ILVES
application

Contents

1 Principal investigator (PI) of the consortium, team leaders, sites of research, name of consortium, date of research plan

Name of consortium: Ilmastomyönteiset ja vähäriskiset kuljetusvaihtoehdot – Developing low carbon and low risk transport systems (ILVES)

Date of research plan: 29 April 2015

Project applicants and responsible persons:

1) UH/FEM: PI (responsible leader of consortium) Professor, fisheries management, **Sakari Kuikka** University of Helsinki: scientific leadership and motivation, Bayesian analysis, decision modeling, Department of Environmental Sciences, Finland, Professor emeritus **Elja Arjas** causal learning from non-experimental data, Associate Professor **Jani Luoto**, Department of Political and Economic Studies, Bayesian methods in economics and effective algorithms

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3) FMI: Dr **Jukka-Pekka Jalkanen** Finnish Meteorological Institute (FMI), Finland, expertise in fleet CO_2 releases and fleet dynamics of large international fleets

4) ÅBO: Dr, Adjunct Professor **Henrik Ringbom** Åbo Akademi, BALEX Finland, Finland, expertise both from operational oil combatting management (former head of environmental unit in EMSA) and in theory of power of marine legislation in risk governance

5) KYAMK: Research Manager, Master mariner **Justiina Halonen**, Kymenlaakson ammattikorkeakoulu, Kymenlaakso University of Applied Sciences, Finland, expertise in education or maritime actors, simulation tools of fleet decision making

6) LUT: Dr **Jyri Vilko** Lappeenranta University of Technology, School of Business and Management, Finland,, expert in logistics and related risk and decision analysis, professor **Pekka Sutela**, world know exåert in Russian political uncertainty, professor **Heikki Haario**, expertise in effective algorithms to find probabilistic dependencies in complex problems

7) KMRA: Dr **Miina Karjalainen**, Kotka Maritime Research Association (KMRA), Finland, expertise in environmental settings of Gulf of Finland and in interdisciplinary analysis of maritime activities

8) AALTO: Prof. **Olli Varis**, Aalto University, Finland, internationally known expert of political and environmental development in third world countries, especially in Middle East

9) CSIRO: Dr **Rich Little**, expertise in societal design of insurance policies, Dr **Beth Fulton**, complex ecosystem – human interaction models and their operational use, Dr **Ken Lee** & Dr **Simon Barry** oil spill risk management in Australia, Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia

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11) HUGIN: Dr, CEO, **Anders Madsen**, HUGIN Expert A/S, Denmark

12) DUKE: **Kenneth Reckhow**, Duke University, USA

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Instead: FEM Risk governance and calculus ltd. To be established in summer 2015 by the help of University of Helsinki

2 Rationale

The proposal develops risk management tools to support decision-making in the Finnish transportation sector. The main aim is to find means to decrease the greenhouse gas (GHG) emissions of the sector and thus, in consequence, to help to achieve the international and national GHG emission reduction targets. The scope of the proposal includes transportation of cargo and passengers on road and railways, and shipping in the Baltic Sea (*Fig. 1*). The considered time horizon expands to year 2050, which is the target year of the EU's policy aiming at significant reductions of GHG emissions from transport sector. This proposal aims at developing solutions matching the goals defined in the EU White paper on transport (EC, 2011) from the point of view of Finnish society.

As far as these aims are concerned, the environmental record of shipping can and must be improved by on-board technology, fuels, and operations. Overall, the EU CO_2 emissions from maritime transport should, according to the White Paper, be cut by 40% (if feasible 50%) by 2050, compared to 2005 levels (EC, 2011). Also Finland has set specific objectives for the climate policy implementation. According to the maritime strategy of Finland for 2014–2022, Finland will be a forerunner in winter and environmental technology, and will export high competence in those fields. Furthermore, the deep water fairway in Saimaa Lake District is part of the core network corridors defined in the Connecting Europe Facility of the EU Infrastructure Package. Developing the inland waterway (IWW) system in Finland would support the White Paper (EC, 2011) targets.

However, GHG emissions are not the only environmental concern that needs to be addressed. ILVES will study the effects of the policy options on several other socio-economic and environmental factors. For instance, a single oil spill in the Gulf of Finland can incur costs up to one billion euros. This cost would be shared between ship-owners through their insurance companies, international oil pollution compensation funds, and Baltic Sea countries. Finland is a member of the Supplementary Fund of the International Oil Pollution Compensation (IOPC) Funds, which has a compensation limit of SDR 750 million (€ 961 million).

However, the compensation is paid only if oil pollution result in an actual and quantifiable economic loss related to property damage, oil combating and clean-up costs, economic losses in fisheries, mariculture or tourism, and costs

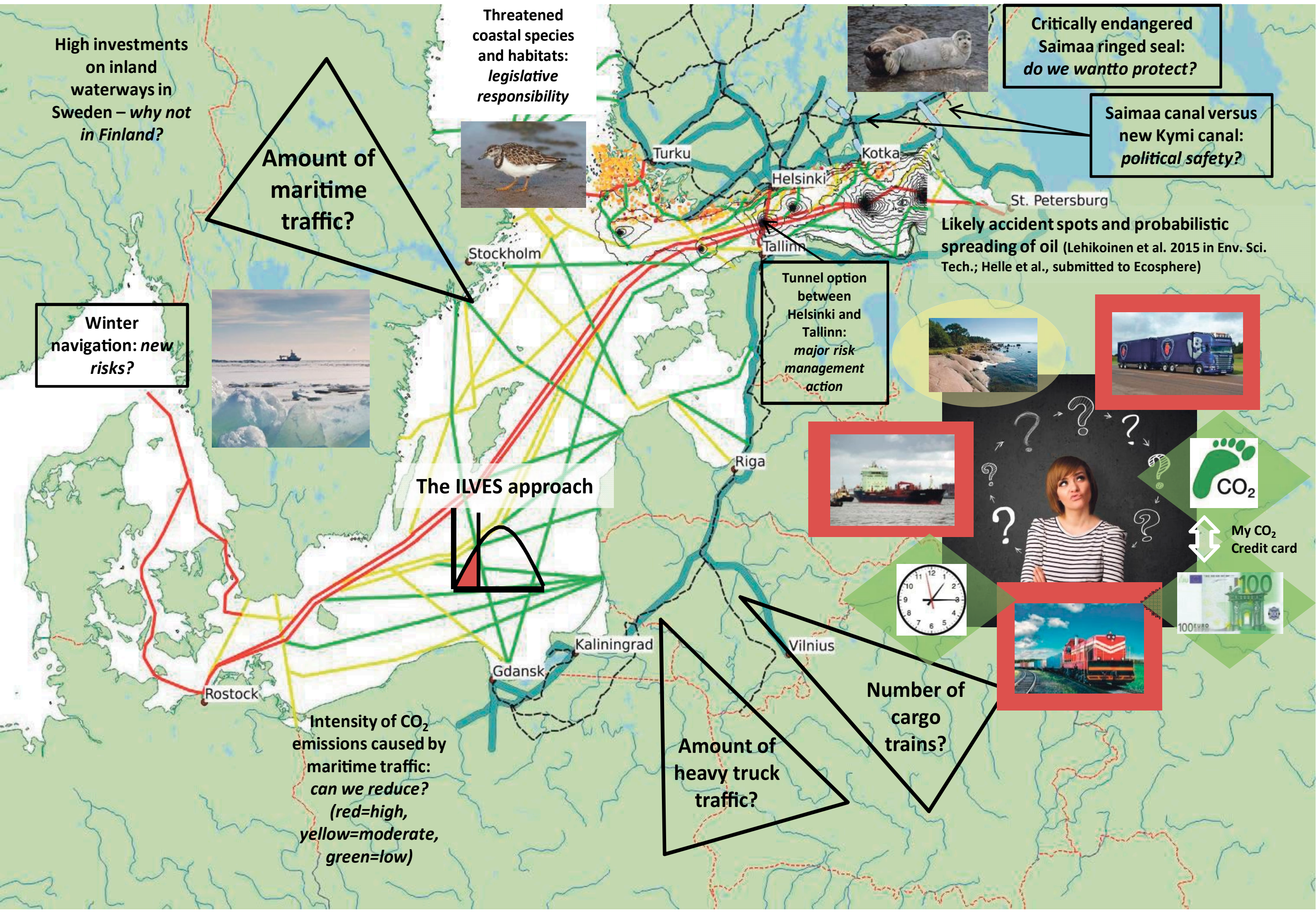


Fig. 1. *The ILVES approach where different forms of traffic and possible development options are shown. Picture describes the selection of best (time, cost and low CO_2) traffic options between maritime traffic, inland water routes, land routes, Helsinki-Tallin tunnel and Kymi canal. Threatened nature values in specified areas are also shown. Picture includes CO_2 emissions of maritime traffic in the Baltic Sea (green=low intensity, yellow=moderate, red=high), locations of threatened species and habitats in the Archipelago Sea and the Gulf of Finland (yellow=moderate oil combating prioritization, orange=high, red =very high), average oiling probability in the Archipelago Sea and the Gulf of Finland based on accident hot spots (white lines describe oil drifting), railways (black dash line), highways with intensive truck traffic of over 2000 tons per year (thick blue line), Helsinki-Tallinn tunnel (black double dash line), inland rivers and lakes (light blue narrow lines and polygons), occurrence of Saimaa ringed seal (species picture), and Saimaa and Kymi canals (thick light blue lines).*

of reinstatement of the environment (IOPC Funds, 2013). Hence, losses to environmental values that are typically difficult to assess are excluded from the compensation scheme.

Furthermore, inland water area, especially the Lake Saimaa district has several protected areas, where the habitats of protected species are close to the Saimaa deep water route where the merchant vessels are sailing. Accident and near miss incidents recorded by maritime authorities reveal that the accidental risk in the Saimaa Lake is relatively high compared to the sea areas. Challenging navigating environment emphasize the importance of piloting or compensatory service for vessels.

The project studies several policy options that have a potential to improve the efficiency of transportation and thus decrease the GHG emissions and investment costs on traffic infrastructure. The set of management options includes structural issues, such as the development of the Finnish dry port structure and railway network, reduction of the number of coastal harbors (Tapaninen, 2015), promotion of inland water ways and harbors, construction of the Kymijoki canal, and the proposed railway tunnel between Helsinki and Tallinn.

Sophisticated modelling tools are necessary to assess the combinations of actions which lead to GHG emission reductions from the transport sector. Therefore, from the methodological point of view, our main objective is to develop new techniques for policy design, which are based on extensive use of the underlying scientific theory, existing data sets, publications, and expert knowledge to provide risk related advice (Haapasaari et al., accepted). We will

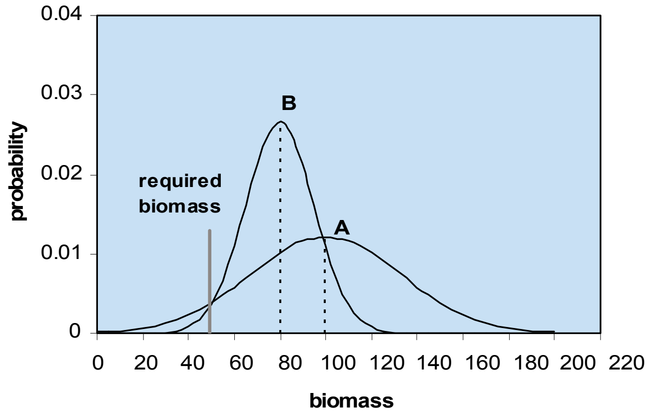


Fig. 2. *Picture shows the impact of biomass point estimate on management decision and causing wrong policy advice.*

combine existing knowledge by summarizing information using probabilistic forecasts. To be more concrete, we forecast the future scenarios by the forward simulation version of the developed model fitted to relevant data, including economic and climate indicators. Indicators describe the state of interest variables by the noise included to likelihood function. We then forecast probabilistic outcomes of the key interest variables conditional on designed policy actions. We use these forecasts as an input in a decision model, where the optimal policy, given the underlying key uncertainties, can be evaluated. This can be done separately or jointly with the key societal aims to understand the role of precise aims in the policy support (Kuikka and Varis 1997, Varis and Kuikka 1997).

The rationale of probabilistic approach is described in *Fig. 2* which shows how the use of a point estimate can provide wrong policy advice in risk averse decision making. For instance, if the criterion is to avoid the risk level of small biomass, a point estimate would suggest policy A that provides better expected value (*Fig. 2*). However, the uncertainty related to this option is estimated to be higher than that of policy option B.

The proposal supports decision-making related to efficient allocation of resources. Science can help to find the optimal policy design, and due to the extreme costs, even small adjustments in infrastructure investments can pay back to national and private economy and society's welfare (for instance, the cost of EU infrastructure development to match the demand for transport is estimated to be over € 1.15 trillion in 2010–2030 (EC, 2011)). Furthermore, we give strategic advice how to allocate research resources by carrying out the value of information analysis (Mäntyniemi et al., 2009). We apply Bayesian techniques to assess the value of information and value of control in planning the policies (that is, we use value-of-control analysis).

This is, to our knowledge, the first study to apply the Bayesian causal modelling techniques to the planning of future legislation options. We are especially looking forward to apply the Pearls algorithm (Pearl, 1995) to the optimal policy design under the case where many variables of a noisy chain link the decisions to aims (*Fig. 3*) (Varis and Kuikka, 1997).

The proposal develops methods that are relevant from the national as well as international point of view. We develop general policy evaluation tools for cases, where the amount of fata, models, papers, experts and other sources of information vary in terms of their quality. We also expect that our approach to evaluate the impacts of various insurance practices will be highly relevant for international insurance practices. Furthermore, the methodology developed related oil spill risks can be seen important for the Finnish and Baltic Sea oil risk management.

For this proposal, we have improved the FEM team by recruiting more skills from UH and Finnish universities and international scientific bodies. At the moment, our approaches are built upon the following publications:

Klemola et al. (2009) published the approach of Bayesian statistics in oil spill risk analysis, but no citations have been obtained to this paper, in a maritime academic journal. There seems to be no tradition for advanced risk analysis in the area.

Juntunen et al. (2005). First step in the methodological process was published in this paper in ICES annual science congress. It was not accepted in a journal of coastal processes. Journal was focusing on oceanology where causalities are based on theory of physics.

Lecklin et al. (2011) showed how the behavior of e.g. birds must be taken into account in conditional probabilities of impacts (close to concept of likelihood in usual statistical models), i.e. do e.g. migrating birds in GoF actively look for oily places where the surface is deadly calm and can seal avoid the oily areas?

Ihaksi et al. (2011) used the concepts of value-of-control, vulnerability of the population and conservation status of the species to plan spatial decisions of locating oil booms by an risk indicator.

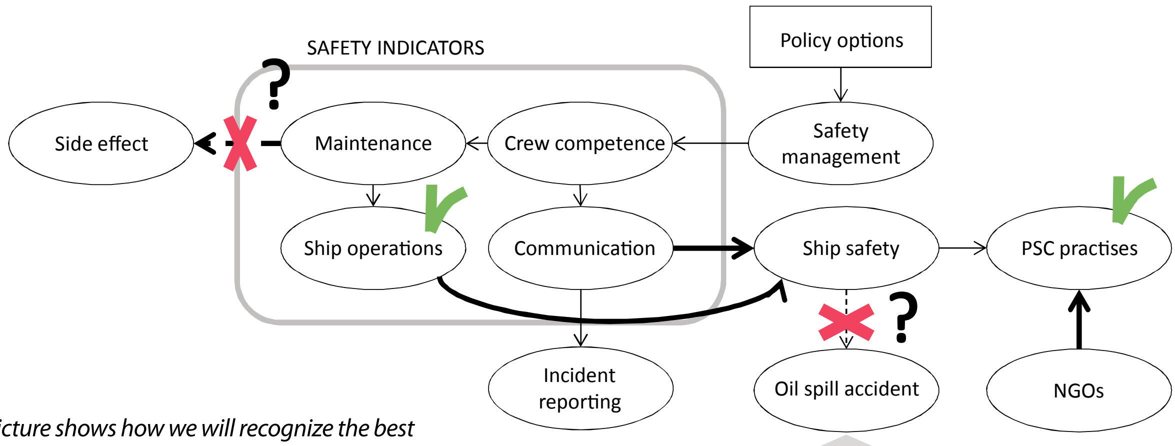
Kokkonen et al. (2010) implemented the spatial knowledge to practical software distributed to firemen who decide in practice, and they liked the product.

Helle et al. (2011) carried out an operational test by a local BBN decision model: how e.g. the logistic limits is going to impact the chance to act in different sizes of accidents, under the aim to safeguard the nature values of the hot spot areas around Tvärminne field station. In a case of big spill, both booms and time run out.

Lehikoinen et al. (2013) evaluated the current effectiveness of oil combatting fleet in Finland under observed weather conditions

Jolma et al. (2014) demonstrated how to use spatial models and software's to estimate key parameters to the BBN model

Helle et al. (accepted) made a probabilistic cost effectiveness analysis of whether the last oil combatting vessels investment (45 million euros) was profitable anymore in Finland. Answer was no, which created discussions in Finland.



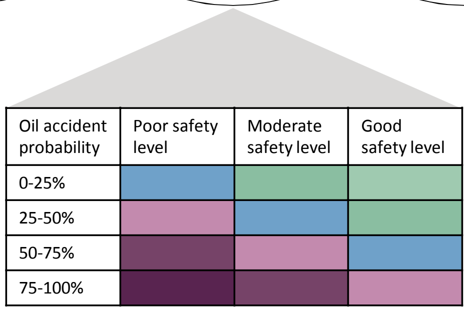


Fig. 3. *Picture shows how we will recognize the best practices in private oil company safety management (e.g. vetting practices) and assess how those can be transferred to national management (e.g. PSC). In addition, we will to recognize the possible harmful side effects of policies and actions (dashed lines), and study by which methods those can prevented (red cross). Thus, we aim to improve the tools for maritime safety and reduce the probability of oil accidents. The higher dependencies are marked with larger arrows. In matrix, darker color describes higher probability. Model is applied from publication Hänninen, Maria; Valdez Banda, Osiris A. and Kujala, Pentti. Bayesian network model of maritime safety management. Expert Systems with Applications, 41, 7837–7846, December 2014.*

3 Societal significance and impact

Transport of goods and people is fundamental to any modern society. International and national trade support creation of jobs, improving employment and welfare. Finland is isolated by sea from the most of the import areas and export markets. The value of the exported goods and services was 77.6 billion € constituting 40% of the GDP in 2013. In terms of weight, 88% of the exported freight was transported by sea in 2012. Harbors link Finland to foreign markets. In 2012, 17 harbors processed over 1 million tons of freight each. The on-shore and off-shore operations, vessel construction and logistics of transport are optimized by business logic. Simultaneously, they have to acknowledge sustainable development and environmental constraints. The aspects of economic competitiveness and environmental risk can be evaluated in a decision support framework. They integrate knowledge related to future CO_2 emission reduction abatement technologies and costs, logistic solutions and the assigned environmental risks with the utilities perceived by the policy makers and stakeholders. As a result, decision support will facilitate balanced argumentation and provide societal, commercial, and environmental benefits in Finland.

The names of the EU maritime legislation packages (e.g. Erika I, Erika II) carry the names of accidents. This is an indication of inertia in science–policy interaction influencing the maritime risk governance in Europe: major accidents provide impulse to improvements in legislation. But, unfortunately, only after the hazard has come true with severe consequences. If same risk management approach would have been adapted in the arenas of nuclear safety and aviation, the earth would be an unpleasant place to live in. No doubt, there are many lessons to learn from those arenas, where it is everyone's imperative interest that no accidents take place. In nuclear risk management, all actions improving safety are based on model outcomes, demonstrating the strong role of science.

We will adapt the most valuable lessons from these disciplines and advocate their implementation in maritime risk management, where the scientific methodological background is weak compared to e.g. precautionary fisheries management. In fisheries, an important field of applied "engineering" ecology, i.e. risk methodology, is highly advanced. In nuclear power management there is a strong trust to build the actions on complex risk models. A comparable approach would assist maritime risk management to learn more effectively from all disciplines.

The main societal impacts of ILVES approach are as follows, given the project findings are implemented successfully:

1) findings will supporting the policy to achieve the targets in CO_2 emission reduction

2) investments based on suggested chain of creating new jobs along inland water ways

3) improved state of environment

4) improving the interest to apply best practices in companies that create main risks, leading to higher quality in all activities.

The strategic answers of ILVES to the 4 questions made by the call are as follows:

A) How can we improve resource efficiency and support the move towards a circular economy, which will serve to boost exports and competence-based growth in Finland?

If the project findings will be implemented by the Finnish government, the need to use fossil energy in shipping and other traffic will decrease. The project findings will support the development of new shipping technology in Finland and therefore support exports. The new methods to develop legislation and other national policy options will support the development towards competence-based growth, as creation of such development needs a combination of national actions (taxes, subsidies, legislation, customer behavior). The new transportation options to inland water will boost local investments. As no development can take place without negative impacts, we look at the oil spill risk changes related to various transportation options.

B) What are the requirements for climate neutrality and resource efficiency in society? We will study the requirements for climate neutral society, by calculating with a Bayesian decision model, what are the prerequisites of the national and international policies to achieve the desired state of the climate aims in transportation policy. Bayesian network models can calculate the states of the system from causes to effects like any models, but they can also calculate backwards, .i. from desired aims back to required policies. This methodology will be important is overall support of climate policy by scientific tools. We will study how the oil companies, shipping companies and the users of these services increase their interest to avoid environmental disasters to decrease the CO_2 emissions. Different policy options (such as taxes, fees, financial instruments and sanctions) are compared to these ways to govern the environmental impacts in society. The legal feasibility of the policy options, bearing in mind the international nature of maritime transport and consequential international law limitations will form part of this assessment.

Fig. 4. *The observing of vessels and other scientific data may describe the reality only in a limited way, if you look to a wrong direction.*

C) In what ways can the public sector best support the overall transition so as to maintain a well-managed move towards a climate-neutral and resource-scarce society? There is no clear answer to this question yet, but we will develop methods, legislation planning tools, practical policy actions and new governance solutions to reach these goals. The potential big impacts of resource-scarce international markets will be studied by the risk analysis of worldwide food production. New machine learning methods are applied to the worldwide food production data sets. Same methodology is used to learn traffic risks from large marine data sets.

D) How can we ensure that businesses, employees, the public sector and consumers possess the resources and skills that promote an ability to adapt to the changes and risks brought about by disruptive technologies? We will analyze how new shipping technologies (such as new fuels, use of electric power in inland water to avoid oil spill risks) and shipping options can be used to support the climate policy in the EU and Finland. We will look at the customer behavior is selecting low carbon products from markets and how the role of NGO's should be revised in the support of creating interests for companies to apply best available techniques to their shipping practices. In addition, we will analyze risks related to the Finnish-Russian agreement on which the use of Saimaa channel is based on. This is a main political risk factor for the investments needed to develop inland waterway traffic.

4 Objectives, expected results

The project involves six topics (*Fig. 5*). These sub-projects have close interconnections, and they support each other.

Topic 1: Analysis of Historical data and meta-analysis on publications

While the considered theoretical models may help to identify the effects of the policy actions, we also use the Pearl's (2000) approach to try to identify causalities of interest from non-experimental data, including data on policy actions in the past. We believe this would be a valuable approach for all policy analysis in the society. Using the empirical and theory based knowledge, we then estimate the likely future impacts of policy actions on the key variables of interest, by simulating the future developments of these variables conditionally on the policy actions. In particular, we consider the forecast horizons of 10, 20, and 30 years, which provide clear yardsticks for an analysis of policy impacts. We insert these predictions into a decision model, where the implementation uncertainty (i.e., how likely it is that a policy will

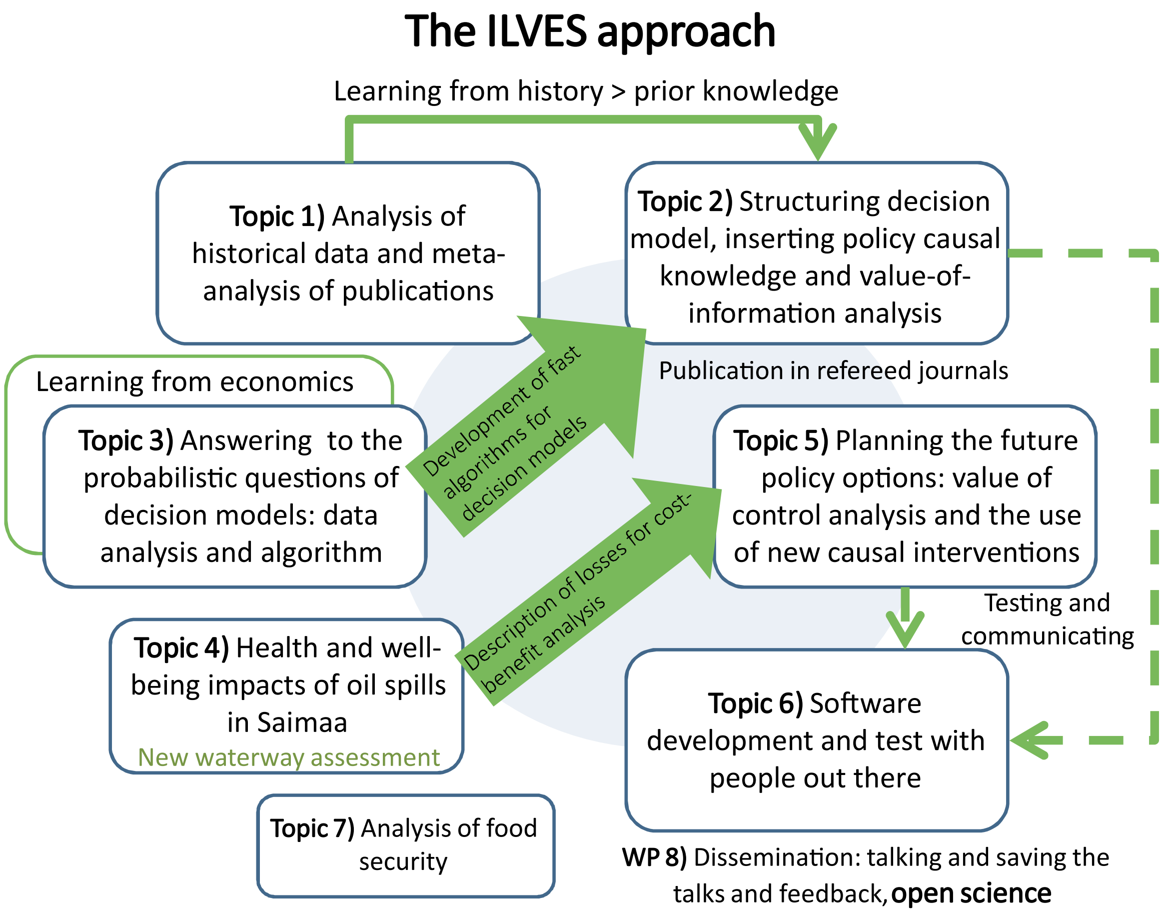


Fig. 5. *The linkages between topics in ILVES approach.*

be adopted in the way proposed) will be evaluated by the experts in maritime policy and law. In this decision model, we account for different types of uncertainty due to using expert judgments, and integrate them into the considered decision model by applying suitable probabilistic weighting. The decision model will also provide value-of-information estimates (Mäntyniemi et al., 2009), which describe what variables should be known more precisely at the time when decisions are made. This information is used in the project to focus the data analysis and the modelling on policy relevant variables. In the planning of potential new policies, we also use the value-of-control analysis, where each probabilistic variable is made at least partly controllable by adding a new decision variable to the model. The analysis will reflect back to the planning of new legislation. This approach to modelling will provide estimates of the likelihood to achieve the given GHG emission reduction targets for the Finnish fleets, and the related economic, social, and environmental interests in probabilistic terms.

Topic 2: Structuring Decision Model

As far as the structural analysis is concerned, we apply an emulator model to learn from the behavior of the complex micro economic models. We also try to identify causalities from the data, by combining the information of the micro economic model with the alternative views of the causal structure of the system. This will be achieved by an effective utilization of the views of different experts and stakeholders on causalities. If successful, the learning from causalities by combining micro economic models and expert opinions will be a novelty in economic and environmental analysis. The methodology may have a major impact on the understanding of the impacts of policy actions (yearly interventions by total allowable catches) on stock dynamics, or in environmental management of water quality. The proposed method can be used in any policy evaluation setting, where similar data are available, as in the evaluation of economic policies.

Topic 3: Data Analysis and Algorithms

In practice, risks and probabilities can not be directly measured. Therefore, we need sophisticated modelling tools to assess them. Our goal is to develop new techniques for probabilistic forecasting, including descriptive time series methods and models that combine the underlying scientific theory with data (e.g. Kuikka et al. (2014)). We especially plan to devise methods for combining the forecasts from the different models, to incorporate all available information into the probabilistic forecasts. Our goal in this project is the development of statistical tools and techniques for combining the predictive distributions obtained from large scale models in the described situation.

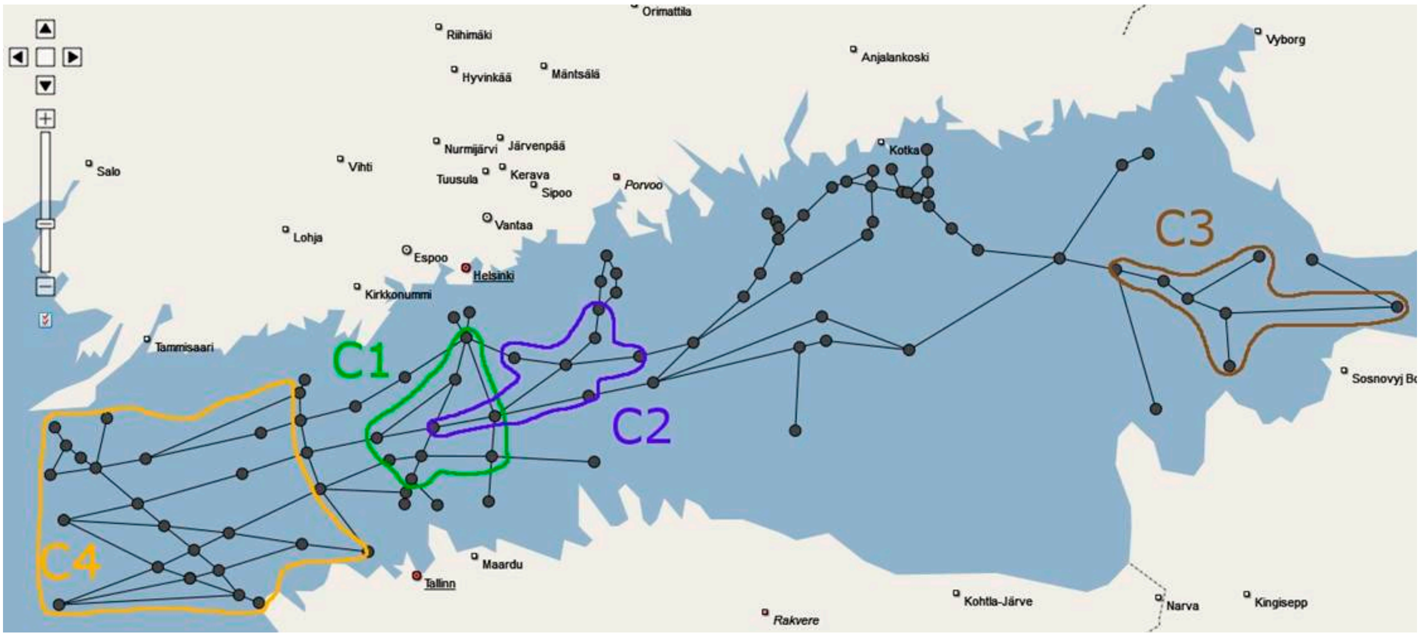


Fig. 6. *Definition of risk areas of maritime traffic in the Gulf of Finland based on traffic data (Lehikoinen et al. 2015)*

There is also an under evaluated link between the Bayesian parameter estimation and decision models. Many of the algorithms use extensive time in estimating the tail probabilities of the distributions. However, the desired accuracy of the approximation of the target posterior distribution is linked to the decisions. In particular, if the ranking of the decision options is no longer sensitive to the quality of the estimates of the posterior, the algorithm can be stopped from running. Therefore, the use of decision models together with parameter estimation is essential for such online decisions or fast decision making, where there is no time to wait for better estimates.

Fig. 7. *The fishermen would be hit hard with a spill. Not all of them can express themselves clearly when telling their story.*

Topic 4: Health and Well-being Impacts of Oil Spills in Saimaa

We will a detailed look at the risks of toxicology of oil spills on inland water ways (*Fig. 6*). The Saimaa deep-water route is particularly difficult to navigate because of its narrowness and fast currents, with the consequence that no oil-combating vessel can significantly decrease the risk of oily shorelines. Accident and near miss incidents recorded by maritime authorities reveal that the accidental risk in the Saimaa Lake is high compared to the sea areas. The Finnish inland water area, and especially the Lake Saimaa district, has several protected areas, where the habitats of protected species are close to a deep water route used by merchant vessels (*Fig. 7*).

Oil spill may also potentially have an impact on human health. The current exposure to PAHs through eating fish from Saimaa will be evaluated. Assessment is based on literature survey of PAH concentrations in different fish species and use of fish consumption data available from previous studies. Health impact assessment is done by utilizing the previously developed open access model, which have been successfully used for determining health impacts of herring consumption in Finland. The current exposure to PAHs through eating fish from Saimaa will be evaluated. Assessment is based on literature survey of PAH concentrations in different fish species and use of fish consumption data available from previous studies. Health impact assessment is done by utilizing the previously developed open access model, which have been successfully used for determining health impacts of herring consumption in Finland. The societal values of recreational use of Saimaa are first estimated based on a literature review of societal utility of inland water bodies and then the questionnaire is used to evaluate the effects of oils spills on wellbeing.

Topic 5: Planning the Future Policy Options

Alternative future scenarios for environmental policy changes in shipping (efficacy of Emission Control Areas, vessel speed limitations and use of LNG as fuel) will be tested using actual traffic data from Automatic Identification System (AIS) (Jalkanen et al., 2012) and chemical transport modeling. These facilitate the evaluation of environmental performance of maritime policy changes and have been already used as background scientific material at HELCOM and IMO. The use of actual ship traffic patterns and volumes aim at reducing the cumulative uncertainty of the cost/benefit analysis, thus improving the overall performance of the Bayesian approach (Helle et al., accepted). The shipping scenario work directly contributes to the revision of the national program of measures of the marine strategy, the first version of which already incorporates Bayesian modelling. Our proposal extends the work described in the national program of measures by offering a more complete view on different transport models and including several future scenarios up to year 2050.

Topic 6: Software Development

We will further develop software development and test with people out there: are people interested about our products given their values? We will use systematically Metropol feedback systems in the yearly ICES WGMABS open risk communication meetings (2016: St Petersburg to meet industry, 2017 to help international WWF to adapt those parts of ILVES and WGMABS approaches which are needed for successful risk governance.

Topic 8. Analysis of food security

The food security projections will be drawn from global analyses of food consumption-production dynamics, taking into account risks related to hydrological and climatic factors, climate change (Kummu et al.,2014), supply-loss-demand chain uncertainties and risks, as well as trade factors (Porkka et al. 2015). These analyses provide results in several scales including by country, by food-production unit and partly also by grid cell. Results for Finland can thus be directly obtained, and the trade flows as well as forcing functions, e.g., from climatic risks can implicitly be calculated; the former ones even singled out by trading partner. The outcomes of global food security models will be used as inputs to Bayesian network models, and the vulnerability approach will be used to assess the societal and environmental risks, resilience and adaptation capacity of the food production-trade-consumption system.

Topic 9: Dissemination

In here, we will especially give talks and obtain feedback on spoken messages, by using the modern web based techniques (*Fig. 9*). Systematic use of Metropol feedback systems in the yearly ICES WGMABS open risk communication meetings (2016: St Petersburg to meet industry, 2017 to help international WWF to adapt those parts of ILVES and WGMABS approaches which are needed for successful risk governance) is likely a very good opportunity to start discussions before disasters take place.

5 Research methods and material, support from research environment

5.1 Research Methods

In addition to existing standard research methods commonly used in empirical and theoretical analyses, one of the main objectives of the project is the introduction of new methods that will subsequently be subjected to the scrutiny of empirical applications. Moreover, the properties of the new methods and major modifications of existing methodology will be studied by means of simulation experiments. Because of the complexity of the models to be considered, computer intensive methods based on simulation will play a central role in the majority of the empirical and theoretical analyses.

The overall modeling approach including partners is as follows. The ILVES approach is strongly led by Bayesian inference and decision analysis tools. The experiences of FEM group are used in developing and leading this process. The economic estimation and simulation models of VATT, together with the large datasets, are used to estimate economic changes. The UH/ECON will provide skills in the Bayesian time series analysis and in testing the theories given the observations. HUT will provide the models related to world wide food security and likely future risks. FMI will provide state of the art models to describe the emissions of shipping fleets, their atmospheric dispersion and impacts to the human health and the environment, LTU will provide knowledge in Bayesian MCMC analysis of complex models, the models used to manage logistic chains, and the expert knowledge and international expert views of Russian development having a potential impact on planned logistic pathways through Saimaa lake area. Åbo Akademi will provide expert knowledge in evaluation of current and potentially future national and international maritime legislation and its probabilistic impact on risks. KMRA will add to the stakeholder contacts and dissemination. KYAMK will provide practical experience from maritime activities, and the databases of inland shipping routes and possibilities. University of Duke will provide Bayesian modelling skills in analysis of the Gulf of Mexico oil spill impact analysis economic analysis. CSIRO will provide Bayesian expertise in exploitation and risk analysis, analysis of insurances to increase the interest to avoid accidents, and expertise in oil spill risk analysis. HUGIN Expert A/S will look at the interactive web tools to analyze the utility functions of the decision making. Moreover, it will develop more expert judgment orientated interface for Hugin software.

Cost benefit analysis of developing inland waterways: In the probabilistic cost benefit analysis of the more intensive use of inland water ways, KYAMK will compile the SYKE data of the location of threatened species in areas where an oil spill is possible. Moreover, we value the damages to the use of summer cabins in the lake area by implementing an interactive questionnaire in the web, aiming to estimate the willingness to pay of the Finnish cottages owners to prevent spills. The potential losses of nature values and recreational values are the key elements of risks related to new traffic options in inland water ways. Moreover, as a an alternative policy of safeguarding nature values only (to see whether the aims lead to different policies) we will use the techniques of Ihaksi et al. (2011) to estimate the impacts of possible oil accident on threatened species. Among these, the Saimaa purpose seal is the most threatened and charismatic species, where Finland has a responsibility in safeguarding the population.

In the modeling of oil spill impacts in an ecosystem, whole ILVES team will invest on the combined knowledge of theory and data sets. UH/FEM and CSIRO will use Atlantis ecosystem model (Fulton et al., 2011) as a platform, it includes both theoretical thinking and parameterizations in various parts of worlds oceans. UH (8 pm for Bayesian part of oil risk) and CSIRO (8 pm for making other parameter settings available and modeling them) lead the process and Duke provides the Gulf of Mexico data sets and causal learning in non-experimental data with human induced impacts.

Sub-models of Atlantis simulate oceanographic processes, estuarine and atmospheric inputs, nutrient cycles and biogeochemical factors driving primary production, predator-prey relationships among functional groups, habitat interactions, species movements and invasive species and human uses of marine ecosystems, such as fishing, aquaculture, energy and transport. Saying in other words from causal inference, Atlantis is a set of human induced impacts and ecosystem causal knowledge and model can be used as ”reality with likelihood based provision of simulated noisy data sets” when testing whether causal algorithms find a correct model structure from these simulated data sets.

We create a learning component to Atlantis by using Bayesian inference, where some of the parameter values are obtained from other areas where Atlantis has been pa-

Fig. 8. *During winter navigation ships are exposed to greater risks than when sailing in ice-free waters. The combination of unusual ice conditions for mariners and the existence of rocks in unpredictable areas make the Gulf of Finland and Archipelago Sea very difficult areas for navigation and ship operations. Drifting ice fields can disturb the ship's radar image, make aids to navigation disappear under ice and move ice channels in ambiguous ways. Photo by Timo Kuparinen.*

rameterized, some are coming from publications related to previous spills and some are expert judgment's. Especially, we look at the Gulf of Mexico oil spill databases to learn oil impacts (Duke). We will apply the Atlantis to the Baltic and link the spatial risk estimate values (Lehikoinen et al., 2015) to the ecosystem. This is a combination of theory and data in historical data analysis and in future simulations.

For the risk analysis models of the worldwide food security and its impacts on the food security in Finland, Aalto will use the expert judgments on the chances that the fleets do no operate like assumed, due to for example harbor strikes. The food security models on the expert judgment models, where the aim of the Bayesian analysis is to model the uncertainties in causalities. These models are based on link matrixes, and they currently include expert understanding without extensive data analysis, and therefore they can be used as priors for more data based analysis. We use the machine learning algorithms of FEM Consultations (to be developed in this project) to run these additional analysis, using the extensive data sets of FAO. The sensitivities and risks of the system will thereafter be analyzed by sensitivity analysis that focus especially on uncertainties in causal relationships, like carried out for climate change models in Varis and Kuikka (1997).

In the analysis of inland water ways, LUT will also look also at the Kymijoki option which is estimated economically several times and the estimates can be used to look at the optional costs of such traffic option, where we invest on the inland harbor chains, by the Russian uncertainty of keeping the Saimaa channel open must be taken into account. We use expert knowledge (Professor Pekka Sutela and e.g. Russian transport specialist Professor Evgeny Korovyakovskiy) to look at the conditional probabilities needed to define impacting processes and potential futures. VATT will analyze an economic risk analysis by recreational values, where willingness to pay estimates to avoid spills are exploited (Helle et al., accepted) and by making a new questionnaire in the web to cottage owners.

In building the option of investing on new channel option for river Kymijoki, UH/FEM will analyze the sediment contamination is a risk related to the building of channel, where the toxic elements in sediments are then released and a human health risk activated This needs to be compared to the risks caused to e.g. Saimaa ringed seal, which is a small population where the safeguarding responsibility of Finland is of very high status. We apply the risk methodology developed for GoF to the inland waterways to be able to compare the environmental risks caused by traffic options. This knowledge is made available to customers by using the new tools in web to show

In order to support methods for vessel safety evaluations, KYAMK will focus their work on the operational safety risk in inland waterborne traffic is estimated with expert in the field; pilots and captains of the vessels (*Fig. 8*). Reconstructing the operating environment of Saimaa deep-water route and the connected fairways to the navigation simulator enables focused ship maneuver training in identified high-risk areas. Shipping route specific simulation allows also to test the performance and applicability of different size and types of vessels.

5.2 Data management plan

The data used in the empirical applications will be drawn from various sources, including commercial databases, such as the Datastream database as well as databases provided by central banks and other government agencies over the internet, and official statistics. In addition to data, we apply modern methods of biometrics to learn conditional probabilities of causalities from published papers.

We utilize the existing large databases of:

- VATT and Bank of Finland for the economic data
- National and international vessel databases of Trafi
- Lloyds register database for vessels around the world (to be paid by the project)
- Traffic databases of Trafi, already analyzed in TUT modelling of CO_2 emissions
- CO_2 footprint estimates of SYKE and University of Oulu
- Fish stock estimates of ICES (International Council For the Exploration of the Sea) for the impacts on stocks and fisheries
- Threatened species database of SYKE, which is already linked (Jolma et al., 2015) to vessel accident estimates, and to the spread of oil after an accident on a given area

spread of oil is based on the use of XX model where the observed weather data is used to estimate likely hit of oil to the threatened species

- Tiira bird databases
- Ship emission, pollutant transport and numerical weather prediction datasets of the Finnish Meteorological Institute
- Bank Of Finland Databases on national economy and on the experts judgments based over the years to enable the comparison off an expert and models in future predictions
- The knowledge bases of CSIRO to apply best insurance practices in oil production industry to vessel traffic, especially tankers.

As a novelty, we will provide, in addition to raw data sets, the databases of probabilistic model estimates. These will be established to the web pages governed by VATT. This will enable the estimation of probabilistic dependencies for any combination of input – output data sets. However, as the data is only historical observations, the more useful information for other scientists than those in ILVES consortium are the estimates of interest variables. We will provide probabilistic databases of the estimates to allow effective estimation of prior probabilities for future analysis. This will enable the more effective learning in sciences, where it is important from the point of view of end user of the information, that estimates include also other knowledge than just the data that happens to be observed in single studies.

In expert elicitation, we use the best experts available in Finland and thus follow the approach taken by Kuikka and Varis (1997) in the modeling of climate change impacts.

6 Ethical issues

Our proposal does not contain work with human embryo/fetus, humans or animals. This proposal does not have research components, which include genetic data, personal information (religion, sexual or political orientation) or tracking of people. Recruitment as well as the advancement and salary of the employed researchers are based solely on personal achievements and not on gender.

7 Implementation: schedule, budget, distribution of work

Table 1 gives the overall schedule of the project, and the distribution between partners. The total budget is given in the tables of the proposal in Finish Academy system. The current plant of the distribution of work is like here, but it is likely that there are revision needs that will be handled in the Consortium meetings that will be arranged every 6 months.

8 Research teams, collaboration

The consortium consists of the following research teams:

1) University of Helsinki, Fisheries and Environmental management group (FEM), Finland

The group leader and the PI of ILVES proposal is professor Sakari Kuikka, who is specialized to multidisciplinary decision analysis by Bayesian decision models. This group consists of biologists, social scientists, economists, statisticians, mathematicians and engineering scientists. The interdisciplinary research group (link to group webpages here) applies Bayesian statistics and decision theory to management of natural resources and environmental values. Group was, together with professor Corander's group in statistics, where FEM has close co-operation, ranked as third in the series of "Societal impact" in the evaluation of research groups in the University of Helsinki evaluations, in 2012. Kuikka has been coordinator in 4 FP or Horizon 2020 projects of EU: 1) PRONE, which was about developing risk methodology for fisheries, 2) ECOKNOWS, which was about developing Bayesian models and learning databases in fisheries science, 3) IBAM, which was about use of Bayesian integrative methods in environmental management and 3) current project GOHERR, which is about developing governance for human and ecosystem health management of Baltic Sea. Kuikka is also the chair of ICES working group for Working Group on Risks of Maritime Activities in the Baltic Sea (WGMABS), which aims to develop a new oil risk management and advisory system for Baltic Sea, being an important route to implement the project findings in active policy (*Fig. 9*). Professor Samu Mäntyniemi is specialized in Bayesian risk analysis.

2) VATT Institute for Economic Research, Policy Analysis and Modelling Unit, Finland

VATT is a public body under the Finnish Ministry of Finance. The Institute has complete independence in conducting its research, which meets high standards of scientific quality. The purpose of VATT research is to support informed decision-making and its focus is on policy-relevant topics. VATT research covers the analysis of public finances and evaluation of economic reforms, the labour market, environmental policies, and the long-term prospects of the economy including energy and climate policy considerations. VATT participates in EU projects such as APRAISE to design effective, efficient and efficacious policy mixes to achieve environmental objectives under different circumstances which are socially acceptable; and Low Carbon Finland 2050 project, which aims at identifying robust roadmaps for competitive low carbon society and sustainable green growth strategies for Finland.

3) Finnish Meteorological Institute, Finland

FMI is a leading expert in meteorology, air quality, climate change, earth observation, marine and arctic research areas. The main objective of FMI is to improve the safety and the quality of living of Finnish citizens. In order to do this the FMI observes the physical state of the atmosphere, its chemical composition and electromagnetic phenomena. The Institute has several laboratories which analyze the most important air pollutants, develop new measurement techniques and test the reliability of the measurements. Dr. Jukka-Pekka Jalkanen is a senior researcher in the dispersion modelling group of the FMI. He is the head developer of STEAM emission model for maritime traffic. He has written 32 peer-reviewed papers of which 17 most recent ones concern ship emissions. Dr Jalkanen has acted as WP

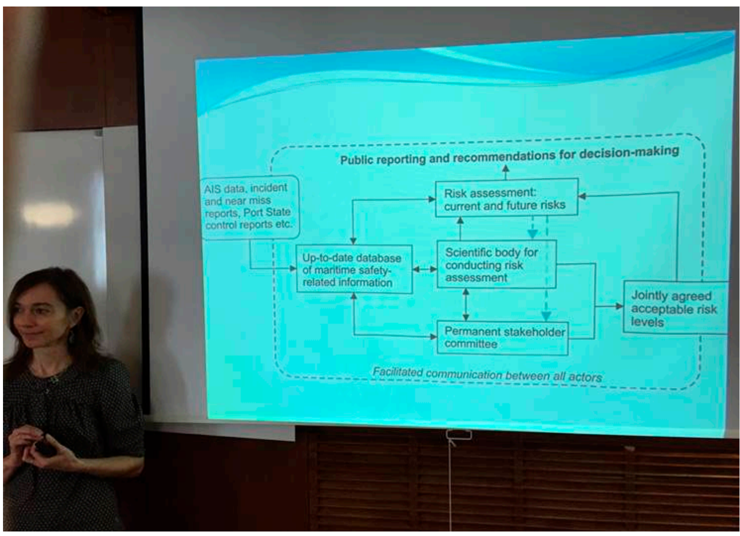


Fig 9. *The suggested new policy (Marine Policy, under minor revision) needs to be communicate openly and with humble attitude.*

Table 1. *Person months*

1. UH	190.4
2. VATT	47,6
3. FMI	68
4. ÅBO	47,6
5. KYAM	47,6
6. LTU	68
7. KMRC	47,6
8. Aalto University	47,6
9. CSIRO	(220 000 e)
10. DUKE	(220 000 e)
11. NHA	47,6
12. HUGIN	47,6
13. FEM Consultations	47,6

leader in several shipping related projects, and is currently involved in two projects concentrating on wintertime navigation (KAMON) and sustainable shipping scenario studies in the Baltic Sea (SHEBA).

4) Åbo Akademi, Finland

The role of Åbo Akademi (Department of Law) is to assess the legal framework for the different policy options discussed in the ILVES proposal, based on existing national, international and EU legislation in the area and on the constraints imposed by international and EU law. Adjunct Professor Henrik Ringbom has performed similar work both at the Scandinavian Institute of Maritime Law, where

Table 2. *Description of topics and tasks, and their time allocation during the ILVES project (starting from May 2015).*

	YEARS					
TOPICS and TASKS	**1**	**2**	**3**	**4**	**5**	**6**
1: Analysis of historical data and publications						
1.1 Setting up databases	XXXXXXXXX					
1.2 Meta-analysis	XXXXXXXXXXXXXXXXXX					
1.3 Hier. modeling		XXXXXXXXXXXXXXXXXXX				
1.4 Prob. databases			XXXXXXXXXXXXXXXXXXXXXXXXXXX			
2: Decision model (DM)						
2.1 First versions of DM	XXXXXXXXXXXXX					
2.2 Emulators		XXXXXXXXXXXXXXXXXXX				
2.3 Causal structures			XXXXXXXXXXXXXXXXXXXXXXXXX			
3: Data analysis and algorithms						
3.1 Causal.: Data bases	XXXXXXXXXXXX					
3.2 Causal.: Experts	XXXXXXXXXXXXXXXX					
3.3 Model parametriz.		XXXXXXXXXXXXXXXXXXXXX				
3.4 Algorithms	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX					
3.5 Conditional prob.				XXXXXXXXXXXXXXXXXXX		
4: Oil spill analysis						
4.1 Human health		XXXXXXXXXXXXXXXXXXXXXX				
4.2 Saimaa ringed seal		XXXXXXXXXXXXXXX				
5: Future policy options						
5.1 Current policies	XXXXXXX					
5.2 Possible policies	XXXXXXXXXXXXXXXXXXXXXXXX					
5.3 Probabilities		XXXXXXXXXXXXXXXXX				
5.4 Conclusions				XXXXXXXXXXX		
6: Software development						
6.1 Software structures	XXXXXXXXXXXXXX					
6.2 Coding		XXXXXXXXXXXXXXXXXXX				
6.3 Tests with citizens			XXXXXXXXXXXXXXXXXX			
7: Food security						
7.1 Risk identification	XXXXXXXXXXXXXX					
7.2 Risk assessment		XXXXXXXXXXXXXXXX				
7.3 Risk management			XXXXXXXXXXXXXX			
7.4 Risk communication					XXXXXXXXXXXXX	
8: Dissemination	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX					

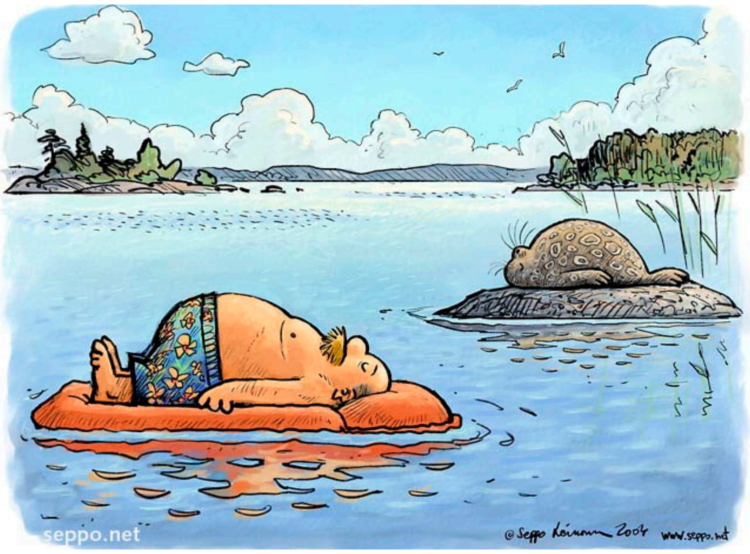


Fig. 10. *In Saimaa area, different stakeholder groups exist and they all need to be noticed when different environmental policies are implemented. Picture by Seppo Leinonen/sepponet.fi*

he is currently a part-time Professor, and as a Head of the Environment Unit at the European Maritime Safety Agency (EMSA). At Åbo Akademi he is currently, in close cooperation with the Faculty of Law at the University of Turku, in charge of setting up BALEX (Baltic Area Legal Studies); a research and teaching center that specifically focuses on legal issues of relevance for the Baltic Sea region.

5) KYAMK, Kymenlaakso University of Applied Sciences, Seafaring and logistics, Finland

KYAMK Seafaring research and development activities focus on maritime safety management i.e. preventive and response measures to marine pollution, as well as on maritime training. KYAMK has proven competence in areas of marine technology and sustainable energy solutions related to port operations and sea transport, and has experienced in developing energy technologies and methods. Master Mariner Justiina Halonen is an expert in ship-source oil spill response. Halonen educates oils spill response tactics for Finnish authorities and has conducted regional spill response contingency planning over ten years. Halonen's reasearch interests include maritime safety management, safety performance indicators in inland waterborne traffic and ship maneuvering simulation.

6) Lappeenranta University of Technology, School of Business and Management, Finland

Adjunct professor Jyri Vilko (professor in logistics) has applied simulation studies to evaluate alternative logistics and is the leading Finnish expert in his field. Professor Haario is an expert in Bayesian parameter estimation of complex models and has developed probabilistic Bayesian version of the FMI weather forecast model. Professor Pekka Sutela is a world known expert in national economics and in political stability in Russia. He provides valuable expert knowledge to simulations of policy success and economic development. There is a connection to Thailand's best business school logistics scientists to support the distribution of methods to third countries. Associate professor Ossi Taipale is specialist in software development with long experience in implementations of sales and transportation networks.

7) Kotka Maritime Research Association (KMRA), Finland

KMRA operates in close collaboration with the maritime industry, universities, research organizations, institutes and authorities both nationally and internationally. The aim of the KMRA is to improve the interaction between science and society to make the most of the results, by conveying theory into practice (*Fig. 10*). The practical solutions based on scientific research can improve the profitability of maritime industries and decrease the environmental impacts of maritime transportation. KMRA has coordinated interdisciplinary projects where practical tools have been developed to support decision making. KMRA has been the responsible partner in many projects for coordination, internal and external communication and information/publicity activities in these projects. In ILVES consortium the role of KMRA is to communicate and disseminate the essential findings of the project to the target groups and end users within the maritime sector.

8) Aalto University, Water & Development Research Group, Finland

The Water & Development Research Group is a cross-disciplinary research group operating at the Aalto University. The group has a long research tradition in water and development issues as well as in integrated management of water resources. The group leader, prof. Olli Varis has a strong expertise in water resources management, development and food security research, environmental and social impact assessment, computational modeling, multidisciplinary natural resources and development studies. He is also well-known for his methodological publications on computational modeling and data analysis, especially from the field of Bayesian networks and related decision analysis. He has coordinated and participated in many national and international research projects.

9) Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia

CSIRO is Australia's national science organization and a leading multidisciplinary research organization. In ILVES, CSIRO will contribute to oil spill risk analysis, studying financial risk management and insurance as a policy tool, and the development of oil spill modules of varying complexity for the Atlantis ecosystem model. Dr. Rich Little (team leader) is a Senior Research Scientist at CSIRO Marine and Atmospheric Research. His research specializes in modelling population dynamics, economics, and management decision-making in natural resource and marine environmental science.

10) National Institute for Health and Welfare (NHA), Finland

National Institute for Health and Welfare (THL) is a government research institute. It has wide expertise in public health, environmental health and health impact assessment. THL is the main developed and user of open policy practice and Opasnet worldwide. THL has gained good practical experience about what practices work and what don't, and where the problems lie in science-policy interface when opening data and models. The Unicorn research group in THL is led by Adjunct professor, MD Jouni Tuomisto (JT; THL PI). Tasks: health modelling, decision analysis, Opasnet web-workspace. Merits: More than 20 years of expertise in environmental health issues, risk assessment, decision analysis, modelling, and decision support. Developed the method open policy practice and the web-workspace Opasnet. 98 peer-reviewed scientific articles.

11) HUGIN Expert A/S, Denmark

HUGIN EXPERT A/S is a Danish SME established in 1989. The company is a leading provider of tools and services for advanced decision support based on complex statistical models known as probabilistic graphical models (i.e., Bayesian Belief networks and influence diagrams). Since 1989 the company has collaborated with some of the World's largest IT companies and its technology is being utilized in a wide variety of IT systems. HUGIN EXPERT has a long history of active participation in RTD projects, for instance, supported by the European Commission or companies. HUGIN EXPERT will play an important role in ILVES in relation to the use of Bayesian network technology. This includes both the use of the HUGIN software tool for development and deployment of Bayesian network models as well as the development of Bayesian network software to support the needs and requirements of ILVES. The Chief Executive Officer of HUGIN EXPERT is Anders L Madsen. He has a PhD in Decision Support Systems (1999). Since 2011 he has been an adjunct Professor of Computer Science, Aalborg University, Denmark.

12) Duke University, USA

Duke University is one of the premier research universities in the US; it has excellent research programs in environmental sciences and Bayesian statistics. The Duke team will be led by Professor Kenneth H. Reckhow, who has focused much of his 38 year research career on Bayesian water quality modeling. In addition, Dr. Reckhow has served as Chair of the US National Academy of Sciences Panel on the USEPA Total Maximum Daily Load Program (2001), as a member of the US National Academy of Sciences Panel on the USGS National Water Quality Assessment (2000-01), as a member of the US National Academy of Sciences Panel on Restoration of the Everglades Ecosystem (2003-05), as Chair of the US National Academy of Sciences Panel on Chesapeake Bay Restoration, and is currently Chair of the USEPA Board of Scientific Counsellors overseeing EPA's internal and externally-funded water research. He has published two books and over 100 papers, principally on water quality modeling, monitoring, and pollutant loading analysis, with a focus on uncertainty, risk, and decision analysis, often involving Bayesian analysis.

The consortium as a whole offers an excellent combination of skills which are needed to support environmental and economic policy with modern calculus systems. Understanding correctly the real causal relationships in a system where society makes a new intervention must be based on as good causal understanding as possible. The priors of the models must use the existing published papers as effectively as possible. Here the modeling skills and expert understanding of ILVES consortium meet in a unique way to solve practical problems.

12) FEM Risk governance and calculus ltd.
A company that will be established to pay costs and salary
of prof emeritus Elja Arjas. Aims e.g. to help implementing
environmentally based vetting criteria and insurance fees
maritime activities. Owns copyright of new causal discove

9 Mobility plan

UH/FEM Sakari Kuikka will visit CSIRO in winter 2015–summer 2016. During this trip the oil spill risk methods of Finland will be reviewed and the CSIRO modelling skills will be used to plan the insurance schemes as tools to manage the oil disaster risks. Also the adding of oil spill element to Atlantis will be developed during this visit. Kuikka will also visit Waikato University in New Zealand, who are developing Weka software for data analysis with Bayesian nets, as well as graphical interfaces to evaluate large data or simulation datasets. Kuikka will also visit Duke University for approximately two months in years 2015–2018. 30 000 € is included in the budget.

LUT School of Business and Management (LBM): Jyri Vilko will visit Thammasat University in the winter 2015-2016. During this researcher exchange he will collaborate with the local researchers in researching the inland water ways usage potential in South East Asian and Finnish perspectives. In 2017 Professor Vilko will visit the Massey University, in New Zealand. The aim of the visit is to collaborate in studying supply chain relationships and responsibilities in multi modal logistics. 30 000 € is included in the budget.

Dr Inari Helle will visit CSIRO in 2016 for a year to provide knowledge from the oil spill risk analysis carried out in FEM group Finland. Moreover, she will adapt the best practices rules applied in Australian oil industry and offer the essential parts of these to the recommendations made for international companies dealing wit oil carrying.

Dr Riikka Venesjärvi will visit Duke University in the end of 2016 – beginning 2017 in order to work with the Gulf of Mexico data sets and their provision to meta-analysis in order to establish a learning system in the model framework built to Atlantic model, CSIRO. The related Bayesian algorithms will be developed together with LTU, Duke, UH and CSIRO.

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11 Interaction plan

11.1 Objectives of interaction

Since the objective of ILVES is to produce new techniques for policy design which relies on extensive use of scientific theory, datasets, literature and expert knowledge, the information is summarized within a probabilistic framework. The very basic philosophy of risk communication in the ILVES approach extends the conventional methods in science: our primary aim is to have an impact on policy. However, our work needs to be of a high scientific quality in order to justify the policy advice.

Our aims of interaction include several levels, and the objectives are internal and external. Because these two are tightly coupled, same means of interaction can be applied to both objectives.

The main objective of internal interaction is to ensure functioning communication between the consortium research teams. Successful working requires continuous flow of information between several partners, but in addition to this "traditional" interaction related to research work, the integration of knowledge in ILVES approach involves great deal of learning at many levels. Hence, we do not only aim at information flows between research teams but a more profound approach of mutual learning. Although this is a challenging task and may call for a new mindset, we trust this aim is achievable within the consortium.

The objectives of external interactions are manifold. As we aim at finding solutions that have international significance related to maritime safety and oil spill risk assessment, our objective is to develop new scientific methodologies to support policies enhancing reduction of greenhouse gases and increasing transport safety. At a national level, the specific features of Finnish transportation will be taken into account and the stakeholders operating in the field of transportation in Finland will be the key end-users of knowledge produced by ILVES.

11.2 Target group/stakeholders/partners

The partnership of the project include experts of emission modeling, security supply modeling and logistic solutions modeling, interdisciplinary risk analysis, policy design, economic research, insurance policy, legislation and risk communication (see consortium). The integration of knowledge in ILVES approach involves a great deal of interaction among all these disciplines, and to this end the information will be collected into one web based platform. We have a high number of letters of commitment from outsiders: City of Helsinki, Ministry of Traffic and Communication, Environment Ministry, The Waterway Association of Finland, the Finnish Border Guard, CISRO Australia.

The three main target groups will be:

1) POLICY-MAKERS: the theme related decision-makers (politicians, authorities), which are operating in international, national and regional level. The proposal will improve significantly the possibilities to change maritime policy as a more science based policy. Therefor such a policy dialogue between policy-makers and scientist is essential. This group includes also operational authorities, e.g. oil rescue services.

2) MARITIME INDUSTRY: all representatives related to maritime transport; shipping companies, port operators, operators and transporters (road, railway), representatives from shipping technology, investors.

3) CITIZENS: NGO's, product consumers, citizens.

In the Fintrip program of the Ministry of Traffic and Communication, a network of research and innovation activities has been planned. ILVES consortium will contribute heavily to this activity by offering best available scientific tools for interdisciplinary risk analysis. The program defines that co-operation is needed in education, research, product development and export. Potential customers include international oil industry, insurance companies and shipping companies. ILVES will create scientific risk analysis products for these actors. Also, ILVES approach has potential to contribute to the long term programme of measures when national plans are revised. The time period covered by the national programmes is usually short, the next 5 years, whereas ILVES looks at 30 years to the future.

Also at an international level the results of the research have importance for several actors. The review by Haapasaari et al. (accepted) on the best practices of risk governance in nuclear risk analysis framework will be used as an example to adapt the new approaches. When suggesting the risk governance for international maritime activities (called Blue Belt in EU's White Paper), we also use the good experiences obtained from EU Common Fisheries Policy, where the involvement of stakeholders to yearly policy decisions is well organized. The new ICES working group WGMABS (http://www.ices.dk/community/groups/Pages/WGMABS.aspx), chaired by Sakari Kuikka, will be used as one way to disseminate the findings to society. HELCOM (Helsinki Commission) is an active customer for such advice. In addition, the assessment of oil spill risks related to inland waterways will offer the regional rescue services a database of ecological values that can be used in contingency planning and, in case of an oil spill, to allocate oil combating resources.

Stakeholders according to targeted societal impacts will be:

1. Findings supporting the policy to achieve CO_2 emissions

- Policy-makers international, national level

2. Investments based suggested chain of creating new jobs along inland water ways

- Regional representatives from the region of South-Karelia and other regions linked to the Lake Saimaa area
- Regional authorities, policy-makers, maritime industry operating in inland waters, key representatives from industry using the transportation, citizens

3. Improved state of environment

- Policy makers, NGO's, regional groups (e.g. environmental policy council of the region of Kymenlaakso), citizens

4. Improving the interest to apply best practices in companies that create main risks

- Industry representatives, Finnish Chambers of Commerce

The social network analysis is used to look how the information flows between stakeholders. The aim is to construct a scientifically based approach to plan effective dissemination.

11.3 Means of interaction

The main platform for interaction will be an interactive website. It will serve as the platform for internal communication and mutual learning. In the website, the end-users can test the policy options by using a decision support tool. In the interactive tool the objective settings are inquired from the users in such a way, that the decision model can rank the decision alternatives. This will create a learning database from the value weights of the stakeholders (task of Hugin company, Denmark) and citizens (separately for different groups). The interactive web pages will be set up at the onset of the project, and maintained also after the project closure.

The Enduser Advisory Board (EAB) will be established for the project. The EAB will be chaired by Dr Anita Mäkinen (Trafi), responsible for maritime and air traffic gas emissions. We use the risk governance lessons learned in aviation to help identifying risk governance options for maritime activities. This will be based on the active role of the Trafi agency, which is responsible for the traffic policy design in Finland. The EAB will be responsible for providing the formulation of relevant policy options and the probabilities for the likely implementation success of policies. The other invited EAB members include:

There will be tailored events for each target group: conferences and workshops to disseminate the scientific results and policy options compiled by the project, but also to raise awareness of the technical platform intended to facilitate the information exchange. In addition, engaging the stakeholders via EAB very early on ensures that the end-users and beneficiaries will have access to the latest progress of the project online.

Timing of the events will be planned to strengthen the existing events. For example, ILVES will arrange, together with ICES (International Council for the Exploration of the Sea) a yearly workshop for relevant stakeholder groups. The workshops will be related to the work of ICES WGMABS (ICES Working Group on Risks of Maritime Activities in the Baltic Sea), which is chaired by prof. Sakari Kuikka. The meetings will include participants from industry, NGO's, policy makers and scientists. This activity is the basis of risk communication in ILVES. It is already agreed that WGMABS and ILVES consortium will arrange together the next ICES WGMABS workshop in 2016.

Media relations will be established based on the existing strong networks of partner consortium. Instead of one-way communication, an interactive approach will be created: this will include the web platform for information sharing, but also engaging the stakeholders (and also the general public) via social media.

We will also build on the art in risk communication. Cartoon artist and humorist Seppo Leinonen (sepponet.fi) will provide material how the humor may open ways to communicate risks. It is especially important for human cognition, that we understand the causalities correctly, as otherwise we cannot link the observations to hypotheses. We need communication that creates an interest to understand causalities, and supports the hidden intuitive understanding of causalities in our imagination.

It is often said that there is no way to impact human values, which are said to come from home's values and atmospheres. Here, we will use the beauty of Baltic Sea as a potentially effective, and likely the only that matters, way to have any imact on people's values. Do I love the ocean or just the city life with movies representing Artificial Reality (AR)? It is also said that humor can break barriers that would otherwise be difficult to break. Tht may be the case e.g. between NGO and industry frank communication of risks. Here, we will apply, as a small test, the humor by clownery. The skill to be funny is based on the fact that a human will find her funny features by interactive processes. This is based on a summer school in France, where a student in theater articulacy, is taking part.

11.4 Responsibilities and implementation

Coordinator and KMRA are responsible for implementing the stakeholder communication plan. KMRA will be in charge of organizing the meetings and communication with end-users (Fig. 11). KMRA has operated in close collaboration with the maritime industry, universities, research organizations, institutes and authorities both nationally and internationally. KMRA has coordinated interdisciplinary projects where practical tools have been developed to support decision making. Most significant projects in the field have been 1) **SAFGOF** (ERDF funding) and 2) **MIMIC** (Central Baltic Interreg) where traffic growth scenarios, accident probabilities and biological information about consequences of oil accidents were combined to produce probabilistic risk maps; 3) **OILRISK** (Central Baltic Interreg) where the impacts of oil on coastal and marine species and habitats were evaluated and estimates how well certain nature values can be safeguarded with booms or protective sheets were given, and 4) **TOPCONS** (ENPI CBC) where a tool to support maritime spatial planning was developed. KMRA has been the responsible partner for coordination, internal and external communication and information/publicity activities in these projects.

In ILVES consortium the role of KMRA is to communicate and disseminate the essential findings of the project to the target groups and end users within the maritime sector. KMRA will organize all meetings and communicate with end-users, and also save the communication records from meetings related to relevance and understand ability of Bayesian inference.

11.5 Schedule

ILVES consortium will make a detailed plan of the interaction activities. The interaction will start by creating the web-based platform for communication and data exchange. This platform will be further developed during the project and serve as the platform for end-users to test the models and to collect information from them.

The first version of the model will be designed by the end of the first year of the project. To this first version a conceptual framework will created which will be elaborated in further communication and feedback with the stakeholders and experts.

The second, updated version will be available by the end of the third year. This version will be used for policy analysis and evaluation during the fourth year. The evaluations will be carried out in co-operation with the end-users in order to elaborate the dependencies and causalities of the model.

This tested version will be updated during the last two years and to decrease the scientific uncertainties to a minimum. The main forum for raising awareness among policy-makers and authorities will be the Enduser Advisory Board (EAB). During the project, raising the awareness of the project among stakeholders, end-users and also among general public will be carried out by organizing tailored events (conferences, workshops, public events) and informing them over the internet, including social media.

Solution and know-how sharing will be taken on a practical level by applying the latest information collected by the project on training and information activities targeted towards the maritime sector.

After the project, the internet platform will remain open and the lessons learned will be available to all interested parties.

Fig. 11. *An artistic view about communication. Picture by Seppo Leinonen/sepponet.fi*