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The Level of Efficiency in Handling Container Traffic at Penang Port: A Simulation Study

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ABSTRACT

The six-month period (January 1995 - June 1995) data was extracted from "Pelabuhan Kontena" (PELKON) system and tested using SIMAN simulation process. Among the data available from the PELKON system are: arrival time of a ship, departure time of a ship, operation time for loading and unloading, total number of equipment used, number of containers unloaded, number of containers loaded, size of a ship, country of registration, last port of call, and next port of call. The arrival pattern of large ships (having a capacity to carry 507 or more containers) and small ships (having a capacity to carry less than 507 containers) follows Weibull distribution and Log-normal distribution, respectively. As a whole, there is no significant differences between the number of ships recorded by the PELKON data and the simulation process. A number of experimental studies such as acquiring less Port Crane, improvement of management service and integrated Prime Mover operation have been carried out to determine the effect on the container handling operations. The findings show that when one of the four port cranes did not work, the number of export containers decreased by 14.2% and 11.5% for import containers. If the services had been upgraded by 25%, the average time for unloading export containers could be shortened by 27.1% and the average time for loading import containers could be reduced by 7.9%. If the movement of prime movers had been integrated, the handling of export containers could be upgraded by 8.0% and 4.3% for import containers.
[Keywords: Penang Port, containers, simulation, traffic, efficiency]

ABSTRAK

Data kajian ini telah dikumpul selama enam bulan (Januari 1995 - Jun 1995) yang disimpan daripada sistem "Pelabuhan Kontena" (PELKON) dan diuji dengan menggunakan proses simulasi perisian SIMAN. Antara maklumat yang disimpan oleh sistem PELKON adalah masa ketibaan sesebuah kapal, masa berlepas sesebuah kapal, masa yang diperlukan untuk operasi punggah dan muat kontena, jumlah peralatan yang digunakan, bilangan kontena yang dipunggah, saiz kapal, nama dan negara kapal didaftarkan, pelabuhan yang disinggahi oleh kapal berkenaan, dan pelabuhan yang akan dituju selepas ini. Taburan ketibaan bagi kapal besar (berkeupayaan membawa 507 kontena atau lebih) dan kapal kecil (membawa kurang daripada 507 kontena) didapati masing-masing mengikut taburan Weibull dan

Log-Normal. Secara keseluruhan, didapati tiada perbezaan ketara antara jumlah kapal yang diperoleh daripada sistem PELKON dan daripada output simulasi. Kajian simulasi dilakukan dengan mengurangkan bilangan "Port Crane" dan mengintegrasikan pergerakan "prime mover" bagi menentukan impak ke atas kecekapan fasiliti di pelabuhan. Hasil kajian mendapati bahawa salah satu daripada empat "Port Crane" rosak, jumlah kontena yang dikendalikan untuk eksport didapati berkurangan sebanyak 14.2% dan 11.5% pula bagi kontena yang diimport. Sekiranya perkhidmatan ditingkatkan sebanyak 25%, purata masa bagi pemunggahan kontena eksport boleh dipendekkan sebanyak 27.1% dan purata masa bagi pemunggahan kontena import pula boleh dipendekkan sebanyak 7.9%. Jika pergerakan "prime mover" diintegrasikan, pengendalian kontena eksport boleh ditingkatkan sebanyak 8.0% dan 4.3% pula bagi kontena import.

INTRODUCTION

Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behaviour of the system and/or evaluating various strategies for the operation of the system. Simulation involves the modelling of a process or system in such a way that the model mimics the response of the actual system to events that take place over time (Pegden et al., 1992). By a model we mean a representation of a group of objects or ideas in some form other than that of the entity itself. By a system we mean a group or collection of interrelated elements that cooperate to accomplish some stated objective.

SIMAN is a powerful, general purpose simulation language for modelling discrete, continuous and/or combined systems. Discrete-change systems can be modelled by using either a process interaction or event-scheduling orientation. Continuous-change systems are modelled with algebraic, difference, or differential equations. A combination of these orientations can be used to model combine discrete-continuous models (Pegden et al., 1992).

SIMAN is designed around a logical modeling framework in which the simulation problem is segmented into a "model" component and an "experiment" components. The model describes the physical elements of the system (machines, workers, storage points, transporters, information, parts flow, etc.) and their logical interrelationships. The experiment specifies the experimental conditions under which the model is to run, including elements such as initial conditions, resource availability, type of statistics gathered, and length of run.

Once a model and experiment have been defined, they are linked and executed by SIMAN to generate the simulated response of the system. As the simulation is executed, SIMAN automatically saves the responses specified in the experiment. The SIMAN Output Processor can then be used to generate plots, tables, bar charts, histograms, correlograms, and confidence intervals from the saved data (Pegden et al., 1992).

PROBLEM STATEMENT

Available data suggest that 91% of the national trade is by way of sea-ports (Penang Port Commission, 1991). Eight ports are situated in Peninsular Malaysia and eleven in Sabah and Sarawak. Along with the above ports, there are two marine-ports such as Pulau Langkawi and Port Dickson.

Port located in Klang, Penang and Johore are the three main ports that handle containers. Most Malaysian ports are situated along the main shipping route such as Straits of Malacca and the South China Sea. These ports that are strategically placed can enhance revenue. Obviously the revenue depends greatly on the facilities offered by the ports such as handling cargoes, containers and storage area. To be more competitive, a number of main ports are in the process of improving their capabilities.

The port of Penang is an international seaport located strategically in the Straits of Malacca, on the north-western coast of Peninsular Malaysia. It also serves as an important transhipment centre for cargo to and from countries in the Bay of Bengal Region. The port is an ideal all-weather haven for ships from the East and West.

Cargo through the Port of Penang is handled both at Penang Port Commission wharves as well as at private jetties licensed by PPC together with other Government Agencies. In 1991, PPC handled 9.89 million tonnes or 82.0% of the total port throughput as against 8.63 million tonnes or 79.5% in 1990. The other 2.17 million tonnes or 18.0% of the port tonnage moved through private jetties in 1991 (Penang Port Commission, 1991).

Penang Port Commission operates five terminals namely Butterworth wharves, Prai Bulk Cargo Terminal, Swettenham Pier, Vegetable Oil Tanker Pier and Prai Wharf. Butterworth Wharves is the main gateway for containerised and breakbulk cargo. Breakbulk cargo is also handled at Swettenham Pier in Georgetown, Penang, though on a smaller scale. A total number of 5,801 ships called at the Port of Penang in 1991, an increase of 4.9% over 1990 (Penang Port Commission, 1991).

The rapid economic development of Malaysia has caused congestion and this increases the shipping waiting time which can be critical depending on the type of cargo. According to the procedure, the ship would inform the port authority a week before the arrival and the expected time of its arrival will be updated and scheduled. If the ship fails to arrive within the expected time then this will normally cause a delay in its loading and unloading for about a week.

Cargo transhipment, that is 1% of the total port tonnage is experiencing a drop of 21.7% to 29,945 metric freight tons in 1991. Container traffic posted a growth of 13.2% to 251,849 TEUs, reflecting the rapid growth of containerisation at the port (Penang Port Commission, 1991).

PORT OPERATION

The arriving ships will have to wait for the landing signal from the berth tower and selection is based on the following criteria: Final Advance Notification (FAN) and Priority Berth Scheme (PBS). Small ships (with loading of less than 507 containers) generally would qualify only for FAN whereas larger ships (loading of 507 or more containers) would qualify for both PBS and FAN. That means ships that qualify for PBS would also be qualified for FAN. The expected arrival of ships can be classified into four categories: early, on time, late and no arrival. Usage of pilotage service would normally delay the ship arrival time by approximately one hour.

Allocation of wharves depends on the size of ships and arrival time. Large ships would normally require two wharves. Once the ship is at berth, loading and unloading containers will be done by Port Cranes. The number of Port Cranes required depends on the following: size of ships, containers loaded and the stowage plan.

Prime Mover is assigned accordingly with a maximum of two groups to a ship where each group will have five to six Prime Movers. The unloading operation depends on the arrangement of containers in the ship. If the container is at the top and within reach of Port Crane, it will be moved over to Prime Mover straight away. Otherwise, in the case of container being stacked at the bottom, then, those at the top will be removed away or placed onto the wharf first. Full Container Load (FCL) would normally be moved over to Prime Mover of the shipping agent whereas the Less Container Load (LCL) would be placed on the shipping yard. The distance between wharf and import container yard is 0.5 km to 0.6 km whereas the distance between wharf and export container yard is 0.3 km. However, the distance between these yards is 0.2 km apart. The overall moving time from wharf to import and export yards (with loading and unloading operation) is approximately 15 to 20 minutes.

OBJECTIVE

The general objective of this study was to identify the problems faced by the port management of Penang Port at Butterworth in handling containers This leads to two specific objectives which are to:

- Study the efficiency of container traffic handling.
- Formulate a suitable container traffic system for Penang Port at Butterworth.

METHODOLOGY

The data were extracted from the "*PELABUHAN KONTENA*" (PELKON) System that is currently being used by Penang Port Sendirian Berhad (PPSB) to co-ordinate all related activities for import and export. Among the data available from the PELKON System being used are: arrival time of a ship, departure time of a ship, operation time for loading and unloading, total number of equipment used, number of containers unloaded, number of containers loaded, size of a ship, country of registration, lost port of call, and next port of call.

The data for six-month period (January 1995 - June 1995) were used to verify and validate the simulation modelling process by using SIMAN software (Pegden, 1992). The information considered in the analysis are as follows:

i. Ship arrival distribution based on the size of ships.
ii. Number of import and export containers based on size.
iii. Utilization of port cranes.
iv. Unloading time of export container.
v. Loading time of export container.
vi. Effects on the port service operation if:
   - one of the Port Cranes malfunctions,
   - management services is up graded, by 25%,
   - Prime Mover is integrated.

For example, average time needed to unload import container from Prime Mover to the shipyard is assumed complete once the Rubber Tyre Gantry has placed the container to its various slots. Utilization of Rubber Tyre Gantry for loading and unloading is recorded for analyzing the level of work in operation in this shipyard. Utilization of Port Crane at this port is also recorded and a breakdown of any of these four Port Cranes would affect the service at this port.

DISCUSSION

Arrival of Ships Distribution

The arrival pattern (Table 1) of large ships (having a capacity to carry 507 or more containers) and small ships (having a capacity to carry less than 507 containers) follows Weibull distribution and Log-normal distribution, respectively.

Table 1
Distribution of Arrival of Ships

Type of Ships	Distribution
Large ships	Weibull (14.3, 1.13)
Small ships	Log-normal (18.7,19.56)

Service at Wharf

There are three wharves available, that is, wharves 4, 5 and 6 which are located next to each other, at the container port to serve both types of ship. A large ship requires two wharves to disembark either wharves 4 and 5 or wharves 5 and 6.

Among the information required from the simulation process are average time for loading and unloading, utilization of each wharf and number of ships called. Utilization of wharf is calculated as from the time the ship called in till the time it departed. The simulated output shows very high utilization factors, namely, 96.6%, 95.5% and 93.4% at wharves 4, 5 and 6, respectively. The simulated output also shows that there are 573 small ships called compared to only 31 large ships (Table 2).

Table 2
Number of Ships Called at Port

Type of Ships Output	Simulated	PELKON Data	Deviation (%)
Large Ships	31	30	3.3
Small Ships	573	574	-0.2
Total	604	604	0

Table 2 shows that, generally there is no difference (total deviation=0%) between the number of ships called recorded by the PELKON system and the simulation process.

Import Container

There are two types of import containers (20-foot and 40-foot containers) handled by Penang Port which are categorized based on container length. The six-month period data indicate that an average of 105 containers was handled at each arrival.

Prime Mover utilization was analyzed to determine the number of Prime Movers required in order to maximize the unloading activity. Utilization means number of Prime Movers that is fully in operation either in unloading process of handling Port Crane or Rubber Tyre Gantry. Note that unloaded (empty) Prime Mover moving from wharf to yard (to and fro) is not considered as being utilized.

Table 3 shows the number of import containers recorded by the PELKON system and simulation process. It indicates that there are no significant difference between the number of import containers recorded by the PELKON System and the one obtained through simulation. On the whole, the simulation process shows a deviation short by only 3.6% compared to the PELKON System.

Table 3
Number of Import Containers

Types of Containers	Simulated Output	PELKON Data	Deviation (%)
20-foot	40,620	42,092	-3.5
40-foot	20,870	21,664	-3.7
Total	61,490	63,756	-3.6

Export Container
The containers are conveyed to wharf by Prime Mover and on average 125 units of containers are loaded at each arrival.

Table 4 shows the number of export containers recorded by the PELKON system and simulation process. There is no significant difference between the number of export containers recorded by the PELKON System and the one obtained through simulation. Overall, the simulation process indicates a deviation short by only 6.2% compared to the PELKON figure.

Table 4
Number of Export Containers

Types of Containers	Simulated Output	PELKON Data	Deviation (%)
20-foot	43,218	46,253	-6.6
40-foot	27,639	29,247	-5.5
Total	70,857	75,500	-6.2

Feasibility Studies
A number of feasibility studies have been carried out to determine the effect on the container handling operation in term of Port Cranes utilization, number of containers handled and time required to handle the containers. The suggested changes for the system are as follows: acquiring less Port Cranes, improvement of management service and integrated Prime Mover operation.

(a) Acquiring Less Port Cranes

The simulated output is shown in Table 5 when one of the Port Cranes (say, Port Crane 2) is assumed to have malfunctioned. It indicates an increase in utilization of 5.9%, 7.6% and 8.1% for Port Cranes 1, 3 and 4, respectively.

Table 5
Port Crane Utilization When Port Crane 2 Malfunctioned

Port Crane	All Four Pcs (%)	Three pcs (%)	Deviation (%)
Port Crane 1	43.4	49.3	-5.9
Port Crane 3	36.2	43.8	-7.6
Port Crane 4	33.3	41.4	-8.1

Table 6 shows the effect on handling number of containers that indicates a decrease of 14.2% and 11.5% for export and import containers, respectively. On the whole, there is a decrease in handling both containers (13.0%) when Port Crane 2 is assumed to have malfunctioned.

(b) Improvement of Management Service (25%)

By upgrading port services, say, 25%, such as giving staff training, recruiting more workers and having modern equipment; a more effective system would be accomplished. Table 7 illustrates time saving for handling of containers by 27.1% and 7.9% for loading and unloading, respectively.

Table 6
Number of Containers when Port Crane 2 Malfunctioned

Handling of Containers by	Export	Import	Total
All Four Port Cranes	70,857	61,490	132,347
Three Port Cranes	60,815	54,390	115,205
Deviation (%)	-14.2	-11.5	-13.0

(c) Integrated Prime Mover Operation

Currently, Prime Mover is loaded only on a one-way and remains idle on a return trip. Therefore, it is suggested the handling of containers (loading and unloading) from yard to wharf (to and from) should be integrated. This operation could be implemented with proper planning and scheduling. With integrated Prime Mover, the overall number of containers handled indicates improvement by 6.6% (8% for export and 4.3% for import containers) as shown in Table 8.

Table 7
Average Time (Hour) for Handling Containers

Modelling System	Export (Loading)	Import (Unloading)
Current System	8.40	2.02
25% Improvement (New System)	6.12	1.86
Deviation (%)	-127.1	-7.9

Table 8
Number of Containers with Integrated Prime Mover

Loaded Prime Mover	Export	Import	Total
One-way Loaded PM	70,857	61,490	132,347
Integrated PM	76,935	64,165	141,100
Deviation (%)	8.0	4.3	6.6

Table 9
Average Time (Hour) for Handling Containers

Modelling System	Export (Loading)	Import (Unloading)
Current System	8.40	2.02
25% Improvement (New System)	2.54	1.42
Deviation (%)	-69.8	-29.7

Table 9 shows time saving for handling number of containers by 69.8% and 29.7% for export and import, respectively, based on the new system.

RECOMMENDATION AND CONCLUSION

Findings in this study reveal that a suitable efficient model could be developed with the introduction of the following activities:

i. Regular maintenance schedule of Port Crane and Prime Mover.

ii. Improve management service.
iii. Integrate loading and unloading of Prime Mover for export and import operations.

From the experimental studies, this model has achieved the following results as in Table 10 and Table 11.

The number of containers handled has improved (2.9% for export and 5.1% for import containers) and average time for handling of containers also reduced distinctly (74.5% export and 34.7% for import containers). This indicates efficiency and time saving.

Table 10
Number of Export and Import Containers

Operation	New Model	Old Model	Deviation (%)
Export	72,910	70,857	2.9
Import	64,622	61,490	5.1

Table 11
Average Time (Hour) for Handling of Export and Import Containers

Operation	New Model	Old Model	Deviation (%)
Export	2.14	8.40	-74.5
Import	1.32	2.02	-34.7

BIBLIOGRAPHY

Branch, A. E. (1990). *Import/export Documentation.* New York: Chapman and Hall.

Law, A.M & Kelton, W.D. (1982). *Simulation Modeling and Analysis.* New York: McGraw-Hill.

Marthur, K. & Solow, D. (1994). *Management Science The Art of Decision Making.* Englewood Cliffs: Prentice-Hall Inc.

Mc Haney, R.R. (1991). *Computer Simulation: A Practical Perspective.* United Kingdom: Academic Press.

Pegden, C.D., Shahnon,R.E. & Sadowski, R.P. (1992). *Introduction to Simulation Using SIMAN.* New Jersey: Prentice-Hall.

Penang Port Commission (1991). *Annual Report.* Penang.

Penang Port Commission (1992). *Annual Report.* Penang.

Penang Port Commission (1994). *Port Procedure Book.* Penang.

Pidd, M. (1994). *Computer Simulation in Management Science.* London: John-Wiley & Son.

Pritsker, A.A.B. (1986). *Introduction to Simulation and SLAM II.* New York: A Haksted Press Book.

Robinson, S. (1994). *Successful Simulation : A Practical Approach to Simulation Projects.* London: McGraw-Hill.

Sirat, M. (1991). *The federal ports in Malaysia and privatisation.* Unpublished thesis, University of Wales, Cardiff.

Szymankiewiesz, J., McDonald, J. & Turner, K. (1988). *Solving Business Problem By Simulation.* United Kingdom: McGraw Hill.