ELEMENTS FOR DEFINING THE INTERMODAL TERMINALS STRUCTURE

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Abstract: *In order to meet increasingly complex requirements in the fields of logistics and transport, intensive development of intermodal transport networks is necessary in which intermodal terminals (IT), as nodes in these networks, play a key role. ITs are dynamic and complex systems that can differ in terms of various elements (functions, services, subsystems, users, applied technologies, etc.) that define the different terminal structures. The subject of the paper is the comprehensive identification and classification of these elements in order to create the preconditions for defining IT typical structures and their further analysis, evaluation, comparison, etc. The paper identifies and describes 13 elements classified into four levels: organizational, operational, physical/spatial and technological.*

Keywords*: intermodal terminal, structure, element.*

1. INTRODUCTION

Trends of globalization, technological development and specialization, demographic and climate changes, etc. change the established patterns of transport processes. In order to meet the high expectations of participants in these processes, while respecting the principles of sustainable development, it is necessary to develop functional intermodal networks in which intermodal terminals (IT) play a key role. IT is a place for the transshipment and storage of intermodal transport units (ITU), change of transport mode and collecting and storage of goods. ITs are dynamic and complex systems, which can be different in terms of the large number of structural elements. In the literature, the authors were mainly focusing on one element, e.g. place and role in the network (Park & Medda, 2010; Woxenius, 1997), ownership (Rodrigue, 2014; Alderton, 1999), management model (Vieira & Neto, 2016; Monios, 2015) location (Zečević et al., 2017 , Roso et al., 2015; Brnjac & Čavar, 2009), subsystems structure (Kemme, 2013), or on a number of elements, e.g. transshipment system technologies and location (Kutin et al., 2017) or transport modes, flows volumes and resources (Wiegmans et al., 1999). However, the attempts to analyze a large number of elements (Notteboom & Rodrigue, 2009), as well as the attempts to classify them (Bichou & Gray, 2005) are rare. Using the achievements of the aforementioned researches, this paper identifies the elements for defining the IT structure and classifies them into four levels: organizational, operational,

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physical/spatial and technological. The aim of the paper was to define a comprehensive set of elements based on which it will be possible to: select those that are crucial for defining IT types, define the IT types and perform their classification, analysis, comparison, evaluation, etc. The following describes the IT structural elements.

2. ORGANIZATIONAL ELEMENTS FOR DEFINING THE IT STRUCTURE

This part of the paper describes the elements for defining the IT structure that belong to the organizational level: terminal founders and owners, organizational structure and place and role of the IT in the network/chain.

2.1 Founders and owners of the terminal

The founders and owners of the IT represent the investors, i.e. the owners of the capital used for the construction of the IT. In the literature, there are various classifications of the financing models (Beth, 1985; Alderton, 1999), but the common for all of them is the differentiation of financing by the public or private sector owned capital. Accordingly, three basic financing models can be defined: public, private and public-private partnership (PPP) (Cullinane & Song, 2002). In private financing, it is very important to realistically predict the expected flows volumes, upon which the future business of the terminal and the return of the invested funds depend. The main problems that may arise are high operating costs, especially in the initial stages of development, as well as delays or time-consuming design and construction (Rodrigue, 2014). On the other hand, the establishment of IT by the public sector can lead to the problem of constructing a larger number of ITs than necessary or their irrational location, all due to the efforts of the public sector to economically develop a region (Rodrigue et al., 2010). In addition, the problem with public financing is the lack of experience and professional staff that would manage the operation of the IT after its construction. Due to the above, in practice ITs are mostly established on the basis of PPP, which represents a business arrangement between the public and private entities, which creates the conditions for designing, constructing or financing the infrastructure (Tadić & Zečević, 2010). In this business arrangement, members of the public sector are mainly in charge of fulfilling conditions from the regulatory and legal area and providing subsidies that enable positive business operations in the initial stages of development, while members of the private sector are mainly responsible for the design, construction and operation of the IT.

2.2 Terminal management models

Terminal management involves a wider process of distributing competencies, allocating resources, and managing relationships, behavior, and activities in the IT to achieve the desired business outcome. Management models are crucial for the successful development of intermodal services by the operator, depending on its ability to cooperate, integrate, consolidate and plan (Monios, 2015). IT management models can depend on the orientation of the IT (local, regional, global), service provider, infrastructure (land, roads, rail tracks, berths, plateaus for the disposal of ITUs etc.) and superstructure (equipment and facilities in the terminal used for performing the activities) owners (public, private, PPP), who employs personnel, etc. (Vieira & Neto, 2016). This paper adopted the classification of management models based exclusively on the relationship between the owner and operator of the terminal, i.e. who employs the personnel, who owns the infrastructure and superstructure and who manages them, i.e. who makes operational decisions. Accordingly, the following basic management models are explained below (Bichou & Gray, 2005, Vieira & Neto, 2016, Monios, 2015). The d*irect management model* implies that a single entity, which owns the entire infrastructure and superstructure, directly manages all operations, functions, development and other operational activities, and employs complete personnel. *The management model through the daughter company* implies that the owner of complete infrastructure and superstructure, which is usually a public sector entity, establishes a "daughter" company that deals with daily operational decisions. The personnel is employed in the "daughter" company, and the economic entity that owns it act as a supervisor. The i*nstrumental management model* is characterized by a distribution of operational activities. One business entity, usually a public sector member, is the owner of the IT infrastructure and superstructure and employs the personnel, while other entities, usually some smaller operators, are in charge of individual operations and activities in the terminal (transshipment, transport, warehousing operations, etc.). *The leasing model* is based on the fact that one business entity is the owner of complete infrastructure and superstructure, but it gives long-term leasing to another entity (operator) who completely independently manages the terminal, makes decisions and employs personnel. *The "landlord" model* that is based on the fact that one business entity is the owner of the infrastructure and takes care of its maintenance, while another business entity (or several of them) owns the superstructure and pays the owner of the infrastructure a certain fee for its use. The owner of the superstructure independently makes operational decisions and employs personnel.

2.3 Place and role of the terminal in the network/chain

Transport systems are characterized by the movement of goods through networks where terminals represent nodes in which processes of consolidation, sorting, storage, transshipment, changes of transport means and modes are realized. These nodes can be classified in different ways, depending on the place and role in the network. This paper divides the ITs into two main groups: maritime terminals and inland terminals. Maritime terminals are located in the maritime ports and they connect parts of the maritime (*global, regional or feeder*) and land (*multifunctional, intermodal or simple*) networks, while inland terminals are nodes in the land networks connected by the road, rail or river transport modes. *Global maritime networks* directly connect ports on different continents. *Regional maritime networks* directly connect ports in the same region, or indirectly ports on different continents. In *feeder maritime networks*, smaller ports are linked to other ports in the region (regional or global) but through indirect connections. *Multifunctional land networks* include a very large catchment area spreading across the entire continent, which is connected to the port by all available modes of transport and their combinations. *Intermodal land networks* have a somewhat smaller catchment area connected to the port mainly by a combination of road, rail and river transport. *Simple land network* has a very small catchment area (mainly the territory of one state or a couple of neighboring states) connected to the port by road or rail transport. Based on the defined network categories Park & Medda (2010) defined nine basic types of maritime terminals. *Terminals in dominant ports* connect global maritime networks with multifunctional land networks and have a very large catchment area, i.e. access to global, mega-markets. *Terminals in superior ports* connect global maritime networks with limited intermodal land networks. *Terminals in intermediary ports* have direct connections with global ports on one side, but very limited simple land networks serving a small catchment area on the other. T*erminals in versatile ports* connect regional maritime networks with highly branched multifunctional land networks. *Terminals in ordinary ports* make a connection between regional maritime networks and intermodal land networks. *Terminals in developing ports* represent a link between regional maritime networks and simple land networks. *Terminals in specialized ports* are connected to feeder maritime networks on one side and multifunctional land networks on the other. *Terminals in industrial ports* make a connection between the feeder maritime network and intermodal land network. *Terminals in peripheral ports* are the simplest terminals that have very small catchment area and connect the feeder maritime network with the simple land network. On the other hand, Woxenius (1997) defines types of inland ITs according to the five basic categories of land intermodal networks. *Terminals for direct connections* are the nodes in the transport networks in which all operations are carried out at the locations near the sender and receiver, between which the direct connections are established. *Terminals for corridors* are the nodes in the networks based on the corridors (mostly of the rail or river transport modes) where flows pass through multiple terminals on a fixed route, each of which can be connected to several smaller satellite (feeder) terminals. *Terminals for hub and spoke networks* in which all flows pass through a central terminal called a hub, which is connected to a large number of satellite terminals of different sizes. *Terminal for fixed routes* in systems where all terminals in the network belong to one of the possible routes (transport lines). *Terminals for allocated routes* are the nodes in the networks in which routes are dynamically allocated in real time as a result of actual requests.

3. OPERATIONAL ELEMENTS FOR DEFINING THE IT STRUCTURE

Elements of the operational level for defining the terminal structure include the elements directly dependent on the number, type, frequency, intensity and the way of realization of the processes, activities and operations in the terminal. Elements belonging to this level are: type of cargo/transport units, structure of functions and terminal services and terminal users, which are described in more detail below.

3.1 Type of cargo/transport units

Although by the definition the ITUs are manipulated within the ITs, in practice there appears different types of cargo and transport units. Generally all cargo can be divided into containerized and non-containerized (Middendorf, 1998). Non-containerized cargo can be divided into: break-bulk, dry bulk and liquid bulk. On the other side, a special category represents the containerized cargo, i.e. the transport of various goods and materials in transport units whose composition does not change during the transport. The concept of containerization does not necessarily mean that the container is used as an ITU (Notteboom & Rodrigue, 2009). Although containers are the most common form of ITUs, terminals can be equipped or specialized for handling other ITUs such as swap bodies, parts of the vehicles (semi-trailers, railway cars) or the entire vehicles (of road, rail or water transport modes). Types of cargo and the ITUs influence the technologies and structure of the subsystems, and thus the overall IT structure.

3.2 Structure of terminals' functions and services

IT, depending on the size, flows volume and intensity, user requests and other influences, may have different functions and services. In the literature there are various ways of classifying the terminal functions (Wiegmans et al., 1999; de Villiers, 2015), and in this paper the classification made by Zečević (2006) is adopted, according to which all terminals can be divided into four categories: A, B, C and D. Terminals of category A perform the basic functions (reception, transshipment, disposal and shipping of transport means and ITUs), B perform basic and supplementary functions (e.g. ITUs charging and discharging, storing the goods, maintaining ITUs, etc.), C, in addition to the aforementioned, performs the accompanying functions (e.g. ITUs collection and dispatching, collection and distribution work with non-containerized cargo, vehicles and handling equipment maintenance, etc.), and D, in addition to all aforementioned, perform additional functions in order to achieve the complete logistics service (e.g., services with the special ITUs, educational and advisory services, planning and organization of door-to-door transport, VAL (Value Added Logistics) services, etc.).

3.3 Terminal users

Terminal users are the customers of the terminal services, which can be physical or legal entities (more often legal), owners or organizers of the freight and transport flows passing through the IT (Zečević, 2006). They can be divided into those whose core business is logistics and organization of goods transport and those whom this is not the core business. The users whose core business is logistics and transport organization can be the owners or the operators of the IT. Users whom the logistics and transport organization is not the core business can be industry, trade and other companies. Regarding the type and number of users, ITs can appear in different variants, from those with one user, through those with several users of the same type to the variants that involve a large number of different types of users.

4. PHYSICAL/SPATIAL ELEMENTS FOR DEFINING THE IT STRUCTURE

This section deals with the analysis of elements that affect the physical and spatial characteristics of the terminal, such as: location, size, territory coverage and spatial organization - layout of the terminal.

4.1 Terminal location

The successful functioning of IT depends to a large extent on its location (Zečević et al., 2017). The most comprehensive delimitation considering the location involves defining the position of the IT in relation to the macro and micro environment. In relation to the macro environment, the IT location is mostly dependent on the place and role of the terminal in the network, and accordingly, a basic division can be made to terminals located in the coastal areas and inland, as well as the division into terminals located in the urban areas, which is usually the case, and terminals in the rural areas (Teye, 2017). Regarding the micro environment, the IT location depends to a large extent on: the needs and demands of various stakeholders, mostly users, the socio-economic systems in the immediate area, as well as the position in relation to the transport corridors and logistics nodes and their connection with them. The theoretical location of the terminals in urban areas can have a wide dispersion, from the immediate urban areas to the periphery of the urban areas, whereas in relation to the traffic infrastructure, ITs can go from having weak technological connection with the transport nodes and main roads to being located within the transport nodes and on the main roads of different transport modes. In practice, however, from the micro perspective, the ITs are mostly located in industrial and commercial complexes, freight railway stations, ports, airports and freight villages (Zečević, 2006). By combining various aspects of location, various types of the IT location can be obtained.

4.2 Terminal size

The IT size can be expressed using different measures. Notteboom & Rodrigue (2009) express the IT size by the flow volumes passing through the terminal or by the area occupied by it. They also point out the strong link between the size and IT functions and state that the IT size can be expressed by the structure of functions and services it performs. On the other hand, Wiegmans et al. (1999) define the IT size in relation to the present transport modes, flow volumes, transport infrastructure within the terminal, area and the resources it has at its disposal (e.g. transport means, handling equipment). Within the ITIP project (2001), the classification of IT sizes is given based on the connections between the different transport modes and the annual flow volumes. As the flow volume appears as the most common measure for determining the terminal size, this paper adopted the classification of "small" ITs with a capacity of up to 100,000 TEU/year (Twenty-foot Equivalent Unit), "medium" with a capacity of 100,000 up to 200,000 TEU/year, "large" with a capacity between 200,000 and 400,000 TEU/year, "very large" with a capacity between 400,000 and 1,200,000 TEU/year and "mega" ITs with a capacity of over 1,200,000 TEU/year.

4.3 Territory coverage (catchment area)

Catchment area is the area of origin of the freight and transport flows which at some point pass through the IT (Zečević, 2006). One terminal can have different catchment areas for different freight and-transport flows, transport chain technologies and types of services (Zečević, 2006). The size of the terminal catchment area is defined by different factors, and the most important ones are(Zečević, 2006, Notteboom & Rodrigue, 2009): IT size, structure of the systems and services, users structure, structure and intensity of freight and transport flows, geopolitical position of the region in which the IT is located, presence and proximity of transport corridors, IT connectivity with potential customers, place and role of IT in the network, network density, etc. In relation to the size of the dominant catchment area, ITs can be divided into: local, national, international and mega (Zečević, 2006). The dominant catchment area of local IT covers the territory of a city, metropolitan area or a province in which the terminal is located. National ITs attract the flows from the territory of entire state, and international ITs from the territories of several countries, regions, part or the whole continent. The dominant catchment area of mega IT is of a global nature and can cover any territory in the world.

4.4 Spatial organization of the terminal - layout

In terms of spatial organization and subsystem positioning, ITs can appear in large number of different variants. While planning the IT, a number of parameters and potential stochastic interactions between the subsystems, potential technologies, flow volumes and structure, present modes of transport, etc. must be taken into account. In addition, there may be various constraints at the site of the IT construction, such as variations in soil quality, slope of terrain, different topology, plot shape, etc., but also the existance of infrastructural elements such as power lines, gas pipelines etc. Because of this, the layout design (planning of the subsystems' spatial organization) is a very complex process (Roy & de Koster, 2013). However, regardless of the mentioned aspects of the problem, most ITs have comparable layouts which can be classified into one of the types of spatial organization of subsystems, and according to the present transport modes, as layouts for: river/maritime-rail-road IT (Kemme, 2013), river/maritime-road IT (Zhang et al., 2016), rail-road IT (de Villiers, 2015) and river/maritime-rail IT (Wiese et al., 2011). Each type of the IT layout has a typical zone structure, which is defined in relation to the dominant functions that are being performed within them. Each zone consists of modules, i.e. organizational units that can comprise one or more subsystems or some of their parts.

5. TECHNOLOGICAL ELEMENTS FOR DEFINING THE IT STRUCTURE

This section describes in more detail the technological elements for defining the IT structure: connection of transport modes and transport chain technologies, subsystem structure and technologies of the basic terminal subsystems.

5.1 Connection of the transport modes and transport chain technologies

Modes of transport which can be present in ITs are waterborne, rail, road and much less airborne. Waterborne modes of transport can be further divided into deep-sea, short-sea, and inland waterway transport on the rivers and navigable channels (Nazari, 2005). Considering the number of present transport modes, ITs can be classified as uni-modal (only one mode of transport is present, the basic role is mostly consolidation of flows), bi-modal (connects two modes of transport, most often appear in the form of Short-sea-Road, River-Road and Rail-Road ITs), tri-modal (linking three modes of transport, most often appear in the forms of Deep-sea/Short-sea-Rail-Road and River-Rail-Road ITs) and quadri-modal (most often connecting road, rail, river and sea modes of transport) (Notteboom & Rodrigue, 2009). In addition to transport modes, it is also important to consider the technologies of intermodal transport chains because they significantly affect the technologies of subsystems in the terminal, in particular the technology of transshipment and storage. The most frequent is the container transport technology, in which a container is used as a transport unit. In addition to this, there are technologies in which parts or entire vehicles appear as transport units, and there can be (Zečević, 2006): Road-Rail, Rail-Road, Inland-River-Maritime and River-Maritime technologies.

5.2 Subsystems structure

IT subsystems are functionally organized units within the system which are responsible for the partial or complete realization of one or more functions. Examples of the IT subsystems structure defining the subsystems of water connection, storage and land connection, can be found in the literature (Kemme, 2013; Brinkmann, 2011; Steenken et al., 2004). This classification is too generalized, the subsystems are bulky and encompass a large number of different functions and are predominantly related to maritime terminals, therefore not universally applicable. Considering that the structure of the subsystem is influenced to a large extent by the structure of functions (Chapter 3.2), the IT subsystems can be classified as those for the realization of the basic, supplementary, accompanying and additional administrative and information functions. Accordingly, 4 categories of IT are defined: A, B, C and D. Category A includes group of *subsystems for the implementation of the basic functions* consisting of: infrastructure of the present transport modes, subsystems for the ITU storage, transshipment and administration of the IT. Category B, in addition to the subsystems of the category A, also includes a g*roup of subsystems for the implementation of supplementary functions*, including subsystems for: charging and discharging of containers, washing and cleaning of containers, repair, service and maintenance of containers, storage of non-containerized cargo. Category C in addition includes the *subsystems for the implementation of accompanying functions*, including subsystems for: service and maintenance of transport and handling equipment, collection and dispatching of containers, shipping and distribution activities. Category D, in addition to the aforementioned, includes *subsystems for the implementation of additional functions*, which include subsystems for: servicing of special containers, finishing, processing and other functions for goods, etc.

5.3 Technologies of the basic subsystems

Each of the subsystems implies the presence of different technological elements that enable the realization of the related functions. The technologies of the basic subsystems (transport, storage and transshipment) have the greatest impact on the other elements of the IT structure. The technologies include all processes, activities, technological requirements, mode and sequence of their realization and technological elements, which can be significantly different for various ITs. However, there are processes, procedures and requirements that are general and common to all ITs. In transport technologies, for example, these are receiving and dispatching of external transport means, internal transport between subsystems, etc. In transshipment technology, these are processes of loading/unloading of ITUs on and from transportation means, manipulations in the subsystems of charging, discharging, servicing, maintenance, etc. In storage technologies, these are the processes of disposal, storing and deployment the ITUs and other non-containerized goods, etc. These technological requirements can be realized by various technological elements, and most often these are transport and handling equipment which, depending on the requirements they realize, can be divided into equipment with dominant horizontal operation (mainly used for internal transport) and equipment with dominant vertical operation (mainly used for the loading/unloading and the disposal/deployment of the ITUs). By combining the transport (e.g. Steenken et al., 2004), transshipment (e.g. Krstić et al., 2019) and storage (e.g. Kalmar, 2011) technologies, different terminal structures are obtained.

6. CONCLUSION

The paper identified and classified the elements for defining the structure of the IT. The basic characteristics of the structural elements, and the IT categories in relation to them, are described. A total of 13 elements have been identified, which are classified into 4 levels. The purpose of defining a comprehensive set of elements is to create the basis for selecting the key elements on the basis of which IT types can be defined. By further analysis, evaluation, comparison, efficiency determination, etc., types of ITs that would represent benchmarks for the terminals which have the potential to evolve into these types, or serve as the model for the development of some future terminals, can be identified. These are at the same time the future research directions.

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