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Oil pipeline critical infrastructure network

Keywords

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Abstract

In the article there are described main oil pipeline installations and main oil terminals in the Baltic Sea region. Oil facilities are gathered in the network of critical infrastructure. Impact of changing climate/weather on that infrastructure is taken into account. One medium size terminal is described in details and weather impact on the operation of that terminal is considered.

1. Oil pipeline installations in Baltic Sea region

Energy production and transportation in, on or across the Baltic Sea has fossil and renewable dimensions. Oil is extracted from four oil platforms, all of them being located in the south-eastern part of the Baltic Sea. Three of the platforms, Baltic Beta, Petro Baltic and PG-1, are in Polish waters (extracted oil is transported by tankers), and one, MLSP D-6, is in Russian waters (extracted oil is transported by 1 pipeline to Baltiysk near Kaliningrad). The reserves in these oil fields (Kravtsovskoye, B-3) are estimated to last until 2030 or longer (WWF, 2010). Interest in oil exploration in the Baltic Sea is growing and further oil has been found southeast of Gotland as well as along the German-Polish coastline but this is not yet extracted.

Transportation of fossil energy across the Baltic Sea plays an increasing role. In particular Russia possesses large amounts of oil and gas and has a strong strategic and economic interest in the export of its fossil energy carriers. Furthermore Russia is currently enlarging its infrastructure for oil export via the Baltic Sea. The Baltic Pipeline System (BPS) transports oil from West Siberia and Urals-Volga regions to Primorsk, an oil terminal at the eastern part of the Gulf of Finland. This pipeline system was expanded by BPS-2 in March 2012, connecting the Druzhba pipeline near the Russia-Belarus border with the new oil terminal Ust-Luga. The new oil port of Ust-Luga, south-west of St. Petersburg, was opened in April 2012. Russia, the world's top oil producer, exported about 28 per cent of its crude oil via the Baltic in 2011 [1]. All in all about 70,000 tanker movements are registered by AIS in the Baltic per year [2].

There are few strategic oil pipelines in the Baltic coast region (in EU). Latvian port Ventspils is linked to oil extraction fields and transportation routes of Russian Federation via system of two pipelines, from which only one is still operational. It is an oil product pipeline from Skrudaliena (Russian - Latvian border) to Ventspils with annual capacity is 6 mln tons. Maintenance and management of the pipelines is carried out by Latvian – Russian joint-stock company LatRosTrans.

Another oil pipeline in the Baltic States is a crude oil pipelines between the Mazeikiai Refinery and Butinge Terminal operated by Orlen Lietuva company. The valves and pumps of the crude oil pipeline Mazeikiai – Butinge are controlled at Butinge control room. The pipeline pressures are controlled in the similar manner.

Butinge was planned and designed as a single-point offshore mooring. The facilities are capable of handling 8 million tons of crude oil for exports and 5 to 6 million tons for import. An offshore submarine pipeline measuring 7.5 kilometers in length connects to the shore facilities. Pumps load crude oil to tankers and transport the same over a distance of 91.5 kilometers to the refinery of Orlen Lietuva near Mazeikai.

In Poland there is very few significant oil pipeline near the seaside. One of them is The Pomeranian Pipeline connecting Storage Tank Farm in Plock with Tank Farm in Oil Terminal Gdansk. Russian crude oil is transported through the pipeline to Gdansk Lotos Refinery and Oil Terminal for export. Capacity of the pipeline is close to 30 mln tons per year towards Plock and about 27 mln tons per year towards Gdansk.

The Schwedt-Rostock connection is a part of Friendship pipeline that has 200 km and transports crude oil imported from Russia to terminal in Rostock. The strategic nature of the oil plant in Schwedt lies in its location. In addition to being connected to the Friendship pipeline, the plant can also receive raw crude by sea via a terminal in Rostock, which is connected to the 2 processing plants through a pipeline running from Rostock to Schwedt. The pipeline has limited capacity (about 7 million tons per year). The other problem is limited port handling capacity in Rostock (about 9 million tons), which, so far can only handle tankers with a maximum capacity of 100 ,000 DWT.

The Baltic Pipeline System (BTS) is a Russian oil transport system build and operated by the Russian oil pipeline company Transneft. The BTS transports oil from the Timan-Pechora region, West Siberia and Urals-Volga regions to Primorsk oil terminal at the eastern part of the Gulf of Finland.

The project started on a grounds of President of the Russian Federation Regulation in 1997 and construction was completed in December 2001. In April 2006 the Baltic Pipeline System reached full design capacity.

The Baltic Pipeline System consists of the following elements:

- Yaroslavl-Kirishi pipeline,
- Kirishi pumping station,
- Kirishi-Primorsk pipeline,
- Oil terminal in Primorsk.

BTS ends with a terminal port of Primorsk (Sankt Petersburg Region), through which oil is loaded on tankers and exported to the west. The capacity of the oil terminal is 70 milion tons / year and to be increased to 130 million tons / year.

In 2012 the Baltic Pipeline System has been supplemented by Baltic Pipeline System – 2 (BTS-2). Transneft launched the first line of the BTS-2 leading from Unecha in Briansk region, near the border with Belarus and Ukraine, where is a branch of oil pipeline "Druzhba", to the port of Ust-Luga on the Gulf of Finland, 110 km southwest of Petersburg, and Kirishi refinery.

The Baltic Pipeline System-2 consists of the following elements:

- Unecha-Andreapol pipeline
- Andreapol pumping station
- Andreapol – Veliky Novgorod pipeline
- Veliky Novgorod pumping station
- Veliky Novgorod – Ust-Luga pipeline
- Oil terminal in Ust-Luga

Ultimately, the pipeline will consist of two pipelines with a total capacity of 50 million tons per year. The first was calculated at 30 million tons. Of this, 15 million tons will be transported to Ust-Luga and 15 million tons to Kirishi refinery. Diameter of the pipeline will vary between 1,020 and 1,067 millimetres.

Baltic Pipeline System (BTS-2) oil pipeline has eliminated Russia’s dependence on transit states. As a result of building BTS-2, Russia will be able to send oil on its territory, and later by the sea. It gives independence from transit oil by "Druzhba" pipeline through Ukraine, Belarus and Poland.

Denmark has one crude oil pipeline connecting some of the offshore production to the refinery and export terminal, both at Fredericia. Owned and operated by DONG Oil Pipe A/S, the pipeline is 330 km long and has a capacity of 360 thousands of barrels a day. System includes the off-shore tie-in platform Gorm “E” located in North Sea and operated by DONG Energy. Oil pipeline connect Gorm “E” across the peninsula of Jutland with Oil Terminal in Fredericia with crude storage and export facilities adjacent to the processes mostly Danish North Sea crude oil supplied by pipeline from Danish off-shore production.

The transportation of crude is regulated by the Pipeline Act (“Rørledningsloven”) which defines the commercial framework for the operation of the pipeline system and commits DONG Oil Pipe A/S to accept deliveries from any crude producer, however subject to technical feasibility.

The crude oil terminal in Fredericia will be modified and expanded in connection with the commissioning of the Hejre Processing Platform on Hejre Field in the Danish sector of the North Sea.

A product pipeline system, NEPS (Northern European Pipeline System), extends from Heide in Germany to North Jutland and is owned and operated by the Danish military forces. In addition, the FDO (national stockholding agency) owns and operates a number of product pipelines in Jutland and in Zealand, including one from the Kalundborg refinery to the Hedehusene terminal. This pipeline supplies a large volume of oil products to the Copenhagen area.

2. Oil terminals in Baltic Sea Region

The oil terminals distribution in the countries of Baltic Sea Region are presented in *Figure 1.*

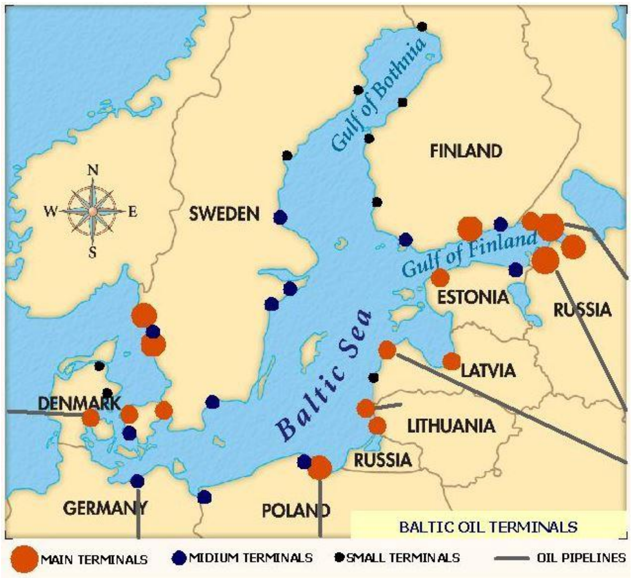

Figure 1. Oil terminals in Baltic Sea Region

In Poland, there are three oil port terminals in Poland. The main oil port terminal is The Naftoport Oil Terminal in Port of Gdansk and it has a capacity of about 34 Mt (millions of tons) per year. Naftoport supply of crude oil to Polish and German refineries and is used also for exports of Russian crude oils. Naftoport is suitable for oil tankers of the size up to 300 000 ton DWT with the lengths up to 340 m and the maximum draught of 15m. Additionally, there are two other oil terminals for imports and exports of oil products: Dębogórze Oil Terminal connected with Gdynia Port by pipelines with a capacity of 3.5 Mt per year and Szczecin-Świnoujście with capacity of 1.5 Mt per year.

In Lithuania, there are two oil terminalas in Lithuania. Klaipedos Nafta Terminal offer discharging oil products and crude oil from tankers and loading into tankers. Total capacity of terminal is 9 Mt per year. The Butinge Terminal is the newest facility of ORLEN Lietuva situated in an all-year-round ice-free area of the Baltic Sea. Terminal is capable for exports of 8 Mt and imports 6 Mt of crude oil per year.

In Latvia the main oil ports in Latvia are Ventspils and Riga. Additionally there is one small oil port in Liepaja.

In Port of Riga there are few terminals with ability to handle oil products with total capacity of 20 Mt of per year. Ventspils nafta terminals (VNT) is the largest crude oil and petroleum product transhipment terminal in the Baltic States operating in port of Ventspils. The terminal capacity is 9 Mt of oil products per year. DG Terminal in Port of Liepaja is liquid bulk terminal founded in 2000. Terminal services transhipment of crude oil, crude oil products and petrochemical products with capacity of 0,7 Mt per year.

In Estonia, the main oil port in Estonia is Tallinn. Port of Tallin consists of four harbours on the northern coast. There are few terminals with ability to handle crude oil and oil products. Total capacity of all terminals located in Port of Tallinn is 24 Mt per year. Sillamäe Port is the easternmost deep-water port of the European Union that can be navigated year round. The Sillamäe terminal handles the transit of oil products and export of shale oil produced in Estonia with a capacity of 4.5 Mt per year.

In Finland there are three main oil port terminals: Skoldvik (Porvoo), Naantali and Hamina-Kotka. Crude oils and refined products are imported also through four small oil import terminals. Only Porvoo and Naantali terminals, owned by Neste Oil, can import crude oils with a total crude oil import capacity of 19 Mt per year in Porvoo and 7 Mt per year in Naantali. Russian crude oil is imported mainly from the nearby Russian oil port Primorsk. Importing and exporting capacity for oil products in the Porvoo and Naantali terminals sums up to 18 Mt per year: 15 Mt per year in Porvoo and 3 Mt per year in Naantali.

In Russia, in Baltic Region they have four large oil ports in the Gulf of Finland and one small oil port in Kaliningrad (Baltiysk). Ports of Primorsk and Ust-Luga are the biggest oil ports in Baltic Region. Primorsk Oil Terminal is the largest in the North-West of Russian Federation providing stevedoring services for more than fifty Russian oil companies in the course of transferring export crude oil supplied through Baltic piping system (BTS) via Primorsk port. Terminal capacity is 80 Mt per year. Oil Terminal in Ust-Luga is oil product filling terminal executing oil products transfer from railway cars into tankers. Terminal capacity is more than 30 Mt per year. CJSC Petersburg Oil Terminal (POT) is a major Russian oil product transhipment facility in the Baltic region, which tranships 15% of all oil products on the Baltic Sea. POT capacity is 12 Mt per year. LUKOIL Company put in operation transhipment and offloading complex (TOC) on the island of Vysotsk, Leningrad region. The terminal capacity is 9 Mt of oil products per year. In port of Kaliningrad there are few export location with its ability to handle crude oil and oil product received by rail from Russia and Belarus. Total capacity of this terminals is about 3 Mt per year.

In Germany, the main Baltic oil terminal in Germany is Grosstanklager-Ölhafen Rostock GmbH (GÖR) Terminal located in Port of Rostock. Terminal with capacity 3 Mt per year offer export and import of crude oil and oil products. GÖR is connected with refineries in Schwedt, Böhlen and Leuna via PCK and RRB pipelines.

In Denmark, the main terminals for loading and discharging oil products on tankers are the ports of Fredericia with capacity of 9 Mt per year, Kalundborg (Statoil-Havnen) with capacity 8 Mt, Aarhus with capacity 1,2 Mt, Aalborg and Stigsnaes with capacity 1 Mt per year. The various other ports are used only for importing oil products.

In Sweden, the biggest oil terminals are located in westernmost coast of Sweden, on the border of Baltic and North Sea, between Kattegat and Skagerrak Straits. Gothenburg Energy Port is the largest energy port for open access in Scandinavia and the site of several refineries and storage companies. Its advantageous geographical location makes the Port of Gothenburg a hub for the whole of the Scandinavian market. Each year, 2,500 tankers put into the Gothenburg Energy Port and half of the crude oil that enters Sweden does so via the Port of Gothenburg. Each year over 20 Mt of crude oil and oil products are handled.

Terminal in Port of Brofjorden is owned and operated by Preem AB’s refinery "Preemraff Lysekil". Terminal is suitable for oil tankers of the size up to 500 000 ton DWT with maximum draught of 28 m. Total capacity of crude oil and other oil products is about 30 Mt per year. Other terminals for discharging and loading oil products on tankers are located in ports of Stenungsund, Karlshamn, Oxelösund, Nynäshamn and Gälve with capacity of 1-3 Mt per year each. Additionally there are five small oil terminals in Kvarken Ports (Umeå), Sundsvall, Halland (Varberg), Halland (Halmstad) and Norrköping with capacity of 0.5-1 Mt per year each. Copenhagen – Malmö Port: CMP is located in cities of Copenhagen in Denmark and Malmö in Sweden. CMP has the largest liquid bulk terminals in the Øresund region: Malmö oil terminal – Oljehamnen and Copenhagen oil terminal - Prøvestenen**.** Import and export of liquid bulk products are oriented towards international and regional markets. The annual turnover of oil at CMP's terminals in Copenhagen and Malmö is close to 7 Mt of crude oil and oil products.

3. Oil pipeline critical infrastructure network interactions with Baltic Sea environment and other critical infrastructures

On the basis of the reviewing Section 1 and Section 2 of this paper, we define the Baltic Oil Pipeline Critical Infrastructure Network (BOPCIN) composed of 9 following pipelines connected with the oil terminals near the Baltic seaside:

1. Oil piping system (OP_1 , 1 pipeline) transporting oil from oil rig installation in Russian Baltic EEZ to Baltic seaside Oil Terminal in Baltyisk near Kaliningrad;
2. Oil piping system (OP_2 , 2 pipelines) transporting oil from Skrudaliene (Russia-Latvian border) to Latvian Baltic Port Terminal in Ventspils;
3. Oil piping system (OP_3 , 1 pipeline) transporting oil from Mazeikiai Rafinery (Lithuania) to Butinge Oil Terminal (Latvia Baltic seaside);
4. Oil piping system (OP_4 , Pomeranian Pipeline, 1 pipeline) transporting oil from Oil Terminal in Płock (Central Poland) to Oil Terminal in Gdańsk (Poland Baltic seaside);
5. Oil piping system (OP_5 , 2-3 pipelines) transporting oil between the pier of Gdynia Port (Poland Baltic seaside) and Oil Terminal in Dębogórze (near Poland Baltic seaside);
6. Oil piping system (OP_6 , Friendship/Drushba Pipeline, 1 pipeline) transporting oil from Oil Terminal in Płock (Central Poland) to Oil Terminal in Schwedt-Rostock (Germany, near Baltic seaside);
7. Oil piping system (OP_7 , Pomeranian Pipeline, 1 pipeline) transporting oil from Oil Terminal in Timan-Pechora (Russia, West Siberia) to Oil Terminal in Primorsk (Russia, Gulf of Finland Baltic seaside);
8. Oil piping system (OP_8 , 1 pipeline) transporting oil from Oil Terminal in Unecha (Russia, Briansk Region) to Oil Terminal in Ust-Luga (Russia, Gulf of Finland Baltic seaside);
9. Oil piping system (OP_9 , 1 pipeline) transporting oil from offshore platform Gorm “E”(located in North Sea) to Oil Terminal in Fredericia (Denmark Baltic seaside).

First of all, the BOPCIN is interacting with the oil terminals associated with it. It is involved in cooperation with and dependent on the BSCIN (Baltic Shipping Critical Infrastructure Network), the BORCIN and other Baltic Industrial installations activity. The BOPCIN also cooperates and interacts with train and trucks European land oil transportation network and with other European and Asian land oil piping transportation critical infrastructures.

The BOPCIN interacts strongly with the climate-weather change process, what was presented in [3] and will be discussed in details in the Section 5 of this paper.

4. Operation process of oil piping transportation system between Gdynia Port and Dębogórze Terminal

In this section one member of BOPCIN the oil piping transportation system OP_5, operating in Poland is analysed in details. The considered oil piping transportation system is operating at one of the Baltic Oil Terminals that is designated for the reception from ships, the storage and sending by carriages or cars the oil products. It is also designated for receiving from carriages or cars, the storage and loading the tankers with oil products such like petrol and oil.

Figure 2. Oil pipelines from Gdynia Port to Terminal in Debogorze

The considered terminal is composed of three parts *A*, *B* and *C*, linked by the piping transportation system with the pier. The scheme of this terminal is presented in *Figure 3.*

The unloading of tankers is performed at the pier placed in the port. The pier is connected with terminal part *A* through the transportation subsystem S_1 built of two piping lines composed of steel pipe segments with diameter of 600 mm. In the part *A* there is a supporting station fortifying tankers pumps and making possible further transport of oil by the subsystem S_2 to the terminal part *B*. The subsystem S_2 is built of two piping lines composed of steel pipe segments of the diameter 600 mm. The terminal part *B* is connected with the terminal part *C* by the subsystem S_3. The subsystem S_3 is built of one piping line composed of steel pipe segments of the diameter 500 mm and two piping lines composed of steel pipe segments of diameter 350 mm. The terminal part *C* is designated for the loading the rail cisterns with oil products and for the wagon sending to the railway station of the port and further to the interior of the country.

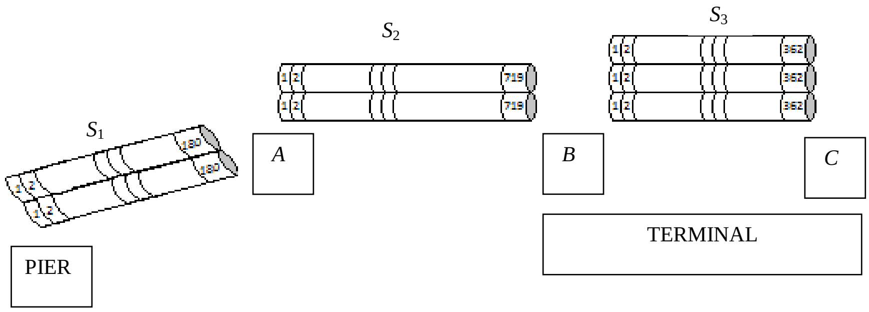

Figure 3. Gdynia Port - Dębogórze Terminal Oil Piping Transportation System

Thus, the port oil pipeline transportation system consists of three subsystems:
- the subsystem S_1 composed of two pipelines, each composed of 178 pipe segments and 2 valves,
- the subsystem S_2 composed of two pipelines, each composed of 717 pipe segments and 2 valves,
- the subsystem S_3 composed of three pipelines, each composed of 360 pipe segments and 2 valves.

The subsystems S_1, S_2, S_3, indicated in *Figure 3* are forming a general series port oil pipeline system safety structure presented in *Figure 4.*

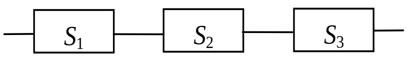

Figure 4. General scheme of the port oil pipeline system safety structure

The system is a series system composed of two series-parallel subsystems S_1, S_2, each containing two pipelines and one series-“2 out of 3” subsystem S_3, containing 3 pipelines.

The subsystems S_1, S_2 and S_3 are forming a general series port oil pipeline system safety structure presented in *Figure 4.* However, the pipeline system safety structure and its subsystems and components safety depend on its changing in time operation states.

Taking into account expert opinions on the varying in time operation process of the considered piping system, we distinguish the following as its eight operation states:

- an operation state z_1 – transport of one kind of medium from the terminal part B to part C using two out of three pipelines of the subsystem S_3,
- an operation state z_2 – transport of one kind of medium from the terminal part C to part B using one out of three pipelines of the subsystem S_3,
- an operation state z_3 – transport of one kind of medium from the terminal part B through part A to pier using one out of two pipelines of the subsystem S_1, and one out of two pipelines of the subsystem S_2,
- an operation state z_4 – transport of one kind of medium from the pier through parts A and B to part C using one out of two pipelines of the subsystem S_1, one out of two pipelines in subsystem S_2, and two out of three pipelines of the subsystem S_3,
- an operation state z_5 – transport of one kind of medium from the pier through part A to B using one out of two pipelines of the subsystem S_1, and one out of two pipelines of the subsystem S_2,
- an operation state z_6 – transport of one kind of medium from the terminal part B to C using two out of three pipelines of the subsystem S_3, and simultaneously transport one kind of medium from the pier through part A to B using one out of two pipelines of the subsystem S_1 and one out of two pipelines of the subsystem S_2,
- an operation state z_7 – transport of one kind of medium from the terminal part B to C using one out of three pipelines of the subsystem S_3 and simultaneously transport second kind of medium from the terminal part C to B using one out of three pipelines of the subsystem S_3.

The influence of the above system operation states changing on the changes of the pipeline system safety structure is as follows.

At the system operation states z_1 and z_7, the system is composed of the subsystem S_3, that is a series-”2 out of 3” system containing three series subsystems with the scheme showed in *Figure 5*.

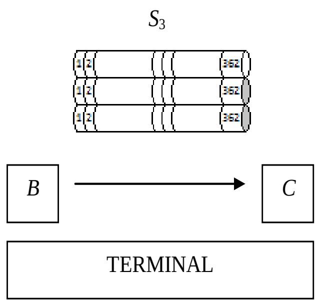

Figure 5. The scheme of the port oil piping transportation system at the operation states z_1 and z_7

At the system operation state z_2, the system is composed of a series-parallel subsystem S_3, which contains three pipelines with the scheme showed in *Figure 6*.

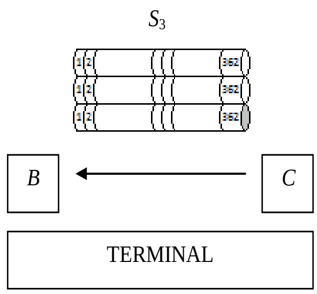

Figure 6. The scheme of the port oil piping transportation system at the operation state z_2

At the system operation states z_3 and z_5, the system is series and composed of two series-parallel subsystems S_1, S_2, each containing two pipelines with the scheme showed in *Figure 7*.

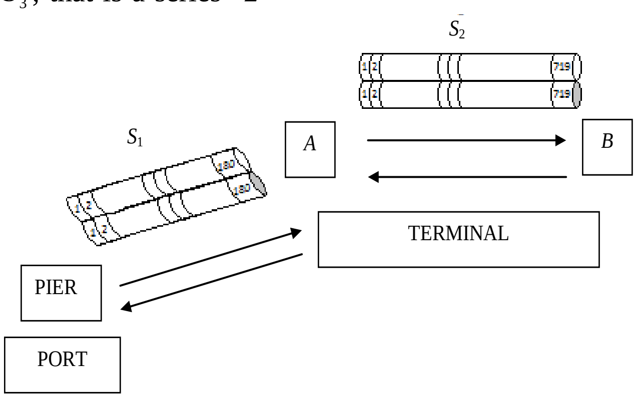

Figure 7. The scheme of the port oil piping transportation system at the operation states z_3 and z_5

At the system operation states z_4 and z_6, the system is series and composed of two series-parallel subsystems S_1, S_2, each containing two pipelines and one series-"2 out of 3" subsystem S_3 with the scheme showed in *Figure 8.*

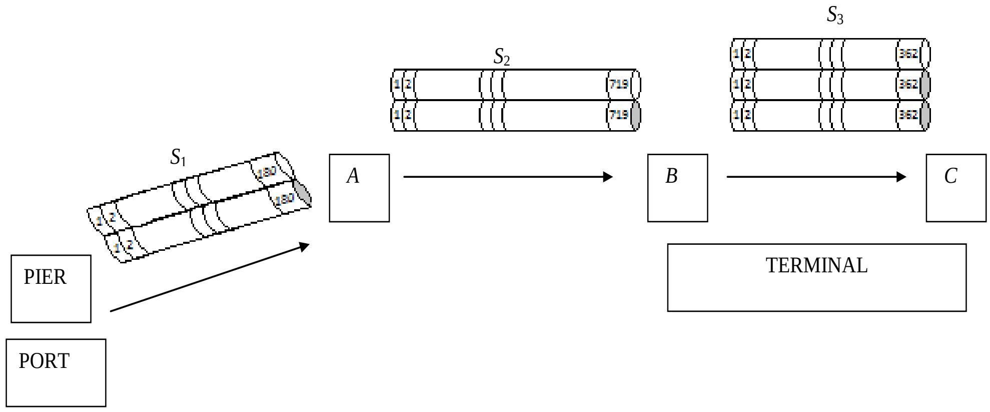

Figure 8. The scheme of the port oil piping transportation system at the operation states z_4 and z_6

The modelling of the port oil piping transportation system operation process is done in [4] and next its unknown parameters statistical identification is performed in [8].

5. Climate-Weather Change Impact on Operation Process of oil piping transportation system between Gdynia Port and Dębogórze Terminal

Apart from the influence of the considered pipeline system operation process, the climate-weather changes in its operating environment have essential influence on its safety structure and its subsystems and components safety. The different kinds of those impacts are discussed in details in [3].
Considering different environmental conditions of the oil piping system operating area the climate-weather hazards and their consequences in the following two cases are analyzed:
- Port Oil Transportation System operating under sea waters in Gdynia Port;
- Port Oil Transportation System operating at land in Dębogórze Terminal.

To identify those different kinds of the climate-weather impacts on the considered piping system, firstly the modelling of the climate-weather change process is done in [5] and next its unknown parameters statistical identification is performed in [9]. In these reports, the following four cases of the climate-weather operation conditions are distinguished:
- Climate-Weather Change Process for Initial Point of Port Oil Piping Transportation System Operating at Under Water Baltic Sea Area;
- Climate-Weather Change Process for Midpoint of Port Oil Piping Transportation System Operating at Under Water Baltic Sea Area;
- Climate-Weather Change Process for End Point of Port Oil Piping Transportation System Operating at Under Water Baltic Sea Area;
- Climate-Weather Change Process for Port Oil Piping Transportation System Operating at Land Baltic Seaside Area.

6. Conclusion

In the paper there are presented oil pipelines and oil terminals that are a critical infrastructure objects in the Baltic Sea region. Moreover they are treated as a critical infrastructure network. That kind of approach, together with taking into account Climate-Weather change impact, is a new, comprehensive approach to the critical infrastructure in the oil industry.
Modelling Critical Infrastructure Operation Process (CIOP) including Operating Environment Threats (OET) performed in [4] and Modelling Climate-Weather Change Process (C-WCP) including Extreme Weather Hazards (EWH) performed in [5] will be join in [6] to construct the Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH). Similarly, Identification methods and procedures of Critical Infrastructure Operation Process (CIOP) including Operating Environment Threats (OET), presented in [8] and identification methods and procedures of Climate-Weather Change Process (C-WCP) including Extreme Weather Hazards (EWH) presented in [9] will be collected together in [10] the identification methods and procedures of unknown parameters of Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards

(EWH).

Practical applications of the results of the above reports will be done in [7] to modelling the port oil piping transportation system operation process at the southern Baltic Sea area using the Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) in this region and in [11] to evaluation of unknown parameters of the port oil piping transportation system operation process related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) at the southern Baltic Sea area.

Further, the identified operation process of the port oil transportation system will be used in the reports prepared in the next steps of the research described in this report Conclusions.

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References

[1] Bloomberg, Putin's Port Project to Divert Russia Urals Oil to Baltic [available at: http://www.bloomberg.com/news/2012-04-05/putin-s-port-project-to-divert-russia-urals-oil-tobaltic.html; last accessed: 3.07.2012].

[2] HELCOM. (2010). Maritime Activities in the Baltic Sea. Balt. Sea Environ. Proc. 123.

[3] EU-CIRCLE Report D1.3-GMU4. (2015). *Contributions to generating Questionnaire of End User Needs*.

[4] EU-CIRCLE Report D2.1-GMU2 (2016). *Modelling outside dependences influence on Critical Infrastructure Safety (CIS) – Modelling Critical Infrastructure Operation Process (CIOP) including Operating Environment Threats (OET).*

[5] EU-CIRCLE Report D2.1-GMU3. (2016). *Modelling outside dependences influence on Critical Infrastructure Safety (CIS) – Modelling Climate-Weather Change Process (C-WCP) including Extreme Weather Hazards (EWH).*

[6] EU-CIRCLE Report D2.1-GMU4. (2016). *Modelling outside dependences influence on Critical Infrastructure Safety (CIS) - Designing Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) by linking CIOP and C-WCP models*.

[7] EU-CIRCLE Report D2.2-GMU1. (2016). *Modelling port piping transportation system operation process at the southern Baltic Sea area using the Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) in this region.*

[8] EU-CIRCLE Report D2.3-GMU1. (2016). *Identification methods and procedures of Critical Infrastructure Operation Process (CIOP) including Operating Environment Threats (OET).*

[9] EU-CIRCLE Report D2.3-GMU2. (2016). *Identification methods and procedures of Climate-Weather Change Process (C-WCP) including Extreme Weather Hazards (EWH).*

[10] EU-CIRCLE Report D2.3-GMU3. (2016). *Identification methods and procedures of unknown parameters of Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH).*

[11] EU-CIRCLE Report D2.3-GMU4. (2016). *Evaluation of unknown parameters of a port oil piping transportation system operation process related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) at the southern Baltic Sea area*.

[12] Grabski, F. (2002). *Semi-Markov Models of Systems Reliability and Operations Analysis.* System Research Institute, Polish Academy of Science, (*in Polish*).

[13] Guze, S., Kołowrocki, K. & Soszyńska, J. (2008). Modeling environment and infrastructure influence on reliability and operation processes of port transportation systems. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 2, 1, 179-188.

[14] Hänninen, S. & Rytkönen, J. (2004). Oil transportation and terminal development in the Gulf of Finland. *Technical Research Centre of Finland*, VTT publications 547, Espoo, Finland.

[15] Kolowrocki, K. & Soszynska, J. (2009). Modeling environment and infrastructure influence on reliability and operation process of port oil transportation system. *Electronic Journal Reliability & Risk Analisys: Theory & Applications* 2, 3, 131-142.

[16] Kolowrocki, K. & Soszynska, J. (2010). Reliability modeling of a port oil transportation system's operation processes. *International Journal of Performance Engineering* 6, 1, 77-87.