# OPTIMAL SIZE OF A LOGISTIC TERMINAL

***Burciu Ştefan, Ştefănică Cristina, University "Politehnica" Bucharest, Splaiul Independentei 313, Bucharest, Zip Code 060042, ROMANIA***

***Abstract:*** *Regression models have often been used to determine the size of logistic terminals within urban areas. Although these models may be good for calculating the required size of logistic terminals of a company because they can easily represent the relationship between the required facility size of a logistic terminal and the amount of goods handled within it, they can't represent the overall impact on urban logistics systems, especially on traffic conditions on the road network. Berths are established for trucks to load and unload goods within logistic terminals and therefore relate more strongly to the traffic conditions outside logistic terminals than other facilities. The size of other facilities within logistic terminals is also considered, with construction and management costs being incorporated into berth costs.*

*Optimization of the number of berth must take into account the characteristics of truck arrivals at berth and loading/unloading service ability provided by them so that the impact of constructing logistic terminals on society at large can be considered. This can be represented by queuing theory using a trade-off between transportation costs and facility costs within a logistic terminal.*
***Key words:*** *logistic terminal, berths, network, queuing theory, distribution.*

## 1. LOGISTIC TERMINALS FOR URBAN GOODS DISTRIBUTION

The concept of logistic terminal is based on existing industrial areas; logistic terminals may be part of a large area with mixed industries. The location for logistic terminals has to be selected carefully in order to have access both to urban areas and to other regions (the accessibility for interregional connections). The terminals must have the proper dimensions in order to be used efficiently, and to limit the competition with other terminals and to guarantee a proper level of service in each part of urban area.

A logistic terminal is an area of specialized industries in a distribution region, that generates both logistical and traffic activities and that serves as a transfer point for regional transport and distribution. Public and private transfer points are located in these terminals. The terminals are useful for logistic activities such as storage, sorting and distribution. These activities are concentrated around one or more transfer points for different transport modes.

These logistic terminals are attractive and offer a lot of facilities for transport companies, distribution centers, warehouses (of wholesale or retail organizations or import companies), trade centers and added value of logistic activities.

A logistic park is part of a national network of logistic parks that are connected by different modalities. This national network is thus better equipped for flexible time patterns (off-peak use of the road network, night transport, etc.), changing demands for transport, and providing different transport services, than it would be without multimodal connections.

Beside regional logistic terminals an area may contain local logistic terminals. Local logistic terminal is comparable to regional logistic terminal (it is subordinated rather than autonomous) and it runs on a smaller scale. Local logistic terminals are needed in a part of a region and have the advantage of their location. Thus, there is no optimal location for one logistic terminal.

Both regional and local terminals have two functions:

- to facilitate logistic and traffic activities by providing space and transport services;
- to support concentration and consolidation of goods flows by developing certain transport services.

These services may be supported by information and communication systems in certain cases the service area of logistic terminals will cover the border areas.

## 2. FREIGHT CENTERS AND LOGISTIC TERMINALS

The development of fright centers and logistic terminals is the result of national policies regarding freight transport. The term of “freight center” is used as a generic name for public or private transshipment terminals, or for other transport activities that contain transshipment facilities.

The original concept of “freight center” refers to a building for transshipment activities, or a transfer point between long-distance and short-distance transport (e.g. regional transfer points). A logistic terminal is a spatial concentration of transfer points (e.g. freight centers).

The basic functions of a freight center are:

- the receiving – that includes the control of goods’ quantity and quality;
- the storage – that includes goods’ movement from the reception to the storage place;

- the order picking - that includes goods' transport from the storage place to the loading platform, an extra control and goods' packing
- the goods' delivery - that includes the stocking or the intermediate storage of goods

The reason for developing freight centers and logistic terminals are:

- to facilitate the logistic activities with location, space and transport facilities
- to consolidate goods flows by developing particular transport services

Windborne International Group (1994) uses the following definition for freight centers, which is also applicable to logistic parks:

> "Freight centers form intersections of at least two different transport modes at which independent companies from the distribution sector and other transport-intensive business (e.g. component manufacturers) are located in a designated area. The aim is to enhance co-operation between transport modes and to improve the supply of distribution services in a region. A freight centre also implies an organizational element, in that individual forms co-operate or share the use of on-site facilities (for example through information systems) and may therefore benefit from significant synergetic effects. Freight centers are intended to improve urban goods traffic, to boost the regional economy and to enhance international trade."

The definition suggests that freight centers are generally multimodal. Numerous freight centers are only transfer points between long-distance and short-distance road transport. For this reason, long-distance and short-distance road transport can go together with different transport modes.

## 3. SIZE OF A LOGISTIC TERMINAL

More regression models have been used to determine the size of logistic terminals within urban areas. We have to admit that even thought models can be fit to size the logistic terminals of a company as they emphasize the relation between the facilities and the quantity of goods in need of a logistic terminal, these models can't point the general impact on urban logistic system and especially on traffic conditions on the road network so, the behavior of the vehicles in and outside logistic terminals should be integrated in the models of determining the optimal size of a logistic terminal.

This paragraph is meant to optimize the size of logistic terminal represented by the number of berths necessary to load and unload goods in/from trucks within the logistic terminals. That's why berth are more likely connected to the traffic condition outside logistic terminals. Besides the traffic conditions the size of other facilities offered by the logistic terminal is also considered in this model along with the costs of construction and management as part of the costs for the berths.

The optimization of the number of berth should also take in consideration the characteristic of trucks arrived and their capacity of loading/unloading, so that the impact of logistic terminals on society is enhanced. This can be represented by queuing theory, using the trade-of between transportation costs and facility costs within logistic terminals. In the case of logistic terminals inputs and decision variables needed to determine the number of berths is: Inputs:

$c_b$ - the berths costs per hour at logistic terminal including penalty costs due to waiting above the accepted time limit (m.u./hour/berth)

T – time period considered (hours)

$c_t$ - transportation costs per hour for each vehicle (m.u./hour/vehicle)

Decision variables:

y – number of berths

Using this inputs and decision variables it can be formulated the following objective to determine the optimal number of berths:

$$\min C = c_b T y + c_t T n(y,V), \quad (1)$$

where:

C – total cost at logistic terminal during period T (m.u.)

V – total number of trucks using logistic terminal during period T (vehicles)

n(y,V) – average number of trucks in logistic terminal for the number of berths y during period T.

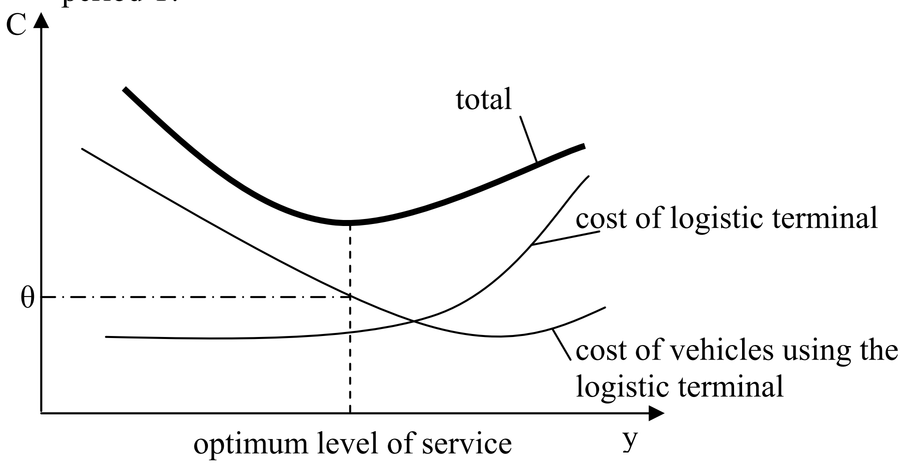


**Fig. 1** *The variation of vehicles and logistic terminal costs sum as a function of berths*

This way of handling the problem of determining the optimal size of logistic terminal can be further studied using models based on “harmony of levels”.

If the relation is divided by $c_t T$ :

$$\min r = \frac{c}{c_t T} = \frac{c_{bi}}{c_t} y + n(y,V) = r_{bt} y + n(y,V) , \tag{2}$$

where:

r – ratio of total cost and transportation cost per truck at logistic terminal for the number of berths y during period T

$r_{bt}$ - berth-truck cost ratio

Giving values to $c_t T$ the ratio r can be considered criteria for determining the optimal number of berths. In equation (2) the berth-truck cost ratio $r_{bt}$ can be calculated by cost analyses performed in advanced and so, if the number of berths y is fixed the ratio r is only a function of n(y,V) representing the average number of trucks in logistics terminal (n(y,V)=n).

The average number of trucks in logistic terminal is equal to the sum of the average number of trucks in waiting and in service as following:

$$n = n_w + a , \tag{3}$$

where:

a – traffic intensity

$n_w$ - average number of trucks waiting at a logistic terminal for berths, if trucks arrival follow a Poisson distribution and service times an exponential distribution for.

$$a = \frac{\lambda}{\mu} , \tag{4}$$

where:

λ-arrival intensity of trucks (vehicles/hour)

μ – service intensity of trucks (vehicles/hour)

Both λ and μ can be expressed as a function of V, total number of trucks using a logistic terminal. $n_w$ can be derived from Little’s formula:

$$n_w = \lambda W_1 , \tag{5}$$

where:

$W_1$ - average waiting time of trucks (h)

In the case of Poisson distribution for truck arrivals and exponential distribution for service times, $W_1$ :

$$W_1 = \frac{a^y}{\mu(y-1)!(y-a)^2}\left\{\sum_{n=0}^{y-1}\frac{a^n}{n!}+\frac{a^y}{(y-1)!(y-a)}\right\}^{-1}, \tag{6}$$

Replacing $W_1$ in equation (5), then:

$$n_w = \lambda W_1 = \frac{a^{s+1}}{(s-1)!(s-a)^2}\left\{\sum_{n=0}^{s-1}\frac{a^n}{n!}+\frac{a^s}{(s-1)!(s-a)}\right\}^{-1} + a, \tag{7}$$

So, the average number of trucks n can be obtained by substituting equation (7) into equation (3)

$$n = \frac{a^{s+1}}{(s-1)!(s-a)^2}\left\{\sum_{n=0}^{s-1}\frac{a^n}{n!}+\frac{a^s}{(s-1)!(s-a)}\right\}^{-1} + a, \tag{8}$$

The model described is applied to an existing logistic terminal in order to determine the optimal number of berths for trucks that transport goods in and outside a city. The inputs for the mathematical model were obtained by a survey at a platform of a freight carrier within a logistic terminal. Table 1 shows the main characteristics of trucks arrivals and service times obtained from that survey. The results shows that the optimal number of berths for vans is 12 and for trucks 4. There ware 13 berths for vans and trucks but the berths weren't used and some of them were use for parking during off peak hours.

*Table 1.* Characteristics of trucks arrivals and service times

| | Vans | Trucks |
|---|---|---|
| Period T [h] | 15 (5 a.m.-8 p.m.) | 24 (0 a.m.-12.p.m.) |
| Arrival intensity [veh/10 min] | 3.08 | 0.91 |
| Service intensity [veh/10 min] | 0.31 | 0.37 |
| Traffic intensity | 9.94 | 2.46 |
| Arrival repartition | Poisson | Poisson |
| Service repartition | Exponential | Erlang (k=2) |

**REFERENCES**


[1] Binsbergen, A., Visser, J., "Innovation Steps Towards Efficient Goods Distribution Systems for Urban Areas" , DUP Science, 2001

[2] Gattorna, J., "Managementul logisticii şi distribuţiei", Teora, 2001

[3] Raicu, Ş., Popa, M., "Some difficult problems in using the models of queueing theory for the real systems study", SIMSIS9, 1996

[4] Taniguchi, E., "City Logistics", Elsevier, 2001