CHEMICAL ENGINEERING TRANSACTIONS
VOL. 77, 2019
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Genserik Reniers, Bruno Fabiano

ISBN 978-88-95608-74-7; **ISSN** 2283-9216
DOI: 10.3303/CET1977173

Openrisk: a Risk Management Toolbox for Prevention and Response of Pollution from Maritime Activities

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Risks in the maritime domain have various sources, of which the transportation of oil and other noxious substances is one of the key concerns to industry and public stakeholders (HELCOM, 2018b). With the increased presence of off-shore wind farms, off-shore production and processing facilities, new risks have also emerged over the past decades. The previous large-scale ship and off-shore accidents, such as Erika (1999), Prestige (2002) and Deepwater Horizon (2010) have demonstrated that e.g. oil spills can have disastrous impacts on the marine and coastal ecosystems (Venesjärvi R., 2016), and they can cause also significant economic losses (Yamada Y., 2009). In addition to the accidental spills, there are also operational spills, which are small, but frequent, intentional or inadvertent spillages in the sea due to ship operations (Neves A. et al., 2015).

1. Introduction

To be prepared and to respond to different kinds of spills, states have implemented various national mechanisms for pollution in the maritime domain, including activities that are often embedded in regional cooperation frameworks clustered around certain sea areas. For instance, within the frameworks of the Helsinki Convention, the Bonn Agreement and the Barcelona Convention with the REMPEC, these activities include, e.g. adoption of operational procedures between the Contracting Parties, combating exercises for testing the regional cooperation in practice and risk assessments of designated sea areas. To summarize, the importance of effective risk management within the context of Pollution Preparedness and Response has been recognized both in national and regional level in Europe and worldwide.

To support the risk-informed decision-making processes of Pollution Preparedness and Response authorities, several risk assessment tools and techniques have been developed during the past. To identify gaps in the existing open source risk assessment tool selection, fill these gaps, and integrate the tools in a structured manner, the Helsinki Commission (HELCOM) initiated a project to develop a freely available toolbox, known as the OpenRisk Toolbox. This is a set of tools and techniques especially for identifying hazards and analyzing risks of maritime activities. It is focused on accidental oil spills from maritime transportation, where regional cooperation would be required. While several of the currently available tools focus exclusively on the accidental oil spill risks related to maritime transportation, the toolbox is envisaged to be open, so other methods can be included to address risks from other maritime or off-shore activities. This paper briefly introduces the OpenRisk project, provides an overview of the OpenRisk Toolbox, and outlines future directions.

Paper Received: 29 October 2018; Revised: 19 April 2019; Accepted: 16 June 2019

Please cite this article as: Laine V., Goerlandt F., Baldauf M., Mehdi R., Koldenhof Y., 2019, OpenRisk: A risk management toolbox for prevention and response of pollution from maritime activities, Chemical Engineering Transactions, 77, 1033-1038 DOI:10.3303/CET1977173

2. OpenRisk project

The OpenRisk project is focused on open source tools for regional risk assessments to improve European Pollution Preparedness and Response at sea (here after, referred to as PPR). The aim of this project is to take the first step in developing a toolbox of joint and open methods that enable frequent assessments of spill risks from maritime accidents. The expected main end-users of this so-called `OpenRisk Toolbox` are national authorities and regional organizations of Europe working on spill prevention, preparedness and response. As such, the project focuses on risks related to spills from ship accidents. The OpenRisk project is still ongoing and continues until the end of 2018.

During the OpenRisk project, four inter-regional workshops on risk assessment for PPR are organized in cooperation with the European regional agreements. The main purpose of these workshops is to ensure that the OpenRisk project focuses on the right objectives, and that these are achieved. The first workshop was addressed to the end-user needs related to the OpenRisk Toolbox, and to the objectives of the entire project (HELCOM, 2017a). Prior to the workshop, the authors conducted also a questionnaire on the matter in hand. In the second workshop, the focus was on obtaining knowledge from the end-users concerning some of the features of the risk assessment tools, which could be included to the OpenRisk Toolbox (HELCOM, 2017b). Simultaneously, there was discussion about the proposal that the OpenRisk project's main output would be an ISO 31000:2018 standard based guideline for the PPR risk management processes, which would include also the OpenRisk Toolbox (ISO, 2018). The results of the workshop confirmed the approach. The third workshop was addressed to the practical testing of the potential risk assessment tools for the OpenRisk Toolbox to obtain knowledge about their usability form the end-users' point of view (HELCOM, 2018b). This workshop was used also to receive feedback on the first version of the ISO 31000:2018 standard based integrated guideline. The feedback received from the workshop participants was very positive. The purpose of the last workshop is to present the outcomes of the OpenRisk project and to outline future directions.

Consequently, the primary outcome of the OpenRisk project will be a guideline for the PPR risk management processes, including the OpenRisk Toolbox. Secondary, the project will produce a case study, and reports of the four inter-regional workshops. This paper focuses on the OpenRisk Toolbox section of the upcoming integrated guideline. More specifically, it presents the tools that are included in the toolbox, including the type of knowledge they can provide and some of their key features. The implementation of the ISO 31000:2018 standard to the PPR risk management processes, and linking of the risk assessment tools of the OpenRisk Toolbox to these processes will be discussed in an upcoming article.

3. OpenRisk Toolbox

Based on the results obtained from the authors' questionnaire and from the first OpenRisk workshop, it became obvious that different PPR authorities of Europe have different needs related to the OpenRisk Toolbox. For instance, some of them need risk assessment tools to support short-term tactical planning, whereas others need them for long-term strategic planning. Furthermore, the results showed that there are significant differences between European countries in terms of scope of activities, available resources, operational areas, access to data and the like, which had to be considered when selecting the proper tools.

To face the challenge, the authors conducted an extensive literature review on available open source risk assessment tools and techniques to select those, which can provide useful knowledge for the European PPR decision-making processes. The aim of this review was also to define the current state of art on these tools, to search gaps on it, and to cover these gaps to some extent. Consequently, based on the expertise of authors and on the results of subsequent OpenRisk workshops, a total of 20 different risk assessment tools are selected to the OpenRisk Toolbox. These tools can be used for different purposes as needed by the European PPR authorities, depending on the decisions to be made, available resources and other information needs. The tools cover the three stages of a typical risk assessment process: risk identification, risk analysis and risk evaluation. They are also freely available to the European PPR authorities, many of which have a proven track record in maritime risk management. This includes tools such as PAWSA, IWRAP Mk II and SeaTrack Web. Other tools are more generic such as Delphi, FRAM and Cost-Benefit Analysis. In addition, the tools Marin Risk Index, ADSAM C/G and ERC-M are developed particularly for the project to cover some of the identified gaps. The process for integrating the OpenRisk Toolbox into PPR risk management processes is still in progress and is discussed in the final chapter. The 20 tools of the OpenRisk Toolbox are presented in the following tables. Table 1 shows an overview of the currently included tools and techniques, focusing on the purpose and knowledge generated by applying the tool. For instance, the AISyRisk can be utilized for relocating the on-shore response equipment, as it provides knowledge on the accident risks in different sea areas. It can also be used to identify trends concerning shipping risks over time, which may signal the need for additional risk management interventions. ADSAM C/G can be useful to define how much and what kind of equipment is needed, as it provides knowledge on the potential target spill. Table 2 focuses on the attributes of the tools, which are important in the context of planning which tools to use in a given organization. These attributes include the required resources and capabilities for using the tool, the tool´s complexity, and whether the tool provides quantitative or qualitative risk information. For instance, using the AISyRisk requires only low resources and skills from the end-users and the output of this tool is quantitative, while using the FRAM requires high resources and skills, with qualitative results obtained.

Table 1: OpenRisk Toolbox: Purpose and knowledge generated by application of the tools

Nr		Tool specifications
1	ID	AISyRisk (Kystverket, 2018)
	Name	AISyRisk
	Risk management questions	• Where are the historic accident risks in the sea area? • How do the risks develop over time?
2	ID	MarinRisk (Koldenhof Y. et al., 2010)
	Name	MarinRisk Index
	Risk management questions	• Where are the historic accident risks in the sea area? • How do the risks develop over time?
3	ID	Delphi (Zaloom V. et al., 2008)
	Name	Delphi Method
	Risk management questions	• What kinds of future hazards should be considered? • What are the associated risk levels?
4	ID	RiskData Hub (EC, 2016)
	Name	RiskData Hub
	Risk management questions	• Where are the historic accident risks in the sea area? • How do the risks develop over time?
5	ID	IWRAP Mk II (IALA, 2017)
	Name	IALA Waterway Risk Assessment Programme
	Risk management questions	• What is the accident likelihood in different sea areas? • What accident scenarios are likely? • What is the effect of different risk control options on the risk level?
6	ID	PAWSA (Harrald J. et al., 2000)
	Name	Ports and Waterways Safety Assessment
	Risk management questions	• How important are different waterway factors as contributors to risk? • What is the effect of risk control options on the risk level?
7	ID	ERC-M (ARMS-WG, 2010)
	Name	Maritime Event Risk Classification Method
	Risk management questions	• What kinds of hazards occur in the sea area? • What is the risk level in different sea areas? • What accident scenarios are likely? • Which issues are contributing factors to the event occurrence?
8	ID	ADSAM-C/G (Goerlandt F. et al., 2017)
	Name	Accidental Damage and Spill Assessment Model for Collision & Grounding
	Risk management questions	• What size of oil spills can occur in a collision or grounding accident?
9	ID	SeaTrack Web (HELCOM, 2003)
	Name	SeaTrack Web
	Risk management questions	• Where does the oil drift to in the sea area?
10	ID	NG-SRW (Aps R. et al., 2016)
	Name	Next Generation SmartResponse Web
	Risk management questions	• What size of oil spills can occur in a collision or grounding accident? • Where does the oil drift to in the sea area? • What are the consequences to the ecosystem and human use of marine space?
11	ID	ERSP Calculator, EBSP Calculator, and EDSP Calculator (BSEE., 2018)
	Name	Response System Planning Calculators
	Risk management questions	• What is the potential of the response system to recover, burn, or disperse the spille
12	ID	BowTie (Mokhtari K. et al., 2011)
	Name	BowTie Method
	Risk management questions	• Which factors contribute to the event occurrence and/or its consequences? • What is the effectiveness of different controls to mitigate risks?

13	ID	FRAM (Hollnagel E., 2012)
	Name	Functional Resonance Analysis Method
	Risk management questions	• Which system functions are responsible for the variation in the system performance?
14	ID	KPIs (ARPEL, 2017)
	Name	Key Performance Indicators
	Risk management questions	• How important are different system indicators in regards event occurrence and/or cons • What is the performance of different system elements compared to target levels?
15	ID	SBOSRT (Helle I. et al., 2016)
	Name	Spatial Bayesian Oil Spill Risk Tool
	Risk management questions	• What are the oil spill risks in the sea area? • What is the extent of ecological damage in different oil spill risk scenarios?
16	ID	ISRAM (IMO, 2010)
	Name	Integrated Strategic Risk Analysis Methods
	Risk management questions	• What are the oil spill risks in the sea area? • What size of spills can occur? • Where does the oil spill drift to in the sea area? • What are the consequences to the ecosystem and human use of marine space? • What is the effect of different risk control options on the risk level?
17	ID	SoE (Goerlandt F. et al., 2016)
	Name	Strength of Evidence Assessment Schemes
	Risk management questions	• How much can the results of the risk analysis be relied on? • How much evidence is there for the elements in the risk analysis?
18	ID	RM-PCDS (IMO, 2013)
	Name	Risk Matrices and Probability-Consequence Diagrams
	Risk management questions	• How do risks compare to one another in the different dimensions of risk?
19	ID	ALARP (Ale B. et al., 2015)
	Name	As Low as Reasonably Practicable Principle
	Risk management questions	• Are the risks acceptable? • Should further risk control options be implemented?
20	ID	CBA (Boardman N., 2006)
	Name	Cost-Benefit Analysis
	Risk management questions	• How cost-effective are different risk control options?

Table 2: OpenRisk Toolbox: Attributes of the tools

Nr	Tool name	Resources needed	Skill required	Output
1	AISyRisk	Low	Low	QT
2	MarinRisk	Low	Medium	QT
3	Delphi Method	Medium	Medium	QL
4	RiskData Hub	Medium	Low	QT
5	IALA Waterway Risk Assessment Programme	Medium	Medium	QT
6	Ports and Waterways Safety Assessment	High	Low	QL
7	Maritime Event Risk Classification Method	Medium	Medium	QL
8	Accidental Damage and Spill Assessment Model for Collision and Grounding	Low	Medium	QT
9	SeaTrack Web	Low	Medium	QT
10	Next Generation SmartResponse Web	Low	Medium	QT|QL
11	Response System Planning Calculators	Low	Medium	QT
12	BowTie Method	Medium	Medium	QT|QL
13	Functional Resonance Analysis Method	High	High	QL
14	Key Performance Indicators	Medium	Medium	QT|QL
15	Spatial Bayesian Oil Spill Risk Tool	High	High	QT
16	Integrated Strategic Risk Analysis Methods	High	High	QT
17	Strength of Evidence Assessment Schemes	Low	Low	QL
18	Risk Matrices and Probability-Consequence Diagrams	Low	Low	QT|QL
19	As Low As Reasonably Practicable Principle	Low	Medium	QT|QL
20	Cost-Benefit Analysis	Medium	Medium	QT

Note: QL = qualitative, QT = quantitative

4. Conclusions

To conclude, the here presented OpenRisk Toolbox is currently populated with 20 different open source risk assessment tools, which are applicable for the PPR risk management. They are selected based on an extensive literature review, the expertise of authors and the results of the OpenRisk workshops, which focused on the end-users' point of view. In addition, it should be highlighted that three new risk assessment tools are provided to cover the previous gaps. Without doubt, there are also other open source risk assessment tools that could be included to the OpenRisk Toolbox, e.g. focusing on other pollution related risks of maritime activities. But as stated earlier, this toolbox is envisaged to be open. Consequently, more tools can be added to the toolbox if needed, including those for assessing the risks of maritime transportation or offshore activities.

The OpenRisk project is still in progress and in the next phase, the focus will be on completing the integrated guideline as that is the primary project outcome. This includes: i) finalizing the implementation of the ISO 31000:2018 standard to the PPR risk management processes, ii) providing a logical solution to integrate the tools of the OpenRisk Toolbox to the established new PPR risk management processes, and iii) creating a coherent solution to describe all the key features of the tools included in the toolbox. Thereafter, the final phase of the project will be to test some of these tools in practice through a case study.

To ensure the sustainability of the project results, the final workshop will mainly focus on disseminating the results, and on planning next steps. Currently, several model-based risk assessment tools are available for risks of different maritime activities. To keep up with the current rapid developments in the maritime industry, based on initial discussions in the already conducted workshops, the authors recommend that a follow-up project would be addressed to providing an integrated software platform for the PPR risk management needs. This may include an extension to maritime safety related topics, because prevention, preparedness, and response all aim to improve maritime safety and marine ecosystem sustainability, where having a holistic assessment of these aspects may facilitate more cost-efficient risk-informed decision making.

Acknowledgments

The OpenRisk project has received funding from by the European Civil Protection and Humanitarian Aid Operations (EC DG-ECHO), and is supported by the European regional agreements on pollution preparedness and response, the European Maritime Safety Agency (EMSA) and the Norwegian Coastal Administration. This support is gratefully acknowledged.

References

Ale B.J.M., Hartford D.N.D., Slater D. 2015. ALARP and CBA all in the same game. Safety Science 76:90-100.

Aps R., Fetissov M., Goerlandt F., Kopti M., Kujala P. 2016. STAMP-Mar based safety management of maritime navigation in the Gulf of Finland (Baltic Sea), European Navigation Conference 2016, Helsinki, 30 May-2 June 2016, IEEE Xplore, pp. 1−8.

ARMS WG, 2010. The ARMS Methodology for Operational Risk Assessment in Aviation Organisations. SkyBrary, 67 p.

ARPEL, 2017. Oil Spill Response Planning and Readiness Assessment Manual V 2.1.

Boardman N.E. 2006. Cost-benefit Analysis: Concepts and Practice (3rd ed.). Upper Saddle River, NJ: Prentice Hall. ISBN 0-13-143583-3.

BSEE, 2018. Response System Planning Calculators. <www.bsee.gov/what-we-do/oil-spill-preparedness/response-system-planning-calculators >Accessed 29.04.2018.

EC, 2016. Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030: a disaster risk-informed approach for all EU policies. European Commission SWD (2016)205 final/2.

Goerlandt F., Reniers G. 2016. On the assessment of uncertainties in risk diagrams. Safety Science 84:67-77.

Goerlandt F., Li F., Lu L., Oamen G. 2017. Cargo and bunker tank information for oil outflow calculations. Designs of tankers, container ships and bulk carriers representative for the Northern Baltic Sea area. Aalto University publication series SCIENCE+TECHNOLOGY 9/2017. Unigrafia Oy, Helsinki.

Harrald J.R., Merrick J. 2000. Development of a Decision Support Tool for Assessing Vessel Traffic Management Requirements for U.S. Ports. Proceedings of the 7th Annual Conference of the International Emergency Management Society, pp. 165-174, May 16-19, Orlando, FL

HELCOM, 2003. Further development and use of drift forecasting for oils and other harmful substances in the Baltic. HELCOM Recommendation 24/7. Baltic Marine Environment Protection Commission.

HELCOM, 2017a. First OpenRisk Inter-regional Workshop on Risk Assessment Methods for Pollution Prevention and Response. Helsinki, Finland, 13-14 June 2017.

HELCOM, 2017b. Second OpenRisk Inter-regional Workshop on Risk Assessment Tools for Pollution Prevention and Response. Lisbon, Portugal, 12 October 2017.

HELCOM, 2018a. Third OpenRisk Inter-regional Workshop on Risk Assessment Tools for Pollution Preparedness and Response. Valletta, Malta, 24-25 April 2018.

HELCOM, 2018b. HELCOM Assessment on maritime activities in the Baltic Sea 2018. Baltic Sea Environment Proceedings No.152. Helsinki Commission, Helsinki. 253pp.

Helle I., Jolma A., Venesjärvi R. 2016: Species and habitats in danger: Estimating the relative risk posed by oil spills in the northern Baltic Sea. Ecosphere 7(5): e01344.

Hollnagel E. 2012. FRAM – The Functional Resonance Analysis Method. Farnham, UK: Ashgate.

IALA, 2017. The use of IALA waterway risk assessment programme (IWRAP MKII). IALA Guideline G1123, Edition 1.0. The International Association of Marine Aids to Navigation and Lighthouse Authorities, Saint Germaine en Laye, France.

IMO, 2010. Manual on oil spill risk evaluation and assessment of response preparedness. International Maritime Organisation, London, UK.

IMO, 2013. Revised guidelines for formal safety assessment (FSA) for use in the IMO rule-making process. International Maritime Organization, London, UK. MSC-MEPC.2/Circ.12.

ISO, 2018. ISO31000:2018 Risk management. Guidelines. International Organization for Standardization.

Koldenhof Y., Nijsse H., van der Tak C., Glansdorp C.C. 2010. Risk analysis as an integrated operational and legal instrument with respect to the safety of maritime traffic. Proceedings of the conference Risk Analysis VII, WITpress PI-245-PI-256.

Kystverket, 2018. Norwegian Costal Administration. 2018. Automated calculation of risk related to ship traffic.

Neves A., Pinardi N., Martins F., Janeiro J, Samaras A., Zodiatis G., Dominics M. 2015. Towards a common oil spill risk assessment framework. Journal of Environmental Management 159 (2015) 158-168.

Mokhtari K., Ren J., Roberts C., Wang J. (2011). Application of a generic bow-tie method based risk analysis framework on risk management of sea ports and offshore terminals. Journal of Hazardous Materials 192(2):465-475.

Venesjärvi R. 2016. Knowledge-based marine conservation in oil spill risk management. University of Helsinki 63 p.

Yamada Y. 2009. The cost of oil spills from tankers in relation to weight of spilled oil. Marine Technology 46(4):219-228.

Zaloom V., Subhedar V. 2008. Use of the Delphi Method to Prioritize Events Impacting Operations in the Maritime Domain. Lamar University, Texas, USA.