council of Canadian Academies (CCA) Expert Panel on Energy Use and Climate Change: A Synthesis of the Latest Developments. He is *Honorary Diplomate, Water Resources Engineers (Hon.D.WRE)* in the American Academy of Water Resources Engineers (AAWRE), which is a subsidiary of the American Society of Civil Engineers (ASCE), and is *Member* of the Omega Alpha Association Systems Engineering Honor Society. In addition, Keith served for two terms as *Chair* of his Department and for many years was a *Member* of the Board of Governors and Senate at the University of Waterloo. He has been highly active in professional organizations such as the Royal Society of Canada, IEEE SMC Society, CAE, Group Decision and Negotiation, and AWRA; is the *Founder* of International Conference on Water Resources and Environment Research (ICWRER) and is *Chair* of its Steering Committee; and is an *Associate Editor* of many international journals including the IEEE Transactions on Systems, Man and Cybernetics: Systems; Group Decision and Negotiation; and Systems Engineering.

Seminar Presentations

Keith Hipel has been privileged to deliver stimulating seminars in many nations around the globe on thought-provoking topics which include:

Environmental Issues of General Interest

1. **Tackling Climate Change: A System of Systems Engineering Perspective**
2. **Trade versus the Environment: Strategic Settlement from a Systems Engineering Perspective**
3. **Water Resources in Canada: A Strategic Viewpoint**
4. **Strategic Investigations of Water Conflicts in the Middle East**

System of Systems Engineering

5. **Competition and Cooperation in Societal and Technological Systems of Systems**
6. **Strategic Opportunities in Systems Engineering**

Systems Governance

7. **Responsible Governance in a Complex World: A System of Systems Engineering Design**
8. **Value-Focused Policy Design: A System of Systems Engineering Perspective**
9. **Risk Management of Extreme Events: A System of Systems Engineering Methodology**

The Graph Model for Conflict Resolution

10. **The Decision Support System GMCR II in Negotiations over Groundwater Contamination**
11. **Decision Support Systems in Water Resources and Environmental Management**
12. **A Systems Engineering Approach to Conflict Resolution** (Cuban Missile Crisis Application)
13. **Attitudes in the Graph Model for Conflict Resolution** (War of 1812 Application)

Equitable Allocation of Water

14. **Systems Thinking in Fair Water Resources Allocation (**South Saskatchewan River Basin Application)

Environmetrics

15. Trend Analysis in Environmental Impact Assessment

Research, Education and Professional Engineering

16. Fulfillment and Success in Research (can complement other speeches)

17. How to Conduct Original Research in Graduate Studies (can complement other speeches)

18. Educational Innovations at the University of Waterloo: Cooperative Workterm Experience, International Exchange Programs, and Systems Design Engineering

19. The Internationalization of Engineering Education: A Tale of Two Countries

20. Accreditation of Engineering Programs and Licensing of Engineers in Canada

Note: Please contact Keith Hipel at kwhipel@waterloo.ca at the University of Waterloo if you would like him to deliver a seminar at a conference, local professional chapter or other research gathering.

Tackling Climate Change:

A System of Systems Engineering Perspective

A Research Seminar by

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Abstract

An integrative and adaptive approach to Responsible Governance is put forward for addressing climate change based on a System of Systems (SoS) Engineering framework that reflects the values of stakeholders using a participatory approach and achieves desirable systems goals such as resilience, sustainability and fairness. Currently, the world is suffering from an "Atmospheric Tragedy of the Commons" in which every nation is knowingly releasing deadly greenhouse gases in order to selfishly maximize its own economic benefits at the expense of destroying the "Atmospheric Commons" and thereby causing severe climate change which will adversely affect all countries around the globe. To overcome this strategically unwise type of individual behavior, a cooperative approach to good governance is suggested which will benefit every nation economically in the long term and, more importantly, satisfy ethical systems objectives. More specifically, the "Fee and Dividend" concept devised by James Hansen and others is suggested as a truly insightful, yet simple, method for solving the tough strategic decision-making aspects of climate change via: (1) Taxing carbon at its source or point of first sale (Fee). (2) Distributing 100% of this tax uniformly to all citizens (Dividend). (3) Negotiating a level of tax for each nation (Liability). (4) Increasing the tax over time in combination with stricter regulations to bring atmospheric carbon accumulation to a stipulated level (Survival). When compared to other alternatives, such as Cap and Trade, the "Fee and Dividend" idea may form the basis of a feasible and sensible method for handling climate change in the same way that the 1987 "Montreal Protocol on Substances that Deplete the Ozone Layer", and its extended versions thereof, constitute exceptional international agreements for cooperatively controlling the size of the ozone hole before it reached the point of no return. Indeed, the citizens of the world are most grateful to the truly remarkable scientists, consisting of Mario Molina, Paul Crutzen and Frank Rowland, who received the 1995 Nobel Prize for Chemistry for explaining how CFCs created

the ozone hole. In fact, responsible governance is not only needed in proactively combating climate change and the ozone hole but in many other highly interconnected complex SoS problems such as the failed American financial system, growing gap between the rich and poor, unfair medical systems, irresponsible energy production and usage, widespread pollution of both natural and societal systems, and unreliable aging infrastructure. Accordingly, extensive research is urgently needed for developing a comprehensive theoretical structure for System of Systems Science and Engineering for suitably solving current and emerging complex systems problems.

Related References

Hansen, J., "Storms of my Grandchildren: The Truth about the Coming Climate Catastrophe and Our Last Chance to Save Humanity", Bloomsbury, New York, 2009.

Hipel, K.W. and Bernath Walker, S., "Conflict Analysis in Environmental Management", Environmetrics, Vol. 22, pages 279-293, 2011.

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Hipel, K.W., Obeidi, A., Fang, L., and Kilgour, D.M., "Sustainable Environmental Management from a System of Systems Perspective", In System of Systems Engineering: Innovations for the 21st Century, edited by M. Jamshidi, Wiley, New York, Chapter 18, pages 443-481, 2009.

Hipel, K.W., Obeidi, A., Fang, L., and Kilgour, D.M., "Adaptive Systems Thinking in Integrated Water Resources Management with Insights into Conflicts over Water Exports", INFOR, Vol. 46, No. 1, pages 51-69, 2008.

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Trade versus the Environment:

Strategic Settlement from a

Systems Engineering Perspective

A Presentation by

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Abstract

The key goal of this research is to employ a Systems Engineering approach to conflict resolution to clearly identify the ubiquitous conflict taking place at the local, national and global levels between the basic values underlying trading agreements and those principles providing the foundations for environmental stewardship, and to suggest solutions as to how this most basic of disputes can be responsibly resolved. Subsequent to outlining the current situation involving free trade among nations and associated environmental problems, the positions of both sides in this chronic dispute between trade and the environment are summarized. Supporting the stance of free trade is the fundamental driving forces of profit maximization, while in direct opposition to this market-driven value system are the principles of maintaining a healthy environment and related social welfare objectives. Accordingly, this global clash of values is systematically studied as a game in which the values of the Global Market-Driven Economy (GMDE) are in confrontation with those of a Sustainable Ecosystem (SES) philosophy. A Systems Engineering tool for strategic analysis, called the Graph Model for Conflict, is utilized for realistically capturing the key characteristics of this type of complex conflict and for providing strategic insights regarding its potential resolution. In particular, a systematic Graph Model investigation reveals that the environment and social standards will continue to deteriorate if the entrenched positions and related value systems of both camps persist. However, based on the strategic understanding gained from this formal conflict study, a number of positive proposals are put forward for resolving this conflict from a win/win perspective, at least in the long run. To highlight inherent advantages of employing a formal Systems Engineering tool for addressing

strategic conflict problems, the application is used for illustrating how the Graph Model can be conveniently applied to a specific dispute and comments regarding the capabilities and benefits of the conflict methodology are provided at each step in the modeling and analysis procedure.

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Hipel, K.W. and Obeidi, A., "Trade versus the Environment: Strategic Settlement from a Systems Engineering Perspective", Systems Engineering, Vol. 8, No. 3, pp. 211-233, 2005.

Water Resources in Canada: A Strategic Viewpoint

A Presentation by

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Abstract

Strategic issues regarding the abundance, quality, and spatial and temporal distribution of Canada's valuable water resources are put into perspective and recommendations are presented for responsible water governance. Although Canada appears to have a plentiful supply of fresh water, in reality this is not the case in many parts of the country due to factors such as the ongoing negative impacts of climate change, increasing water demand, and widespread pollution. Because of Canada's sheer physical size and its diverse geographical regions and climate zones, some of Canada's major water problems are regionally based rather than being common difficulties occurring in many parts of the country. Pressing regional water problems that are addressed are melting glaciers, droughts in the prairies, oil sands water usage and pollution, Red River flooding, fluctuating water levels and pollution in the Great Lakes, impacts of the James Bay hydroelectric project, and the threat and possible repercussions of water exports. Water challenges affecting many regions of the country are discussed including groundwater over-exploitation, contaminants of emerging concern and brownfields. To alleviate Canada's strategic water problems, an important overall recommendation is that all levels of government in Canada adopt an adaptive, integrative and participatory approach to water governance from a system of systems engineering perspective. In consultation with all levels of government and key stakeholders, Canada should develop a comprehensive national water policy that reflects the values of Canadians, is in consonance with the legislative power of the various levels of government and follows the philosophy of the aforesaid systems thinking paradigm. A wide range of other recommendations which are formulated includes promoting efficiencies in water use as well as improving and expanding water monitoring and analysis programs.

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Hipel, K.W., Fang, L., Ouarda, T.B.M.J., and Bristow, M., "An Introduction to the Special Issue on Tackling Challenging Water Resources Problems in Canada: A Systems Approach", DOI: 10.1080/07011784.2013.773643, Canadian Water Resources Journal, Vol. 38, No. 1, pp. 3-11, 2013.

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Hipel, K.W., Obeidi, A., Fang, L., and Kilgour, D.M., "Adaptive Systems Thinking in Integrated Water Resources Management with Insights into Conflicts over Water Exports", INFOR, Vol. 46, No. 1, pages 51-69, 2008.

Acknowledgements

The contents of this address are based on research that Keith Hipel carried out with Andrew D. Miall and Daniel W. Smith for inclusion in a white paper on this topic completed for the Inter American National Academy of Science (IANAS) on behalf of the Academy of Sciences within the Royal Society of Canada. A English version of this paper was published in 2013 as listed above. An earlier version of this paper constituted an opening keynote address delivered by K.W. Hipel at Water 2010: Hydrology, Hydraulics and Water Resources in an Uncertain Environment – the 10th International Symposium on Stochastic Hydraulics and 5th International Conference on Water Resources and Environment Research (ICWRER), held at Loews Hotel le Concorde Quebec, Quebec City, Quebec, Canada, July 5th to 7th, 2010.

Strategic Investigations of Water Conflicts in the Middle East

A Research Presentation by

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Abstract

The great import of methodologies from group decision and negotiation, and the Graph Model for Conflict Resolution in particular, for resolving a wide variety of conflicts is put into perspective by this study involving the use of the Graph Model to systematically investigate conflicts over water in the Middle East. Because of the relative scarcity of fresh water at many locations around the globe, widespread pollution of water by industrial and agricultural activities, and disruption of the hydrological cycle via climate change and land-use alterations, conflicts over the quality and fair distribution of water resources are increasing in number and intensity, both within and among nations. Indeed, neighboring countries' relations over water can range from highly cooperative to explicitly hostile, up to and including war. Following an overview of the types of water conflicts and formal techniques for addressing them, strategic analyses are executed using the Graph Model for three connected water conflicts that occurred along the Euphrates River in 1975, 1990, and 1998. The goal is to gain strategic insight into the causes and eventual resolutions of these disputes, and to learn how similar situations can be effectively managed in the future. The three conflicts involve Turkey, the upstream country of both the Euphrates and Tigris Rivers, and one or both of Syria and Iraq, which lie downstream. The analyses demonstrate the importance to conflict resolution of coalitions and third-party interventions.

Reference

Hipel, K.W., Kilgour, D.M., and Kinsara, R.A., "Strategic Investigations of Water Conflicts in the Middle East", Group Decision and Negotiation, DOI: 10.1007/s10726-012-9325-3, online since January 13, 2013, Vol. 23, No. 3, pp. 355-376, May 2014.

Competition and Cooperation in Societal and Technological Systems of Systems

A Presentation by

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Abstract

An encompassing perspective on competition and cooperation is presented for multiple participants strategically interacting within societal and technological systems of systems according to their underlying value systems as they strive to reach their goals. By appreciating the reality that systems of systems are inhabited by multiple participants or agents having multiple objectives, one can adhere to adaptive and integrative decision making principles to properly design, construct, maintain, and operate systems of systems that serve the interests of stakeholders in a fair and sustainable manner throughout the systems' life cycles. An insightful way is explained for classifying systems of systems in the world according to environmental (natural world), societal (real life), intelligent (artificial life) and integrated (mixed life) systems of systems. To examine strategic behaviour in societal systems of systems, some of the latest contributions in systems thinking techniques are discussed for advancing the paradigm of the Graph Model for Conflict Resolution including modeling value systems, taking preference uncertainty and strength of preference into account, describing how emotions can affect decision making under conflict, and tracing the evolution of a conflict from a status quo situation to a final equilibrium. A real world environmental conflict is employed to illustrate how cooperation among decision makers can produce a more preferred win/win resolution which cannot be reached when they behave independently in a purely competitive manner. In fact, tremendous opportunities abound for researchers and practitioners in systems, man and cybernetics to develop flexible smart systems tools in multiple participant-multiple objective decision making for both cooperative and independent interactive situations to tackle pressing global problems such as global warming, unemployment, globalization of trade, over-population, widespread pollution, poverty, terrorism, and proliferation of nuclear weapons, from a multidisciplinary viewpoint. Moreover, it is pointed out that universal multiple participant decision making techniques need to be developed or significantly expanded and improved for employment in many diverse kinds of systems of systems such that multi-agents' value systems and protocols

governing competitive and cooperative behaviour among agents are based upon ethical principles such as the prioritization of societal well-being, social justice, environmental protection, and sustainable development. As exemplified by the devastating tsunami of December 26, 2004 in Southern Asia, created by the undersea Sumatra-Andaman earthquake, in which more than 230,000 people died, adaptive and integrative policy and governance systems are required such that decisions can be made in real time based upon enormous amounts of data being collected over widespread areas so that appropriate remedial actions, such as large-scale evacuations of people in low-lying coastal areas, can be immediately implemented.

Source

The first version of this speech was delivered as the opening keynote address by K.W. Hipel at the "2007 IEEE International Conference on Systems, Man and Cybernetics" held at the Delta Centre-Ville, Montreal, Quebec, Canada, from October 7th to 10th, 2007.

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Strategic Opportunities in Systems Engineering

A Presentation by

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Abstract

Strategic opportunities in Systems Engineering are described based upon the opinions obtained in a survey of international leaders in the field. Overall, the respondents recommend that extensive research be carried out to develop a comprehensive theoretical framework for Systems Engineering methodologies and associated techniques which can innovatively address complex systems problems from a "system of systems" perspective. Moreover, the field of Systems Engineering should expand beyond its traditional application domains in the military and industry by addressing challenging and complex interdisciplinary problems now confronting society. Areas in which systems problems require the creative talents of Systems Engineers for solving them include energy, global warming, infrastructure renewal, service systems, international governance, globalization, policy analysis, security systems, catastrophic events, agriculture, environmental degradation, conflict over water, poverty and intelligent transportation systems. To achieve this, the realm of Systems Engineering must become broader in scope and embrace non-technical considerations such as politics, culture and value systems. Prior to presenting the results on strategic opportunities, complementary, yet different definitions of Systems Engineering obtained in the survey are given, and the history and practice of Systems Engineering are reviewed.

Related Reference

Hipel, K.W., Jamshidi, M.M., Tien, J.J., and White III, C.C., "The Future of Systems, Man and Cybernetics: Application Domains and Research Methods", IEEE Transactions on Systems, Man, and Cybernetics, Part C, Applications and Reviews, Vol. 37, No. 5, pages 726-743, 2007.

Responsible Governance in a Complex World:

A System of Systems Engineering Design

An Invited Address by

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Abstract

An integrative and adaptive design for Responsible Governance is put forward for addressing large-scale complex problems facing society based on a System of Systems (SoS) Engineering framework that reflects the values of stakeholders using a participatory approach and achieves desirable systems goals such as resilience, sustainability and fairness. To demonstrate that this can actually be accomplished in practice, Singapore is employed as a remarkable example in which the nation was purposefully designed according to sound Systems Engineering principles resulting in a highly respected country that brings prosperity, fairness and fulfillment to its citizens and serves as a beacon of hope for other countries to emulate. In contrast to Singapore's success, a range of tough interconnected systems problems are described for which systems solutions are urgently needed: the failed American financial system, unfair medical systems, unreliable aging infrastructure, self-induced climate change, preparing for extreme weather conditions like hurricane Katrina, fair trade and the electrical system collapse in North America. As is explained, the underlying cause for underperformance or system collapse in these large-scale problems is a faulty value system. Accordingly, ethical system values reflecting the values systems of stakeholders, including nature and future generations, constitute the solid foundations upon which Responsible Governance is constructed. Extensive research is urgently needed for developing a comprehensive theoretical structure for System of Systems Engineering for suitably solving current and emerging complex systems problems.

Related References

Bristow, M., Fang, L., and Hipel, K.W., "System of Systems Engineering and Risk Management of Extreme Events: Concepts and Case Study", Risk Analysis: An International Journal, Special Issue on the Risk of Extreme and Catastrophic Events, DOI:10.1111/j.1539-6924.2012.01867.x, published online on July 15, 2012, Vol. 32, No. 11, pp. 1935-1955, 2012.

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Value-Focused Policy Design:

A System of Systems Engineering Perspective

A Presentation by

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Abstract

A comprehensive procedure for designing fair policies within a system of systems engineering framework is developed and its application to common pool resources governance problems are discussed. A system of systems policy design process is presented which consists of four main phases: 1) pluralistic problem definition; 2) alternatives generation; 3) negotiation and decision making; 4) implementation including monitoring, evaluation and conflict resolution. Subsequently, a value-focused thinking approach for constructing preferences of participants is proposed. Next, an agent-based modelling and simulation framework is developed for testing alternative policies within the overall policy design process. Furthermore, strategic interactions among participants are considered along with their risk perceptions to determine likely risk management outcomes. The applicability of the foregoing procedure is demonstrated using case studies in international maritime critical infrastructure, global food security, and groundwater pollution prevention.

References

Bristow, M., Fang, L., and Hipel, K.W., "System of Systems Engineering and Risk Management of Extreme Events: Concepts and Case Study," *Risk Analysis: An International Journal*, Special Issue on Risk of Extreme and Catastrophic Events, Vol. 32, No. 11, pp. 1935-1955, 2012.

Bristow, M., Fang, L., and Hipel, K.W., "Agent-based Modeling of Competitive and Cooperative Behavior under Conflict", IEEE Transactions on System, Man, and Cybernetics: Systems, Vol. 44, No. 7, pp. 834-850, 2014.

Hipel, K.,W., Fang, L., and Heng, M., "System of Systems Approach to Policy Development for Global Food Security", Journal of Systems Science and Systems Engineering, Vol. 19, No. 1, pp. 1-21, 2010.

Risk Management of Extreme Events:

A System of Systems Engineering Methodology

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Abstract

A system of systems engineering methodology for risk management is advanced and its application to a case in the Straits of Malacca and Singapore is presented. The domain of risk analysis is expanded to consider strategic interactions among multiple participants in the management of extreme risk in a system of systems. In the case of extreme events affecting a system of systems, cause-and-effect relationships among initiating events and losses may be difficult to ascertain due to interactions of multiple systems and participants (complexity). Moreover, selection of threats, hazards, and consequences on which to focus may be unclear or contentious to participants within multiple interacting systems (ambiguity). Finally, all types of risk, by definition, involve potential losses due to uncertain events (uncertainty). Therefore, the system of systems engineering methodology presented in this research addresses complex, ambiguous, and uncertain aspects of extreme risk. This research provides an integrative and adaptive systems approach to analyze risk such that strategic interactions among multiple participants are considered. The applicability of the foregoing procedure is demonstrated using a real-world development of managing maritime global critical infrastructure.

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The Decision Support System GMCR II in Negotiations over Groundwater Contamination

A Presentation by

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Abstract

A groundwater contamination conflict is employed as an illustrative case study to clearly demonstrate how the decision support system GMCR II can be conveniently applied to environmental negotiations as well as other kinds of disputes. The controversy, systematically studied using GMCR II, is the strategic conflict that arose after the discovery of a carcinogen in the aquifer supplying water to the town of Elmira, located in Southern Ontario, Canada, about 100 km west of Toronto. At the model formulation stage, GMCR II is utilized to describe the Elmira dispute in terms of decision makers, options or courses of action available to each decision maker, feasible states or scenarios that could take place, allowable moves available to each decision maker, and relative preferences among states for each of the disputants. At the subsequent analysis step, GMCR II generates a range of useful analytical results that may assist an interested party in better understanding the strategic aspects of the conflict and envisioning possible pathways for optimal decision making. For the Elmira dispute, potential equilibria or compromise resolutions are suggested and the reasons for the decision of two of the disputants to form a coalition and bring about a dramatic resolution to the conflict are explained. Current and future developments in the graph model methodology are outlined, including the design of the next generation of a decision support system for GMCR II.

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Decision Support Systems in Water Resources and Environmental Management

A Presentation by

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Abstract

The design, construction and use of decision support systems in water resources and environmental management is illustrated by the application of GMCR II to a controversy over the pollution of an underground aquifer that was apparently caused by a chemical factory. The decision support system GMCR II helps analysts gain a systematic understanding of strategic conflicts in the real world, thereby producing valuable strategic advice for decision makers. The capacity of GMCR II to model a conflict effectively depends on its flexible procedures to elicit key characteristics of the conflict, such as the relative preferences of each decision maker. Using these procedures, underlying mathematical structures are automatically calibrated so that advanced algorithms can carry out a comprehensive analysis of the model. Practitioners and researchers in water resources and environmental management have played pioneering roles in the development and application of noteworthy decision support systems based on both physical and societal systems models. This technology has permitted them to address a wide range of challenging systems problems, which will be extended much further in the future.

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A Systems Engineering Approach to Conflict Resolution

A Presentation by

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Abstract

The overall objectives of the research are to put the theory and practice of conflict resolution into proper perspective and to introduce the graph model for conflict resolution as a flexible decision technology for systematically studying real-world conflicts which can arise in engineering, international politics, business, and many other fields. Specific challenges that had to be overcome in the development of the graph model are described and it is explained how ideas from computational engineering and elsewhere were used to conquer them. For example, a difficult hurdle to surpass in the design of any decision model is how to obtain preference information. Accordingly, within the graph model paradigm for conflict resolution a number of flexible procedures have been designed for conveniently eliciting ordinal preference information for each of the decision makers. Other algorithmic and computational difficulties that had to be surmounted include developing techniques for handling very large conflicts, taking into account irreversible moves by decision makers, and carefully defining solution concepts for mathematically describing a rich range of human behaviour that can take place under conditions of conflict. The foregoing and other related developments have been incorporated into the decision support system GMCR II which permits practitioners and researchers to carry out comprehensive strategic studies within a user-friendly windows operating environment. The Cuban Missile Crisis of 1962 is employed for clearly demonstrating how GMCR II can be effectively used for modeling, analyzing, and better understanding real-world conflict. Strategic results obtained for some environmental and water resources conflicts are also presented.

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Attitudes in the Graph Model for Conflict

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Abstract

A flexible systems engineering methodology is developed for formally considering the role of positive, negative and neutral attitudes in conflict resolution. To achieve this, various definitions of human behaviour under conflict contained within the Graph Model for Conflict Resolution are expanded to include the effects of attitudes in strategic decision making. In particular, the definitions for Nash Stability, General Metarationality, Symmetric Metarationality, and Sequential Stability are appropriately modified for handling attitudes with respect to the relational attitudes that a given decision maker may have regarding himself and each of the other decision makers in the conflict. To demonstrate how attitude analysis can be readily applied to real world conflicts as well as the valuable strategic insights that can be garnered, the attitude methodology is applied to a military and an environmental dispute. More specifically, this formal approach to investigating attitudes is utilized for systemically studying the War of 1812 to 1814 between the United States of America and Great Britain in order to provide enhanced insights into the causes of the war. To capture misperceptions of decision makers in the War of 1812, attitudes are studied within the structure of a hypergame. Combining attitudes and misperceptions within the paradigm of the Graph Model furnishes a flexible analytical tool which demonstrates that misunderstanding of attitudes by Great Britain and the United States may have contributed to the outbreak of this war. In the second application, negotiations over the redevelopment of a brownfield or land polluted by industry, is strategically examined using attitudes to ascertain a win-win resolution.

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Systems Thinking

in

Fair Water Resources Allocation

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Abstract

Systems thinking approaches are employed to construct a formal decision making methodology for equitably allocating water among competing users in a river basin when taking into account both the societal and physical systems aspects of the allocation problem. In particular, within the societal component of the decision problem, multiple participants, their multiple objectives, equity principles, and economic factors are considered, while the physical systems part reflects relevant hydrologic and environmental factors. The Cooperative Water Allocation Model (CWAM) incorporates these societal and physical systems concerns within the framework of a large-scale optimization program which is divided into two main steps. Firstly, water is allocated among users based on existing legal water rights regimes or agreements. Secondly, water and associated benefits are reallocated among stakeholders to maximize basin-wide welfare. CWAM is applied to the South Saskatchewan River Basin located in the Canadian province of Alberta to demonstrate how it can be conveniently applied to a water allocation system of systems problem.

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Trend Analysis in

Environmental Impact Assessment

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Abstract

Intervention analysis techniques are described for identifying and statistically modelling trends which may be present in water quality time series. At the exploratory data analysis stage, simple graphical and modelling methods can be employed for visually detecting and examining trends in a time series caused by one or more external interventions. For instance, a plot of a robust locally weighted regression smooth through a graph of the observations over time may reveal trends and other interesting statistical properties contained in the time series. In addition, statistical tests, such as different versions of the nonparametric Mann-Kendall test, can be used to detect the presence of trends caused by unknown or known external interventions. To characterize rigorously and estimate trends which may be known in advance or else detected using exploratory data analysis studies, different parametric methods can be utilized at the confirmatory data analysis stage. Specifically, the time series modelling approach to intervention analysis can be employed to estimate the magnitudes of the changes in the mean level of the series due to the interventions. Particular types of regression models can also be used for estimating trends, especially when there are many missing observations. To demonstrate how intervention analysis methods can be effectively used in environmental impact assessment, representative applications to water quality time series are presented.

Fulfillment and Success in Research

A Presentation by

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Abstract

Keith Hipel uses the valuable experience that he has gained during a long and exciting career as an academic in Systems Design Engineering at the University of Waterloo to explain how to have contentment and impact in research and mentoring students. Of fundamental importance is to carry out research with your students and colleagues in the area of your heart's desire and to have fun passing on your knowledge to others and solving pressing problems using your ideas. By focusing on how you can help others in your academic work and not worrying about the impact of your research and teaching in terms of personal recognition, you will automatically be travelling down the road of success. When an entrepreneur develops novel products to benefit society, monetary gain usually follows after years of hard work and many setbacks along the way. Likewise, as you gain maturity in your academic career while pursuing your scholarly goals, you will eventually receive prestigious awards, have your theoretical concepts utilized by industry and government for tackling practical problems, be awarded patents and see your research highly cited by others. The Hirsch Index, popularly referred to as the H-Index, constitutes a useful means for gauging the long-term impact of your research. An H-Index of 30, for example, means that you have written 30 papers each of which has been cited by authors in the literature at least 30 times. As you travel down your academic path keep in mind a number of "rules of thumb" to keep you on the highway of success. Firstly, it is difficult to predict which of your papers will be highly referenced. However, publishing your research in high quality, well-known journals is a necessary condition for your contributions to gain widespread acceptance. It is a waste of your time to publish your better research in journals that are not well known and of lower quality. Also, keep in mind that creative papers published in good journals may not become popular straight away, but could be highly referenced years later – do not expect instant recognition, although this may sometimes happen. Even though the monetary payback may be small, it is certainly worthwhile to every so often bring your many ideas together in a systematic, logical, comprehensive and insightful manner within a well-written book that puts your findings into proper perspective – the fact is that a good book is highly cited. Take advantage of opportunities to carry out high-level consulting in order for you to show leadership to industry and discover where useful research is needed. Remember that design, which constitutes the heart of engineering, is creative problem solving or informed decision making for effectively solving a

challenging problem in the face of conflicting value systems of stakeholders and high uncertainty. Overall, enjoy what you do as you design solutions to tough theoretical and practical problems and you will achieve genuine contentment in your career.

Keith W. Hipel is *University Professor* of Systems Design Engineering and *Coordinator* of the Conflict Analysis Group at the University of Waterloo in Canada. He is *President* of the Academy of Science within the Royal Society of Canada, *Senior Fellow* at the Centre for International Governance Innovation, and *Past Chair* of the Board of Governors at Renison University College. Prof. Hipel thoroughly enjoys mentoring students and is a recipient of the *Distinguished Teacher Award*, *Faculty of Engineering Teaching Excellence Award*, and the *Award of Excellence in Graduate Supervision* from the University of Waterloo, as well as the *2011 Outstanding Engineering Educator Award* from IEEE Canada. His major research interests are the development of conflict resolution, multiple objective decision making and time series analysis techniques from a systems thinking perspective with applications in water resources management, hydrology, energy, environmental engineering and sustainable development. Dr. Hipel has received widespread recognition for his interdisciplinary research in systems engineering via *Fellow* designations from the Royal Society of Canada (RSC), IEEE, International Council on Systems Engineering, Canadian Academy of Engineering, American Water Resources Association, and Engineering Institute of Canada. He is the recipient of the *Japan Society for Promotion of Science (JSPS) Eminent Scientist Award*; *Norbert Wiener Award* and the *Joseph G. Wohl Outstanding Career Award* from the IEEE Systems, Man, and Cybernetics Society; *Docteur Honoris Causa* from École Centrale de Lille in France; *Sir John William Dawson Medal* from the RSC; *Doctor Honoris Causa* from Obuda University in Hungary; and *Engineering Medal for Research and Development* from Ontario Professional Engineers.

How to Conduct Original Research in Graduate Studies

A Research Seminar by

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Abstract

Based on four decades in mentoring Canadian and international graduate students, Keith Hipel uses the valuable experience, knowledge and insights that he has garnered to explain how to execute meaningful and original research. Of utmost importance is to follow your heart's desire in carrying your research as a personal challenges to help others and society. In your domain of interest, find a problem for which a satisfactory solution does not yet exist. In an engineering thesis, often a methodology is created to tackle a tough practical problem such as designing a sustainable energy production system in which greenhouse gases are substantially reduced. Think like a detective when you carry out a literature review to ascertain where gaps exist in the literature and what types of attempts have been made in the past, if any, to bridge these gaps. Mainly keep track of what is of interest to you in a general sense and how it may be used in your research. Later, you can read the key papers in detail and upgrade your expertise in areas most closely tied to your research. You should not hesitate to discuss your ideas with others and seek guidance from your supervisors, experts and peers. Be sure to take every opportunity to attend lectures by experts at your university and international conference so you can obtain the latest information that is relevant with respect to your research. Use simple examples to develop, test and refine your research ideas and as the methodology you are developing matures, apply it to real world problems and make it as general as possible to it can be utilized in many application domains. Use a system of systems engineering framework to put your research into perspective and employ real data to demonstrate that your new methodology is a significant improvement over its competitors. To ensure progress in your research and construct academic networks, regularly obtain feedback by consulting with experts and presenting your findings at international conferences. Expand a conference paper via further research into a full-length journal paper for submission to a leading international journal for review and constructive

criticism. Do not procrastinate in submitting an article for review. In a given paper, clearly highlight your original contributions in comparison to what has been done in the past and demonstrate that your new methodological developments work better than other approaches to creatively solve problems according to various criteria. Often systems research can be completed as separate, yet connected components – as each section is finished submit it for review. You can send methodological contributions to systems engineering and operational research journals for review, while application papers containing insights from the utilization of the methodological innovations can be sent to journals stressing real-world case studies. As an author, there is a range of useful tips that you can follow to write a first-class paper that will present your original ideas in a convincing way, such as clearly highlighting your key contributions and explaining how a reader can benefit from employing your ideas. The expeditious publication of your high quality research will help to build your academic career and provide confidence for you to tackle other challenging research problems in order to benefit society. Job opportunities, promotion and recognition will naturally follow.

Keith W. Hipel is *University Professor* of Systems Design Engineering and *Coordinator* of the Conflict Analysis Group at the University of Waterloo in Canada. He is *President* of the Academy of Science within the Royal Society of Canada, *Senior Fellow* at the Centre for International Governance Innovation, and *Past Chair* of the Board of Governors at Renison University College. Prof. Hipel thoroughly enjoys mentoring students and is a recipient of the *Distinguished Teacher Award*, *Faculty of Engineering Teaching Excellence Award*, and the *Award of Excellence in Graduate Supervision* from the University of Waterloo, as well as the *2011 Outstanding Engineering Educator Award* from IEEE Canada. His major research interests are the development of conflict resolution, multiple objective decision making and time series analysis techniques from a systems thinking perspective with applications in water resources management, hydrology, energy, environmental engineering and sustainable development. Dr. Hipel has received widespread recognition for his interdisciplinary research in systems engineering via *Fellow* designations from the Royal Society of Canada (RSC), IEEE, International Council on Systems Engineering, Canadian Academy of Engineering, American Water Resources Association, and Engineering Institute of Canada. He is the recipient of the *Japan Society for Promotion of Science (JSPS) Eminent Scientist Award*; *Norbert Wiener Award* and the *Joseph G. Wohl Outstanding Career Award* from the IEEE Systems, Man, and Cybernetics Society; *Docteur Honoris Causa* from École Centrale de Lille in France; *Sir John William Dawson Medal* from the RSC; *Doctor Honoris Causa* from Obuda University in Hungary; and *Engineering Medal for Research and Development* from Ontario Professional Engineers.

Educational Innovations at the

University of Waterloo:

Cooperative Workterm Experience, International Exchange Programs, and Systems Design Engineering

A Presentation by

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Abstract

The objectives of this seminar are to explain three innovative educational opportunities at the University of Waterloo. Firstly, education of engineers is significantly enhanced through its highly attractive cooperative program in which all undergraduate students in engineering must obtain valuable workterm experience during their undergraduate studies. Secondly, Waterloo engineering students have the opportunity to personally experience a foreign culture on a firsthand basis by studying and working in a foreign country, such as Japan, through participation in one of the many international exchange programs in engineering. This type of international exposure prepares Waterloo students to become full and responsible participants in the international marketplace of the 21st century. Moreover, a background in Systems Design Engineering allows Waterloo students to solve challenging interdisciplinary problems that lie at the interface of society, technology and the environment. The foregoing and other academic innovations are why the University of Waterloo is ranked by the Maclean's annual survey as the best overall university in Canada, the most innovative and the leaders of tomorrow.

The Internationalization of Engineering Education:

A Tale of Two Countries

A Presentation by

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Abstract

Two international exchange programs in engineering between universities in Japan and Canada are described in order to explain the significant benefits gained by the undergraduate and graduate students as well as by the academic staff who participate and to highlight key principles to follow in the design and execution of exchange programs in general. One of these notably successful engineering exchange programs is between the University of Waterloo located in Southern Ontario, Canada, and Tottori University in Japan, while the other is between Waterloo and Kyoto University. Both of these programs include foreign students taking courses for credit or audit at the host university, and, for the case of graduate students, also receiving guidance in their research. Moreover, upon completion of one academic semester in Japan, all of the undergraduate Waterloo students studying at Tottori University are employed in Japanese industry for three to four months before returning to Canada. Of paramount importance to the education of the participating undergraduate and graduate students is the opportunity to learn by first-hand experience the language and culture of a foreign country. In fact, one of the key findings of a survey completed by Canadian and Japanese students who took part in the exchange programs is that living in a different culture greatly enhanced their own personal development. The addition of this international perspective to a solid education in engineering opens many doors of opportunity for exchange program alumni, who are well prepared to fully participate in the global marketplace of the 21st century and to assist society in responsibly reaching an equitable and sustainable future.

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Accreditation of Engineering Programs and Licensing of Engineers in Canada

A Presentation by

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Abstract

Thanks in large part to Canada's Professional Engineers, Canada is a world leader in producing products such as telecommunication equipment, commercial aircraft, Candu reactors, skidoo's and seadoo's, automobiles, petrochemicals, and imaginative software. The creation of wealth in Canada through the endeavours of engineers was made possible by wise and timely investments in engineering education and the engineering profession. One purpose of this presentation is to explain how engineering programs receive accreditation through a stringent reviewing process carried out by the Canadian Engineering Accreditation Board (CEAB) in order to uphold strict educational standards that produce world-class engineers. Another objective is to describe how engineering is regulated and engineers are licensed in each of Canada's ten provinces and three territories. At the national level, Engineers Canada (formerly called the Canadian Council of Professional Engineers (CCPE)) furnishes a single voice for engineering throughout the nation and maintains educational standards through its CEAB. Engineers Canada is also the link with the engineering profession in other countries, such as those connected to Canada through international trading agreements.