

# Identifying flows of information and energy in cyber-physical systems: A framework for safety risk analysis

**Carreras Guzman, Nelson Humberto; Kozin, Igor**

*Published in:*
4th Society for Risk Analysis (SRA) Nordic Chapter Conference: Exploring the risk, safety, security and resilience nexus

*Publication date:*
2018

*Document Version*
Publisher's PDF, also known as Version of record

Exploring the risk, safety, security and resilience nexus

Society for Risk Analysis Nordic Conference

Stavanger 8.-9. november

SEROS Centre for Risk Management and Societal Safety

University of Stavanger

SRA

# SRA NORDIC 2018 ABSTRACTS

## PARALLEL SESSIONS I, THURSDAY 8. NOVEMBER

65098 Roger Flage

Location: Sølvberget

### CONCEPTUALISATIONS OF RISK, VULNERABILITY AND RELATED CONCEPTS IN INFRASTRUCTURE RESEARCH

Coauthors:
Roger Flage, Associate professor , University of Stavanger
Seth Guikema, Associate Professor, University of Michigan
Caroline Johnson, PhD Student, University of Stavanger

In this talk we, we review, classify and discuss conceptualisations of risk, vulnerability and related concepts such as resilience and complexity in infrastructure research. Definitions found in the literature are classified according to the distinction made in the Society for Risk Analysis (SRA) glossary between i) overall qualitative concepts and ii) their associated measurements. Most of the reviewed definitions are found to correspond to the measurement type of definitions, meaning that a separation between i) and ii) as found in the SRA glossary is not commonly adopted. As an alternative approach, and in line with the SRA glossary, we show how starting from an overall qualitative, uncertainty-based risk conceptualisation linked to a risk metric covering specified consequences, a measure of uncertainty and the knowledge dimension can provide a unified foundation for risk assessment and management in the infrastructure context. We also discuss how the risk metric provides a framework for infrastructure modelling. The presentation can be seen as a demonstration of how generic risk analysis can support applied risk analysis.

64989 Johansson, Jonas

Location: Sølvberget

### ADDRESSING CASCADING CONSEQUENCES FOR CRITICAL INFRASTRUCTURE AND VITAL SOCIETAL FUNCTIONS IN FLOODING EVENTS

Coauthors:
Björn Arvidsson, PhD student, Lund University
Nicklas Guldåker, University lecturer, Department of Human Geography
Linn Svegrup, Phd Student, Lund University

Although there have been significant advances in the research field of critical infrastructures and vital societal functions during the last decade, there still exist many challenges in implementing and carrying out studies in practice. One of these challenges is a feasible method for mapping, analysing and visualising the cascading consequences that arise for critical infrastructures and societal functions affected by large spatial hazards. The presented study is the result from commissioned work for the Swedish Civil Contingencies Agency (MSB), aiming at contributing to improved risk, vulnerability and continuity management for regions in Sweden at risk of being affected by severe spatial hazards. The study takes it basis from, and connects to, ongoing work in Sweden relating to the risk of severe flooding events in accordance to the EU Floods Directive and work related to critical infrastructure protection in accordance to the EU Directive on European Critical Infrastructures. The results from the study where mainly derived through a literature review and workshops, utilising a flood prone region in Sweden

as a case. The literature review focused on methods and approaches, both scientific and in grey literature, for estimation, visualisation and weighing of consequence arising for critical infrastructures and vital societal functions for large spatial hazards. Here a specific focus was on literature addressing the issue of interdependencies and the use of GIS. The workshops involved participants from critical infrastructure operators, municipalities, regional county boards, MSB, Statistics Sweden, among others, aiming at the practical needs and challenges for a method and for testing the developed method. From the literature review it was clear that most studies focus on analysing the direct consequences of large spatial hazards. Only few studies address the indirect consequences that arise due to interdependencies, revealing that indirect consequences can be as high or higher than the direct consequences. This necessitates the need for addressing indirect consequences systematically. The review also highlighted that the required underlying data is not easily attainable and comes with several challenges with respect to collection, analysis and visualization of the results for decision making. The developed method is concluded to both fulfil a need, as expressed by the participants in the workshops, and was considered as a feasible approach to start addressing the issue of cascading consequences during large spatial events. However, we also conclude that, based on the literature review and the practical challenges present in this area, ample research opportunities exist.

64918 Stødle, Kaia

Location: Sølvberget

**INTERDEPENDENT INFRASTRUCTURE SYSTEM RISK ANALYSIS OF THE REAL-WORLD POWER AND WATER DISTRIBUTION SYSTEM AT ST. KITTS**

Coauthors:
Logan Brunner, Environmental Systems Engineer, TNO
Roger Flage, Associate professor , University of Stavanger
Seth Guikema, Associate Professor, University of Michigan
Caroline Johnson, PhD Student, University of Stavanger
Julian Saliani, Reporting Analyst, Vox Media, Inc.

Critical infrastructure systems underlie the economy, national security, and health of modern society. These infrastructures have become increasingly interdependent, which poses challenges for modelling the systems. Although a number of methods have been developed for this purpose, few case studies of real-world interdependent infrastructures have been conducted. In this project, the effect of hurricane disruptions on the performance of the connected power and water system of St. Kitts is studied. The water system is dependent on the power system because of wells that require electricity to pump water into the distribution system. Despite significant data limitations about the infrastructures, a representative model of the real-world interdependent power and water system was developed and the effect of hurricane activities were analyzed. The analysis results provided information about the most vulnerable parts of the infrastructures and critical linkages between the power and water distribution systems.

64916 Johnson, Caroline

Location: Sølvberget

**CHARACTERISING THE ROBUSTNESS OF POWER-LAW NETWORKS GIVEN SPATIALLY-CORRELATED DISRUPTIONS**

Coauthors:
Roger Flage, Associate professor , University of Stavanger
Seth Guikema, Associate Professor, University of Michigan
Allison Reilly, Assistant Professor, University of Maryland

Knowing the ability of networked infrastructure to maintain operability following a spatially distributed hazard (e.g., earthquake or hurricane) is paramount to managing risk and planning for recovery. Leveraging topological properties of the network, along with characteristics of the hazard field, may be an expedient way of predicting network robustness compared to more computationally-intensive simulation methods. Prior work has shown that some topological properties are insightful for predicting robustness, considered here to be the size of the largest connect graph after failures, especially for networks experiencing random failures. In this work, we consider the effect that spatially-correlated failures have on network robustness using only spatial properties of the hazard and topological properties of networks. The results suggest that for spatially-correlated disruptions the spatial properties of the hazard are the most influential factors in predicting the robustness of the network. The topological properties of the network that are significant for predicting the robustness are mean nodal degree, mean and maximum betweenness centrality, mean and standard deviation of clustering coefficient and the maximum and standard deviation of path

length. These findings are compared to those when random failures occur, providing insight into structural factors that are influential, regardless of the type of disruption.

64940 Hassel, Henrik

Location: Sølvberget

## CHALLENGES IN THE IMPLEMENTATION OF A RISK AND CONTINUITY MANAGEMENT PROCESS FOR MUNICIPAL CRITICAL SOCIETAL FUNCTIONS

Coauthors:
Alexander Cedergren, Assistant professor, Division of risk management and societal safety, Lund University

The area of critical infrastructure protection (CIP) typically focuses its attention on large-scale, often technical, networked infrastructures, such as electric power distribution, telecommunication, transportation and water distribution. However, a substantial share of critical functions constitute systems that are "softer" in the sense that they more accurately can be described as an interacting network of people, organizations and artifacts, such as health care, child care, fire and rescue services, that collectively provide services that are essential for the functioning of society. In Sweden, several of these functions are performed by municipalities and regulation requires them to work systematically to ensure the resilience of these critical functions. This oral presentation focuses on ongoing work in the municipality of Malmö where a risk and continuity management process is currently being implemented in municipal departments. The presentation will address challenges that have arisen during the implementation phase. Challenges in four different themes have been identified. First, there have been challenges in introducing continuity management principles in the area of municipal services (which is not an area where continuity management first was developed for). Secondly, challenges have arisen when employing risk and continuity management in a multi-actor setting, e.g. where individual analyses are performed in municipal departments but where these are interrelated in different ways requiring coordination and harmonization (for example in terms of how different elements are described or how judgments are made). Third, there have been challenges in balancing the positive sides of autonomy in the municipal departments (e.g. sense of ownership) with the negative sides (e.g. lack of competence and experience in conducting risk assessments). Finally, practical challenges have arisen in relation to the different perspectives, backgrounds and competencies of the partners responsible for developing and implementing the RVA-work. The main conclusion is that the implementation of a risk and continuity management process in a municipal setting has to overcome an array of methodological and practical challenges to be successful. With a more systematized documentation and exchange of lessons learned, some of these could probably have been predicted and avoided or at least mitigated. Creating a repository of common challenges and solution proposals, preferably validated ones, would therefore be a significant contribution towards more successful practical implementation of risk and continuity management in the context of critical societal functions.

64947 Botheju, Deshai

Location: Atlantic Hall

## EFFECTIVE MANAGEMENT OF RISK STUDIES IN OFFSHORE OIL & GAS INDUSTRY

Risk assessment studies are widely used in offshore greenfield and brownfield projects, as it is a mandatory part of the safety management system as per governing regulations and compliance requirements in many parts of the world. It is also a common practice for project contractors to get these risk assessments conducted via expert third party vendors who are specialized in quantitative risk assessments. Such subcontracting of risk studies comes with its own challenges. The current abstract briefly addresses this perspective and tries to formulate some key guidelines for effective management of third part risk studies. One of the key blunders identified in offshore industry is the direct acceptance of risk study results as they are. It is emphasized here the necessity of project contractor to critically review the risk study results (often comes as reports) and validate their relevance. The main challenge in this regard is the involvement of personnel from different discipline backgrounds. The project contractor normally has designers with engineering background. On the other hand, the third party risk evaluators are often having mathematical or statistical methods backgrounds. This mismatch between the two sides often leads to misinterpretations and erroneous outcomes. To solve the issue, both sides have to have a certain common ground understanding, even though they do not have to become the subject experts of other party's discipline. Being too vague or too general in final conclusions is another common undesired outcome seen in many risk studies. This makes the study outcome to be less useful in arriving critical decisions related to safety systems design. The risk owner will also find such risk studies to be of little use, after spending significant amounts of financial resources to fund risk assessments. Note that the offshore risk assessments are among the most expensive of all safety

studies in the industry. The presentation of risk study results is often found to be improvable. The study reports do not always highlight the most useful aspects for safety engineering designers. Instead, in many cases, the reports revolve around too detailed statistical figures that might be of interest to the risk statisticians but of a little practical use to safety system design decision makers. Recognition and resolution of the above mentioned aspects, among others, can result in a vastly improved usage of risk studies while achieving enhanced cost effectiveness in overall safety management.

64903 Abdelmalek, Mohamed

Location: Atlantic Hall

**PERFORMANCE-BASED ONLINE INDICATORS OF SAFETY BARRIERS AT THE OPERATIONS PHASE OF THE ASSET**

Uncertainties about the performance of the various safety barriers during the early design stages are expected due to the lack of the operational knowledge. Furthermore, safety measures on the oil and gas facilities involve operational and organisational barrier elements. The inclusion of those elements in the process of safety barrier analysis increases the possibility of relying on strong assumptions to compensate for the lack of the operational knowledge. Accordingly, such critical factors have to be monitored continuously during the operation phase to manage the impact of the unexpected changes of those elements. Therefore, this paper provides a method for monitoring the status of safety barriers through online indicators of the underlying critical performance influencing factors. The utilisation of this approach is beneficial in capturing early warning signals about any degradation in the barrier performance which influences the barrier health and risk level.

65351 Rastayesh, Sima

Location: Atlantic Hall

**RISK ANALYSIS FOR WIND TURBINES NEAR HIGHWAYS**

Coauthors:
John Dalsgaard Sørensen, Professor , Aalborg University
Sima Rastayesh, PhD Fellow, Aalborg University

Wind energy is one of the leading sources of renewable energy in Denmark and other countries; Wind energy is increasingly be used in cold climate sites. Icing and ice throw of ice pieces can be a significant issue that should be taken into account in a risk assessment related to the impact on the environmental from a wind turbine(WT). In addition also the potential impact from failed WT blades has to be taken into account. Environmental impact assessment has to be performed e.g. when WTs are planned to be located in areas where people are living and in cases where WTs are planned to be placed near a road or a highway. Generally, the safety factors used for design of WTs do not cover such situations; since the safety factors have been calibrated assuming that no or almost no human fatalities are in danger in case of failure of parts of a WT. In Denmark, one of the issues that is considered for design is icing of WTs blades; although in this country, the frequency of icing event is not considerable, still it should be taken into account. Several investigations are on-going in order to establish rules and guidelines related to icing. Assessment of risks due to items thrown away from WTs is important in connection with planning and installation of WTs near highways in many countries. The following scenarios should be considered in an assessment of the risks for the environment around a WT: 1) part of a WT blade or the whole blade may fail/collapse and thrown away from the turbine; 2) icing may occur when the WT is in operation and ice pieces may be thrown away, and 3) the WT is stopped in situations with icing and ice pieces may be thrown away due to high wind speeds. Assessment of the risk of people in a car passing on highways near a WT due to throwing away from blades parts or ice pieces in case of over-icing is presented in this paper. The above three cases are considered in the risk assessment; furthermore, the probability per km that a person in a vehicle is killed is estimated due to ice throw from an idling or an operating WT as well as total or partial failure/collapse of a WT as a function of distance to a road.

64914 Guldåker, Nicklas

Location: Atlantic Hall

**DIFFERENT SPATIAL VISUALIZATION TECHNIQUES FOR FIRE PREVENTION IN STOCKHOLM AND GÖTEBORG**

The aim with this paper is to examine how different GIS-based visualization methods can be applied and come to practical uses in the emergency service's fire preventive work. These techniques motivate and facilitate various

forms of fire prevention such as selection of areas or neighborhoods, blocks or buildings before home visits, identification and targeting of different risk groups and customized information campaigns about certain types of fires in fire risk prone areas. Presented analytical methods include dot mapping, kernel density and choropleth mapping. Results indicate strengths and weaknesses with these techniques and that they can complement each other in the emergency service's fire preventive work. The generic functionality of these techniques makes them useful for analyzing other types of incidents and risks, such as crimes and location-based diseases. The paper focuses on residential fires in Stockholm and Gothenburg.

64898 Carreras Guzman

Location: Atlantic Hall

## IDENTIFYING FLOWS OF INFORMATION AND ENERGY IN CYBER-PHYSICAL SYSTEMS: A FRAMEWORK FOR SAFETY RISK ANALYSIS

Coauthors:
Nelson H. Carreras Guzman, PhD fellow, Technical University of Denmark
Igor Kozine, Senior Researcher, Technical University of Denmark

Cyber-physical systems (CPS) are engineered system of systems integrating cyber processes to the feedback control of physical processes in cooperative (semi)automated control configurations with their related human roles. The concept of CPS encompasses a wide range of applications, from autonomous vehicles, critical infrastructures, industrial control systems, military defence systems, medical devices, among others. Overall, these applications share a set of key features: controlling some physical processes in real-time, while retaining a relation between automation and human factors. In recent years, several models have emerged in the literature to understand the interdependencies between security and safety in CPS. In their review, Humayed et al. [1] demonstrated the suitability of modelling many CPS applications according to three types of interactions or aspects. Namely, they modelled CPS as an integration of cyber, cyber-physical, and physical aspects. Using the taxonomy of cross-domain attacks illustrated in [2], this model describes adversarial, accidental and environmental sources of risk in CPS and their propagation throughout the aspects of the system. Despite being a good starting point for the identification of a comprehensive set of sources of risk, this model only provides a general description of the method and final physical impacts to the system and its environment. We argue that the lack of a conceptual framework impedes a detailed identification of safety risks, i.e. potential human injuries, damage to assets, and impacts to the natural environment. Therefore, we developed a unified safety and security framework for safety risk analysis of CPS. This framework is a refinement of the Uncontrolled Flows of Energy (UFOE) concept presented in [3]. The UFOE concept considers a source of risk as a loss of confinement resulting in uncontrolled energy flows. By incorporating the concept of Uncontrolled Flows of Information (UFOI), we facilitate the identification of UFOI leading to UFOE. This concept is the basis for the Uncontrolled Flows of Information and Energy (UFOI-E) framework for safety risk analysis. In particular, this paper develops the UFOI-E framework in three phases. First, we refine the definition of CPS aspects described in [1], conceiving them as system layers exchanging information and energy flows. Second, we illustrate a diagrammatic representation to identify the typical flows present throughout CPS, both within their layers and across their interfaces. Moreover, this representation includes the physical and cyber environments and their interactions with the system. Third, we introduce a taxonomy of UFOI-E in CPS and their potential safety-related consequences.

65097 Sahlin, Ullrika

Location: Valberget

## ARE THERE INDIVIDUAL DIFFERENCES IN THE ABILITY TO EXPRESS UNCERTAINTY?

Coauthors:
Ullrika Sahlin, Associate Professor, CEC

The ability to express epistemic uncertainty is an important skill for risk assessors and scientific experts to successfully assess and communicate uncertainty. Before asking questions like: Is this ability something different from the ability to synthesize knowledge and make predictions? Can the ability to express uncertainty be improved and, if so, how? Can insights about risk perception be to the ability to express uncertainty? We need to ask if such ability exists. We use computer games to measure people's ability to express epistemic uncertainty. The games allows the players to explore their ability to express uncertainty by a probability interval (Bean Guesser, Probability Guess), a lower bound on a frequency (Frequency Guesser), a probability density function (Probability Bee) and as a belief in a proposition (Quiztimate). The feedback in the games rely on proper scoring rules, which motivates the players to express their uncertainty as honestly as possible. Data is currently being collected from, mostly students,

to test if there were individual differences in the ability to express uncertainty. The poster present the games and preliminary results from the study.

65099 Bennett, Chris

Location: Valberget

**BENDING, BREAKING OR FIGHTING BACK: RESPONSES OF SOME HOSPITAL STAFF TO IRREDUCIBLE THREATS TO PATIENT SAFETY**

Decision making in response to a particular threat or hazard is normally focused on selection of an appropriate behaviour to reduce the perceived risk it poses. However, a problem arises if the threat is perceived to be outside the sphere of influence of the person concerned. In many situations of this sort the most obvious behavioural choice is to avoid the threat altogether. Some threats, though, may appear both irreducible and unavoidable. In these circumstances some sort of adaptation to enable toleration of the threat is indicated. This paper draws on qualitative empirical data from research on the contribution of staff perceptions of risk to patient safety in NHS hospitals. Participants were ward-based clinical staff observed and interviewed during their working day and staff reporting insufficient staff as an adverse event, interviewed retrospectively about the choices they had made at the time. The paper explores some of the adaptive strategies adopted by individuals obliged to work on wards where the staff available were insufficient to provide quality care for all the patients. Under these circumstances, seen as posing a threat to patient safety, a wide range of cognitive and emotional responses were identified. One frequent response was acquiescence to lowered standards of care, sometimes reluctantly and complainingly but also sometimes through an altered perception of the degree of risk involved (cognitive dissonance). Yet another involved withdrawing from the situation completely by going on sick leave or even resigning from the job. Responses that were adaptive and resilient were characterised by refusal to recognise inability to influence the situation and (though often fruitlessly) continuing to explore alternatives. Not only did responses to the same threat at the same time vary between individuals, but the same individual might respond differently to the same threat on a different day. Here the determining factor appeared to be the degree of emotion experienced at that time. Hence, a member of staff, having acquiesced to the situation on many previous occasions, might suddenly decide they "couldn't take it any more". Such an emotional response might prove to be the trigger for giving up and resigning. However, it more frequently generated an opposite reaction, effecting a change in the perception that there was no way of influencing the threat. This led to the more resilient response of exploration of alternative actions with the chance, however faint, of bringing about improvement in an apparently intractable situation.

65337 Nilsen, Aud Solveig

Location: Valberget

**WHAT ARE NEW RISKS TO COME?**

What are new risks to come? Due to more severe weather conditions, it is not enough to adapt and protect infrastructure. We also have to provide vital social functions under severe conditions (Pursiainen 2009, 2018). There is a need for more resilience to be able to withstand challenges (Haimes 2006, 2009, Rødsok 2017). Do we have tools to foresee coming risks? Trough foresight management and setting different frames for forthcoming risk, we can set some future scenarios (Karlsen 2016, Selmer-Andersen, Karlsen 2016 ). Looking upon worst case scenarios can be a way to plan for risks to come. The severity of incidents will be evident when looking for worst cases. We need a general public governance, not looking into the specifics of crisis but be able to combine insight from different angles. Some challenges to look further upon: Weather conditions. Predictions by the UN climate panel, there will be more extreme weather. In Norway this year, we have had drought, severe winds and now more heavy rainfalls than before. In other parts of the world, there has been tornados, with many killed. In England there is lack of ditches- when rain comes it easily overflows the roads and is very vulnerable. National level- rainfall- how to cope? Instead of protecting every infrastructure (that is to expensive), we need to increase robustness. Trough worst case scenarios vulnerability will be revealed. This can lead to different kinds of solutions. Stricter regulations – electricity companies constrains in concession take out less water levels, due to robustness against droughts. Increasing the knowledge about heavy rainfall, lead the water away from vulnerable areas. Alternative ways of working- brainstorming arenas and the ability to try out solutions How do the government cope with extensive floods and how can they increase the ability of an effective risk management? Infrastructure – what effect has severe weather conditions? The decrease in GNP in future will restrain public services. In what respect can this lead to risks? Looking into other countries, we can be able to gain experiences. In UK the National Health Service has been under constrains the later years, (guardian- ) Vital societal functions- what effects will decrease in GNP have The unknown incident. Even if there are new and unfamiliar crises, some features in crisis management are the same (Nilsen 2017). To be prepared for the worst you may enhance the ability to less extensive crises.

65354 Tarigan, Ari

Location: Valberget

## ANALYSIS OF CORRELATIONS BETWEEN PSYCHOLOGICAL FACTORS AND SELF-REPORTED BEHAVIOR OF MOTORCYCLISTS DEPENDING ON SELF-REPORTED USAGE OF DIFFERENT TYPES OF MOTORCYCLE FACILITIES IN MALAYSIA

Coauthors:
Satoshi Fujii, Professor, Kyoto University
Nur Sabahiah Abdul Sukor, Senior Lecturer, Universiti Sains Malaysia (USM)

Segregated road lanes for motorcyclists are one of the practices implemented by the Malaysian authority to decrease the number of road crashes involving motorcycles. In this study, the motorcycle lanes are divided into three types, exclusive, inclusive, and paved shoulder. This study examined the correlations between motorcyclists' psychological factors and their risky riding behaviors (speeding and neglecting to wear helmet), depending on self-reported usage of different types of motorcycle facilities. The psychological factors discussed in this study were: attitude, desire, perceived behavior control, moral obligation, perceived danger, fear of being caught, and perception of others' behaviors towards the risky behaviors. Quantitative analyses, including Structural Equation Modeling, were used as the analytical tools. The results demonstrated the statistically significant relationship of exclusive road lanes' usage on speeding behavior. However, no statistically significant correlation was found for segregated lanes' usage on helmet wearing behavior. Psychological factors were found affecting the motorcyclists' likelihood of performing the risky behaviors. However, these factors influence speeding and helmet wearing behavior differently. The study offers recommendations and theoretical contributions to explain the complex relationships among the uses of segregated lanes, riders' psychological factors, and their risky behaviors.

64946 Skotnes, Ruth Østgaard

Location: Valberget

## RISK COMMUNICATION OF INVISIBLE DANGERS

Invisible dangers are risks that we cannot see, and often neither touch, taste, or smell. Examples are asbestos fibers, radiation from radon, mold spores and other indoor particulate matter, gas leaks, or pathogens like the Legionella bacteria. The distinction between visible and invisible hazards is not always clear. Nevertheless, whether the risk is observable or not can affect how people perceive the risk, and may therefore represent other challenges for risk communicators compared to visible dangers. Invisible dangers can often be characterized as uncertain, complex, and ambiguous risk problems. They may have either sudden, direct consequences (e.g. gas leaks) or delayed, long-term consequences (e.g. radon). When risks are invisible, people need to rely on measurements and expert opinions about the risk. However, invisible dangers are sometimes difficult to measure and different interpretations of the results among experts and lay people may occur. This paper describes a project studying risk communication of invisible dangers through six in-depth case studies in four Norwegian municipalities. Norwegian municipalities have a statutory responsibility to inform and safeguard its citizens against hazards that may pose a risk to people and health. The studied municipalities have experienced challenges with risk communication of invisible dangers, which, in some situations, have led to conflict with stakeholders (i.e. those who are directly affected by the risk) and a media crisis. The main purpose of the project is to help municipalities better understand the differences between visible and invisible dangers and evolve from using reactive crisis communication to more proactive risk communication. A knowledge-based tool for practicing risk communication will be developed during the project. It is important for risk communicators to understand that different groups may have different risk perceptions. Preliminary results suggest that invisible dangers which are assessed as low risks by the municipality may become a crisis if the dangers invoke distress or fear among the stakeholders. Other invisible dangers may in turn cause less fear than the municipality had foreseen in a risk assessment. It is important for the municipalities to establish trust. The municipality needs to take the stakeholders seriously, be honest, and share all information with the stakeholders as soon as possible, preferably before the media is informed. Another key factor is to show the stakeholders that measures aiming at reducing the risk are taken as fast as possible. Involving stakeholders in risk management decision-making processes has also been shown to have a calming effect.

64983 Salmela, Laura

Location: Atlantic Hall

**ANALYZING RISK IN DIGITALIZED BORDER MANAGEMENT SYSTEMS: THE STATE OF PLAY**

Coauthors:
Anna-Mari Heikkilä, Senior Scientist, Technical Research Centre of Finland VTT
Sirra Toivonen, Senior Scientist, Technical Research Centre of Finland VTT

Novel digital infrastructures and other enhanced ICT tools, such as biometrics-enabled e-gates, advanced analytics and predictive modelling transform European border management with increasing intensity. Advanced technologies are claimed to offer border agencies new means to address evolving security threats and growing volumes in trade and travel. However, their development, deployment and application can also contribute to the build-up of new vulnerabilities whose identification may require a change in the approach they are currently being assessed. Present methods of document fraud for example involve high use of advanced technologies, such as 3D printing; and alterations in genuine travel documents or the manufacturing of complete counterfeits may be difficult to detect particularly in automated processes and thus create a serious, unanticipated capability-based system vulnerability. By reviewing current approaches and used analysis methods, this paper discusses the implications for addressing risk in security critical context, where the risks are yet to become known but have most likely already happened.

64901 Glesner, Colin

Location: Atlantic Hall

**SAFETY AND SECURITY: TWO CULTURES?**

Research on safety and security in critical infrastructures is typically split into two separate domains: safety culture and security culture. As a consequence, no stabilized and comparable definitions of safety and security have been developed. Nor is it clear how the two concepts relate to one another, and whether they can coexist, as is often assumed by institutional regulatory and policy bodies (e.g. International Atomic Energy Agency, 2016b) and some authors (Gandhi & Kang, 2013; Reniers, Cremer, & Buytaert, 2011). We may hence ask: how do safety and security cultures interact? which synergies and discrepancies do they entail? and can they be articulated together? To address these questions, this paper provides a first-of-its-kind systematic literature review of the concepts of safety culture and security culture in critical infrastructures. It highlights several lacunae, such as the existence of a certain fuzziness among definitions due to ontological contradictions regarding safety and security cultures conceptions. Besides, it stresses the non-integration of technological and procedural elements as active safety and security cultures' elements. In order to overcome the identified pitfalls, it suggests mutually informed and comparable safety and security cultures definitions that incorporate technological, procedural and human aspects and mobilize vulnerability and resilience approaches. Building on this theoretical endeavor, it proposes an integrated model of safety and security cultures that paves the way for empirical research within critical infrastructures.

65356 Ylönen, Marja

Location: Atlantic Hall

**DECOMMISSIONING OF NUCLEAR POWER INSTALLATIONS AS A CHALLENGE TO RISK GOVERNANCE – CALL FOR A SOCIOTECHNICAL PERSPECTIVE**

A considerable number of nuclear facilities have reached the end of their life cycles in the Europe and worldwide. According to a meeting organized by the International Atomic Energy Agency, the decommissioning should be undertaken as soon as reasonably possible after the shutdown of a plant. However, there are social, political, ethical, legal, financial and technical aspects that affect the decommissioning. This paper focuses on the uncertainties and risks related to the decommissioning at the societal and organizational level and the relationships between the safety, security and safeguards in the decommissioning of a nuclear reactor. Theoretical framework consist of risk governance and sociotechnical perspective and the concept of institutional strength-in-depth (IAEA 2017). The data consists of documents of the International Atomic Energy Agency and interviews with the Finnish authorities, licensees and nuclear safety regulators as regards decommissioning projects. The method is content analysis. The paper sketches the relevant sociotechnical aspects related to governance of decommissioning. In addition, it reflects upon the need for integration of both the sociotechnical perspective and risk management as well as the methodological developments to support the sociotechnical perspective.

65091 Song, Guozheng

Location: Atlantic Hall

## PROBABILISTIC ASSESSMENT OF INTEGRATED SAFETY AND SECURITY RELATED ABNORMAL EVENTS IN CHEMICAL PLANTS

Coauthors:
Faisal Khan, Professor, Memorial University of Newfoundland
Nicola Paltrinieri, Associate Professor, NTNU

Conventional risk assessment of chemical plants considers process accident related causal factors. In the current geopolitical situation, chemical plants have become the target of terrorism attacks, making security concerns as important as safety. To protect the public and environment from undue risks, security related causal factors need to be considered as part of the risk analysis of chemical plants. This work presents an integrated approach to dynamically assess the occurrence probability of abnormal events. The abnormal event is a state of a process plant arrived either due to a process accident or an intentional (terrorist) threat. This approach considers both safety and security related risk factors in a unified framework. A Bayesian network is used to model specific evolution scenarios of process accidents directly initiated from security related factors and the interaction of causal factors. This model enables to dynamically analyse the occurrence probabilities of abnormal events and causal factors given evidence; it could also capture the impacts of interaction among safety and security related causal factors on these occurrence probabilities. The proposed approach is applied to an oil storage tank to demonstrate its applicability and effectiveness. It is observed that the effect of dependency between correlative accidental and security related factors significantly change the occurrence probability of abnormal events in dynamical assessment.

65100 Olausson, Pär M

Location: Sølvberget

## BLACKOUT AHEAD: METHODOLOGICAL CONCERNS IN STUDIES OF NATIONAL CRISIS MANAGEMENT

Coauthors:
Christine Große, PhD student, RCR, Mid-Sweden University
Susanne Wallman-Lundåsen, Asociate Professor, RCR, Mid-Sweden University

Modern societies are increasingly dependent upon electricity. Due to this dependency, societies risk to be unable to maintain certain vital societal functions in the case of power shortage or power outage. To strengthen the ability to perpetuate important public tasks, Sweden has developed a national planning process, called Styrel. This process involves a multi-level-system of actors from public and private actors at different levels in society. The county administrative board (CAB) serves as a coordinator between the municipalities within the county and a multitude of national agencies. Our project has viewed the planning system from the perspective of critical infrastructure protection and investigated the Styrel process as an example of a planning process within the Swedish crisis management system. Studies within the project have revealed several challenges that actors within the planning system encounter. These challenges include information sharing, cooperation, governance networking, and feedback. Information security stands out as one crucial factor in this context. As information regarding the electric supply system often is classified, it is impossible to share information between organizations and in some instances even within the same organization. In some cases, the organization responsible for the planning process to proceed had no access to data or was not able to interpret the data. Limited access to information was one of the methodological challenges that this project had to handle. Empirical data that is necessary for conducting this kind of study is severely limited for researchers due to information security reasons. This paper addresses the methodological challenges that studies of critical infrastructures are likely to encounter and must consider. During the project, the data collection conducted interviews with 47 officials at municipalities, 4 coordinators at the CAB, 15 representatives from power grid companies, and a survey including all coordinators at the 21 CABs. One empirical finding relates to the fact that information pertaining the results of the planning process remains classified. Therefore, actors seldom know whether and to what extent objects that municipalities have prioritized will actually receive electricity in a case of power shortage. In turn, this restriction may prompt practical difficulties to subsequent planning and emergency response. In other words, the different layers of classified information within the planning system may result in a paradoxical outcome where what was created to enable plans may in itself create uncertainty. Further studies of critical infrastructure must enhance mutual understanding among actors and simultaneously respect relevant security issues.

64905 Holtmanns, Silke

Location: Sølvberget

**INFORMATION ACCESS IN DISASTER AREAS**

Coauthors:
Hannu Hietalahti, Mobile Expert, Nokia

When disasters like dust storms, hurricanes or floodings strike, then often electricity fails. People have no longer have access via fixed Internet. Mobile networks in disaster areas are also facing severe issues, base stations are destroyed, run out of power, engines can't be restarted, roads are blocked e.g. in the Harvey flooding in Houston only 3 out 10 base stations were working. There exist public warning system messages, but the information transmitted is often very coarse and contains only basic instructions. On the other hand, people need detailed information where is the next shelter, which roads are free, where to get drinking water etc and mobile connection is the only way to get to that information. In US operators during the Hurricane Ilma waved all costs to enable communication in disaster areas for citizens. In the extreme situation, such as flooding rescue workers are strained to set up basic communications for several days in the disaster area and victims of the disaster have problems accessing reliably information, the communications are limited by none of the domestic operators being able to offer full coverage over the affected area as part of their network is affected by the disaster. Users are bound to their network operators, even in disaster situations. The phones can see other networks, but they are labelled as "Forbidden Networks". In a disaster case, the operators may offer free access to all users in order to provide connectivity for both the victims and the rescue workers. This leads to situations, where the emergency number gets overloaded, because that is the only number people can call via any network. Technically the usage of "any" network can be achieved on certain conditions and network configurations. But today the main hindrance to free access to any network in the affected area is the UE mandate to respect the commercial agreements that make other networks of the home country so called "Forbidden Networks" as they are competitors to the home operator. In this talk, we will outline the details how a set of mobile networks in a geographic area can be set into a disaster mode for a time and how to set it back afterwards. This disaster mode would offer communication to all users that have a phone, independent of subscription and home operator.

64896 Sørensen, Jarle Løwe

Location: Sølvberget

**NORWEGIAN MARITIME CRISIS COLLABORATION EXERCISES: ARE THEY USEFUL?**

Crisis collaboration exercises are perceived as developing and testing cross-sectoral team integration, preparedness efforts, and response. However, the general problem is that crisis collaboration exercises may tend to produce results with limited usefulness in actual crisis work. Sources to date are conflicting as to why the usefulness of collaboration exercises is limited, the cited reasons ranging from a lack of sufficient attention to variation to failing to prioritize the strategic learning aspects of collaborative exercises. Not engaging in sufficient collaboration in times of crisis may affect society's ability to deal with adverse. A lack of collaboration may further result in less resilience, flexibility, and efficiency when it comes to dealing with disaster situations. Crisis collaboration exercises probably may tend to produce results with limited usefulness in actual crisis work because interested organizations tend to focus more on individual priorities and tasks than on collaboration development. Collaboration might also be minimized because exercises have been found to be dominated by mechanical behavior that evades organic practice, which has been found to strengthen emergency handling by emphasizing overlapping and seamlessness. Future research was needed to examine the perceived level of learning in and usefulness of crisis collaboration exercises. Specifically, there was a need to examine the effects of collaboration learning to see whether concentration on these elements during exercises can strengthen collaborative behavior in actual operations. My doctoral study found a moderately strong statistically significant relationship between participation in Norwegian maritime crisis collaboration exercises and perceived levels of learning and usefulness. However, it also discovered a need for greater emphasis on collaboration learning and usefulness.

64904 Kvarnlöf, Linda

Location: Sølvberget

**PERSPECTIVES ON SWEDISH HOUSEHOLD CRISIS PREPAREDNESS: A RESEARCH OVERVIEW**

This paper summarizes research on Swedish household crisis preparedness published between 2013-2018. Drawing on statistics, reports and scientific journals this paper deals with questions like how official actors of crisis management perceive public crisis preparedness, how citizens perceive risks and their willingness to prepare for them and how citizens perceive different crisis communication campaigns. From this research some general trends

are identified and discussed. For example: Why is it that official actors perceive public crisis preparedness as lower than how citizens themselves perceive it? Why is it that younger people are less prone to take preventive actions towards risks in their everyday life compared to the rest of the population and how can we empower younger people to be more crisis prepared? How can we explain the fact that rural households seems to be more prepared than urban households and how can we elaborate this further through future research? Thus, this paper finishes with a discussion of possible future research questions in the field of (Swedish) household crisis preparedness.

65355 Grøtan, Tor Olav

Location: Valberget

**ADDRESSING THE NEW STRAINS OF SOCIETY IN TERMS OF HIDDEN, DYNAMIC AND EMERGENT VULNERABILITIES**

New strains of society emerge at the perimeter of what society is prepared for. The New Strains project addresses hidden, dynamic and emerging threats and vulnerabilities that challenge the premises of traditional risk management methods, with a special focus on ICT as the "infrastructure of infrastructures". Signs of new strains are experienced, perceived or imagined by those who work with societal safety and security on a daily basis. Researchers can help to articulate and systematize, and introduce new opportunities and perspectives to further challenge awareness. Risk analysts and decision makers may then recognize hidden, dynamic and emerging threats and the increasing degree of linkage between systems. Sector-specific framings may be put together into a larger "landscape" with new links and overlaps, propagation effects travelling quickly and unobstructed. Actors' attention is thus drawn to limitations in their own and others' imagination, modeling and responsiveness, and possible saturation effects. The contribution to critical thinking is accomplished through a "take to the limit" approach combining (saturated) threat pictures into conceived threat landscapes potentially ripe for spillover and cascade effects, a stress-testing approach that extends into exploration of resilient performance, a resilience landscape concept that brings back acting subjects as a key aspect of resilient functioning, a "pulse of risk" concept that is sensitive to weak signals and resilient performance, and a discursive approach that serve the purpose of nurturing joint understanding of vulnerabilities, threats and risks, as well as mutual recognition of resilience capabilities across heterogeneous landscapes. These concepts are enabled for practical impact through a "take it to the limit" interview guide, a workshop format for creating and documenting threat landscapes, a sensitization model for incorporating the ubiquitous impact of ICT, a portfolio of stress-test approaches building on previous work but extended with support for exploring rudimentary resilience capabilities, a training by gaming approach that can be used to reveal, explore and develop resilient capabilities supporting a polycentric governance scheme, and "pulse of risk" methods that support the combination of traditional risk management, machine learning, sensitization for re-orienteering through attention to of resilient performance through a "drift" model, or other weak signals.

64899 Stålhane, Tor

Location: Valberget

**AGILITY AND RESILIENCE**

Coauthors:
Stig Ole Johnsen, senior researcher scientist, SINTEF Digital

Key attributes of resilience are dependability, robustness and the ability to handle the unknown. A computing system can be said to be robust if it retains its ability to deliver service in conditions that are beyond its normal domain of operation. The need for resilience stems from the observation that new challenges appear more and more often. This is a challenge when doing safety analysis. Known threats can be handled via standard analysis methods such as FMEA, PHA or HazOp. However, the goal of resilience is to handle the unknown threats. We suggest handling this by learning from past errors and near misses, by applying resilience patterns and by using an incremental and flexible development process – the agile process called Scrum and the IEC 61508 compliant version of Scrum, called SafeScrum. The proposed paper will discuss the following issues: •How can we understand the challenges related to resilience? Based on the Cynefin theory and the probe – sense – respond approach. •How to learn from accidents to support resilience – both those that are handled and those are not handled at all. This part will focus on scenario analysis as enabled by the STEP method. The method will be illustrated by a small network security example. • Resilience patterns – what they are, how they are used, and how they are realized in order to achieve and improve resilience. The realizations will be illustrated with UML patterns that can be used to implement the suggested solutions. •SafeScrum and resilience – how the SafeScrum process can make the realization of resilience more efficient. The main point here is that an agile development process is incremental; it is thus easier to use new knowledge – e.g., knowledge about new threats – to improve the solution during development and

operations. However, resilience does not end with the development and operation of the software. The paper will thus also discuss the following important issues: •Not all resilience responsibility can be left to the computer system alone. Thus, the operators need training in how to discover and handle situations that the computer cannot handle. • Operator experience should be fed back to the computer developers in order to improve further versions of the system. The shorter this feedback loop is the better. The agile community has developed a process for this, called DevOps.

64909 Stene, Lillian Katarina

Location: Valberget

**HOW WILL DIFFERENT RISK PERSPECTIVES WITHIN NAVAL ORGANISATIONS IN THE HIGH NORTH AFFECT RESILIENCE?**

Coauthors:
Stene, Lillian Katarina, - University of Stavanger
Richard Utne, Officer, Norwegian Armed Forces, the Navy

How will different risk perspectives within naval organisations in the High North affect resilience? The Norwegian Ministry of Justice and Public Security emphasized in their 2016-2017 report to the Parliament, that the need for a common understanding of preparedness concepts and knowledge of how cross-institutional organizations use concepts and definitions is a prerequisite for understanding and interaction in preparedness and crisis response measures. The concept of civil preparedness means national measures to maintain or establish effective transportation during times of tension, crisis, and war, in which merchant ships and thus naval cooperation plays a crucial role. How will different risk perspectives within naval organisations in the High North affect resilience? This article discuss how different risk perspectives among actors (organizations) cooperating under crisis and complex emergencies might influence resilience in crisis management situations. The discussion are based on different risk perspectives, and lean on data collected among Norwegian naval organizations holding vital roles and tasks in a necessary coordination and cooperation during a crisis or emergency. Important elements of a functional and resilient crisis management situation presupposes a common understanding of the ruling preparedness concepts, smooth coordination and effective and transparent information and communication processes. Different risk perspectives will influence how preparedness concepts are understood and how coordination and information/ communication processes are conducted. The empirical data identifies that the representative organizations have splayed risk perspectives, within their own sectors and within the sectoral levels of communication. This applies to the investigated organizations as well as the numerous documents, regulations, guidelines, and directives. Further, it applies to the different organizations from the top level, to the educational system and at the operational level. The overall prominent risk perspective seems to be a mix of ideas and concepts of risk. How does this influence resilience? Is it a strength for the overall picture that different risk perspectives are represented, will this cover more aspects and give more flexibility, - or will this hinder the vital coordination and communication necessary for a resilient preparedness planning and an appropriate crisis management?

64911 Thaheem, Muhammad Jamaluddin

Location: Valberget

**RESILIENCE VS EVOLUTION: A BIO-INSPIRED DEBATE**

Coauthors:
Hamza Saeed, Graduate student, National University of Sciences and Technology (NUST), Islamabad, Pakistan
Sehrish Shoukat, Graduate student, National University of Sciences and Technology (NUST), Islamabad, Pakistan

Systems are prone to risk which either diminishes their functionality or causes a total failure. As a risk response strategy, resilient systems demonstrate a state of stability in the face of unprecedented causality, or recovery to equilibrium quickly after the impact of perturbation. This resilience is caused by the inherent rigidity of the system, or its contingent response mechanism, which originates from a prolonged resistance to change. A continued rigidity poses additional stress which undermines the functionality of the system, requiring contingent resource to enhance its functionality. The natural systems have been managing this risk since forever. Such that they either demonstrate rigidity for as long as possible, for example some pre-historic species resisted the change but eventually this rigidity caused their extinction - in other words, failure of risk management due to inappropriate response strategy. Contrary to this, some natural systems experience a shift in their form, shape, functionality and various other features. This shift is called 'evolution' which leads to removal of additional stress and achieves a new level of equilibrium. Evolution of species in response to climate change is a classic example of natural systems experiencing a shift to accommodate changing conditions - in other words, success of risk management due to evolutionary

adaptation. This bio-inspired risk management seems to have worked well for the natural systems in the form of survival and evolution. But manmade systems for managing risk in large complex projects do not demonstrate such a success and therefore they have a lot of catching up to do to learn from their natural counterparts. This study deals with the basic phenomenon of resilience and evolution, and their comparison in the light of risk management framework within complex projects. It provides a bio-inspired guideline for the current risk resilient systems to incorporate stress and adapt to change by evolution.

## PARALLEL SESSIONS III, THURSDAY 8. NOVEMBER

65346 Steen, Riana

Location: Sølvberget

### ON THE APPLICATION OF SAFETY 2 CONCEPT IN A SECURITY CONTEXT

The main purpose of this paper is to draw attention to how the main idea of safety-II concept can be supported by the triplet "value, threat, vulnerability" security risk perspective. This risk perspective could be understood as follow: when a threat actor intentionally exploits vulnerability in an organization and causes harm to value at stake, security risk is realized. In which degree the system in question is vulnerable, depends on its coping capabilities. Both threat and vulnerability are associated with uncertainty. In this work we look closely into these issues: Safety-I, Safety-II and security, and explores how to develop a security risk assessment which is suitable for application in safety-II concept. Whereas the conventional safety management approaches (Safety-I) are based on hindsight knowledge and risk assessments calculating historical data-based probabilities, the concept of safety-II looks for ways to enhance the ability of organisations to be resilient in the sense that they recognise, adapt to and absorb disturbances and surprises. Three determinants that shape safety-II concept in the security perspective are the capacity of organization (human, institutional, physical, and financial) to operate in changing circumstances; strategy formation that promote the willingness to devote resources to security purposes, mainly driven by organization's leader; and organizational culture that encourage people to speak up (respond), think creatively (anticipate), and act as mindful participants (monitor and learn).

64994 Slimani, Nizar

Location: Sølvberget

### COPING WITH UNCERTAINTY: ENERGY SECURITIZATION IN THE U.S. (2004-2014)

This paper generates a greater understanding of America's energy security between 2004 and 2014 by exposing the ways through which energy was securitized during the time period under study. The central argument of this research is that energy security is a contested issue; its meanings are not fixed as they can be constructed either negatively or positively through discourse and practice. Statist energy security constructions are based on a national security ontology, in which the bounded autonomous state seeks to immunize itself from an external "Other", whose threatening presence requires "emergency measures". America's energy crisis was used by the American administration to present a perceived shift in the danger and threat that America faces, thus legitimating particular energy policies and practices. Managing this risk requires stockpiling fossil fuel reserves as well as assuring reliable energy supplies at reasonable prices. As might be expected, this proved to be problematic as it inevitably spurs zero-sum competition, perpetuates geopolitical tension and threatens both human and environmental security. Notwithstanding, the very existence of dissent voices and alternative energy security constructions reveals that security can be thought differently through a networked set of actors working to secure human rights and biosphere integrity. Thus, by illustrating the contested nature of energy security, this research paper highlights the importance of discourse and practice in shaping the value of security and provides the potential for destabilizing its defective ontology and expanding its scope.

65336 Heyerdahl, Anne

Location: Sølvberget

### STANDARDIZATION OF SECURITY RISK ANALYSIS – THE IMPORTANCE OF IDEAS ABOUT RISK AND SECURITY

A new risk analysis approach within the field of security has been developed and standardized by Standards Norway the last 5-10 years. Especially after the publication of the standard, a disagreement arouse, primarily between practitioners, on whether security risks are different from other types of risk, and what this difference consists of. It was also a disagreement on whether or not a different approach to risk is needed for malicious acts.

Although the risk approach to security planning is in many respects not new, especially within the military, it was new to present security threats as 'risks' and security measures as a process of risk management, with a structured risk analysis as a central tool. Although the guideline and later standards recommend a risk analysis approach, this new narrative also stresses the difference between security related risks (understood as harmful, malicious acts) and risks within what is often described as 'safety', which is understood as risks related to unintentional incidents like accidents and natural disasters.
In my analysis of the discourse on the security risk approach, special attention is given to two related, but different concepts; the concepts of 'risk' and 'security'. I argue that the newly developed security risk approach builds on an understanding of security where 'security' is a dual concept –something we either have or do not have. This stands in contrast to a risk approach, especially in an economic sense, where trade-offs and the willingness to accept losses to achieve gains are at the heart of the thinking.

64949 Bongiovanni, Ivano

Location: Sølvberget

## ANTECEDENTS, PRECURSORS, ROOT CAUSES: UNPACKING THE DEEPEST REASONS FOR INFORMATION SECURITY BREACHES

Coauthors:
Denis Fischbacher-Smith, Professor, University of Glasgow
Jordan Schroeder, Managing CISO, Hefestis Ltd.

Despite the mounting attention that information security has attracted in the last two decades, security breaches are mainly addressed by practitioners, and investigated by researchers, with a focus on solutions, and consequences. Less interest has been placed in understanding the deepest reasons why, despite growing investments in defences, cybersecurity breaches still happen. Reports on the growing number of such breaches have flooded the internet. Their authors, mainly vendors and consulting companies, regularly highlight clear-cut statistics on the fact that malicious external attacks are the most common immediate cause. Yet, when it comes to further unpacking the reasons underlying such malicious attacks, these reports provide little answers. The motives for such shortage include, among others, the ever-present reticence by public and private organisations with sharing information about their breaches. This is in striking contrast with the information security unwritten law that 'humans are the weakest link'. Further, there is an untested suspicion that this has contributed to driving information security investments towards technological solutions more than towards addressing the human factor. This presentation aims at providing an overview of the methodologies, frameworks and approaches that could prove fruitful in unpacking the organisational reasons underlying security breaches. To do so, we build a comparison between operational risk management and information security management and draw lessons that the former can provide to the latter. The two conceptual trajectories are similar: an initial focus on the immediate, technical causes of adverse events, was followed by increased efforts in finding technical solutions (crisis prevention); then, the acknowledgement of the role played in the background by human factors (in the form, for example, of organisational precursors) led to investing further resources in containing the effects of the adverse events (resilience). As we argue that a 30-year gap exists between the two domains (with ¬Man-made Disasters constituting the watershed in operational risk management, and the concept of cyber-resilience surfacing only recently), information security needs additional efforts with the acknowledgement phase. Recent attempts, in practice and literature, to apply root cause, chain-of-events and hazard analysis techniques to cybersecurity have demonstrated several limitations: they need detailed systemic information, which makes them at best costly; they fall short with unpacking the managerial causes of breaches (e.g., inadequate supervision); they tend to be subject to the analyst's interpretation; etc. Addressing these limitations, we propose avenues for a new conceptual framework aimed at unpacking the systemic causes of information security breaches.

64900 Taarup-Esbensen, Jacob

Location: Atlantic Hall

## MANAGING COMMUNITY RISK

This paper proposes a model for how extractive companies identify and manage community risks. The primary focus of the industry has traditionally been on the technical challenges of identifying and extracting minerals from the ground. However, there is a growing concern among both researchers and practitioners regarding how to identify and mitigate nontechnical risks. Prior research has shown that uncertainty surrounding different community groups can cause delays, resulting in significant losses or, in some cases, even cause projects to be completely terminated (BSR, 2003; Gifford & Kestler, 2008; Kemp & Owen, 2013; Prno & Slocombe, 2014). This paper defines community risks as the loss of legitimacy (Kostova & Zaheer, 1999; Stevens et al., 2016; Suchmann, 1995) among

three types of community groups affected by a given extractive project (Calvano, 2008; Selmier et al. 2015; Wegner, 1998). Communities of place (CofP) are the geographic locations surrounding corporate facilities or operations and where the project directly impacts communities. Communities of Relations (CofR) are groups affected through their employment, investment or procurement opportunities arising from the project but might not be directly affected by the physical project itself. Communities of interest (CofI) have a vested interest in the industry and in the project and can assert their influence on the legitimacy of the project. Each of these community groups consider different legitimacy demands and evaluate the impact of corporate decisions based on criteria of relevance to each group. Legitimacy is the acceptance of the extractive project by the community regarding its financial, cultural, social, legal, environmental and political impact. CofP, CofR and CofI can influence each other and thereby the sense-making process between communities, thus affecting the acceptance level of the project. It is therefore possible that a low level of legitimacy at the CofR or CofI level can have a significant local influence on acceptance of the CofP, or vice versa. Creating a model focused on legitimacy and community groups addresses the shortcomings witnessed in the Corporate Social Responsibility and Stakeholder Theory literature, which tend to become very complicated in their practical application (Campbell et al., 2012; Gao & Zhang, 2006; Greenwood, 2007). To support the model an empirical case study of mining companies operating in Armenia, a small resource-rich nation experiencing challenges with community risks, is included.

65361 Cedergren, Alexander
Location: Atlantic Hall

**HOW CAN THE PRACTICAL IMPACT FROM MUNICIPAL RISK ASSESSMENTS BE EVALUATED?**

Coauthors:
Henrik Hassel, Associate professor, Division of risk management and societal safety, Lund University

In many countries, there are legal requirements for public actors to conduct risk assessments as a way of reducing risk and vulnerability of their core activities, and strengthening their capacity to prepare for and manage crises. A challenging question is how we know that such risk assessments have a positive impact on societal safety, i.e. if, and to what extent, they give rise to their intended effects. This question is challenging for a number of reasons. Firstly, the feedback from a successful development and implementation of a risk assessment and management process in the public sector is not readily visible, as this would, in principle, eliminate the occurrence of crisis events. Yet, it would be difficult to conclude whether such outcome can be explained by the risk assessment or by other factors. Secondly, due to ethical and practical considerations, it is not possible to compare two groups of municipalities in which one group has implemented arrangements of risk assessment and one has not, which ideally would be the case in order to draw conclusions from their effects. Thirdly, due to the complex environment and the vast number of confounding variables, cause-effect relationships between risk assessment activities and their ensuing practical impact remains elusive. The presentation evolves around this intricate question by drawing on an ongoing research project conducted in the municipality of Malmö, Sweden. This project was initiated two years ago, and during this time we have been involved in developing and implementing a method for risk assessment in the municipality. The method integrates principles from the areas of risk management and continuity management. The risk assessment process is implemented in a decentralised approach, where preparedness planners in each municipal department is responsible for implementing the method. The results draws on several workshops and interviews focusing on how the process and outcomes related to risk assessment can be evaluated, based on the outcomes achieved so far. To date, most attention has been placed on the initial stages of developing and implementing the risk assessment method, and one important conclusion from this work relates to the importance of adopting the method to its intended end-users, as they typically have limited skills and training in the area of risk assessment. The presentation will also include reflections on the work ahead and the upcoming challenges of identifying relevant indicators for evaluating practical impacts from risk assessments.

65084 Lehikoinen, Annukka
Location: Atlantic Hall

**DIOXINS IN BALTIC HERRING AND SALMON: A CROSS-SECTORAL DECISION ANALYSIS FOR OPTIMAL MANAGEMENT OF THE PROBLEM**

Coauthors:
Päivi Haapasaari, Researcher (PhD), Innovative Fisheries Management (IFM), Department of Planning, Aalborg University

Ecosystem-based management requires developing systems analytic approaches capable of integrating social and ecological knowledge. With a multi-disciplinary research team we used a Bayesian influence diagram to integrate different types of knowledge for evaluating alternative strategies to manage the dioxin problem of Baltic salmon

and herring fisheries. The following strategies were evaluated: 1) decreasing dioxin and nutrient loading to the ecosystem, 2) herring and salmon fishing strategies, 3) dietary recommendations, and 4) improved information concerning the origin of fish and the benefits of fish eating. The strategies were aimed to 1) decrease dioxin concentrations in Baltic fish and/or catches, 2) decrease the dioxin exposure of humans caused by eating Baltic salmon and herring, and 3) increase the human consumption of safe-to-eat Baltic fish. The purpose of the modelling was to study the potential utility of cross-sectoral management of the dioxin problem. We wanted to analyze the joint effects and interlinkages of sectoral management decisions and to identify optimal cross-sectoral management strategies by adopting a social-ecological multi-objective perspective. The results show that dioxin management should take into account the predator-prey dynamics between Baltic salmon and herring in the ecosystem, as well as the sum of these fish species in human diet. Reducing dioxin emissions and developing information sharing, products and markets to promote the use of smaller (herring under 17 cm and salmon between 40-80 cm) fish would be the best individual strategies to control the dioxin problem. The usefulness of herring fisheries management to reduce dioxins in fish was found uncertain and, if being the only strategy adopted, even negative. The results also suggest that targeting information and recommendations to the right consumer groups is important. The analysis demonstrates the requirement to understand the effects of management measures in a holistic way: managing only one species or policy domain may not be effective, and may also have unanticipated systemic effects in the ecosystem. This implies, that to control the dioxin problem, collaboration between the public health, environmental and fisheries sectors is needed.

64993 Kloza, Dariusz
Location: Valberget

**SKETCHING THE RELATIONSHIP BETWEEN RISK (MANAGEMENT) AND IMPACT (ASSESSMENT)**

For many decades, the concepts of risk and impact, and, consequently, the processes of their analysis (management, assessment), have been used in domains ranging from insurance, corporate governance, technology development, national security to the protection of natural and human environment. Recently, the protection of privacy and personal data has been built on the concept of risk and subjected to impact assessment. Most notably, in the European Union, the General Data Protection Regulation introduced a legal requirement for data controllers to assess the 'impact of the envisaged processing operations on the protection of personal data' (Article 35). Despite the continued growth of the concepts of risk and impact, and of the processes of their analysis, the relationship between them is rather understudied. These are often confused or their differences, if any, are rather ignored, especially in the domains recently subjected to risk or impact analysis. Hence, the need for an in-depth study of this relationship is essential, not only for the integrity of these processes, so that they deliver as honest and as complete results as possible, but also for legal certainty. Both concepts of risk and impact, and their analysis processes, share a lot of characteristic features, yet, at the same time, they differ significantly. For example, both risk and impact are concerned with the future and the processes of their analysis are similarly structured. Yet, while risk is frequently understood as a possibility of a consequence that is solely negative, impact is often perceived as encompassing also positive outcomes. Risks are usually 'managed', impacts are only 'assessed', i.e. in the process of impact assessment, a step treating future consequences is deliberately not included and hence left outside. Furthermore, there exist many methods to analyse the impacts and the analysis of risk is one of them. The data protection impact assessment process is illustrative of this relationship. The General Data Protection Regulation requires employing two methods: first, a legal analysis of proportionality and necessity, and, second, a risk assessment with a list of 'measures envisaged to address the risks'. I propose an early list of similarities and differences between risk (management) and (impact) assessment with a view to bring more clarity to the relation between these two closely woven approaches to managing the future. I will draw conclusions about the practical added-value of the operationalising them on parallel tracks, using the domain of personal data protection as an example.

64950 Hausken, Kjell
Location: Valberget

**PRINCIPAL AGENT THEORY, GAME THEORY AND THE PRECAUTIONARY PRINCIPLE**

Sandin (1999, p. 889) expresses the precautionary principle (PP) as follows: "If there is (1) a threat, which is (2) uncertain, then (3) some kind of action (4) is mandatory." All PP formulations are insufficiently precise about which players assess the threat and uncertainty, issue the mandate, and perform the action. This article intends to resolve this deficiency by applying principal agent theory which includes games played by principals and agents. Principals assess the uncertainty and issue the mandate, while agents perform the action. We consider four dimensions of the PP (Sandin, 1999), i.e. (1) the threat dimension, (2) the uncertainty dimension, (3) the action dimension, and (4) the command dimension. The threat in dimension 1 may arise from interacting natural, technological, and

human factors. The principals are involved in dimensions 2 and 4, and the agents in dimension 3. A flow diagram is developed. Principals assess whether the threat is uncertain above a threshold. If it is, the principals choose agents which are paid and mandatorily commanded to decrease the uncertainty below the threshold. After the agents' action, the process is repeated through a feedback loop impacting the threat, upon which the principals anew assess the uncertainty against the threshold. The process is repeated until the uncertainty is below the threshold. How principals and agents are interpositioned, and what they assess and do related to the PP, are illustrated graphically and verbally. Moral hazard and adverse selection prevalent in principal agent theory related to the PP are considered, impacting how the uncertainty may be brought below the threshold. The four PP dimensions are characterized to understand the nature of each. Games and game characteristics in the four dimensions are identified. Games may occur between natural, technological, and human factors causing the threat, between multiple principals and external actors, between principals and agents, between multiple agents, and between agents and external actors. A game between two principal and two agents is analyzed. Twelve kinds of uncertainty are presented for the role of principal agent theory in the PP. These involve the natures of the threat, uncertainty, and threshold; the states of nature, technology, knowledge, and information; whether a game is played; who the players are; which game is played; strategy sets; utilities; beliefs; incomplete information; imperfect information; risk attitudes; and bounded rationality. Sandin, P. (1999). Dimensions of the Precautionary Principle. Human and Ecological Risk Assessment: An International Journal, 5(5), 889-907.

64906 Raices Cruz, Ivette

Location: Valberget

**QUANTIFYING IMPRECISION BY BOUNDS ON PROBABILITIES**

There are challenges in quantifying uncertainty in risk analysis. Bayesian analysis quantifies uncertainty by probability. It combines previous information given by prior probability distributions with data to get as results posterior probability distributions. Specifying prior probability distributions may be difficult in practice but important when the choice of prior has an impact on the posterior and posterior expectations. If so, more than one prior can be chosen for the problem at hand and their impact should be evaluated. This is possible by Generalized Bayesian analysis, which can been seen as a merge between Bayesian analysis and sensitivity analysis. Generalized Bayesian analysis quantifies uncertainty using sets of prior probability distributions, which result on sets of posterior probability distributions and bounds on probabilities. This approach allows to quantify imprecision by estimating lower and upper bounds on probabilities. As an example, a Generalized Bayesian analysis is applied on a published meta-analysis on the effect of biomanipulation of freshwater lakes.

65349 Kuikka, Sakari

Location: Valberget

**NEED TO KNOW AND NEED TO DO: VALUE-OF-INFORMATION AND VALUE-OF-CONTROL IN BAYESIAN DECISION ANALYSIS**

The value-of-information (VOI) is a well-known concept in Bayesian decision analysis. It is an estimate of how much one should, as maximum, allocate to improve the knowledge about the system before the management action is carried out. Management action aims to improve the state of the system, whereas the VOI analysis is focused on the improved knowledge. Both aspects are described in one model. The analysis is based on the prior distributions of the knowledge: if this is what I know at the moment, is there a possibility that the decision will be changed, if I increase the amount of knowledge? This is described by probability distributions. Surprisingly, the concept of value-of-control is poorly known, and very seldomly applied in decision analysis. It describes how much more likely it is to achieve the objectives (increase the value of objective function) if some of the probabilistic variables are changed to be decision variables, which increases the controllability of the uncertain system described by the model. It should be in the heart of any management analysis, including the evaluation of how likely it is that a new law leads to desired state of the system. It seems that the VOI and VOC are related: there is no need to know if the controllability of the system is poor.

64894 Bansal, Surbhi

Location: Sølvberget

**RETURN ON INVESTMENT (ROI) FOR EVALUATING SAFETY MEASURES. REVIEW AND DISCUSSION**

Coauthors:
Eirik Bjorheim Abrahamsen, Professor, University of Stavanger
Surbhi Bansal, PhD, University of Stavanger
Jon Tømmerås Selvik, Associate Professor, University of Stavanger

Return on Investment (ROI) is a performance measure that quantifies the expected return of an investment, relative to the amount of money invested. In this paper we discuss the usefulness of this performance measure, with special attention on decision situations related to safety. We conclude that ROI should be used with caution, as focusing solely on the expected values does not in general give sufficient weight to the uncertainties. To improve the basis for prioritizing safety measures by using ROI, we recommend including assessments of ROI, given an accidental event. We also highlight the importance of reflecting the strength of knowledge on which the ROI values are based.

64907 Sørskår, Leif Inge Kjærvoll

Location: Sølvberget

**A SYSTEMS APPROACH TO ECONOMIC EVALUATION OF NEW HEALTH TECHNOLOGY IN HELICOPTER EMERGENCY MEDICAL SERVICES**

Coauthors:
Eirik Bjorheim Abrahamsen, Professor, University of Stavanger
Håkon Bjorheim Abrahamsen, Associate Professor II, University of Stavanger

It is common to apply economic evaluation methods when evaluating new technology in helicopter emergency medical services (HEMS). The results of such methods may give fruitful insight, but, as HEMS is a complex sociotechnical system, it is challenging to perform in practice. A change in one part of the system affects the whole system, and unintended economic consequences might emerge if there is a lack of consideration of system factors and their interactions. Such consequences may eventually lead to overall less quality and safety for the patients. As a contribution to address this issue, we suggest a conceptual method using a systems model for evaluating the system factors as part of the economic evaluation.

65101 Milazzo, Maria Francesca

Location: Sølvberget

**SUPPORTING DECISION-MAKING IN THE CHEMICAL INDUSTRY BY A DYNAMIC INTERPRETATION OF THE ALARP PRINCIPLE**

Coauthors:
Eirik Bjorheim Abrahamsen, Professor, University of Stavanger
Håkon Bjorheim Abrahamsen, Associate Professor II, University of Stavanger
Jon Tømmerås Selvik, Associate Professor, University of Stavanger

The selection of safety measures to reduce the risk level and environmental impacts in major-hazard industries is commonly supported by the ALARP (As Low As Reasonably Practicable) principle reinforced by cost-benefit analyses and the grossly disproportionate criterion. Nevertheless, decision-makers should also pay attention to the whole context and account for the level of uncertainty in and knowledge of the chemical process, the use of best available technologies, the potential of major losses due to the release of hazardous materials, and many other elements. Recently, a dynamic interpretation of the ALARP principle has been proposed, which involves considering decisions oscillating between two borderlines, where reference is made, in one case, to expected values and, in the other, to the precautionary principle, and deciding which is more appropriate. This contribution will provide some examples from the chemical industry, showing the appropriateness of a dynamic interpretation of the ALARP principle.

64910 Langdalen, Henrik

Location: Sølvberget

## SOCIO-ECONOMIC PROFITABILITY OF SECURITY MEASURES IS MORE THAN EXPECTED BENEFITS MINUS EXPECTED COSTS

Coauthors:
Eirik Bjorheim Abrahamsen, Professor, University of Stavanger
Sissel Haugdal Jore, Associate professor, University of Stavanger
Jon Tømmerås Selvik, Associate professor, University of Stavanger

In this paper, we will discuss the use of socio-economic profitability as a fundamental prerequisite for investments in security measures. Among economists, profitability is often interpreted as the expected benefits minus expected costs. A reference to costs and benefits is important prior to investments in security measures, but socio-economic profitability, interpreted as expected benefits minus expected costs, is not in general appropriate as a fundamental prerequisite for investments in security measures. The cost-benefit approach, which is justified by the portfolio theory, can provide useful information in the decision, but the weight on uncertainty has to be placed outside the frame of the expected net present value calculations. We will discuss five challenges with socio-economic profitability as a fundamental prerequisite for investments in security measures, when profitability is interpreted as expected benefits minus expected costs. (1) The portfolio theory restricts our focus to production values, requiring all attributes to be transformed into one comparable unit. (2) Expected values may be poor predictions of the real consequences and are conditional on the analyst's background knowledge, and if there is a potential for big losses it is inappropriate to ignore the unsystematic risk. (3) The likelihood of an attack is difficult to assign, which weakens the ability to select and prioritize security measures based on their cost-benefit calculated profitability. (4) In security contexts, investments and risk management are subject to corporate procedures, which may affect the value of a portfolio. (5) Key stakeholders may have different preferences of the values to be protected and what measures to implement. Implementation of security measures includes discussions of societal, economic, ethical, symbolic and political nature, which cannot be replaced by a one-dimensional mathematical equation. Social discourse, communication with stakeholders, cautionary/precautionary principles, robustness, resilience, etc., have a role to play when investing in security. The purpose of the paper is to point out that the profitability of a security measure must be assessed in a broader context than is the case in a traditional cost-benefit analysis.

64939 Arvidsson, Björn

Location: Valberget

## CRITICAL INFRASTRUCTURES, GISCIENCE AND RISK GOVERNANCE: A LITERATURE REVIEW OF SYNERGISTIC RESEARCH OPPORTUNITIES

Coauthors:
Nicklas Guldåker, University lecturer, Department of Human Geography
Jonas Johansson, Associate Professor, Lund University

Critical infrastructures today are highly interdependent and increasingly important in providing services to the rest of the society. At the same time, each type of infrastructure requires specialised knowledge to design and manage. Therefore, to get a better understanding of how the infrastructures and the effect of interdependencies work as a whole, it is necessary to have an interdisciplinary approach to Critical Infrastructure Protection (CIP). We have identified two research fields with high potential for synergies with the CIP field, namely Geographical Information Science (GIScience) and Risk Governance (RG). GIScience is a mature research field which encompasses, for example, spatial data collection, spatial statistics, theories of spatial data and data structures. RG is a relatively young field which focuses on how several stakeholders can manage shared risks, for example, the effect of interdependencies, together. Other researchers have also expressed a potential for synergies in combining these areas. This study reviews scientific literature that integrates either GIScience or RG in a CIP context, or preferably all three fields simultaneously. The review was carried out based on a scoping study methodology. Preliminary results from the study show that GIScience is used to perform a variety of tasks within a CIP-context such as data collection, information management, both supporting and performing modelling and simulation, hazard mapping, vulnerability mapping or visualisation of data. Most GIScience-related articles are closer related to risk management or disaster risk reduction, and only a few combine it also slightly with an RG perspective. An interesting finding is that quite a few articles consider national geographical information databases as critical infrastructures by themselves. Another observation is that GIS is often used in combination with network theory, either to perform analysis directly in GIS software or as a pre- or post-processor for network analysis. The RG and CIP articles seem to focus on the need for a shift from risk management to risk governance within CIP. However, they remain limited to a conceptual level. We found several useful examples of combining GIScience or RG with CIP in the gathered

material, although we did not find any articles that integrated all three fields as we see it. We conclude that there seem to be significant benefits and research opportunities in more closely and coherently integrating GIScience and RG approaches and methods to address research problems within the CIP-field.

64944 Rydén Sonesson, Tove

Location: Valberget

## MODELLING AND SIMULATION OF CRITICAL INFRASTRUCTURES FOR SUPPORTING RISK GOVERNANCE: AN EXPLORATORY LITERATURE REVIEW

Coauthors:
Alexander Cedergren, Assistant professor, Division of risk management and societal safety, Lund University
Jonas Johansson, Associate Professor, Lund University

Over the past couple of decades, increased interdependencies between and institutional defragmentation of, our Critical Infrastructures (CIs) have created a setting were traditional risk management might no longer suffice. In particular, analysis and management of risks have evolved from being a predominantly intra-organisational task towards a process that also requires inter-organisational coordination. Consequently, new approaches to analyse and manage risks are needed to deal with the complexity originating from these processes. We hypothesise that modelling and simulations studies could be one such potential instrument. The purpose of this study is to explore if and how modelling and simulation studies of multiple interdependent CIs can be used to support risk governance needs and activities in the specified context. A structured scoping study analysis was conducted to identify promising examples, challenges and research gaps in the existing scientific literature. In line with the purpose of the study, we searched for three types of papers, those having: (1) a modelling and simulation approach, (2) a governance and management approach, and (3) an approach combining the two. Only papers related to the CI topic were selected. Apart from summarising a large number of models, methods and frameworks, three preliminary areas of future research on how existing modelling frameworks can evolve to better aid risk governance activities were identified and will be discussed during the presentation. Firstly, a minimal number of papers focus on or include specific techniques for appropriate data collection and dissemination of results. Secondly, many papers lack broader contextual considerations or a decision-making perspective, e.g. few methodologies offer a structured way of describing and delineating system boundaries and assumptions, which is vital for making an informed decision. Lastly, the different frameworks, models and methods presented in the studied papers display rather diverse conceptual focal points (e.g. risk, resilience, disruption, or criticality), but similar overall purposes (i.e. reducing negative societal consequences). We conclude that there are significant research opportunities when utilising modelling and simulation approaches for supporting risk governance in the context of interdependent critical infrastructures, which we will address in future research.

65350 Grottenberg, Lars Ole

Location: Valberget

## TOWARDS AN ACTIVE FLU MANAGEMENT BASED ON REAL-TIME SPATIOTEMPORAL INFORMATION FROM SOCIETAL SYSTEMS

The societal ability to respond to major outbreaks is heavily dependent on successful interactions between a wide series of participants, components, and processes. Urban societies present a series of complex and dynamic systems, with many interacting subsystems and processes that change fluidly depending on time of day, societal trends, and a host of other influencing factors. Efficient preventive measures and management procedures is reliant on understanding the contextual state of critical societal functions, as spread of influenza within a population is strongly driven by human social patterns at the individual and societal levels. Acquiring and maintaining a situational awareness of ongoing and emerging trends is fundamental for all stages of flu management process. It is our belief that this awareness can be achieved through surveillance of societal-scale processes, by monitoring key indicators derived from transport systems, utilities, goods distribution networks and communication traffic. It is expected that changes in use patterns from these key societal systems habits corresponds to swings in daily and weekly flu activity and that these differences can be measured through multivariate geostatistical analysis of these data streams. Conceptually one could be able to monitor changes in human behaviour and activity in near real-time by using indicators derived from outside the clinical health services. Maintaining a data-driven contextual understanding of societal trends offers a powerful set of tools that can be incorporated into preventive and responsive epidemic management processes.

65089 Rød, Bjarte

Location: Valberget

## CRITICAL INFRASTRUCTURES - HOW RESILIENT ARE THEY?

Coauthors:
Jonas Johansson, Associate Professor, Lund University

A highly interconnected society are reliant on critical infrastructures (CI) that are providing essential services, especially those constituting so called back-bone infrastructures, such as power, electronic communication, and water supply. Cascading failures, because of interdependencies between critical infrastructures, mean that indirect consequences of natural and man-made disasters may be more severe than expected. Protecting infrastructures against all types of threats and hazards is difficult, technological impossible, or prohibitively expensive. Hence, there has been a move from protection of critical infrastructure to resilience of critical infrastructure during the last decade. Lately, numerous methodologies, approaches and frameworks have been develop to analyse and assess resilience of CIs. However, there exists few studies with applications on "real-life" infrastructures, and there seems to be no clear agreement on how resilient CIs should or should not be. In this scoping study, first, we examine scientific studies that are aiming at assessing how resilient critical infrastructures are and if the results point in the same direction or if they differ. Secondly, we wish to investigate if we can find evidence towards answering how interdependent different infrastructures are and how their resilience affects each other due to these interdependencies. A systematic literature search is done, limited to technical infrastructures and studies using (1) empirical data of CIs, (2) modelling and simulation of CIs, and, (3) index methods that has been applied to Cis. A flora of different definitions and metrics on resilience exists. Hence, we take a pragmatic approach of identifying studies that are addressing both the vulnerability of the system and the recovery of the system towards internal and external threats and hazards. Initial findings indicate that generally few studies focus on both vulnerability/ robustness and rapidity/recovery simultaneously. Modelling and simulation studies often focus on vulnerability, while empirical studies tends to focus on recovery. Further, there are few studies that actually address resilience building measures per say, rather that the derived results are targeted and valid for such work. It is hence our conclusion that more research is needed where suggested methods and approaches are applied to real-life infrastructures in order to draw relevant conclusions with respect to their level of resilience and the effect of interdependencies.

65092 Kiste, Andreas

Location: Atlantic Hall

## RISK PERCEPTION AND HARMONIZED RAILWAY TUNNEL SAFETY; THE FEAR OF (NOT) INTERFERING

Coauthors:
Magnus Bjelkerud, Risk & Safety Advisor, Self-Employed

Europe is changing towards a harmonized rail sector. The goal of full interoperability between states might become true. In order to fully achieve the objectives, infrastructure, trains, and operations must comply to the same standards. In addition, will a harmonized safety level ensure less specific applications, and a robust customer service enhancing the total transport safety. In Norway, there are two opposite stakeholders within railway tunnel safety. The probability enforcers (PE), and the consequence minimizers(CM). The PE desires to design both a safe and a robust tunnel. A design that ensures that passengers are able to self evacuate if a train is caught on fire inside a tunnel. The CMs are firm on the notion that passengers needs help to evacuate from a burning train, and that this help must be assisted by systems within the tunnel (systems like fire ventilation and fire water pipes) and the fire- and rescue services. August 2018, Bergen. Bane NOR is designing safety concept for new Ulriken Railway tunnel. According to media, local fire departments fear for the safety of passengers, because Bane NOR is designing the tunnel without fire ventilation and fire water piping. National Rail Authority (NRA) is criticizing Bane NOR for reducing the safety level in new railway tunnels, compared to the level of exciting, fairly new railway tunnels. Bane NOR is arguing for compliance to standards for railway tunnel safety in Europe (TSI SRT), that aims to ensure a harmonized safety level for rail systems across Europe, ensuring roles and responsibilities across organizations. All stakeholders argue; "We know the "right" safety measures for railway tunnels". Throughout Europe, this is an ongoing discussion between the stakeholders. This presentation will explore the climate for this discussion, and use data, human factors, risk psychology and statistics to argue what mitigating actions are needed to design safe and robust enough railway tunnels for the future. Further, the authors discuss and argue why the stakeholders perceive risk of fire in tunnels different, and how risk communication should be planned in order to achieve a harmonized safety level in Norway.

64951 Oramah, Chinwe, Philomina

Location: Atlantic Hall

**THE IMPACT OF CLIMATE SECURITY ON CLIMATE CHANGE ADAPTATION: AN ANALYSIS OF LOCAL RISK GOVERNANCE IN NIGERIA.**

Climate security has prompted discussion about adaptation leading to emphasis on disaster risk reduction, sustainable development and the resilience of socio-ecological system. In Nigeria, the security consequences of climate change are often manifested at the local level. However, the existing national adaptation strategies have attended limitedly to the role of local institutions and communities in designing and implementing adaptation. Local institutions play critical roles in adaptation practices, but these institutions often times lack basic resources and services required for effective adaptation. Given that resources required for adaptation by these local communities expand beyond local boundaries, institutional arrangement and participatory management becomes more relevant. Hence, climate security is seen as a positive development for adaptation in terms of awareness, support, collaboration, resource allocation and policy prioritization. Since external intervention in form of collaboration and financial support will be critical to strengthen local adaptation practices, there is therefore need to encourage multi-level governance to manage the range of climate related risks facing these communities. This implies that there is need for government actors, non-governmental actors and local based actors to collaborate for effective risk governance practice. Despite the scientific conceptual underpinning for climate security and its relationship with adaptation, the application of the concept within the field of practice remains contested. This paper will address three themes that illustrate the implication of climate security for adaptation in Nigeria. Firstly, the paper will provides empirical contribution to understanding how climate security politics taking place at the international and national level affects adaptation practices at the local level. Secondly, we argue that concern for adaptation should be integrated into existing societal risks and vulnerabilities related to sustainable development. Thirdly, the paper will argue that, the extent to which adaptation support is implemented in practice is dependent on existing risk governance structures.

65104 Keränen, Jaana

Location: Atlantic Hall

**TOOLS AND METHODS OF CLIMATE RISK ASSESSMENT FOR REGIONAL DECISION MAKERS**

Climate change has a significant impact on the Nordic region. Even though Finland will probably not be affected by major floods or recurrent long-term heatwaves, there are still many climate change impacts which need to be carefully taken into account. The importance of climate change adaptation has been identified in Finland, also on a regional level. As the main stakeholders for responding to climate change, the authorities are tasked with developing adaptation strategies. At the regional level, the municipalities themselves have the main role for adapting to climate change through their broad mandates in land-use planning and building regulations, for instance. Several risk assessment methods have been developed to support decision-making in relation to climate change over the past decade. A systematic literature review, focusing on papers that described climate risks that were considered important in a Finnish context, allowed us to assess and clarify the latest approaches and methods. Additionally, we concentrated on the sectors and industries that are important to the Finnish economy and are supposed to be the most affected by climate change. This paper presents a review of suitable methods for regional decision-making related to climate change adaptation and climate risk management.

65348 Ogunbode, Charles

Location: Atlantic Hall

**THE RESILIENCE PARADOX: COPING ATTENUATES THE LINK BETWEEN FLOODING EXPERIENCES AND INTENTIONS TO MITIGATE CLIMATE CHANGE**

Coauthors:
Gisela Böhm, Professor, University of Bergen

Climate change is expected to increase the frequency, intensity and unpredictability of extreme weather across the globe and these events are likely to have significant mental health implications. The mental health literature broadly characterises negative emotional reactions to extreme weather as undesirable impacts on wellbeing. Yet, research suggests that negative emotional responses to risk experiences are an important motivation for action. This presentation addresses the intersection of mental health and functional perspectives on negative emotions, with a specific focus on the potential that reduced negative emotional responses to extreme weather may also translate to diminished motivation to undertake climate change mitigation actions – which we term the 'resilience paradox'. Using survey data gathered in the aftermath of severe flooding across the UK in winter 2013/2014, we present new evidence indicating that self-appraised coping ability moderates the link between flooding experience and negative

emotions and thereby attenuates the indirect link between flooding experience and climate change mitigation intentions. We conclude that support for communities exposed to extreme weather impacts must extend beyond building emotional, physical and infrastructural resilience to include acknowledgement of the involvement of climate change and communication of the need for action to combat future climate risks.