

SRA Nordic 2017 Abstracts

Thu2 THURSDAY NOVEMBER 2, 11.00 - 12.30

Thu2.1 Risk analysis and assessment, modelling and scenarios

Thu2.1.1 *Adversarial risk analysis for simulation-based assessment of weapon*

J. Roponen¹, A. Salo¹, D. Rios Insua²

The acquisition of weapon system entails multi-million dollar investments which call for well-founded decision support. In this paper, we present new methods for determining efficient portfolios of countermeasures which consist of anti-aircraft deployment and camouflage as alternative options for defending against unmanned aerial vehicle (UAV) reconnaissance. Our methods are general enough in that they can be applied to many comparable portfolio optimization problems in an adversarial setting.

The types of methods for supporting decisions about investments into weapons and troop assignments extend from mathematical simulation models to the use of expert elicitation techniques, but most methods do not explicitly account for the decisions that an intelligent adversary can take. The adversarial risk analysis (ARA) approach does consider these decisions (Banks, Rios and Ríos Insua, 2015). ARA also allows the problem to be divided into smaller sub-problems that can be solved with different methods while accounting for uncertainties in the technical parameters, the environment and the adversary's actions. (Roponen and Salo, 2015)

We extend ARA research by introducing the concepts of ranking intervals and dominance relations of portfolios (Salo and Punkka, 2011) in the context of ARA. Specifically, these concepts help determine which portfolios outperform others in view of all relevant uncertainties. We also present an illustrative case study in which a supply battalion is threatened by UAV reconnaissance and possibly by artillery fire as well. Our case combines the results from two different simulation models of which the first determines the success probabilities of the reconnaissance while the second calculates the losses due to the artillery fire in keeping with the information gained by the attacker. We use ARA to (i) characterize the input parameters needed in both simulators, (ii) to combine the computational results from them both, and (iii) to produce a tentative ranking of alternative portfolios of countermeasures.

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2. Instituto de Ciencias Matemáticas, Spain

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Roponen, J. and Salo, A., 2015. Adversarial Risk Analysis for Enhancing Combat Simulation Models. *Journal of Military Studies*, 6(2), pp.82-103.

Salo, A. and Punkka, A., 2011. Ranking Intervals and Dominance Relations for Ratio-Based Efficiency Analysis. *Management Science*, 57(1), pp.200-214.

Thu2.1.2 Practical modelling approach for assessing cascading effects of critical infrastructures

A. Helminen¹, T. Hakkarainen¹

A practical modelling approach for assessing cascading effects of critical infrastructures (CIs) is presented. The overall objective in the modelling is to specify threats and dependencies leading to the cascading effects of identified CIs.

The threats are presented as threat functions describing the expected level of intensity of threats at a certain time and location. The dependencies are presented in interdependency tables stating the rules of CI dependencies. The predicted cascading effects are set on a timeline in order to create a common picture of the situation. The timeline can be used to understand the incident evolution and to mitigate the consequences.

For the modelling approach two initial requirements were set. The modelling approach should be versatile to be used in different accident scenarios implementing information from different kinds of threat functions. It should be scalable in the level of detail so that the spatial modelling of the accident scenario concurs with the overall assessment objectives.

In an accident scenario, the overall assessment objective is often two-fold. It can be the crisis management during the accident, or it can be the accident recovery to normal life with functioning CIs. In the crisis management during the accident, the main focus is in the short-term operations trying to minimize the injury of people and the damage to the environment and property. In the accident recovery, the focus is more in the long-term operations trying to repair the subsequent damages. The two overall objectives are of course overlapping and their actual difference is in the time span of the operations.

The modelling approach was developed using a flooding scenario in a densely populated area as an example. The crisis management during the accident was chosen as the overall assessment objective. An accident scenario map, locating the initiating events and CIs, was defined and a hexagonal grid was laid on the map. The relevant CIs for each hex were identified, and their interdependencies and vulnerabilities were defined in the model. A reference point was chosen for each hex. The threat function results on the reference point were then applied to all CIs in the hex. The threat function describing the expected level of water in the different locations of the polder area at a certain time was provided by a separate modelling tool. The initial failure times (i.e. not considering the interdependencies) of the CIs were determined. The final failure times were determined taking into account the interdependencies between the CIs, and the cascading effects were assessed.

The modelling approach results are best utilized in the preparedness and training phase of crisis management. It gives guidance for the planning of emergency response by revealing the CIs that are important to protect in order to prevent or mitigate the escalation of the accident. The failure times can be compared with the estimated response times to evaluate the feasibility of different accident responses and what kind of impact the responses can have to the overall accident sequence.

1. Risk and Asset Management, VTT Technical Research Centre of Finland Ltd, Espoo, Finland.

Thu2.1.3 *Influence of risk scenarios in port operations on supply chain resilience*

H. Thorisson¹, J. H. Lambert¹

In the age of increasing air transportation and instant telecommunication, global commerce still relies heavily on maritime freight shipping. As vessels get bigger and volumes higher, there is an increased stress on port facilities to move cargo fast and efficient without compromising on quality of services, safety of workers, and security procedures. This topic is of increasing relevance in the Nordic region if the Northwest Passage becomes a viable alternative for shipping between Asia and the Atlantic and Iceland, Norway, and the Faroe Islands emerge as candidate location for transshipment ports.

This paper studies the influence of emergent and future conditions of commerce, environment, policies, and other on port operations. Particular attention is given to conditions that have the potential to change priorities of the system stakeholders. This includes security threats and terrorism which might call for stricter screening of workers and cargo, thus creating new bottlenecks. An optimization-simulation method is used to evaluate the resilience of vessel berthing schedules. By changing input parameter to simulate scenarios such as slower handling times and partial closure of facilities, the effects on outputs such as cost, delays, and resource utilization are quantified. Uncertainty arising in the modeling process and their implications to the interpretation of results are discussed and classified as systematic uncertainties, incidental uncertainties, and interpretation uncertainties. Lessons learned from the study are valuable to port owners and operators, shipping lines, trucking and rail companies, and local authorities. Ensuring reliability of port operations is a critical to economies, especially in remote communities that rely on imports of food and other goods.

1. University of Virginia

Thu2.1.4 *Oil spill risks and coastal biota: a spatial risk assessment in the Gulf of Finland*

I. Helle¹, A. Jolma², R. Venesjärvi³

Oil spills resulting from tanker accidents can have negative impacts on biodiversity in coastal areas. The Gulf of Finland, the easternmost sub-basin of the Baltic Sea, has witnessed a rapid increase in maritime oil transportation within the past two decades. Intensified oil transportation has raised concerns about the risks that major oil accidents may pose to sensitivity coastal ecosystems. I will present the results of the spatial risk assessment, which we conducted in order to study the risk that potential tanker accidents pose to threatened species and habitat types living in the northern coast of the Gulf of Finland. The analysis involved three components: a Bayesian network model which described tanker accidents and their characteristics within the study area, probabilistic maps that represented the movement of oil after an accident, and a database of threatened species and habitats in the area. The results showed that spatial risk posed by oil spills varied across the study area. The relative risk was highest for seashore meadows. Our analysis emphasizes the importance of studies, which are not based only on one or two specific factors such as accident probabilities or the trajectories of spilled oil, but also covers the resources at risk as broadly as possible.

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Thu2.1.5 *Creation of believable safety cases for safety-critical digital I&C*

J-E. Holmberg¹, B. Wahlström²

Accumulated experience has shown that the construction and acceptance of safety cases connected to safety-critical digital instrumentation and control (I&C) for various industrial applications and especially for nuclear power plant, has become increasingly difficult. This development can to some extent be explained with the difficulty to take a new technology into operation and complexity of design, but it appears that many of the difficulties lie in diverging views on what a believable safety case should contain.

One approach for coping with the problems have been to introduce increasingly detailed systems of requirements that the I&C should fulfil. Standards supply one approach, but the difficulty is the selection of standards to be used and the provision of evidence that they have been followed. Unfortunately, this approach has brought other problems, because systems have often been created with the implicit assumption that arguments regarding safety should be consistent, complete and correct (C3), which is not possible to ensure, except in restricted cases. What safety cases should contain has, however, often been left open, commencing in debates, where consensus has been difficult to reach.

We argue that a believable safety case has to be based on an early agreement on the scope and content of a safety case. Elements of that safety case have to be collected during the design project, partly as structural and partly as empirical evidence that the requirements are fulfilled. A key is a systematic use of safety principles that are defined in the management system used to govern the design process. Only in this way claims for excellence of both process and product can be supported by necessary evidence.

The presentation tries to remedy some of these problems by building an idealised process description of I&C projects together with arguments, claims and evidence that should become a part of the safety case. We base our proposal on experience from licensing digital I&C in

Finland for the nuclear domain. We think that the issues discussed in this presentation are relevant for other domains, too.

Our work suggests needs for R&D efforts in the field of safety automation design to identify typical classes of design errors and means for their detection and removal. It would also be beneficial if system vendors could agree on sharing information on the efficiency of methods and tools that they use to ensure high quality products intended for safety critical applications.

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Thu2.2 Risk and Crisis Management

Thu2.2.1 Risk management practice in construction: Case study Landssimareitur, Reykjavik

M. Tegeltija¹, I. Kozine¹, B. J. Gunnarsson¹

Both researchers and practitioners agree that a project performance depends to a great extent on the quality of its project risk management. More concretely, the design phase in the construction industry carries a large amount of uncertainties under which decisions that impact the overall performance need to be made. Therefore, the way we manage risks in that phase plays a crucial role.

Deciding on a risk management strategy is of particular importance in construction industry. Given the time pressures, work overload and a large number of stakeholders, there is a tendency to rely on managers' experiences rather than seeking a proper study of risks and uncertainties. On the other hand, applying sophisticated risk analysis methods and techniques can be challenging since it requires employees who are educated and well trained in their usage. However, that is not always attainable which is why a number of user-friendly computer based tools appeared. Such tools allow practitioners to manage risks in a systematic way after only a short training.

Our case study is the Landssimareitur construction project in the city center of Reykjavik of 0,7 billion Icelandic krona that started November 2015, and project delivery is scheduled for late 2019. The project includes a hotel, apartments, bars, restaurants and a music hall. Through semi-structured interviews in the construction's company we document the challenges with the still ongoing design phase.

After that, we examine the current risk management practice in construction projects and look for available tools and methods. We further investigate which method has the highest potential for the implementation in the case company. By using RamRisk tool we demonstrate the benefit of an early involvement of such risk analysis, as well as its practicability, for the project outcome. The tool allows assigning responsibilities of identified risks to different users which was one of the main needs of the contractor.

In the presentation, we will present the case study in detail, introduce the tool mentioned and show the result of the simulations/analyses applied. We will emphasize the need to address project risk management challenges more thoroughly in future risk analysis research by providing an overview of the current state of the art in the field. And finally, we would like to start the discussion on opportunities for project risk management knowledge sharing in the Nordic countries.

1. Technical University of Denmark, Denmark

Thu2.2.2 The Challenges of Risk Management of the Critical Traffic Infrastructure

M. Turunen¹

The Critical traffic infrastructure and public transport, has always been an attractive so called soft target for terrorists and other criminals to commit a different kind of violent attacks. As holder of critical infrastructure we need to think about hazards and threats; the protection of critical assets; the protection of critical functions; organization issues that affect the level of security; and the needs for methods to assess and quantify security risks.

The Risks of the critical traffic infrastructure and public transport will be categorizing to five types: strategic, functional, economical, human and informational risks. Nowadays the critical infrastructure holders risk management consist of hybrid risks. The cyber-attacks alone or with physical attacks can damage seriously our whole traffic system and basic functions of our society and destroy citizens trustworthy to public traffic. They are some reasons, why in Finland the responsibility of authorities' preparedness to many kind of risks, including war, based by law.

The risk positions consist of strategic choices. The strategic goals and approach need to assets with recognizing to possibilities and excepted changes of an existing functional atmosphere. Basic issue of critical infrastructure risk management is to recognizing what is our risk position and what kind of risks we can take and what is the value of damages if some taken risk actualize? What kind of impact do we can expect? There are 3 different cross-cutting criteria: casualties, economic effect and public effect.

The main question is that are they our risk-managements measures and tools to updated and over coverage? How our risk management models, tools and preparing plans can adapt to the situation of hybrid disaster? And what are the responsibilities between government and private sector?

The traditional physical risk management measures are not adequate nowadays. We need to develop and effectively use to measures and tools to affect people's mind. Those measures can be consisting of strategic communication for citizens and common warnings for criminals that we have capabilities to react effectively in any situation, for example.

1. Finnish Transport Agency

Thu2.2.3 *Chaos and Complexity: Accepting the Challenges of 21st Century Crisis Management*

D. Rubens¹

Crisis management in the 21s century is facing an existential challenge that was unknown to previous generations, and that challenge can be encapsulated in a single word: 'complexity'. Complexity is at the heart of 21st century risk and crisis management, and any model of crisis management that claims to be able to survive in the face of chaos and confusion of a genuine crisis event must acknowledge both the reality of complexity, and the challenges associated with meeting and overcoming it.

This presentation looks at complexity from three perspectives. Firstly, it examines the external environment, and the nature of the complex problems that we are facing. Secondly, the nature of the solutions that we need to provide, and the complexity associated with creating transnational, trans-boundary and trans-jurisdictional frameworks that can create the integrated crisis response frameworks that are needed in the face of modern crisis events. Thirdly, the presentation will look at how crisis managers can learn from the attributes associated with High Reliability Organisations (HROs), and can transfer the qualities associated with what are normally highly-controlled environments to the chaos of crisis management.

The presentation itself offers a mixture of case studies – NASA, British Petroleum and Deepwater Horizon, national infrastructure failures, FEMA and the Hurricane Katrina failure and recent major IT failures - and academic approaches to HROs that creates an underpinning theoretical foundation on which subsequent work can be developed.

The presentation is designed for senior practitioners who are responsible for maintaining high-levels – and often zero-failure – capabilities within complex organisations, and will give attendees a series of take-aways that will be of immediate relevance to their own working context.

Dr David Rubens completed his professional doctorate in Security and Risk Management at University of Portsmouth, and has established himself as a recognised authority on all aspects of strategic management of complex operations operating in complex environments. He is a member of the London Resilience Gold Command Crisis Management project academic advisory group, was a member of the academic planning team for Exercise Unified Response (London 2016), the largest multi-national, multi-agency emergency response exercise ever held in Europe, and has worked with government agencies, corporations, global events, NGO's and emergency response organisations across Latin America, SE Asia, Middle East, East and West Africa and eastern Europe.

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Thu2.2.4 *Vulnerability of critical infrastructures and operational capability of authorities*

O. Heino¹, P. Verho¹, J. Kalalahti², P. Jukarainen², T. Kekki³

The ways of living, practices, and routines of people, as well as the overall functioning of modern societies, have become more and more dependent on certain infrastructures, such as water and energy systems as well as information and communications technology systems. These critical infrastructures operate in the background, where they contribute to public prosperity, convenience, and health. An interesting feature of critical infrastructures is their interdependency. Systems can be partially or entirely reliant upon one another. Thus, interdependency makes it difficult to predict how a disruption in one system will affect others, causing impacts that cascade throughout society. For example, supply of electricity is important as such for the modern society, but most of the infrastructures are dependent on electricity.

Critical infrastructures' manifold connections with society are revealed when they do not function as expected. When a crisis does break out, a wide range of key players —such as police and emergency authorities and infrastructure operators— with different competencies and thinking patterns must work together to address it. To protect communities, attention must therefore be paid to the vulnerability of interdependent critical infrastructure systems, on the one hand, and to the authorities' ability to function in an effective and coordinated manner on the other. With respect to the latter, a crisis may reveal challenging operational environment, which can be described as complex or chaotic. It is then required that the actors, which typically rely on bureaucratic procedures, are also able to utilise informal rules, shared responsibilities, and flexible organisation through a so-called post-bureaucracy.

In Finland, research on the issues mentioned above has taken its first steps in the form of the KIVI project (“Vulnerability of critical infrastructures and operational capability of authorities”), which began in February 2017. The project aims to enable anticipation of and preparedness for crises and disturbances of human origin by developing updateable tools to evaluate operational abilities of infrastructure service providers, police, emergency services, and operators of water and electricity services during a situation of severe disruption. Human origin means that for police there might be need for criminal investigation in addition to maintenance of order. This

paper discusses the research setting of the KIVI project and presents key findings of a literature review and workshops done by multidisciplinary research team.

1. Tampere University of Technology
2. Police University College
3. Finnish National Rescue Association

Thu2.2.5 *The evolving role of science for risk analysis: a transatlantic study*

F. Boudier¹

Recently, there has been much speculation about the impact of “fake news” and other alternative facts as well as their implications for the relationship between science and policy. Arguably, salient political world events – such as the election of President Donald Trump in the US or the UK “Brexit” vote to leave the EU have triggered new worries. In both cases, populist claims with little scientific basis have been heard, as well as statements that challenge or even dismiss the prevalent scientific view. Do science and evidence play a dwindling role? Are unscientific claims becoming more widespread and influential? Have we entered a “Post-Truth” society? We asked twenty influential players from policy science and industry on both sides of the Atlantic to reflect on the changing nature of the relationship between science and policy in the “post-Trump”, “post-Brexit environment”. An analysis of their answers will be presented with a focus on concrete lessons for risk analysis.

1. Maastricht University

Thu2.3 Ethical aspects and regulation of security risks

Thu2.3.1 *Security at chemical facilities – overview of different regulatory approaches taken in EU Member States*

F. Huess Hedlund¹

It is a European Union policy goal to enhance high-risk chemical facility security. This presentation presents some results of a study carried out for the European Commission, DG Home Affairs.

The study aimed to provide an overview of existing provisions and measures that help to enhance security at chemical facilities. These provisions and measures may for instance have their background in safety legislation or non-regulatory initiatives implemented by industry or in specific legislative provisions targeting security aspects implemented by individual Member States.

This presentation briefly reviews: 1) the concept of a high-risk chemical facility; 2) the analytical framework developed to identify security elements relevant for a chemical facility; and 3) possible synergies, the extent to which safety measures can be expected also to improve security. The study found that Member States have taken three distinct regulatory approaches: 1) folding security into Seveso safety legislation; 2) enlarging the scope of existing national security provisions; and 3) encouraging partnerships with industry associations to promote voluntary initiatives such as the security addendum to the Responsible Care programme.

Denmark has recently taken the first approach, adding security to Seveso (III) safety reporting. The presentation briefly reviews some of the resulting challenges.

1. COWI / Danish Technical University (DTU)

Thu2.3.2 *Biosecurity of Synthetic Biology and Genome Editing*

M. Ahteensuu¹

The so-called SynBioSecurity argument, simply put, says that synthetic biology (together with genome editing) introduces new risks of design, construction and use of synthetic (or edited) pathogens for malicious purposes; therefore, there is a need for extra regulations and oversight. In synthetic biology, engineering-based modelling and building are applied to biology. On the one hand, it involves redesigning natural living systems to fulfil specific purposes, for example, to produce drugs in yeast. On the other hand, researchers are constructing new kinds of living (and xenobiological) systems and their parts, such as alternatives to the natural nucleic acids. Genome editing techniques are typically considered one branch of synthetic biology, and they enable making exact changes at the level of nucleotides at a chosen location. In this genome editing differs from traditional genetic engineering in which the focus is on a gene level and a locus of the change in the genome cannot be decided beforehand. Techniques include, for instance, CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats) and ZFN (Zinc Finger Nucleases).

In my paper, I will consider the general argument from SynBioSecurity in the form it has typically been presented in the relevant literature and discussions, and suggest a new version of the argument, specifically targeted to the European context. I will argue that three developments related to synthetic biology and genome editing raise, indeed, biosecurity risks compared to the situation earlier. The developments include (1) a spread of the required know-how, (2) better availability of the techniques, instruments and biological parts, and (3) new technical possibilities such as “resurrecting” disappeared pathogens. It turns out, however, that the general argument needs to be qualified, and that many improvements to SynBioSecurity have already been implemented, mainly as self-governance of research and industry. Moreover, I will highlight differences in response to SynBioSecurity risks in the US and the EU, and discuss possible reasons for why in the former biosecurity concerns related to synthetic biology have received more attention in media and by regulators than in the latter. Finally, while ethical questions that are highly similar to those of synthetic biology have been extensively discussed before, the rise in the relative risk of bioterrorism calls for biosecurity considerations that are somewhat new. The pressing extrinsic issue is how to assess and manage situations where there are possible but difficult-to-quantify harms and possible rogue individual or groups’ actions that are difficult to supervise.

1. University of Turku

Thu2.3.3 *Discourse analytic approach to the concepts of security and safety*

K. Telaranta¹

The Copenhagen School argues that security is a speech act, and by talking security subjects are transformed to matters of security, which enables extraordinary means to be used in the name of security. When one speaks about the objective of security, that can mean among many, the integrity of state borders, low crime rate or the absence of accidents and their consequences.

Without committing to the theory of securitization, the concept of security can be seen as a social construction. The relationship between individual and society is dialectic, and speaking about reality, in this case the concept of security both describes the status quo of objective reality, but this subjective speech also modifies reality. Knowledge and people's conceptions of what reality is become embedded in the institutional fabric of society.

In my doctoral dissertation I will study the powers of code enforcement authorities and the relationship of the powers identified to the fundamental right of privacy. The competence of code enforcement authorities is directly or indirectly related to the concepts of safety or security, and those concepts are hard to study juridically. By using the method of discourse analysis, I have taken socio-legal approach to the previously mentioned concepts.

Finnish language has the word "turvallisuus", which covers the aspects of both security and safety. I have analyzed the use of this word in legislative proposals in Finland and tried to identify the different meanings allocated to safety and security in the "turvallisuus" speech of the Finnish legislator.

In my presentation I will discuss about the preliminary results of my findings before finishing an article on the subject. I would expose the four distinctive discourses of "turvallisuus" that can be detected in the proposal documents and consider the differences in the security/safety speech of the legislator.

1. Faculty of Management, University of Tampere

Thu2.3.4 *The Customs - an important contributor to security?*

R. S. Folgerø¹, L. K. Stene²

Prior to the 2011 Norway terror attacks referred to as 22 July, the Norwegian Customs alarmed the Norwegian Security Police Service about the terrorist's import of weapon related products. The terrorist's purchases initially led to place him on the watch list of the Norwegian Security Police Service, which did not act on the information given. The Norwegian Security Police' poor coordination with the Customs was criticized by the federal nominated Report of the 22 July Commission.

In our modern society and changing world, the Customs has become an increasingly more important player in ensuring safe societies. Today's Customs are supposed to monitor the carriage of goods and to detect and reduce means used for criminal activities threatening societal security. Risk regulations related to i.e. food- or product security, dissemination of disease, illegal import of weapons or drugs and even the spread of weapons of mass destruction are in the scope of their tasks as a society protector. Further, the fight against border crossing criminal networks has high priority (Folgerø, 2017).

This research aims to highlight whether the Customs as an important player in preventive security, actually is regarded as such. It is therefore interesting to study to which extent the Customs is considered by the state as a relevant contributor in societal security efforts to build a safe society.

The risk-based approach to regulation is an approach that has become very popular in many sectors across the world covering both state and non-state bodies (Baldwin et al 2012). This also applies to Norwegian governance and the Norwegian Customs combined with other control strategies. Nevertheless, it seems like the Customs' capacity to contribute is not fully utilized by the state and coordinating agencies, and that the principals for Norwegian risk management and coordination could benefit from a better use of the Customs' professional knowledge.

Accordingly, the article discusses the challenge of the state to regard the Customs as an important contributor to security from a risk-based regulation perspective.

Data used in this research are mainly collected through analysing strategic official documents related to societal security and Customs management in the period of 2000 to 2017 (Folgerø, 2017).

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Thu2.3.5 Technology and Society at Automated Borders: Risk of Discrimination and Fundamental Rights

G. Sanchez Nieminen^{1,2}, V. Ikonen^{1,2}

The complex reality of border control, increasing number of travellers and increasing variety of threats faced by the European Union and its citizens, present an environment in which information based technology became essential to enhance security and performance of the European border management. Authentic and validated information about European and non-European travellers who are crossing the external border of Schengen area is the key to detect effectively those who can cross the border without further interaction and those who represent a threat to the EU, in order to improve security and even reduce the likelihood of terrorist attacks.

New border technologies based on information systems, collection of travellers' personal data and biometrics, such as the Automated Border Control system has already been applied in airport border checkpoints, and its

adoption is spreading around the EU in order to guarantee the security of border and the flow of passengers. However, after conducting a literature review it was possible to conclude that the number of member states adopting technology and information systems in their external border checkpoints is increasing every year, regardless if proper social and ethical considerations have not been assessed yet. The risk of discrimination based on ethnicity, race, religion, sex, gender identity and disability while using these new border control technologies has received little attention by the industry, policy makers and researchers.

This research is developed in collaboration with the EU Horizon 2020 BODEGA- Proactive Enhancement of Human Performance in Border Control project and VTT Technical Research Centre of Finland and it investigates how technologies influence the risk of discrimination in border control processes and if they can possibly create solutions that support non-discrimination. The Responsible Research and Innovation framework is adopted in this study to generate value-oriented results and recommendations for the European border management, and to ensure that security will not be enhanced at the expense of the respect for travellers' fundamental rights.

Until this moment, research findings indicate possibilities to improve the current border control system with the implementation of new practices and technologies that can effectively reduce the risk of discrimination based on race, gender identity, sex and dress manners, without undermining security during the process of border check.

1. Faculty of Social Sciences, Value-Driven Decision Making, University of Tampere
2. VTT Technical Research Centre of Finland

Thu4 THURSDAY NOVEMBER 2, 15.15 – 17.15

Thu4.1 Cyber security and security intelligence (A)

Thu4.1.1 *Active mitigation support against advanced persistent threat risk*

I. Karanta¹, M. Rautila¹

Advanced persistent threat (APT) attacks are arguably among the most serious security hazards of computer systems and information networks (information infrastructure, II) supporting e.g. critical infrastructures (CI). Due to their nature, APT's are usually very difficult to detect, and even if detected, difficult to recover from. Further, new forms of APT are probably being developed all the time, with considerable resources. Thus, the defenders of the infrastructure - typically, the personnel of a security operating center (SOC) - face a formidable task in mitigation and need assistance. Existing incident management systems generally do not provide active mitigation assistance. If mitigation-related information is only available in a passive form (e.g. as part of help files), the defenders are unlikely to find the needed information or even search for it in a meaningful way. Thus, there is a need for active decision support system that provides the defenders with advice on how to proceed with mitigation, given the current phase in the attack lifecycle and various kinds of information available on the II, CI, and APT attacks.

We propose a framework for active mitigation support against APTs to SOC personnel. Operational information is collected, and, combined with information about the structure and functioning of the II and CI, and possible threats,

used to provide advice to the defenders on what mitigation actions to take in different phases of defense lifecycle (preparation, detection, resolution and closure). The framework uses ontologies for knowledge representation, and expert systems for selecting appropriate mitigation actions for a given situation. Altogether, the actions constitute a mitigation process that covers the whole defense lifecycle. We briefly describe a demonstration prototype constructed for the resolution phase, and its use as a part of a larger demonstration covering the defense of a banking infrastructure against APT. We propose that active mitigation support could be a useful means of the management of information security risks more generally, and could also provide a basis for the automation of mitigation against information security risks.

1. VTT Technical Research Centre of Finland

Thu4.1.2 *Industrial Cyber Risk and assessing it in real world*

L. Haapamäki¹

Late development in the communications environment has increased cyber risk for companies significantly and the tertiary impact of a wide scale attack on Critical Infrastructure has potentially devastating effect on the society. Sectra has developed a holistic security assessment approach to enable balancing of security related risks in both production and business environments. The holistic approach identifies security risks based on actual threats, assets and consequences. It covers both physical security, logical security as well as the organizational security domain. Resulting methodology regain control over societal risks by correlating relevant security parameters into a tool that enables business development within organizations that are critical for our society.

Cyber risk is by nature catastrophic and autocorrelated. We outline a real world approach in evaluating the environment, assessing the balanced risk and valuating the exposure.

Sectra does cyber security protection for several critical infrastructure operators and research on industrial cyber security.

1. Executive Vice President CI Sectra Communications

Thu4.1.3 *Managing cyber and physical risk of water entities*

L. Poussa¹, H. Pentikäinen¹, S. Nojonen¹, T. Välisalo¹, R. Molarius¹

The security of critical infrastructures is one of the main concerns of the modern society and the concern is constantly increasing. Especially cyber security sets infrastructure owners to new operational environment when ensuring their business continuity. Espionage, data theft, denial of service and malware such as ransomware are currently the primary concerns of companies but they may also relate to infrastructures.

Another major threat area for cyber-security concerns and already common for critical infrastructures are the harassment and deliberate take-over and management of physical control systems. This may be an external threat but also caused by an insider. For example, in Australian Maroochy Shire an unseated employer managed to deliberately pumping wastewater into parks and river in year 2000.

In recent years, the possibilities to cause unwanted and adverse disturbances within the process of industrial control systems have grown and cyber related disturbances have become even more common in critical infrastructures. Unfortunately, infrastructure owners such as water and wastewater entities do not often have specific knowledge about their vulnerabilities to cyberattacks.

During the last years, there have been lot of discussions considering physical risk and cyber risk assessment and their relation. These risk types have been traditionally dealt separately among different specialists.

However, as cyber risks are bound with management of ICT and Industrial Control Systems (ICS) they also have effect on operation of physical systems and therefore they should be considered parallel. The challenge has been to combine these two risk types and provide methods to support the identification and analysis of physical risks and cyber risks.

VTT presents the new risk assessment framework and method for cyber physical risk assessment and highlights the main finding from testing the tool with a Finnish water company. The new framework and method will support critical infrastructure owners to understand and prepare for cyber-physical threats and thus ensure the continuity and safety of the system. The approach is four-step process that relies on physical risk assessment. The process starts with identification of the most adverse physical effects, which is followed by the identification of their possible connections to ICT and ICS systems. The last two steps are detection and management of cyber security vulnerabilities.

1. VTT Technical Research Centre of Finland

Thu4.1.4 Risk assessment of machinery system with respect to safety and cyber security

T. Malm¹, T. Ahonen¹, T. Välisalo¹

There is a long tradition at machinery sector to make risk assessments considering safety issues. Currently, the assessment is made usually according to ISO 12100 and if the focus is on control systems then often according to ISO 13849-1. Cyber security issues have emerged to publicity mainly because of the threat associated to money and confidentiality. It is evident that security may affect also safety. Therefore, machine builders have increased their interest in security issues also. Current paper is related to cases where cyber security issues may have an effect on machinery safety. There are already several standard proposals related to the connection between cyber security and safety, but the field is still evolving. The idea is that security issues must not impair safety, but on the other hand, the required resources must be in line with the risk.

The paper addressed the needs to combine risk assessments to cover both safety and related cyber security issues. The security issues covered in this case are then limited to safety functions of control systems, communication, safety of machinery misuse (interfaces) and other safety-related situations that are found rare but possible.

Safety-related risk is a function of severity and probability, whereas security risk is a function of negative impact and likelihood. There are similarities, but it is more difficult to put numbers on security risks. Security risk may change as technologies or circumstances change, but it does not wear out and a long use history does not necessarily guarantee a secure system. Standard proposals suggest that there should be target security levels (SL 1 – SL 4), which specifies the general risk level and the target to countermeasures against security risks. There is

some similarity to Safety Integrity Levels (SIL) and to Performance Levels (PL), which are applied to measure safety risk and related protective measures of machinery safety functions.

Although, the risk assessment from safety and security point of view have many similarities it is still difficult to integrate the security risk assessment to safety risk assessment. Many safety requirements are obligatory, but security risks are voluntary, unless there is a clear connection to a safety issue e.g. reasonably foreseeable misuse. Without systematic approach combining safety and security it can e.g. be difficult to say that a specific security issue has no effect on safety. Current paper contributes to the development of the integrated approach and brings out its pros and cons.

1. VTT Technical Research Centre of Finland, Box 1300, FI-33101 Tampere, Finland

Thu4.1.5 *Systematic Security Intelligence Approach – A method developing to prevent loss of knowledge*

P. Gustafson¹

This paper presents a systematic security intelligence approach that was developed to deal with and eliminate attempts to as an insider get near knowledge sources.

In its 2016 annual book, the Swedish Security Services states that they have blocked between 30 and 40 attempts to procure products or transfer knowledge connected to mass destruction weapons (Swedish Security Services, 2017:18). To stop trade with dual-use products requires methods for early indications, ongoing understanding, and insight into the patterns and processes of how the modus operandi is carried out. The following three indicators – perception, vigilance and alarm – are particularly useful in the analysis of a structured threat and in structured degrees of preparedness (Agrell, 2005; 2013; 2015).

The approach evaluated in this paper consists an early warning method of an Indicator Graph and an Indicator Matrix. The Indicator Matrix enables the implementation of systematic security intelligence work as a tool for early warning of knowledge loss and can be used as a checklist in the confirmation process. The Indicator Matrix usefulness in the early warning in trade of dual-use products was evaluated retroactively by applying it to a real case that occurred at Halmstad University, 1999 (Gustafson, 2017). The evaluation of the case study show that if systematic security work had been undertaken from the very start, it most likely would have prevented the situations from taking place. A good security intelligence system needs to maintain preparedness based on the understanding that errors and inconsistencies occur along the way that are worth reacting too. This can be done with the help of such a tool (Gustafson, 2017). The Indicator Matrix was also evaluated in case studies regarding suspect attempt of information loss. In three well-known cases from the academic world in Sweden, the SLU-spy, the Umeå-spy and the Thyratron-man and also one unpublished case. The Indicator Matrix evaluated by interviewing two Chief Security Officer that was involved in the first two cases. In the case with the Thyratron-man, the prosecutor's preliminary investigation materials and protocols from the District Court of Halmstad (1999-11-25), will be used. In the unpublished case, the study is based on the researchers own notes.

1. Lund University, Lund, SWEDEN

Thu4.2 Mapping and communicating risks and threats

Thu4.2.1 *Methods for National Level Risk Mapping*

K. Giritli Nygren¹, S. Öhman², A. Olofsson²

Our modern society is exposed to multiple hazards and risks. In order to manage risks successfully, it is important to have a good overview of potential risks that our society is subject to and how they are perceived and valued. The aim of this paper is to investigate possible ways to map and analyse risks that the Swedish society and its inhabitants are exposed to and aware of. To achieve this, previous studies are mapped and critically assessed. The following questions have guided the work: What are the currently existing methods to describe risks on a broader societal level? What are the gaps of these currently existing methods, their advantages and disadvantages? What methods can be relevant for Sweden? The paper analyses previous studies including examples of methods, structure and visualization of data to map risk nationally or in larger regions. The paper concludes with recommendations applicable in Swedish context to prepare a national level risk mapping.

1. Forum for gender studies
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Thu4.2.2 *Internet of Things – Threats and opportunities for Finnish society and companies*

H. Kortelainen¹, T. Uusitalo¹, J. Hanski¹

Digitalization is one of the major global trends that is expected to transform the industry by enhancing the collection and analysis of information in a crucial way. The recent developments in technology and the reduced cost of sensors and IT systems enable a more advanced form of digitalization called the Internet of Things (IoT). The aim of this study was to identify the threats and opportunities that IoT technologies will introduce to Finnish society and companies. The study was implemented in three phases: 1) a SWOT analysis in expert workshop was carried out, 2) the SWOT analysis results were compared with literature and European level analyses, and 3) representatives of Finnish industry were interviewed to add industry perspectives to the analysis.

The SWOT results raised up several major threats, opportunities, weaknesses and strengths at national level. The perceived threats included the possibility that IoT will render some jobs unnecessary. On the other hand, IoT as a global development opens new possibilities to create new business for Finnish pioneering companies. The interviews in industrial companies created a more detailed understanding of the threats and opportunities experienced in the enterprises. The threats are related to security issues, contracts and responsibilities, and the opportunities to novel business models and novel product characteristics and services. The different life cycles of system components create challenges for decision-making at companies. Especially the relatively short life cycles of ICT systems complicate the product management of equipment suppliers. The lifecycle perspective and the flexibility and customizability of systems must be taken into consideration in the design phase. The cost benefit perspective and customer value are seen as key decision-making criteria for building IoT systems. New business

models such as leasing, sales of capacity or products as a service are considered to become more commonly available through real-time access provided by IoT.

IoT provides opportunities for long-term cost savings, e.g. in energy and raw materials efficiency and in improving productivity. Sensors, data collection and analytics should be integrated in enterprise resource planning and automation systems so that information can be accessed in real-time.

The IoT is a revolutionary turning point. It is a threat to those who stick to old working methods too long, but an opportunity for those who seize the opportunities. Many actors perceive the upheaval as a threat to their present position and, particularly at companies, to their turnover and profitability structures and levels.

1. VTT Technical Research Centre of Finland

Thu4.2.3 *Agency Risk communication: the Swedish case of radon*

R. Löfstedt¹

Sweden has a substantial radon problem. There are three primary sources of radon including leaching from the ground/bedrock, via the water from drilled wells and finally from building materials. The WHO recommended radon standard is set at 100 Bequerels per cubic meter (Bqm3), yet the Swedish Housing Agency has put forward a guidance for double that amount at 200 Bqm3. Some houses have much higher levels than that—one house was measured having 28,000 BQ3. Radon is estimated to cause 450 cases of lung cancer per year. As the Swedish Housing Agency has concluded that it will be impossible for Sweden to meet the WHO guidelines, it has instigated a major risk communication programme on the topic, to help inform Swedes how to both measure and reduce radon levels in homes. This paper evaluates the Housing Agency's risk communication programme on radon.

1. King's College London

Thu4.2.4 *Managing novel technology induced risks via stakeholder cooperation*

R. Molarius¹

Risks involved in new technologies or arising from novel new configurations of old technologies recurrently result in major accidents in societies. For example, in Finland, a new configuration in a waste water purification plant resulted in over 8000 people falling ill in 2004 (Heikkilä et al. 2011), and during 2010, new procedures in building constructions brought about the collapse or risk of collapse of over ten ceilings or roofs of public buildings such as sport and shopping centres (Safety Investigation Authority 2011). These incidents highlight a need for comprehensive risk management. However, these accidents could have been easy to avoid using conventional risk assessments as there were only a few owners and actors for the systems.

The situation is different when the scenario is about technical systems that interact with the built environment more broadly and where many connected actors, stakeholders and citizens are involved. For example, in 2008 the new bioleaching technology to extract nickel from ore was taken into commercial use in Finland as the first in Europe (Riekkola-Vanhanen 2013). Six years later, in 2012 one of the personnel died due to a lack of safety equipment; additionally, there were significant challenges associated with the management of the process waters

which consequently resulted in the company's bankruptcy. In this case several risk analyses were performed but none of them considered the local climate and surrounding environmental circumstances. In this case, a more comprehensive, multidisciplinary risk assessment process that would combine the knowledge of different stakeholders, authorities and citizens could have helped to avoid the sad outcome.

It is clear that even if the enterprise has a very clear picture of the risk figure on its own, it is generally reluctant to reveal commercially sensitive process information to others, or even incapable of understanding the all expectations and constraints that the natural and built environments may impose. Statutory, governmental authorities are the only ones who are even in a position to form a comprehensive picture of the impact of an activity over a whole region. Therefore, there is a need for co-operation between all governmental authorities and other stakeholders to combine their knowledge to form a comprehensive risk figure.

This paper presents a new approach to the proactive risk identification process for authorities. It is a collaborative method based on integrated assessment, which was tested in three stakeholder workshops.

1. VTT Technical Research Centre of Finland

Thu4.2.5 *Best practices to improve maritime safety in the Gulf of Finland: a risk governance approach*

P. Haapasaari¹, I. Helle¹, A. Lehikoinen¹, J. Lappalainen², S. Kuikka¹

The Gulf of Finland of the Baltic Sea is a vulnerable sea area with high volumes of maritime traffic and difficult navigation conditions. The reactive international rules are not anymore regarded adequate in ensuring safety in this sea area. In this paper, a regional proactive risk governance approach is suggested for improving the effectiveness of safety policy formulation and management in the Gulf of Finland, based on the risk governance framework developed by the International Risk Governance Council (IRGC), the Formal Safety Assessment approach adopted by the International Maritime Safety Organisation (IMO), and best practices sought from other sectors and sea areas. The approach is based on a formal process of identifying, assessing and evaluating accident risks at the regional level, and adjusting policies or management practices before accidents occur. The proposed approach sees maritime safety as a holistic system, and manages it by combining a scientific risk assessment with stakeholder input to identify risks and risk control options, and to evaluate risks. A regional proactive approach can improve safety by focusing on actual risks, by designing tailor-made safety measures to control them, by enhancing a positive safety culture in the shipping industry, and by increasing trust among all involved.

1. Fisheries and Environmental Management Group (FEM), Department of Environmental Sciences, University of Helsinki

2. Finnish Transport Safety Agency

Thu4.2.6 *Anxiety as a Psychological Background of the Fear of Crime*

J. Burianek¹

Paper is based on data from a representative survey on the fear of crime conducted in the Czech Republic in 2015 on a sample of 929 respondents. In addition to the questions on fear of crime (Ferraro 1995, Lee and Farrall 2009, Jackson 2009) it works with a scale STAI-T-6 (Fioravanti-Bastos et al. 2011) measuring the anxiety. This offers an opportunity to test the hypothesis about the impact of this characteristic in the confrontation with other parameters, such as the influence of social status, victim experience and perceived disorganization in the neighborhood. The influence of anxiety appears to be negligible and statistically proven, however it is relatively small and replaceable, yet as the most important factor in the regression analysis performed the perceived disorganization was confirmed. It means that the fear of crime has a realistic basis and it is embedded in the everyday experience of the respondents.

1. Charles University Prague

Thu4.3 **Bayesian approach: applications and experiences from different fields**

Thu4.3.1 *Generalized Bayesian Analysis to quantify quality in evidence by imprecision*

I. Raices Cruz¹, U. Sahlin¹, M. Troffaes², J. Lindström¹, N.-E. Sahlin¹

A characteristic of evidence based decision making is the rating of quality in sources of evidence in inputs and weight their influence on the final recommendations (i.e. the output) accordingly. There is a concern that current practice of statistical analysis in evidence synthesis may miss to grade quality in the assessment output. Instead of classical meta analysis, Bayesian meta analysis enables uncertainty to be quantified by probability, but this does not reflect quality in output. To better account for deep uncertainty arising from low quality in knowledge, alternative ways to represent uncertainty and make decisions have been developed such as imprecise probability or bounds or intervals on probabilities. A possible approach for quantifying lower quality in evidence synthesis output is to use generalized Bayesian analysis, where lower quality emerges as imprecision on probability. A Bayesian analysis can be generalized by allowing for more than one prior per parameter. Sets of priors results in sets of posteriors which gives lower and upper bounds on posterior beliefs (imprecise probabilities), lower and upper bounds on credible intervals or lower and upper bounds on expected decision objectives (previsions). A large difference between lower and upper previsions is an indication of a lower degree of quality in evidence. In order to make this operational, there is a need to improve methods for sampling in generalized Bayesian analysis. In this study we demonstrate iterative importance sampling as way to bound previsions more efficiently in generalized Bayesian analysis. We use a decision problem choosing a medical treatment where there is little data available for one of the treatments.

1. Lund University, Sweden
2. Durham University, UK

Thu4.3.2 *On Practical Applicability of Ranked Nodes Method for Constructing Conditional Probability Tables of Bayesian Networks*

P. Laitila¹

Risk assessment and management often entails the problem that there is a poor amount of historical data or relevant data is challenging to identify. However, many times there is still available an abundance of expert knowledge as well as varied information and data on indirectly related risks. In these types of situations, Bayesian networks (BNs) provide good means to support risk assessment. A BN represents the relationships of causes and effects both qualitatively and quantitatively enabling one to quantify risks rigorously and communicate results in a clear way. The nodes of a BN represent random variables and the links between them indicate direct dependencies. The dependencies are quantified in conditional probability tables (CPTs) that can combine historical data and expert assessments. The main challenge in the construction of CPTs based on expert knowledge is that a single CPT may consist of hundreds or even thousands of elements. Assessing so many probabilities coherently and without biases may be an insuperable problem for the expert due to cognitive strain or scarcity of time. To alleviate this problem, there are various parametric methods that allow an automatic generation of a CPT based on parameters that are elicited from the expert and whose number is significantly smaller than the size of the CPT. Our work is focused on one such method called Ranked Nodes Method (RNM). It is designed for random variables measured with subjective ordinal scales. Previously, we have developed a novel approach for applying RNM to random variables with well-established interval scales. Our new contribution is a study exploring how well CPTs generated with RNM can fit to CPTs found from various real-world BN models. The results indicate that a good average fit is obtained to a large portion of the investigated CPTs. This confirms the usefulness of RNM in practical BN applications of risk assessment and management.

1. Systems Analysis Laboratory, Aalto University, Finland

Thu4.3.3 *Bayesian networks for scenario analysis of nuclear waste repositories*

E. Tosoni^{1,2}, A. Salo¹, E. Zio^{2,3}

Scenario analysis of prospective nuclear waste repositories involves challenges in (i) building a system model of all significant Features, Events and Processes (FEPs); (ii) characterizing and treating the epistemic uncertainties; (iii) ensuring comprehensiveness of the analysis.

We employ a Bayesian network (BN) as a system model of the repository and its environment. In a BN, the FEPs and the safety indicator (e.g. the radionuclide discharge) are represented by nodes which correspond to stochastic variables with discrete states. Causal dependences between the nodes are shown as directed arcs which indicate that the state of a given node depends on those of its parent nodes. The dependences at a given node are quantified through conditional probabilities for different subscenarios which are defined as combinations of the node's parents' states. These probabilities can be estimated either by eliciting expert judgments or by reproducing the

underlying phenomena through computer-code simulations or laboratory experiments. Finally, safety is assessed by examining whether the probability of the failure event in which the safety indicator exceeds the regulatory limit is higher than the given acceptability threshold.

We characterize epistemic uncertainties through probability intervals from which the corresponding interval-valued probability for the failure event is computed through multilinear optimization. This interval is conclusive if it does not overlap with the acceptability threshold: if it lies below (above) the threshold, the repository can be deemed safe (unsafe).

Comprehensiveness is achieved if all selections of unconditional and conditional state probabilities from their respective intervals leads to a conclusive failure-probability interval. Yet ensuring comprehensiveness can be challenging when resource constraints limit how many simulations/ experiments can be performed to obtain more precise state probability estimates, i.e., narrower intervals: performing simulations/experiments indiscriminately may not make the failure-probability interval conclusive.

In this setting, we propose an algorithm for identifying which simulations should be performed to achieve comprehensiveness as efficiently as possible. For a given node, this algorithm guides decisions about which subscenarios should be selected for further analyses through simulation/experiments to obtain improved estimates of the conditional probabilities, with the aim to increase a proxy measure of conclusiveness. The algorithm terminates once conclusiveness has been reached, or the available resources for analyses have been consumed. Our approach is illustrated with a BN representing a simplified nuclear waste repository in which most dependences are addressed through expert judgments, while a computer code simulates the radionuclide discharge.

1. Systems Analysis Laboratory, Aalto University, Finland
2. Laboratorio Analisi di Segnale Analisi di Sistema, Politecnico di Milano, Italy
3. Chair on Systems Science and the Energetic Challenge - École Centrale Paris and Supelec

Thu4.3.4 *Practical experiences in applying Bayesian decision models to fisheries and environmental problems: lessons learned*

S. Kuikka¹

Currently Bayesian inference can be divided to three main categories: 1) Parameter estimation with simulation models 2) Artificial intelligence algorithms, often used to classification problems 3) Decision analysis, where influence diagrams is a main tool. Both simulation models and direct reading of data, based on artificial intelligence algorithms, can be used to estimate the required probability distributions for decision models. In many applications, also expert knowledge plays an important role.

Priors form an important part of Bayesian inference. In 1980's, they were seen as a subjective element in scientific analysis, and a high number of papers were published where one essential aim was to develop a modeling approach where prior is as uninformative as possible. Since then, it has been realized that informative prior is actually a strong element of Bayesian inference: it allows a systematic learning possibility from history, in form of published papers (e.g. meta-analysis) or expert knowledge. A long history in science can be utilized to improve predictions.

We review the experiences of using Bayesian inference both in fisheries and environmental management, mainly in oil spill risk analysis. We conclude that in environmental management it has been easier to publish and use Bayesian models than in fisheries, where advisory task has likely been an important reason for delaying the development of Bayesian inference in the nearby history.

1. Fisheries and Environmental Management Group (FEM), Department of Environmental Sciences, University of Helsinki

Thu4.3.5 *A Bayesian approach for dynamics portfolio optimization of safety barriers*

A. Mancuso^{1,2}, M. Compare³, A. Salo¹, E. Zio^{2,3,4}

Safety barriers are crucial to reduce risks: their selection is commonly made based on ranking the risk sources through Risk Importance Measures which allow (i) evaluating the impacts resulting from the implementation of the safety barriers and (ii) guiding the allocation of the budget available for their installation. The ranking is used within an iterative procedure in which the most hazardous risk sources are identified sequentially and corresponding safety barriers are allocated to reduce their contribution to overall risk. This is repeated until the budget for safety barriers is depleted or the risk becomes acceptable with respect to given predefined criteria concerning the residual risk. Yet, this procedure can lead to suboptimal combinations of safety barriers (portfolios) because of its iterative character.

In this paper, we propose a method of Portfolio Decision Analysis for the selection of cost-efficient portfolios of safety barriers in high-risk installations. In this method, the sequences of events which can cause accidents are modelled as Bayesian Networks (BN), whose nodes represent component failure events and whose arcs indicate causal dependencies between them. In the BN model, alternative safety barriers affect the probability distributions of component failures and, thus, the residual risk. The method provides a holistic approach to risk management: instead of iteratively selecting single barriers based on successive Risk Importance Measures, the risk analysis is performed for all the possible portfolios of safety barriers and the one of minimum overall residual risk at a given level of cost can be selected. The method is extended to capture the dynamical behavior of engineering systems through Dynamic Bayesian Networks and it is applied to the accident scenario of a vapor cloud ignition at Universal Form Clamp on June 14 2006.

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3. Aramis s.r.l., Milano, Italy

4. Chair on Systems Science and the Energetic Challenge - École Centrale Paris and Supelec

Thu4.4 Analysing and mitigating environmental and climate risks

Thu4.4.1 *Extreme climate events in a Hydropower station studied with a Bayesian Network approach*

H. D. Estrada-Lugo¹

In recent years global warming effects have notoriously change climate conditions resulting in an increase of extreme climate events namely, extreme precipitation, floods, droughts and sea level raising, situations that may trigger accidents in technological facilities (e.g. nuclear, wind or hydropower).

In the design stage, the installations are thought to resist, among other factors, climate conditions in the area where they are meant to be built. However, extreme climate events are expected to be more frequent and change the scenarios for which the facilities were built. This represent a serious threat for both the facility structure and working personnel. With this in mind, it is necessary to carry out risk assessments that take into account the new situations as well as the uncertainty factor associated with the global warming effect in the vulnerability quantification to adapt or increase the robustness of the installations in order to prevent accidents triggered by climate events.

The Bayesian Network method has increasingly been used to perform risk assessments proving to be a reliable and powerful tool. However, this method is restricted to discrete and Gaussian distributions, which lead to discretization of continuous data and impoverishing of information. Furthermore, the high uncertainty of variables involved leads to imprecise predictions or analyses with low-veracity results. In response to that, it has been found that Bayesian Networks enhanced with system reliability methods (EBN) help to overcome limitations of traditional networks and provide the uncertainty quantification affecting the outputs as result of the imprecision and random nature of available data.

The method has been implemented in the general purpose software OpenCossan. This work is an example used to understand the application of EBN to the production of a simple risk assessment assuming climate factors like extreme precipitation, wind rate and debris flow that can trigger severe accidents. Data from the Lianghekou hydropower station in the southwest of China are taken into account for this case study. However, when information is missing, suitable data for this case have been selected from additional literature. With results obtained, future research will be done to overcome the limitations of the presented method.

1. The University of Liverpool

Thu4.4.2 *Risk management and political influence in the face of future climate change*

A. Beijer Lundberg¹

Expected future climate change will most likely result in significant changes in the hydrological system, and consequently more intense periods of heavy rainfall and increasing flood risk. These floods threaten both public and private property, but the use and development of both are governed by planning laws, which are controlled by some political body. Such a body is per definition accountable to its voters. Due to the very large values which

are at risk during major flood events, political decision related to planning for climate change have significant economic consequences for the areas which are assessed to be in the risk zone. The value of land and property of individual voters is therefore dependent on political decisions, and this obviously influences the political system. The administrative response can consequently not be separated from the political response.

A framework is therefore developed to assess the political influence on practical risk management for climate change. The use of scenario planning for flooding is demonstrated to be useful for both existing property and future development, and it is demonstrated that the political influence is highly significant for existing property, in which political decisions will have significant consequences for large numbers of voters.

The political influence is shown to be the cause of much value-at-risk from flooding in some specific areas around the world. In these areas, intense political pressure, resulting from different economic interests, encourages property to stay or even to be further developed in flood-prone zones. The sharing of costs before and after the flood event is highly dependent on the political process, and efficient management of climate change must acknowledge this.

The developed framework is subsequently employed to suggest how long-term planning by different political bodies can be used to reduce the risk of climate change. Some practical examples are given and specific hazards are discussed.

1. ELU Konsult AB, Sweden

Thu4.4.3 *Mitigating the risk and assessing the impact of extreme weather on critical infrastructure*

M. Räikkönen¹, R. Molarius¹, K. Mäki¹, K. Forssén¹, A. Tagg², P.J Petiet³.

Infrastructures are an essential part of our highly developed society. Therefore, the increasing number of extreme weather events (EWE), resulting from climate change, poses a growing challenge for the protection of critical infrastructures (CI). Recent experiences have highlighted the economic and societal reliance on a dependable and resilient infrastructure, and the far-reaching impacts that outages or malfunctions can have. In all, mitigating the risk and assessing the severity of EWE impact on CI is a challenging task and various aspects should be taken into account.

The EU-funded INTACT project addresses these CI challenges and attempts to bring together cutting-edge knowledge and experience from across Europe to inform the development of best practice approaches in planning, crisis response and recovery capabilities. In this paper, we present a structured approach to assess EWE impacts on CI and resilience and vulnerability of CI as well as risk reduction generated by different measures. It follows mainly the passage from hazard and CI identification, vulnerability analysis and potential damage estimation to loss assessment. The decision process of the approach is flexible in the sense that it encompasses a rigorous quantitative assessment, but allows also a combined semi-quantitative assessment. The approach forms part of the overall INTACT Wiki, which is the main output of the project. The wiki presents structures for models and data requirements for decision making; identifies tools and methods that support decision-making; supports analysis of measures to protect CI through simulation; and indicates gaps in modelling and data availability.

The approach enhances transparency of decision-making and contributes to more comprehensive use of available information. Moreover, the approach provides a holistic view to risk management and CI protection by combining and incorporating several assessment methods into one aggregated structure. In practice, this means connecting the worlds of climate and risk management researchers, meteorologists, first responders, and CI operators, owners and planners. Although risk management of CI is a multidisciplinary issue, we found (huge) differences in understanding, language and approach between these worlds.

1. VTT Technical Research Centre of Finland
2. HR Wallingford Ltd., UK
3. TNO, The Netherlands

Thu4.4.4 *Cost-effective greenhouse gas abatement measures on dairy farms analysed with Bayesian decision support tools*

S. Nisonen^{1,2}

We study the cost-effectiveness of various local-level greenhouse gas abatement measures that are easily available for farmers on Finnish dairy farms. We construct a decision support tool based on Bayesian networks. The probabilistic model behind the decision support tool combines two different methods in estimating the changes in climate impact. Initially, emissions are estimated with the well-established method of life-cycle assessment. The changes relative to these baseline impacts, achieved by the abatement measures, as well as the costs of the abatement measures are estimated using expert elicitation. We construct a Bayesian network, which describes the changes in emissions depending on the state of the farm and then convert it to a limited memory influence diagram by adding decision nodes and assigning utilities to the end states of the farm. A single policy updating algorithm is then used to identify the optimal decision policies in the limited memory influence diagram. The cost-effectiveness of the abatement measures is found to depend heavily both on the properties of the dairy farm and on the level of abatement that is already in place on the dairy farm. Increasing local energy production capabilities and increasing the share of renewable energy are found to be the measures that are most often among the most cost-effective. The uncertainties inherent in the dynamics of complex systems like dairy farms lead to difficulties in decision making and policy design. The probabilistic approach used in this study alleviates these problems, allowing for more informed decisions.

1. University of Helsinki
2. National Resources Institute Finland

Thu4.4.5 *Combining exploratory scenarios and Bayesian belief network to analyse the sustainability of Baltic herring and salmon fisheries*

M. Pihlajamäki^{1,2}, A. Lehtikoinen³, P. Haapasaari², S. Sarkki⁴

Exploratory scenario method is often used in planning for long-term sustainable use of environmental resources. Exploratory scenarios are plausible and relevant storylines on how the future might unfold. This paper combines

exploratory scenario method and Bayesian belief networks (BBN) to analyse the sustainability of commercial Baltic herring and salmon fisheries in 2040. First, following the matrix logic approach, two critically uncertain driving forces were identified to build a scenario cross. These were 1) whether governance in the EU is integrated or fragmented, and 2) whether environmental awareness and engagement in the Baltic Sea region is high or low. Four contrasting storylines for the future of Baltic herring and salmon fisheries (Inequality, Transformation to sustainability, Transformation to protectionism, and Business-as-usual) were created based on the identified driving forces and elements, and their respective causal links. Second, the storylines were formulated as a Bayesian influence diagram to quantify and analyse the impacts of the driving forces to the social-ecological system and ultimately achieving the fisheries management objectives, including ecological, social and economic sustainability, and increasing fisheries contribution to food security and safety. The BBN presented in this paper is an artificial intelligence tool to help in thinking the complex future scenarios in a systemic way. This type of systematic futures thinking could potentially increase the ability of the fisheries governance systems to deal with unfavourable or unexpected future developments.

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2. University of Helsinki, Department of Environmental Sciences, Helsinki, Finland
3. University of Helsinki, Department of Environmental Sciences, Kotka Maritime Research Center, Kotka, Finland
4. University of Oulu, Faculty of Humanities, Oulu, Finland

Fri2 FRIDAY NOVEMBER 3, 13.10 – 14.40

Fri2.1 Analysing and managing environmental and climate risks

Fri2.1.1 *The signal crayfish and the Swedes – the story of a risk management that went wrong*

U. Sahlin¹, L. Edsman², P. Bohman²

Swedes love their crayfish parties. For a small fraction of the population, these parties are preceded by an early fishing tour on a quiet lake, or cooking them using one's own recipe. Signal crayfish *Pacifastacus leniusculus* was introduced from North America to Sweden in the 1960s to replace the disappearing native noble crayfish *Astacus astacus*, which had been decimated by 50 percent due to the disease crayfish plague. Despite good intentions, the signal crayfish turned out to be a chronic carrier, spreading the plague much more, and making the situation for the remaining noble crayfish populations much worse. Today, intentional illegal introductions of signal crayfish into new waters, also known as "the man with the bucket syndrome" is the major cause of plague outbreaks in noble crayfish populations. As a consequence of the EU Regulation on Invasive Alien Species of 2015, signal crayfish is placed on the list of Invasive Alien Species of Union concern. This means that measures must be taken to eradicate or control signal crayfish in Sweden. We present the outcome from a risk analysis to support the Swedish risk management program for this invasive species. This is a true story of how managing one risk creates another, how attitudes of the risk manager can change over time, illegal activities, ignorance, frustration among

stakeholders such as local fishing right owners associations, and not the least a geographical diversity in risk and attitudes across Sweden.

1. Centre of Environmental and Climate Research, Lund University, Sweden
2. Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden

Fri2.1.2 To eat or not to eat? A systems analytic approach to evaluate the sustainable use of the dioxin-rich Baltic herring and salmon

A. Lehtikoinen¹, L. Ronkainen¹, P. Haapasaari¹

Ecosystem-based fisheries management aims to achieve sustainable use of the fish stocks in a socioecologically balanced manner, paying attention to human-environment interconnections. This requires systemic perspective to management: the interactions between species, environmental conditions and human pressures determine the productivity and health of the ecosystem. These further on define the limits of the sustainable use, where both social (including food safety aspects), environmental and economic aspects are considered. We examine dioxin flux in different basins of the Baltic Sea and analyze alternative ways to reduce the dioxins accumulating to humans via eating Baltic herring and salmon. Dioxin compounds accumulate to fatty tissues, thus the concentrations in the organisms increase cumulatively when shifting upwards along the food chain. On the other hand, fatty fish as part of human diet form an excellent source of healthy Omega-3 fatty acids and vitamin-D. We study the impact of different fishing regulations and fish eating recommendations to find ecologically and socially sustainable ways to use Baltic herring and salmon, acknowledging the risks and utilities to different sectors. A probabilistic influence diagram is presented for the Bothnian Sea area, based on modular model coupling, where the output of an ecosystem model serves as an input to a human health risk-benefit model. The management options are evaluated from the multi-criteria perspective, acknowledging all the three aspects of sustainability.

1. University of Helsinki, Department of Environmental Sciences

Fri2.1.3 The role of recorded, quantitative impact data in national risk assessments

K. Pilli-Sihvola¹

The National Risk Assessment (NRA) of Finland (2015) raises two types of hydro-meteorological hazards, floods and storms, as perils that may pose regional societal risks. The worst identified case, A large-scale winter storm followed by a long cold spell, is expected to cause major infrastructure damage and disruption in societal functions. The Finnish NRA uses a risk matrix-based approach in measuring the risks the perils are posing: the likelihood of the natural hazard is multiplied by the expected consequences, assessed based on expert judgement. Currently, the European Union is emphasising the use of quantitative disaster damage and loss data in the national risk assessments. This has resulted in national efforts to create disaster damage and loss databases.

How is a disaster damage and loss database developed in a data-rich country with a significant share of data owned by private companies, how can these databases improve national risk assessments, and what additional

information beyond impact data is needed to capture the current and emerging risks posed by weather and climate?

This presentation will describe the on-going development of the weather damage and loss database in Finland. The database and derived analyses will be used to a) improve risk assessments, b) observe and analyze the trends and aggregate statistics of damage and loss related to extreme-weather events and c) improve weather impact forecasting and early warnings. The database has been under development for the past two years, and it is currently further developed and used in the National weather and climate risk assessment (SIETO-project), commissioned by the Prime Minister's Office of Finland. The presentation will focus specifically on the challenges in its development, identify potential use of quantitative damage and loss data and also assess the limitations of its use in national risk assessments.

The database currently focuses on the hazard and its impacts, but in order to fully understand the current and particularly future risk landscape of society and improve the possibilities for reducing the risks, also underlying information on the exposure and vulnerability factors of society and people is needed; and particularly how these will change in the future. Pure extrapolation from existing data does not suffice, as emerging risks, for instance due to climate change, will change the risk landscape of Finland. We will discuss this aspect and present examples illustrating the needs of data on exposure and vulnerability as well.

1. Finnish Meteorological Institute

Fri2.1.4 *Political conflicts and errors in databases on protected areas*

M. Blasi¹, C. Danelutti², M. Valderrabano²

The World Database on Protected Areas (WDPA) is the most up to date and complete source of information of protected areas with a global coverage. WDPA is managed by United Nations Environment Program's World Conservation Monitoring Centre (UNEP-WCMC) with support from IUCN and its World Commission on Protected Areas (WCPA). The WDPA provide information to the online platform Protected Planet at www.protectedplanet.net, which is a system that enables a range of users to use that data for policy development, information-based decision-making, and conservation programs.

Credibility in this risk management relies on the WDPA being up-to-date and accurate. In some countries, this is not the case. There are for example protected areas in WDPA, which in reality are not protected, and vice versa.

In this talk, we present the results from an evaluation of the accuracy of some countries in the Mediterranean basin. This evaluation has been done by comparing the WDPA dataset with the most up to date official authority's data for each country. Special focus is placed in North African, Middle East and Balkan countries. We study the link between war conflicts and unstable political situation and lack of data, misspellings or ambiguity in what to call or name protected areas.

1. Centre for Environmental and Climate Research, Lund University, Lund (Sweden)

2. IUCN Centre for the Mediterranean Cooperation (IUCN-Med), Malaga (Spain)

Fri2.1.5 Climate change mitigation strategy under uncertainty and learning on climate sensitivity and damages

T. Ekhholm¹

Climate change mitigation can be framed as a case of large-scale risk management due to the magnitude of uncertainties and potential damages involved. The optimal action against climate change can be, in principle, estimated through cost-benefit analyses. However, such analyses have drawn considerable critique due to contestable choices on discounting and high uncertainties on climate sensitivity and climatic damages. Consequentially, it is argued, cost-benefit analysis can suggest mitigation rates that are nearly arbitrary.

This study maps optimal emission pathways using a sequential decision-making approach, which allows hedging against uncertainties and readjusting the mitigation strategies over time to reflect new information on climate sensitivity and damages.

Scenarios are calculated with SCORE, a lightweight stochastic integrated assessment model, using the climate damage representation from DICE. Two probability distributions are employed for climate sensitivity and the damage function exponent, while a binomial lattice is used to represent the learning process for both factors. Alternative cases cover also two sets of time-dependent mitigation cost curves, here based on a recent multi-model study on the Shared Socioeconomic Pathways; and three discount rate choices. The results consider the evolution of greenhouse gas emissions, carbon pricing and the long-term stabilization temperature under sequential decision-making in scenarios, where the uncertainty on climate sensitivity and climate damages decrease gradually through exogenous learning.

For most of the considered parametrizations, optimal near-term emissions pathways that hedge against climatic and damage risks fall between 1.5°C and 2°C emission pathways; thus giving support for the Paris Agreement targets.

The consideration of uncertainty adds a substantial risk component to carbon pricing, adding a 30% to 95% risk component to the carbon price compared to the corresponding deterministic cases. Relatedly, learning can induce significant price volatility in a decadal timescale. Volatility until 2050 is somewhat higher than until 2100, with the maximum of calculated cases around 25%. The carbon price volatility for the coming decades can therefore be of similar magnitude than stock price volatilities due to the considered uncertainties.

Sequential decision-making allows hedging against uncertainties and readjusting the temperature target over time to reflect new information on climate sensitivity and damages, leading to diverse stabilization temperatures in the long-term. Assumptions on mitigation costs, climate sensitivity and damages affect optimal near-term mitigation and long-term stabilization temperature more strongly than the discount rate choice.

1. Systems Analysis Laboratory, Aalto University, Finland

Fri2.2 Risk perceptions and societal aspects

Fri2.2.1 *Environmental risks in urban infrastructure projects: stakeholders' perceptions and public participation in environmental compensation planning in Lithuania*

A. Balžekienė¹

Modern cities face a dilemma of balancing the interests of economic growth and preserving ecosystems services in urban environments. The application of environmental compensation in cities focus upon ensuring no net loss for biodiversity or positive net gain. However, the planning of environmental compensation measures often involves tension between local communities, developers and municipalities. The perception and communication of environmental risks and threats in urban infrastructure projects by various stakeholders shape the acceptability of these projects by local communities. The identification of environmental compensation measures also reflect the values and worldviews of involved stakeholders.

This presentation is analyzing how the risks of urban infrastructure projects are perceived by involved stakeholders, and how the public is involved in discussion about the measures of environmental compensation in Lithuanian biggest cities. This study used data from interviews and focus groups discussions with stakeholders (municipalities, local communities, central governmental bodies and representative of developers) on selected urban infrastructure projects in Lithuania. Research was conducted in 2016-2017 and was funded by Lithuanian research council. Lithuanian cases are also compared to the environmental compensation practices in Sweden, particularly with the municipalities that have approved guidelines for environmental compensation (e.g. Gothenburg municipality).

1. Kaunas university of technology, Institute of Public Policy and Administration

Fri2.2.2 *Riskisation as a driver of regionalisation in the Asian-Arctic - Case - Chinese Multi-Level Actors*

L. Kauppila¹, S. Kopra²

In this paper, we adopt the conception of risk as an analytical tool to understand and explain the process of regionalisation. We emphasise the socially constructed nature of risks and define them as actor- and context-specific perceptions of undesirable events. Inspired by William Clapton's work, we argue that Chinese processes of riskisation – a dynamic process of identification, assessment and management of unwanted events – drive forward region formation in the 'Asian-Arctic', an emerging macro-region in the High North. Based on both Chinese and English language primary sources, we explore how risk perceptions motivate Chinese actors in the regionalisation in the High North. On the one hand, we analyse what kind of role the Arctic change plays in the risk management calculus of the Chinese government; On the other, we examine the ways the making use of Arctic opportunities helps the Chinese government and other actors mitigate and manage risks that prevent them from acting out their core functions in the Chinese society: safeguarding energy security, protecting the citizens from non-traditional security threats and making profit to fuel the country's economic growth. Ultimately, we pinpoint

how various simultaneous processes of riskisation are leading into interdependence between the Chinese actors and their Arctic counterparts – a process that shapes our understanding of the High North as a space of flows in which China plays an integral role. In other words, we conclude that the becoming of a new macro-region of Asian-Arctic is a consequence of dynamic processes of riskisation.

The paper can be divided into three sections. We first identify the Chinese actors that participate in riskisation and the consequent processes of regionalisation. Second, as riskisation is always shaped by ideologies, values and norms, we next explore the normative underpinnings of the way actors seek to define and manage risks in China. This way we also shed light on the possible normative changes that China's entrance to the High North creates. Finally, we discuss the significance of the emerging Asian-Arctic region - the ultimate effect of Chinese processes of Arctic riskisation - on both world politics and Chinese domestic context.

1. Centre for East Asian Studies, University of Turku

2. Arctic Centre, University of Lapland

Fri2.2.3 *Unlocking the Potentials of Youth Social Movements to Foster Societal Resilience*

Z. N. Tag Eldeen^{1,2}

The constant reminders of unpredictability of what could be catastrophic adds more responsibilities on the young generation whom now find the steps on the prosperity ladder of their Europe dream, are illusory and future uncertainty has replaced the dream. To counter these trends a strategy that places the young people at the core of strengthening social cohesion and building a societal resilience is needed. The aim of this proposal is to explore the potentials of Youth-led Social Movements in Sweden through investigating their creative role in their communities; develop innovative ways and technologies to build on that capacity; and incorporate their role to prevent, mitigate and resist risk and its consequences. Combination of four lines of thoughts will build the research theoretical framework: communicative planning; social movements, information technologies; the notions of risk society and resilience. This will enable investigations outside the traditional boundaries of each discipline to analyze empirical findings. Qualitative and quantitative methods are used including theater, photography, and e-forums. Theoretically, the research will bring a new dimension to planning for resilience in the context of world risk society. Practically, new areas of collaboration between municipality planners, emergency managers and decision makers to incorporate a positive role of young activists to strengthen societal resilience using advanced technologies will be identified.

1. The Royal Institute of Technology, KTH, Stockholm

2. The Swedish University of Agriculture sciences, SLU, Uppsala

Fri2.2.4 *Enhancing Risk Perception by Seafarers and Cruise Ship Passengers in the Arctic Ocean*

S. Kirchner¹

Shipping is essential for the global economy. Even though shipping is becoming safer, it remains an inherently dangerous activity. Every day, between one and two million seafarers are risking their lives in order to keep the

flow of goods across the oceans running. International law has been used as a tool to enhance safety in shipping. Due to climate change, new sea routes become available in the Arctic Ocean, some of which are already used by cruise vessels. This research aims at answering the questions how international law can be used to enhance the skills of those working on cruise ships operating in the Arctic in order to reduce the risk of disasters and which measures are available to enhance the ability of seafarers to perceive risks in a work environment with which many are not yet familiar. While natural factors such as extreme weather events play an important role in many shipping disasters, many incidents and casualties are caused by human failure. In the Arctic, this risk awareness is often absent among newcomers to the region. As shipping in the Arctic is just beginning to take off, most non-local seafarers have no Arctic experience at all. The dangers experienced by seafarers in the Arctic Ocean include both general dangers associated with maritime travel in general and particular risks which follow from the specific circumstances in the Arctic. The focus of the research is on the role of international law in the development of seafarer training. Even though in legal terms the focus of training requirements is very much on seafarers, many risks apply to everybody traveling by ship in the Arctic, including other members of the crew with non-seafaring roles and passengers. Risk awareness, be it general or Arctic-specific, is an important element in ensuring human safety. In a second step, the question will be asked how lessons learned in the context of international seafarer training law can be transferred to enhancing risk awareness among cruise ship passengers as well.

1. Arctic Law at the Arctic Centre of the University of Lapland, Rovaniemi, Finland

Fri2.2.5 *Social Indicators of Security and Risk Perceptions*

R. Kachef¹

More often than not, perception is far stronger than reality in laypeople's sense of security. This is commonly exemplified when a sticker announcing that a property is secure is as influential as actually securing the property. The popular Broken Window Theory proposes that the aesthetics and approachability of a community influences not only individual perception of security, but in fact impacts the instances of minor crimes. This presentation will explore crime and litter data to illustrate spatial autocorrelations between the cleanliness and the safety of municipalities in Sweden; highlighting that perception, appearance and safety are closely intertwined.

1. King's College London

Fri2.2.6 *Findings of safety assurance of fuel cell and other hydrogen based applications - legislation and safety analysis*

J. Sarsama¹, M. Nissilä¹

Hydrogen economy and related fuel cell and electrolysis technologies are considered as one potential way towards a climate-neutral energy system. Hydrogen technologies provide for example a solution for the storage of solar and wind energy. In addition, fuel cells provide higher efficiency of electricity generation when compared to e.g. internal combustion engines.

As with all new technologies, ensuring safety is an important part of developing fuel cell and electrolysis technologies. One inherent challenge related to these technologies arise from the properties of hydrogen such as small molecule size, wide flammability range and interaction with some metals (risk of embrittlement).

This presentation reviews some safety related findings of five VTT's fuel cell development projects. On one hand, applicable European safety legislation and standards concerning fuel cell and other hydrogen applications were examined. On the other hand, safety studies were carried out for hydrogen-based systems designed, built and ultimately taken in use for research purposes.

The legislative part concentrated on the identification of relevant directives and other legal acts for the four different hydrogen based applications in the focus of the study. Safety studies were carried out for three fuel cell applications and for one pressurized electrolysis application. Hazard and Operability analysis (HazOp) was the safety analysis method for the fuel cell applications, and for the electrolysis application, the method was Preliminary Hazard Analysis (PHA).

One result of the legislative part was that the published information on the topic is quite scarce. In addition, the reviewed material did not always clearly raise the justification to apply certain directives. The definition of directives or other legal acts that apply to specific types of fuel cell or hydrogen applications turned out to be quite a challenging task. The number of potentially enforceable directives can be quite high.

The selected safety analysis methods suited well to the examination of the systems and provided new and valuable understanding on their safety aspects. In addition, a great deal of improvement proposals were discovered. This was especially the case with HazOp studies, as these were carried out in a more detailed level. The HazOp method was suitable also because the applications did not include only fuel cell technology but also different types of primary fuel processing (reforming, partial oxidation) and hydrogen purification steps (e.g. PSA - Pressure Swing Adsorption). More detailed considerations on the safety and security aspects of the studied systems are highlighted in the presentation.

1. VTT Technical Research Centre of Finland

Fri2.3 Emotions, risk perceptions and thought errors

Fri2.3.1 *The security trap: when feeling safe isn't being safe*

C. Bennett¹

Security is defined by Chambers dictionary as "the state, feeling, or means of being secure". This paper addresses the second of these definitions, the feeling of security.

While there is much research on how perceptions of risk in relation to a threat may be modified and frequently heightened by emotion, less has been written about the obverse effect, where feelings of security may reduce perception of risk. One key finding from the doctoral study of NHS hospital staff on which this paper is based, is that feelings may be more important than cognitive assessment in predicting behavioural choices. In particular, it demonstrates how exactly the same threat can evoke completely different responses on different occasions depending on the type and degree of emotion it engenders at that time.

For example, a shortage of staff which is seen to put patients at risk may trigger submission of an adverse event report. However on other days the same situation may be tolerated without activation of a behavioural response. The actual threat remains unchanged, the staff member's cognitive assessment of the degree of risk to patients is also unchanged; what is different is how they feel about the situation, that for some reason they feel more secure and less anxious about the prospect of patients being harmed by having insufficient staff to look after their needs. This paper uses empirical data to explore some of the many environmental and relational influences that may contribute to feelings of security inhibiting action. Examples include: habituation to risk signals which only infrequently lead to actual harm; belief in the superiority of the assessment of risk made by others over one's own, especially when that assessment is made by those of higher status; and acquiescence to organisational and cultural norms seen to absolve the individual from personal responsibility.

In terms of patient safety, these are worrying observations. History abounds with instances of people ignoring dangers of which they were well aware with disastrous consequences. The NHS itself is no exception to this, as evidenced by high profile cases in which failures to act to resolve patient safety issues have led to unnecessary suffering and death. It is thus important to explore factors which may contribute to the development of a sense of security which is at odds with the degree of assessed risk.

1. King's College London

Fri2.3.2 *Emotional Reactions to Climate Change: A Comparison Across Norway, Great Britain, Germany, and France*

G. Böhm¹, C. Mays², K. Steentjes³, E. Tvinnereim⁴, H.-R. Pfister⁵

The current paper presents an international comparison of emotional reactions to climate change. Emotions are a strong motivational force and influence both judgments and behaviors in manifold ways. The present paper draws on appraisal theories of emotion according to which emotions are based on specific cognitive appraisals of the situation. The present study compares the following five specific emotions that we have shown in our previous research to be important in the context of environmental risks (e.g., Böhm, 2003; Böhm & Pfister, 2000, 2005, 2015): worry, hope, fear, outrage, and guilt. We expect the following relationships between emotions and underlying cognitive appraisals: Worry, hope and fear are assumed to indicate that a person focuses on potential future consequences. While hope implies that negative consequences appear avoidable or positive consequences achievable, worry and fear anticipate exclusively negative consequences. Outrage and guilt are hypothesized to be based on moral evaluations; outrage implying that others are seen as culprits whereas guilt results from self-blame.

This paper uses survey data collected in the 'European Perceptions of Climate Change' project using representative national samples (each approximately N = 1000) from Great Britain, Germany, Norway, and France. All measures were taken using a multi-item survey instrument. Face-to-face interviews were conducted in three of the four countries (UK, Germany, France). In Norway, telephone interviews were conducted.

Results show that Norway and UK on the one hand and Germany and France on the other hand show similar profiles of emotional responses. While in Norway and UK hope is the most intense emotional response to climate change, fear and outrage dominate in France and Germany. Across all countries, outrage is the most and guilt the

least intense reported emotion. With respect to underlying cognitive appraisals we largely find the expected relationships. Hope decreases with increasing severity of anticipated climate change impacts. Hope increases with beliefs that imply that the problem may be solved, such as perceived collective efficacy in tackling climate change. Fear is mainly related to the severity of anticipated climate change impacts and the personal relevance of these impacts. Outrage and guilt are most strongly predicted from having moral concerns with respect to climate change. Results document the important role and cultural diversity of emotional responses to climate change and support appraisal theoretical approaches to explaining emotional reactions.

1. University of Bergen, Bergen, Norway
2. SYMLOG, Paris, France
3. Cardiff University, Cardiff, United Kingdom
4. UniResearch Rokkan Center, Bergen, Norway
5. Leuphana University Lüneburg, Germany

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Fri2.3.3 *Risk assessment, disabled people and self-experiences of falling in residential areas in Sweden – learnings from qualitative interviews*

J. Lundälv^{1,2}

In Sweden, 1.5 million people between the ages of 16 and 84 suffer from disabilities. During the period 2010 and 2050, the population over 65 years is expected to increase by 30 percent. In order to create safe residential environments, there is a need for regulation of equipment and that disabled people can be guaranteed a high quality of housing adaptation (HA) so that they can live as others in their homes. This study include a total of 65 people (40 women and 25 men) aged 20-90 with various disabilities and chronic illnesses. Interviews has been conducted focusing on injuries involving people in their homes in Västra Götaland County. The interviews took place during 2016-2017 and included; people with impaired mobility, visual impairments, hearing impairments, neuropsychiatric disorders, Parkinson's disease, Osteoporosis, Rheumatic Diseases and Acquired Brain Injuries. 53.8% (N=32) of the individuals had been injured. The type of accommodation was: condominiums (N=23), tenant rentals (N = 22), house (N=18), cottage (N=1) and student residence (N=1). It was most common to have been injured in kitchen environment or in the bathroom/toilet and in hallway (N=24). Eight people had been injured in external environments (balcony, entrance staircase or patio). The most common injuries were ulcer and bruises.

People with Rheumatic Diseases and Parkinson's Disease had been injured to the greatest extent in the material. 15 out of 21 interviewees with these diseases had been injured. Half of the interviewees (N=30) felt anxiety that they would be injured again. The concern was the women in which single women felt most worried about being at risk again injured in their homes. Anxiety to be injured were greatest in the age groups 20-40 years (54.5%) and 65-79 years (53.8%). 27 of the interviewees perceived that their relatives were anxiety that they would be injured in the future. People with impaired mobility reported to the greatest extent that they did not feel safe in home. Six of 10 experienced anxiety in their homes. Good lighting points in homes kitchen environment, hallway and stairway. The present study was funded by the Swedish Civil Contingencies Agency, Sweden. The research study has been evaluated by the Regional Research Ethics Committee in Gothenburg which has approved it during 2016.

1. Department of Social Work, Gothenburg University, Sweden

2. Chalmers University of Technology, Department of Architecture and Civil Engineering, Sweden.

Fri2.3.4 Human thought errors – the ultimate risk factor

P. Saariluoma¹

Risks can be seen as factors, which can lead to unintended, unwilled and negative outcome in any human context. Human actions have their goals, but it is always possible that the goals cannot be reached. If the outcome of action is worse than, what acting people originally thought, somewhere in information processing and thinking an error has been take place. The reasons, mostly psychologically analyzable and explainable, can be called thought risks. The realized risks caused by human thinking can be called thought risks. The factors, which explain the realized risks, can be called reasons for thought errors and existing states of affairs, which maintain risky thinking, can be called risk factors. Of course, human risks associated to human thinking can be subsumed into rational psychological and human research analysis. It is always possible to understand why people have made though errors.

Eventually, there are no other risks than human risks, because only people can act. If a technical artefact fails, it behaves, as it should in following the laws of nature. The true reason to failure must be reached from the way technical artefact has been used, designed or built. RORO ship Estonia did not sank, because its keel was destroyed by heavy sea, but because designers did not have good models to calculate the weight of waves, the keel was mistakenly built, the ship was not intended to sail on such open seas as, the test were not strictest possible, captain used too high speed against waves and eventually the storm was hard. All these factors lead to human decision and thinking processes. Had some of these factors been different, Estonia could still be a sailing risk.

The example with many others show how human thinking is involved in apparently technical risks. For this reason, it makes sense to consider the conditions in which people design, and decide about future technology supported action models. The true reasons for apparently, technical failures can be found from the conditions under which people think. It may be that their capacities are exceeded; it may be that they have too many things to too, they have too little knowledge, and they may follow illusory thought models.

In sum, it is possible to develop practices for eliminating and thus lessening the probability of thought risks in human action.

1. Universtiy of Jyväskylä, Finland