

Evaluating the Level of Service of Ferry Ports A Methodological Proposal

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Abstract Quality of transport service is a crucial factor to provide transport services in line with the users expectations. In this research, we start from previous knowledge of the concept Level of Service (LOS) in the transport sector to evaluate whether tools and scales defined in previous studies are also applicable in defining the level of service in the ferry port. We decided to focus on the tool for measuring service quality in Ro-Ro ferry ports because they are the most important and often the only connection between the island and the mainland. Therefore, they are an essential factor in ensuring the sustainable development of the islands.

Keywords Maritime passenger services. Level of service. Port management. Transport service quality. Maritime transport.

Summary 1 Introduction. – 2 The Concept of Level of Service in the Transport Sector. – 3 Shortcomings of Previous Research on the Level of Service. – 4 Main Ferry Port Land Areas. – 5 Proposal of Methodology. – 5.1 Evaluation of the Capacity and Level of Service of the Quay Apron Area. – 5.2 Evaluation of the Capacity and Level of Service of the Marshalling Area. – 5.3 Evaluation of the Capacity and Level of Service of the Area for Passenger and Luggage Accommodation.

1 Introduction

The quality of transport services is a crucial factor for providing adequate transport services that meet the needs and desires of users. In this research, the previous knowledge on the concept of level of service (LOS) in the transport sector was analysed to find out whether the LOS scales defined in previous research and used as tools for determining service quality in road and air transport planning manuals are also suitable for determining service quality in the ferry port. The LOS guidelines and technological processes described in the HCM (*Highway Capacity Manual*), ADRM (*Airport Development Reference Manual*), and TCQSM (*Transit Capacity and Quality of Service Manual*) manuals were analysed to answer this research question.

In these manuals, each scale is explicitly defined for each subsystem of the transport system. For this research, the Ro-Ro ferry port area has been divided into three main subsystems based on the technological processes of transport within the port area: quay apron area, marshalling area or vehicle staging area and area for passenger, and luggage accommodation.

Based on the results of desktop analysis of existing maritime port service quality concepts and formulas for calculating sustainable capacity of Ro-Ro ferry ports, a methodology for assessing capacity and service levels in Ro-Ro ferry ports was proposed using the existing LOS scales.

2 The Concept of Level of Service in the Transport Sector

In traffic engineering, the quality of service of a particular traffic object is often determined with the concept of 'level of service' (hereafter: LOS), which uses a six-level scale from A to F, where A means an excellent quality of service, while F is an unacceptable quality of service (often also defined as a system breakdown). This concept presents and rates the quality of service of each traffic object in a simple way. The simplicity of this concept makes it easier to present the current and future performance of the traffic object to the decision-makers and the general (non-technical) public.

The concept of LOS for traffic objects was first defined in the second edition of the HCM in 1965 after the concept of traffic capacity had been defined in the previous first edition in 1950. Since then, LOS has been used as an elementary benchmark for the planning, design, and organisation of road facilities. The HCM guidelines have become a standard reference code when defining capacity and LOS procedures in road transport, especially after the third edition in 1985 and other editions since then.

For walkways, including stairways, LOS is further defined in 1970 in the doctoral thesis of John J. Fruin (1970) and in his book (1971), published as a result of the author's dissertation.¹

Based on the HCM and the Fruin guideline for LOS, Transport Canada (TC)² defined the concept of LOS for airports in the mid to late 1970s. This concept was adopted in 1981 by the Airport Associations Coordinating Council (IATA 1981), now Airports Council International (ACI) and International Air Transport Association (IATA), which incorporated it in the ADRM with some modifications.³ As the publisher of the ADRM-a is IATA, these guidelines are often referred to in practice as 'IATA guidelines'.

The methods for analysing the capacity and quality of public transport from the perspective of passengers and transport operators are, in addition to the HCM, also defined in the TCQSM. The first TCQSM was published in 1999 (Kittelson & Associates 1999) and summarised the methods for determining public transport capacity and LOS for bus and rail transport objects.⁴ Although the determination of capacity for ferry transport is not defined in the first edition,⁵ it has been included in the second and last third editions (TCRP 2003; 2013)

All previously listed authors/manuals define LOS using a six-level scale from A to F. Still, the parameters and the way of determining these levels differ from author to author, i.e., manual to manual. Moreover, the parameters for traffic objects also change regarding the perception of space in different cultures (Šimunović 2006, 180).

1 Fruin (1970, 1971) has produced guidelines for the design of walkways and stairways based on his research at bus and rail terminals managed by the Port Authority of New York and New Jersey.

2 The results of the research and definition of LOS TC were published in the *Interim Level of Service Standards* and *Airport Services and Security*. During the research, a methodology for measuring LOS was developed known as CASE (Canadian Airport System Evaluation). The TC has defined standards for a total of five main passenger stop-over areas, namely: counter, waiting/circulation area, holding area, baggage claim area and police, customs, or immigration control. These standards and methodology are shown in TRB 2010a, 146-50.

3 The 1981 ADRM has been regularly updated and is now known as the manual that provides guidelines for designing airport facilities with user needs in mind.

4 The concept of LOS for rail transport is defined in the TCQSM, which defines this concept LOS according to the guidelines provided by Fruin. In addition to TCQSM, the LOS concept according to Fruin has also been adopted by the British railway company Network Rail (Network Rail 2011) to define guidelines for assessing the capacity of a passenger railway station.

5 In the first edition, ferry transport is mentioned only as one of the modes of transport offering regular public transport services.

3 Shortcomings of Previous Research on the Level of Service

Previous research on LOS has not considered the perception of passengers with reduced mobility and safety as indicators for service level, nor has it recognised that they need to be considered in future LOS research.

When planning transport facilities, persons with reduced mobility should be considered so that they can board, access, move around, stay and work without hindrance. At the EU level, the accessibility of buildings for all persons is considered one of the essential requirements for buildings. It is laid down in Regulation No 305/2011 (EU 2011). The standards for transportation facilities in the United States of America are laid down in the Americans with Disabilities Act (ADA) (U.S. Department of Transportation s.d.). According to the provisions of ADA, all new transport stations must be accessible to persons with reduced mobility.

For maritime passenger transport, the guidelines are issued jointly by the Irish Department of Transport and the National Disability Authority (NDA s.d.). In contrast, in the UK, the DPTAC (Disabled Persons Transport Advisory Committee) issues guidelines for the ship-building industry with the support of the IMO. The latter guidelines were evaluated for their uptake and effectiveness between 2004 and 2005 as part of the UK national project, whose final report was published in 2006 (Keith et al. 2006).

The needs of persons with reduced mobility must be considered in the design of the object. It is also important to consider the condition of emergency evacuations in individual facilities (safety).

4 Main Ferry Port Land Areas

The maritime port area comprises the sea and land areas of the port and is used for the conduct of port activities. The port's land area includes all port infrastructure and port superstructures, from the coastline to the final land boundary of the port area.

Different authors have classified the maritime port areas differently in analysing the port area, so there is no universally accepted classification. From the perspective of the functional elements of the port, previous works have divided the maritime port area into:

- quayside, yard, landside, and hinterland (Böse 2011, 13-21; Bichou 2009, 136-44);
- marshalling yards, passenger facilities, berth facilities (Agerchou et al. 2004, 291-7);

- terminal forecourt (landside),⁶ terminal (wetside),⁷ buildings (PIANC 1995, 33-8);
- landside facilities, dockside facilities, en-route (vessel route) (TCRP 2013, 9-28).

Considering the technological processes of traffic in the ferry port and the functionality and connectivity of the individual port facilities, the land area of the ferry port is divided into three areas (Stupalo 2015, 30):

1. quay apron area;
2. marshalling area or vehicle staging area;
3. area for passenger accommodation.

5 Proposal of Methodology

The analysis of the LOS scales identified in the available literature and described in the previous chapters has shown that specific scales can be used in ferry ports to assess capacity and service levels. The applicability of these scales to evaluate individual parts of public transport passenger terminals, including the maritime passenger terminal, has already been identified in the TCQSM manual.

The scales identified have separately assessed the area for passengers and the area for road vehicles. These areas within the ferry terminal can be further divided into three subsystems: 1) processing area, 2) holding areas, and 3) links or corridors. The appropriateness of this subdivision in the analysis of traffic objects has already been recognised in studies by the National Academies of Sciences, Engineering, and Medicine (TRB 2010a, 147) and IATA (1981, 8). Although these areas have been recognised, the LOS scale for the processing area has not been identified in previous research, but the LOS scales for the other two subsystems have.

In line with the mainland areas of the ferry port defined in the previous chapter, the following sub-chapters pay particular attention to the level of service in each of these areas.

6 Port connections to the public road network.

7 Area from the forecourt to the final land boundary of the port area.

5.1 Evaluation of the Capacity and Level of Service of the Quay Apron Area

The Quay apron area can be divided into two elementary subsystems:

- area for the movement and stay of passengers/pedestrians (if boarding is not via a bridge)
- area for the movement and stay of road vehicles.

The level of service of an area designated for passenger/pedestrian movement can be further divided into three subsystems:

- traffic processing points – need not be part of the quay apron area subsystems. It takes place when the passenger (with or without a vehicle) buys the ticket or hands it over to the ticket officer in this area, e.g., when boarding the vessel. As mentioned above, the LOS scale for this subsystem has not been identified in the literature;
- holding area – if more passengers/vehicles arrive at the vessel than can be handled via the loading ramp/bridge, a queue forms next to the ship. A queue may also form when a passenger buys a ticket or hands it over to a staff member at that location. Given the characteristics of this subsystem, it can be evaluated:
 - for passengers – using the LOS scale for queuing, defined by Fruin (1987, 84-7)
 - for vehicles – no LOS scale has been identified in the literature that could apply to this subsystem. Considering the characteristics of this subsystem, it was concluded that the application of the LOS scale within the HCM for the intersection system is not appropriate. Intersections are evaluated in the manual by the indicator ‘regulated waiting’, i.e., the difference between the time of free passage of the vehicle and the time of passage, which includes the time of stopping and restarting the vehicle,
 - for vehicles – no LOS scale applicable to this subsystem was found in the literature. Considering the characteristics of this subsystem, it was concluded that the application of the LOS scale within the HCM for the signalised and unsignalised intersections is not appropriate. Indicator *control delay*⁸ is the main service measure in the HCM for evaluating LOS at the intersection.

⁸ “Control delay includes delay associated with vehicle slowing in advance of an intersection, the time spent stopped on an intersection approach, the time spent as vehicles move up in the queue, and the time needed for vehicles to accelerate to their desired speed” (TRB 2010b, 4-15).

- links or corridors – the primary purpose of links or corridors in the quay apron area is to connect the area intended for passenger accommodation (if embarking/disembarking of passengers is not done across the bridge) and the marshalling area with the vessel (when embarking), and connecting the vessel with port exit points when disembarking). Given the characteristics of this subsystem, it can be evaluated:
 - for passengers – depending on the design of the links or corridor, different LOS scales have been identified in the literature. In the ferry port, the links or corridors of the quay apron area are located primarily near the vehicle movement area. Therefore, the LOS scales defined within the HCM for pedestrian mode (TRB 2010b), for urban street and segment measures, were identified as applicable for the evaluation of pedestrian/passenger links/corridors. In addition to these scales, walkway sections can also be valued using Fruin’s LOS scales for walkways (Fruin 1987, 74-8) and stairways (Fruin 1987, 79-83). The analysis of Fruin’s indicators showed that the values are approximate but not identical to the HCM indicators (TRB 2010b, ch. 23, 3-4) used to evaluate off-street pedestrian facilities. It was concluded that there is no satisfactory way to determine the most appropriate scale. The selection of the scale should be on the traffic planner who evaluates the facility.
 - for vehicles – after analysing quay apron area; it was concluded that no LOS scale is applicable for evaluating the roads of this area, since the level of service within this area, perceived by the passenger, depends on various factors decided mainly by the (for example location of each vehicle on the vessel, order (priority) of parking, method of disembarkation/embarkation, etc.). Factors that port has influence relate to ensuring appropriate marking of this area and its width.

5.2 Evaluation of the Capacity and Level of Service of the Marshalling Area

Research conducted by Stupalo (2015) didn’t identify the LOS scale, which could be applied to evaluate the capacity and level of service of the marshalling area. Therefore, the need for additional research focused on defining the LOS scale of the marshalling area was recognised.

Possible indicators for the evaluation of this area are the capacity of the area and the width of the holding lanes. Based on these indicators suitability of this area can be evaluated depending on the traffic demand (whether the area is sufficient for the accommoda-

tion of all vehicles in rest, and whether it is suitable for passenger accommodation, the possibility of unobstructed entry/exit of passengers to/from the vehicles).

According to Morales-Fusco and Saurí (2009) optimal size of marshalling area in Ro-Ro terminals is the size that can accommodate twice as many vehicles as capacity of the biggest vessel that reaches the terminal. In this type of terminal vehicles usually do not leave the port area immediately upon disembarkation but are stored within the port area. However, this is not the case in the ferry port, where vehicles, after disembarking, usually immediately leave the port area. Therefore, the optimal capacity of the marshalling area in the ferry port would be the one that enables simultaneously accommodation of vehicles which corresponds to the capacity of the average vessel or the biggest vessel that reaches the terminal.

While considering the level of service of the marshalling area, the proposal for the boundary between LOS C and LOS D is when the length of the holding lanes stops being enough, and there is an overflow of traffic to adjacent roads. This proposal is consistent with the IATA definition for the boundary between LOS C and D (TRB 2010a, 150) for passenger queuing. If overflow causes dysfunction to the port's secondary processes, they could be used to further elaborate scale to lower LOS levels.

The percentage of area utilisation, its design, and organisations, including the entrance system for vehicles to the marshalling area (e.g., ticket booths, the possibility of reservation), could also be considered. All these factors affect the time spent within the marshalling area.

5.3 Evaluation of the Capacity and Level of Service of the Area for Passenger and Luggage Accommodation

The area for passenger and luggage accommodation is intended for movement and retention of passengers/pedestrians.

Processors, which refers to the ticket, customs and police booths and other similar facilities for monetary, regulatory or security processes of traffic, are not defined by LOS scales in the before mentioned manuals. But the need for their definition has been recognised. Further research should focus on defining adequate processing time in these facilities based on the data obtained from passengers and service providers. Maximum queuing time guidelines are defined in ADRM but not using the LOS scale.⁹

⁹ The maximum waiting time has been defined for different areas (e.g., check-in economy, baggage claim, security), but only as a time that is “short to acceptable” and “acceptable to long” (IATA 2004, 189).

The level of service of *reservoirs* can be determined based on standards defined by IATA (2004) and Fruin (1987) for:

- ticket or check-in queue area – two LOS scales have been identified:
 - IATA’s LOS scale for check-in queue area (IATA 2004, 180-7) is based on the size of the area for passenger/pedestrian (sq. meter/occupant) regarding the width of the queue, number of bags and number of luggage carts;
 - Fruin’s LOS scale for queuing (Fruin 1987, 84-7) is based on average pedestrian area occupancy (sq. feet/person) and average inter-person spacing (feet).

It was concluded that there is no satisfactory way to determine the most appropriate scale. The selection of the scale should be on the traffic planner who evaluates the facility.

- wait/circulation area – the LOS scale for this space is defined by IATA and is based on the size of the area for passenger/pedestrian (IATA 2004, 297-8) and, only for LOS C (IATA 2004, 184), on location (before and after check-in), presence of luggage carts and the passengers’ speed;
- holding area – the LOS scale for this space is defined by IATA based on the percentage of occupied space (IATA 2004, 186, 297-8).
- border control area – two scales have been identified:
 - IATA’s LOS scale for passport control (IATA 2004, 185-6);
 - Fruin’s LOS scale for queuing (Fruin 1987, 84-7).

Both scales evaluate the object concerning the surface area per passenger, and the values of the indicators are approximate, although not identical. Therefore, there is no satisfactory way to determine the most appropriate scale, and the selection of the scale should be on the traffic planner who evaluates the facility.

The level of service of links/corridors within an area for passenger and luggage accommodation can be determined based on Fruin’s guidelines, which are also recommended in the TCQSM manual (TCRP 2013, ch. 10, 39-62) for:

- doorway and walkways – the LOS is based on the pedestrian space (sq. feet/person), avg. speed (feet/min), flow per unit width (person/feet/min) and volume-to-capacity ratio (v/c);¹⁰
- stairways – the level of service is based on average pedestrian area occupancy and average flow volumes (Fruin 1987, 79-84;

10 Volume-to-capacity (v/c) or demand-to-capacity (d/c) ratio is a special case service measure. This measure is used when defining a boundary between LOS E and LOS F, but not to define other LOS thresholds. This measure cannot be measured directly in the field, nor is it a measure of traveller perceptions. Until capacity is reached (i.e., when flow breaks down or queues build on) the d/c ratio is not perceived by travellers (TRB 2010b, ch. 5, 9).

TCRP 2013, 10-48). LOS for stairs is also prescribed by HCM (TRB 2010b, ch. 23, 3), but since TCQSM recommended using Fruin's LOS scale, its application should be considered when measuring the level of service of the ferry port.

Links or corridors connecting the port building to the outer entrances and exits of the port (with the exception of the bridge connecting the terminal building to the ferry) can be assessed using indicators defined in the HCM defined indicators for urban roads and sections of urban roads, i.e., based on LOS scales defined for the evaluation of facilities with interrupted traffic flow.¹¹

The study period¹² should be minimum during the peak hour. For evaluation analysis, approach C (TRB 2010b, ch. 16, 2) should be used, with a study period of one hour with consecutive analysis periods of 15 minutes. This approach considers systematic variations in traffic flow between periods and queues that carry over to the next analysis period and produces a more accurate representation of delay.

From the manuals described earlier, it can be concluded that the LOS at the ferry port, whose main purpose is to provide public transport services, should be from LOS D (in shorter periods) to LOS C or even higher. This means that the LOS should not be below LOS C during the busiest 15 minutes of the peak hour. A higher level of service can be adopted by ferry ports that want to attract shipowners and passengers with quality service.

The proposed methodology analyses the level of service from the perspective of passengers, i.e., users of transport services, and does not include an analysis of the level of service from the shipowner's perspective (transport service provider). The methodology covers the area from the entry into the port area to the boarding into the ship (ship's ramp).

As a result of the defined methodology answer to the research question from the introduction is: The service level guidelines set out in the road, and air transport manuals are applicable when evaluating the capacity and service level of a ferry port.

11 Guidelines are defined in TRB 2010b.

12 The study period is the time interval represented by the performance evaluation. It consists of one or more consecutive analysis periods. An analysis period is the time interval evaluated by a single application of the methodology.

Bibliography

- Agerschou, H.; Dand, I.; Ernst, T.; Ghoos, H.; Jensen, O.J.; Korsgaard, J.; Land, J.M.; McKay, T.; Oumeraci, H.; Petersen, J.B.; Runge-Schmidt, L.; Svendsen, H.L. (2004). *Planning and Design of Ports and Marine Terminals*. 2nd ed. London: Thomas Telford.
- Bichou, K. (2009). *Port Operations, Planning and Logistics*. London: Informa.
- Böse, J.W. (ed.) (2011). *Handbook of Terminal Planning*. New York: Springer Science+Business Media. Operations research/computer science interfaces series 49.
- EU (2011). *Laying Down Harmonised Conditions for the Marketing of Construction Products and Repealing Council Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 Directive 89/106/EEC*.
- Fruin, J.J. (1970). *Designing for Pedestrians a Level of Service Concept* [PhD Dissertation]. New York (US): Polytechnic Institute of Brooklyn.
- Fruin, J.J. (1971). *Pedestrian Planning and Design*. New York: Metropolitan Association of Urban Designers and Environmental Planners, Inc.
- Fruin, J.J. (1987). *Pedestrian Planning and Design*. Mobile (AL): Elevator World, Inc.
- IATA, International Air Transport Association (1981). *Guidelines for Airport Capacity/Demand Management*. Geneva: Airport Associations Coordinating Council.
- IATA (2004). *Airport Development Reference Manual*. 9th ed. Montreal; Genova: International Air Transport Association.
- Keith, S.; Whitney, G.; Sentinella, J.; Wong, W.; Platt-Evans, C.; Fielding, C.; Smith, L. (2006). *Review of DPTAC Guidance: Large Passenger Ships and Passenger Infrastructure (Final Report)*. Unpublished project report UPRSE/187/05. <https://web.archive.nationalarchives.gov.uk/ukgwa/20070205205450/http://www.dptac.gov.uk/pubs/guideshipfinal/index.htm>.
- Kittelson & Associates, Inc. (1999). *Transit Capacity and Quality of Service Manual*. 1st ed. Washington, DC. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_6-a.pdf.
- Morales-Fusco, P.; Saurí, S. (2009). "Performance Indicators for Roll-on-Roll-off Terminals: A Planning Assessment Tool". *Transportation Research Record*, 2100(1), 38-46. <https://doi.org/10.3141/2100-05>.
- NDA, National Disability Authority (s.d.). *Guidelines for Accessible Maritime Passenger Transport*. Ireland. <https://nda.ie/nda-files/guidelines-for-accessible-maritime-passenger-transport.pdf>.
- Network Rail (2011). *Station Capacity-Assessment Guidance*. London. <https://pdfslide.net/download/link/station-capacity-assessment-guidance>.
- PIANC, Permanent International Association of Navigation Congresses (1995). *Port Facilities for Ferries, Practical Guide*. Brussels.
- Šimunović, L.J. (2006). *Sustavno istraživanje parametara pješačkog toka u urbanim sredinama* [PhD Thesis]. Zagreb: University of Zagreb.
- Stupalo, V. (2015). *Methods for Evaluation of Capacity and Level of Service in Ferry Port* [PhD Thesis]. Zagreb: University of Zagreb.
- TCRP, Transit Cooperative Research Program (2003). *Report 100: Transit Capacity and Quality of Service Manual*. 2nd ed. Washington, DC: National Academies of Sciences, Engineering, and Medicine. <http://www.trb.org/Main/Blurbs/153590.aspx>.

- TCRP (2013). *Report 165: Transit Capacity and Quality of Service Manual*. 3rd ed. Washington, DC: National Academies of Sciences, Engineering, and Medicine. <http://doi.org/10.17226/24766>.
- TRB, Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine (2010a). *ACRP Report 25: Airport passenger terminal planning and design*. Vol. 1, *Guidebook*. Washington, DC: National Academies of Sciences, Engineering, and Medicine. <https://doi.org/10.17226/22964>.
- TRB (2010b). *Highway Capacity Manual*. 5th ed. Washington, DC: National Academies of Sciences, Engineering, and Medicine. <https://www.trb.org/Main/Blurbs/164718.aspx>.
- U.S. Department of Transportation (s.d.). *ADA Standards for Transportation Facilities*. <https://www.transit.dot.gov/regulations-and-guidance/civil-rights-ada/ada-regulations>.