



Research highlights in **safety & security**



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Innovations for safe and secure world

VTT Technical Research Centre of Finland is a globally networked multidisciplinary applied research organisation. Our goal is to provide high-end multi-technology solutions and innovation services that enhance our customers' competitiveness, thereby supporting the sustainable development of society, employment, and wellbeing.

The main driver behind our research at VTT is to promote innovative solutions and new businesses by foreseeing the future needs of our customers already at the research stage, and by combining our multidisciplinary expertise with the know-how of our partners at key stages of their innovation process. Global networking and basic research with partner universities are also important features of our service.

Safety and security research at VTT dates back to our founding in 1942. We have extensive expertise in all relevant fields of science and research, from general safety issues to security-specific projects. Our main focus is the safety and security of infrastructure, services and people in society and the security and continuity of business and industry.

Trends in safety and security

Our world has changed. We have moved from safe, protected stand-alone homes to interconnected, open and global living environments. Globalisation has enabled the beneficial free movement of many things, but it has also brought risks and threats. Emerging technologies – and their potential misuse – also present new threats. These changes

have transformed the basic nature of safety and security, from protection and control of losses to holistic cultivation of operations and resilient facilities and structures.

Many factors contribute to creating and improving safety and security – including their perception. Feelings of safety and security are rooted in a sense of stability, peace and well-being which are derived, in turn, from the presence of well-functioning systems running behind the scenes. The safety and security needs of society are also in a state of constant change, and safety science has been evolving accordingly, from reactively studying why things go wrong to proactively identifying what makes things go right.

Threats cannot be completely eliminated or predicted with accuracy. We have to live with risk. Achieving acceptable levels of safety and security in modern society requires a new approach to research and development. New ways of thinking, a new safety culture and novel concepts of safety management are needed.

In assuring safety, we can benefit from available new technology and adjust our operations accordingly. We can be prepared for hazards by developing early warning systems, robust and adaptable operating systems, and reliable contingency planning. These resilient systems will ensure public safety, secure our living environments and even provide emergency help when needed. In parallel with technical solutions, human practices and procedures also need to be developed, accepted and adopted in society.

Intentional damages



Unintentional damages

Research assuring safety and security

VTT's safety and security research covers a broad range of technologies with a broad scope of applications. The basic principle of our work is impact optimisation. Appropriate technologies and competencies are combined to develop safety and security solutions for specific applications and problems. We carry out research and development together with other stakeholders including end users, technology providers and authorities.

Urban security and the role of information technology in living environments are emerging areas of interest. Present societies are vulnerable to natural and industrial disasters and organised crime in addition to everyday accidents and incidental crime. Urbanised societies are heavily dependent on technical infrastructures such as energy, communication and water systems, transportation and logistics, and public services.

Health and care services are vital to public welfare and social security. Ageing populations are placing a growing burden on health services and setting new effectiveness requirements for public and private service providers. VTT research in this area addresses the ability of societies to sustain essential health and care services and to secure people's living and health needs and basic values in both normal and extraordinary situations.

Risk management and disaster resilience are of critical importance to business and industry. There is a need for greater emphasis on both direct and indirect safety and security threats to ensure the continuity of operations. During recent years, research has shifted from failures and accidents to more holistic risk management approaches addressing overall risks to business.

Emergency preparedness and response capabilities are needed. VTT's technical

research aims at supporting the mitigation of consequences and their impact in all kinds of emergencies, from man-made accidents to natural disasters. Interoperable systems improve information sharing, communication, and the efficiency of rescue and reconstruction measures. Simulation platforms and advanced training tools enable better preparedness and understanding of various emergency situations.

Critical infrastructure protection and cyber security are aimed at eliminating disturbances and interference in critical infrastructures. In order to protect the well-being of citizens it is crucial to develop methods and technical solutions to reduce the vulnerability of society. The majority of safety and security work at VTT is carried out as an integral part of developing utility networks and their operating processes.

Industrial safety and occupational safety remain a worldwide challenge in many industrial sectors. Healthy and safe working conditions are closely associated with productivity and performance, with high quality work going hand in hand with a high quality working environment. Modern companies view safety as a property of an organisation and safety management as the practice of managing the sociotechnical systems producing safety.

Safety and security are also vital considerations in complex multimodal supply chains and future transport systems. Long-term, system-level foresight provides means for expanding the scope of transport safety and security research beyond current mobility patterns, transport vehicles and infrastructures.

Novel solutions and policies need to be developed and assessed to enable new prospects for supply chain security management. Added to this, better road safety is needed to reduce the enormous socio-economic losses resulting from inadequate traffic safety.

In addition to human losses, accidents, injuries and illnesses have an enormous eco-

nomical impact through decreased productivity. Strategic decision making involves optimizing decisions across strategic, financial and risky investments. Economic analyses are needed to ensure that scarce resources are allocated rationally with respect to available investment and asset options. In addition to this, decision makers have to weigh up other aspects, such as safety and environmental impacts and business dynamics.

Challenges of safety and security research

Safety and security should be an integral aspect of all research related to technological development, changing business environments or societal needs. Technological solutions must be based on the needs of the user, and the need for safety and security products and services will continue to be an important research driver in the future. More commitment to their development is needed from policy makers and regulators in order to encourage and support providers.

Seamless interaction between users and providers is needed to define, adapt and optimize the use of technologies to address changing threats and challenges. Service providers represent a broad variety of actors and competencies. End users are diverse and their operations and tasks have become more and more complex.

For future development, better understanding of user needs is crucial. Close cooperation with users and customers is needed to support development and innovation processes. Technology alone cannot assure security, but security without the support of technology is not possible.

The global market for security products and services continues to grow. The market has utilised solutions from the defence sector, adapting military technologies to the regulations, processes and specifications of the civil market. In order to support the security market, multi-use technologies have been emphasised.

However, because of new threats and needs, better understanding of the principles governing the security market is needed. As this market is still highly diverse, dispersed and fragmented, research plays an important role in solution development.

The innovation potential in the safety and security sector is still high. In the future, the sector will increasingly utilize the evolving innovation ecosystem, which covers all stages of the innovation chain, and international competence networks and centres of excellence developed in the EU will further strengthen safety and security knowledge and expertise.

New technologies, such as micro- and nanotechnology, surveillance technology and information technology offer new capabilities to improve safety and security. These technological and industrial innovations will enable better assurance of the vital functions of society, while technology and systems integration and interoperability will promote the implementation and application of innovative solutions.

Despite new technologies and practices, not all threats to our safety and security can be eliminated. We must live with the residual risk and be as prepared as possible. This required resilience implies that adequate early warning

systems, robust and adaptable operating systems, and good contingency plans have to be developed.

VTT's foundation is in our technologies and research and innovation services that enhance the international competitiveness of companies, society and other customers. We have strong expertise in Finnish research and industry. The next challenge is to harness and network this competence efficiently and effectively in the international context.

This publication

This publication presents a collection of extended abstracts of recent and current safety and security research projects at VTT. While the target readership is the international research community, the content is of value also to industry and other stakeholders. Only VTT's public research is covered, i.e. proprietary contract projects for industry and policy makers are not specifically discussed here.

The collection provides a comprehensive overview of VTT's current safety and security research and the range of competencies available for serving our customers and for working together with researchers from other organisations.

November 2013



Veikko Rouhiainen,
Research Professor



Matti Kokkala,
Vice President

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Urban security
and smart city

Foresight and identification of security threats



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Safety used to be all about protecting the individual from threats and dangers in their immediate environment. Today, the concept has evolved to encompass whole workplaces and entire organisations. Throughout these changes the responsibility for safety and security has shifted from the individual to the organisation and business networks, and, in society, to local, regional, national and international authorities and organisations. However, global changes are beyond the control of these bodies. Organisations must therefore be prepared for new emerging threats and build resilience against them.

Foresight to enhance the resilience of organisations

In the globalised 21st century, protectionist approaches are no longer enough; global changes and threats cannot be avoided or prevented. The only feasible strategy for survival – both for individuals and organisations – is to build resilience and to be prepared and agile.

Foresight provides systematic analysis of future changes and threats

Foresight methods offer systematic ways to scrutinize future developments and changes [1, 2]. PESTE analysis, for example, examines the future from Political, Economic, Social, Technological and Environmental perspectives. By doing so, strong drivers are identified and their role and impact on the development of, for example, safety and security, can be

analysed. Weak signals, on the other hand, serve as early indicators of new developments or surprising upcoming changes in the environment.

In the EU FP7 Security SECUR-ED project [3] an early warning system for mass transport was developed. First, a generic model of a threat scenario was created (Figure 1). Next, a range of potential scenarios was identified based on different damage mechanisms. Possible weak signals and their sources were then explored in each phase of the different scenarios, and an early warning system was then built based on these weak signals.

Possibilities and benefits of foresight in safety and security

In safety and security, clearly the most effective way of managing risks and minimizing damage is to prevent incidents from happening in the first place. But how can this be done when traditional hazard elimination approaches no longer work?

In the dynamic global environment, threats and risks continuously change and emerge. Static risk assessment alone cannot guarantee safety and security – more forward-looking approaches are needed. Foresight helps to perceive and analyse possible futures: future threats can be envisioned and resilience developed to overcome emerging dangers. To build resilience new capabilities and technologies may be needed, for which VTT's broad technological competence provides strong support.

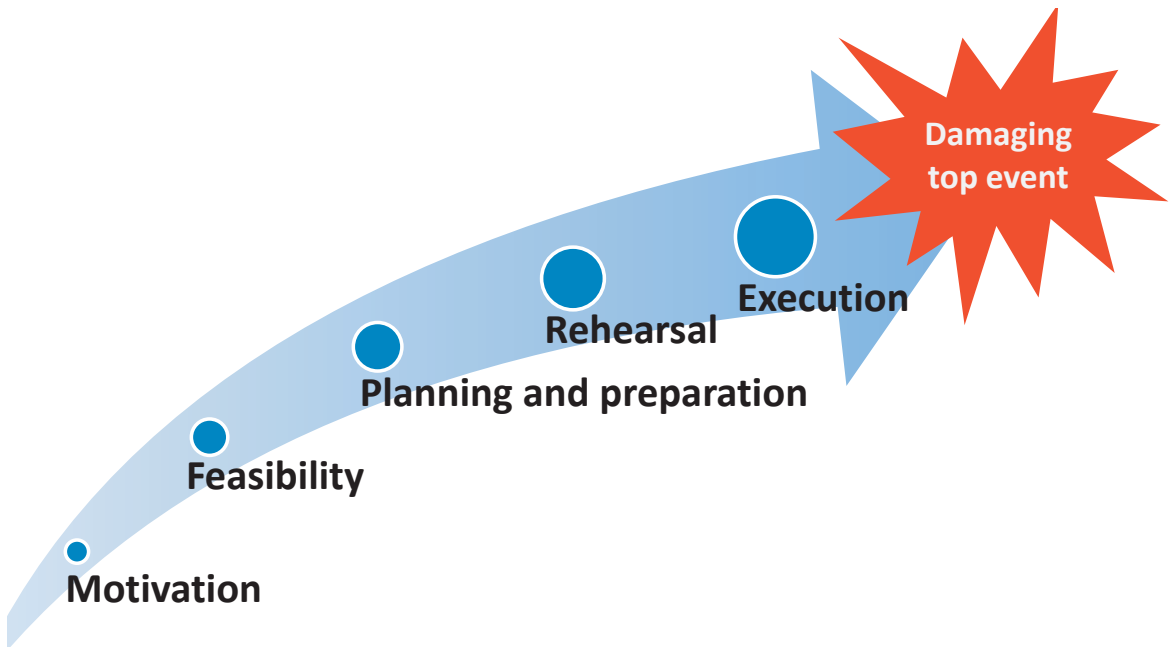


Figure 1. The phases of a potential large-scale attack scenario.

Assessing future impacts and risks is highly challenging and entails two-fold uncertainties: the future developments themselves and the risks inherent in them. However, foresight helps us to understand emerging phenomena, thereby enabling us to build appropriate resilience and preparedness.

Acknowledgements

The SECUR-ED project was funded by the European Commission. Special thanks to EDISOFT for their active contribution and expertise in developing the early warning system.

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Safe living environments – from residents’ experiences to safety and security solutions



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The Internal Security Programme of the Finnish Ministry of the Interior identifies safety and security as key factors affecting people’s well-being and movement and behaviour in public places. A high-quality living environment provides a variety of services and entertainment choices as well as the possibility to use and enjoy them without fear. In the AATU research project, the views and experiences of residents concerning the liveability and safety of their living environment were identified and developed as safety and security business solutions. The key factors enhancing and sustaining safety identified by the residents are shown in Figure 1.

Creating safe living environments takes cooperation

Developing business concepts into practical solutions often requires multi-player cooperation. The mix of different functions and responsibilities involved in creating safe and secure living environments is similarly shared across local and regional authorities. A positive consequence of this multi-actor cooperation is that safety and security issues are managed from a variety of perspectives. In addition to public authorities, the safety and security of living environments is continuously developed and maintained by many representatives of

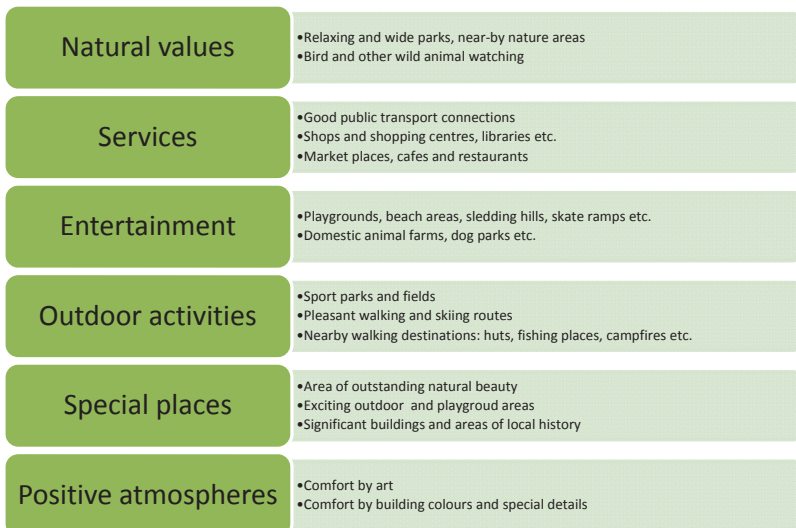


Figure 1. What makes a good living environment? A summary of resident survey responses.



Figure 2. The development of safety and security suggestions into business solutions.

the private and third sector as well as active-minded citizens.

Residents' views and experiences examined

The study utilised two safety surveys conducted among residents by the City of Helsinki. Expert interviews and safety walks carried out in the survey areas were also exploited to obtain further information on living environment safety and security issues. The collected information was utilised in brainstorming sessions (Figure 2) organised for expert groups on topics such as safety coordination, property maintenance, infrastructure planning, and commerce, with the aim of discussing and developing the themes further.

Discussion

The study outlined nine business concepts thought to have potential for improving living safety and enabling business continuity. Some of the concepts underlined better communication and shared safety planning, for instance, in traffic arrangements. Other concepts focussed on maintenance of the environment and good lighting solutions. Concepts for supporting and activating services for incapacitated persons were also developed. Some concepts aimed at strengthening sense of community and feel-

ing of safety by organizing neighbourhood events and activities. Safer living environments were found to consist of a broad mix of different elements and functions.

Acknowledgements

The study was funded by Tekes – the Finnish Funding Agency for Technology and Innovation. Research partners in the AATU project included VTT, the University of Helsinki, and Aalto-University. The Cities of Helsinki, Espoo and Vantaa provided interesting case study areas, and the project partners Culminatum Innovation Oy Ltd, Innojok Oy, Ramboll Finland Oy and Skanska Talonrakennus Oy are gratefully acknowledged for their valuable contributions.

Related publications

Keränen, J., Vaattovaara, M., Kortteinen, M., Ratvio, R., Koski, H. & Rantala, T. 2013. Safe living environments. Structural backgrounds, residents' experiences and everyday safety solutions. (In Finnish.) VTT Technology 88. VTT, Espoo. 251 p. www.vtt.fi/inf/pdf/technology/2013/T88.pdf.

Ministry of the Interior. 2008. Safety first. Internal Security Programme. Publications of the Ministry of the Interior 25/2008, Helsinki. ISBN 978-952-491-365-2 (pdf). 99 p.

Urban flood alarm system – SmartAlarm



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More than half of the world’s natural disasters are floods, affecting millions of people each year. More than 3 billion people have been affected by major floods over the last century, including almost 7 million deaths and 441 billion USD in damages (www.em-dat.net).

VTT is currently conducting extensive research on urban flooding and related ICT solutions. Key challenges addressed include minimizing damage to people, property and businesses caused by heavy rain flooding; predicting floods and alerting authorities and the public; locating potential flood sites; and determining who should be alerted and informed first and what this information should contain.

The first concept and related research prototype of a local early warning system for urban floods caused by heavy rains has been developed by VTT under the Tekes project SmartAlarm (Urban Flood Alarm System).

Benefits of the SmartAlarm flood early warning system

VTT’s SmartAlarm concept and research prototype applications allow us to predict when and where water from a rain event will accumulate. The prediction can be used to give early warnings about imminent flood events. However, it is not enough to know when and where a flood will occur. In order to benefit from the prediction, it must be known what to do when the event occurs and what the consequences of certain warnings or actions will be. For example, people within the danger area must be warned while at the same time

preventing the general public from approaching or entering the area.

Methods and technologies

The SmartAlarm concept of a local early warning system for urban flooding caused by heavy rains is shown in Figure 1.

Methods and technologies used include simulation and modelling (fully integrated 3D surface and subsurface drainage and sewer network and underground space simulation model), Bayesian nowcasting (short-term precipitation predictions using radar images), LIDAR scanning (accurate street-level 3D models of urban areas), measurement (weather radar, rain gauge sensors, water levels, network flows, surveillance cameras, etc.) and modern ICT technologies, such as web services and other IP-based data communication, GPS, Google Maps, and IOS-based tablet and smartphone technologies.

Prototype applications

The concept includes two prototype applications. The first prototype alerts and reports targeted information on flood events to different end user groups, such as key building security personnel, rescue services, local control room operators, etc. The second prototype application is an urban flood situation awareness and guidance system. The system reports which locations in the target area (*building, block, city, country*) are, or will be, in a critical situation now or in the coming minutes or hours (10 min, 30 min, 1 hour,

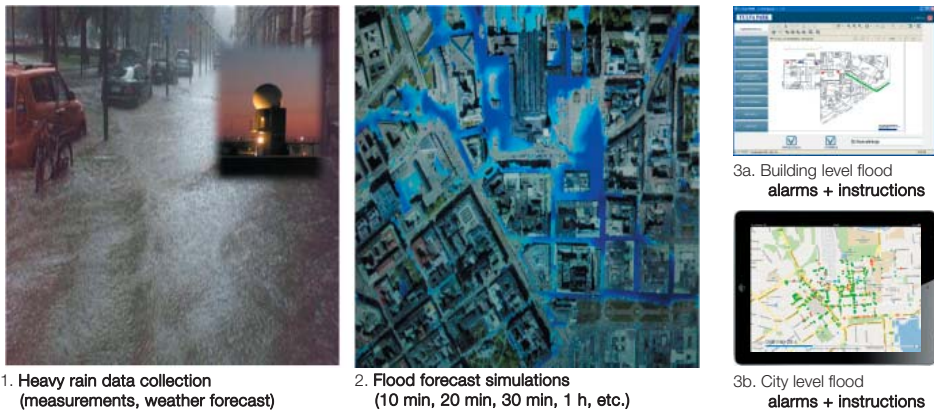


Figure 1. The SmartAlarm concept – local early warning system for urban flooding from heavy rains.

2 hours, etc.). The system also gives other flood-related information, such as emergency procedures, etc.

Towards more comprehensive ICT solutions for minimizing urban flood damages

The research focussed on developing a concept and research prototype of a local early warning system for urban flooding and testing the system in the centre of Helsinki. In future, the concept will be developed further in different security-related projects.

Acknowledgements

Funding for the research was provided by Tekes – the Finnish Funding Agency for Technology and Innovation. The authors also wish to thank the personnel of all participating organisations WaterHope, Pöyry CM Oy, Ramboll Finland Oy, Vaisala Oyj, Kone Oyj, Federation of Finnish Financial Services, Solibri Oy, VR Group Ltd (Helsinki Central Railway Station), Helsinki City Rescue Department, Helsinki City Transport (HKL) (Central Railway Station metro station), HYY Real Estate (Kaivokatu 10 office building), Ilmarinen (World Trade Center), Sponda Oyj (City-Center project) and AquaFence, as well

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Health and care services



Proactive prevention of hospital infections



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Healthcare-associated infections (HAI) are a global, lethal and costly problem. In Europe, HAIs occur in 7.1% of all patients resulting in 37,000 deaths and 7 billion euros in direct costs each year [1]. Current infection precautions emphasise hand hygiene, aseptic work practises and isolation of infected patients, but recent studies [2, 3, 4,] imply that the cleanliness of hospital surfaces and indoor air are also critical factors in the battle against infectious pathogens and fast-spreading epidemics.

Focus on clean work environments

The studies conducted in the Finnish High-Tech Hospital framework show that more attention should be paid to the interaction between patient work and the environmental cleanliness of health care facilities. Boosting hygiene levels in public and private hospitals

is likely to reduce the number and cost of hospital epidemics and improves personnel and patient safety and the overall economy of the health care sector.

Methods

Multidisciplinary approaches for controlling surface and indoor air hygiene in operating rooms and isolation wards were generated and piloted in five Finnish hospitals. The methods applied practices used in clean production in pharmaceutical, electronics and food industries, such as combining airborne particle concentration measurements and video data (Figure 1). Microbiological cleanliness levels for surfaces, work wear, laundry-clean textiles, instrument tables and room air in different areas of operating facilities were suggested. Figure 2 illustrates the measured microbial levels and the limits for operating facility surfaces.

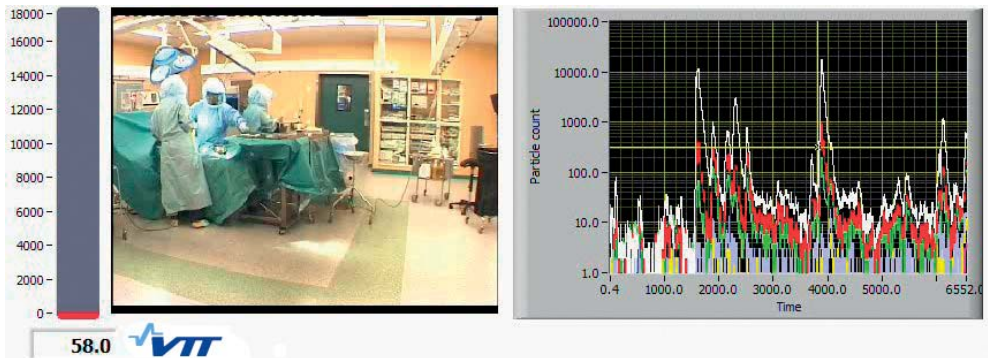


Figure 1. Variation in airborne particle concentration during orthopaedic surgery.

Discussion

Unlike the food industry, there is no operations model for continuous high-hygiene improvement in the health care sector. In the future, self-assessment and self-control practices regarding hygiene and cleanliness open new possibilities for infection-safe nursing environments as well as cooperation and global business opportunities for pioneering solutions relating to cleaning services, diagnostics and information systems.

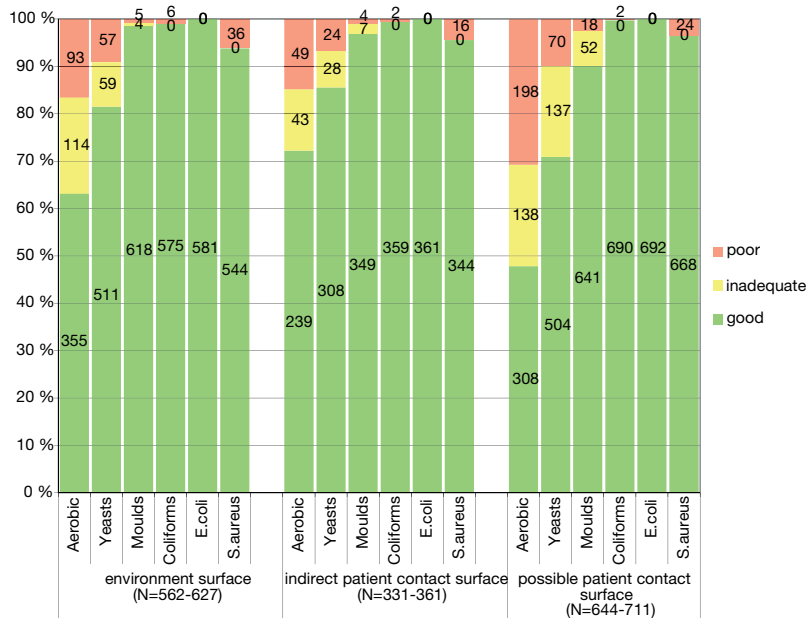
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Sample	Aerobic bacteria			Yeasts			Moulds		
	good	inadequate	poor	good	inadequate	poor	good	inadequate	poor
Environment surface	<20	20-50	>50	<10	10-25	>25	<10	10-25	>25
Indirect patient contact surface	<10	10-25	>25	<2	2-5	>5	<2	2-5	>5
Possible patient contact surface	<3	3-10	>10	<1	1-3	>3	<1	1-3	>3

Sample	Coliforms			E. coli			S. aureus		
	good	inadequate	poor	good	inadequate	poor	good	inadequate	poor
Environment surface	<1	1-10	>10	<1	1-5	>5	<1	1-5	>5
Indirect patient contact surface	<1	1-5	>5	<1	1-2	>2	<1	1-2	>2
Possible patient contact surface	<1	1-2	>2	<1	1	>1	<1	1	>1

Figure 2. Measured microbial levels and suggested limits for high-hygiene surfaces in operating facilities.

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Evaluation and development of patient safety culture



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Systematic improvement of patient safety is a growing priority in Finland and internationally. Problems in medical care reduce patient health and well-being and impose extra costs on society. A strong safety culture, in contrast, provides an essential basis for fostering and maintaining proper high-quality care. VTT has developed a methodology to support health care organisations in systematically and proactively evaluating and developing their organisational safety culture.

Importance of a clear safety culture evaluation and development methodology

In the midst of everyday challenges and faced with a myriad of organisational changes and improvement efforts, it can be difficult for health care personnel to see the ‘big picture’ of what is happening in their organisation in terms of patient safety. A systematic safety culture evaluation carried out from time to time with the help of external evaluators offers an invaluable

means of identifying important issues and areas for improvement and what development steps should be taken. A clear conceptual methodology is needed to achieve

objective, transparent evaluations.

Patient safety culture concept explained

We define patient safety culture as the willingness and ability of an organisation to understand safety and hazards as well as the willingness and ability to act on safety [1]. We view safety not only as an absence of errors or incidents, but as the presence of organisational attributes that enable the staff to carry out their work in a safe manner. [1].

The methodology

Aspects of VTT’s patient safety culture evaluation and development methodology have been developed and tested over the years in several research and development projects [e.g. 1, 2, 3, 4, 5]. The basis of the methodology has been formalised in the DISC (Design for Integrated Safety Culture) model [6]. The DISC model defines the criteria for a good organisational safety culture as well as the safety management functions that organisations should perform. The central tool in the safety culture evaluation is the TUKU safety culture survey [7], which has been tested – and is currently in use – in several Finnish hospitals. A Swedish language version of the TUKU survey is also currently in use. The TUKU survey is complemented with interviews, other document and data analysis (e.g. analysis of incident data and the organisation’s safety management system) and personnel seminars. A typical safety culture evaluation process is depicted in Figure 1. The evaluation is carried out col-

VTT’s patient safety culture evaluation and development methodology has been implemented for example by the Vaasa Central Hospital – one of the forerunners of patient safety improvement in Finland.

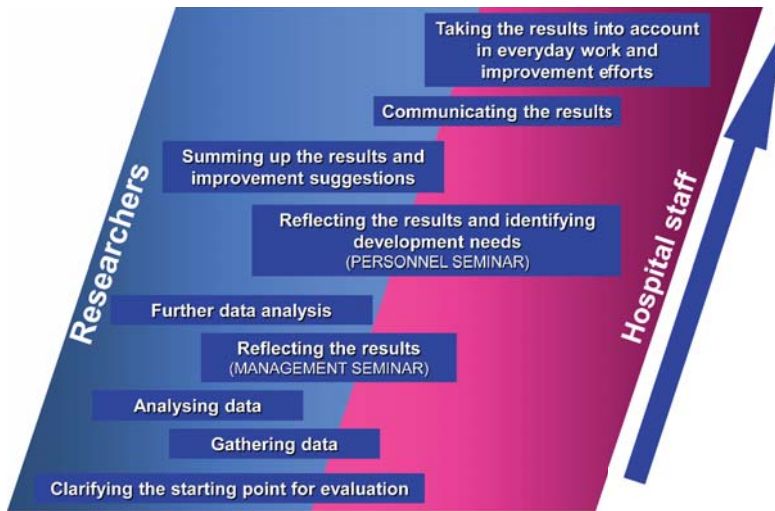


Figure 1. The safety culture evaluation and development process.

laboratively between the researchers, or other external evaluators, and the organisation’s own personnel.

Discussion

The evaluation and development of organisational patient safety culture provides an important means of fostering patient health and well-being and reducing the medical harm and costs to society arising from sub-standard care. VTT’s organisational patient safety culture evaluation and development methodology supports organisations in achieving these important goals.

Acknowledgements

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A new concept for the provision of safety and security related services for the elderly



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Finland has the fastest ageing population in Europe. The economic, social and political consequences and implications that this trend entails present opportunities as well as major challenges. More and more, the challenge lies in guaranteeing safe, high quality services for the elderly in a cost-efficient manner. VTT is working to address this problem in cooperation with companies, institutions and municipalities through the development of a novel operating model and versatile use of technology (see Figure 1).

Benefits of the new concept

The new product and service concept supports the planning and provision of more comprehensive services for the elderly through seamless cooperation with private and public sector actors. In addition, municipalities' competencies in the procurement and implementation of technology solutions will be enhanced. The new operating model enables those responsible for purchasing solutions for the elderly to take their needs and limitations into better account. The selection and development of technological solutions can be done in a needs-based manner, taking into account the costs and benefits to the relevant stakeholders.

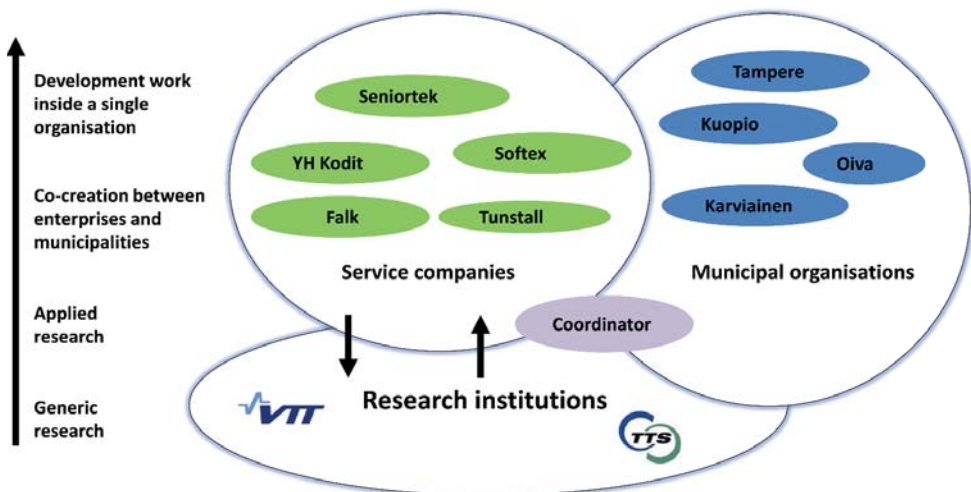


Figure 1. Collaboration between companies, municipalities and research institutions. The findings were utilised by service companies and municipal organisations.

Identifying the needs and effects of safety and security services

A multi-method approach was chosen for data collection and analysis of user/customer experiences. Group work, semi-structured interviews and questionnaires were used to collect data from elderly people, public and private service providers and technology providers. The data was analysed using qualitative content analysis and, in the case of questionnaires, statistical methods were applied. Findings related to elderly peoples' perceptions of safety, security and services were reported and practical development work with municipalities and companies was conducted through workshop sessions.

Towards more comprehensive and collaborative service provision

A key focus of the research was on understanding the phenomena related to the creation of safety and security and elderly people's experiences and feelings of safety and applying this knowledge in the development of new product and service concepts in cooperation with municipalities and private service providers. The new operating model opens up new business opportunities as the new service solutions are conceptualised for export. In the future, the model will take into special account the operational reliability and risk management of systems throughout their life cycle as well as the opportunities provided by new PPP models.

Acknowledgements

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Modelling biocontamination on board manned spacecraft



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For deep space exploration to become a reality, critical risks to astronaut health and performance must be resolved. One key challenge is the control of microbial contamination. As part of a joint EU-Russia research effort, VTT participated in the development of an advanced model to predict airborne microbial contamination. Effective countermeasures require a clear understanding of microbial sources, transport in spacecraft air and surface deposition. This can be achieved by reliable models simulating bioaerosol dynamics.

Managing microbial threats in space habitats

Airborne microbes or biofilms on the surfaces of manned spacecraft may cause health risks to crewmembers as well as degradation of materials and equipment, especially during long-duration space flights. This is due to the enhanced pathogenicity of microbes under microgravity conditions and reduced immune response. The developed computational fluid dynamics (CFD) model can be used to predict dispersion of airborne microbes and

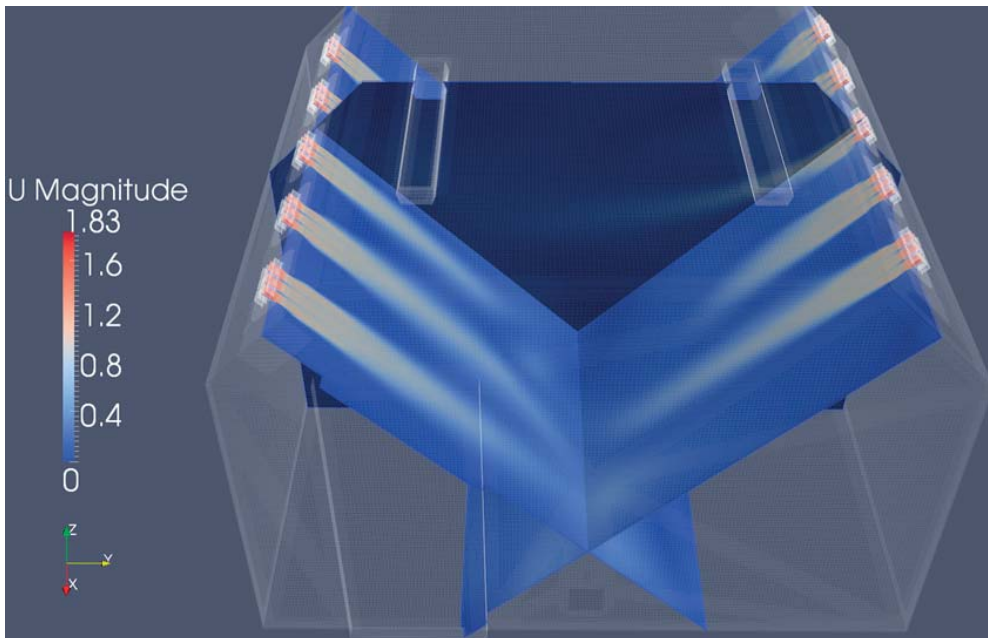


Figure 1. VTT test room simulation: predicted air velocities in the ventilation and air conditioning system of the Columbus Module of the International Space Station. (Source: Kulmala & Kokkonen 2012.)

deposition onto surfaces in confined spaces. The results are useful in preventing biocontamination and minimizing the exposure of spacecraft crew members, thus contributing to astronaut safety, health and performance during manned space missions.

Development of a validated model for biocontamination evaluation and control

For detailed bioaerosol transport and deposition predictions an advanced CFD model was needed. This was developed stepwise: first, a model for reliable air velocity distribution prediction was developed, then the particle dispersion was included, and, finally, the particle deposition models were incorporated. At each step the model was validated using experimental air velocity, concentrations and deposition measurements carried out at a VTT facility using a similar air distribution arrangement as on the Columbus module of the International Space Station (ISS). (See Figure 1.) Ultimately, the model was validated with bioaerosol measurements conducted at the BIOS3 facility in Krasnoyarsk, Siberia. In these experiments the bioaerosols were generated using a representative set of bacteria and fungi from samples retrieved from the ISS to provide realistic conditions.

Benefits of the developed model

The results contribute to the design and maintenance of healthy and productive operating environments for spacecraft crew, which is crucial to the viability of long-distance manned space exploration. The developed model can also be used for controlling biocontamination in the space industry, particularly with respect to mission-critical spacecraft components.

In terrestrial applications the developed model can be used for predicting bioaerosol dispersion and occupant exposure in various enclosed spaces such as airplanes, hospitals, and mass transport systems. When combined with dose-response data, the

results can be used to estimate the risk of spread of infectious diseases.

Acknowledgements

The research leading to these results received funding from the European Union Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n° 263076 within the BIOSMHARS project (Biocontamination Specific Modelling in Habitats Related to Space). The Institute of Biophysics at the Siberian Branch of the Russian Academy of Science is thanked for their valuable cooperation during the physical and biological validation experiments.

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Crisis management and disaster resilience

Decision support for crisis and emergency management



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New technical solutions can support decision making at various levels of crisis and emergency management, saving lives and minimizing damage to people, property and society. Better communication and sensor technologies together with novel scenario modelling and simulation techniques benefit crisis management professionals from the operational level to strategic planning, enabling better preparedness and faster response times. [1, 2, 3]

Improved preparedness for complex crisis situations

Attaining sufficient preparedness for complex emergencies requires sound cross-organisational cooperation in policy-level decision making. The integration of available and future crisis management models and tools will support cooperation and improve understanding of the impacts of various actions before and during a crisis.

Towards better, more high-tech and cost-effective command and control

Improved information flow between command control and first responders can be achieved through novel means of information gathering at the scene of the event. Beyond successfully identifying the needs of emergency crews, control centres and the public, the new fieldwork approach developed by VTT with domestic and international partners fosters end-user collaboration with different agencies and fire-fighting command centres.

Pre-analysed information from the accident site to the rescue services

Situational awareness of rescue services can be improved by providing pre-analysed information and appropriate situation overviews to specific end-users direct from the accident site. The concept developed by VTT supports decision-making in emergency situations through the use of interconnected multiple servers, sensors, communication products and interface systems. The system produces common operational picture (COP) and enhances the situational awareness of decision makers, the media and the public.

Impact on crisis management

Through better understanding of potential crisis situations, local and national preparedness and response levels can be increased. Cross-organisational and multi-agency cooperation can be thus improved both before and during a crisis. Decision-makers benefit from user-centred tools for cross-examining dynamic scenario evaluations through simulation; setting action parameters for optimisation of operational activities and strategic actions; and visualising their impacts and the evolvement of the crisis.

New, enhanced communication and sensor technologies will enable emergency crews to respond much more efficiently to fire and rescue incidents.

Acknowledgements

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Extreme weather event risk indicator for Europe



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A novel extreme weather risk indicator (EWRI) was developed as part of the Extreme Weather Impacts on European Networks of Transport (EWENT) project. The EWRI is applied to the European transportation system in order to indicate and rank the risks to the transport systems of the Member States of the EU-27.

How to use the EWRI?

The devised EWRI risk indicator is able to assist decision makers at the national and international, as well as state and federal levels in the prioritisation of extreme weather risks within their jurisdiction. The EWRI can also be used as a ranking and benchmarking system, although it is unable to measure extreme weather risk in absolute terms. The indicator can help transport organisations to select the most secure routes for transferring goods within Europe. The EWRI indicates the relative risk of various transport modes in different countries. (See Figures 1 and 2.)

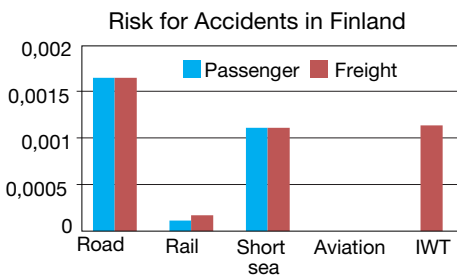


Figure 1. Relative extreme weather risk indicator (EWRI) for transport accident risk in Finland.

Definition of the EWRI

In this study, risk was defined as a product of natural hazard and vulnerability. The first step in defining the EWRI was to determine the most severe weather phenomena per transport mode in different parts of Europe. The probability of these weather phenomena were assessed by the Finnish Meteorological Office [1]. The hazard indicator was defined as the probability of the consequences of the weather phenomena occurring. Next, the vulnerability indicator was defined as a function of population density, infrastructure quality and coping capacity of states. Finally, the risk indicator was defined as a function of vulnerability and hazard.

Novelty and benefits of the EWRI

The novelty of the EWRI lies in its application area (transportation) and wide use of both empirical and statistical data. The EWRI's vulnerability indicator is based on material and data that are relatively easily available at the EU-27 level, such as IMF or Eurostat statistics. In this study, the EWRI results are presented Europe-wide, but the method can be targeted at the national level. To do so, more specific data is, however, required for vulnerability analysis, such as infrastructure quality indexes, maintenance costs and infrastructure repair cost.

Acknowledgements

The European Commission is acknowledged for supporting this research through its 7th Framework Program. The EWENT consortium,

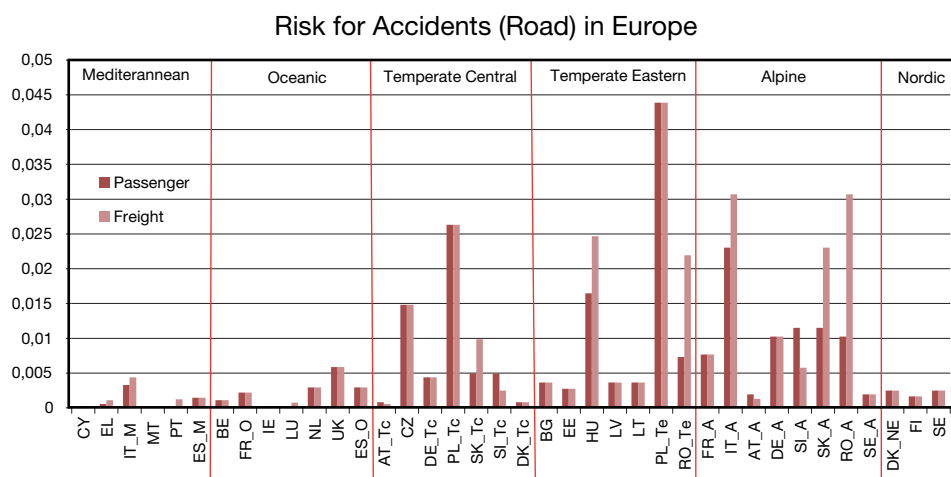


Figure 2. Relative extreme weather risk indicator (EWRI) for road accident risk in Europe. Member States are presented with abbreviations. Some members are shown twice as they belong to two climate regions. Regions: M = Mediterranean, O = Oceanic, Tc = Temperate central, Te = Temperate east, A = Alpine, NE = Northern (see [1]).

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Bayesian games for security assessment – basic assumptions and limitations



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Introduction

VTT’s contribution to the EDA-funded project Athena 2010–2012 focused on exploring the feasibility of game theory in modelling the use of roadside Improvised Explosive Devices (IEDs). The conclusions are applicable to civil security, particularly in the context of organised crime.

Game theory in modelling organised crime

Game theory provides an approach for modelling and analysing players’ rational choices in a game-like conflict. In a conflict between two opponents, the win of one is equal to the loss of the other. In a static game, the players may make their moves separately, but at the same time they know the actions chosen by the

other players. A famous example is the ‘prisoner’s dilemma’, in which the criminals know the risks and payoffs (years in prison) related to their choice to either keep silent or betray their partner in crime.

It can be argued that the payoffs or utilities for the opponents in Afghanistan, i.e. the International Security Assistance Force (ISAF) and the Insurgents, as well as in organised crime, are also known: the mission of the ISAF/police is to safeguard law and order, whereas organised crime strives for power and wealth irrespective of law and order. This can be modelled as a constant-sum game. The adopted tactics (choices) are, however, not fully known. Tactics are continuously developed by the adversaries, and will, from time to time, materialize in kinetic actions (see Figure 1).

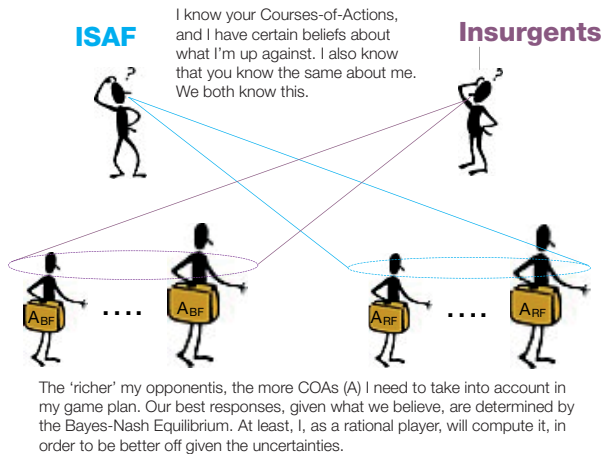


Figure 1. In a Bayes game, uncertainty about the opponents courses of action is modelled by defining opponent types that may be encountered in a game instantiation.

Bayesian gaming takes tactical uncertainty into account

The Bayesian game formulation allows the modelling of the uncertainty of the players' adopted tactics [1]. In the game, the players do not know the type of the other player(s), but they do know the joint probability distribution p for all types. In an actualisation of a game each player knows his own type, but not the others'.

In a Bayesian game, the payoff matrix shows the expected utilities associated with each player's 'strategies'. The strategies are combinations of the player's type and a tactic played by this type. It also reveals for the players what is the equilibrium strategy of each player. This Bayes-Nash equilibrium (BNE) point guarantees the *maximum expected utility* given the tactical uncertainty. All *rational* players are assumed to know it, and follow it.

For a detailed description of the tactics and the expected utility computations related to the strategies of peacekeeping forces and rebels in the context of Improvised Explosive Devices, see report [2].

Application of Bayesian games in security assessment

The main assumption of Bayesian games is that the joint distribution of types p (and thus tactics) are known to all players. This reflects the idea that all players in the 'war theatre' share the same experience of what has happened earlier, also including more uncommon tactics like feints. The key assumption is that all players have correctly assessed the type

distribution p . A consequence of this is that in Bayesian games surprise tactics are not allowed in the game formulation.

A game where the players are free to specify odd types, reflecting surprise tactics, would lead to games called Selten games [2]. Such specification freedom would lead to the loss of the commonly known joint distribution p . As a consequence, the game would represent an imaginary game by its creator rather than being a game shared. Selten game formulation would allow intelligence (private information!) to be more flexibly modelled as opposed to Bayesian games. The usefulness of this property (with associated more complex modelling) remains an open research question for future research.

Acknowledgements

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CBRNE threats and protection



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Accidental or malevolent releases of chemical, biological, radiological or nuclear (CBRN) materials are rare, but their consequences can be devastating. Worldwide political instability together with emerging technologies, environmental changes and continuing globalisation with ever-increasing travel, trade and transport of goods across borders are placing growing burdens on our security environment and preparedness. This research expands our current knowledge of potential CBRN scenarios and their consequences and identifies adap-

tive and cost-efficient solutions for critical infrastructure and civilian protection against various CBRNE incidents.

Protection against CBRN threats

The results are useful for authorities and other stakeholders responsible for preparing for and responding to CBRN incidents. These include public health agencies, emergency services, critical infrastructure operators and emergency supply agencies. The research presents a balanced and comprehensive view of pos-

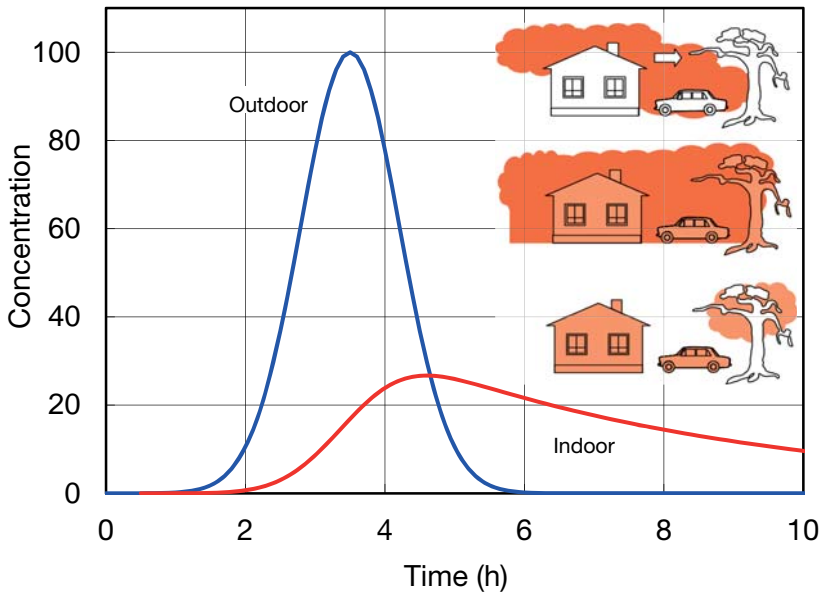


Figure 1. Time delay between indoor and outdoor concentrations in the event of a large-scale outdoor release.

sible threat scenarios as well as methods to analytically evaluate their consequences. An example analysis is illustrated in Figure 1, showing the modelling results for indoor concentration in the event of an outdoor release. The study also resulted in commercial initiatives in the CBRNE arena for participating companies.

Identification and prioritisation of key scenarios

First, an overview of intentional, accidental or natural CBRNE incidents was created. This included attacks and other accidents involving CBRBE materials, as well as natural disasters such as pandemics. This overview was then used as a basis for discussions and workshops with invited experts to prioritize scenarios for gap analysis and identification of actors and needed capabilities. Relevant EU projects were utilised to gain complementary information and a European-level perspective [1, 2].

Benefits to society and business

The project results will be used to increase security by developing and improving technologies and products to protect against CBRN threats. Some of the technologies, such as enhanced air filtration systems, can also be used to protect against fine particles, which are common health damaging pollutants. The R&D work has been utilised in quality control of exported new CBRN protection systems, in networking and activating Finnish companies to participate in EU FP7 Security projects.

The project also produced new information on the performance of personal protective equipment and developed a new decontamination method.

Acknowledgements

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Emergency response



Simulation of fire service response time and reliability



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The performance of crisis management organisations, such as the fire services, has traditionally been evaluated based on statistics or large-scale exercises. However, numerical simulations can be used to expand our understanding and to quantify the sufficiency of existing or planned resources. The simulations can reveal the impact of various organisational factors and procedures on response times, helping answer the core question: “How fast can resources be deployed – on average, and in the worst case?”

How long does it take to...?

Optimisation and impact assessment of the fire services of cities and industrial facilities have gained interest due to tightening economic constraints. These tasks involve measuring the efficiency and reliability of the organisational response. VTT’s development of new simulation capabilities for this purpose originally started with the need to quantify human reliability in nuclear power plants [1, 2].

Further applications were soon found in urban risk management [3] and the evaluation of fire service tactical procedures. Common to all applications has been the need to simulate the performance of multi-agent/agency organisations.

Stochastic operation time modelling

Probabilistic fire simulations using deterministic models have been in use for some time. However, coupling the timing and reliability of human operations with these fire simulations required a new modelling approach. Building a complex response model from individual unit operations resulted in an easy-to-use model, and implementing the model within the (Excel-based) Probabilistic Fire Simulator provided the necessary tools. Description of inter-organisational/agent dependencies was a key step in application development. Use of experts in the assessment of time distributions and error probabilities provided realism, and

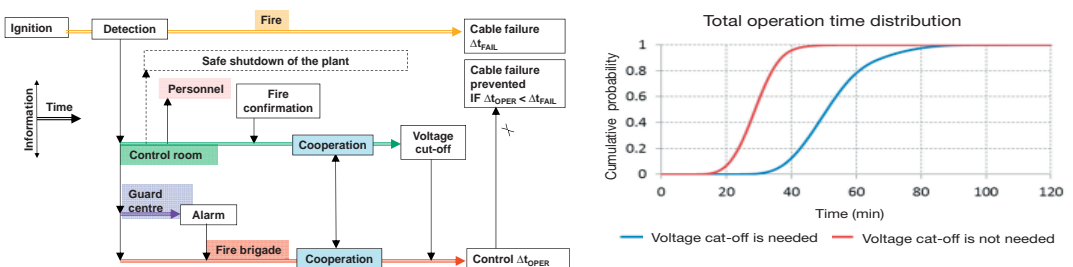


Figure 1. Simulation results: Operation time distributions for two alternative scenarios of cooperation between the fire brigade and technical personnel.

empirical observations supported parameter setting. An example of the model layout and simulation results is shown in Figure 1.

Modelling facilitates the switch from preconceptions and tacit expectations to risk-conscious progress

Simulation-based performance evaluation has become an integral part of the toolkit used to support decision making on fire service investments and maintenance in industrial and public environments. The key to its effectiveness is the modelling process itself, which promotes the use of a systemic approach in describing multi-organisational responsibilities and expectations.

Acknowledgements

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APPLICATIONS

Olkiluoto Nuclear Power Plant

The first application originated from the need to estimate the probability that the plant fire brigade can suppress an envisioned cable room fire before safety system failure occurs. Modelling the co-operation between the firefighters and the plant control room and electricians proved crucial.

Tampere Central Arena

A combination of a busy railway and massive public buildings raised the question of the fire service's ability to control a potential major fire incident, such as a 200 MW tanker fire. Modelling the complex interdependencies between more than 10 organisations revealed important vulnerabilities and risks due to the outsourcing of critical services.

Fire brigade tactics in residential fires

Together with the Helsinki City Fire Department, the model is used to optimize firefighting tactics in residential multi-storey buildings.

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Numerical simulations on the performance of water-based fire suppression systems



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The development of new water-based fire suppression technologies has traditionally involved extensive full-scale fire performance testing. As the applications of the technologies grow larger in terms of physical dimensions and fire risks, performance testing of the systems calls for increasing and sometimes prohibitive resources both in terms of time and money. Recent developments in the capabilities of fire simulation software, especially the Fire Dynamics Simulator [1], suggest that some experimental effort may be replaced by computer simulations, cutting the R&D cost of fire suppression systems.

Can we predict the performance of fire suppression systems?

Today, fire simulation based on computational fluid dynamics is primarily applied in performance-based fire protection design to predict the spread of smoke in large buildings. For such applications, the physical and numerical models involved are considered relatively mature, as they mostly concern locations far from the fire. However, modelling fire suppression involves the detailed and complex physical and chemical phenomena in the flame itself. Some of these phenomena, such as the formation of carbon monoxide and soot in flames can be regarded as ongoing research topics. On the other hand, the flame suppression mechanisms of chemically inert agents, such as inert gases and, importantly, water, are quite well understood, and corresponding physical models can be implemented and validated in fire simulation codes.

An important aspect for any fire suppression system is the ability to discharge the extinguishing medium into the protected space in the most efficient manner. This is particularly true for high pressure water mist systems, as the small droplets must rely on the collective spray dynamics in order to penetrate far in the protected space. The water sprays also affect the distribution of smoke in the protected space, and reduce gas temperatures through evaporation. It is clear that an essential part of predicting the fire suppression performance of water-based systems is the ability to correctly reproduce the dynamics of water sprays.

How will R&D on fire suppression systems be changed?

Despite advances in numerical modelling, experimental work will not disappear, and large and expensive fire tests will be needed in the future. Having the capability to credibly simulate the performance of fire suppression systems will, however, reduce the quantity of full-scale tests. It is no longer necessary to perform numerous tests on a system to reveal performance trends regarding system design parameters (e.g. pressure, flow rate, nozzle type), as these trends can be revealed through simulations.

Modelling as a sales support tool

The vendor of a fire suppression system may encounter a customer or an authority having jurisdiction demanding extra evidence on the performance of the proposed fire suppression system for the application in question.

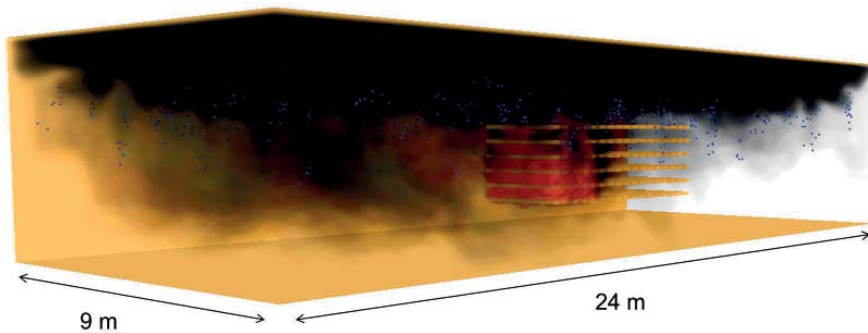


Figure 1. Fire simulation in a traffic tunnel, showing a section of the tunnel where the fire and the fire suppression system are located. Snapshot from the moment of suppression system activation.

Often this is related to a quantity that was not specifically measured in a standardised fire performance test, or it may be that the geometry or conditions of the room or building somehow differ from those of the test. In such cases, re-testing of the system is impossible. Computer simulations offer a means of extrapolating the existing test results and providing the required evidence of performance.

Acknowledgements

Financial support for the project has been given by VTT, Marioff Corporation Oy, Rautaruukki Oyj, YIT Kiinteistöteknikka Oy, and Markku Kauriala Ltd. The project has included intensive collaboration with the Building and Fire Research Laboratory of the National Institute of Standards and Technology, USA, and Hughes Associates, Inc., USA, who together with VTT form the core development team of the Fire Dynamics Simulator software package.

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RESEARCH HIGHLIGHTS:

Water spray dynamics

Water sprays of a high-pressure water mist system were experimentally characterised in detail, followed by high-resolution simulations reproducing the experimentally observed dynamics. This makes it possible to construct 'virtual spray heads', numerical models of complex high-pressure water mist spray patterns.

Gas phase flame extinguishment

A new physical model was implemented in FDS, yielding accurate predictions of flame extinguishing concentrations for a range of chemically inert gaseous extinguishing agents.

Fire suppression in traffic tunnel

The ability of FDS to predict the fire suppression performance of a high pressure water mist system in a large-scale fire test of a heavy goods vehicle fire in a traffic tunnel was demonstrated (Figure 1).

Evacuation safety of passenger trains



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Evacuation safety of passenger trains has been studied as a part of the TRANSFEU (Transport Fire Safety Engineering in the European Union) project [1]. The main objective of the project was to develop a fire-safe, performance-based design methodology to efficiently support the standardisation of European surface transport, including trains, ships and buses. In particular, TRANSFEU investigated the toxicity effects of fire effluents generated under dynamic conditions on passengers and crew in railway applications.

Benefits of evacuation simulations

Evacuation simulations of passenger train scenarios were performed using FDS+Evac [2], the evacuation module of the Fire Dynamics Simulator (FDS) program [3]. The goal was to develop a simulation tool for the prediction of Required Safe Escape Time (RSET), i.e. the time required to perform a safe escape from the place of danger to a place of safety. Compared to analytical models, simulation gives more possibilities to take into account different geometries and different physical and psychological properties of evacuees and to study the effects of different parameters on evacuation times.

Simulation scenarios and issues examined

The simulation scenarios in the TRANSFEU project included the evacuation of a commuter train carriage and a double decker carriage at and between stations. The selected train geometries included stairs and doors of various dimensions having effects on exit flows. For each simulation scenario, evacuation strategies and schemes were defined, including places of relative and absolute safety. Sub-scenarios including fire location, train dwelling time, number of passengers, exit step height and luggage carrying were defined for sensitivity analysis. Evacuations were simulated separately from fire modelling. An example evacuation simulation visualisation is shown in Figure 1.

Prediction of required safe escape time (RSET)

Since the simulation scenarios included stochastic variables (location of people, individual detection and reaction times, walking speed, and body diameter), each scenario was simulated several times with different parameter values randomly chosen from statistical distributions. Typically 10 realisations

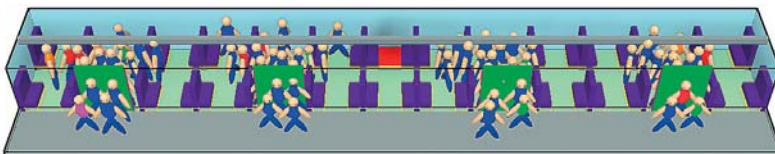


Figure 1. Visualisation of evacuation simulation: a commuter train being evacuated between stations.

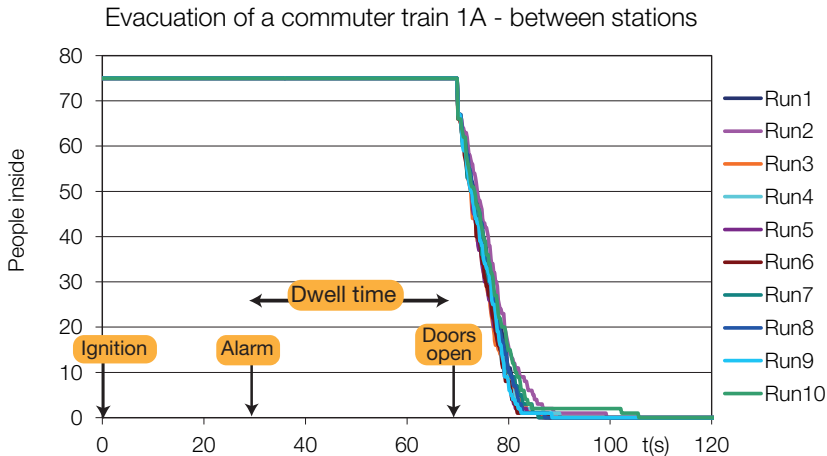


Figure 2. Ten realisations of a commuter train evacuation between stations. The alarm takes place at $t=30$ s and the doors open at $t=70$ s. The average RSET is 89 seconds (95% confidence interval ± 6 s). The effect of a preparatory evacuation phase before train stoppage is observed as small differences between individual simulations.

of each situation were implemented, and the average RSET with a confidence interval was obtained as a result. An example of the results is presented in Figure 2. More information is provided in the deliverable [4].

Improving safety with simulation tools

The developed evacuation simulation procedure is applicable to various train scenarios with different features and details. Fire and evacuation simulations can also be performed simultaneously, enabling the effects of fire-related conditions to be taken into account and evacuee exposure to toxic substances to be quantified. VTT has generalised the toxicity model within the Fire Dynamics Simulator to account for a wide range of gases. Using this simulation tool in vehicle design, fire-induced risks to people can be evaluated quantitatively, thus improving the safety of passengers and crew of trains and other surface transport.

Acknowledgements

The research leading to these results has received funding from the European Com-

munity's Seventh Framework Programme (FP7/2007–2013) under grant agreement no. 233786.

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User's situation awareness in demanding conditions is improved by wearable user interface



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People operating in extremely demanding, potentially life-threatening environments are often required to make rapid decisions and function in close coordination with others. Such activity is difficult to support with technology. Poorly designed technical solutions can even deteriorate the actor's ability to function and increase their workload.

Identifying information needs in demanding conditions

The aim of the research was to support situation awareness in demanding operating conditions through the use of wearable multimodal user interfaces [1, 2]. Actors' information needs in demanding usage contexts were investigated and wearable and context-aware user interfaces suited to these operating conditions were developed. The research process involved task and work analysis, specification of requirements for a personal situation awareness system, and conceptual design and evaluation of prototype systems (Figure 1).

Possibilities of new wearable user interface

A concept and a prototype of a wearable multimodal user interface for supporting situation awareness was developed. Key characteristics of the system include timely collection and delivery of reliable, accurate information in a context-adaptive way and communication

support within the chain of command. The system is suitable for use by special forces personnel in peacekeeping operations and fire and rescue personnel. Development work is being continued under other jointly-funded and commercial projects (e.g. EDA CEDS-FSP).

Discussion

One of the main lessons learned from our research is that improving the situational awareness, decision making ability, performance efficiency and performance accuracy of an infantry soldier or firefighter is very difficult to achieve. New technologies frequently cause more problems than they solve [1, 2]. Future development of military and fire-fighting situational awareness technologies must therefore be based on the methods and techniques of cognitive modelling, evidence-based training, and human factors engineering [3]. These tools will play a crucial role in identifying human cognitive capacities and constraints, enabling the design of better technical solutions.

Acknowledgements

This work has been supported by Aalto University, Desigence Oy, The Finnish Defence Forces, Finnish Institute of Occupational Health, Insta, Nokia, Savox, Suunto, Tekes – the Finnish Funding Agency for Technology and Innovation and VTT.

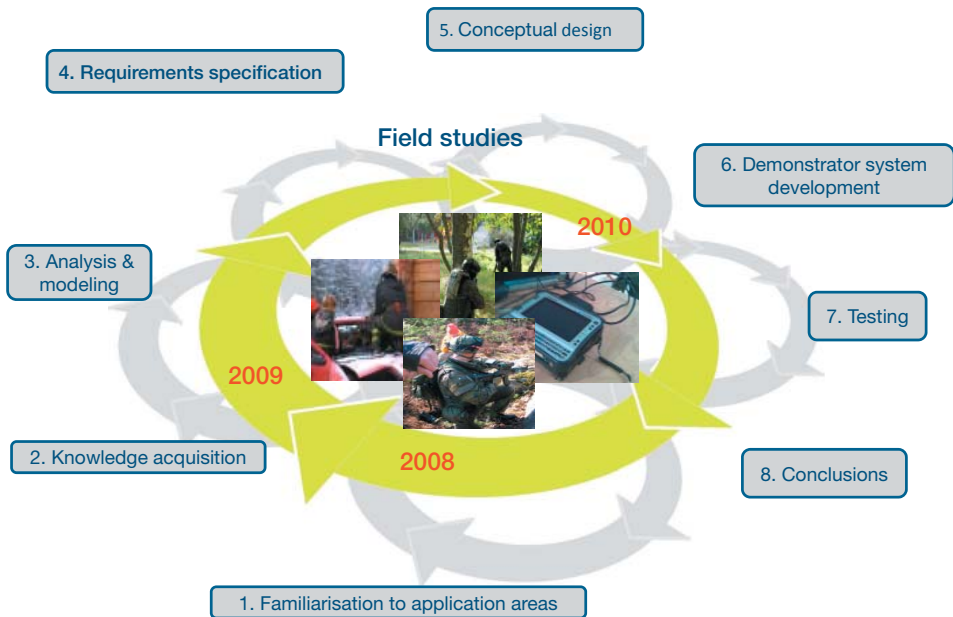


Figure 1. Design sequence of the SAWUI project.

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Sensor networks for urban search and rescue operations



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In the search and rescue of building collapse victims time is critical. Rescuers need to be equipped with technologies and methods that match and support their courage and determination to save lives. VTT has played a leading role in instrument development for the EU-funded Second Generation Locator for Urban Search and Rescue Operations (SGL for USaR) project. VTT's aim was to provide technological support to enable maximum effective use of the limited time available to rescue teams.

Technology for heroes

Fast location of trapped or buried victims is essential in rescue operations. The solution developed by VTT for the SGL for USaR platform is based directly on the needs of rescuers [1, 2], covering the integration of early location methods, attended and unattended monitoring of ruins, detection of human signatures or hazardous conditions, and support for field coordination using data collected from inside the collapsed structures. The sensor probes of the system's wireless sensor network are equipped with positioning capability and an open ICT platform to meet the mobility and time-critical requirements of rescue operations.

Sensor networks for challenging environments

Human victims of a building collapse have characteristic audio, visual and chemical profiles that can be distinguished from mechanical events, gas leaks and fires. Continuous moni-

toring of these individual fingerprints from inside the voids of damaged and partially collapsed structures can be carried out using the portable multidisciplinary 'FIRST' responder device [1] and wireless 'REDS' sensor network [3] built for human detection and hazard recognition as part of the SGL for USaR project. The developed system can cover a vast range of applications, from unmanned security to industrial monitoring.

Tested and demonstrated technology

VTT's outstanding knowledge of wireless instrumentation and optical analysers combined with its rapid prototyping expertise ensured that the technologies provided are able to perform reliably in the most challenging operating environments. The technologies developed by VTT and other project partners were successfully demonstrated at the final demonstration event in Gava near Barcelona in a real operational scenario and with real rescue teams (Figure 1).

Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-13) under grant agreement No. 217967; "SGL for USaR" project (Second Generation Locator for Urban Search and Rescue Operations – www.sgl-eu.org). The valuable contributions of our project partners in the development and testing phases are gratefully acknowledged.



Figure 1. FIRST responder device being tested in the Gava test field.

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Meeting the demands in Emergency Response Centre work



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Finnish Emergency Response Centre (ERC) operations are currently under reform. The aims of the reform include harmonisation of ERC operations at the national level and the development of the information system to be used in ERCs. To get an overview of the situation, VTT, under commission by the ERC Administration, conducted an analysis of the work of ERC operators and examined by means of mathematical modelling and simulation whether operational efficiency could be improved by combining ERCs into larger units.

Importance of the research

The work of the Emergency Response Centre operator is vital and highly demanding. Key challenges relate to handling incoming calls, with callers at peak times having to queue for assistance. Shorter queuing times means lives saved. If this can be done without overburdening the operator, motivation and work efficiency can be maintained, and if it can be done at minimal cost, tax payers also benefit.

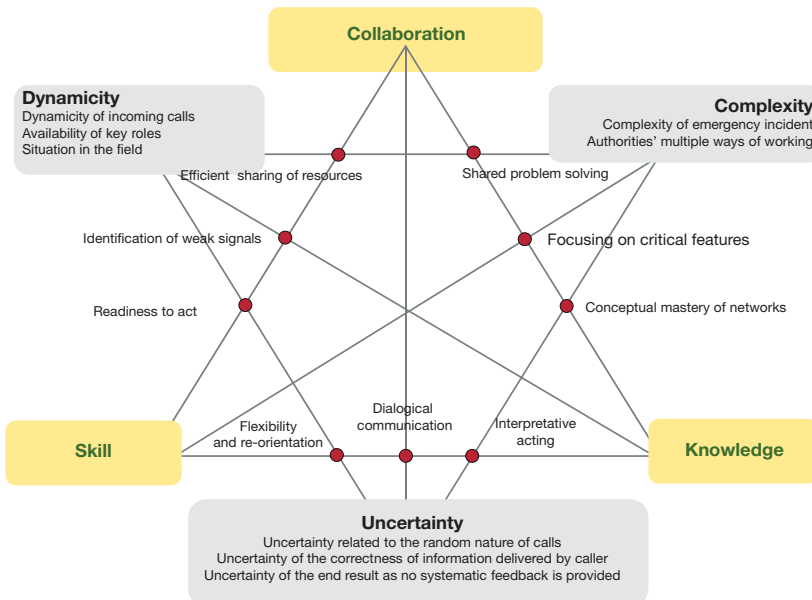


Figure 1. The challenges of the emergency response domain related to dynamism, complexity and uncertainty (grey background), tackled by the resources of skill, knowledge and collaboration (yellow background) and the corresponding nine core-tasks (red dots).

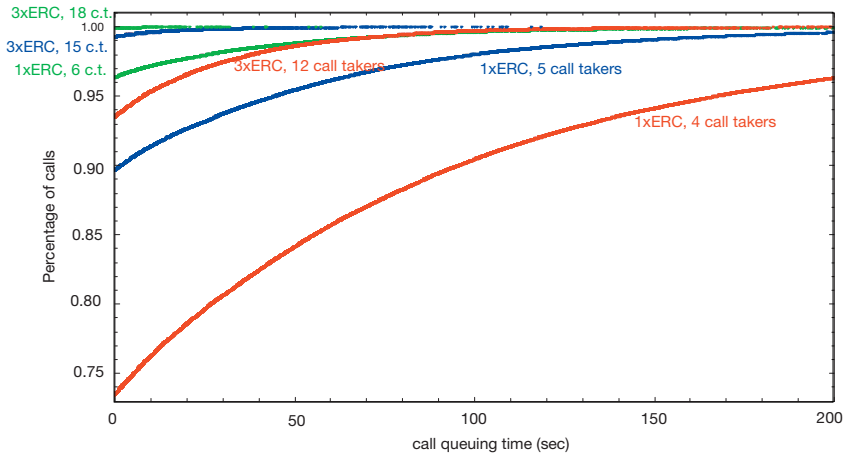


Figure 2. Illustration of the impact of Emergency Response Centre (ERC) size and number of call takes on call queuing times. Larger centres provide shorter call waiting times than smaller units (compare colour pairs) even if the number of incoming calls to larger ERCs is correspondingly higher.

Core-task analysis and key findings

VTT studied the work of ERC operators through direct observation and interviews. The information obtained was analysed by applying VTT's core-task analysis methodology [1] to gain an overview of the generic control demands of emergency response work. It was found that a high proportion of challenges relate to the handling of incoming calls (Figure 1). Based on real data on incoming calls and call handling times [2], VTT analysed the effect of scaling the number of calls and call takers on call queuing times. Queuing times were found to be shorter with more operators per unit, even if the number of calls increased correspondingly (Figure 2).

Discussion

The methodology used in the study proved efficient and provided valuable information regarding the specific characteristics of the domain. The same methodology can be used to study many types of complex work, to improve current performance or to develop

new ideas for work enhancement. The core-task analysis reveals the challenges and the resources of work. Mathematical modelling and simulation can be used to study the workflow of the service process while taking random aspects properly into account.

Acknowledgements

The Emergency Response Centre Administration is gratefully acknowledged for providing excellent opportunities to study the work of ERC operators and for supplying the data for mathematical modelling and simulations.

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Critical
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Information system for multi-actor management of major disturbances in electricity supply



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Major disturbances in electricity supply have impacted the functioning of society and the well-being and safety of Finnish citizens in recent years [1, 2]. Official post-disturbance reports [3, 4] have highlighted the need for significant improvements in information exchange between distribution system operators (DSOs), rescue services and municipalities during power outages. An information system concept to notably enhance the information exchange and multi-actor management of major disturbances was developed in a research project carried out by VTT and TUT. [5]

Core of the system – simultaneous map-based presentation of outage information and user criticality

The system concept combines and presents DSOs' real-time outage information on a common map-based system together with criticality information of focal electricity users. Outage information comprises the extent, current duration and estimated remaining duration of an outage. Figure 1 presents an example of the situational overview provided by the system: the critical outage time of a pumping station has been exceeded (symbol red), while the outage time of a cellular network base station is still clearly below its critical value (symbol green); the symbol sizes correspond to the severity of the consequences of exceeding the critical outage time. [5]

Main benefits – formation of shared situational view and aligning of actors' repair and rescue operations

The developed system supports the actors involved in the management of disturbance situations, i.e. DSOs, rescue services and municipalities. The system helps actors to gain a shared situational view of the disturbance and its propagation and to align their repair and rescue activities so that disturbances are managed optimally. Ideally, the system is established so that it follows the geographical areas of responsibility of the rescue service organisations. This ensures that the rescue organisations responsible for commanding rescue operations get the critical information they need from a single source. [5]

Discussion

The system can enhance information exchange and the management of major disturbances notably. It would also fulfil the new legislative requirement prescribed for DSOs: [6] *“In disturbance situations DSOs shall participate in the formation of a situational overview and supply any information relevant to this purpose to the responsible authorities.”* By expanding the system to cover other infrastructures such as telecommunications, water supply, district heating, etc., further benefits could be gained [7]. As regards the system realisation, practical implementation of the system and allocation of costs remain as challenges [5].

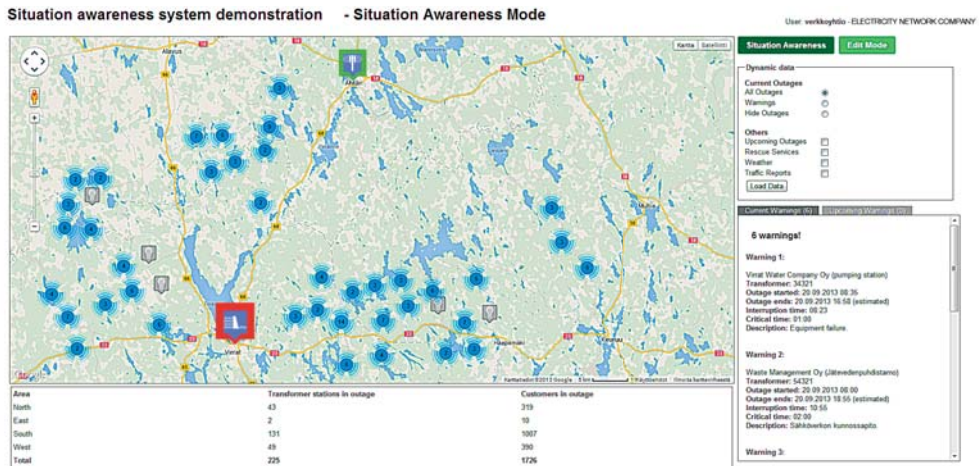


Figure 1. Example of the situational overview provided by the system.

Acknowledgements

The project was coordinated by TUT and supported by Tekes. Other project partners were Fortum Sähkönsiirto, Vattenfall Verkko, Tampereen Sähköverkko, Turku Energia Sähköverkot, ABB, ST-pooli / Finnish Energy Industries, the National Emergency Supply Agency and the Rescue departments of Pirkanmaa and South-west Finland. Further project funding besides VTT was provided by TUT, the involved companies, ST-pooli and the National Emergency Supply Agency.

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Tools for risk-aware communications network operation



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We depend more and more deeply on a complex web of interdependent communications networks – in particular the Internet. We need to be aware of the risks that this dependence entails and find the best ways to cope with them. To investigate this challenge, VTT has accomplished a series of research projects in collaboration with Finnish industrial and governmental partners and academic colleagues from Norway, Italy and Poland.

Tools based on a socio-technical approach to network dependability

It is important to understand that our communication infrastructure is a complex socio-technical system that is largely maintained by private enterprises [1]. The dependability of this infrastructure has many aspects, and the various actors within it have different viewpoints and interests, as depicted in Figure 1. Against this background, three tools were developed to assess network dependability: (1) The Depend-

ability Case [2] approach serves as a tool for assessing and keeping in grasp all aspects of dependability and which network providers can use both internally and as a format for communication with regulators. (2) Pioneering research on the work of operating personnel was carried out to address the often neglected human factors aspect of network dependability [3], resulting in the Core Task Analysis approach similar to that presented by Marja Liinasuo on page 50. (3) Even networks with good structural redundancy often have temporary single points of failure when some of their elements are down. We have developed a technique for computing and visualising dynamic variation in the risk of connectivity losses and Service Level Agreement penalties [4], as demonstrated by the Finnish University and Research Network (FUNET) example in Figure 2.

Scientific background of the tools

Our Dependability Case approach is an adaptation of the well-established Safety Case methodology [5] for the communication networking context. VTT's general methodology [6] for analysing work demands in complex technical environments was also applied in the human factors analyses. The dynamic risk assessment tool developed applies our earlier findings [7] on stochastic modelling of network failure processes.

Towards proactive network management

The tools and methods described here are elements of an emerging broader concept

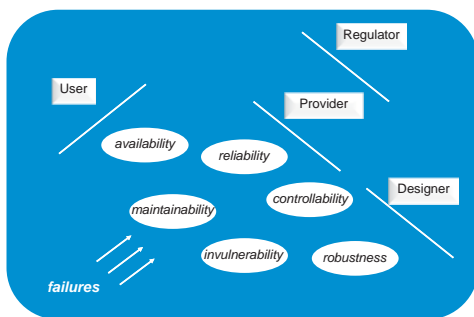


Figure 1. Main dependability aspects of the Internet infrastructure and actor groups with different viewpoints and interests.

of how care should be taken of the communication network infrastructure. Our paper on risk-aware communications networking [1] outlines this concept, with a special focus on risks. From the network provider's perspective, proactivity will be a key feature of future network management.

Acknowledgements

This research was carried out under Tekes – the Finnish Funding Agency for Technology and Innovation projects IPLU, IPLU-II and Goodnet, and the RISKASIP project of the Network of Excellence Euro-NF. We also gratefully acknowledge the EU Commission, the Finnish Ministry of Transport and Communications and the Finnish National Emergency Supply Agency as well as the participating companies (BaseN, Corenet, Creanord, CSC, Digita, Elisa, Ericsson, EXFO Nethawk, Finnet, Fortum, F-Secure, Nokia Siemens Networks, TDC, TeliaSonera and TREX) for their valued support.

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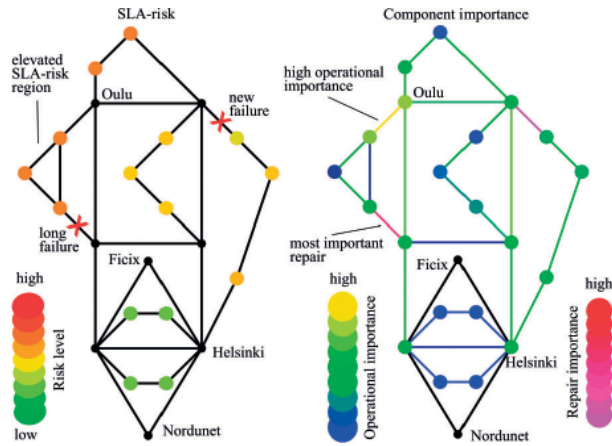


Figure 2. Illustration of Service Level Agreement (SLA) failure risk regarding connectivity to the exchange points Ficix and Nordunet when two links are down. In this network situation the colour code on the left shows the risk of breaking a 1-month SLA at access nodes. The importance of operability or repair of a network component is indicated on the right in terms of network-wide SLA risks. These illustrations are dynamic and can be readily computed for any SLA or failure situation in the network.

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Cyber security of critical infrastructures



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The cyber security of critical infrastructures (CI) has become a focal concern for a number of national and international actors, each with their own, specific interests [1, 2]. As CIs present a logical target for cyber warfare and cyber terrorism, cyber security is climbing the agenda across governments and organisations. Due to their very criticality, CIs are of keen interest to CI operators and military and intelligence organisations, as well as to terror groups seeking to cause harm through sabotage. The cyber security of CIs depends on the overall security of numerous interconnected sub-structures – achieving this demands profound expertise in all aspects of cyber security.

Importance of cyber security in critical infrastructures

In the modern networked world, critical infrastructures are numerous interlinked. Failure of one part of the system can have unexpected cascading effects throughout the infrastructure. There is therefore a need for all parties involved to be properly secured and prepared in the face of cyber threats and other failures. The current preparedness levels of many organisations and nation states are inadequate. Cyber security is thus a crucial research and development priority both nationally and internationally and offers considerable scope for new business innovations and emerging technologies.

VTT develops innovative cyber-secure solutions

VTT is working on multiple research fronts to develop cyber-secure solutions for critical infrastructures. Novel network security monitoring methods are being investigated and commonly available open-source tools adapted to leverage these methods. Currently, we are finalising a proof-of-concept implementation for one such system working on network packet capture data from multiple industrial sites. Another current example is an on-going nationwide collaboration with the National Emergency Supply Agency (NESA) in which VTT is working towards improving Finland's national preparedness against cyber attacks. As a multi-technology applied research organisation, VTT's research capability covers all fields of cyber security relevant

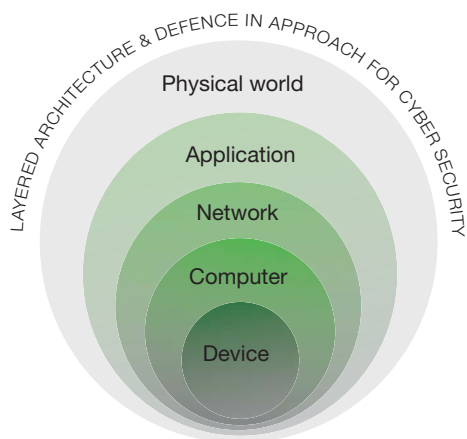


Figure 1. Layered architecture & defence in depth.

to critical infrastructures, as the figure below illustrates. Figure 1 presents two leading security principles – layered architecture and defence in depth – spanning from the physical world to the single device level.

Discussion

VTT conducts extensive research in the fields of critical infrastructures (CI) and industrial control systems (ICS). Current efforts are focussed on enhancing cyber security in the following CI and ICS contexts: wireless connections, good security practices, remote access, vendor management, control and communications networks, and CI interdependency. VTT is an active player in the research and development of CI and ICS cyber security, both in Finland and internationally.

VTT is an expert research partner in the field of cyber security R&D with extensive experience in research project management and the coordination of project initiatives.

Acknowledgements

Much of our research and development work in critical infrastructure cyber security has been carried out with funding from Tekes – the Finnish Funding Agency for Technology and Innovation and with valuable assistance from our collaborators, for which we are grateful. Other important past and present collaborators include Metso Oyj, the National Emergency Supply Agency (NESA) and the Radiation and Nuclear Safety Authority (STUK). The valuable contributions of the

many other companies and agencies involved in our research projects are also gratefully acknowledged. Key examples of recent projects include the TEKES-funded DIAMONDS project, the TEKES- and company-funded TITAN project, as well as VTT-funded internal projects, such as INCYSE.

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Industrial Control System (ICS) security for industrial plants



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Benefits

In this research, we defined the basic cyber security practices for industrial automation users and advanced these according to Finnish companies' needs. The project results support the continuation of industrial production and prevent information security incidents in its automated parts. A common easily adaptable model, guidelines and requirements for better resolving and managing the cyber security of automated industrial production were developed.

Users

The main users of the results are industrial production sites, plants and corporate managements. The project results were immediately exploited in several industrial projects and nationally hosted initiatives. The national projects (e.g. TEO-TT, COREQ-VE, COREQ-ACT projects) aimed at improving the cyber security of the automation user industries and the automation system developers and vendors.

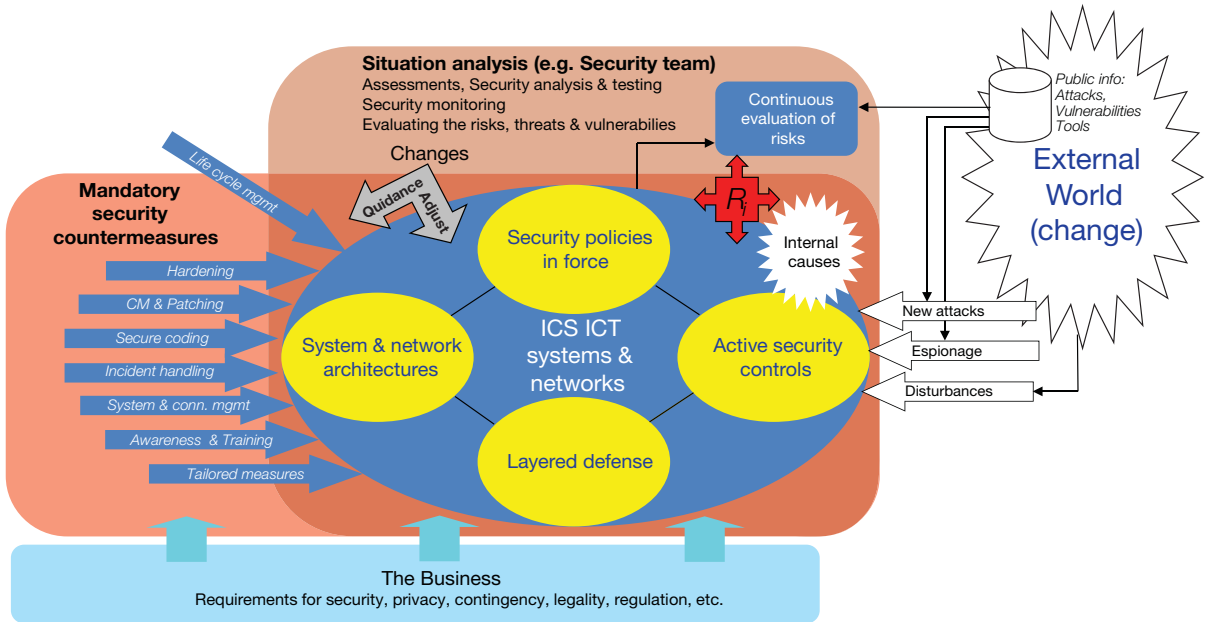


Figure 1. Industrial control system cyber security ingredients.

Methods

The used methods included:

Information security testing and monitoring research: *vulnerability assessments, security and robustness testing of various systems, network monitoring experiments, tool evaluations.*

Information security management research: *standards study and evaluation, best practice development, definition of security evaluation guidelines, company evaluations, etc.*

Solution

The main project results of VTT are described in TITAN-Handbook (in Finnish), which included:

- Security trends,
- Analysis of feasible security standards,
- Security evaluation process,
- Evaluation criteria,
- Descriptions of security testing methods and tools,
- Practical experiences, etc.

In addition, the major information security ingredients for ICS systems and services were identified and described in Figure 1.

Acknowledgements

Major funding was provided by the Tekes Safety and Security Program. The authors wish to thank the personnel of all participating organisations (Codonomicon, Fortum, Landis+Gyr Enermet, Metso Automation, National Emergency Supply Agency, EXFO

Nethawk, and Radiation and Nuclear Safety Authority). We would also like to thank our colleagues from Tampere University of Technology (at Department of automation science and engineering).

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Evaluating of control centres from users' perspective



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Introduction

Continuous monitoring and control of industrial production processes and of traffic and telecommunication networks involves the monitoring of vast amounts of information. Optimisation of the presentation of this information requires that the user-interfaces are evaluated from the human factors perspective. However, up-to-date knowledge of the human factors (HF) evaluation criteria of complex interfaces is scarce. To address this knowledge gap, VTT has developed an evaluation method to test the quality of control centres from the human factors perspective. [1]

Systems usability as the hallmark of a good control centre

Systems usability (SU) is the principal aim of good control centre design. SU refers to a technology's overall appropriateness for a given task or function. More specifically, SU defines a technology's appropriateness as a tool for fulfilling the following three key functions: the instrumental function, i.e., the tool's effectiveness with regard to its intended purpose, the psychological function, i.e., the

readiness of the tool to be combined with the actors' capabilities, and the communicative function, i.e., the tool's capability to support coordination and to develop shared understanding among actors. The SU of a tool is measured in terms of performance outcome, way of acting, and user experience. A 3-by-3 grid emerges, which defines the criteria for SU (see Figure 1). A good control centre should fulfil all SU criteria in order to be functional, safe and support user well-being. [2]

Systems usability evaluation process

The control centre evaluation process consists of three phases: modelling, data collection and analysis, and assessment (Figure 2). Via modelling of work demands and situations, an explicit reference to the data collection,

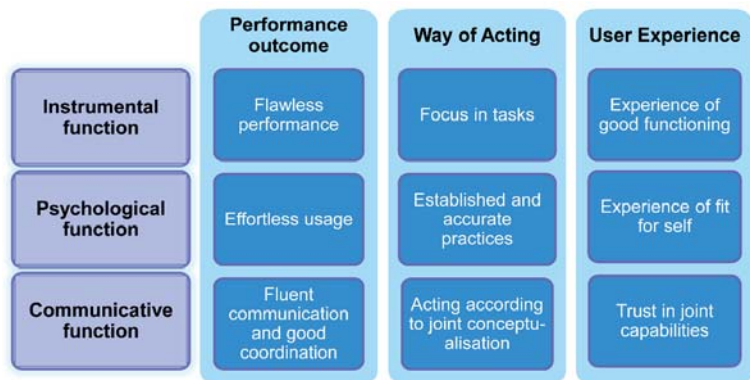


Figure 1. Systems usability (SU) criteria. The SU criteria emerge by considering three generic tool functions (vertical axis) with regard to different aspects of tool usage (horizontal axis).

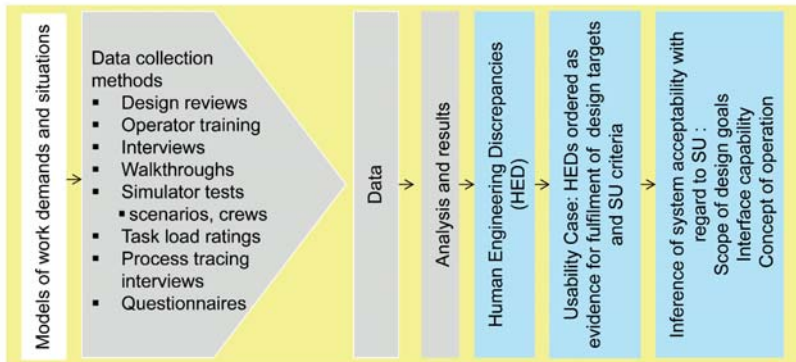


Figure 2. Evaluation procedure used in assessing the acceptance of the systems usability of control room systems: Modelling (white), Data collection and primary analysis of performance (grey), and Assessment of acceptability (blue).

analysis and evaluation is created. A comprehensive set of data on the usage of control room interfaces is collected, and the analysis of the data is carried out. In the assessment, all problems (Human Engineering Discrepancies) encountered in the use of the system are identified. To weigh up the significance of these discrepancies, a systematic reasoning process is applied: the investigators identify claims regarding fulfilment of systems usability, gather evidence to test the fulfilment of these claims, and develop arguments as to why the evidence might question the fulfilment of given claims. This Usability Case approach was developed and tested in previous research projects, and is currently applied in nuclear power plant control room evaluation. The approach is well suited to the evolutionary design of complex interfaces.

Discussion

The developed VTT method has been discussed in international scientific forums and developed on the basis of this feedback. The currently on-going large-scale customer project has challenged the method further, and the method has been consequently shaped to meet the practical constraints of complex design processes.

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VTT has, in collaboration with Fortum Power and Heat, Nuclear Competence Center developed a method to accomplish a human factors evaluation of the modernised control room of Loviisa NPP. The methodology is tailored to fit the evolutionary design of the new control room, and qualified to meet the international requirements for HF evaluations.



Industrial safety



Development of an environmental stress test-case mining



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Stress testing has become a popular method for testing systems against extraordinary events, e.g. regarding the emergency preparedness of nuclear power plants or the stability of banks against financial threats. Stress testing differs considerably from the other risk management tools used in industrial applications. VTT is developing a general method for stress testing in cooperation with Finnish environmental authorities. The first application of the method is focused on the mining sector.

Stress testing in general

After the Fukushima nuclear power plant accident in 2011 in Japan, the European Nuclear Safety Regulators Group (ENSREG) reviewed the safety level of European nuclear power plants using a stress testing procedure [1]. The stress test focused on the preparedness of the European nuclear power plants against natural phenomena such as earthquake and

flooding and other situations such as loss of electrical power or loss of ultimate heat sink. Generally, all stressors were beyond the normal design basis. The same principle was used when the financial sector was tested, where stresses were defined as something that cannot be considered as business as usual – something extraordinary that the banks should be able to handle. Stress testing is also used in medical science, where stress is defined as a response of an organism to a stressor, i.e. stimulus.

Stress testing vs. risk analysis

Stress tests can be considered a risk management tool, just like risk analyses. The scope, however, is quite different. Risk analysis is considered a comprehensive tool that often concentrates on hazard identification. Risk analysis is usually limited to the design basis of a plant or site and it should cover all normal operational phases of a system.

Table 1. Key differences between risk analysis and stress testing.

Feature	Risk analysis	Stress test
Scope	broad	focused
External factors (e.g. environmental conditions)	within design basis	beyond design basis, extraordinary events
Level of detail	low	high
Responsiveness	proactive	reactive
Objective	hazard identification	determining consequences of a hazardous event
Required expertise	medium	high

Table 1 lists some key differences between risk analysis and stress tests.

In a stress test, hazardous stressors are identified before stress testing is started. The stressors could be environmental conditions (e.g. low or high temperature, heavy rainfall, earthquake, etc.) outside the design basis, phenomena having an effect on the target system and the potential to cause problems at the site under survey. The stressors could also be the consequences of hazardous situations, in which case the aim of the tests is to determine how the target system can cope with them and minimize, e.g., discharges to the surrounding environment.

The main phase in stress testing is the identification of stressors. This can be accomplished with traditional risk analysis methods (e.g. HazOp, Failure Mode and Effect Analysis, Potential Problem Analysis), or stressors can be derived from the accident reports of similar industrial applications, as in the Fukushima case: the problems encountered in Fukushima were formulated as stressors and all nuclear power plants in the EU area were virtually exposed to these same threats.

Case study: Stress testing of Finnish mines

During the past two years, a couple of dam leakages have occurred at the Talvivaara mine and other mines in Finland have also encountered accidents causing environmental threats. In response to these incidents, the Finnish environmental authorities took the decision in late 2012 that certain mines should

undergo stress testing. The selected mines were either metal mines, underground mines or other mines with on-site dams containing environmentally hazardous waste. VTT, as an expert in industrial risk management, was involved in the stress testing methodology development group lead by the Ministry of the Environment.

The stress testing was designed to be as comprehensive as possible. Another important requirement was that the testing should be relatively simple for mines to answer. The main phase of stress testing, the identification of stressors, was carried out by a team consisting of Finnish authorities, representatives of research institutes and ministries. In light of the recent Talvivaara mine incidents, the main focus of stress testing was on water management. The mines were asked to describe and assess their own preparedness against the hazardous situations presented in the stress test. The results of the stress tests will be published at the end of 2013.

Acknowledgements

Funding for the stress testing methodology development was provided by the Ministry of the Environment and VTT.

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Defining the principles and practices of safety management in complex systems



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The way safety is managed in an organisation depends heavily on the beliefs and assumptions managers have concerning organisational behaviour and safety [3]. The classical safety management paradigm typically views organisations as machine-like entities and emphasises procedural adherence, strict quality control, clear distribution of liabilities, and supervision of workers as the means to manage safety. Accidents and incidents are typically seen as caused by harmful variance in human activity, i.e., human or organisational errors. In modern complex organisations, such centralised control strategies are not enough to manage safety [1, 2]. Contrary to the traditional view, safety can be seen not only as the absence of something negative, but also as the presence of something positive [1, 3, 7].

Complex organisations and the challenge of assuring safety

We view safety as a property of an organisation (including both social and technological aspects) and safety management as the practice of managing the sociotechnical system producing safety. Safety management that adopts this positive and systemic view of safety needs to rely on new kinds of management practices. Instead of aiming to predict and control individual acts, proactive safety management puts more focus on increasing the potential of the organisation to function safely and effectively on a daily basis. This requires the development of new models and tools to facilitate effective safety management.

The framework for safety management

Based on our research in the nuclear [6] and health care sectors [2, 5], we have defined the premises and principles of safety management in complex safety-critical organisations. These principles cover contradictory aspects such as creating capability for self-organizing while defining system boundaries, and facilitating interaction while prioritizing certain connections. Thus, safety management in complex systems needs to build on a number of contradictory principles and control functions. The framework we have constructed [6] helps companies in balancing these principles (see Figure 1 for simplified illustration of the framework). Our on-going work focuses on further clarifying the complexity of safety-critical organisations and validating our preliminary framework.

Discussion

In addition to constraining unwanted variability through the use of safety barriers and standardisation, safety management should focus on increasing the capability of an organisation to function safely on a daily basis. This means that rather than seeking to reduce complexity, organisations should also seek to offer their personnel the means to cope with complexity. Safety management needs to focus on creating potential for safety in the organisation. We have proposed that safety-critical organisations should be viewed as complex adaptive systems. This sets requirements for safety management, but also opportunities



Figure 1. Adaptive safety management builds on several different principles.

for managing safety-critical organisations in an integrated manner where safety, employee wellbeing and economic efficiency are considered together. For safety-critical organisations, safety denotes the organisation's capability to succeed in changing circumstances.

Acknowledgements

The authors would like to acknowledge the funding from the National Nuclear Safety Research Programme SAFIR and Tekes – the Finnish Funding Agency for Technology and Innovation as well as the invaluable contribution of the participating companies.

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Safety requirements for machine software



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The importance of software in machinery continues to grow as hardware functions are replaced with software and the number of safety functions increases. This has crucial consequences for machine safety. Software failure in safety-critical areas, such as drive-by-wire systems, automated stability control and control of automated guided vehicles (AGVs), can result in accidents, fatalities and costly material losses.

Big software – big challenges

The Standish Group's Chaos Report [1] addresses the reasons for and frequency of failing software projects. According to the report, first published in 1994, as many as 31% of software projects (8,380 cases) fail or are cancelled. According to Capers Jones, an alarmingly high proportion of large-scale projects are impaired (65%) [2]. The problem becomes even more acute when considering the current trend towards ever bigger pro-

jects. So far, machine software systems have been relatively small and there are only few connections between control systems. However, as program sizes increase in the future, with nearly all systems also connected to the internet, the challenges will be considerably greater.

Better requirements specification - key to fewer defects

According to the Jones research data (about 12,500 cases), the average share of requirements specification related defects is 31%, whereas for better quality software (well-tested, defect density among the best 10%) the share is over 60% [2]. Defect occurrence is therefore lower in higher quality software, as can be expected, but, at the same time, the better software, the higher the share of defects in the requirements specification phase. If we assume (and trust) that the overall software defect density will be lower in the future, the share of requirements specification related defects will, therefore, be higher. Means are therefore needed to tackle defects related to requirements specification.

Better software – huge cost benefits

Despite the wide range of methods and tools available for dealing with requirements specifications, the challenge nevertheless remains. There is no silver bullet to solve the problem, but many case-specific methods, tools and perspectives can, however, be drawn on. One observed key element in making bet-

Research outcomes:

Solution:

- Ideas for a software development model
- Criteria for selecting methods
- Case criticality and developer needs

Benefits:

Well-defined yet flexible development process means typically lower design costs. Safety under control means less accidents, better product confidence and peace of mind for designers.

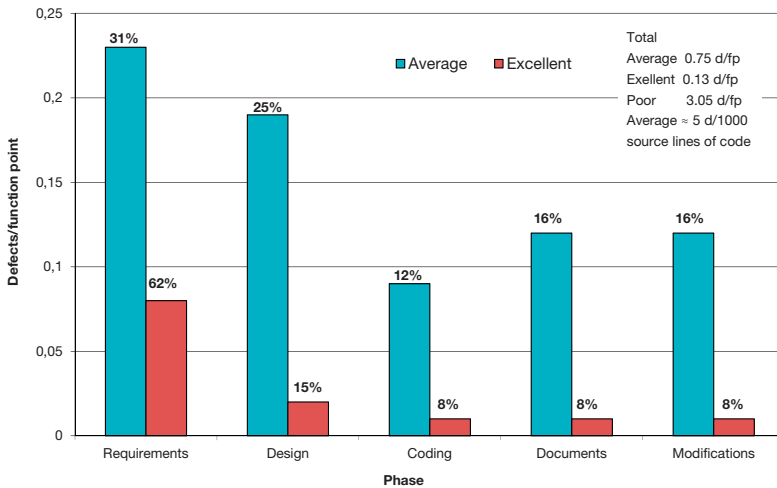


Figure 1. Software quality has a huge effect on the number of software defects. Whereas most other defects can be screened out through verification and validation, defects related to requirements are hard to detect, even in top quality software.

ter requirements specifications is discussion between vendors, customers and other stakeholders [3]. This research also defines a typical safety-related software development process specific to machine builders [4]. Error-free software would provide enormous cost benefits to society but unfortunately only very small-scale programs can meet this goal. Much room for better methods and tools remains, as high quality software can bring immense benefits to society.

Acknowledgements

The paper outlines the ideas developed in the Finnish national project ‘Safety-critical software in machinery’. The main financier of the project was Tekes – the Finnish Funding Agency for Technology and Innovation. The project was realised by VTT and Tampere University of Technology. The contribution of the nine project partner companies is also gratefully acknowledged.

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Error-free critical software through formal model checking



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Ensuring the correct functioning of automation systems in safety-critical industries is essential for the safety of people and the environment. Model checking [1] is a formal method for exhaustive system analysis covering all possible system behaviours. It complements and has several advantages over traditional methods such as testing and simulation, which are based on exercising a limited set of test cases, thus leaving a large share of possible error scenarios outside the scope of examination.

Model checking finds hidden software errors

In model checking, the system design and its requirements are expressed in a format that the software tool (the model checker) understands. Instead of analysing only certain selected scenarios, as is done in testing and simulation, the analysis is done through a graph using efficient algorithms. (Figure 1.) This makes it possible to find hidden errors in system designs that could easily remain undiscovered if relying solely on traditional methods.

Practical experiences and further development

Model checking is a computationally powerful method, but it also has limitations in terms of the size and complexity of the systems that can be analysed [2]. As the number of possible model states grows exponentially with the number of inputs and elements in the system, the analysis task can become too complex for existing methods and comput-

ers due to a state explosion problem [3]. To address this challenge, VTT is conducting ongoing research to facilitate the analysis of even larger, more complex systems [4] and to automate model construction by utilizing already available electronic design data. Tool support is also under development to assist in requirements formulation and visualizing the results of model checking [5]. VTT has also been consulting the Finnish Radiation and Nuclear Safety Authority (STUK) and the power company Fortum on evaluating nuclear automation systems through model checking.

Discussion

Automation systems are becoming increasingly complex as digital technology and sophisticated design tools make it easy to produce overly complicated design solutions. As this complexity increases, the testing and exhaustive analysis of systems is becoming ever more challenging. The developed formal model checking method enables efficient and exhaustive system assessment and facilitates the identification of hidden design errors early in the development cycle. As a result, system development costs can be decreased and overall quality and system safety taken to a higher level.

Acknowledgements

This research was largely carried out jointly with the Department of Information and Computer Science of Aalto University. The majority of practical examples utilised in the research were provided by Finnish nuclear power com-

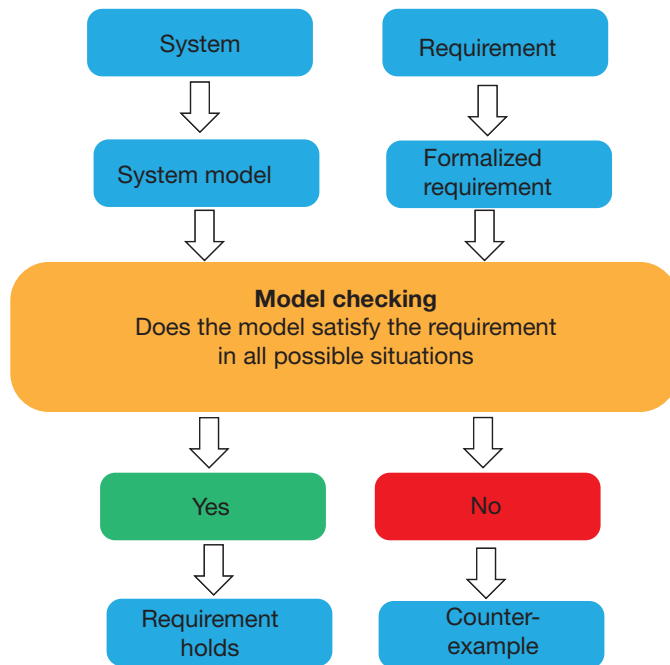


Figure 1. The model checking process.

panies Fortum and TVO. A major part of the development work was financed by the Finnish Research Programme on Nuclear Power Plant Safety (SAFIR) [6].

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Finnish nuclear power plant safety research 2011–2014



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Public nuclear power plant safety research in Finland has been conducted under national research programmes since 1989. The mission of the research programme derives from the stipulations of the Finnish Nuclear Energy Act concerning ensuring the availability of expertise in nuclear safety. The ongoing four-year research programme SAFIR2014 has an annual volume of about 70 person-years, of which VTT's contribution is 50 person-years. In 2012 research was conducted in 42 projects, 35 of which were managed by VTT. VTT is also responsible for the administration of the programme.

Public research to support nuclear power plant safety

The objective of the SAFIR2014 programme is to develop and maintain the experimental research capability, safety assessment methods and nuclear safety expertise of Finnish nuclear power plants (NPPs). The research needs have been identified by key organisations in the area of nuclear energy – the Finnish nuclear safety authority (STUK), licensee holders and the research community – and are described in the SAFIR2014 Framework Plan [1]. The period 2011–2014 involves licensing processes for NPPs in use or under construction and plant supplier selections for planned NPPs, which are reflected in the research activities. In addition, the Fukushima accident has had an impact on the research needs.

Education of experts, high-level safety research, and development of research infrastructure

The SAFIR2014 programme guarantees the continuation of research and expertise in an area critical to Finland. Research is organised in nine research areas (see Figure 1), and each of these areas include 2–7 research projects. Research results achieved in 2011–2012 are documented in the SAFIR2014 Interim Report [2]. One of the programme's principal tasks is to conduct high-level international nuclear safety research, and international co-operation is an essential part of the programme. SAFIR2014 also funds the renewal and development of nuclear energy research infrastructure.

Discussion

Research in the SAFIR2014 programme covers all aspects of NPP safety. In addition to the high level of research, particular attention is paid to training of new experts in the field. The construction of new power plants in Finland increases the need for experts, while the retirement of experts involved in the construction and operation of existing plants continues. The public research programme offers an ideal growth platform for future experts in nuclear safety.

Acknowledgements

The SAFIR2014 programme is funded by the State Nuclear Waste Management Fund (VYR), as well as other key organisations operating in the area of nuclear energy. The

Distribution of total funding by research areas in 2011-2012

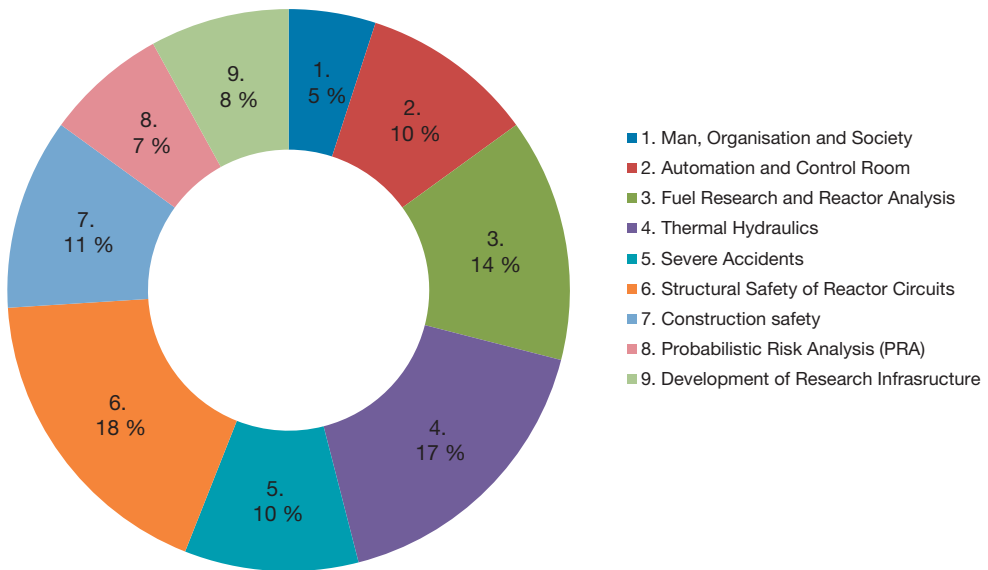


Figure 1. Total funding by research areas.

VYR fund consists of annual fees collected from Finnish nuclear facility operators. VYR's share of the total funding is about 55%, and VTT's share nearly 30%. Organisations contributing to the research include VTT, Lappeenranta University of Technology, Aalto University, Finnish Meteorological Institute, Fortum Power and Heat, Helsinki University Institute of Seismology, ÅF consulting and FiSMA Ry.

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Probabilistic risk analysis and decision making with FinPSA



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Probabilistic risk analysis (PRA) is an essential part of safety management in safety-critical industries such as process industry, power production and transportation. PRA provides essential information for identifying weaknesses in technological systems and optimizing the design, operation and maintenance of systems. When used in decision making, PRA must be carried out in a qualified manner and supported by appropriate computer codes. FinPSA is a software tool to support the main activities related to PRA through easy model creation, efficient and versatile analysis, good traceability, flexible reporting, and information exchange capabilities.

Challenges of probabilistic risk analysis

As the complexity of mission-critical systems increases, finding effective ways to assess their dependability has become a major objective. In the nuclear domain, it is a general regulatory requirement to quantitatively

assess the risk and reliability of the plant and to apply risk criteria in the licensing process [1]. How risk criteria should be applied is not self-evident due to challenges in assessing the risk of complex systems comprehensively and different views regarding probabilistic information. VTT's research addresses all aspects of risk-informed decision making: methods, tools and applications.

Recent research activities

A recent Nordic project has explored the issue of probabilistic safety goals for nuclear power plants and provided guidance on resolving some of the key problems identified, such as the issue of consistency of judgment, and the comparability of safety goals used in different industries [2]. Methods for human reliability analysis have also been compared and validated in international benchmark studies [3, 4]. The FinPSA development work aims to ensure that a well-qualified PRA model is available for end users in the long term [5].

Risk-informed applications

Various risk-informed applications have been used in Finland to support the operation of nuclear power plants, as well as in the licensing of the new Olkiluoto 3 plant [6]. In the development and analysis of PRA models, dedicated computer codes play an important role. These codes handle complex mathematical models. Because the results of PRA analyses are used in safety decision making, PRA computer code must fulfil rigorous quality and performance requirements.

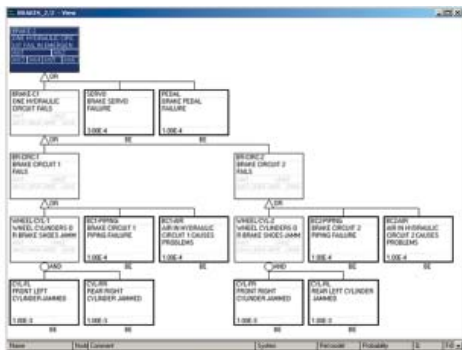


Figure 1. Fault tree example.

FinPSA users

FinPSA is used by nuclear power company Teollisuuden Voima Oy (TVO), the Finnish Radiation and Nuclear Safety Authority (STUK), the Swiss Federal Nuclear Safety Inspectorate (ENSI) and the nuclear power plant vendor AREVA.

Acknowledgements

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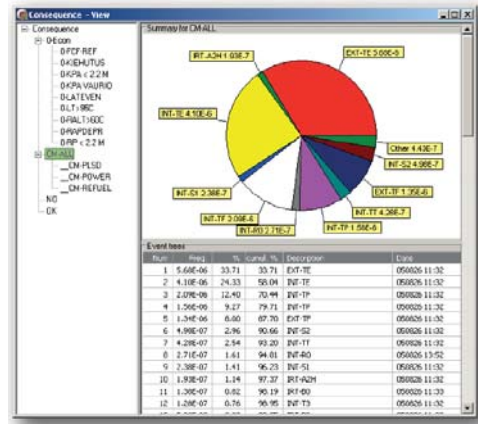


Figure 2. Presentation of results from the quantification of consequences.

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Virtual prototyping in TALOS – Faster development through parallel software, communication, and system engineering



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The TALOS¹ project built a mobile system based on unmanned ground vehicles for the surveillance of large border areas. FRONTEX and national border guards participated in the end-user advisory board. The TALOS system with two UGVs was demonstrated successfully in April 2012 in Wroclaw, Poland (Figure 1).

Virtual prototype

VTT built a virtual prototype of the TALOS system consisting of:

- UGV multi-body, hydraulic and tire models (Figure 2)
- Radio propagation models and real-time KPI monitoring
- World model database on environment and tactical objects
- 3D visualisation for dynamic situation monitoring

J AUS (Joint Architecture for Unmanned Systems) protocol and software was used for communication between nodes. Other public domain software were also supported to enable sharing within the consortia (PostGIS, PostgreSQL, GDAL, PROJ, ODE, and OSG).

Benefits to users

The models and simulation enabled concurrent development, adjustment and testing of the TALOS system components, e.g., in the areas of:

- UGV low-level control system and waypoint driving

- Interfaces and data transfer between multiple subsystems
- Generation of sensor data and imagery prior to real UGV readiness

Discussion

The main challenge to the TALOS system was the autonomous behaviour of UGVs. Intelligent waypoint and primitive drivers and the obstacle detection module increased UGV autonomy, but the challenge of robotic perception and navigation without GPS or SLAM remains. Another key challenge was in guaranteeing a sufficient data rate for mobile communication and transfer of surveillance sensor data from the UGVs. Real-time QoS monitoring with accurate environment modelling and handover possibility were implemented to minimize risk.

Acknowledgements

The TALOS project was funded by the European Community's 7. Framework Programme under grant agreement No. 218081. The project coordinator was PIAP. Other partners included Aselsan, EBIC, HAI, IAI, ITTI, ONERA, Defendec, Sonaca, STM, TP, TTI, and WUT.

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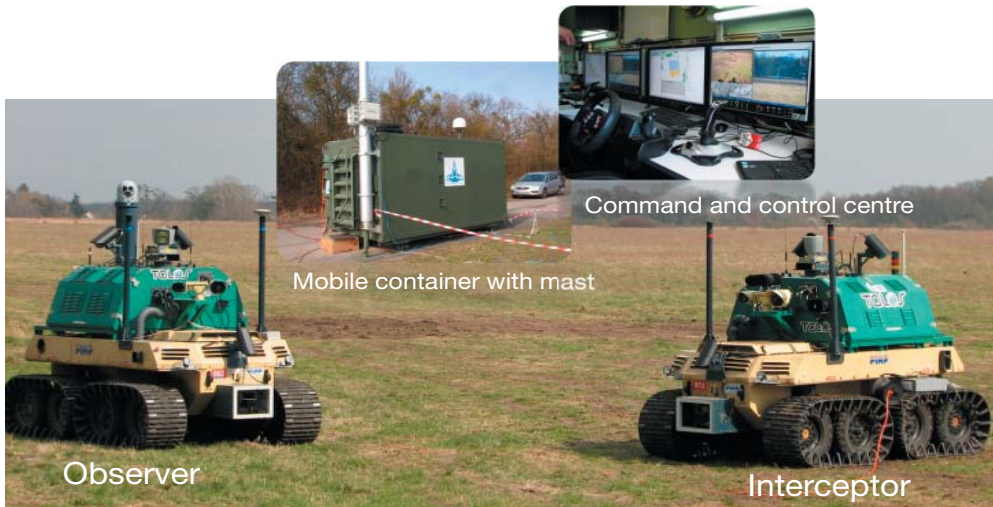


Figure 1. TALOS system consists of a mobile container with mast and command and control centre and two UGVs with surveillance sensors: laser, radar and optical video cameras.

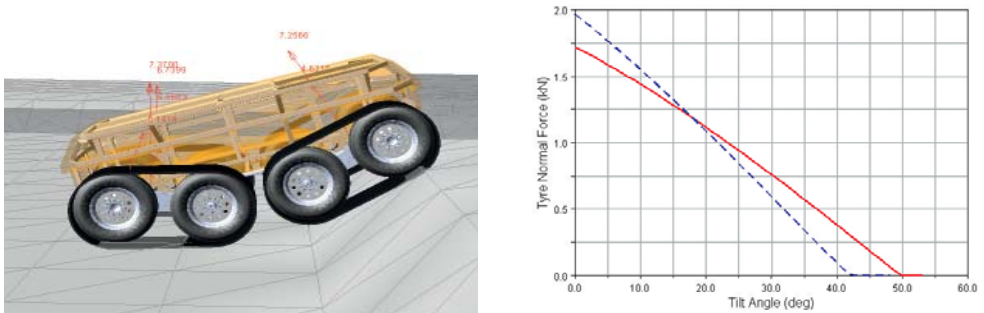


Figure 2. Left: UGV model used in safety envelope development. Right: Lateral tilt limit curve.

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Development of distributed intelligence surveillance networks



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Future surveillance systems will perform a range of automatic image and signal analysis operations. As areas of surveillance increase and larger numbers of cameras and sensors are installed, the processing power of centralised computing systems will be rapidly exhausted. Next-generation surveillance systems are therefore likely to be based on distributed processing.

With the switch from analogue to digital camera technology, the compression, encryption and local conversion of data already necessitate major local processing power and local intelligence. Efficient software tools are therefore needed for the assessment and building of distributed surveillance systems. For this purpose, VTT has developed a hardware test platform and software tools to support distributed systems design. [1], [2]

Development methods and block diagram of the development platform

The development methods consisted of analyses based on an experimental distributed surveillance system. In order to obtain a realistic view of potential bottlenecks and weaknesses in a large-scale network, VTT built a system based on commercial state-of-the-art components including especially wired and wireless communication facilities and high resolution cameras. Basic recognition was assumed to be performed at remote stations, while central command and data storage were conducted at a single master station. Figure 1 shows a block diagram of the generic test setup.

Test setup of the development platform

Figure 2 shows the implemented test setup. The key functions were:

- Identification or recognition of an alert situation (simulated in the test setup)
- Forwarding information in the system
- Alerting the human operator for necessary actions

Main results

The testing and development platform (test setup, see above) for analysing camera surveillance systems was the first deliverable to be developed, as no off-the-shelf solutions were available. During this phase, the communication and implementation principles between the remote stations and the master control station were proposed. These rules were especially important in cases where the user interface of the master control station worked with large numbers of cameras, and where human performance and observation only were not sufficient for actual recognition, but where rapid actions were required by security personnel.

The main communication test results included: parameters relevant to the surveillance setups (camera resolution, etc.), knowledge of spare (residual) capacity for actual surveillance tasks, and the achieved video data rates and data volumes. Furthermore, concrete boundary conditions were identified for the design of optimal digital surveillance camera interfaces in situations where compression and encryption algo-

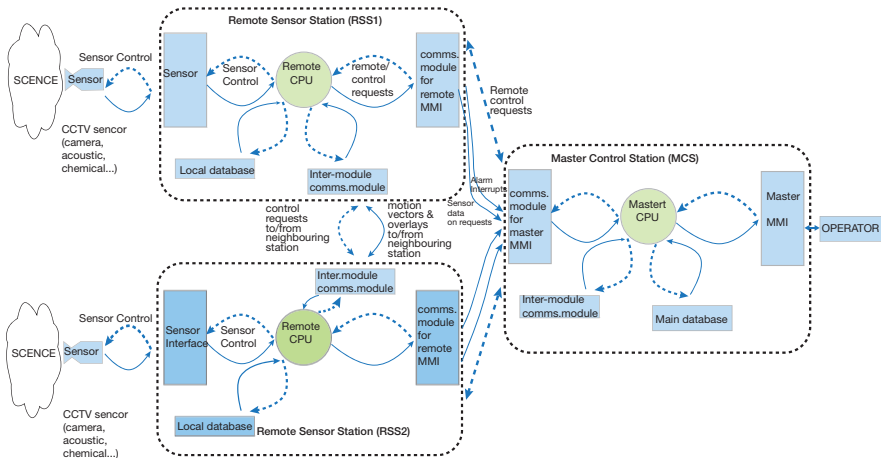


Figure 1. Generic block diagram of a distributed intelligence surveillance system.

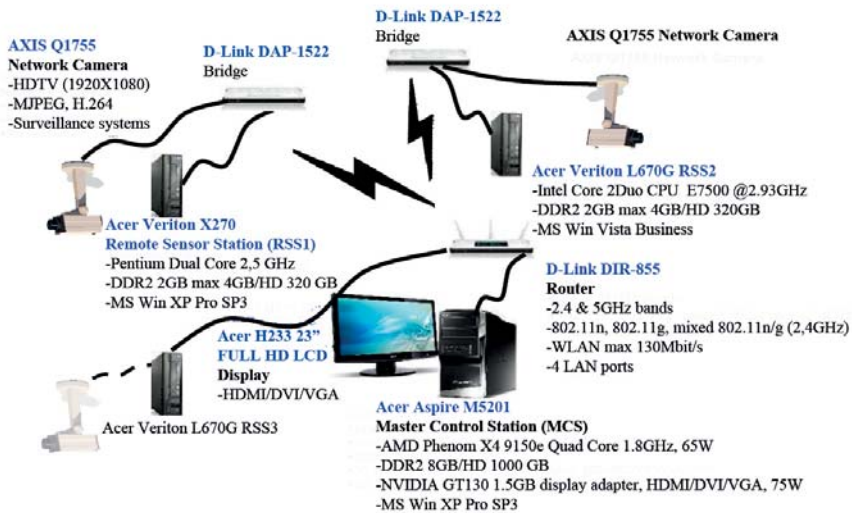


Figure 2. The implemented test setup; two physical remote stations were implemented; larger networks could be implemented as virtual cameras. Both wired and wireless links were realised.

gorithms are embedded within an intelligent camera.

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Building Information Modelling (BIM) promoting construction safety



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Occupational safety in building construction remains a worldwide problem. In Finland, one in four fatal occupational accidents takes place in the construction field, falling from height being a major safety risk at construction sites [1]. The growing implementation of Building Information Modelling (BIM) in the Architecture/Engineering/Construction (AEC) and Facilities Management industry is changing the way safety can be approached [2]. 3D and 4D BIM can be used to promote safety by improving safety planning, management, and communication, and by integrating safety more closely into construction planning.

New BIM technology for better safety

BIM-based 3D site layout plans (Figure 1) have proved to be a versatile and useful visualisation source, and are becoming a clear application area for BIM in the construction

industry. BIM-based fall prevention planning (Figure 2), as well as various 4D work order visualisations, including temporary site equipment and arrangements, show potential as novel and effective visual supports for planning, discussing, managing and communicating safety-related issues. Existing and emerging new technologies that can be used together with BIM include automated planning [2], info screens, virtual reality rooms, and mobile devices [1].

Experimental research and pilot testing

VTT has developed BIM-based safety related procedures and tools in several sequential research projects. Alongside literature researches, interviews and workshops carried out in cooperation with industry representatives, the primary research methods have included hands-on modelling testing, demon-

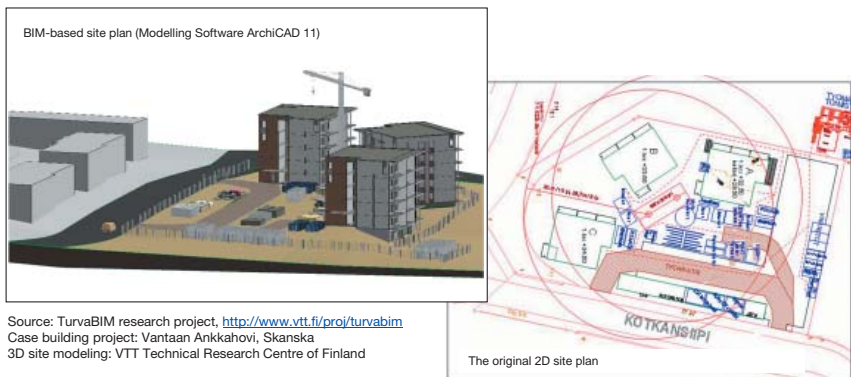


Figure 1. Example of a three-dimensional BIM-based site plan and corresponding original 2D plan.

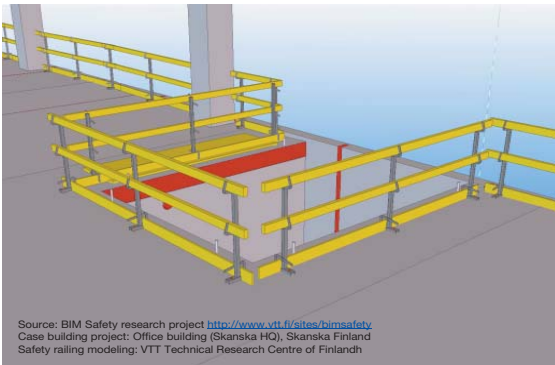


Figure 2. Example BIM-based fall prevention plan.

strations, pilot testing and feedback collection in real on-going building construction projects. The research has improved current understanding of the application of BIM technologies in site safety planning and management.

Detailed BIM-based planning and visualisations improve site safety

Although safety planning is considered a key part of construction production planning, it is traditionally carried out to a certain extent separately and is largely paper-based. Virtual 4D construction planning is a breakthrough. VTT has developed 4D safety planning, especially fall protection planning, to advantage this new technology more intensively to promote safety. For BIM-based planning, a more detailed installation order plan is needed than is traditionally made for building assemblies in construction planning stage. As a result of more detailed and careful planning and using BIM-based visual material for safety communication, site safety is improved.

Acknowledgements

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opment work. The authors also gratefully acknowledge the following collaborators as financiers or research partners: the Finnish Work Environment Fund, Skanska Finland, TVO Ltd, Tekla Finland, M.A.D. (Micro Aided Design Ltd/Graphisoft Finland), A-Insinöörit Ltd, Tampere University of Technology, Finnish Institute of Occupational Health, Georgia Institute of Technology and VTT.

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Improving product safety in the medical and food industry through direct marking technologies



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Counterfeit food and medical products are a growing global problem. According to a World Customs Institute estimate, the counterfeit food industry is currently valued at around 35 billion euros [1], while the counterfeit drug industry has been estimated to be worth 60 billion euros in 2010 [2]. The main consequence of counterfeiting is the proliferation of out-of-date, unsafe, and even potentially life-threatening products. Ensuring the traceability of food and medical products is also a key concern with respect to product recall and liability issues. Studies have revealed vast information losses from one link in the value chain to the next, in some industry sectors as high as 80–95% [3].

Importance of direct marking

Current means of ensuring product authenticity and traceability are limited to incorporating safety and security features into product packaging. However, in addition to marking and customizing product packages, there is also a need to directly mark the actual products themselves in order to guarantee their authenticity, traceability and user safety. Direct marking opens up a new realm of product authenticity, traceability, safety and brand promotion solutions for food and medical industry brand owners, logistics, retail stores and consumers.

Laser marking and inkjet printing as effective direct marking technologies

Laser marking and inkjet printing are currently used for label-free marking of product surfaces – primarily for decorative purposes. However, these digital direct marking techniques also offer huge potential for new product safety applications. (Figure 1.) They can be easily automated, are suitable for mass production, and can be integrated into existing production lines. The objective of the Dimasafety project was to determine how direct marking technologies can improve the safety of medical and food products, and what benefits direct marking can bring to these market sectors with respect to market needs.

Traceability, product safety, anti-counterfeiting and brand promotion through direct marking

Based on our technology analysis, inkjet printing and laser marking both offer huge potential in the direct marking of edible products [4]. The technologies are mature enough to be adapted and seamlessly integrated into existing food and medical production processes and value chains. According to our business analysis, the biggest benefits of direct marking for the medical industry are in anti-counterfeiting and traceability. For the food industry the biggest benefits



Figure 1. Direct marking methods offer potential for security marking and promotional marking on edible products. Left: laser marking on biscuits. Right: inkjet printing on pharmaceutical capsules (photographs by Heidi Eriksson and Liisa Hakola).

are in brand promotion and product safety. Example food safety improvements include prevention of mixing of unpacked food items, and improved tracking and tracing in product withdrawals.

Acknowledgements

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Water supply security



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Drinking water contamination, accidental or intentional, is one of the most formidable threat scenarios faced by developed countries. Drinking water distribution systems are often outdated, vast and complex, making them difficult to monitor and vulnerable to multiple threats. Contamination incidents cause public fear and anxiety in society and generate distrust in public infrastructure. It is therefore essential to detect harmful substances as early as possible in order to manage the contamination situation and minimize the effects.

New early-warning monitoring systems are needed

Conventional water quality analysis consists of laboratory-based testing for contaminants. However, this approach is too slow in the case of large-scale incidents, as seen in Nokia, Finland, in 2007 when hundreds of people fell ill before the source of contamination was determined [1]. Alternative indicators of water distribution network contamination together with efficient, timely monitoring and mitigation systems therefore need to be found and developed. After all, water service providers are responsible for delivering safe drinking water and for proper management of critical systems in order to keep their customers safe.

System design based on vulnerabilities

Early-warning systems must be based on comprehensive vulnerability assessment of the whole water supply system. Existing vulnerability analysis methods are based on valve



Photo: Riitta Molarius

nodes, hydraulic modelling and network sensitivity analysis. These methods cannot ensure that mitigation measures are targeted in the right place at the right time. A new vulnerability assessment approach is therefore needed that takes into account the hydraulic conditions in the distribution network as well as the main contamination sources, including potential vandalism or sabotage. The approach should also include sensors for detecting hazards such as foreign substances, unexpected flow direction or pressure changes. The sensor system should also support preventive measures through integration with an on-line early warning information system. (Figure 1.)

One of the main internal sources of vulnerability in critical infrastructures arises from private-public partnerships [2] where the water

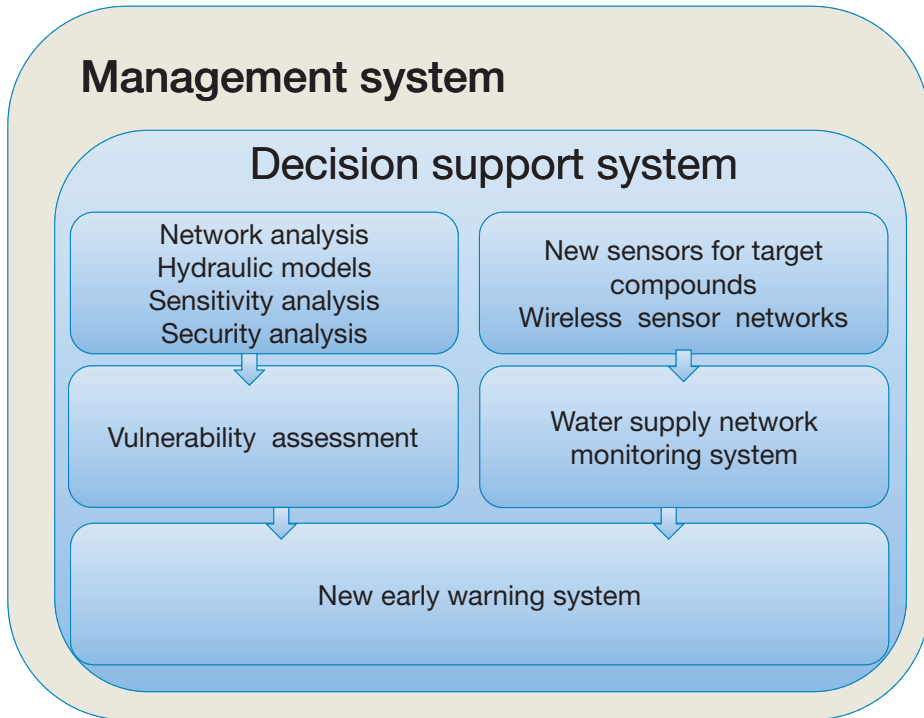


Figure 1. Water security Decision Support System.

plant no longer has direct control over the entry of employees or equipment to their premises [3]. Therefore, in order to be effective, early warning systems also need to be linked to a general management system framework.

In recent projects VTT has developed components of this progressive water monitoring system and done research on water service sector to help water service providers ensure the safety and security of drinking water. Further development work will be done in close co-operation with water companies, universities and enterprises operating in the water sector.

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Safety and security of transport system and supply chain



Long-term foresight for safe and secure transport systems



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Ensuring the safety and security of future transport systems calls for new, innovative approaches. There is a need to go beyond mode-specific impact assessments and to expand the scope of transport safety and security research beyond current mobility patterns, transport vehicles and infrastructures. Long-term, system-level foresight provides the means for this. As outcomes of participatory foresight processes, novel solutions and policies can be developed and assessed under the aim of shared understanding.

Foresight Toolbox

Research to develop and apply foresight methods and tools in key areas of transport safety and security serves strategic transport planning. Features of the *VTT Foresight Toolbox* include:

- *vision building process* to create images of future transport systems (Figure 1)
- analysis of systemic, socio-technical changes and transitions in transport systems
- *system transition roadmap* to structure and assess strategies and measures towards a transport policy goal.

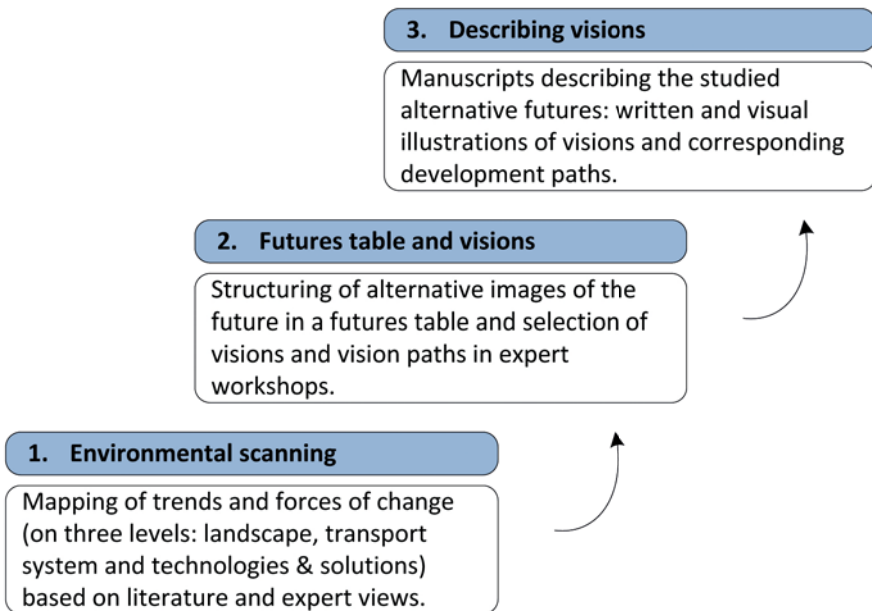


Figure 1. Main phases of the vision building process [1].

A variety of theoretical approaches and research methods are employed: transition management, multi-level perspective, futures table, futures wheel, environmental scanning, stakeholder analysis, etc. Practical working methods include literature studies, workshops, surveys and interviews.

Examples of research applications

One of the first foresight studies addressing transport safety and security was a test-scale vision of the Finnish transport system in 2100, in which a few metropolitan areas defined the economic competitiveness of the entire nation [1]. Next, a full-scale vision of a safe and secure Finnish transport system in 2100 was created together with the Finnish Transport Agency and the Finnish Transport Safety Agency Trafi [2, 3]. Recent projects have resulted in case studies on urban transport, e.g. aimed at achieving the vision of emission-free transport in the Helsinki region by 2050 through increased use of public transport and uptake of electric vehicles and biofuels.

Discussion

Effective long-term decision making and strategic planning of transport systems necessitates the exploration of future paths and visions. Public authorities, transport service providers and the automotive and energy industries have acknowledged the importance of active, forward-facing strategies. The VTT Foresight Toolbox offers a variety of methods and tools to serve these needs, and custom-

made working processes can be designed and carried out to support various decision making contexts. Transport safety and security represents an application area of vital and growing importance.

Acknowledgements

In addition to valuable contributions by VTT researchers from a range of disciplines, the input of experts and authorities from various fields by way of interviews and workshops is gratefully acknowledged. Research funding for the past and on-going projects has been obtained from several sources, and a special acknowledgment is given to the *Traffic Safety 2025* research programme (<http://www.vtt.fi/proj/tl2025/index.jsp>).

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Evidence-based safety tools for road and level crossing improvements



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Road safety ranking and impact assessment of road infrastructure projects have been requested for the trans-European road network [1]. However, science-based safety evaluation tools are not widely available or used. If the allocation of road safety improvements is not based on scientifically proven tools, the effectiveness of safety work is brought sharply into question.

Scientific research enhances traffic safety improvements

Currently, road safety practitioners use accident records as the basis of evaluations for road safety improvements. Applying advanced model-based estimates such as those used by the TARVA tool would provide essentially more reliable results. Applying internationally scientifically developed methods would have tremendous consequences for current practices and the effectiveness of safety work.

Accident record failed to predict future accidents

We compared different ways of predicting accident numbers. Predictions based on five-year data were compared with the actual number of accidents during the following years. The results showed that the most accurate estimates are produced by empirical Bayesian models, followed by simple accident prediction models and even distribution of accidents among sites. Relying on the accident record alone was shown to be by far the least accurate option – in many cases, even the lottery performed better than the accident

record. Similar results were obtained for road and railway level crossing accidents [2].

Forward together

The TARVA tool has been used to evaluate the safety effects of road improvements on public roads in Finland for over 15 years, and enhanced versions have recently been released for Lithuanian roads and Finnish level crossings. Our experience suggests that making predictions and evaluations using the same principle and tools will remarkably improve the quality and comparability of safety estimations.

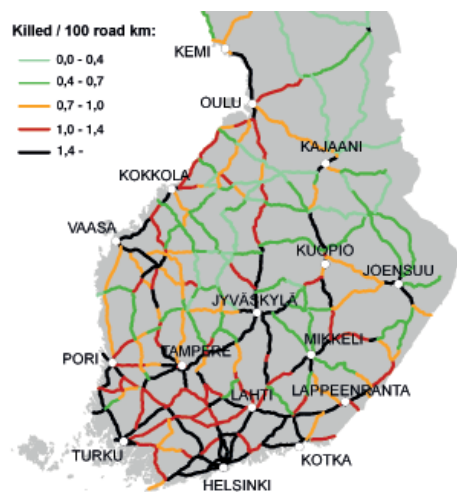


Figure 1. Reliable estimates of the current safety situation of the public road network are continuously updated using scientific tools [2].

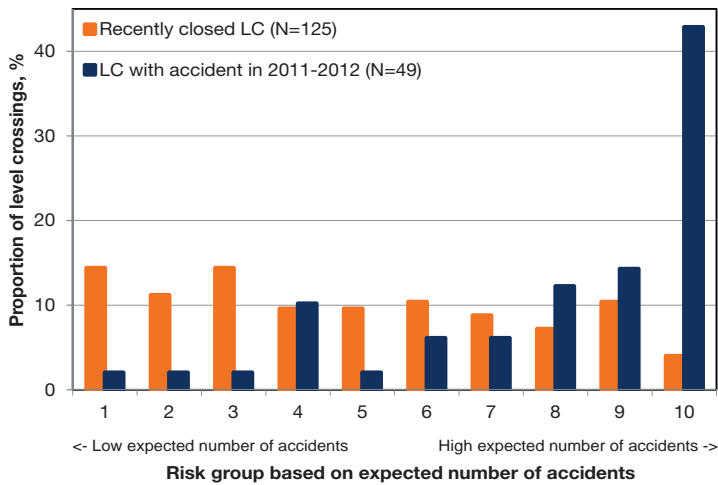


Figure 2. Using data up to 2010 Tarva was able to predict at which level crossing accidents would occur during the following years. The tool was not yet available when the level crossings to be closed were selected.

Acknowledgements

The TARVA projects were funded by the Finnish Transport Agency, the Finnish Transport Safety Agency and the Lithuanian Road Administration in cooperation with Vilnius Gediminas Technical University and the Public Enterprise Road and Transport Research Institute.

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Tarva applications for safety ranking and safety effect evaluations:

Finnish public roads

The tool is used by Transport Agency, all the Centres for Economic Development, Transport and Environment and consultants.

Lithuanian roads of national significance

The tool is used by the Vilnius Gediminas Technical University and the Public Enterprise Road and Transport Research Institute.

Finnish railway level crossings

The tool is used by Transport Agency, Transport safety Agency and some Centres for Economic Development, Transport and Environment as well as consultants.

Development of an in-vehicle warning system for railway level crossings



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Level crossing accidents are an existing traffic safety problem for road users and a major safety issue for railways [1–2]. The developed in-vehicle warning system aims to reduce the number of accidents at level crossings by increasing the alertness and awareness of the car driver approaching a level crossing [3]. The system is expected to improve safety especially at passive level crossings with occasional vehicle drivers where existing safety measures for level crossings are expensive to implement. The main objectives of the project were to study the technical functionality, reliability and dependability and socio-economic benefits and costs of the system as well as user experience and potential other application areas and business models [4].

Benefits for stakeholders

Car drivers equipped with the system will benefit from improved safety especially at level crossings with no active safety measures. The system also contributes to the political objective of ‘vision zero’ which states that no one should be killed or seriously injured in traffic. This objective has been widely adopted by public authorities in the Nordic countries. When implemented, the system will introduce new business opportunities to service providers and facilitate deployment of ITS in the railway sector.

Methods used in the study

The study was started by planning, designing and implementing a pilot system on a railway

line between Hanko and Hyvinkää in Southern Finland. The pilot system consisted of 54 train units, a few in-vehicle systems and two servers utilizing mobile network and GPS positioning. The system was then evaluated in terms of reliability and technical operation based on data collected during the pilot and on experiences from the implementation of the system. The other aspects of the system were evaluated based on a literature study, interviews and stakeholder workshops.

Discussion

The study [4] and its predecessor [3] have demonstrated fully operational in-vehicle warning system for railway level crossings. The public mobile networks based concept has been developed as a functional system [4], creating world-class knowledge in this area [5]. The system does, however, require further development [6]. When successfully implemented, the system will create new business opportunities for Finnish service providers, consultants, device manufacturers and software companies working with intelligent transport systems. Further development work on the system is being carried out in the LeCross project funded by the European Space Agency. The main focus of this project is the utilisation of space assets to provide warnings to road users at level crossings.

Acknowledgements

The development and evaluation of the system was funded by Tekes – the Finnish Agency for Technology and Innovation, VTT Technical



Research Centre of Finland, the Finnish Rail Agency, the Finnish Rail Administration and private companies (Mitron Oy, Mobisoft Oy, Semel Oy and SunIT Oy). The authors wish to thank the Finnish State Railways and other stakeholders which have contributed to the project and made it possible.

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Concepts and technologies to improve multimodal supply chain security



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Multimodal supply chains are complex systems, characterised by multiple changes in transport modes and vehicles. This complexity increases the risk of theft, untimely delivery and freight quality deterioration [1]. There is therefore a growing need to manage the security and efficiency of consignments from door to door. Rapid developments in security technologies and solutions are enabling this by opening up new prospects for supply chain security management, while new technologies are enabling improved supply chain risk management against crime and terrorism.

Supply chain data sharing

The key supply chain stakeholders for sharing supply chain data are the logistics service client, including the consignor and consignee, and the transport service provider [2], as well as transport regulators such as customs and transport network managers. Security and monitoring technologies and applications are being developed to collect and transfer information related to door-to-door transport, such as transport data to supply chain parties, goods information to customs authorities, security-related information on cargo integrity, and information on shipment status. The availability of such information broadens the scope for rational decision making and for more efficient and secure management of the whole supply chain.

Approved technologies

VTT is monitoring and developing different technologies and solutions for the collection of

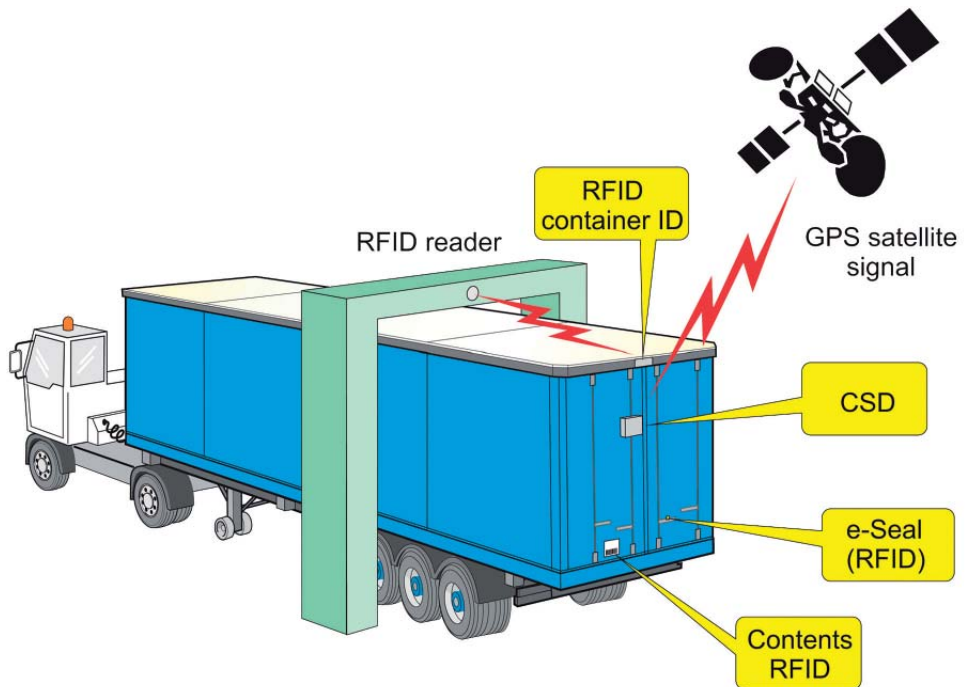
shipment information. RFID enables controlled collection of real-time information on the location of shipments [3]. E-seals provide real-time monitoring and tracking of container and other transport units, thus improving visibility [4]. Tracking devices, consisting of GNSS sensors and cellular or satellite communications enable tracking in real time. MEMS-based environmental sensors and intrusion sensors can collect additional information on the quality and integrity of the shipment. In VTT's Smart Container Chain Management project [5] container security devices (CSDs) successfully monitored the location and door status (closed, open) in the Asia–Europe transport chain.

Discussion

Four monitoring concepts can be distinguished: 1) Black box, where no data is available, 2) Notifications between actors, 3) Manual or automated identification, and 4) Continuous monitoring based on systems and devices. The main difference between these concepts is the frequency of monitoring data updates. The development of novel security technologies and concepts is opening up new avenues for business, and the number of security technology providers in Finland is growing. We aim at utilizing new technologies in security applications for high-tech solutions.

Acknowledgements

The following EU-funded projects served as valuable resources in this research: Interactive Knowledge Platform for Maritime Transport



and Logistics (SKEMA), E-Freight Capabilities for Co-Modal Transport (e-Freight), Smart Container Chain Management (SMART-CM), Security Upgrade for Ports (SUPPORT), and Monitoring and Tracking of Shipping Containers (CONTAIN).

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Disturbance-free supply chains



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Logistics aims to execute the delivery process productively, economically, securely and safely, taking into account the customers' requirements. As supply chains become more complex, they tend to be more difficult to control. Disturbances lead to delays, additional costs and product damages. A disturbance-free supply chain is efficient, reliable, visible, resilient and economical. This demands for different types of management and security measures dependent on the characteristics of the supply chain.

Need for better information on supply chain disturbances

Critical disturbances that occur often and have wide impacts are easy to identify. However, most disruptions are minor and their root causes and value losses remain largely unresolved and unseen. These minor disruptions may, however, have a considerable impact in the long run.

To help keep disturbances under control and enable supply chain resilience, there is a need for advanced information management and/or technologies that are capable of keeping supply chain actors informed about disturbances, such as lengthy delays, theft or deterioration of product quality.

Concept for managing supply chain security

The disturbance-free supply chain concept includes technological, business and risk management perspectives. Advanced information exchange and traceability are

required for the supply chain to perform efficiently. Measuring supply chain performance and learning from disturbances leads to continual improvement.

The developed solution uses tracking devices, attached either to the transport unit or directly to the consignment, which send data to a service centre. Any disturbances are alerted either by the device directly or via service centre software, resulting in immediate action by service centre personnel. The tracking concept has been demonstrated in several international shipments. Key challenges include training the personnel involved, identification of disturbances, and the return logistics of the devices.



Figure 1. Supply chain security is achieved through real-time monitoring.

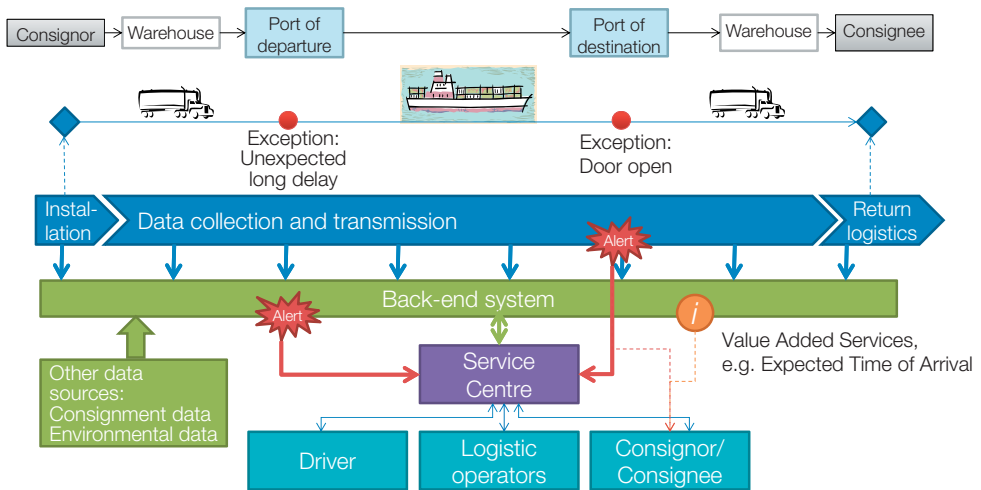


Figure 2. Supply chain continuous monitoring model, including real-time tracking.

Benefits of the concept

Tighter control over supply chain security enables delivery quality and timeliness to be improved and losses to be reduced, leading to better business for the companies involved. The technology enables a more versatile tracking and tracing service and provides customers with an effective new tool for real-time risk management and identifying critical nodes in the supply chain.

This improved business environment enables more efficient global operations, enhanced security and disturbance management, and new value-added services for customers of logistics operators. Service providers benefit from new disturbance management solutions which can be provided globally to logistics operators and other stakeholders of the value chain.

Acknowledgements

This research was carried out within the framework of the SCIE and LogProof projects funded by Tekes – the Finnish Funding Agency for Technology and Innovation.

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New security screening technology developed – Asqella spinning it out



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VTT spin-off Asqella sells new passive THz imaging systems capable of remote detection of items concealed about the body. The company has received close to a million euros in funding from an angel syndicate, VTT and the Finnish Funding Agency for Technology and Innovation (Tekes).

The company sees major market potential in applications such as high-throughput screening for loss prevention, event security, and security in public places. The technology will become available to customers during 2014.

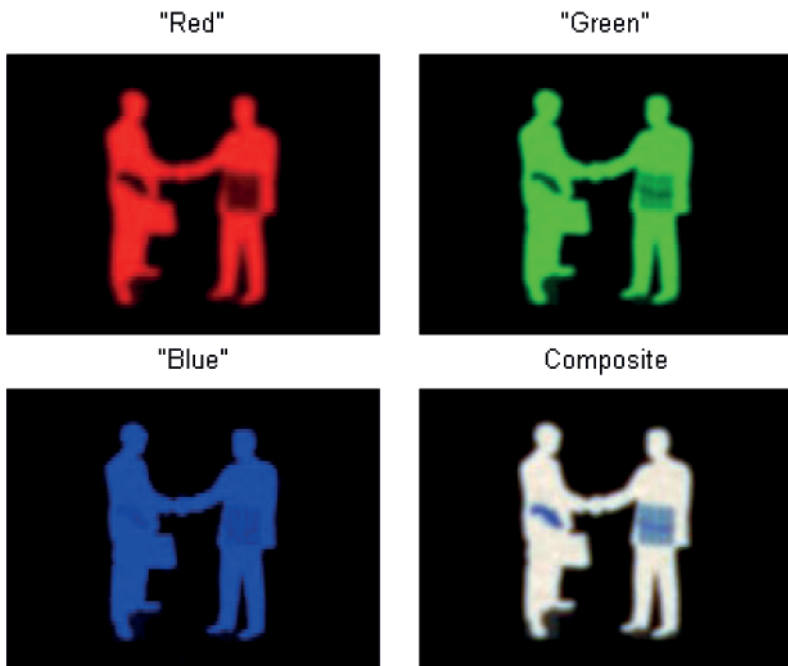


Figure 1. Simulated multi-band images from the THz camera. The low frequencies (250 GHz = “Red”) yield better penetration and thus stronger contrast than the high frequencies (~700 GHz = “Blue”), whilst the high frequency channels can recover more spatial detail in favourable operating conditions.

The new Asqella product involves no radiation, health concerns are absent. The new financing will catalyse product development and accelerate routes to the global security screening market.

The product gives the customer the capability to safely detect concealed items on moving subjects at a stand-off range of 5 to 15 metres. The system is totally passive, neither irradiating the person screened nor revealing anatomical details.

Stand-off screening, the capacity for remote detection of concealed objects the capacity to screen at a distance, has been of considerable global interest for several years, but technical challenges have limited the effectiveness of existing techniques.

After years of scientific research Asqella can now provide highly effective yet acceptable screening capability well beyond any other product available today. The spectroscopic camera technology used by Asqella represents a milestone technology leap – comparable to the transition from black-and-white to colour TV.

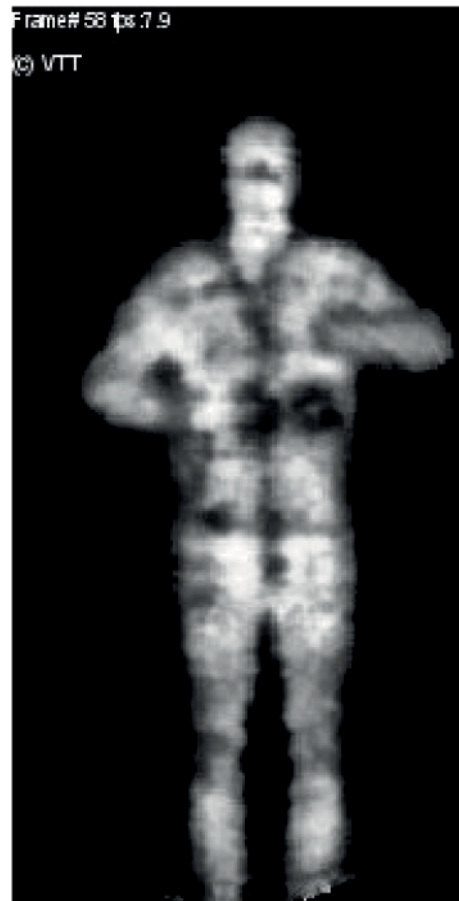
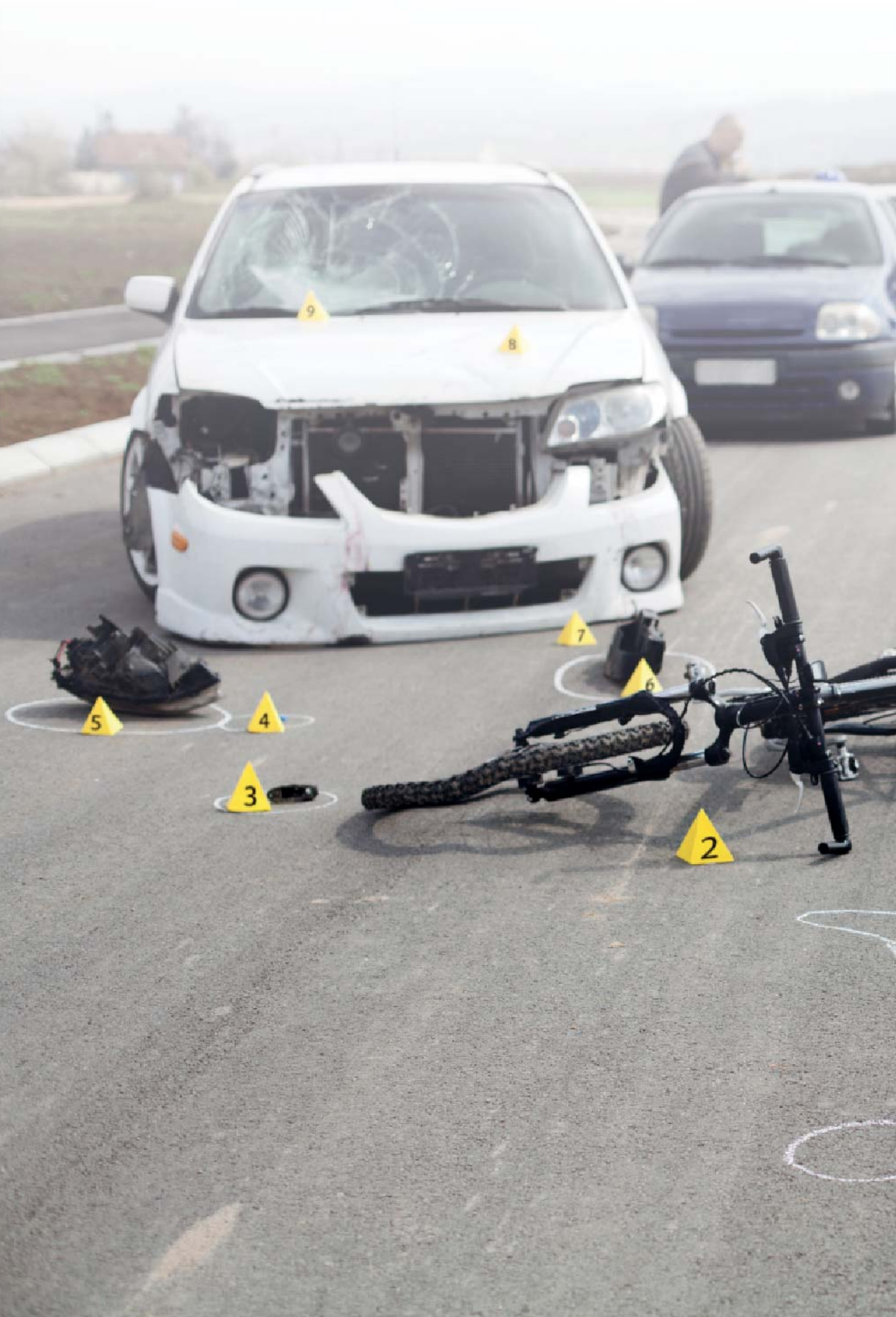


Figure 2. A frame from a passive broadband THz video, filmed at a 5-metre distance from the subject, who is concealing a CD-ROM beneath their jacket.



Road safety



Towards safer road transport through systematic safety management



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Safety management plays a central role in organisations striving for improved health and safety. Safety management offers a systematic means of achieving continuous safety improvements, and has its roots in safety-critical industries. Safety management focuses directly on the structures and functioning of management [1] and includes strategic decision making and operational actions to prevent accidents and other harmful events [2]. Safety management systems have been successfully implemented for years in the rail, aviation and maritime transport sectors. Safety management is a relatively new concept in road transport [3], offering potential for substantial safety benefits.

Implementing safety management systems

Although the concept of a road traffic safety (RTS) management system is new, several core elements of safety management are already in use by Finnish road transport companies and authorities. The implementation of RTS management systems in public organisations and private companies involved in road transport has been found as a new tool to improve road safety. Consequently, our activities have focused on supporting Finnish organisations in implementing RTS management systems as well as providing tools for organisations to improve their safety performance.

Three recent studies

Three research projects aimed at improving road traffic safety have been implemented. The



first, preliminary study explored the preparation of a road traffic safety management system for the Finnish Transport Agency [4]. As a result of the study, performance factors were proposed as the starting point for an RTS management system. The second study focused on the development of an incident reporting system for companies operating in the road transport sector [5]. The key requirements were that the safety management system supports the identification and reporting of incidents, and that

reported incidents are taken into consideration by the user organisations. The third, on-going, study explores the practices currently used in Finnish road transport companies to manage their overall safety and to what degree different management systems have been taken into use.

Discussion

Road transport companies operate in a challenging environment. Road transport is heavily legislated, and competition for market share and tight schedules are inherent aspects of daily business. In Finland, transport agencies are tasked with improving road safety and are taking considerable steps to do so. Twinned with these improvements, RTS management systems help organisations to reduce road traffic incidents in a cost-effective way. Measurable performance factors, as proposed by VTT, provide organisations with a tool for continuous safety improvement and systematic safety management.

Acknowledgements

The reported studies were supported by members of the research programme “Traffic Safety 2025”. More information about the programme is available at <http://www.vtt.fi/proj/tl2025>.

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Improving the safety of vulnerable road users through Intelligent Transport Systems



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During the last years, major steps have been made to increase road safety and the number of fatalities in the EU has decreased overall. The use of Intelligent Transport Systems (ITS) has facilitated this decrease. However, Vulnerable Road Users (VRUs), such as pedestrians, cyclists, motorcyclists, moped riders, have not enjoyed the same decrease in fatalities experienced by other traffic participants [1]. Together, they account for 68% of the fatalities in urban

areas [1]. Whilst the total number of road fatalities in the last decade has decreased in EU-14, this has coincided with a corresponding increase in fatalities for PTW riders which is much higher than their contribution to traffic. The accident risk for PTW riders is much greater than for car drivers – depending on the countries, it is between about 5 and 25 times greater [2].



Figure 1. Improving the safety of vulnerable road users, such as cyclists, is a key priority in traffic safety research.

Intelligent Transport Systems (ITS) assist in improving safety and mobility

New sensing and communication technologies allow to make VRUs more visible for vehicles, as well as to communicate with other road users and with the infrastructure. Starting from accident data, the most critical scenarios for road users and the needs of the different stakeholders are identified. Methods, which have been developed for vehicle safety applications assessment, are adapted to take the specific characteristics of VRUs.

Recommendations for improving safety

Through assessment of the safety and societal impact of different ITS applications, recommendations are made for actions at policy level to improve VRUs' safety and mobility, as well as on how to improve the usability and performance of ITS applications. The EU-project 2-BE-SAFE [3] focused on the conspicuity of mopeds and motorcycles (PTWs). From experiments, variations of specific frontal light configurations were found as promising solutions to enhance PTWs conspicuity, such as yellow coloured headlights, Alternating Blinking Light System (ABLS) and additional lights on the fork and handlebars for motorcycles.

Placing the VRU in the centre of safety research

Through the use of ITS applications, the safety of vehicles has been improved during the previous years. Now work has to be performed to increase the safety of pedestrians, cyclists and motorcyclists. The project VRUITS, which started in April 2013, will investigate how ITS applications can improve the mobility and safety of VRUs [4], including elderly and disabled, more mobile. The project will assess how new communication and sensing technologies can be applied to make travelling safer and easier for VRUs.

Acknowledgements

The work performed has been co-sponsored by the European Commission in the 2-BE-SAFE and VRUITS projects.

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Talking vehicles make driving cooperative



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The concept of cooperative driving goes back to the idea of automated highways. The first ever proposal for an automated highway system, presented by General Motors in the 1960s, was based on the idea of car front wheels being automatically positioned in response to signals picked up by tuned coils mounted on the front of the car. Today, cooperative driving is all about *foresighted* driving – the early detection of hazards and the timely provision of information to support the driver. This is achieved by communication-based systems that extend the driver’s horizon beyond their field of view and warn of incidents and adverse conditions ahead, leading to higher situational awareness. The aim is to contribute to safe and efficient mobility by enabling drivers to slow down early enough and by increasing the headway distance between vehicles.

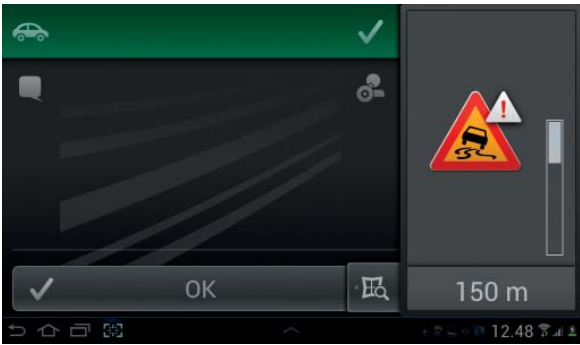
DRIVE C2X project launched to evaluate cooperative driving

DRIVE C2X identified four major objectives:

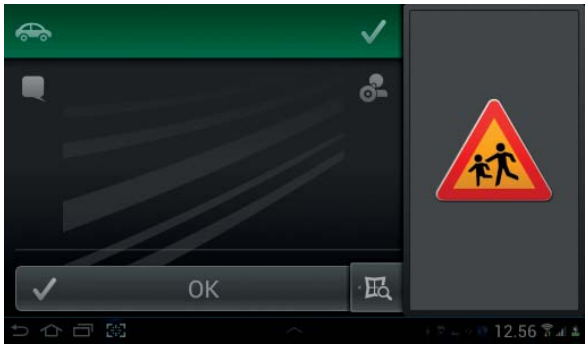
1. Create and harmonise a Europe-wide testing environment for cooperative systems
2. Coordinate the tests carried out in parallel throughout the DRIVE C2X community
3. Evaluate cooperative systems, and
4. Promote cooperative driving

Field trials are currently being carried out with the following two objectives, to determine i) whether vehicle-centric communication works in real-life conditions, and ii) the impacts of various cooperative functions, such as:

- Local danger alerts (Figure 1)
- Driving assistance and intelligent speed adaptation
- Traffic flow



a)



b)

Figure 1. Screenshots from the dashboard device, showing messages displayed to the driver: a) Slippery road 150 metres ahead; b) Warning – school zone, children crossing.



Figure 2. DRIVE C2X functions are being field tested in seven European countries.

- Traffic control systems
- Internet access and local information services, and
- Test site-specific functions defined independently by each test site

Field testing the system

Before actual field operational testing, several preparative testing procedures were conducted on the DRIVE C2X reference system to enable the safety and other functions to be field tested. The field operational testing currently in progress will provide comprehensive knowledge of the impacts of the DRIVE C2X functions at different levels ranging from individual driver behaviour to the impacts on national and European transport systems and society. The estimation of specific impacts in target areas such as safety, the environment, efficiency and mobility are based on changes in driver behaviour. The measures used are therefore focussed on driving and travelling behaviour. For each impact area, the most effective measures compatible with

the indicators and criteria are applied. These target-area-specific impact estimates form the basis for regional and Europe-wide impact estimates. Field operational tests are being currently carried out in seven European countries (Figure 2). The project is coordinated by Daimler AG in partnership with the European Institute of Communication Technology (EICT) and VTT.

Acknowledgements

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007–2013) under grant agreement n° 270410, DRIVE C2X.

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Road markings as a safety measure



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In 2011, 77 people died in head-on collisions and 70 people died in single-vehicle accidents on Finnish public roads, accounting for 66% of all road fatalities. Effective, cost-effective measures are therefore needed to prevent vehicles from drifting into oncoming traffic or off the road. Introducing new road markings is relatively inexpensive to implement, yet their safety effect cannot always be guaranteed. Kallberg [1], for example, found that the use of delineator posts on winding roads increases night-time accident risk due to increased driving speed, whereas the risk is reduced on straighter roads.

Three field tests

Centreline and shoulder line rumble strips, marked on 3,500 road kilometres in Finland, are designed to alert drowsy or distracted drivers if their vehicle veers onto them. In our case study, their effect on accident rates was investigated using before-after-analysis with a reference group and applying an empirical Bayesian approach [2]. Wide central area markings consisting of two centre lines 0.7–1.0 m apart with a rumble strip between were implemented on four two-lane main road sections and their effects on vehicle speed and lateral lane position were studied [3]. The effects of delineator

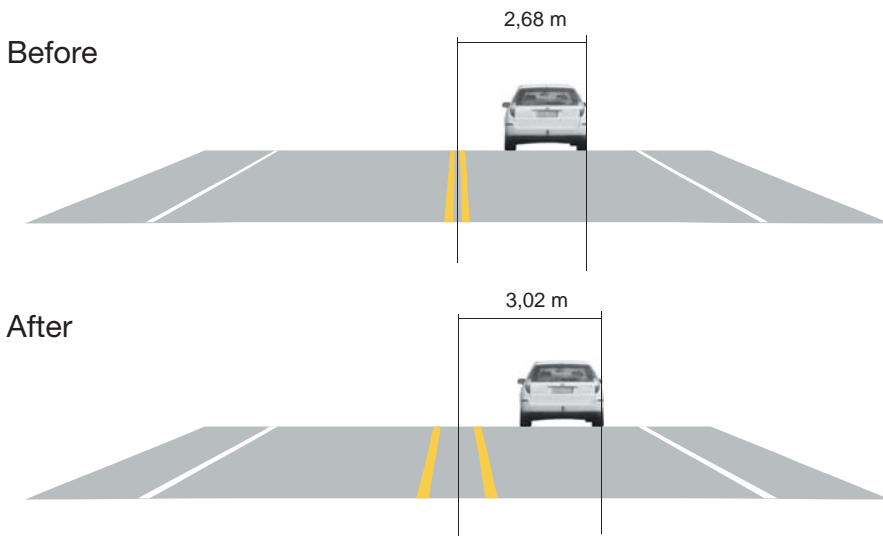


Figure 1. Wide central reservation markings increase the distance between passing vehicles, giving drivers more time to react if a vehicle veers into oncoming traffic.

post frequency on speed was also investigated by introducing three different frequencies alternately on the same road section [4].

Main findings

Centreline rumble strips showed a reduction of 10% in off-road left and head-on personal injury accidents on two-lane roads [2]. The widest central area (1.0 m wide) increased the distance between vehicles driving in opposite directions (Figure 1), while a narrower version (0.7 m) together with narrower lanes decreased driving speed [3]. The marking was estimated to reduce head-on collisions and run-off-road accidents to the left by 10%. In the delineator post study, the three alternative configurations and no-post option resulted in approximately the same mean speed [4].

Discussion

Our results show that centreline rumble strips and wide central area markings are a cost-effective road safety measures. Wide central area markings can be considered as an effective intermediate alternative to a centreline barrier. The results concerning delineator post frequency conflict with Kallberg's [1] previous study. Thus, further research is needed to determine whether the effects of delineator posts on speed have changed over time.

Acknowledgements

The rumble strip and wide central area marking studies were funded by the Finnish Transport Agency. The wide central reservation study was conducted in collaboration with consult-

ant companies Ramboll Finland and Trafix. The study on delineator post frequency was conducted on commission by the Nordic collaboration NMF (Nordic meeting for improved road equipment) and forms part of a larger project.

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Car tyres and road safety



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Use of the correct type and condition of car tyre with respect to prevailing road conditions is a crucial road safety factor. VTT has conducted several recent studies on tyre characteristics and their impacts on road safety.

Safety effects of tyres

The most common tyre faults in Finland include inadequate tread depth on summer tyres, worn or missing studs on winter tyres, and incor-

rect tyre pressure [1]. Fatal accident data for 2000–2006 collected by Finnish road accident investigation teams show tyre defects of these types to be twice as prevalent in vehicles older than 10 years compared to newer cars [1]. Importantly, the results indicate that cars fitted with illegal summer tyre tread depths, i.e. less than 1.6 mm, were three times more likely to be involved in fatal crashes than cars with tyre tread depths of 3.5 mm or more [2]. However,

tread depth was also shown to correlate with behavioural factors, and increased accident risk was shown to often be a consequence of speeding and driving while intoxicated rather than tyre faults. Furthermore, tyre-related risk factors have been more common in fatal accidents in winter.

Condition of winter tyres

Winter tyre condition has generally improved since 2001 [3]. Nevertheless, in 2010 almost one in ten cars in Finland had borderline tread depth on one or more winter tyres. Inadequate tyres were most frequently found on vehicles driven by young drivers. Furthermore, our results reveal that the proportion of Finnish passenger cars fitted with non-studded winter tyres designed for central European winter conditions is as high as 17% [4]. This figure is high enough to be of considerable concern with regard to road safety, as such tyres are not designed for Nordic conditions of ice and snow. Recently, the EU set out a new regulation on the labelling of non-studded tyres. The new labelling provides information on wet grip capability, but makes no mention of grip performance in snowy and icy road conditions. Although the results show no perceived difference in driver experience between the two winter tyre types [5], the labelling is considered insufficient for the Nordic countries.

Discussion

Road accident numbers and the risk of fatal accidents could be significantly reduced by improving tyre condition. Drivers need to be better informed about the importance of correct tyre type and condition as part of basic driving instruction. Consumers should also be provided with understandable and detailed tyre information. In addition to improving awareness of the type and condition of vehicle tyres, it is also essential that drivers are aware of the characteristics of different tyre types and have the knowledge and ability to adapt their driving behaviour according to the prevailing driving conditions.

Acknowledgements

The studies were supported by members of the research programme “Traffic Safety 2025”. More information about the programme is available at <http://www.vtt.fi/proj/tl2025>.

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A large amount of US dollar bills, including \$100 and \$20 bills, are falling from the top of the frame into a green field below. The bills are scattered across a bright blue sky with light clouds. The text "Economic aspects of safety and security" is overlaid in the upper portion of the image.

Economic aspects of safety and security

Managing strategic risks through cost-benefit evaluation



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In capital-intensive industries and the infrastructure sector, strategic decision-making often involves optimizing investment portfolios and maintenance processes across strategic, financial and risk objectives. Economic analyses are needed to ensure scarce resources, like time and money, are allocated rationally with respect to available investment and asset development options. In addition to this, decision makers also have to weigh up other aspects, such as safety and environmental impacts and business dynamics. Companies therefore need systematic methods for balancing prospective profits and benefits against risk.

Investments as a source of business resilience and growth

Companies have strategic reasons for proactive risk-taking when exploring new investment opportunities under turbulent market conditions. Firms may also be in danger of losing competitive advantage due to decreasing operational performance and

productivity or new, more stringent environmental standards. Risks are inherent to all business decisions, and making effective investment decisions also requires risk management procedures that allow companies to evaluate related benefits and costs in a structured way. For many companies, however, strategic risk analysis remains a highly underestimated part of investment portfolio management.

Portfolio optimisation – weighing up the costs and benefits of investment options

The developed investment portfolio evaluation approach [1, 2] offers both practical quantitative and semi-quantitative methods for optimizing and supporting business-driven asset strategy decisions under economic and other constraints. The approach utilizes systematic methodologies such as investment appraisal, AHP, expert judgement, risk analysis and Monte Carlo simulation. Figures 1 and 2 illustrate the results of a case study. Visual

reports help the decision maker to choose the most profitable investment portfolio that offers the best response to likely changes in the market and risk attitude.

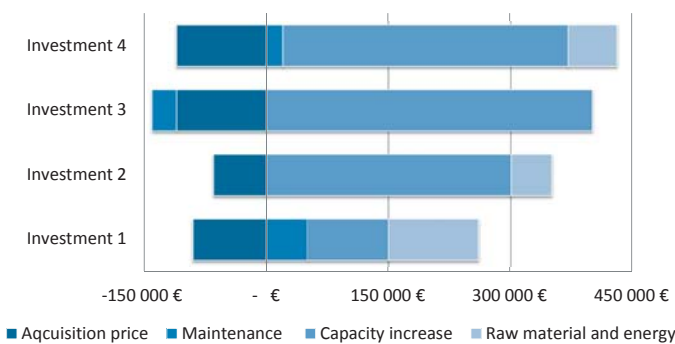
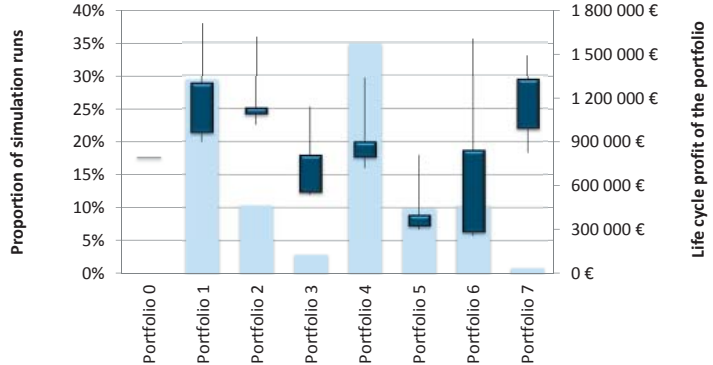


Figure 1. Different graphs can be formulated, e.g. to illustrate the cost and profit structure of various investment options.

Figure 2. Monte Carlo simulations of investment portfolios indicate the profitability and expected variation of



New tools for managing strategic risks

A recent study [3] indicates that companies with more mature risk management practices generate the highest revenue growth. The findings underline the importance of incorporating risk management into strategic decision making. In addition to investment decisions, VTT has developed special tools to support risk-conscious decision making in innovation processes [4], merger and acquisition decisions [5], and business transformation [6]. VTT's portfolio for supporting strategic decision making will be further developed to create awareness of strategic risks and to advance tools for risk-conscious processes in industrial service networks.

Acknowledgements

The authors extend sincere thanks to all participant companies for their fruitful cooperation and contributions to the model development.

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Hanski, J., Kunttu, S., Rääkkönen, M. & Reunanen, M. Development of knowledge-intensive product-service systems. Outcomes from the MaintenanceKIBS project 2012. *VTT Technology* 21. VTT, Espoo 2012. 65 p. <http://www.vtt.fi/inf/pdf/technology/2012/T21.pdf>.

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Market opportunities and networking of the security and safety business in Finland



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Growing awareness of security and safety issues, increased outsourcing of public security functions and technology convergence and integration represent some of the biggest current changes in the security and safety industry. Security systems, products and services are increasingly becoming an integral part of day-to-day life, and the importance of the industry is growing. Today's security and safety industry is rapidly expanding beyond its traditional boundaries. This calls for a more comprehensive business approach and for companies to integrate their services and technologies. For networked players, the market offers great opportunities also from outside the traditional security business field.

Identifying network structures and markets

This paper presents the results of two research projects aimed at expanding current knowledge of the structure, volume and opportunities of the security and safety busi-

ness sector in Finland [1, 2]. The focus was on identifying the most promising markets and growth areas for companies in Finland. The projects also supported networking within four chosen areas of safety and security: elderly care (personal safety), supply chains, situational awareness and built environments. Based on the research results, methods and concrete tools for companies for supporting and advancing networking and internationalisation were presented.

Extensive and versatile research methods and material utilised

Nine workshops with a total of 168 participants were organised to collect research data and to facilitate the participating organisations in networking and scenario discussions. In addition, 77 people from public and private organisations were interviewed and 81 people answered an online questionnaire. A literature review was conducted covering international market reports, industry surveys, press releases, exhibition catalogues, membership lists, journal articles and news databases. Information on the turnover, imports, exports and R&D of the relevant 815 companies were also utilised.

Opportunities and challenges in the security and safety market

Market reviews predict 8.1% annual growth in the safety and security market globally, with Asia as a major growth region. The industry offers growth opportunities for a variety of vendors from diverse industries, and also serves

The main results were compiled as a toolbox for security companies, containing knowledge, models, methods and tips for self-assessment of internationalisation potential, for taking first steps in international markets, and for building international networks.

several customer groups with extremely varying demands. Network cooperation involves the consolidation of different security products and/or services as a comprehensive solution offering. This requires the cooperation and coordination of different companies within, and even beyond, the industry. The key challenges identified in the industry were: 1) meeting the increasing needs of customers, 2) networking, 3) business know-how, 4) innovativeness, and 5) internationalisation.

Acknowledgements

The projects were funded by Tekes – the Finnish Funding Agency for Technology and Innovation, VTT, and the Aalto University School of Business. The participant companies and individuals are gratefully acknowledged for their contributions to the interviews and workshops and for their valuable information and comments.

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Figure 1. Areas of market potential in the security and safety business sector.

Proposals for action supporting potential security and safety business areas:

- Strengthening social networks
- Promoting the growth of security and safety industry integrators
- Developing business know-how and promoting vertical networking
- Participating in research and development
- Turning Finland into a test field for security and safety
- Promoting internationalisation
- Developing auditing practices associated with security and safety services
- Supporting innovation activity

Supplier-perceived customer value in security services



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The market for business-to-business security services is broad, yet highly competitive and price-sensitive. Customers tend to perceive security services as of secondary importance to their core business, which can lead to reluctant and reactive service procurement. Under these circumstances increased customer value offers one option for security service providers to differentiate from competitors and raise the profile of their services in the eyes of their customers. The purpose of this research was to explore how security suppliers perceive customer value, and how these perceptions can be used to develop business-to-business security services.

Security suppliers' concerns regarding customer value

This research indicates that supplier-perceived customer value consists of a bundle of core concerns regarding various customer benefits, characteristics of the customer relationship, and impacts of competition, quality and price (Figure 1).

As Figure 1 suggests, security suppliers' concerns regarding customer value are characterised by a focus on supplier efficiency and value-based differentiation. Supplier efficiency [1] is viewed in terms of traditional, transaction-oriented security business, in which security products and man-hours are

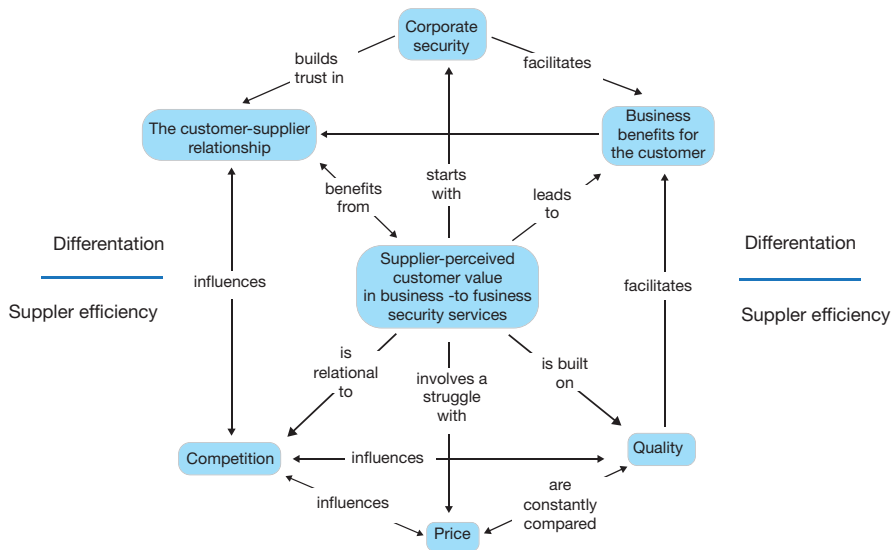


Figure 1. Security suppliers' concerns surrounding customer value and the linkages between the concerns.

exchanged for money without further consideration of additional value and customer benefits. Value-based differentiation [2], on the other hand, is viewed in terms of security suppliers' current intentions and pursuit of more customer-oriented security business and new value drivers for the customer.

Qualitative study with a grounded theory approach

The research was carried out as a qualitative study following the grounded theory research approach [3]. Interviews with 50 managers from seven Finnish security companies form the research data. In the data analysis, several qualitative analysis methods, such as open and selective coding, constant comparison, concept mapping, argumentation analysis and narratives, were used to extract the security suppliers' viewpoints on customer value.

Contribution to security services development

Security suppliers are often in the position of providing business support services for their customers. Suppliers themselves perceive the confining box of 'support services' as a restricting brand, from which they try to find an escape. The most promising way out of the box seems to be enhanced customer closeness, which proved to be the main concern of the informants in this study. Through closer customer relationships, security suppliers try to integrate security service activities into the customer's core business processes, more directly influence core customer activities and new business prospects, and consequently increase the importance of the security services to the customer's business success.

Acknowledgements

This research was a part of the VALUESSE research project [4], funded by Tekes – the Finnish Funding Agency for Technology and Innovation and conducted in close cooperation with the Aalto University School of Business. In total, 10 Finnish companies

participated in the project, of which seven companies were included in this research. This abstract is an extract from the author's dissertation published in September 2013 [5].

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Economic value of safety



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Safety has traditionally been approached from a normative basis as a legal or ethical obligation. As a result, safety has often been regarded as a ‘necessary evil’ and a cost to business. Much of the true value of safety thus often remains unseen and untapped, with safety aspects separated from the ‘real’ work of business management. This separation prevents the full potential of safety from being exploited. Measuring the true economic value of safety reverses this trend by enabling safety to be optimally managed and included as an integral, productive part of successful business.

Importance of evaluating the economic value of safety

The economic value of safety is highly understudied. New research in this area might show that safety is still an under-deployed asset in business and industry – that the economic value of safety far exceeds the savings from avoided accidents alone. If, however, this is shown not to be the case, the need for normative control would be confirmed. In both cases, assessing the economic value of safety is a clear precondition for rational and profitable decision making. Even if the basic requirement is found to be a safety norm, economic evaluation would enable effective fulfilment of that norm. In our current research we are developing models for evaluating the economic value

of safety. In doing so, we have broadened the concept of safety as: ‘the capability of an organisation to sustainably assure its financial and human wellbeing’.

How the evaluation models are being developed

The research is being carried out in parallel theoretical scientific and practical development projects. In the scientific project, safety and value models are being developed by three research organisations on the basis of literature reviews, questionnaires, interviews and workshops arranged in cooperation with the participating industrial companies. In the development project, practical solutions are being developed for a business group in company-specific case studies and the concepts of the scientific project are being tested. The project period ends in December 2013.

Safety as an intangible asset for profitability

The evaluation of the economic value of safety aims to reveal the economic potential of safety and safety work in industrial contexts. Safety is regarded as an intangible asset that has an important role for the profitability of the enterprise. In cases where the economic value of safety is proven to be significant, new business opportunities related to safety management will open.

Costs and benefits of safety

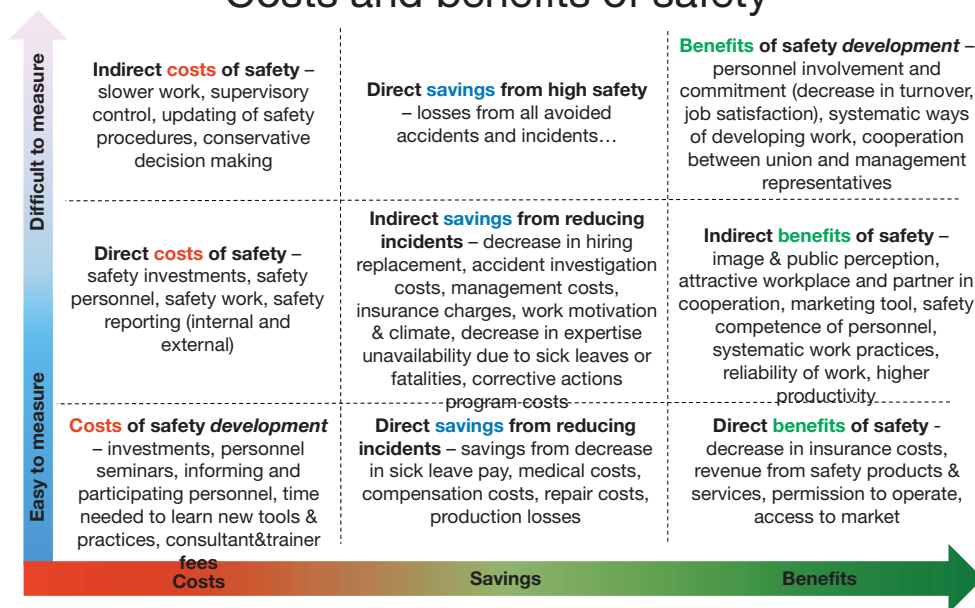


Figure 1. The economic value of safety consists of costs, savings and benefits (added value). The difficulty of measuring the different types of costs, savings and benefits varies.

Acknowledgements

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Improving resilience provides new solutions for risk management



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Resilience has become a widely adopted concept in risk, security and safety management. It describes an organisation's ability to anticipate, monitor and respond to threats and opportunities. Resilience has been defined as a firm's ability to dynamically reinvent business models and strategies as the business environment changes, to continuously anticipate and adjust to changes and to change before the need becomes critical [1].

Need for resilience

To be successful and resilient in an ever-changing business environment, companies must be pro-active. Changes in the business environment provide opportunities for developing new products and services. Industrial practitioners need to be creative to identify changes in markets and to optimize their operating network according to the new requirements. Methods and tools that focus on improving resilience are therefore needed to provide new solutions for managing uncertainties.

Resilience research results

VTT is currently coordinating a FP7-funded EU project on the development and implementation of new sustainability-based industrial models and concepts. New business models need new methods, new divisions of work, and monitoring tools that help organisations become resilient to future change [2]. VTT has carried out a study on how to apply resilience engineering concepts

in Finnish industry. The results indicated that resilience engineering is a promising concept that can be used to improve safety management [3]. Furthermore, we have developed a vulnerability assessment and management approach that provides means for identifying weak points of critical infrastructures and their capacity to react and sustain normal conditions in different scenarios. This approach can also guide the selection process for alternative actions to improve the resilience [4].

New methods and tools

Companies and public sector organisations face external risks that are beyond their ability to influence or control. Improving resilience is the preferred approach to cope with this. The SustainValue EU FP7-funded project is currently developing new methods and tools for manufacturing networks to better cope with increasing sustainability demands. The HARMONISE EU FP7 project will develop a comprehensive concept for the enhanced security, resilience and sustainability of large-scale urban built infrastructure and development. VTT will lead the development of a platform containing, for example, relevant urban resilience information and will also host a portfolio of search, diagnostic, scenario modelling and management tools.

Acknowledgements

The research has been funded by the European Commission, the Finnish Work Environment Fund and VTT.

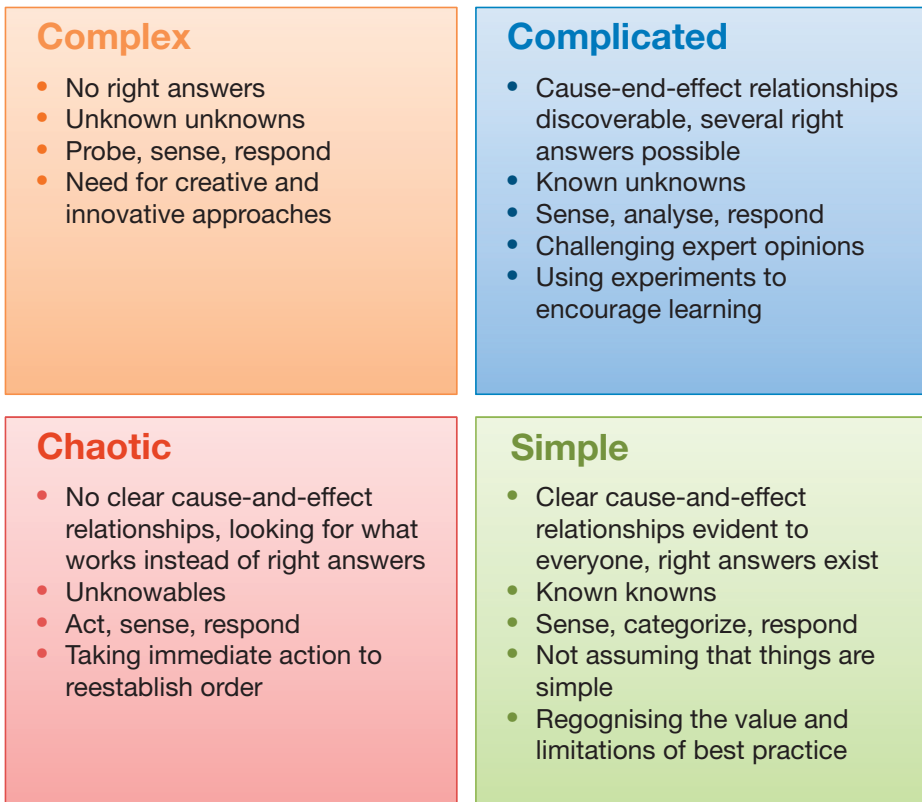


Figure 1. Characteristics of the business environment and response options. Increasing complexity calls for more resilient operations. Adopted from [5].

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Innovation management in security organisations



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This article presents some of the key results of VTT’s contribution to the development of innovation management within the security sector under the Innovation Management Models for Security Organisations (INNOSEC) project of the EU. The aim of INNOSEC is to develop a modular innovation management model to enable public and private security organisations to design, develop and implement innovation initiatives that are responsive to changes in the security environment.

Importance of innovation management

INNOSEC addresses the current need among European security organisations for better management of their innovation capability. The project responds to the challenges faced by security sector actors in keeping pace with their innovation processes within a dynamic, highly complex operating environment characterised by high levels of uncertainty. The vast majority of security organisations are under considerable pressure to cut costs,

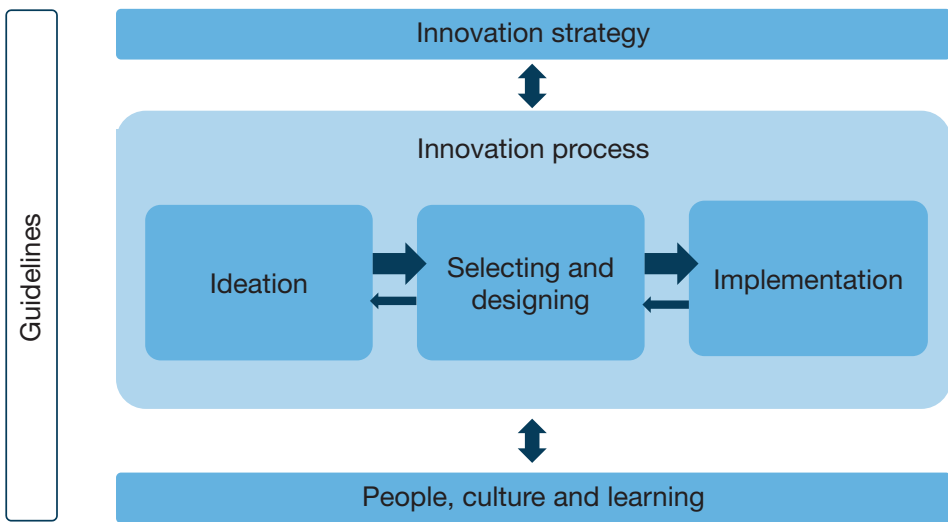


Figure 1. Modules of the INNOSEC innovation management model for security organisations.

and must therefore seek new innovative ways to fulfil their security tasks. These organisations include public and private organisations directly responsible for carrying out security missions as well as departments or units of organisations outside the security sector that carry out security functions.

Research approach

The innovation management practices of different security organisations across Europe were surveyed based on interviews. These findings were combined with VTT's leading expertise in innovation management across a range of sectors and with the research results from previous related projects, such as INNORISK. Based on these results, specifications for the INNOSEC innovation management model were drawn up and a prototype model was developed and tested within a number of security organisations. Feedback from these trials was used to further refine the model.

Implementation of the results and discussion

The developed INNOSEC innovation management model consists of five modules together with user guidelines for application of the model, as depicted in Figure 1. The modules include: Innovation strategy; Ideation; Selecting and Designing; Implementation; and People, Culture and Learning. Each module includes a number of key sub-topics, such as idea generation, searching, and idea management in the module "Idea-

tion". The model's modular design enables it to be flexibly implemented with respect to the security organisation's current management and operational practices – the organisation can implement the whole model or select modules or elements that best meet its specific needs.

The INNOSEC model is generic. Based on our findings, the most effective support for innovation management is achieved through customised implementation of the modules in practice. When successfully implemented, the innovation management model enables security organisations to cost effectively fulfil their security mission.

Acknowledgements

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Related publications

The project results are published on the project websites:

<http://www.vtt.fi/innorisk>

<http://www.innosec-project.eu/>

Value assessment of security decisions



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Security-related decisions, as many other policy decisions, are usually taken in complex socio-economic and political environments. In that environment the decision maker is typically confronted with numerous stakeholders with multiple needs, requirements and values. To make good and justifiable security decisions, the decision maker needs to assess alternatives available in order to find an option that delivers maximum benefits whilst satisfying the requirements and expect-

tations of the stakeholders. VTT participated in a consortium developing a framework and tool for assessing the value of security decisions [1].

Support for policy decision making at the strategic level

The framework for integration of economic and risk assessment is aimed at policy decision makers to support structured and rational decision making on alternative secu-

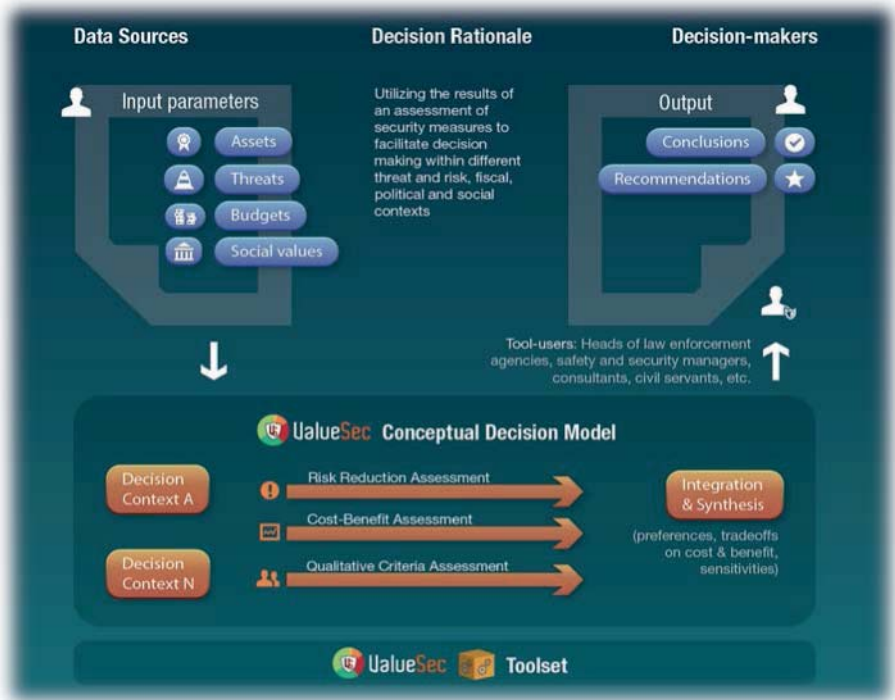


Figure 1. Framework for three-pillar assessment of security decision alternatives [1, 2].

rity measures where an expedient balance between technical cost-effectiveness and political sensitivities must be found. Decision makers are usually subject to official liability and supervised by other authorities. A formal and transparent assessment process is therefore highly valuable and needed to support decision making.

Integrating economic and risk assessment

The developed security decision assessment framework and analysis tools are based on a three pillar approach: risk reduction assessment (RRA), cost benefit assessment (CBA) and qualitative criteria assessment (QCA) (Figure 1). The RRA pillar assesses the risk reduction gained by implementing a security measure; the CBA assesses the economic implications i.e. costs and benefits of the measure; and the QCA integrates qualitative and often intangible criteria, such as ethical, societal and political criteria, into the semi-quantitative assessment. The assessment produces both aggregated and pillar-specific results in numerical and graphical form.

Valuable decisions

From a policy decision making standpoint, neither under- nor over-investment is desirable. Ideally, security measures should be decided on in line with the true interests of the general public. The developed integrated assessment process helps policymakers better anticipate security development, future threats and their economic and societal impacts, and thus make informed and better decisions. [3]

Acknowledgements

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Author(s)	Veikko Rouhiainen
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