PUBLICATIONS OF THE HAZARD PROJECT
13:2017

MODELLING SPREAD LIMITATIONS OF OIL SPILLS AT SEA

Sambor Guze
Krzysztof Kołowrocki
Jolanta Mazurek

Department of Mathematics. Faculty of Navigation, Gdynia Maritime University

13:2017

MODELLING SPREAD LIMITATIONS OF OIL SPILLS AT SEA

Sambor Guze
Krzysztof Kołowrocki
Jolanta Mazurek

Department of Mathematics. Faculty of Navigation, Gdynia Maritime University

Turku 2017

ISBN 978-951-29-7084-1

2017

PUBLISHED BY:
HAZARD Project
Turku School of Economics
University of Turku
Rehtorinpellonkatu 3, FI- 20014 University of Turku, Finland
http://blogit.utu.fi/hazard/

Editor-in-Chief of HAZARD Publication Series:

Professor Lauri Ojala
Turku School of Economics
University of Turku, Finland

Members of the Editorial Team of HAZARD Publication Series:

Professor Wolfgang Kersten
Institute of Business Logistics and General Management
Hamburg University of Technology, Germany

Mr. Torbjörn Lindström
Southwest Finland Emergency Service

Associate Professor Daniel Ekwall
Faculty of Textiles Engineering and Business
University of Borås, Sweden

Mr. Norbert Smietanka
HHLA AG, Hamburg, Germany

Dr. Jarmo Malmsten
Turku School of Economics
University of Turku, Finland

University Professor Joanna Soszyńska-Budny
Faculty of Navigation
Gdynia Maritime University, Poland

Editorial Officer of HAZARD Publication Series:

Ms. Mariikka Whiteman
Turku School of Economics, University of Turku, Finland

All rights reserved. Whilst all reasonable care has taken to ensure the accuracy of this publication, the publishers cannot accept responsibility for any errors or omissions.

This publication has been produced with the financial assistance of the European Union. The content of this publication is the sole responsibility of the publisher and under no circumstances can be regarded as reflecting the position of the European Union.

The content of this publication reflects the authors views. The Investitionbank Schleswig-Holstein is not liable for any use that may be made of the information contained herein.

Photo credits for the cover: Mr. Esko Keski-Oja, Finland

Published 25.9.2017

This publication is co-financed from financial resources of the Ministry of Science and Higher Education, Poland for science in the years 2016-2019 granted for realization of the co-finance projects.

The article has been published earlier in JPSRA/ASMDA Proceedings.

Keywords

Drift trend, Oil spill domain, Spread limitations, Stochastic model.

Abstract

To describe the oil spill central point position a two-dimensional stochastic process is used and its drift trend curve is determined. The oil spill domain movement general model for various hydro-meteorological conditions is constructed and the method of this model unknown parameters estimation is proposed. These methods are used to predict the spill domain movement and to prevent and to mitigate the oil spill consequences by constructing the algorithm for oil spill spread limitations. An exemplary application of this procedure is given.

TABLE OF CONTENTS

1 INTRODUCTION..7

2 OIL SPILL BASIC CHARACTERISTICS..8

3 STOCHASTIC MODEL OF OIL SPILL...9

  3.1 Oil Spill Drift Trend Determination..9
  3.2 Oil Spill Drift Domain Determination..10
  3.3 Oil Spill Domain for Fixed Climate-Weather Conditions..................................12
  3.4 Oil Spill Domain for Varying Climate-Weather Conditions...............................13
  3.5 Oil Spill Drift Trend and Position Distribution Parameters Statistical Identification...14

4 OIL SPILLS SPREAD LIMITATIONS ALGORITHM..16

5 CONCLUSIONS...19

1 INTRODUCTION

Nowadays, approximately 60% of the world's oil is transported by sea. Thus, the important thing is to maintain the highest level of the safety during the oil extraction, handling, and storing. Especially, it is very important aspect for closed seas such as the Baltic Sea or the Mediterranean Sea, because even small pollution gives very high impact for environment. Unfortunately, despite all efforts, sometimes a smaller or larger leakage of oil occurs. In that situation, the most important thing is time to react and take appropriate actions to minimize the negative effects. There are functioning a lot of models of the spill. Some of them simulate only the advective processes (Al-Rabeh [1], Huang [6], Reed et. al. [12], Spaulding [14]) and some also take into account the spreading processes (Fay [3], Guze et. al. [5], Huang [6], NOAA [10], Reed et.al [12]).

The improvement of the methods of the oil spill domain determination is one of real possibilities leading to the maritime environment protection and chermical pollution reduction. Therefore it seems to be necessary to start with the new and better methods of oil spill domains at sea determination for different hydro-meteorological conditions and different kinds of oil spills. The most important criterion of new methods should be the attainment time minimising of the reaction to oil spills. One of the essential factors that could ensure these criteria fulfilment is the accuracy of methods of oil spills domain determination. Those methods are a basic part of the integral problem of oil spill and pollution-fighting at the sea directed to the elaboration of a complete information system assisting national maritime environment protection administration to reduce the consequences the oil spills at the sea.

Thus, the main aim of the paper is to propose a probabilistic approach to determination of oil spills domains. It is presented in 5 succeeded subsections, where oil spill trend and drift domain for different hydro-meteorological conditions and oil spill kinds, the pollution-fighting time distribution, and the oil spill random position distribution are determined. Furthermore, the oil spill drift trend and position distribution parameters statistical identification procedure is presented with accordance to the least squares method (Kołowrocki [7], Kołowrocki and Soszyńska-Budny [8], Rice [13]). Finally, the algorithm for oil spill spread limitations is proposed as the possible stochastic oil spill model application. The exemplary results of computer simulation based on introduced model and algorithm are showed.

The suggested probabilistic approach to oil spill domains determination can improve the efficiency of pollution combat at the sea.

2 OIL SPILL BASIC CHARACTERISTICS

According to the “Trajectory Analysis Handbook” NOAA [11] the parameters affecting oil spill movement are as follows:

a) weather conditions (wind, temperature, and rainfall),
b) ocean conditions (tides and currents),
c) physical parameters of the materials which could be spilled, i.e.:
    - specific gravity (or density);
    - evaporation rate;
    - boiling range;
    - viscosity;
    - pour point;
    - emulsification ability;
    - water solubility.

Some of these factors are related. For example, the evaporation rate is dependent on weather conditions (especially wind) and the boiling range of the material. Similarly, the spread rate depends on weather, viscosity, and the pour point. Emulsification is a very complex parameter since both oil-in-water and water-in-oil emulsions can be involved and wind and wave conditions are usually controlling NOAA [11].

In the other hand, there are following characteristics of spills NPC [9]:

- maximum area of spread [m^2],
- maximum radius of a circular slick [m],
- time to reach maximum radius [min],
- spill volume [gallons],
- spreading coefficient [dynes/cm].

According to results of Fay [3], estimates of initial spill volume and a spreading equation are required to determine the spreading radius of a hypothetical spill as a function of time. Wind speed and direction, local tidal currents, and the general circulation along the coast are required to determine the trajectory of the slick, and estimates of the general circulation of the water body are needed to predict the fate of that fraction of the spill which may mix downward into the water column.

3 STOCHASTIC MODEL OF OIL SPILL

In this section, the stochastic model of oil spill is proposed. This tool gives the possibility to determine the drift trend and the domain of the oil spill. This model adapts and transforms the approach and the results concerned with the survivor search domain at the sea restricted areas determination considered in Blokus and Kołowrocki [2] in the way presented in next five subsections.

3.1 Oil Spill Drift Trend Determination

For each fixed state c_k, k = 1,2,…,w, of the climate-weather process $C\text{-}W(t)$ we define a two-dimensional stochastic process

$(X^k(t), Y^k(t)),\ t \in <0,T>,$

(1)

such that

$(X^k, Y^k) : <0,T> \to R^2,$

(2)

where $X^k(t),\ Y^k(t)$ respectively are an abscissa and an ordinate of the plane *Oxy* point, in which the central point of the oil spill is placed at the moment *t* while the climate-weather process $C\text{-}W(t)$ is at the state c_k, k = 1,2,…,w. The point in which an accident has happened and an oil spill was placed in the water we assume as the origin $O(0,0)$ of the co-ordinate system *Oxy*. The value of a parameter *t* at the moment of the accident we assume equal to 0. It means that the process $(X^k(t), Y^k(t)),$ is a random two-dimensional co-ordinate (a random position) of the oil spill central point after the time *t* from the accident moment and that at the accident moment $t = 0$ the oil spill is at the point $O(0,0)$, i.e. $(X^k(0), Y^k(0)) = (0,0).$ After some time, the oil spill starts his drift along a curve called a drift curve. In further analysis we assume that processes

$(X^k(t), Y^k(t)),\ t \in <0,T>,\ k = 1,2,\ldots,m,$

are two-dimensional normal processes

$$N(m_X^k(t), m_Y^k(t), \rho_{XY}^k(t), \sigma_X^k(t), \sigma_Y^k(t)),\ t \in <0,T>, \qquad (3)$$

with varying in time expected values

$$m_X^k(t) = E[X^k(t)],\ \ m_Y^k(t) = E[Y^k(t)], \qquad (4)$$

standard deviations

$\sigma_X^k(t),\ \sigma_Y^k(t)$

and correlation coefficients

$\rho_{XY}^k(t),$

i.e. with the joint density functions

$$\varphi_t^{\,k}(x,y) = \frac{1}{2\pi\sigma_X^k(t)\sigma_Y^k(t)\sqrt{1-(\rho_{XY}^k(t))^2}}\exp\{-\frac{1}{2(1-(\rho_{XY}{}^k(t))^2)}[\frac{(x-m_X{}^k(t))^2}{(\sigma_X{}^k(t))^2}$$

$$-2\rho_{XY}{}^k(t)\frac{(x-m_X{}^k(t))(y-m_Y{}^k(t))}{\sigma_X{}^k(t)\sigma_Y{}^k(t)}+\frac{(y-m_Y{}^k(t))^2}{(\sigma_Y{}^k(t))^2}]\}, \tag{5}$$

where $(x,y)\in R^2$, $t \in <0,T>$.

Then, the points $(m_X^k(t), m_Y^k(t))$, $t \in <0,T>$, create a curve K^k which may be described in the following parametric form

$$K^k : \begin{cases} x^k = x^k(t) \\ y^k = y^k(t), t \in <0,T>. \end{cases} \tag{6}$$

called an oil spill drift trend and presented in Figure 1.

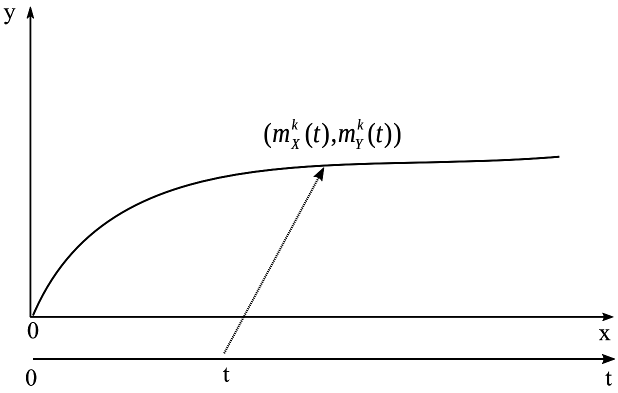

Figure 1. The oil spill drift trend

3.2 Oil Spill Drift Domain Determination

We are interested in finding the domain $D^k(t)$ such that the oil spill is placed within it with a fixed probability *p*. More exactly, we are looking for *p* such that

$$P((X^k(t),Y^k(t)) \in D^k(t)) = \iint\limits_{D^{(k)}(t)} \varphi_t^k(x,y)\,dxdy = p, \tag{7}$$

where

$$D^k(t) = \{(x,y): \frac{1}{1-(\rho_{XY}^k(t))^2}[\frac{(x-m_X^k(t))^2}{(\sigma_X^k(t))^2} - 2\rho_{XY}^k(t)\frac{(x-m_X^k(t))(y-m_Y^k(t))}{\sigma_X^k(t)\sigma_Y^k(t)} + \frac{(y-m_Y^k(t))^2}{(\sigma_Y^k(t))^2}] \le c^2\} \tag{8}$$

is the domain bounded by an ellipse being the projection on the plane $0xy$ of the curve rising as the result of intersection of the density function surface

$$\pi_1^k = \{(x,y,z): z = \varphi_t^k(x,y), (x,y) \in R^2\} \tag{9}$$

and the plane

$$\pi_2^k = \{(x,y,z):\ z = \frac{1}{2\pi\sigma_X^k\sigma_Y^k\sqrt{1-(\rho_{XY}^k(t))^2}}\exp[-\frac{1}{2}c^2], (x,y) \in R^2\}. \tag{10}$$

The graph of the domain $D^k(t)$ is given in Figure 2.

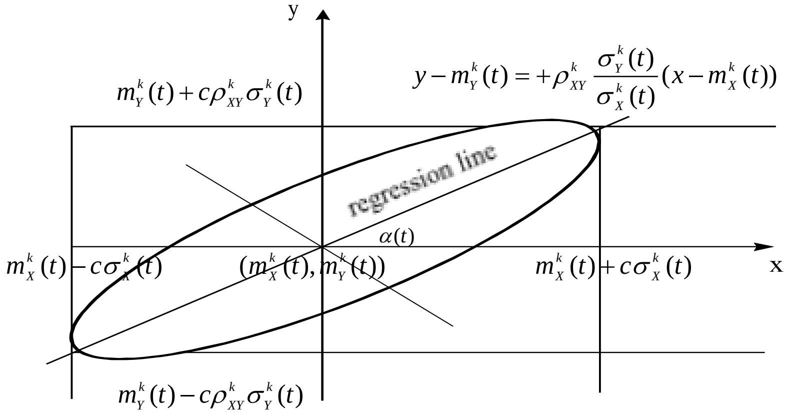

Figure. 2. Domain of integration $D^k(t)$

Since

$$P((X^k(t),Y^k(t)) \in D^k(t)) = 1 - \exp[-\frac{1}{2}c^2], \tag{11}$$

then for a fixed probability *p*, the equality

$$p = P((X^k(t),Y^k(t)) \in D^k) \tag{12}$$

holds if $c^2 = -2\ln(1-p)$. Thus, the domain in which at the moment t the oil spill is placed with the fixed probability *p* is given by

$$D^k(t) = \{(x,y): \frac{1}{1-(\rho_{XY}^k(t))^2}[\frac{(x-m_X^k(t))^2}{(\sigma_X^k(t))^2} - 2\rho_{XY}^k(t)\frac{(x-m_X^k(t))(y-m_Y^k(t))}{\sigma_X^k(t)\sigma_Y^k(t)} + \frac{(y-m_Y^k(t))^2}{(\sigma_Y^k(t))^2}] \le -2\ln(1-p)\}.$$

(13)

3.3 Oil Spill Domain for Fixed Climate-Weather Conditions

We suppose that the climate-weather process $C-W(t)$ is in a fixed state c_k, $k=1,2,...,w.$ Assuming a time step Δt and a number of steps *s*, $s \ge 1,$ such that

$(s-1)\Delta t < E[\theta_k] \le s\Delta t,$

where $E[\theta_k]$ is the expected value of the process $C-W(t)$ sojourn time at the state c_k, $k=1,2,...,w,$ we receive the following sequence of domains (Figure 3)

$D^k(\Delta t), D^k(2\Delta t),..., D^k(s\Delta t),$ in which at the moments $\Delta t, 2\Delta t, \ldots, s\Delta t,$ the oil spill is placed with probability $p.$

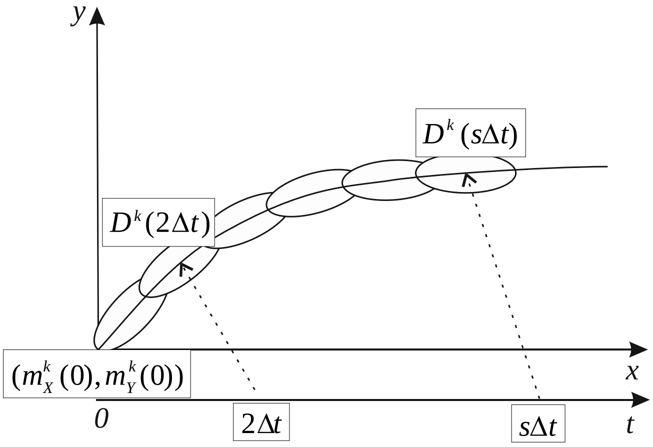

Figure 3. Sequence of oil spill domains

Then the oil spill domain is described by the sum of selected domains (Figure 4)

$D^k(v\Delta t) \cup D^k((v+1)\Delta t) \cup \ . \ . \ . \ \cup D^k(w\Delta t),$

where v is such that

$v\Delta t < m_U^k + m_V^k \le (v+1)\Delta t,$ (14)

while w is such that

$$(w-1)\Delta t < m_U^k + m_V^k + m_T^k \le w\Delta t,$$

and

$$m_U^k = E[U^k], \quad m_V^k = E[V^k], \quad m_T^k = E[T^k],$$

are the expected values of the pollution-fighting unit activation time U^k, the time necessary to reach the oil spill domain by the pollution-fighting unit V^k and the unit pollution fighting time T^k, which are determined in the paper Section 3.4.

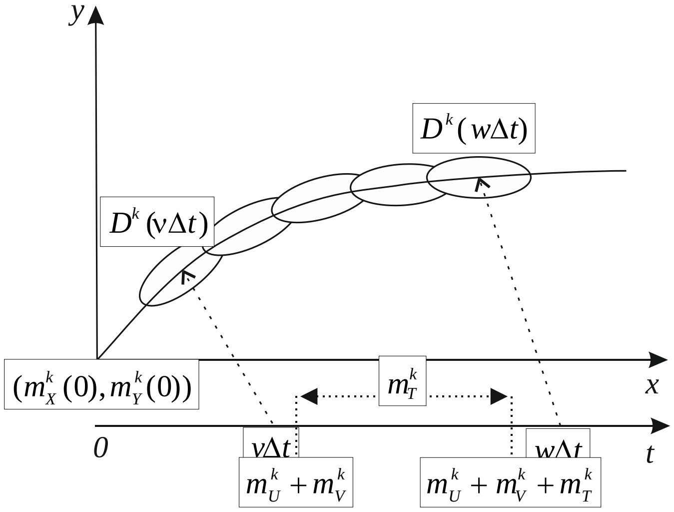

Figure 4. Oil spill domain for fixed hydro-meteorological conditions

3.4 Oil Spill Domain for Varying Climate-Weather Conditions

We assume that the process of hydro-meteorological conditions changing in succession takes the states $c_{k_1}, c_{k_2}, \ldots,\ k_i \in \{1, 2, \ldots, w\}$. For a time step Δt we determine the oil spill domain as the sum of the domains (Figure 5)

$$\bigcup_{i=1}^{n} [D^{k_i}(v_i \Delta t) \cup D^{k_i}((v_i+1)\Delta t) \cup \ \ . \ \ . \ \ . \ \ \cup D^{k_i}(w_i \Delta t)], \tag{15}$$

where v_i is such that

$$v_i \Delta t < \overline{U}^{k_1} + \overline{V}^{k_1} + \sum_{j=1}^{i-1} \overline{\theta}_{kjk_{j+1}} \le (v_i + 1)\Delta t, \quad i = 1,2,\ldots,n,$$

while w_i is such that

$$w_i \Delta t < \overline{U}^{k_1} + \overline{V}^{k_1} + \sum_{j=1}^{i} \overline{\theta}_{kjk_{j+1}} \le (w_i + 1)\Delta t, \quad i = 1,2,\ldots,n,$$ and $\overline{U}^{k_1}, \quad \overline{V}^{k_1}, \ \overline{\theta}_{k_j k_{j+1}},$

are the realisations of the pollution-fighting unit activation time U^{k_1}, the time necessary to reach the oil spill domain by the pollution-fighting unit V^{k_1} and the process $A(t)$ sojourn time $\theta_{k_j k_{j+1}}$ in the state k_j while the next transition will be done to the state k_{j+1} respectively and n is such that

$$\overline{U}^{k_1} + \overline{V}^{k_1} + \sum_{j=1}^{n-1} \overline{\theta}_{kjk_{j+1}} < \max_{1 \le j \le n}\{E(T^{k_j})\} \le \ \overline{U}^{k_1} + \overline{V}^{k_1} + \sum_{j=1}^{n} \overline{\theta}_{kjk_{j+1}}. \qquad (16)$$

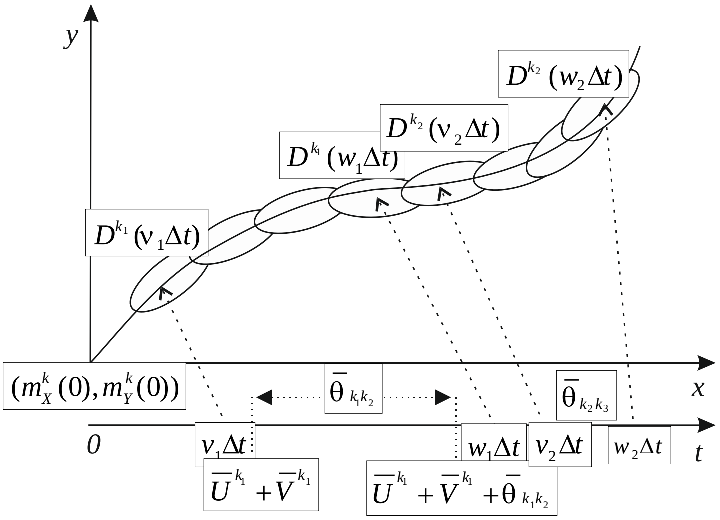

Figure 5. Oil spill domain for changing hydro-meteorological conditions

3.5 Oil Spill Drift Trend and Position Distribution Parameters Statistical Identification

To determine the evaluations of oil spill drift trend and parameters of joint density function $\varphi_t^k(x, y)$ it is necessary to perform the following steps:

- to fix the number N^k and the moments of observations $t_1, t_2, \ldots, t_{N^k}$, in which the oil spill positions are determined,
- to fix the numbers of the process $(X^k(t), Y^k(t))$ realisations $n^k(1),\ n^k(2),\ \cdots,\ n^k(N^k)$ at the moments $t_1, t_2, \ldots, t_{N^k}$,
- to fix the oil spill positions $(x'^k_1(t_v), y'^k_1(t_v)),\ (x'^k_2(t_v), y'^k_2(t_v)),\ \ldots,\ (x'^k_{n^k(v)}(t_v), y'^k_{n^k(v)}(t_v)),$ at each moment $t_v, v = 1,2,\ldots,N^k$,
- to calculate mean oil spill positions according to the formulae

$$m'^{\,k}_X(t_v) = \frac{1}{n^k(v)} \sum_{v=1}^{n^k(v)} x'^k_v(t_v),\ \ m'^{\,k}_Y(t_v) = \frac{1}{n^k(v)} \sum_{v=1}^{n^k(v)} y'^k_v(t_v),\ \ v = 1.2,\ldots,N^k,$$

- to calculate oil spill position standard deviations according to the formulae

$$\sigma'_X{}^k(t_\nu) = \sqrt{\frac{1}{n^k(\nu)} \sum_{\nu=1}^{n^k(\nu)} [x'^k_\nu(t_\nu)]^2 - [m_X{}^k(t_\nu)]^2} \ ,$$

$$\sigma'_Y{}^k(t_\nu) = \sqrt{\frac{1}{n^k(\nu)} \sum_{\nu=1}^{n^k(\nu)} [y'^k(t_\nu)]^2 - [m_Y{}^k(t_\nu)]^2} \ , \ \nu = 1.2,\ldots, N^k,$$

- to calculate oil spill position correlation coefficients according to the formula

$$\rho'_{XY}{}^k(t_\nu) = \frac{\frac{1}{n^k(\nu)} \sum_{\nu=1}^{n^k(\nu)} x'^k_\nu(t_\nu) y'^k_\nu(t_\nu) - m_X{}^k(t_\nu) m_Y{}^k(t)}{\sigma_{X\,i}{}^k(t_\nu)\sigma_{Y\,i}{}^k(t_\nu)}, \ \nu = 1,2,\ldots, N^k,$$

- to find parametric forms of the oil spill drift trend and remaining parameters of oil spill position distribution according to the least squares method (Kołowrocki [7], Kołowrocki and Soszyńska-Budny [8], Rice [13]).

4 OIL SPILLS SPREAD LIMITATIONS ALGORITHM

In this Section, the algorithm for oil spills spread limitations is introduced as the possible application of the oil spill stochastic model introduced in Section 3. It is done on the basis of the customizing discrete-time oil spill control model which was introduced in Guze et. al [5].

To simplify the considered problem, the water area affected by oil spill is represented by the Cartesian grid graph $G = (V, E)$, where the $V(G) = \{v_1, v_2, ...\}$ is a grid vertex set and $E(G) = \{e_1, e_2, ...\}$ is an edge set. According to this assumption, the water area is divided into equal-size squares and the vertex $v \in E(G)$ is in central of them. Furthermore, if $v_i, v_j \in E(G)$, $i, j = 1,2,...,$ then we call v_i and v_j adjacent vertices. In Cartesian grid graphs every vertex is adjacent to four other vertices.

The possible states of the vertex in algorithm are: “empty”, “oil-affected”, and “barrier-filled”. Moreover, there are two modes of barriers: “attack” and “defence”. The both barriers are performed simultaneously with assumption, that the barrier in attack mode is use in vertices located on the oil spill drift trend and vertices in defence mode in opposite direction. In the algorithm of the oil spill spread limitation, the barriers may be set on the “empty” vertices only, because a vertex state already “oil-affected” or “barrier-filled” cannot be changed.

First step to introduce the oil spills spread limitations algorithm, it is necessary to build the oil spill spread model. In this paper, the discrete-time oil spill spread model converts the results mentioned in Section 3.2 without the impact of the hydro-meteorological conditions is showed. This model uses the cycles as the measure of the time. It is built according to following steps:

- Oil spill appears on the water area in cycle 0.
- First vertex changes its state from “empty” to “oil-affected” is the oil spill source.
- The oil spill source designates the grid centre as the central vertex $(0,0)$. Additionally, it divides the grid into four quarters and sets the system of coordinates.
- In each subsequent cycle, the oil spill spreads from the “oil-affected” vertices to every adjacent “empty” vertex.

The exemplary results of the oil slick in cycle 3, 7, 11 received on the basis of the above procedure are presented in the Fig. 6.

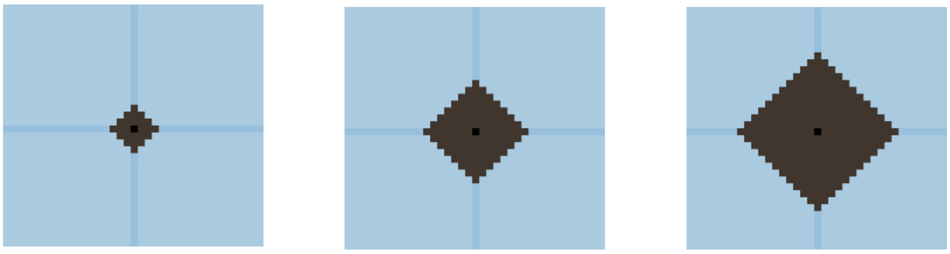
(A) (B) (C)

Fig. 6. The spreading of the oil spill in cycles: N=3 (A), N=7 (B), N=11 (C)

After introducing the all necessary notations, procedures and assumptions the proposed algorithm is as follows:

Algorithm for oil spills spread limitations

Input: The water area affected by oil spill and represents by the Cartesian grid graph $G=(V,E)$

Steps:

1. To find, on the beginning and in the end of the oil spill drift, the empty vertices adjacent to "oil-affected" ones and to put the barriers in defence mode and next to, simultaneously, the barriers in attack mode, according to general assumption about their location.
2. To change the state of the selected vertices on "barrier-filled".
3. For every empty vertex, adjacent to "oil-affected", and while oil spill is not encircled do:
    a. If empty vertex is on the way of the oil spill drift trend
        i. to put:
            - the barrier in attack mode;
            - and simultaneously the barrier in defence mode in opposite direction;
        ii. to change the vertex state on "barrier-filled";
    b. else
        i. to put:
            - the barrier in defence mode;
            - and simultaneously the barrier in attack mode in opposite direction;
        ii. to change the vertex state on "barrier-filled".

Results: A series of barriers surrounds the oil-affected area and an oil slick without possibility to spread further.

The surrounding of the oil spill is performed according to above algorithm built on the basis of "firefighter algorithm" (Fogarty[4]). According to this approach if the action of surrounding the oil spill starts in cycle $N+1$ and 2 barriers are available in each cycle on the Cartesian grid graphs the number of cycles needed to go around the oil slick is equal $32N+1$ and the number of square of a spill area is equal $318N^2+14N+1$(Fogarty [4]).

The exemplary simulation results given in Fig. 7 represents an oil slick on the Cartesian grid graph (oil spill source marked with black).

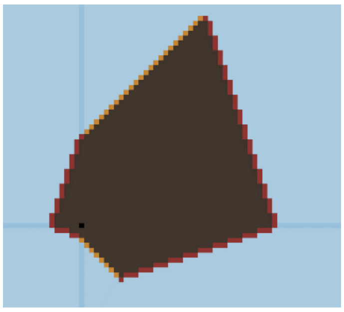

Figure 7. The resulting Cartesian grid graph model. The red squares represent barriers in attack mode and the yellow squares represent barriers in defense mode

The action started in cycle 3 and lasted for 65 cycles. The number of 130 barriers is used. Oil spill spreads to 1301 vertices. On the Cartesian grid graph 2 barriers in each cycle are minimum number of barriers allowing to surround the oil spill.

5 CONCLUSIONS

In the paper the oil spill domains have been determined for different hydro-meteorological conditions and oil spill kinds by the oil spill drift trend, the pollution-fighting time distribution and the oil spill random position distribution.

Furthermore, the oil spills spread limitations algorithm has been introduced. The exemplary results of proposed algorithm have been presented according to the time-discrete oil spill control model. It has been used to present the possible application of proposed stochastic model.

In practically point of view a weak point of the presented method is large cost of the experiment necessary to perform at the sea in order to identify particular components of the model.

In the other side, a strong point of this method is the fact that the experiments for a restricted sea region should be done only once and the model may be used for all pollution combat actions at this sea region.

The suggested probabilistic approach to oil spill domains determination would surely improve the efficiency of pollution combat at the sea.

References

1. A.H. Al-Rabeh, H.M. Cekirge, N. Gunay. A stochastic simulation model of oil spill fate and transport Applied Mathematical Modelling, pp. 322-329, 1989.
2. A. Blokus and K. Kołowrocki. On determination of survivor search domain at sea restricted areas. Risk Decision and Policy, 8, 81-89, 2003.
3. J. A. Fay. Physical Processes in the Spread of Oil on a Water Surface. Proceedings of Joint Conference on Prevention and Control of Oil Spills, sponsored by American Petroleum Industry, Environmental Protection Agency, and United States Coast Guard, 1971.
4. P. Fogarty. Catching the Fire on Grids, Master of Science Thesis, University of Vermont, 2003.
5. S. Guze, J. Mazurek and L. Smolarek. Use of random walk in two-dimensional lattice graphs to describe influence of wind and sea currents on oil slick movement. Journal of KONES Powertrain and Transport, Vol. 23, No. 2, 2016.

HAZARD project has 15 full Partners and a total budget of 4.3 million euros. It is executed from spring 2016 till spring 2019, and is part-funded by EU’s Baltic Sea Region Interreg programme.

HAZARD aims at mitigating the effects of major accidents and emergencies in major multimodal seaports in the Baltic Sea Region, all handling large volumes of cargo and/or passengers.

Port facilities are often located close to residential areas, thus potentially exposing a large number of people to the consequences of accidents. The HAZARD project deals with these concerns by bringing together Rescue Services, other authorities, logistics operators and established knowledge partners.

HAZARD enables better preparedness, coordination and communication, more efficient actions to reduce damages and loss of life in emergencies, and handling of post-emergency situations by making a number of improvements.

These include harmonization and implementation of safety and security standards and regulations, communication between key actors, the use of risk analysis methods and adoption of new technologies.

See more at: http://blogit.utu.fi/hazard/

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

HAZARD

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND