

OPERATIONAL PERFORMANCE OF TERMINALS OF CONTAINERS

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ABSTRACT

The increase of the competition in the freight transport in containers caused the continuous search for improvements in the operational performance of the terminals as a way to stay in the market. Seeking to help the managers of terminals in the decision making process, this paper presents a procedure to evaluate the operational performance in terms of indexes of the different logistic processes developed in those installations.

1. INTRODUCTION

Load terminals are important links in the logistic chain since it is there where the load spends most of the time: while 30% of the total time the load is being transported, 70% of the remaining time, the same one is in the terminal being loaded, discharged, transferred, conditioned and stored expecting its next destination (ABTC, 2000).

Then, the rationalization of the operations carried out in those installations can improve the correspondent performance, bringing a greater competitiveness to global level and a noticeable place in domestic and international markets.

Some measures have been adopted all over the world in order to improve cargo attendance. One of those is the load containerization which brings greater security to all the transportation process as well as facilitates the logistic control of the received load.

The correct dimension of the installations, the use of adequate equipments and the training of the personal for the activities are other factors that contribute for the efficiency of the terminals avoiding or reducing congestions caused by the lack of space for storage, by the unavailability of adequate equipments or by the lack of personal with experience to operate them.

Every terminal is composed by a series of sectors where several activities are carried out. Those sectors and activities, generally, are treated independently one from of the other to guarantee a good operation. But load goes from one sector to other in a sequential way and, many times, equipments and employees are shared to enlarge the efficiency of all the operation.

Being so, it is required to observe the operation of these installations as a whole in order to improve their operational performance. The operations that are developed in a terminal are an assembly of activities, which combined, allow to obtain an index representative of the operational performance associated to the installation. Those activities and operations also can be represented for parameters or indicators of performance that consider, in general, the availability of space, the adequability of the equipment and the experience of the employees.

The objective of this work is to present a procedure based on the multicriterio analysis that, integrating the mentioned characteristics through weights obtained from the opinion of specialized personal permit to obtain the operational performance associated to a terminal of containers.

Despite of being a procedure based on the opinion of specialists, and consequently, of subjective nature, this technique permits to reduce the incompatibilities or inconsistencies of the collected opinions (Philippi *et al*, 2004).

To reach this objective, the sectors and the activities in a terminal of containers were carefully studied and questionnaires to help to organize the activities by sector and the sectors in the terminal in a hierarchical way, were developed and applied to a representative sample of specialists in Brazilian terminals of containers.

The results to these questionnaires allow to compute the necessary weights to obtain the index representative of the operational performance of a terminal of containers.

This work was directed to maritime terminals of containers since this kind represents the majority of the intermodal terminals of containers in Brazil

2. PROPOSED PROCEDURE

In the processes of exportation and importation of merchandises, near 80% of load put into motion between the international ports are carried by means of containers (Yun and Choi, 1999). In Brazil, the number of containers moved in terminals has been increasing along the years, however, problems as lack of areas for storage, congestions of vehicles in the entrance of the installations, difficulties in the process of load release due to the existing bureaucracy make that the Brazilian ports and terminals of containers lose space in the market.

The proposed procedure, represented in the flowchart of Figure 1, aims to help to diminish the mentioned difficulties helping the managers of terminals of containers in the evaluation of their performance, as well as in the identification of possible obstacles and existing problems in all the operational process.

The stages that compose the procedure are described below

3. STAGES OF THE PROCEDURE

3.1 Characterization of the sectors that compose a terminal

The survey and the characterization of the sectors that compose the operational process of a terminal constitute the first stage of the proposed procedure.

The operational procedure of a terminal can be divided into two flows: one of exportation and another one of importation. In this work there were identified and characterized seven sectors present in these flows, which are:

Figure 1: Proposed Procedure

- “Previous Documentation” Sector: present in both flows. It has as responsibility to verify, to organize and to process all the documentation associated to the loading of containers that arrive or leave the terminal.
- “Gate” Sector: door of entrance or exit of the load and present only in the exportation flow. It is responsible for the inspection of shipments of containers that enter and leave the terminal, as well as by their weighting.
- “Discharge” Sector: included in the operational stream of importing, this sector has the responsibility of carry out the load discharment from the vehicles that bring the containers into the terminal.
- “Patio” Sector: where it is carried out the storage of the containers in the reserved area. Present in the two operational flows contains areas for different kinds of containers: full, empty, refrigerated and not refrigerated and in agreement to the kind of operation: exportation and importation.
- “Embarkment” Sector: where it is carried out the loading of the containers in the vehicles for embarking. It is present in the two operational flows.
- “Stripping” Sector: present only in the importation flow, it is responsible for the withdrawal of the merchandises from containers to be delivered to their respective importers. In this sector it is also carried out the inspection by custom officers.
- “Stuffing” Sector: when present in the terminal, it is included in the operational flow of exportation. In it, the merchandise is gathered to be exported in containers.

3.2 Survey of the activities developed in each sector

The survey of the activities developed in the sectors facilitates the identification of parameters and aspects whose performances can be harmful to the terminal global performance. The activities depend on the sector.

The activities developed in “Previous Documentation” sector are: the receipt of booking (documents containing important data sent by the transporter to the terminal), the digitalization of the booking in the system and the confection of the Estimate of Containers Embarking (ECE) and of the Manifesto.

In the “Gate” sector, the developed activities are: containers inspection (verification of the external part of containers and of the integrity of the sealing wax with the intention to verify mischieves, damages or breakings) and containers weighting.

In the “Discharge” sector, the are carried out the inspection and the weighting of the containers as in the “gate” sector. Beyond these activities, there are carried out the discharge of the containers and their transport and transfer to the patio.

In the “Patio” sector, there are carried out the following activities: containers storage and transport and transfer for embarking, stuffing or stripping.

The activities developed in the “Embarkment” sector are: conference of containers for embarkment (verification of the number of the sealing wax and of the physical conditions) and containers loading.

In the “Desconsolidation” sector, there are carried out the activities of desconsolidation (removal of the merchandise that was imported from the containers), load, storage and conference (custom inspection and liberation) of containers.

The activities developed in the “Consolidation” sector are: load inspection (verification of the occurrence of some mischief or damage during the transport to the terminal), storage, consolidation (of the load that will be exported) and transport to the patio.

3.3 Determination of the aspects that influence the productivity of the performed activities

In each of the described sectors there are employees, equipment and space that participate in the performance of the sector. In Table 1, for each sector, there are presented a series of aspects to be measured to help to point out which employee, activity and/or equipment provokes the loss of the desired performance, as result from a

bibliographical survey of the following authors: Gomes (1983), Dexheimer (1997), Pereira (2001), Lima (2004), Ribeiro e Botter (2004).

Table 1: Relation of the aspects associates to the activities of the sectors

Sectors	Aspects
<i>Previous Documentation</i>	Qualification of the employee in processing documentation
	Delays in sending documentation
	Errors performed
<i>Gate</i>	Qualification of the employee in the achievement of inspection / weighting and transfer of containers
	Availability of equipments
	Adequability of the equipment for weighting and transfer
<i>Discharge</i>	Qualification of the employee in unloading vehicles
	Qualification of the employee in achievement containers inspection, weighting and transport
	Availability of equipments
	Efficiency of the equipment for transfer
<i>Patio</i>	Delays due to the achievement of restowage
	Availability of equipments
	Adequability of the equipment for transfer and transport
	Errors in positioning containers in the patio
<i>Embarkment</i>	Storage area availability
	Qualification of the employee in loading vehicles for embarking
	Availability of equipments
	Efficiency of the equipment for transfer
<i>Stripping</i>	Qualification of the employee for the process of embarkment
	Qualification of the employee in the containers stripping activity
	Storage area availability

Availability of equipments
Adequability of the stripping equipment
Qualification of the employee in load nationalization
Errors in load positioning

Qualification of the employee in load inspection
Qualification of the employee in container consolidation
Availability of storage area

Stuffing

Availability of equipments
Adequability of the equipment for consolidation
Adequability of the equipment for transport
Errors in load positioning

3.4 Aspects Hierarchy

Once all the aspects related to each activity as well as all sectors that constitute the terminal are recognized, it is necessary to estimate their influences in the activity global performance and in the terminal global performance. To do this, a questionnaire consisting in two parts was applied to specialist in the area. This questionnaire is presented in the Appendix of this work. While the first part of it will help to perform the aspects hierarchization, the second one will help to order the sectors.

In another words, weights representing the aspects influences in each activity performance as well the sectors influences in the global performance of the terminal, will be obtained.

Since these weights should be useful to measure the performance of any terminal, the specialist that will answer this questionnaire should constitute a representative sample.

3.5 Sectors Performance Indexes

The influence of each aspect in each sector, $I_{i,j}$ is obtained calculating the average of the answers given by the specialists, using Equation 1:

(1)

where: = Answer attributed to the aspect i of the sector j by interviewed k

m = Total of interviewed specialists;

n = Number of aspects of the sector;

l = Total of sectors.

The relative weight of each aspect inside each sector, α_{ij} , is calculated using Equation 2:

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(2)

The sector j performance index, IDS_j , can then be estimated using Equation 3:

(3)

where: = Value to be attributed to the i aspect by the specialist of the sector j of the terminal under analysis.

These values are obtained by means of the application of a new questionnaire to the specialists of the sectors of the terminal that is being evaluated. In this new questionnaire it is requested to the specialist of each sector of the terminal under evaluation to attribute a note varying from 5 (better performance) to 1 (worst performance) to the performance of the aspects in the development of the activities carried out in each sector.

3.6 Sectors Relative Weights

The hierarchy of the sectors to estimate its influence in the terminal global performance can be carried out in the same way that as in the aspects and using the answers to the second part of the questionnaire presented in the Appendix of this work, the relative weights associated to each sector can be computed.

The influence of each sector in the global terminal performance, L_j , is obtained using Equation 4:

$$\forall j = 1, \dots, l \quad (4)$$

where: $M_{j,k}$ = Answer attributed to the sector j by interviewed k

The relative weight of each sector, P_j , is calculated by means of Equation 5:

$$\forall j = 1, \dots, l \quad (5)$$

3.7 Terminal Performance Index (IDT)

Finally, the Terminal Performance Index (IDT) can be computed by means of Equation 6:

$$(6)$$

or by means of Equation 7:

$$(7)$$

Applying the questionnaire presented in the Appendix of this work in a representative sample of specialists of Brazilians terminals of containers, namely Libra terminal Rio S/A (RJ), Tecon Rio Grande S/A (RS), Terminal de Vila Velha S/A (ES), Transbrasa - Transitária Brasileira LTDA (SP), Grupo Rodrimar S/A (SP), Intermarítima Terminais LTDA (BA), Litoral Agência Marítima Ltda (SC), Porto de Itajaí (SC), Container e Transportes Integrados Ltda - CTIL (RS), Terminal Libra 37 (SP), Sepetiba Tecon (RJ), Coopercarga (SC), the relative weights of aspects and sectors, presented in Table 2, were obtained.

Table 2: Relative weights of the aspects and sectors

Aspects / Sectors	Relative weights
1 - Previous documentation	0,155
Qualification of the employee in the processing of documentation	0,329
Delays in sending documentation	0,366
Errors performed in the activities	0,305
2 - Gate	0,142
Qualification of the employee in the achievement of inspection/weighting and transfer of containers	0,342
Availability of equipments	0,378
Adequability of the equipment for weighting and transfer	0,280
3 - Discharge	0,146
Qualification of the employee in unloading vehicles	0,189
Qualification of the employee in achievement containers inspection, weighting and transport	0,209
Availability of equipments	0,274
Efficiency of the equipment for transfer	0,184
Delays due to the achievement of restowage	0,144
4 - Patio	0,160
Availability of equipments	0,316
Adequability of the equipment for transfer and transport	0,221
Errors of positioning containers in the patio	0,206
Storage area availability	0,257
5 - Embarkment	0,155
Qualification of the employee in loading vehicles for embarking	0,226
Availability of equipments	0,300
Efficiency of the equipment for transfer	0,211

Qualification of the employee for the process of embarkment	0,263
6 - Stripping	0,123
Qualification of the employee in the containers stripping activity	0,173
Storage area availability	0,204
Availability of equipments	0,201
Adequability of the stripping equipment	0,167
Qualification of the employee in load nationalization	0,126
Errors in load positioning	0,129
7 - Stuffing	0,119
Qualification of the employee in load inspection	0,138
Qualification of the employee in container stuffing	0,168
Availability of storage area	0,153
Availability of equipments	0,166
Adequability of the equipment for containers stuffing	0,153
Adequability of the equipment for transport	0,113
Errors in load positioning	0,109

This set of weights substituted in equations 6 or 7, allows to obtain the final answer , IDT, once the set of value $\{x_{i,j}\}$ is obtained.

In Table 3 it is presented a scale suggested in this work for the evaluation of the operational performance of any terminal of containers.

Table 3: Scale for evaluation of any terminal operational performance

IDT	Global operational performance
$1 < IDT \leq 2$	NOT SATISFACTORY
$2 < IDT \leq 3$	SATISFACTORY
$3 < IDT \leq 4,5$	GOOD
$4,5 < IDT \leq 5$	EXCELLENT

This answer permits the identification of problems and obstacles regarding the aspects and sectors of the terminal and enables the adoption of measures to mitigate then.

4. CONCLUSIONS

The proposed procedure allows to synthesize the several activities that contribute to improve the global performance of a terminal of containers.

Due to the fact of the use of weights, inconsistencies between the specialists answers which gives the process a subjective nature, are reduced and faded with the size of the sample used.

The weights obtained in this work are representative of Brazilians terminals of containers where technology, equipments, maintenance practices and employees capacitation are about the same.

Several applications of this procedure were developed and the results were satisfactory in pointing out the obstacles for larger operational performance.

BIBLIOGRAPHICAL REFERENCES

Dexheimer, L. (1997) *Sistema para Gerencamento operacional em terminais intermodais de carga*. Dissertação (Mestrado em Engenharia de Transportes) – Instituto Militar de Engenharia, Rio de Janeiro, RJ.

Gomes, L. A. C. (1983) *Análise de Estratégias Operacionais de um Terminal de Contêineres*. Dissertação (Mestrado em Engenharia de Transportes) – Instituto Militar de Engenharia, Rio de Janeiro, RJ.

Lima, R. F. (2004) *Procedimento para Avaliação do Desempenho Operacional de Centros de Distribuição*. Dissertação (Mestrado em Engenharia de Transportes) – Instituto Militar de Engenharia, Rio de Janeiro, RJ.

Pereira, G. S. (2001) *Adequabilidade e Alocação de Equipamentos em Terminais Multimodais de Contêineres*. Dissertação (Mestrado em Engenharia de Transportes) – Instituto Militar de Engenharia, Rio de Janeiro, RJ.

Philippi, A, Roméro, M, Bruna G. (2004) *Curso de Gestão Ambiental*. Ed Baueri – SP Manole.

Yun W. Y, Choi, Y.S. (1999) A simulation model for container-terminal operation analysis using an object-oriented approach. *International Journal of Production Economics*, pp. 221-230.

Ribeiro, F. Botter, R. C. (2004) *Modelo de Simulação para Análise Operacional de pátios de Aeroportos*. Anais do XVIII Congresso de Pesquisa e Ensino em Transportes, Florianópolis, SC.

ABTC – Associação Brasileira de Transporte de Cargas (2000), *A influência dos terminais de cargas Brasileiros* informe janeiro. Disponível em: www.abtc.org.br.

APPENDIX - QUESTIONNAIRE ABOUT THE INFLUENCES OF ASPECTS AND SECTORS IN THE OPERATIONAL PERFORMANCE OF CONTAINERS TERMINAL

Name:

Institution:

Position:

Part I

Objective: This part of this questionnaire has the purpose to determine the influences of aspects in the performance of the activities developed in the terminal, seeking to evaluate their operational performance.

For each of the seven sectors that constitute a containers terminal, order the influence of each of the mentioned aspects in the decreasing form following the indicated scale, where the greatest value corresponds to the larger influence while value 1 corresponds to the aspect with smaller influence.

Scale: [3, 2, 1]

Sector	Aspects	Influence
Previous Documentation	Qualification of the employee in the processing of the documentation	
	Delays in the sending documentation	
	Errors in the documentation sent	

Scale: [3, 2, 1]

Sector	Aspects	Influence
Gate	Qualification of the employee in the achievement of inspection / weighting and overflow	
	Availability of equipments	
	Adequability of the equipment for weighting and overflow	

Scale: [4, 3, 2, 1]

Sector	Aspects	Influence
Patio	Availability of equipments	
	Adequability of the equipment for overflow and transport	
	Errors of positioning containers in the patio.	
	Storage area availability.	

Scale: [4, 3, 2, 1]

Sector	Aspects	Influence
Embarkment	Qualification of the employee in loading vehicles for embarking	
	Equipment availability	
	Efficiency of the equipment for overflow	
	Qualification of employee in liberation / documentation for embarking.	

Scale: [5, 4, 3, 2, 1]

Sector	Aspects	Influence
Discharge	Qualification of employee in unloading vehicles.	
	Qualification of employee in the achievement of the inspection / weighting and transport of containers.	
	Equipments availability	
	Efficiency of the equipment for overflow	
	Delays due to the achievement of restowage	

Scale: [6, 5, 4, 3, 2, 1]

Sector	Aspects	Influence
Stripping	Qualification of employee in container stripping	
	Availability of storage area	

	Availability of equipments	
	Adequability of the equipment for stripping	
	Qualification of employee for load nationalization	
	Load positioned in wrong localities	

Scale: [7, 6, 5, 4, 3, 2, 1]

Sector	Aspects	Influence
Stuffing	Qualification of employee in load inspection	
	Qualification of employee in container stuffing	
	Availability of storage area	
	Availability of equipments.	
	Adequability of the equipment for stuffing	
	Adequability of the equipment for overflow and transport	
	Load positioned in wrong localities	

Part II

Objective: This part of this questionnaire has the purpose to evaluate the influence of each sector in the operational performance of the terminal of containers.

For each of the seven sectors that constitute the terminal of containers, assign:

3 → if the sector is considered as very important,

2 → if it is considered important, and

1 → if its influence in the global performance is small.

Sectors	Importance
Previous Documentation	
Gate	
Patio	
Embarkment	
Discharge	
Stripping	
Stuffing	