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Research Article

UTILIZATION OF FULLY AUTOMATED CONTAINER TERMINALS FOR IMPROVING EFFICIENCY OF PORT LOGISTICS AND SUPPLY CHAIN (PORT COMPLEX OF SHAHID RAJAI)

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ABSTRACT
Globalization and as a result the dramatic expansion of container logistics operations urged the need for optimizing the triple operation of container terminals to increase speed and reduce the time of operation. In this article, in a feasibility study for construction and mobilization of two different types of container terminals (conventional and automated), they have been reviewed, analyzed, and their cost effectiveness have been compared. In this research, several economic and technical aspects of the container terminal of Shahid Rajai, port equipped with container handling equipment dependent on human resources as conventional case and fully automated terminal of the same port (stimulated by ARENA software) as the automated case is studied. Here, the components of costs have a considerable role in the range of economic elements of the project and analysis of the distribution of their relative contribution is essential. Since the economic evaluation of the project based on assumptions and variables which their values are associated with uncertainty and because of the sensitivity and importance of estimation of income risk in this study, COMFAR software is used for the economic and financial analysis and evaluation. Based on the results of the cost analysis, automatic container terminal with an interest rate of 2.5% allocate the most share of capital and operating costs. Also in this type of terminal, the sensitivity of internal rate of return is greater than the selling price of container services from other types of terminals. Ultimately the risk analysis shows that with 90 percent confidence level, the limit of the rate of internal return is not less than 16.89% and this proves the economic advantages of automation of handling equipment for container terminals in ports of Iran.

Keywords: *Container Terminal, Industrial Automation, Automatics, Logistics, Container Handling Equipment Performance*

INTRODUCTION
Increase in the volume of container trade in the world requires strategic management and structure in the ports and terminals with the aim of increasing efficiency and reducing the idle time of Container ships.

The expansion of current port and construction of new ports need major investments and spending considerable amount of time.

Thus beside this long-term strategy, the strategy for efficient use of existing facilities of ports and terminals with a view to increase the efficiency of the current system must be used.

Therefore it seems a logical suggestion to use port comprehensive automation system including automatic handling equipment in today's short-term strategies due to growth, availability, and ever increasing reduction of the finished cost of technology to increase the efficiency of container terminals (Pourahmadi, 2013).

Research Article

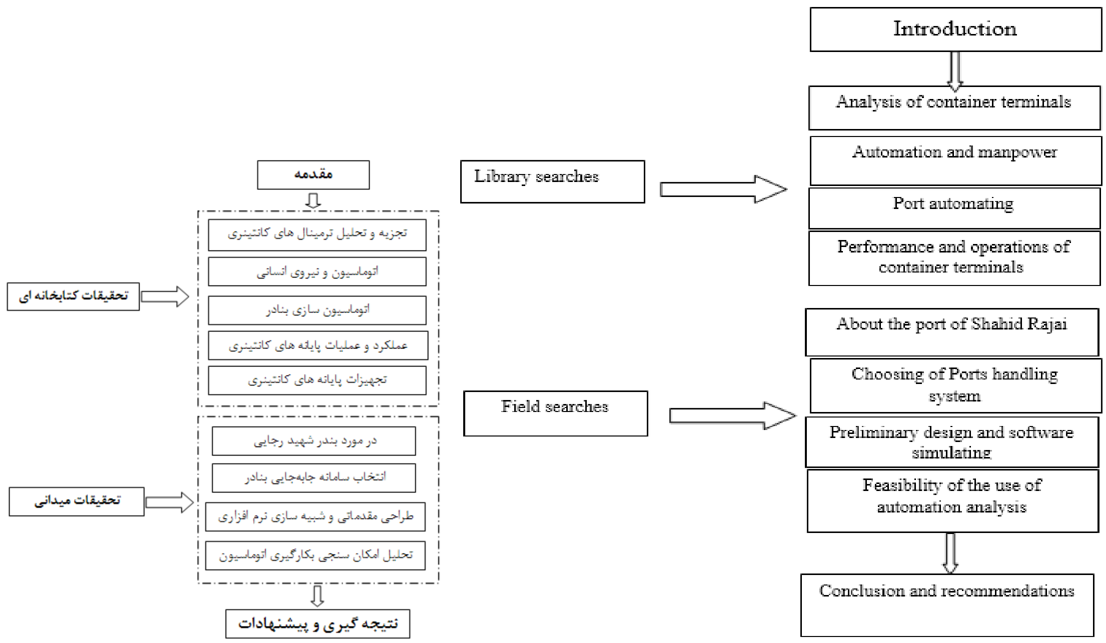

Figure 1: Research conceptual model [REPLACE PERSIAN WORDS WITH ENGLISH]

MATERIALS AND METHODS

In this project by comparing the conventional and automated container terminal (simulated) with different specifications and equipment, their performance has been analyzed. The operations of each of these systems is simulated with ARENA simulation software according to the specifications of the vehicle speed and acceleration and terminal layout and discharging time and the number of vehicles required at each of them. Ultimately, considering the number of vehicles required per each quay crane, each one of the systems has been evaluated.

Effective Parameters

It is considered the rotation time of the ship when a ship sides for loading and unloading container in quay. The rotation time of the ship is known as an important factor in the transport cost of containers and reducing it to the lowest possible value, is one of the main priorities of managers of container terminals. In addition to the greater control capability, Automatic vehicles are able to perform operations which a very high manpower to carry out this operation is needed. In addition, these equipment's can be used 24 hours throughout the week and in the most extreme weather conditions and the goal of the ports which is the time reducing of unloading the ships and also the waiting time reducing of the ships will be achieved consequently.

In the design of an automated container terminal, an automated vehicle must first be chosen among the available types. In this choice, conditions and basic criteria such as emptying time and the number of vehicles for each type have been selected and this choice will influence the related costs directly. For the optimal choice in this research before offering of the system, the results of using of such equipment can be seen and evaluated virtually by using of simulation technology. In the direction of this research, the simulation software of ARENA was used. The mentioned software is able to simulate the activities of transport operations, the process of port logistics, and warehousing. This software has potentials to simulate the operation of a container terminal and it is for this reason that it is used to simulate the operation of the terminals of the world including container terminals. About the simulated terminal in this project, the results of the simulations include the time required to unload the ship and the number of vehicles in each of the systems is for minimizing of the emptying time. For obtaining the values with a high reliability level, each scenario must to be repeated with relevant components adequately. Amounts reported in the following sections is from the mean of obtained numbers of repeated several times of simulation for each scenario. Rotation time of the ship is known as an important factor in the cost of container transport and reducing it to the lowest possible value, is one of the main preferences of managing of container terminals. For further experiments and obtaining of results for the ports of Iran, characteristics of the using model in the simulation is set for the container terminal of complex of Shahid Rajai in Bandar Abbass, the largest and most advanced container terminal of country. In this model, the length of the quay is considered 250 meters and cranes similar to the cranes in mentioned port with a maximum of 35 moves per hour, have been used. It should be noted that in the financial accounting by software of CAMFAR, interest rate is considered in the two cases (Pourahmadi, 2013).

The Operation of Container Terminal

It seems necessary to control the operation for efficiency and coordination of the terminal in order to achieve rapid transfer in large container terminals. So for achieving such coordination, terminals were inclined to the use of information technology and automation control. The use of full automated container terminals increases productivity of unloading and emptying equipment and transport equipment and it also reduces the energy consumption simultaneously. Such terminals will reduce human error by decreasing the number of required personnel and as a result it will increase the safety and security of the terminal.

Today, full automated container terminals are terminals which operate independently and are separated from the rest of port. Humans' entries are forbidden to the terminals and the operation of evacuation, and cargo loading is done by fully automatic equipment’s which are controlled by computer systems.

Logistical Operations at Container Terminal

Logistical operations in container terminal consist of three main processes. They are the quay services (loading and unloading of containers), storage and the gateway port operations. The design of a container terminal is chosen in accordance with the theory of Jonatan. E, 2014 which is shown in the figure below. In one hand, this framework is based on an analysis of the market, the level of service and the demand for transportation services and on the other hand it is based on external conditions and the port situation. The above picture shows the schematic design for a container terminal. Each step of designing includes a repeat back for optimizing. Choosing of the design of the terminal and transport system is also influenced by specific external conditions and site- conditions, such as price and available land area, soil conditions, government support, labor costs, competition and the connections of hinterland of country.

In the initial phase of the terminal design, Queuing theory can be used to make an initial estimate of the length of quay and the required capacity to carry to the quay. In the later stages, simulation models of the design process can be used for accurate determination of employment and exploitation and to achieve an acceptable balance between carrying capacity and efficiency (cost). Terminals performance can be evaluated based on performance indicators. Performance indicators are used in the way and the index of using of the terminal equipment and infrastructure.

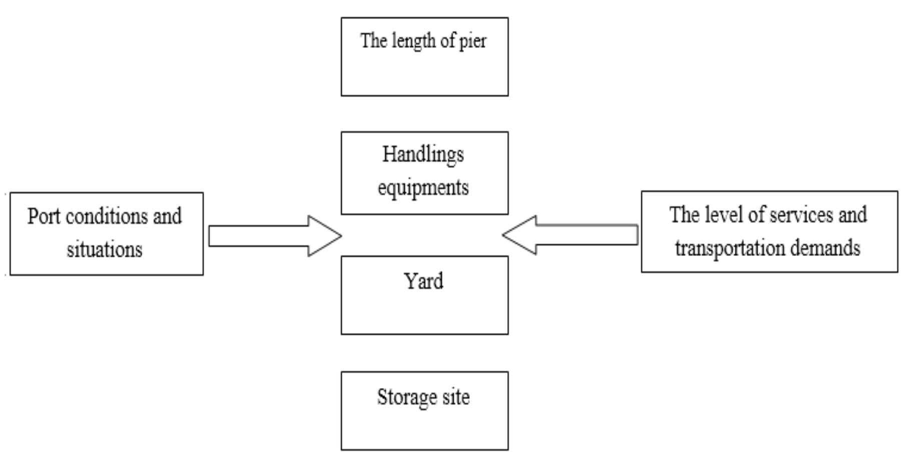

Figure 2: Framework design of container terminal

Preliminary Design of the Container Terminal

In this part of the article in the design of the container terminal, the system of cargo handling is selected. At the beginning of the process, the first sketch of quay should be determined. The length of the quay is chosen according to the size of ships which will use the quay and on the hand it is chosen according to the level of service required and the optimal level of productivity. And in the next stage, the rest of the required systems are calculated according to the capacity of containers and several alternative designs and different equipment is examined. Each of these schemes is compared according to specific criteria and the best scheme will be chosen. Finally, the analysis is focused on engineering economics in terms of justifiability of the scheme and terminal simulation to determine the waiting time of the system. The wall of the quay is not the only expensive part of the terminal but it is known that the costs of one meter length of quay wall will cost $ 35,000 and it will be the most expensive property for a terminal. So the terminal operator prefers that the length of quay be limited but at the same time it should provide the expected services for the ships.

The queuing theory is the best way to calculate the length of the quay. Queuing theory is used to calculate the expected level of customer to get services according to the rate of customers' arrival and rate of services and its types (Ee *et al.*, 2014).

Without getting into the details of queuing theory, this theory has a number of tables according to the different types of services and number of servers which calculates the relative average of the customer expectation to receive service. Queuing theory is a powerful technique to simulate a system and many problems can be solved and simulated by this theory. The basic concepts used in queuing theory are:

- Customer
- Service Providers
- The customer's arrival rate
- Rates of service

For systems of designing of a terminal, Queuing theory is used to determine the required number of RMGs and AGVs. The aim of optimizing of the quay efficiency is to minimize waiting times for the cranes of the quay. AGVs required number is affected by the number of RMGs in terminals. All the process of the work in this calculation is repeated and real output requires many repetitions before a final choice. Queuing theory is a great tool for early evaluation of using of system of the terminal and gaining of efficiency of equipment’s.

Queuing theory is developed by Kendall to determine the waiting time in a system where customers need a particular service.

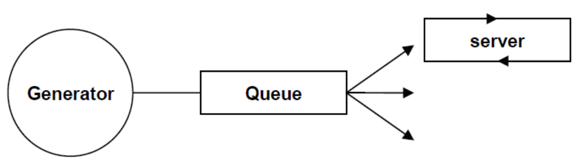

Figure 3: Visualization of queuing theory

In designing of container ports, queuing theory can be on the other side of terminal to determine the waiting times for customers. By using of queuing theory, the average waiting time can be calculated by comparing the average rates with distributions calling services and the time of service. Different algorithms are available determine the average waiting times at the time of service. Practical algorithms are dependent on the arrival rate distribution of call service and the service rate. Queuing theory is used to obtain an indication of required equipment and waiting times for the equipment during the interaction with other equipment. Service rates of queuing purposes of a container terminal are dependent to equipment efficiency. This is the inverse of period time which is assumed the Erlang-ka distribution. The intended algorithm of interpolation between the three different distributions is for calculating of waiting time for Erlang -K distribution of queuing systems in multiple services (Hatzitheodoroue, 2014).

$Wn=(v_a\ v_s\ u) = (1-v_a).v_s.W_n(o,1,u) + v_a.(1- v_a)\ W_n(1, 0, u) + v_a.v_s\ w_n(1,1,u)$

n: number of service / number of generators
v_a: 1 / k = E_k variability in the distribution of internal arrival times
v_s: 1 / m = E_m variability in the distribution of the service times
u: the exploitation of the service
W (0,1, u): the waiting time in the system
W (1,0, u): the waiting time in the system
W (1,1, u): the waiting time in the system
Variability of v_a and v_s and service utilization of u is calculated in the following:
$\mu a / \mu s$: The average time to reach / service time [μ] = s
$\sigma a / \sigma s$: SD arrival time / service time [σ] = s

$$va = \frac{1}{k} = \left(\frac{\sigma a^2}{\mu_a}\right)^2 \quad vs = \frac{1}{m} = \left(\frac{\sigma s^2}{\mu_s}\right)^2 \quad u = \frac{\mu_s}{\mu_a \cdot n}$$

As it was mentioned, In order to use queuing theory to create an operation model of the service provider to service the vessels entering the port, the distribution of real data, customer entry rates of container vessels, servers of services and Posts of the quay container should comply with the Poisson distribution function respectively (Ee *et al.*, 2014). It should be noted that in the case of compliance data from other statistical distributions, there was still the possibility of using the theory. But the formulas were a little more complicated than a simple one. In that case the Arena software is used to analyze the queuing theory.
Based on the structure of the post number one of Container Terminal of Container Complex of Shahid Rajai and according to the design of automated container terminal with capacity of 60,000 tons, 200 m is calculated for the minimum length of the quay. For controlling the ship, 30 m is necessary so 250m is determined for the length of the quay, certainly, the division of the quay to several separate parts is a pure theory because in real ports, the operator works with quay and equipment only.

Table 1: Design criteria according to UNCTAD standards

Maximum vessel	**2,500 TEU**
LOA	200 m
Beam	20 m
Draft	9 m
Design criteria Terminal throughput	
Total annual throughput	200,000 TEU
Landside operations	12 hr/day, 6 days per week
Average waiting time	15% of service time (max.)
Vessel calling rate	10 vessels per week
Waterside operations	24 hr/day, year round
Average dwell time	8 days

References: Pourahmadi, 2014

According to UNCTAD documentation for the planning and management of the container terminal, the occupancy rate of quays should normally be 70 or below. The relative of waiting time to service of container ships should be also limited to 10 to 20%. However, the optimal amount should be below 10%. According to what was said, to calculate the productivity level, the ratio of occupancy and efficiency with respect to the average maximum of waiting time of 15% will not be more than one hundred percent. 250 m is determined for minimum length of the quay and the number of anchorages is one. However the anchorage of two smaller ships can get service simultaneously and do not need to leave the quay to another. According to the following table and interpolation for Series 1 and 2, the emergence of virtual number 1.5 was found (UNCTAD, Port Development, 1985).

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Unnamed Project TABLES QUEUING THEORY

Replications: 1 Time Units: Hours

User Specified

Counter

(u)	(n) 1	2	3	4	5	6	7	8	9
0.1	0.0166	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.2	0.0604	0.0009	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.3	0.1441	0.0235	0.0062	0.0007	0.0002	0.0001	0.0000	0.0000	0.0000
0.4	0.2275	0.0576	0.0205	0.0039	0.0019	0.0009	0.0005	0.0003	0.0001
0.5	0.3904	0.1200	0.0512	0.0142	0.0082	0.0050	0.0031	0.0020	0.0013
0.6	0.6306	0.2300	0.1900	0.0400	0.0265	0.0182	0.0128	0.0093	0.0069
0.7	1.0182	0.4125	0.2300	0.0988	0.0712	0.0532	0.0407	0.0319	0.0026
0.8	1.2000	0.8300	0.4600	0.2300	0.1900	0.1400	0.1200	0.0900	0.0900
0.9	2.0000	2.0000	1.2000	0.6500	0.5700	0.4400	0.4000	0.3200	0.3000

Figure 4: Software analysis of queuing theory Arena, References: Pourahmadi, 2014

By linear interpolation of the results table above, we will have U for waiting time of 0/15

Table 2: Interpolated occupancy rates

Number of harbors	**Waiting time**	**Max U**	
n	%	%	
1	15	30.070	30%
2	15	52.720	53%
1.5	15	41.5	41%

References: Pourahmadi, 2014

To determine the required capacity of productivity and displacement of berth, Maximum U calculated above for determining the amount of operating hours of ships is used annually.

$T \text{ (operational)} = 0.8 \times u_{\text{Harbor}} \times T \text{ (access)}$

$T \text{ (Access)} = 24 \times 365 = 8760$

$n = 1: T_{\text{(operational)}} = 0.8 \times 0.30 \times 8760 = 2102 \text{ hr / yr}$

$n = 1.5: T_{\text{(operational)}} = 0.8 \times 0.41 \times 8760 = 2873 \text{ hr / yr}$

$n = 2: T \text{ (operational)} = 0.8 \times 0\ 53 \times 8760 = 3714 \text{ hr / yr}$

$$\text{Pharbor}=\frac{200000 \text{ teu/yr}}{f.n.T(\text{operational})}$$

$\text{P Harbor}=\frac{200000 \text{ teu/yr}}{1.4\times1\times2102.4}$ =68 movement/hour for n =1

$\text{P Harbor}=\frac{200000 \text{ teu/yr}}{1.4\times1.5\times2873}$ =33 for n =1.5

$\text{P Harbor}=\frac{200000 \text{ teu/yr}}{1.4\times2\times3717}$ = 19 for n = 2

It can be concluded from the above calculations that the quay with the length of 250 meters and a minimum of two cranes to achieve the productivity of 8/49, moves of (33.2 * 1.5) per hour is sufficient. But according to the crane productivity it must move 100,000 containers per two devices which are inconsistent with the capacity. So the number of cranes is considered three for each Harbor. A larger quay with the length of 360 meters with four cranes may have a lower productivity of 3/84 (2*19/2). For n = 1 the number of cranes must be 3 according to the gross productivity. Due to the cost of building of the quay and the required equipments, first case is more appropriate than the second case (Pourahmadi, 2014).

The Period Times of Gantry STS Cranes

For the Gantry Sts Cranes, the minimum time of using for each step is calculated without delay of action. The time required for each stage of the course has a normal distribution, a mean value and a standard deviation. The total of this period of time is feasible and Erlang-k distribution is supposed to be valid. The results of these calculations are shown in the following calculation.

$T\ (cycle) = T_1+T_2+\ldots+T_n \qquad T_i = (\mu_i, \sigma_i)$

$\mu = (Tmax + Tmin)/2 \qquad \mu_{Cycle} = \mu_1+\ldots+\mu_n \qquad \sigma_i = \sqrt{var\ (Ti)}$

$$\sigma_{Cycle} = \sqrt{(\sigma_1^2 + \cdots + \sigma_n^2\ )}$$

Table 3: Characteristics of the cycle functional of Gantry cranes STS

With Container	Δx	V_{max}	t_{min}	t_{max}	μ	2σ	σ
Evacuate to AGV	-	2	20	40	30	100	10
movement variable Ecology	15	3	5	15	10	25	5
Direction of motion to the transponder	25	3	10	23	16.5	42.25	6.5
Loading to the AGV	-	2.5	10	50	30	400	20
Direction of motion of the transponder	25	3	10	23	30	42.25	6.5
The whole motion cycle of the crane	65	-	55	151	103	609.5	24.68

References: Pourahmadi, 2014

The Period Times of RMG

Automated RMGs can be designed for storage warehouse for 6 to 12 container in width and for over 6 containers in length. Although by loading of the containers besides each other's, the cranes movement will be reduced however, increasing the size of the crane means the price increase and will impose a large Static and dynamic load on the foundation of the harbor.

Table 4: Characteristics and performance of automatic RMG cycle

Evacuating the container	Δx	Vmax	t min	tmax	μ	2σ	σ
Receiving container	-	-	20	40	30	100	10
Moving in the slot of	76	69	11	46	28.5	306.2	17.49
Evacuating the container in	-	0.5	15	45	30	225	15
Moving in the slot of	76	6.9	11	46	28.5	306.2	9
The whole motion cycle	152	-	57	177.4	117	441	21
Loading Container	Δx	V_{max}	t_{min}	t_{max}	μ	2σ	σ
Receiving container	76	3.5	21	46	33.5	156.2	12.49
Loading from AGV	-	0.5	10	40	25	225	15
Loading of container from	-	2	15	75	45	900	30
Moving in the slot of	76	3.5	21	46	33.5	42.25	6.5
Moving in the slot of	152	-	67	207	137	256	16

References: Pourahmadi, 2014

The Period Times of RMG

Table 5: Characteristics and performance information of AGV

Evacuating the container	**Δx**	**V_{max}**	**t_{min}**	**t_{max}**	**μ**	**2σ**	**σ**
Receiving container	-	-	20	40	30	100	10
Moving to	295	6	73.6	147.8	110.9	1369	37
Loading of the container from	-	-	20	40	30	100	10
Moving from	295	6	73.6	147.8	110.9	1369	37
	590	-	187.2	562.8	281.8	2401	49
Loading Container	**Δx**	**V_{max}**	**t_{min}**	**t_{max}**	**μ**	**2σ**	**σ**
Receiving container	-	-	20	40	30	100	10
Moving to	295	6	73.6	147.8	110.9	1369	37
Loading of container from	-	-	20	40	30	100	10
Moving from.	295	6	73.6	147.8	110.9	1369	37
	590	-	187.2	562.8	281.8	2401	49

References: Pourahmadi, 2014

Software Analysis for Simulating of Automatic Container Terminal

Any system in which a service is provided in it and the customer needs to that service will form the system of queue. ARENA software package allows the user to design a model of proposal terminal and evaluate its performance.

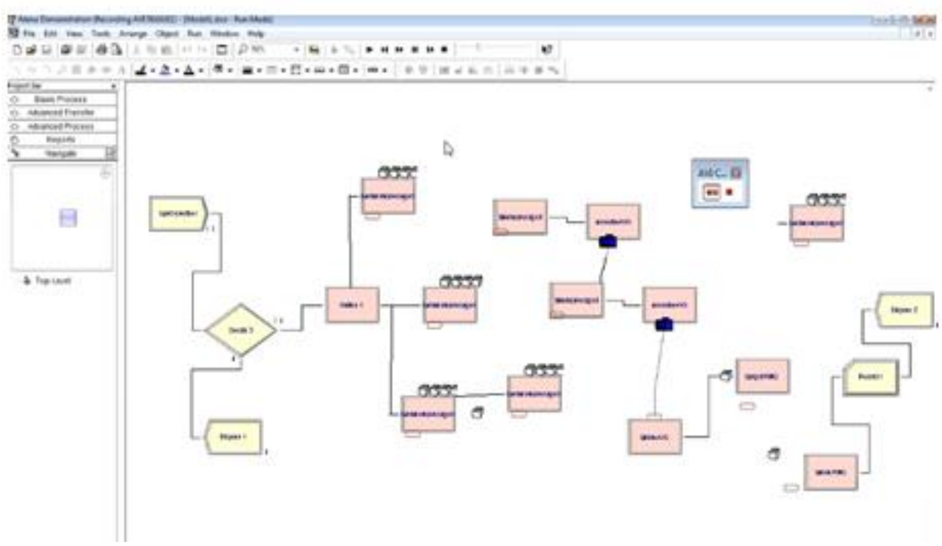

Figure 5: Figure of the model designed by the software of ARENA

The model making consists of modules, for example for the affairs of the quay and the gateway. We have tried to include the details which are based on the fact as much as possible for designing of the simulation model in this project to ensure that the results of the model be more reliable and analyzable. One of the most important parts of this project is producing of compound promoters Modules because unlike of many similar projects, many of the instruments that are directly or indirectly involved in loading and unloading have been considered. The promoters Modules in this module are defined as follows: Increase the number of quay, increase the number of Crane Gantry, increase the number of transponders, and increase the number of Rich Stalker (Pourahmadi, 2014).

Implementing of Simulation and the Results of Simulation to Optimize the Number of Equipments

In this system, the simulation will be created by the module of Create in containers and will be loaded by the cranes. Each crane needs a time of 151 seconds for loading and unloading on AVG according to the calculations then it takes 562 seconds for each AVG to take the container from the crane and deliver it to RMG. Since if we divide 562 to 151 then we will have: 562/151=3.7, then we will result that 4 AVG will be needed for each crane to have the best productivity and for not spending a waiting time for loading. So having of 12 AVG, more than 3 cranes will not be needed, this is evident in simulation and in a stage by having 12 AVG and at another stage by having 15 AVG, and the number of displaced containers and the waiting time of the containers in queues are the same one. Since the AVGs transfers the loads to a place and then will be transferred to another place by RMG, since the transmission time by AVG1 is equal to 562 seconds and the transmission time by RMG is equal to 190 seconds so every 3 AVG is a needed for a RMG. So 4RMG is needed totally. This case was examined by 4 RMG and 6 RMG and the same results were received (Pourahmadi, 2014). The assessment of the equipment of required units which has been specified by the average of queuing theory was done by ARENA software and the simulations were finally performed with a combination of different equipment. The table below shows a general report on the executive outputs of this simulation. Each code represents a number of equipments for each executive unit.

Table 6: Results of the simulation for a number of different equipments

STS/AGV/RMG		1Q	2Q	3Q	4Q	5Q	6Q
Harbor	Total time of execution	101:30:00	121:41:00	95:18:00	110:50:00	113:30:00	128:11:00
	Average of productivity	35,0	34,4	41,4	34,4	32,4	29,3
STS	Average of waiting time	00:28,7	00:39,3	00:18,4	00:25,1	00:28,9	00:32,5
RMG	Efficiency	29.8	33,2	33,1	30,7	32,4	31,6
AVG	The average distance of period	603,7	582,4	592,3	576,5	578,0	566,7

Based on simulation results, we can conclude that the code of 3Q is optimized for the system. Outputs of performances of simulating indicate higher expected efficiency of the quay in 3Q code clearly. As a result, during of the performance of the simulation, no two ships were serviced simultaneously. We conclude that each crane needs to 6 AVG to have the best efficiency and have no waiting time for loading. So by having 2 cranes over 12 AVG are not required that it was also confirmed in the simulation. So by having 12 AVG in one stage and 15 AVG in another stage, the number of displaced containers and waiting time of containers in queues became the same. The final results of equipment specification have written in the table below. General report of output of simulation shows the influence on systems performance related to different general designs. The cumulative effect on productivity of the quay is very large. Similar but less significant to the effects are seen in the service of the coast to land. Extra AGVs may be ready to work for decreasing of waiting time for cranes although the benefit of extra units for each quay crane will decrease by specifying more AGVs.

Table 7: Number of robotic handling equipment

STS gantry cranes	2
AGV	12
Automated RMG	6

References: Pourahmadi, 2014

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The Equipments Purchasing

The numbers of the quay cranes, the required AGVs and RMGs have been specified in top part of this study. In addition to these equipments, a significant number of other support equipments are needed. A general view of costs and required equipment are written in table below. For transport operations, the estimation of the cost of the required equipments of terminal is multiplied by a factor of probability of 20%.

Table 8: The equipments purchasing

Cost($)	Price($)	Lifetime(year)	The Quay cranes
1500000000	50000000	20	cranes STS
42000000	14000000	4	transtinors
1500000000	250000000	20	RMG Automatic cranes
480000000	40000000	10	AGV
80000000	40000000	8	Empty Holders
26000000	13000000	10	Tractor unit
7500000	2500000	4	Chassis
3000000	1500000	4	Vehicles Services
3000000	3000000	4	Van Services
3253500000			The subset of equipments
650700000	20%		Possibility
3904200000			The sum Total

References: Hatzitheodoroue, 1983

The Results of Simulation of Software of Camfar Engineering Economy

Table 9: Comparison of the number of people in traditional and automatic terminal

Robotics container terminal	Container Terminal	
3 people	15people	the Enclosure of the Quay
2 people	9 people	Enclosure
2 people	11 people	the Gateway of the Port
2 people	30 people	Common areas
9 people	65 people	Total members

References: Pourahmadi, 2014

Table 10: general view of CAMFAR calculations

Traditional terminal r=2.5%		Automatic terminal r=2.5%		r=50%		Inflation
209,360,757.17	2.50	505,507,847.64	2.50	-43,414,184.51	50%	The present value of capital
*	11.47	*	16.89	*	-14.05	Internal rate of output of investment
209,360,757.17	2.50	505,507,847.64	2.50	-43,414,184.51	50.00	The net present value of the stock owners

References: Pourahmadi, 2014

Table 11: Consumption costs of automatic terminal

Annual costs	Terminal capacity 200000TEU
6720 million dollars	workers 28%
3840 million dollars	Maintenance 16%
720 million dollars	Fuel and energy costs 3%
11760 million dollars	Total 49%

References: Pourahmadi, 2014

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The amount of Production and sales of products for automatic terminal
Total income 200,000 * $ 120 = $ 24 million
The total cost $ 200,000 * $ 58.80 = 11.760 million
The profit income $ 200,000 * $ 61.20 = 12.240 million

Table 12: Consumption costs of traditional terminal

Annual costs	**Terminal capacity 200000TEU**
12240 million dollars	workers 51%
3840 million dollars	Maintenance 16%
2160 million dollars	Fuel and energy costs 9%
18240 million dollars	Total 76%

References: Pourahmadi, 2014

The amount of production and sale of products
Total income 200,000 * $ 120 = $ 24 million
The total cost $ 200000 * 91.2 $ = 18,240 million
Total profit $ 200000 * 28.8 = 5,760 million

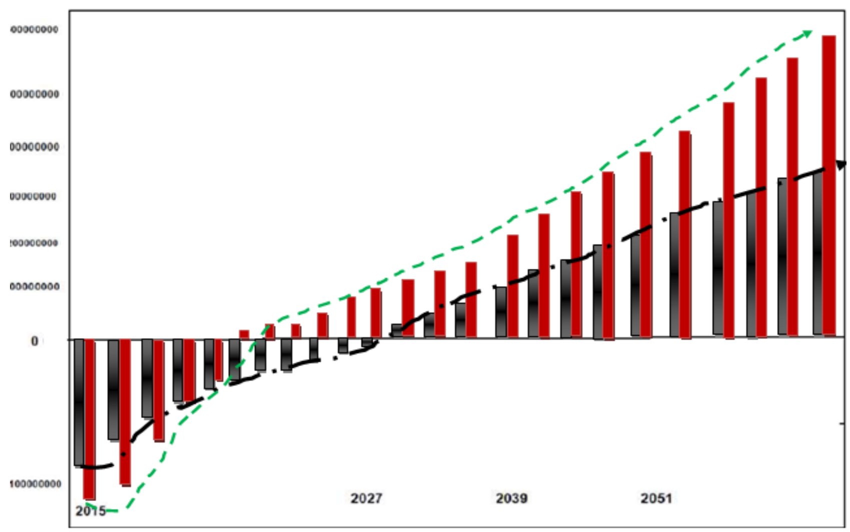

Figure 6: The cumulative net cash flows of traditional and automatic terminal with r = 2.5%

Conclusion

The financial evaluations results of simulating of the container terminal of Shahid Rajai show the financial benefit of automatic terminal compared to conventional container terminal. Saving of operating costs allows the automatic terminal to obtain the required capital in 2014, nine years from time of operation. In contrast, the traditional and conventional terminal will obtain the required capital in 2008, 13 years after the time of operation. It is essential to note that in the last operating year of the terminal in 2060, NPV for the traditional terminal is $ 200 million while the NPV for Robotics terminal is $ 500 million. Thus, according to reports, since the discount rate of 2.5% is considered, IRR in the traditional method equal to 11.47% but in automatic method with the discount of 2.5% ,IRR equals to 16.89% and in robotic method with discount of 11.47%, IRR equals to -14.05%. Thus it can be concluded that automatic method with discount of 2.5% has the best benefit to investors and the automatic method causes loss with rate interest of 50%. Finally, it could be claimed that using of intelligent and automatic transportation equipments of the container terminal with an inflation rate of 2.5 percent is fully justified economically and from the view of return rate of investment.

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