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The Maritime Event Risk Classification Method for risk identification in Pollution Preparedness and Response: Overview and case study

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ABSTRACT: Despite the increased focus on maritime safety, the risk of accidental oil spills remains a cause of concern in Europe and worldwide. In order to manage this issue, risk assessments are used for informing decision makers about the uncertainties that can effect to the occurrence of such spills. This paper focuses on the risk identification stage in context of Pollution Preparedness and Response risk management. This stage of the risk assessment process is critical, because a risk that is not identified will not be included in further analysis nor communicated to the decision makers. First, this paper describes a recently developed maritime application of the Event Risk Classification Method (ERC-M), which has a strong track record in different airlines companies. Second, the paper provides a case study, which is a practical demonstration of this ERC-M tool by using Vessel Traffic Service incident reports as a data source.

1 INTRODUCTION

Maritime transport and related industries are an important source of employment and income for the European economy. Almost 90 per cent of the European Unions' external freight trade is seaborne, and each year more than 400 million passengers embark and disembark at European ports (Eurostat 2018).

It can be argued that this transport mode is even a necessity, but on the other hand, it is also a hazard to the environment as e.g. previous large-scale ship accidents in Europe have demonstrated (Venesjärvi 2016). Because of this, the risk of accidental oil spill is a constant concern in Europe and globally. Currently, the worst scenarios within this context are often associated with large crude oil carriers, such as VLCC and ULCC ship types, as well as with offshore activities (ibid, Babcock-Adams et al. 2017).

On an international level, such as in the International Maritime Organization (IMO) and European Maritime Safety Agency (EMSA), efforts to reduce the risk of accidental oil spills are made along two lines of interrelated work. One line is focused on maritime accident prevention by means of safer ship design (Papanikolaou 2009) and navigation safety (Schröder-Hinrichs et al. 2013). The other line aims to minimize the environmental damage and associated financial costs of such accidents by means of e.g. Pollution Preparedness and Response (PPR). Even though the former is often considered the most cost-efficient option for risk mitigation (Haapasaari et al. 2015), the vision of zero accidents remains only an

ambitious target to aim at (Eliopoulou et al. 2012), and completely eradicating oil spill risk through design has been argued to be unfeasible (Papanikolaou 2009). Therefore, the PPR remains an essential aspect of ensuring a clean marine environment and other related interests of states. For ensuring the effectiveness of the PPR activities, the importance of knowledge obtained from risk assessments has been highlighted (IMO 2010).

In the context of European PPR, several risk assessment projects have been carried out during the past years, such as HELCOM BRISK/BRISK-RU (COWI 2011), BONN BE-AWARE I & II (Bonn Agreement 2014) and REMPEC MEDESS-4MS (Dupont et al. 2013). Recently, the European Civil Protection and Humanitarian Aid Operations (DC ECHO) financed a project called OpenRisk, the main outcome of which was a document 'OpenRisk Guideline for Regional Risk Management to Improve European Pollution Preparedness and Response at Sea' (Laine et al. 2018). This document includes ISO 31000:2018 standard based guidelines for the PPR risk management as well as a collection of 20 different risk assessment tools for this purpose, also known as the OpenRisk Toolbox. Moreover, the OpenRisk project provided e.g. a case study, which was a practical demonstration of some of these tools with the data of the Baltic Sea (Laine et al. 2019).

This paper presents a new risk assessment tool called the Maritime Event Risk Classification (ERC-M), which is based on the ARMS methodology, and it is one of the tools of the OpenRisk Toolbox. The

ERC-M is primarily useful in risk identification as well as in preliminary risk assessment. Furthermore, this paper provides a case study, which is a practical demonstration of the ERC-M by using VTS Incident reports of Finland and Estonia as well as HELCOM accident statistics as a data source.

The remainder of this paper is organized as follows. In Chapter 2, the ERC-M risk assessment tool is presented, including its main features, practical use and link to the overall risk assessment process. Chapter 3 introduces the case study. It begins with establishing the context and determining the risk level for different sea areas, which is followed by defining the typical hazards within these sea areas to identify Safety Issues. Thereafter, the likely accident scenarios are defined for each sea area for further analysis. Finally, Chapter 4 provides discussion and some conclusions.

2 EVENT RISK CLASSIFICATION METHOD

2.1 Background

The Event Risk Classification (ERC) is a part of the ARMS methodology for operational risk assessment. It was originally developed for the aviation industry by the ARMS working group during the period 2007-2010. Currently, this method is widely used by different airlines and has a strong track record in providing useful results (Nisula 2018).

The development of the maritime application of ERC started at the Finnish Transport Safety Agency from 2013 to 2015 (ibid). This work continued in the HELCOM led OpenRisk project in 2017 and resulted in the ERC-M tool, consisting of the definition of event classification matrices for environmental damage, loss of life or injuries and economic losses, and in a process for risk identification and initial risk assessment (Laine et al. 2018).

2.2 Overview

The term risk has been defined in multiple ways (Aven 2012, Goerlandt et al. 2015). The ARMS working group refers to the following definition in its methodology: 'Risk is a state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome' (ARMS WG 2010).

The ARMS methodology has two main components: Event Risk and Safety Issue. By definition, the Event Risk is a risk that was present in an individual experienced event in a specific context (ibid). To clarify this statement, an engine blackout occurring in a low traffic open sea area in good weather conditions, for instance, is a different situation from

a blackout in a high traffic port approach in gale conditions. As this simple example shows, the context of an event is significant from the risk point of view, and therefore it is necessary to take it into account. A Safety Issue is defined as a manifestation of a hazard or combination of several hazards in a specific context (ibid). This can be, for instance, engine blackouts related to use of certain fuel type in cold weather conditions, which have resulted in ships' groundings. In other words, the Safety Issue can be understood as a risk emerging from specific conditions.

The ERC-M method is designed for assessing the Event Risk and to identify Safety Issues. Figure 1 shows the ERC-M matrix, which is used for this purpose. This matrix is a qualitative tool for combining the consequence and likelihood in order to determine the risk class of a particular event. These risk classes are indicated with triage colors and associated codes, and they can be read directly from the cells of the matrix. For instance, the risk class 'Y5' concerns an event, which could have led into serious consequences, and where the effectiveness of the remaining controls is considered minimal. Summarizing the risk classes from different events gives a cumulative value, which can subsequently be used in identifying Safety Issues.

The ERC-M takes into account different types of consequences of an event, as they can be multiple and qualitatively disparate. For this purpose, the application includes separate matrices for the risk of loss of human life, environmental damage, and economic losses, which are briefly described in Tables 1 to 3. The criteria of these matrices have been derived from the ARMS methodology and adapted to the maritime needs during the OpenRisk project through interviews and workshops. Furthermore, the ERC-M takes into account the adequacy and effectiveness of the remaining controls, the criteria of which are shown in Table 4. For an extensive description of the matrices, see the OpenRisk guidelines.

Although the ERC-M is useful for assessing the risk of individual events, in the context of PPR the primary use of this tool is to identify Safety Issues. To clarify this point, it is more important in the given context to identify phenomena based on aggregate statistics rather than assess the risk of single events, if one needs to inform the decision makers on where to focus their risk management efforts. Once such phenomena have been identified, they can be explored with methods applicable for the PPR risk analysis.

Question 2: What was the effectiveness of the remaining controls between this event and the most credible accident scenario?				Question 1: If this event had escalated into an accident outcome, what would have been the most credible outcome?
Effective	Limited	Minimal	Not effective	
Y 7	R 3	B 2	B 3	Catastrophic
Y 3	Y 6	R 2	B 1	Very serious
G 4	Y 2	Y 5	R 1	Serious
G 2	G 3	Y 1	Y 4	Less serious
G 1				Insignificant

Figure1. Basic features of the ERC-M risk assessment matrix.

Table 1. Criteria for the severity of environmental damage.

Consequences	Estimated quantity of oil on the shore	Length of polluted coastline	Examples
-	m ³	km	-
Catastrophic	> 10 000	> 100	Prestige, Erika
Very serious	1 001 - 10 000	11 - 100	Other tanker accidents
Serious	11 - 1 000	2 - 10	General cargo ship accidents
Less serious	0.1 – 10	< 2	Port operations
Insignificant	nil	nil	nil

Table 2. Criteria for the severity of loss of life or injuries.

Consequences	Loss of life or injuries	Examples
-	No.	-
Catastrophic	≥ 100	Estonia, Sewol, Scandinavian Star
Very serious	5 – 99	Other ro-pax accidents
Serious	1 – 4	General cargo ship accidents
Less serious	Less serious injuries	Port operations
Insignificant	nil	nil

Table 3. Criteria for the severity of economic losses.

Consequences	Insurance claims	Examples
-	EUR	-
Catastrophic	H&M ≤ € 750 M P&I ≤ € 100 M	Costa Concordia, Erika
Very serious	H&M ≤ € 120 M P&I ≤ € 20 M	Total losses and wreck removal
Serious	H&M ≤ € 1 M P&I ≤ € 300 T	Dry-docking due to accident
Less serious	H&M € 30 – 100 T C&L € 10 - 50 T	Scratches or small damages
Insignificant	nil	nil

Table 4. Criteria for the effectiveness of remaining controls.

Effectiveness rating	Definition
Effective	An abnormal situation, more demanding to manage, but with a still considerable remaining safety margin.
Limited	An abnormal situation, more demanding to manage, but with a still considerable remaining safety margin.
Minimal	Some controls were still in place but their total effectiveness was minimal.
Not effective	An accident was not avoided, or the only thing separating the event from an accident was pure luck or exceptional skill, which is not trained nor required.

2.3 Use

The ERC-M risk assessment tool can be used to answer the following 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?

In the context of PPR risk management, the primary use of the ERC-M is to identify Safety Issues by aggregating the event data so that the likelihood as well as the potential consequences of events are reflected, not only their number. The knowledge obtained with the ERC-M can be used primarily in the intermittent PPR risk management process, which is one of the four PPR risk management processes included in the OpenRisk guidelines, in line with the principles of ISO 31000:2018 (Laine et al. 2018).

Generally, the intermittent risk management process focuses on gaining a better understanding of the risks in the maritime transportation system from a pollution preparedness viewpoint, i.e. the likelihood of different accident scenarios in various sea areas, and the severity of their consequences in terms of oil outflow, oil drift and ecosystem impacts.

Therefore, the aim of this process is to support the medium-term decision making related to the capacity and organization of the current response fleet in light of the maritime oil pollution risks (focus on preparedness), and to assess the performance of the response system (focus on response). For an extensive description, see the OpenRisk guidelines (ibid).

2.4 Input

The ERC-M deals with a number of data sources. It should be highlighted that this tool can also be used to assess the risk of near-misses and other non-accident events. In PPR the potential data sources can include, but are not limited to i) VTS incident reports, ii) marine casualty reports, iii) shipping companies safety reports, and iv) pilotage incident reports.

The data used for the ERC-M needs to be entered into a structured database, which facilitates risk identification and further analyses. When creating the database, it is necessary to classify the data in different categories and sub-categories, such as location of the event, IMO number of the ship involved, and accident type or the most plausible scenario.

2.5 Processes

The main steps of the ERC-M based risk assessment process are shown in Figure 2. The first step is to collect the data of events and to construct the database for later use.

The second step is the initial risk assessment of events by using the three ERC-M matrices. This step defines the risk class of each event in terms of loss of human life, environmental damage and economic losses. The method contains two questions, which are utilized to place the events in the correct cells in the matrices. These questions are:

1. Had this event escalated into an accident, what would have been the most credible accident outcome?
2. What was the effectiveness of the remaining controls between this event and the most credible accident outcome?

The first question is used to identify the most credible accident outcome when a considered event in a given context occurs. It determines the potential consequences of the event, and is used to determine the classification of the event on the vertical axis of the matrix. The second question focuses on the remaining controls between the event as it occurred and the most credible accident outcome. This relates to the likelihood of the accidental event, and is used to determine the classification of the event on the horizontal axis of the matrix.

The final step in the process is to explore the ERC-M based safety data to identify Safety Issues. Thereafter, the significant phenomena from the PPR point of view can be further analyzed by using other tools such as ADSAM C/G, SeaTrack Web and BowTie, which are all included in the OpenRisk Toolbox (Laine et al. 2018)

2.6 Output

The main output of the ERC-M risk assessment tool is a register of identified risks and hazards related to environmental damages, loss of life or injuries and economic losses as well as associated Safety Issues. The register is also classified, providing preliminary risk level results for the risk analysis stage.

The outputs can be presented as geographical maps, or charts that describe different aspects of risk on ship types, time periods and accidents, for example. The output can also include information about adequacy and effectiveness of the controls.

Figure 2. Simplified summary of the ERC-M process

3 CASE STUDY

3.1 Establishing the context

This case study provides a demonstration on the use of ERC-M risk assessment tool in the context of intermittent PPR risk management process as defined in the OpenRisk guideline. In geographical terms, the scope of this study covers the following Baltic Sea sub-areas: the Gulf of Finland, the Archipelago Sea, and the Åland Sea.

Within this framework, the incidents that occurred in the case study area are first explored to determine their spatial distribution, as well as to assess the risk level in different high incident density sea areas, including temporal changes in them (Sections 3.2 and 3.3). Thereafter, the hazards related to these so-called hot spot sea areas are addressed to identify the corresponding Safety Issues (Section 3.4). Finally, the high incident density sea areas are explored in more detail to define the likely medium-size and the large-scale accidental oil spill scenarios for each one of them for subsequent analysis (Sections 3.5 to 3.7).

Thus, the aim of this case study is to address the following risk management questions of Chapter 2:

- What is the risk level in different sea areas?
- What kinds of hazards occur in the sea area?
- What accident scenarios are likely?

The data used for exploring the first two questions consists of 982 incident reports from the period 2014-2016. The sources include the VTS incident reports of Finland (LIVI 2017) and Estonia (EMA 2017), as well as the HELCOM accident data (HELCOM 2017a), and AIS data (HELCOM 2017b). The VTS Incident reports from the Russian Federation and from Sweden were not available for this study.

3.2 Spatial risk distribution

Figure 3. Spatial density of incidents in the case study area

This section aims to provide an answer to the question: what is the risk level in different sea areas?

In the first stage of this part of the case study, a method called Kernel Density is applied to determine the high incident density sea areas in the study area, focusing on the risk of environmental damage. This method is a Geographic Information System (GIS) application to calculate a magnitude-per-unit area from point features that fall within a neighborhood around each cell (ArcMap 2018).

The spatial distribution of incidents is shown in Figure 3, which is visualized using the ArcMap Density Toolset. It is seen that the density is highest in the Gulf of Finland between Helsinki and Tallinn (Sea area 4) and in the Åland Sea (Sea area 1). Densities are also higher near the Kotka-Hamina sea area in the eastern part of the case study area (Sea area 5), as well as near Hanko in the west (Sea area 3). In addition, a high density area can be identified in the Archipelago Sea (Sea area 2). Due to lack of data, mentioned in Section 3.1, the most eastern parts of the study area and the east coast of Sweden are not well covered in the calculations.

The second tool applied in this stage of the case study is the ERC-M, which is used for the risk identification of the five high incident density sea areas, shown in Figure 3. For this purpose, each incident report has been classified with three ERC-M risk matrices, focusing on the potential damage for the environment, loss of lives, and economic losses.

Table 5 shows that the number of incidents is highest in Sea areas 4 and 1, followed by Sea areas 3, 5 and 2. Based on the ERC-M classification, the incidents with very high or high risk of damage to

the environment are concentrated in Sea areas 4, 3 and 5, whereas those with high risk of loss of life or injuries are distributed more equally. The incidents with very high or high risk of economic losses are mainly concentrated in Sea areas 4, 3 and 5.

In terms of priority, the order of these sea areas is as follows: Sea area 4, 3, 5, 1 and 2. This can be justified based on the focus of this case study, which is the risk of environmental damage, as well with the principles of the ARMS methodology, which emphasize the management of particularly the high risk events (ARMS WG 2010).

Table 5. Different aspects of risk in the sea areas

Risk aspect and severity	Sea area 1	Sea area 2	Sea area 3	Sea area 4	Sea area 5
Environment					
Very high risk	0	0	1	1	0
High risk	0	0	1	1	2
Medium risk	53	36	33	86	50
Low risk	213	18	69	187	46
Total	266	54	104	275	98
Loss of life					
Very high risk	0	0	0	0	0
High risk	3	3	2	6	0
Medium risk	35	7	16	38	12
Low risk	228	44	86	231	86
Total	266	54	104	275	98
Economic					
Very high risk	0	0	1	1	0
High risk	2	3	4	9	5
Medium risk	58	40	39	99	51
Low risk	206	11	60	166	42
Total	266	54	104	275	98

3.3 Temporal risk distribution

The aim of this section is to explore the temporal risk distribution in the case study area to obtain knowledge about the changes in risk level in different months and times of the day. The method applied for this purpose is the ERC-M.

Figure 4 shows the monthly distribution of the incidents in the case study area, with aggregated risk level classifications obtained from application of the ERC-M method. The number is highest in June and December, declining towards early spring and autumn. The incidents with very high risk of environmental damage are also recorded during these same months.

When comparing different times of the day, the number of incidents is distributed very evenly. The variation is around 25 percent of the total number of incidents. Nevertheless, the share of the incidents with very high or high risk of environmental damage is somewhat higher from 04:00 to 10:00 local time.

Figure 4. Number of incidents per month in case study area including the risk of environmental damage

3.4 Hazards related to accidental oil spills

This section aims to provide an answer to the question: what kinds of hazard occur in the sea area?

Maritime accidents are typically classified into different categories, such as grounding, collision, and machinery damage, which can be considered as hazards from the PPR point of view. To address the question it is explored which types of maritime accidents are most likely to occur, and what is the risk of environmental damage in the case of event occurrence.

In this part of the case study, the incidents are first classified into different accident categories, which is followed by the ERC-M classification. Of all 982 incidents, 15% were maritime accidents. The other 85% were violations, near-miss situations, engine failures, etc. In such cases, the classification is based on the most plausible accident scenario within the context of these events.

The results are shown in Figure 5. It is seen that most of the incidents are classified as groundings (309), five of which had a high risk of environmental

damage. This kind of incidents have occurred mainly in Sea areas 4, 5 and 1. Collision is the second most common category (288), and e.g. two of them are classified as very high risk incidents in terms of damage to the environment. Such incidents are prevalent primarily in Sea areas 4, 3 and 1.

To summarize, the hazards within the five high incident density sea areas are primarily grounding or collision ship accidents, in which the risk of environmental damage can be significant. From the temporal point of view, the high risk seasons are mainly summer and winter. To explore these identified Safety Issues in more detail, the next three sections are addressed to define the scenarios for each of the five sea areas.

Figure 5. Risk of damage to the environment in different accident types

3.5 Risk of accidental oil spills in different ship types

This section aims to provide an answer to the question: what accident scenarios are likely?

One common way to classify maritime accidents is to use different merchant ship categories as a base for classification. In this case study, the HELCOM categorization is applied for this purpose, which includes ship types such as cargo, tanker, passenger ships, etc. (HELCOM 2017b). To address the question it is first explored which ship types are likely to experience maritime accidents, including what is the risk of environmental damage in the case of event occurrence. For this purpose, the incidents are first classified into different ship categories. Thereafter, the risk of environmental damage within these incidents is assessed by using the ERC-M tool.

The results are presented in Figure 6, which shows that most of the incidents occurred to cargo ships (436), followed by tankers (145) and passenger ships (132). The incidents with very high risk of damage to the environment occurred only to tankers, whereas high risk incidents can be observed also in other ship categories. The tanker incidents are focused on Sea areas 4, 5 and 3.

Based on these results, it can be argued that most likely accident scenarios are related to cargo ships. But when considering also the risk aspect within the explored incidents, it is justified to consider the tankers as a main priority.

Figure 6. Risk of environmental damage per ship type

3.6 Size of oil tankers

This section is focused on the size of the tankers that are navigating in the high incident density sea areas, for specifying the accident scenarios. The aim is to explore particularly the length distribution of the tankers to determine the base for medium-size and large-scale pollution accident scenarios.

The data used to explore this topic is obtained from the HELCOM AIS database and covers the review period. The results are shown in Figure 6, which are visualized using the Box Plot diagram. It is seen, for instance, that the median length of tankers sailing in Sea area 4 is approximately 160 meters, and the upper extreme is nearly 330 meters. On the other hand, in Sea areas 1 and 2 for instance, the tanker lengths are clearly shorter in both categories, and the range of length distribution is rather narrow compared to the other sea areas.

Figure 7. Distribution of oil tankers overall lengths (LOA).

3.7 Scenarios

This section concludes the determination of the likely scenarios. For this purpose, the previous results of the case study are used as a criterion to select such VTS incident reports which can be used as a base for creating the medium-size and large-scale pollution accident scenarios. Hence, two VTS Incident reports are selected for each of the five high incident density sea areas. The procedure of selection is as follows:

First, the VTS incident reports are classified based on the five high incident density sea areas, shown in Figure 3. Second, only the reports that are classified as either grounding or collision incidents are selected for further analysis, based on the results shown in Figure 4. Third, only reports involving tankers are selected, based on the results shown in Figure 5. Fourth, the length distribution of tankers is used as criteria to continue selection, see Figure 6. Finally, the remaining VTS incident reports are studied individually in order to find the most applicable scenarios for the medium-size and large-scale pollution accidents for each five high incident density sea areas.

The key information from these 10 selected incident scenarios is shown in Table 6. This information can be further utilized in the estimation of the oil spill sizes, the oil spill drifts, and the response effectiveness. For privacy-related reasons, the identities of these vessels are not specified, neither the specific circumstances of the incidents.

It should be highlighted that none of these reported incidents actually led to accidents or oil spills, but they can be used as a starting point to develop plausible accident scenarios. This can be done by reading the VTS incident reports, and by altering the storyline in a plausible way using expert judgment, so that an accident would occur where a tanker would ground or collide with another vessel.

Table 6. Scenarios for different high incident density sea areas

ID	Lat. N	Long. E	Date	ERC-M			LOA [m]
				Env.	Hum.	Econ.	
1	59.78	20.61	30.05.14				125
2	59.72	19.89	04.02.15				183
3	60.44	22.07	12.11.15				117
4	59.93	21.60	18.07.16				144
5	59.75	22.79	04.01.14				183
6	59.76	22.72	18.12.16				244
7	60.20	25.60	09.10.16				252
8	60.07	25.41	10.06.16				145
9	60.10	26.09	12.06.15				249
10	60.48	26.95	28.05.15				125

4 DISCUSSION AND CONCLUSIONS

The strength of the ERC-M is firstly that it takes into account the risk aspects of different kind of events instead of focusing only on their number, see Table 5. As such, the tool highlights better the uncertainties related to e.g. aims of the PPR. Second, this tool is applicable to identify Safety Issues, which can be analyzed thereafter by utilizing scenarios, see Table 6. The knowledge obtained through the process can be used for risk treatment and communicated to the PPR decision makers in order to prevent the risks from getting materialized. Third, the ERC-M addresses the actual events, instead of model representations where assumptions may significantly affect the results (Goerlandt and Kujala 2014). Using data and expert judgment for specific events should increase the analysis reliability. From a practical point of view, the ERC-M is relatively easy to use, but an assessor with maritime expertise is required to make judgments about the classes.

The main weakness of the ERC-M is a strong dependency on the quantity and quality of the input data, see e.g. Figure 3. Furthermore, ERC-M is largely a reactive approach, with input data consisting of actual historic events. Hence, ERC-M cannot be used to assess the risk of e.g. future developments, such as autonomous shipping. Finally, it should be highlighted that the knowledge obtained with ERC-M can be somewhat biased as the outcome is based on expert judgements. However, tests conducted during a PPR risk management workshop indicated that variation in expert judgements in using ERC-M is relatively low (Goerladt et al. 2018).

The OpenRisk Toolbox (Laine et al. 2018) includes a total of 20 different risk assessment tools, which can be linked to results of the ERC-M. For instance, the Delphi tool can be applied to fill up the risk identification gaps of the ERC-M. To analyze the Safety Issues, the likelihoods can be assessed with e.g. the IWRAP tool, whereas the consequences with tools such as ADSAM C/G, SeaTrack Web and ERSP Calculator. In addition, the toolbox includes schemes for assessing the strength of evidence. The risk evaluation stage of the Safety Issues can be conducted with e.g. Risk Matrices and Probability-Consequence Diagrams as well as with the ALARP and Cost-Benefit Analysis tools.

To conclude, this paper has introduced the recently developed ERC-M risk assessment tool and demonstrated its practical application through a case study. The results indicate that the ERC-M can provide useful knowledge related to the risk management questions of Section 2.3. Hence, it can be argued that this tool can also support PPR-related decision making.

Finally, future work will elaborate on the earlier noted four PPR risk management processes, as well as show how the identified Safety Issues can be fur-

ther analyzed and evaluated by utilizing other tools of the OpenRisk Toolbox.

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