FEASIBILITY STUDY FOR THE PORT OF BAR

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AREA OF INTERVENTION 2.2: Improve prevention of environmental risks
Project ”Transnational ENhancement of ECOPORT8 network”
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1 Summary

The idea of this study is to realize a risk analysis at the container and general cargo terminal in the Port of Bar and to provide the guidelines for improving environmental and working safety. These instructions have been proposed in accordance to the “Pareto principle”. The aim of using this principle in the study is twofold. Firstly, it is used in identifying the level of risk at the terminal, and the time intervals within the operating cycle of machinery in which the danger of risk is at the acceptable level. Secondly, the optimal investments in both terminal equipment and employees (re)training in the domains of environmental and occupational safety are estimated. The approximated investments due to “Pareto principle” should contribute to the environmental conservancy and improving working conditions at the terminal in the forthcoming period.
2 Description of the port

The Port of Bar is moderately developed seaport at the South Adriatic Sea, without strict orientation to a specific group of cargo. It was established in 1909, when it has been developed in the direction of satisfying global logistics trends. Its present form has shaped in 1983, when are installed transshipment capacities of 4.5 million tons of cargo per year, which represents about one third of the Port’s projected capacity.

2.1 The Port of Bar organizational structure

The Port of Bar was a unique company until the year 2008. In March 2008 the Government of Montenegro adopted the Program for Restructuring of the Port of Bar. The aim of this program was to enhance the overall business efficiency, strengthen the competitive position of the port in the transport market and remove the obstacles to private sector participation in the provision of port services, as well as, to encourage necessary investment in development projects. This aim was to be achieved through organizational, management and functional optimisation.

Currently, the Port of Bar consists of four organizational units: Port of Bar, Container Terminal and General Cargo, Maritime Operations, and IT Operators (see Figure 1). The port is under the direction of the Port Authority which is located in Kotor. Also there is a private company “Hemosan” which performs a whole range of tasks related to the protection of the environment within the port and beyond it (see Figure 1).

Figure 1. The Port of Bar organisational structure
2.2 Technological organization of the Port of Bar

From the aspect of complex systems and system analysis, the Port of Bar includes multiple sub-systems and structural elements, which means that it also represents:

- a very important subsystem of maritime economy of Montenegro;
- a logistic system defined by the complete logistics objectives and requirements;
- the largest commodity transport center in this part of the Mediterranean;
- a correspondent node between the sea and the land transport system in Montenegro;
- an interphase terminal with the function of changing the physical shape of cargo, etc.

From the aspect of dialectical systems theory, which provides a complete, open, non-isolated, interdisciplinary and dynamic approach to the problem being considered, the Port of Bar is formed of seven following technical and organisational sub-systems:

1. container and general cargo terminal;
2. wood terminal;
3. terminal for grains;
4. bulk cargo terminal;
5. general cargo terminal;
6. liquid cargo terminal, and
7. passenger terminal.

It is to be pointed that within the realisation of this feasibility study in the focus will be placed Container Terminal and General cargo (CTGC) as an EPO (External Port Operator).

Basic features of the Port of Bar as a unified system are as follows:

- total land area is 106 ha;
- waters surface is 90 ha;
- development area is 600 ha;
- total length of railway tracks is 23.5 km;
- total quay length is 3,484 m, with four terminals;
- open warehouses occupy area of 208,288 m²;
- enclosed parking area for trucks is 11,495 m²;
- enclosed warehouses area is 93,990 m²;
- penthouses total area is 23,400 m²;
- grain silo (tank) capacity is 30,000 t;
- refrigerator total area is 7,640 m²;
- the total number of employees is 1,618; etc.

Working process in the Port is organized in two shifts: normal business hours at an interval of 07 am to 09 pm from Monday to Friday, and from 07 am to 2 pm on Saturday.

In the area of the Port of Bar, there is the main breakwater facilities owned by Aluminum Combine from Podgorica, as well. In Figure 2 is given the layout of the Port of Bar.
Figure 2. The Port of Bar layout
3 Chosen EPO (External Port Operator) description

The chosen EPO (External Port Operator) for the Port of Bar is "Container Terminal and General Cargo” (CTGC) JSC-Bar. It was created through the Decision on Restructuring and Separation through forming a new company no. S/XIII-3, which decision was made at the Extraordinary Meeting of Shareholders of the “Port of Bar” JSC-Bar held on 04th September 2009.

Pursuant to this Decision, the Port of Bar was restructured through the separation and founding of a new company “Container Terminal and General Cargo” JSC – Bar to which a number of assets and liabilities were transferred in exchange for the issuance of the Container Terminal and General Cargo shares to Port of Bar shareholders. Apart from the assets and liabilities the “Container Terminal and General Cargo” JSC-Bar took over the employees from the container terminal, general cargo terminal, maintenance, stevedoring, and a part of the administration staff.

On 24th September 2009 the Central Register of the Commercial Court in Podgorica issued a Certificate of registration of the “Container Terminal and General Cargo” joint stock company, Bar

3.1 Agreement on the sale of shares of the CTGC

Having successfully implemented the tender procedure, the Agreement on the sale of 62.09% of the capital of "Container Terminal and General Cargo" JSC was signed on 15th November 2013 between the Government of Montenegro as a seller, and Global Ports Holding from Istanbul as a buyer of shares.

Global Ports’ Operational program envisages the achievement of the commercial objectives of the company's business, including: positioning of CTGC as the Southern Adriatic Gateway to the Balkans, development of CTGC and the town of Bar as a major regional distribution and logistics node for the Balkans, as well as consolidation and strengthening of CTGC as an industrial port for goods from the hinterland of the Balkans.

Global Ports intends to develop a portfolio of products that would include a container handling and maintenance, storage in reefer warehouses (container centre and a distribution and warehousing centre) and intermodal operator of container cargo activities. They will also examine the possibility of the development of cruise business, based on their extensive experience in this field.

Global Ports Holding is a unique Turkish port group and operator. Currently, it operates three leading commercial and cruising ports (Akdeniz - Antalya, Ege Ports – Kusadasi, and Bodrum Cruise Port) one of which is the largest port operator in Turkey, with 50% of the

1 Available from: http://www.ctgc.me/#!about-us/c17b2 (access 31st May 2014)
market in cruise business according to the number of passengers. The company is listed on the Istanbul Stock Exchange and it operates within the framework of the Global Investment Holdings group, which, except for port services, has a diversified investment portfolio in the fields of energy, financial services and real estate.

3.2 CTGC organization

"Container Terminal and General Cargo“ (CTGC) JSC-Bar, as it is said previously, is a terminal operator in the Port of Bar, and its main activities are handling and storing of containers and general cargos (Figure 3). The strategic geographical position of Bar gives a possibility for an efficient and effective connection with all logistics systems in the Mediterranean. Thanks to a good connectivity with various transport networks, an opportunity for establishing distribution centers for a range of product groups arose, in accordance to intermodal and services connectivity trends.

This terminal covers the area of cca 60 ha wholly integrated infrastructure. Overall activity is carried out through three completely technology equipped segments: container terminal, terminal for general cargo, and timber terminal.

Container terminal is equipped for (un)loading and handling of containers, carried out in open storage and closed warehouses, depending on the goods and needed methods of manipulation, including the complete container service (washing, cleaning, etc).

General cargo terminal is equipped for acceptance and dispatch of all types of general cargoes (palletized goods, food products, various metal products, coils, slabs, strips, pipes, bundles, other standard types of cargoes) by using specialized technologies. There are 71 000 m² of closed warehouses on the terminal and other facilities in the port area.

Timber terminal has 24 200m² of constructed shed area, dedicated for storing and drying of timber, ideal technological solutions in terms of handling, storing and functionality of the facilities, in accordance with microclimate impacts.

"Container Terminal and General Cargo“ JSC-Bar is completely under Free Zone regime. It is connected with the global maritime corridor network through key transshipment centers in the Mediterranean by frequent container lines (with precise timetables) of leading world operators such as Mediterranean Shipping Company, Maersk Group, CMA CGM Group, Hapag Lloyd².

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In spatial terms, container and general cargo terminal includes the following (Figure 4):

- operational quay which length is 1,445 m (mole I and the mole II, whose lengths are respectively: 660 m and 785 m);
- nine ships' berths (mole I with four berths, and mole II with 5 berths), whose detail technical features are given in Table 1;
- sea depth along the operational quay is from 10 m to 12 m, which can provide services to ships of 50,000 DWT capacity at mole I, and ships of 20,000-25,000 DWT capacity at mole II;
- system has 14 vertical transhipment mechanizational structures which capacity is from 3 tons to 40 tons (see Table 2), etc.

### 3.3 Container terminal

Container terminal is located at mole I and occupies an area of 60,000 m². The operative quay is 330 m length, and the depth of the sea waters along it is 11 m. The terminal area is divided into zones, and the connections for fridge containers are provided, as well. At the terminal, there are: a plateau for temporary disposal of containers in the zone of the container crane (for 2,650 TEU), a plateau for containers storage, with 13 modular areas (for 2,320 TEU/area) and 6 areas for moving equipment and storage containers in stacks (for 6,320 TEU/area). At the container terminal, handling containers can be realised through the direct manipulation actions from railway wagons or other means of transport.

The terminal consists of:
- operative quay (330 m) with one berth for container ships;
- railway tracks - two tracks of 890 m, and one track of 550 m in the direction of closed storage, and two tracks of 730 m and of 500 m along the operational quay;
• road traffic artery of total area 9,600 m² and a length of 1800 m;
• container storage plateau of 35,000 m²;
• plateau for disposal of fridge containers;
• two closed storage facilities for containers loading and unloading operations (14,330 m³);
• facilities for maintenance and repairing of containers;
• manipulative areas;
• administrative and operating system of the terminal, etc.

The functions of CTGC are as follows:
• shipping services for transportation devices of water, rail and road traffic means;
• direct and indirect (un)loading of containers;
• disposal, storage and protecting containers;
• containers taking on and taking off;
• containers maintenance;
• providing variety of logistics services in the transportation logistics chain, etc.

3.4 General cargo terminal

General cargo terminal is located at the mole I and the mole II, which are spatially and technically designed and equipped for handling all types of general cargo. The structure of the terminal is composed of the following areas/equipment:
• enclosed storage area;
• open storage areas;
• horizontal and vertical machanization with 15 gantry cranes of up to 32 tons;
• operative quay of length 1,370 m, with an average sea depth along it of 10 m, etc.
Figure 4. Container terminal and general cargo (CTGC) EPO layout
(Legend: GAT 1 = Mole I/Pier I, GAT 2 = Mole II/Pier II)

Table 1. Basis spatial and infrastructural features of CTGC EPO

<table>
<thead>
<tr>
<th>No.</th>
<th>Object</th>
<th>Length (m)</th>
<th>Berth no.</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>South shore of pier I</td>
<td>170</td>
<td>11</td>
<td>12.0</td>
</tr>
<tr>
<td>2.</td>
<td>South shore of pier I</td>
<td>160</td>
<td>12</td>
<td>12.0</td>
</tr>
<tr>
<td>3.</td>
<td>North shore of pier I</td>
<td>160</td>
<td>13</td>
<td>11.5</td>
</tr>
<tr>
<td>4.</td>
<td>North shore of pier I</td>
<td>170</td>
<td>14</td>
<td>10.5</td>
</tr>
<tr>
<td>5.</td>
<td>South shore of pier II</td>
<td>160</td>
<td>21</td>
<td>10.5</td>
</tr>
<tr>
<td>6.</td>
<td>South shore of pier II</td>
<td>155</td>
<td>22</td>
<td>10.5</td>
</tr>
<tr>
<td>7.</td>
<td>West shore of pier II</td>
<td>190</td>
<td>23</td>
<td>10.5</td>
</tr>
<tr>
<td>8.</td>
<td>North shore of pier II</td>
<td>140</td>
<td>24</td>
<td>10.5</td>
</tr>
<tr>
<td>9.</td>
<td>North shore of pier II</td>
<td>140</td>
<td>25</td>
<td>10.5</td>
</tr>
<tr>
<td>No.</td>
<td>Device</td>
<td>Label</td>
<td>Age (years)</td>
<td>Location</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>-------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>1.</td>
<td>Frame crane (FC)</td>
<td>KK</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>2.</td>
<td>Portal crane (PC)</td>
<td>PD 1/20</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td>3.</td>
<td>Portal crane (PC)</td>
<td>PD 5/5</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>4.</td>
<td>Portal crane (PC)</td>
<td>PD 3/8</td>
<td>33</td>
<td>13</td>
</tr>
<tr>
<td>5.</td>
<td>Portal crane (PC)</td>
<td>PD 2/8</td>
<td>33</td>
<td>13</td>
</tr>
<tr>
<td>6.</td>
<td>Portal crane (PC)</td>
<td>PD 1/8</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>7.</td>
<td>Portal crane (PC)</td>
<td>PD 2/20</td>
<td>27</td>
<td>14</td>
</tr>
<tr>
<td>8.</td>
<td>Portal crane (PC)</td>
<td>PD 1/5</td>
<td>50</td>
<td>21</td>
</tr>
<tr>
<td>9.</td>
<td>Portal crane (PC)</td>
<td>PD 2/5</td>
<td>50</td>
<td>21</td>
</tr>
<tr>
<td>10.</td>
<td>Portal crane (PC)</td>
<td>PD 3/5</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>11.</td>
<td>Portal crane (PC)</td>
<td>PD 4/5</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>12.</td>
<td>Portal crane (PC)</td>
<td>PD 4/3</td>
<td>44</td>
<td>24</td>
</tr>
<tr>
<td>13.</td>
<td>Portal crane (PC)</td>
<td>PD 3/3</td>
<td>44</td>
<td>24</td>
</tr>
<tr>
<td>14.</td>
<td>Portal crane (PC)</td>
<td>PD 2/3</td>
<td>44</td>
<td>25</td>
</tr>
</tbody>
</table>

**Note:** It is to be noted that some mechanisational structures which are currently exploited at the Container Terminal and General Cargos (CTGC) EPO in the Port of Bar are more than three times older than it is recommended to the commonly adapted standards for the ports of developing countries.³

³ The information obtained through the in-depth interviews with CTGC managers.
4 EPO risk assessment

Common risks at container and general cargo terminal are connected with technology of logistics processes, which belongs to the group of so-called „clean technologies“. The risks at the terminal are associated with cargo handling, cargo damage, its spillage and/or breakage. The risks like: fire, explosion, discharge of fuel, or oil from the port superstructure, etc. occur indeed rarely at this terminal.

The logistics processes, both primary and secondary ones, are schematically presented in Figure 5. These processes which aim to satisfy customers needs are important in identifying risks and their intensity. The assessment of some potential risks, along with their environmental and working safety impacts are presented in Table 3. In other words, risks which might affect port aquatorium, soil and air, as well as workers on port are identified and listed. Also, some of the activities, products and services which might cause environmental devastation are listed.

**Figure 5.** Model of logistics processes at CTGC including potential environmental risks
In addition to presented general risk matrix (Table 3), which can negatively affect air, soil and sea water in the port, here is given a more detailed risk matrix which matches the activities at the terminal related to certain “internal” transportation routes, ship, cargo, cargo handling equipment, transportation devices, and on port workers omissions in cargo manipulating (see Table 4).

It is obvious that potential risks are identified at almost all relations, except between the ship and the following links in the logistics chain: warehouse-warehouse (including container loading and unloading operations), wagon-port gate-warehouse (on both directions) and truck-port gate-warehouse (on both directions). This is quite logical, since the ship is excluded from this links in the transportation/logistics chain. Along all other links in the realization of transportation/logistics processes there are more or less potential risks of an accident occurrence and the environmental damages.

**Table 3. General CTGC risk assessment**

<table>
<thead>
<tr>
<th>Environmental issues</th>
<th>Activities, products &amp; services</th>
<th>Aspects that effect the environment</th>
<th>Impacts on the environment</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air</strong></td>
<td>Cargo transportation by trucks/forklifts over the port area</td>
<td>Air pollution caused by exhausted gasses</td>
<td>Greenhouse effects, greater level of air toxic components, etc.</td>
<td>Using old, “dirty” transportation devices (trucks/forklifts), what causes the need for adapting new transportation technology</td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td>Cargo improper handling</td>
<td>Soil pollution caused by spills of some environmentally harmful types of cargo</td>
<td>Generating soil toxic/harmful components and their discharge</td>
<td>Improving cargo handling procedures and equipment</td>
</tr>
<tr>
<td></td>
<td>Repairing terminal machinery</td>
<td>Soil pollution caused by leakage of lubricants and/or by improper disposal of machine parts</td>
<td>Generating soil toxic/harmful components and their discharge</td>
<td>Improving machinery maintenance and repairing procedures</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>Cargo improper handling</td>
<td>Water pollution caused by spills of some environmentally harmful types of cargo</td>
<td>Generating sea water toxic/harmful components and their discharge</td>
<td>Improving cargo handling procedures and equipment</td>
</tr>
<tr>
<td></td>
<td>Repairing terminal machinery</td>
<td>Water pollution caused by leakage of lubricants and/or by improper disposal of machine parts</td>
<td>Generating sea water toxic/harmful components and their discharge</td>
<td>Improving machinery maintenance and repairing procedures</td>
</tr>
</tbody>
</table>
It should be borne in mind that the risks are almost everywhere and that to each link in the chain of transport and handling containers (including loading and uploading operations) should be given particular attention.

Table 4. Matrix of main CTGC risks

<table>
<thead>
<tr>
<th>Direction / Risk caused by</th>
<th>Ship to shore</th>
<th>Shore to ship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ship I</td>
<td>Cargo II</td>
</tr>
<tr>
<td>Ship-wagon-port gate</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Ship-truck-port gate</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Ship-warehouse</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Ship-buffer-warehouse</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Warehouse-warehouse</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Warehouse-wagon-port gate</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Warehouse-truck-port gate</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Note that in Table 4, in the first row, are marked in red examples in which ways certain factors being connected with port operations can cause the risks:
I Ship: e.g. discharge of fuel and lubricants, discharge of solid waste, fire and explosion, exhaust gases, etc.

II Cargo: physical damage to the packaging, improper stacking and cargo handling, atmospheric impacts (strong wind, rain, extremely high or low temperatures, exposure to strong sunlight, etc.)

III Cargo handling equipment: e.g. electro-mechanical equipment failures, failure of the auxiliary crane’s equipment, improper handling of cargo, cargo tumbling/capsizing, etc.

IV Transportation equipment/devices: e.g. low quality of the equipment, improper handling and maintenance, disregard of equipment exploiting rules, etc.

V Employees (on port workers): e.g. untrained workforce, fatigue at work, lack of motivation, etc.

It is difficult to say explicitly over which previously mentioned relations the risks are the greatest. It depends from situation to situation, but it should be noted that in each of these directions (Table 4) undesirable situation may occur and that the quality of equipment, along with the operators’ knowledge and experience in handling containers and general cargo, are of crucial importance. It is also important that workers have a solid knowledge of the types of cargo, especially dangerous ones, including their readiness to act properly in certain environmental risky situations.

In order to obtain a more complete picture of the potential risks at the container terminal in the Port of Bar, below are given the results of the in-depth interview realized with one of the top managers at the terminal. From given answers, it is possible to draw some conclusions about the nature of the crucial risks which are present at the terminal. Also, the interview results are indicative in terms of identifying the opportunities for environmental risks reduction or even their complete elimination in the perspective.

4.1 Results of in-depth interview with one of the top managers at the CTGC

In this section are given the results of the in-depth interview being carried out few months ago with one of the managers at the CTGC EPO in the Port of Bar.

[The interview]

1. Which is the main form of pollution produced by your activities?
- Logistics operations over the relations ship to ship, ship to shore, shore (truck or railway wagon) to ship;
- Cancellation of manipulative mechanization (horizontal and/or vertical one);
- Improper manipulative operations;
- Damaging of the packaging (package, bales, pallets, sacks, barrel, container, etc.);
- Wastage of goods;
- Meteorological impacts: rain, strong wind, high temperatures, exposure to strong sunlight, etc.
- Errors in the provision of logistic service, etc.

2. **Adverse impacts:**
- Release of dangerous goods;
- Generating hazardous/municipal waste;
- Leakage of lubricating oil, etc.

3. **How important do you consider each of the following potential negative environmental impacts from your activities?**
- Use of natural resources (energy, water, etc.) – 0 (no negative impact)
- Solid waste generation – 2 (moderately negative impact)
- Wastewater effluent – N/A or 0
- Air pollution – 2 or 0 (improvements could be achieved by employing new mechanization, i.e. cleaner technology, and new EU standards)
- Global pollutants (e.g. greenhouse gases) – 2 (caused mostly by old mechanization)
- Aesthetic effects (noise, smell, landscape violation, etc.) – 2
- Soil contamination – 0
- Risk of severe accidents – 2
- Additional: **Manipulative operations are to be safely realized.**

4. **Has your facility undertaken concrete actions to reduce environmental impacts associated with the following?**
- Use of natural resources (energy, water, etc.) – No
- Solid waste generation – Yes
- Wastewater effluent – No
- Local or regional air pollution – Yes
- Global pollutants (e.g. greenhouse gases) – Yes (to certain extent)
- Aesthetic effects (noise, smell, landscape violation, etc.) – Yes (to certain extent)
- Soil contamination – No
- Risk of severe accidence – Yes
- Additional: **Cargo protection of negative atmospheric effects is necessary.**

5. **Taking into consideration the negative environmental impacts stated above, which of the following environmental performance measures does your activity/facility regularly monitor?**
- Use of natural resources (energy, water, etc.) – No
- Solid waste generation – No
- Wastewater effluent – No
- Local or regional air pollution – Yes (indirectly)
- Global pollutants (e.g. greenhouse gases) – Yes (indirectly)
- Aesthetic effects (noise, smell, landscape violation, etc.) – Yes (indirectly)
- Soil contamination – No
- Risk of severe accident – Yes

6. Does your facility have a budget specifically related to environmental matters?
   - Yes, but insufficient.

7. What is your knowledge about the Environmental Management System (EMS)?
   - Fairly good knowledge.

8. Have you ever considered implementing an EMS in your facility/activity?
   - Yes.

9. How important do you consider the following motivations to have been with respect to the environmental practices of your facility?
   - Prevent or control environmental incidents – High importance
   - Regulatory compliance – High importance
   - Corporate profile/image – High importance
   - Costs savings – High importance
   - New technology development – High importance
   - New product development – Low importance
   - Facilities similar to ours are adopting similar practices – High importance

Additional:
- Standardization in technology and operational procedures is of extremely high importance in this context.
- Tracking and implementing EU recommendations, good practices and standards in this domain are of up most importance, as well.

The results of this interview might be indicative in terms of getting crucial information about the main risks at the terminal and the attitudes of the top management at the examined EPO in the Port of Bar towards EMS in general.

Although the analysis of such kind was realized in the previous research phase of the project, it fits well in the purpose of this feasibility study, too. Therefore, it should be taken as a base for further research related to this specific study.
5  EPO (the greatest) risk reduction/elimination action

a) What is (are) the greatest risk(s) at the considered EPO?

As it is previously noted, the risks at container and general cargo terminal are connected with technology of logistics processes, which belongs to the group of so-called „clean technologies“. Therefore, the greatest risks are associated with cargo handling, cargo damage, its spillage and/or breakage. Also injuries of workers on port are possible as a result of improper cargo manipulating or machinery improper maintenance and break down. However, the workers’ injuries with tragic consequences rarely occur. The accidents like fire, explosion, discharge of fuel, or oil leaking from the port superstructures, etc. are also rare ones at this terminal. These data are mostly empirically based.

b) What can be done to reduce or eliminate it(them)?

Above adduced risks could be eliminated by purchasing and adapting new, cleaner and more reliable handling (manipulating) equipment, including vertical (containers and general cargo cranes), horizontal (trucks and forklifts), and auxiliary mechanization.

Storage capacities should be extended and improved, i.e. they are to be more protected from weather conditions as wind, rain, exposure to sunlight, extremely high (or low) temperatures, etc.

Additionally, employees should be periodically (re)trained in EMS in order to enrich level of their awareness and knowledge about the environmental issues and occupational safety. These trainings should be organized in the Port of Bar, in similar ports in the region, or in specialized training centers in the country (Montenegro) or abroad.

c) Risk analysis

Unfortunately, in the Port of Bar there is no detailed evidence on the structure of risks (including environmental ones), as well as on the type and number of incidents that occurred in the port in the previous period. The way in which, by a reasonable certainty, can be assessed the risks intensity and the nature of incidents that may be caused by these risks is Pareto principle (or 80/20 principle). According to this principle, all mechanization structures (vertical, horizontal, and auxiliary) are operational in 80% of the time, while they are not operational during the rest 20% of time. The approximation of nature and extent of risks is graphically presented in Figure 6.
Based on the degree of availability of equipment, according to the Pareto principle, it can be observed that the equipment were 80% of the time working in a normal regime, and that it were in failure during the rest 20% of the exploitation cycle. The time of cancellation has been shared like: 80% on the cases for scheduled repairs and maintenance, and 20% on the risk of cargo handling. According to the current volume of the container traffic, by regression analysis, it is possible to determine the number of risks in the case of an increase in container turnover.

It is clear that every failure and dysfunction of machines are associated with the environment and safety at work.

The dysfunction of mechanization caused by regular preventive services, expressed in hours (h) is shown in Table 5.

**Table 5. Port mechanization dysfunction time (h) caused by regular services**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Annual service (h)</th>
<th>20% of Total</th>
<th>Optimal no. of hours out of function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mechanical</td>
<td>Electrical</td>
<td>Total</td>
</tr>
<tr>
<td>PC (3t)</td>
<td>98</td>
<td>67</td>
<td>165</td>
</tr>
<tr>
<td>PC (5t)</td>
<td>123</td>
<td>76</td>
<td>199</td>
</tr>
<tr>
<td>PC (8t)</td>
<td>100</td>
<td>86</td>
<td>186</td>
</tr>
<tr>
<td>PC (32t)</td>
<td>136</td>
<td>116</td>
<td>252</td>
</tr>
<tr>
<td>FC (40t)</td>
<td>138</td>
<td>222</td>
<td>360</td>
</tr>
<tr>
<td>Sum</td>
<td>595</td>
<td>567</td>
<td>1163</td>
</tr>
</tbody>
</table>

*Legend: PC – Portal Crane; FC – Frame Crane*
Under the assumption that the annual service of the equipment is accelerated for 20% (Table 5), in terms of Pareto logic, it would be yielded positive effects in the amount of 80% when it comes to continuity and efficiency of work processes in the terminal, along with (in)direct positive effects to the EMS and occupational safety issues.

In this context it should also be emphasized that by the increase in the container turnover, grows the potential risks/incidents number. Therefore, with the increase in container turnover (Figure 7) should be expected an increase in the number of incidents. However, since there are no relevant historical data on risks/incidents, it is difficult, or better say – impossible, to make a model that would provide trustworthy correlation between container turnover and level of risks/incidents, i.e. to develop reliable predictive model in order to provide the appropriate preventive acting at the terminal.

![Figure 7. CTGC turnover dynamics from 2010 to 2015 - a predictive model based on linear regression](image)

d) Safety improvements

When it comes to improving safety in the Port of Bar, i.e. at its CTGC EPO, again, well-known and frequently used Pareto principle (or 80/20 principle) will be applied. **More precisely, we shall use the assumption that by the 20% of investments in equipment and**
personnel (re)training in EMS could be achieved 80% of the improvements in terms of risk reduction, prevention of incidents and consequently environmental protection. The plan for purchasing new handling equipment for the CTGC needs, will be taken into consideration, and the assessment will be made in terms how much will cost acquisition of 20% of the total planned procurement (Figure 8). When the personnel is in matter, it will be analyzed the number and structure of employees, and calculated how much will cost (re)trainings for 20% of employees in key sectors for coping better with environmental issues in the future within the port, i.e. considered terminal (Figure 9). Also, we can assume that personnel training will require traveling to another more developed ports and learning on “the face of the place”. These increasing of investments in both handling and transportation mechanization structures, and employees (re)training in the domain of environmental safety and improving working and health conditions, should result in multiple increasing of the positive impacts on environmental protection and ecosystem conservation. This should be achieved in 80/20 amount in accordance to here exploited Pareto principle. The certain time interval, along with the permanent monitoring and controlling will be necessary to prove the validity of the proposed principle.

Figure 8. Pareto principle: new equipment vs. positive environmental effects

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4 An example of Pareto principle: When it comes to expenditure on projects 20% of the cost brings 80% of earnings, and to achieve the remaining 20% of the results, it is necessary 80% of total expenditures.
Figure 9. Pareto principle: employees (re)training vs. positive EMS effects

Within the next section are given some quantitative indicators which are in accordance to the above presented methodology.
6 Human resources, equipment and costs

If we, now, in pursuance of previously outlined want to specify the manpower needed to implement the ideas of purchasing at least 20% of the planned new equipment, and training of at least 20% of employees in the domain of EMS, it should be noted that in the realization of these ideas, first and foremost the managers and the Port Authority must be involved. Besides top managers and members of the Port board of directors, the employees at non-direct and direct on port activities must be evolved to a certain extent, as well.

6.1 Human resources and costs

- Who will they be?

So, the people who will be involved in improving environmental conditions at CTGC EPO of the Port of Bar will be managers and employees at non-direct and direct on port vacations. Their number is given below, in Table 6.

<table>
<thead>
<tr>
<th>Structure of employees</th>
<th>No.</th>
<th>20% of No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port authorities</td>
<td>71</td>
<td>14</td>
</tr>
<tr>
<td>Non-direct on port</td>
<td>75</td>
<td>15</td>
</tr>
<tr>
<td>Direct on port</td>
<td>302</td>
<td>60</td>
</tr>
<tr>
<td>Total:</td>
<td>448</td>
<td>89</td>
</tr>
</tbody>
</table>

Table 6 contains the calculus of 20% of total number of employees at different operations and management levels, what is sufficient number for achieving considerable economic and environmental positive effects due to Pareto principle. Namely, 20% of the employees are to be (re)trained in EMS in order to give their contribution later on to raising EMS quality and to provide environmental conservation and working safety.

- What will be the costs?

The costs of (re)training of the employees in EMS are specified in Table 7. The calculus is made under the assumption that the average cost of EMS training is 700 euros and that the employees need to travel to another port (or other destination, where the training will be organized), and that they also need certain accommodation and per diem funds. The average
traveling costs are taken as 600 euros per travel, while the accommodation and per diem costs are taken approximately as 100 euros per day. The related calculus is given in table below. In estimating these costs the information available at the referred web locations are used\textsuperscript{5,6}.

**Table 7. EMS (re)training costs for 20% of the employees**

<table>
<thead>
<tr>
<th>Structure of employees</th>
<th>Training (5 days)</th>
<th>Traveling (5 days)</th>
<th>Accommodation (5 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port authorities</td>
<td>14x700=9800</td>
<td>14x600=8400</td>
<td>14x5x100=7000</td>
</tr>
<tr>
<td>Non-direct on port</td>
<td>15x700=10500</td>
<td>15x600=9000</td>
<td>15x5x100=7500</td>
</tr>
<tr>
<td>Direct on port</td>
<td>60x700=42000</td>
<td>60x600=36000</td>
<td>60x5x100=30000</td>
</tr>
</tbody>
</table>

Total (Euro): 62300 53400 44500

It is assumed that the employees will have training ones per year and due to the calculus present in table 7 it is evident that the total amount of funds necessary for (re)training in EMS is 160 200 euros. However, if we take into consideration the fact that this investment will raise EMS quality of implementation for approximately 80% in comparison to present state, it is worth to be done. The previous stated is truth, especially if we consider that the investments in education and skills of employees have positive effects in the long run. Also, employees who attended the training will be later on in position to transfer their new-acquired knowledge and skills in the domain of EMS to their colleagues who did not have that opportunity.

- **What will be their duties?**

The duties of the 20% of employees from each of the terminal sectors during attending the courses in EMS will be as follows:

- Conducting an environmental review for the Port/EPO;
- Identifying and evaluating environmental risks;
- Developing appropriate environmental information, data analysis, reporting and recording processes;
- Determining key milestones including key resources required to implement and maintain an effective EMS;
- Documenting an EMS to meet ISO 14001:2004 requirements;

\textsuperscript{5} Available from: [http://www.uvcs.uvic.ca/Program/Certificate-Program-in-Environmental-Occupational-Health/HPEO/](http://www.uvcs.uvic.ca/Program/Certificate-Program-in-Environmental-Occupational-Health/HPEO/) (access \textsuperscript{10th} June 2014)

\textsuperscript{6} Available from: [http://www.cput.ac.za/academic/faculties/appliedsciences/prospectus/course?i=94&seo=TkJ6IEV0VkJST05NRU5UQuwqSEVBFRI](http://www.cput.ac.za/academic/faculties/appliedsciences/prospectus/course?i=94&seo=TkJ6IEV0VkJST05NRU5UQuwqSEVBFRI) (access 10th June 2014)
• Documenting data control and record keeping procedures;
• Developing environmental policies, objectives, targets and management plans;
• Developing environmental awareness, communication and training strategies, and managing cultural change;
• Developing systems for monitoring and measuring an EMS and environmental performance;
• Reporting on the performance of an EMS;
• Operational controls and emergency planning;
• Developing and maintaining EMS documentation;
• Auditing and management review;
• Maintaining an EMS to achieve continual improvement7, etc.

Upon successful completion of the course, participants i.e. selected employees in the port EPO should be able to:
• Analyze the workplace to identify needs;
• Design, plan, develop, support and evaluate the implementation of integrated approaches for environmental management;
• Identify requirements for environmental information and data;
• Make recommendations for the design of the environmental information and data processes;
• Develop the environmental information, data, reporting and recording processes;
• Record and analyze information and data to monitor environmental performance and evaluate methods of prevention;
• Monitor and evaluate the effectiveness of information and data collection, and analyze processes;
• Define parameters of the environmental risk study;
• Analyze and evaluate the environmental risk of a task or process, etc.

The EMS courses are ideal for:
• People involved in planning and/or coordinating the implementation process for a system addressing environmental issues;
• Personnel who have been assigned the task of establishing an EMS within an organization;
• Decision-makers in the implementation process;
• Those wanting more information from organizations that are undertaking the implementation process, etc.

(access 10th June 2014)
For successful completing of the courses, a strong working knowledge of and/or experience working with ISO 14001:2004 is usually desirable.

6.2 New equipment and costs

- What kind of equipment is needed?
The description of main available mechanization for handling containers and general cargo at CTGC are given in Section 3 (Chosen EPO (External Port Operator) description) of this study. The vertical mechanization structures which are key ones for manipulating containers are presented in Table 2, along with some basis technical features. This machinery is quite old and the managers in the Port of Bar are aware that it should be renewed by purchasing new equipment. Consequently, they have made some plan what kind of mechanization structures have priorities to be purchased. After the detail analysis and taking into the consideration port’s and customers’ needs, they realized that the greatest priority belongs to: container bridge crane, container mobile crane, reach-stacker, and forklifts (Figures 10-12)⁸.

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Figure 10. New container crane that is to be purchase e.g. for CTGC needs

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⁸ Available from: http://www.pfri.uniri.hr/~bopri/documents/16-ME-tal_001.pdf (access 13th June 2014)
In Figures 10-12 the above mentioned necessary new equipment at CTGC is shown only illustrative. The following paragraphs contain the technical features of the considered mechanization structures, as well as the accompanying drawings created in AutoCAD program (Figures 13-15) for the purpose of this study.

**Container crane (container gantry, portainer, ship uploader gantry)**

This type of crane is intended for transshipment of containers from ships by lift-on/lift-of technology and it is developed from cranes for handling of bulk cargo from ships, with the difference, that so-called **spreader** is used for container handling, which is a specially developed gripping device for containers capturing and storage (Figure 13).
Up-to-date container cranes have the following positive features:

- high turnover capacity of 15-80 (optimum 25-40) containers per hour of work;
- possibility of efficient application of twin-lift spreader with productivity up to 80 containers per hour of work in two-cycle mode;
- free passage of transport means throughout the portal and the possibility of providing them services in direct manipulation;
- favorable efficiency of the parallel operation compared to other types of cranes;
- the position the crane operator is vertically above the container, so that he/she has a good view of the spreader position;
- movable linkage system on the cart has four dimensioned cables, which prevent rotation of the container during the manipulative operations;
- sensitive control systems enable efficient positioning of the crane and a spreader;
- the spreader has ability to rotate 180° during the operation, etc.

Besides above listed advantages these cranes have the following disadvantages:

- high turnover capacity of 15-80 (optimum 25-40) containers per hour of work;
- high purchase price and the relatively long time of introducing them into the technological process of work;
- high maintenance costs;
- need for the specialized maintenance staff;
- rather single-purpose application, etc.
In order to illustrate the main features of these cranes, their technical and technological characteristics are given in Tables 8 and 9, for two different generations (Panamax and Post-Panamax) of container cranes.

**Table 8. Basic features of a Panamax container crane**

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical features</th>
<th>Range</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spreader load</td>
<td>320-500</td>
<td>kN</td>
</tr>
<tr>
<td>2.</td>
<td>Loading (transshipment) capacity</td>
<td>20-30</td>
<td>cycles/h</td>
</tr>
<tr>
<td>3.</td>
<td>Range between the legs of the crane</td>
<td>15-30</td>
<td>m</td>
</tr>
<tr>
<td>4.</td>
<td>Grasp range from the sea side</td>
<td>Up to 32</td>
<td>m</td>
</tr>
<tr>
<td>5.</td>
<td>Grasp range from the land side</td>
<td>16-25</td>
<td>m</td>
</tr>
<tr>
<td>6.</td>
<td>Lift height of spreader above crane runway</td>
<td>18-32</td>
<td>m</td>
</tr>
<tr>
<td>7.</td>
<td>Lowering height below the line of the pier</td>
<td>10-12</td>
<td>m</td>
</tr>
<tr>
<td>8.</td>
<td>Lifting speed at maximum load</td>
<td>31</td>
<td>m/min</td>
</tr>
<tr>
<td>9.</td>
<td>Lifting speed without load</td>
<td>75</td>
<td>m/min</td>
</tr>
<tr>
<td>10.</td>
<td>Trolley movement speed</td>
<td>122</td>
<td>m/min</td>
</tr>
<tr>
<td>11.</td>
<td>Crane branch lifting speed</td>
<td>5-7</td>
<td>min</td>
</tr>
<tr>
<td>12.</td>
<td>Crane movement speed of the crane along the coast</td>
<td>32</td>
<td>m/min</td>
</tr>
<tr>
<td>13.</td>
<td>Price</td>
<td>3-7</td>
<td>mil. Euro</td>
</tr>
</tbody>
</table>

**Table 9. Basic features of a Post-Panamax container crane**

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical features</th>
<th>Range</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spreader load</td>
<td>350-500</td>
<td>kN</td>
</tr>
<tr>
<td>2.</td>
<td>Loading (transshipment) capacity</td>
<td>25-40</td>
<td>cycles/h</td>
</tr>
<tr>
<td>3.</td>
<td>Range between the legs of the crane</td>
<td>20-30</td>
<td>m</td>
</tr>
<tr>
<td>4.</td>
<td>Grasp range from the sea side</td>
<td>35-47</td>
<td>m</td>
</tr>
<tr>
<td>5.</td>
<td>Grasp range from the land side</td>
<td>18-30</td>
<td>m</td>
</tr>
<tr>
<td>6.</td>
<td>Lift height of spreader above crane runway</td>
<td>25-35</td>
<td>m</td>
</tr>
<tr>
<td>7.</td>
<td>Lowering height below the line of the pier</td>
<td>10-15</td>
<td>m</td>
</tr>
<tr>
<td>8.</td>
<td>Lifting speed at maximum load</td>
<td>30-60</td>
<td>m/min</td>
</tr>
<tr>
<td>9.</td>
<td>Lifting speed without load</td>
<td>60-130</td>
<td>m/min</td>
</tr>
<tr>
<td>10.</td>
<td>Trolley movement speed</td>
<td>150-210</td>
<td>m/min</td>
</tr>
<tr>
<td>11.</td>
<td>Crane branch lifting speed</td>
<td>5-7</td>
<td>min</td>
</tr>
<tr>
<td>12.</td>
<td>Crane movement speed of the crane along the coast</td>
<td>30-60</td>
<td>m/min</td>
</tr>
<tr>
<td>13.</td>
<td>Price</td>
<td>6-10</td>
<td>mil. Euro</td>
</tr>
</tbody>
</table>
Mobile container crane:
The success and expansion of containerization over the past decades have led to a concentration of attention, in all aspects, to the highly specialized transport container terminals. This attention is especially focused on container machinery. In such operating conditions, mobile harbor container cranes are usually used over smaller terminals, which are intended as auxiliary ones for the 100 top terminals in the world.

This type of crane is shown in Figure 14, and it is found its application in those terminals which certainly can not dictate container flows, and whose volume of traffic depends on many factors, and which therefore can be used for assistance to other terminals. The technical-technological characteristics of such cranes do not lag behind stable container cranes, while they price, costs of installation and maintenance are considerably below the same of fixed container mechanization structures.

The principle of mobile cranes operation is the same as with gantry cranes and it is characterized by cyclical repetition of changes the reach of crane arrow and rotation of revolving superstructure. This type of crane has the following advantages due to the container technological operations:

• can be used over the whole terminal area,
• have favorable price, including amortization and interest,
• satisfactory performance level (average handling capacity, access period, etc.),
• favorable period of introduction to the work process,
• low maintenance costs per hour of work,
• lower cost of container operating cycle,
• high mobility and the possibility of engaging at other terminals if necessary, etc.

Deficiencies related to mobile container cranes are:

• the operator is placed at the end of the structure and has poor visibility and difficult positioning,
• single-lift capacity which lead to reduced productivity,
• rotating radius leads to a rotation of the load,
• when working in pairs, the efficiency reduces because of the mutual disturbance of cranes,
• inability of land transportation devices to pass under the crane, etc.

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9 Available from: http://europe.nxtbook.com/nxteu/informa/ci_top100ports2013/#/26 (access 15th June 2014)
The main technical and technological features of the crane are mostly determined by the permitted axle pressure. The characteristics of these cranes are summarized in Table 10.

Table 10. Basic features of mobile container crane

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical features</th>
<th>Range</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Crain hook load</td>
<td>400</td>
<td>kN</td>
</tr>
<tr>
<td>2.</td>
<td>Transshipment (load) capacity</td>
<td>20-25</td>
<td>cycles/h</td>
</tr>
<tr>
<td>3.</td>
<td>Length of mount</td>
<td>6</td>
<td>m</td>
</tr>
<tr>
<td>4.</td>
<td>Stabilizer width</td>
<td>13</td>
<td>m</td>
</tr>
<tr>
<td>5.</td>
<td>Maximum range with respect to the main axis</td>
<td>42</td>
<td>m</td>
</tr>
<tr>
<td>6.</td>
<td>Maximum grasp (reach) from the sea side</td>
<td>36</td>
<td>m</td>
</tr>
<tr>
<td>7.</td>
<td>Maximum lifting height above the pier</td>
<td>46</td>
<td>m</td>
</tr>
<tr>
<td>8.</td>
<td>Speed</td>
<td>15</td>
<td>Km/h</td>
</tr>
<tr>
<td>9.</td>
<td>Rate of change of arrow grasp (reach)</td>
<td>3</td>
<td>Sec</td>
</tr>
<tr>
<td>10.</td>
<td>Rotation speed</td>
<td>1</td>
<td>rad/min</td>
</tr>
<tr>
<td>11.</td>
<td>Price</td>
<td>up to 3.5</td>
<td>mil. Euros</td>
</tr>
</tbody>
</table>

Figure 14. Mobile container crane visage (drawn in AutoCAD)

**Front Lift Tractor (FLT):**

Front lift tractors (FLT) are container handlers which are equipped with container grabbing devices spreaders. Handling of containers can be performed by using the conventional forks, as well. Their purpose is manifold. Therefore, they are usually used at the terminals with
turnover greater than 300,000 TEU/year. Schematic representation of a FLT is given in Figure 15.

![Figure 15. Fork Lift Tractor (FLT) visage (drawn in AutoCAD)](image)

In exploitation, they are often combined with tractor-trailer system. FLTs can be used for manipulating with both empty and full containers: (a) when they are used for handling empty containers, they can stack them up to eight rows, while (b) when they manipulate with full containers, they can stack them up to three rows at the most.

FLTs in handling containers at the container terminal are as follows:
- multi-purpose usability over all subsystems of the container terminal,
- reliability and flexibility of operation,
- easy maintenance,
- possibility of using lower level of operator training,
- operators do not have to be highly trained,
- ability of sorting containers easily, etc.

Deficiencies in exploitation of FLTs at container terminals are:
- poor utilization of storage space, except for handling empty containers,
- complex maneuver operations,
- uneven distribution of weight on the wheels, etc.

Key techno-operational features of FLTs are given below, in Table 11.
### Table 11. Basic features of FLTs

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical features</th>
<th>Range</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spreader load</td>
<td>300-400 kN</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Turning radius</td>
<td>900/7000-1000/8200 mm</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Wheel base</td>
<td>5000-6250 mm</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Cargo moving from central axis</td>
<td>1125-1700 mm</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Lifting height</td>
<td>8550-17990 mm</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Speed</td>
<td>up to 310 m/min</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Full containers lifting speed</td>
<td>17 m/min</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Empty containers lifting speed</td>
<td>19 m/min</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Price</td>
<td>0.3-0.4 mil. Euros</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Delivery</td>
<td>4-6 months</td>
<td></td>
</tr>
</tbody>
</table>

### Reach stacker (RS):

This is a new specialized container means from the family of forklifts. It is usually implemented at terminals with traffic volume greater than 300,000 TEU/year. It is a manipulator with a telescopic shaft, and its scheme is given in Figure 16.

![Reach stacker (RS) visage (drawn in AutoCAD)](image)

Due to the multi-purpose usability and flexibility of operation, RSs are increasingly being used in container terminals and in the so-called *piggy-back* systems. Their efficiency is
particularly evident in the stacking of empty containers and servicing road and rail transportation devices.

The advantages of this type of container handlers are contained in the following:
• multi-purpose usability over all subsystems of the container terminal,
• reliability and flexibility of operation with both full and with empty containers,
• good visibility in realizing manipulations,
• possibility of serving multiple rows of containers (3-4) from one hall of the storage plateau,
• possibility of two wagon serving at two parallel railway tracks, etc.

Deficiencies in the exploitation of these manipulators are as follows:
• poor utilization of storage space, except for the handling empty containers,
• complex maneuver operations,
• uneven distribution of weight on the wheels,
• lack of visibility when working in multiple rows, etc.

In Table 12 are given some basic techno-operational features of RSc employed at container terminals.

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical features</th>
<th>Range</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spreader load at the first row</td>
<td>450</td>
<td>kN</td>
</tr>
<tr>
<td>2.</td>
<td>Spreader load at the second row</td>
<td>250-350</td>
<td>kN</td>
</tr>
<tr>
<td>3.</td>
<td>Spreader load at the third row</td>
<td>110-180</td>
<td>kN</td>
</tr>
<tr>
<td>4.</td>
<td>Turning radius</td>
<td>7800-8100</td>
<td>mm</td>
</tr>
<tr>
<td>5.</td>
<td>Wheel base</td>
<td>5750-6250</td>
<td>mm</td>
</tr>
<tr>
<td>6.</td>
<td>Lifting height</td>
<td>up to 17800</td>
<td>mm</td>
</tr>
<tr>
<td>7.</td>
<td>Speed</td>
<td>up to 310</td>
<td>m/min</td>
</tr>
<tr>
<td>8.</td>
<td>Full containers lifting speed</td>
<td>17</td>
<td>m/min</td>
</tr>
<tr>
<td>9.</td>
<td>Empty containers lifting speed</td>
<td>19</td>
<td>m/min</td>
</tr>
<tr>
<td>10.</td>
<td>Price</td>
<td>0.28-0.42</td>
<td>mil. Euros</td>
</tr>
<tr>
<td>11.</td>
<td>Delivery</td>
<td>4-6</td>
<td>months</td>
</tr>
</tbody>
</table>

These mechanization structures are described, since their presence at a container terminal greatly increases the efficiency and safety of work and indirectly contributes to the improvement of the EMS in a broader sense. This equipment should be largely present at the container terminal and general cargo EPO in the Port of Bar, so within the next part of the
study will be given an overview of the necessary equipment that should be available at the terminal in order to improve the efficiency and safety in realizing cargo handling operations. 

- **Do you have a need for purchasing new equipment, or the action can be done with the existing equipment?**

In the Port of Bar, i.e. at the CTGC EPO there is a plan to purchase new equipment for the container handling needs. This new machinery will be used in parallel with the existing, i.e. currently exploited one. The information about the plan for purchasing new equipment we have received from the managers of the terminal, and they are given in Table 13.

- **What are the costs of the required (new) equipment?**

The Port Authorities has had some preliminary talks with container suppliers of equipment, so as the result of these negotiations, the approximate data on the cost of procurement of certain mechanization structures are available (Table 13). Otherwise, through the official web sites of major suppliers of container equipment, it is not easy to obtain clear data on the costs of container handling structures.

### Table 13. Increasing environmental and working safety by purchasing new equipment

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of machinery</th>
<th>Costs (Euro)</th>
<th>20% of Costs (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Container bridge crane (span 15 m)</td>
<td>7 800 000</td>
<td>1 560 000</td>
</tr>
<tr>
<td>2.</td>
<td>Container mobile crane</td>
<td>2 800 000</td>
<td>560 000</td>
</tr>
<tr>
<td>3.</td>
<td>Reach stacker</td>
<td>320 000</td>
<td>64 000</td>
</tr>
<tr>
<td>4.</td>
<td>Forklift (counterbalanced one)</td>
<td>280 000</td>
<td>56 000</td>
</tr>
<tr>
<td>5.</td>
<td>Forklift (empty containers stacker)</td>
<td>180 000</td>
<td>36 000</td>
</tr>
</tbody>
</table>

20% of total investment (Euro): 2 276 000

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10 Data presented here are collected by the managers at CTGC EPO at Port of Bar, and they are mostly empirically grounded.

11 Available from: [http://www.konecranes.com/equipment/container-handling-cranes](http://www.konecranes.com/equipment/container-handling-cranes) (access 8th June 2014)

This newly purchased machinery should increase the container traffic in the port, create the conditions for hiring new workers, and reduce negative impacts on the environment. The purchase of new container and general cargo handling equipment will primarily reduce the emission of toxic exhaust gases in the atmosphere (primarily CO₂). Also, new equipment will reduce the risks of break downs and possible incidents that may occur as a result of machinery failures.

Since CO₂ is one of the major polluters of the atmosphere, it deserves in this context, as well, a particular attention. At the annual level 50 port container cranes emit CO₂ in the amount as a 5000 cars. World container equipment manufacturers intensively work on developing technological solutions that will minimize harmful environmental impact and increase the economic efficiency of port machinery. World container equipment manufacturers intensively work on developing technological solutions that will minimize harmful environmental impact and increase the economic efficiency of port machinery. Rubber Tyred Gantry (RTG) crane in the port e.g. due to high average consumption of diesel fuel of 20-30 liters per hour, with an average working time of 14 hours, daily generated up to 1.2 tons of CO₂. In addition to CO₂ emissions, these machines emit significant amounts of other harmful exhaust gases. The average crane with load capacity up to 40 tons emits per day in the environment approximately 6.3 kg of NOx, 1.7 kg HC, 1.2 kg SO₂ and 0.7 kg of lampblack, what can be used as a particular curiosity within this study.

Thus, to summarize above discussion, by using the Pareto principle, and preliminary set hypothesis, the investment of cca 2 millions in new container handling vertical and horizontal equipment, the positive effects might be achieved to the extent of 80% when it comes to economic, occupational and primarily environmental issues.

### 6.3 Both personnel (re)training in EMS and purchasing new equipment costs

In order to recapitulate the above presented data, here we have presented here total amount of funds needed for both personnel (re)training in EMS and purchasing new handling equipment at the terminal (Table 14). It is obvious that for purchasing 20% of planned new equipment is necessary 2 276 000 euro and for (re)training of 20% of employees in EMS is necessary 160 200 euros, what is in total 2 436 200 euros. These investments are justified if we bear in mind that they will cause, due to the Pareto principle, 80% improvements when it comes to economic and environmental factors related to successful and sustainable functioning.

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of the terminal, and its optimal positioning at the permanently growing container transport (global) market.

**Table 14. Total investments in improving EMS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New equipment costs</td>
<td>2 276 000</td>
</tr>
<tr>
<td>Employees (re)training costs</td>
<td>160 200</td>
</tr>
<tr>
<td><strong>Total (Euro):</strong></td>
<td><strong>2 436 200</strong></td>
</tr>
</tbody>
</table>

These cost indicators (Tables 7, 13 and 14) can be used as a basis for improving operational processes at the CTGC EPO and thereby raise positive economic effects and reduce the risk of negative impacts on the environment. Adding a quantitative dimension in analyzing such problems, it is always indicative and may support port managers in making right decisions in terms of preserving the ecosystem and improving the safety in the port, health conditions of workers, and preventing consequently occupational diseases in the long term.
7 Worthiness of the EPO proposed environmental action

a) By taking into the consideration both risks and the costs, is the action worthwhile of realizing in economical and environmental terms?

Undoubtedly, the actions towards modernizing the equipment and training staff in EMS are of importance to the institution, in this case to the analyzed EPO “Container Terminal and General Cargo” JSC at the Port of Bar. Bearing in mind that it is difficult to determine exactly the effects on the environment and health of employees, it is opted here for the use of "Pareto principle". Generally speaking, in accordance to this principle, 20% of investments will result in the increase of 80% in efficiency. This works for both machinery park renewing and for employees (re)training in the domain of EMS. So, investments in terms of buying new machinery in the amount of 20% of the planned one to be bought will result in uprising operational efficiency and reliability in the approximate amount of 80%. Similarly, by investing in 20% of number of employees (re)training in EMS, 80% better working conditions and effects when occupational safety and environment conservation are in matter will occur. This looks quite as a lump sum, but it is entirely consistent with the “Pareto principle” or “Pareto optimum” and can be applied in situations when it is difficult to handle with exact amounts of money.

b) How will it affect the strategy of the whole port authorities EMS (short term, up to one year, and long-term)?

The machinery used at the analyzed terminal in the Port of Bar is pretty old, i.e. in some cases it is even three times older in comparison to the optimal age limit. Purchasing new equipment will certainly be of great benefit and it will be reflected throughout increasing the efficiency of logistics processes at the terminal, and environmental protection. This will also reduce the danger of fatal incidents at work among workers directly involved in on port operations. Purchasing new equipment always has a positive effect in the short term and in the long run, as well. Positive effects should clearly be shown immediately after the first year of use, and of course, in the long term through achieving greater turn over and improving overall environmental conditions.

The trainings of workers are directly and indirectly useful. Direct positive effects manifest throughout gaining workers’ new knowledge and skills which they should apply to their everyday posts. Long-term effects will be reflected in the possibility of transferring the acquired knowledge and skills to younger colleagues and those who were not in position to
attend training. It is quite clear that investment in knowledge always has both the short and long term positive effects.

c) Is there a possibility to transfer the new-generated knowledge throughout conducted EMS action to another EPOs within your port, or to another ports?

In this study applied model is based on the well-known and structured “Pareto principle” or “Pareto optimum”, which means that there are no obstacles in applying it to other EPOs in the Port of Bar, and to other similar ports in the region, too. There is no doubt that the proposed investments in equipment and knowledge of employees will result in multiple positive effects on business, environmental conservancy, and occupational safety in the port. In situations where it is not easy to calculate the direct material benefits of some investments, employing the "Pareto principle" has been proved as a suitable optimization method. Thus, the proposed solution for realizing this feasibility study for “Container Terminal and General Cargo” JSC as an EPO at the Port of Bar might be used like a general model for realizing similar studies in the ports being involved into this project and in some similar ports of the South Adriatic, the Aegean and the Black Sea regions in the future.

The studies of such kind might encourage port authorities to take into consideration, more intensively, investment opportunities in the ports' equipment and personnel, which would have positive economic effects, as well as positive effects on the preservation of the environment in the national context and beyond it, because the ports are usually of strategic importance for the overall economic growth and development of a country and a region. More generally, implementing proposed environmental management system measures i.e. investing in equipment and employees EMS knowledge refreshment can increase chances of cutting energy bills, reducing waste and winning customers confidence in the way the port operates responsibly14.

8 Acknowledgement

During the realization of this study, significant contribution has been provided by:

(a) Mr Željko Ivanović, MSc, manager at CTGC EPO at the Port of Bar,

(b) Mr Zoran Nikitović, representative of “Hemosan” company for sanitary and environmental protection, and

(c) the Port of Bar authority representatives,

so we would like to express them our gratitude.