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Development of logistic services in rail transport

Abstract: This article provides a description of the methodology for calculating the capacity of handling cargo handling terminal. The methodology allows the calculation of the capacity of the track infrastructure conditions in the track and landing and cool, handling, transshipment equipment adapted to the technical conditions and Terminal process. The article describes. rigid data IE. infrastructure and equipment which change is possible (or not) through the investment process (e.g. expansion of another place, the purchase of handling equipment) and scale-out data and variables that include factors that may be subject to change in during the operation of the infrastructure and subject to the possibility of impact by the terminal operator on these elements without investment. Indicates the criteria and the role of the selection of the correct location of the Terminal for its activities and building the capabilities of handling terminal.

Keywords: Intermodal Terminal; Handling capacity; Model

The last several years in the Western European Union countries are experiencing a dynamic increase in intermodal transport, these tendencies are moving to our country with a certain delay. Intermodal transport in our country is realized at a much lower level than in developed EU economic countries. In Poland, the volume of intermodal transport in relation to the total weight of transported loads is only 6.12%, while the average EU is 15%. As the quantity of cargo is increasing from year to year, containerization trends are transposed to our country in the scope of the volume of transported goods susceptible to containerisation. It is also connected with the flourishing of the world economy and trade exchange with Asian countries, especially China and South Korea, which in the near future may become the center of world production. More and more trade is also with India. The globalization of world production and the emerging new markets require efficient transport systems that can move relatively large flows of cargo. Among many factors affecting the efficient functioning of transport systems to the basic one should include both linear and point infrastructure. Intermodal transport due to your property is simply a very convenient system.

In one package, which is an intermodal unit, the goods can be transported through various branches of transport, can be temporarily stored, reloaded and not exposed to atmospheric agents or damage. Because highly processed goods dominate in intermodal

transport, this type of transport requires the use of an organization that ensures compliance with the time regime and the appropriate service light accepted by customers. The nature of the transported cargo means that this type of transport is characterized by high sensitivity to the level of economic development and political conditions, especially for our eastern border in the case of transport on the east-west axis. The interest in intermodal transport has also increased in our country. In a fully liberalized railway freight market, a competitive struggle for the most profitable mass transport began a dozen or so years ago. The situation which was created was predictable, railway transport companies in mass transport began to use freight rates very often on the verge of profitability and intensively search for new transport segments. The intermodal transport market in our country is developing quite dynamically and these trends will certainly take a few more years. The terminal port infrastructure has been expanded. Reloading capacity of port terminals reached about 5100 thousand TEU and there are further plans for their extension. The Port of Gdynia plans to build an intermodal terminal outside the current breakwater and deepen the fairway, and build a turntable ship with a length of 450 meters. Port of Szczecin - Świnoujście plans to deepen the fairway to 12.5 meters and construction of an intermodal terminal in Świnoujście next to the newly opened gas port. Modern infrastructure of port terminals has also influenced the possibility of accepting ever-larger container vessels. The DTC's wharfs can now wrap units that hold 20,000 TEUs.

As part of the Operational Program Infrastructure and Environment, in the next financial perspectives, a number of projects were implemented in the field of construction of intermodal terminals and purchase of traction and wagon rolling stock. In the financial perspective 2007-2013, 22 projects were implemented for a total amount of approximately PLN 470 million. New 18 terminals were modernized or built. In the current financial perspective, i.e. 2014-2020, funding has received 31 projects for a total amount of PLN 113376354. Most of the funds were allocated for the purchase of traction and wagon rolling stock. For the construction of the new terminal, financing has been awarded to one project and to the expansion of foam terminals for projects. An additional element in the growth dynamics of intermodal transport is the mention of the development of trade exchange between China and the European Union mentioned above, using the new Silk Road. Despite the high barrier of entry, private railway transport companies are taking over an increasing part of market of this segment of cargo.

Assumptions of calculation models for reloading capabilities

Because investments in the construction of intermodal terminals are very expensive, and their construction is associated with taking investment risk, therefore, many factors should be analyzed at the planning stage to ensure that their size is adapted to needs and the expected pipeline. In the process of investment preparation, a number of analyzes should be carried out in the field of developing a forecast of the volume of cargo handled and adaptation to the needs of terminal infrastructure along with equipment in transshipment equipment. After making forecasts, we make assumptions about the size and equipment of the terminal and after calculating the reloading capacity, we carry out an analysis of the profitability of the investment. These activities are repeated several times by choosing different configurations in terms of the size of the terminal, the amount of handling equipment, the number of tracks and unloading and hence the handling capacity for each configuration by performing a profitability simulation for each configuration. To facilitate the conducted analyzes, an algorithm was created that allows calculating the terminal reloading capability in various variants of its operation.

The created model for calculating the intermodal terminal handling capacity should be treated only as a tool supporting planning and shaping terminal infrastructure. This tool is also

needed in the case of changes in the existing conditions in which the terminal works, e.g. changes in the service amount or, for example. purchase and assembly of a new crane. The result should not be taken into account as the only decisive element in the scope of the investment process or other organizational and commercial changes. Each calculation requires a detailed analysis of conditions specific to a particular terminal (planned or existing). The value of variables and conducting simulations using the model should depend on the purpose for which the test is carried out. When developing the principles of the model's operation, we can use very complex formulas that require the introduction of several variables, however, the more complex the model is, the more results depend on the acquisition of these data. You can specify examples of tasks for which we can carry out simulations using the calculation model:

- Construction of a new terminal.
- Expansion of an existing facility.
- Purchase of reloading devices.
- Research on the impact on the functioning of the terminal of new conditions:
- of trade
- of organization
- about the environment
- Audit seeking a "bottleneck" / problematic factor for a given terminal.

In each of the mentioned cases, the final critical element, i.e. the one that prevents the further increase in the terminal handling capacity, can be:

- the inability to expand the terminal or build a larger terminal due to the lack of possession of appropriate properties - expressed in the maximum achievable parameters of infrastructure introduced to the model,
- no possibility of purchasing additional devices due to the limited space of the squares allowing their collision-free movement,
- required significant change in reloading technology which may result in the need for a comprehensive terminal remodeling and the obtained results will be disproportionate to the costs.

Achieving the above-mentioned limit values assuming no improvement of the work organization situation and the conditions of railway terminal manipulation or other factors affecting its functioning, the only element enabling control and correction of the current terminal handling capabilities, so that it will not paralyze will be trade policy. It will consist mainly of negotiating contract terms regarding the period of container storage as well as timetables for serviced trains or the volume of volume delivered at the same time. However, when determining the annual maximum reloading capacity, average values from particular areas are taken.

A signal to the need to create a new terminal or a significant expansion, e.g. by creating new storage yards, including the so-called depo (empty container yard) will be earlier made predictions about the amount of expected cargo stream as well as the range of services expected for a given location, as well as the first signs of difficulty in negotiating business conditions with contractors that would not satisfy satisfactorily their expectations. Possibilities of storing empty containers on the so-called depo are very often a marketing element aimed at acquiring customers in the scope of the essential service provided at the terminal.

When estimating the maximum intermodal terminal handling capacity, calculations are assumed according to three basic groups of technical conditions for:

1. rail track infrastructure so-called including for and off and arrival departures,

2. transshipment sites,
3. transshipment devices adapted to the technical and procedural conditions of the terminal.

taking into account the organizational conditions adopted for all the elements listed above. One of the three results obtained with the lowest value will be the so-called "bottleneck" and thus will determine the maximum terminal handling capacity.

When calculating the handling capacity for the terminal where the need to purchase new reloading devices was noticed, the key variables will be the work organization at the terminal (expressed in working times of particular types of handicaps per one intermodal unit serviced) and the commercial situation for the expected volume (correction factor for the ability to shape demand for storage services, the type of services envisaged and the associated operating speeds of transshipment facilities)

In the case of a limited investment budget or examination of an existing value object and information entered into the enumeration model, it can be divided into two main groups:

- rigid data,
- scalable and variable data.

Rigid data is a group of infrastructure elements and devices whose change is possible (or not) through the investment process (e.g. expansion of subsequent storage yards, purchase of reloading devices). **Scalable and variable** data include factors that may be subject to changes during the operation of a given infrastructure and it is often possible for the operator of the terminal to influence these elements without the necessity to incur investment outlays. These are the most common organizational and commercial factors with the services rendered, e.g. the correction factor by the possibility of shaping demand for storage services, average storage time, average time of reloading operations considering the organization of work (to a certain extent, i.e. up to the upper limit of the technical capabilities of transhipment facilities), terminal service structure, terminal (in relation to the day or month), e.g. number of intermodal transport operators serviced by the terminal or number of railway carriers served by the terminal. etc.

When planning the construction of new infrastructure, it is possible to simulate the result, also changing to a certain extent rigid data (assuming possession of appropriate properties, especially in terms of its size and access to road and rail infrastructure, e.g. additional loading and unloading tracks). When planning the infrastructure and the number and type of equipment of the new facility, it is necessary to adapt their capabilities to the forecasts and actual expectations of customers planning to transport loads with the participation of the planned service infrastructure. The order of the project implementation using the enumeration model should look like this:

- Determination of long-term forecasts of intermodal freight transport and structures necessary to provide services involving the terminal locations in question.
- To examine the conditions related to the railway maneuvering of the planned facility, as well as the possibilities of communication for the road transport and related time difficulties.
- Determining other difficulties that may affect the future operation of the terminal, e.g. the need to limit the terminal's working time.
- Performing a preliminary simulation of the demand for the terminal infrastructure taking into account the actual forecasts as to customer expectations and the results of other analyzes. The maximum parameters of the facility regarding the infrastructure and reloading devices with the assumed working technology should allow handling of the cargo stream during the entire forecast with a minimum of 20% -30% of the

available transshipment capacity calculated according to the three groups of conditions for the terminal mentioned above.

- Drawing up the concept of construction and equipment of the terminal (in several variants of scope and location), and then the business plan of the undertaking.
- Re-analysis of the terminal variants' possibilities, introducing the actual information about the planned terminal resulting from the concept and business plan.
- • If the result of transshipment possibilities for a given variant shows economic viability and achieves values coinciding with the simulation preceding the preparation of business documentation, it is possible to proceed with the implementation of the pre-design documentation and then the project itself.
- In a situation when technical or economic conditions do not allow for the creation of an object that can handle forecasted cargo assuming 20% -30% provision for transshipment capabilities, analysis (also in terms of trade policy) and simulations performed on the calculation model should determine the weight of individual factors for efficient operation of the terminal. Actions should lead to the development of an optimal solution in the form:
    - Arrangement of investment tasks over time, dividing the project into stages in such a way that it is possible to transfer some less important investment tasks in the initial years to the further period of operation of the terminal,
    - If possible, choose a different location of the terminal enabling the infrastructure to be cheaper and at the same time allowing to achieve appropriate reloading capabilities.
    - Use expensive solutions in the investment process, eg using used reloading equipment, making tracks
      from old materials or storage yards in cheaper technology.

Methodology for calculating the reloading capacity of basic conditions

Calculation of transshipment possibilities according to the infrastructure of the track infrastructure in order to calculate it was assumed:

Rigid data:

- number of transhipment tracks,
- usable length of individual transshipment tracks (for the needs of the transshipment front),
- average index of track capacities for freight wagons (percentage of tracks effectively used for transshipment expressed in decimal numbers),
- indicator of estimated track capacity,
- the average number of 4-axle wagons per 1 full train service,

Scalable and variable data:

- waiting time for the entry of a locomotive/wagons into a terminal from a maneuvering station or for taking them from the terminal from the moment of demand (in h),
- number of servicing of the terminal siding in the era,
- generic structure of large containers (including the division into 20 "and 40").

The result expressed in UTI units is the product of the number of full train sets that can be reloaded per day and the average number of UTI per one full truck warehouse. The last of the numbers is the product of the number of wagons in the train set and the ratio of the number of 20" containers.

In order to determine the average number of full train sets that can be handled per day, the average accumulated time of transshipment of intermodal units arriving in wagon

groups/compositions was calculated with theoretical assumptions of continuous inflow of cargo streams. It results from the actual handling of equipment at a given terminal, corrected by the ratio of estimated track capacity, and it is the accumulated time of reloading of trains/wagons grouped successively on each track, increased by the actual waiting time for maneuvering at the terminal.

In order to determine the number of intermodal units possible to be accepted at the terminal, it was calculated:

- The maximum number of wagons[1] that can be used simultaneously (4 axles
- 19.74 m long) on each track. It is the length of tracks divided by the length of a four-axle wagon,
- Track use efficiency indicator for transshipment purposes. It is a percentage of the length of the tracks enabling the transshipment of the warehouse / wagon group, expressed in decimal numbers,
- One time for transshipment the UTI number within the train depots / groups located on each track and adjusted by the number of 20 "containers and multiplied by the track use efficiency indicator for transshipment purposes.
- Indicator of the number of 20 "containers. It is the percentage of 20 "containers in the whole 20" and 40 "container structure, expressed in decimal numbers plus one.

The calculation of transshipment possibilities according to the conditions for transshipment sites

Included data:

Rigid:

- the number of designated storage positions for intermodal units,
- number of designated storage stations for intermodal units for the transport of dangerous goods and isothermal containers
- area of storage yards,
- possible number of container storage layers,

Scalable and variable:

- average expected for the time of container storage at the terminal (expressed in days),
- an indicator correcting the possibilities of shaping the demand for storage services,
- •quantitative structure of the types of intermodal units (20 ", 40", dangerous, isothermal, semi-trailers).

The result expressed in UTI is the quotient of the terminal constituent capacity (in UTI) and the adjusted average storage time per container passing through the terminal (in days). The average storage time is adjusted by the index of the scale owner's ability to scale the demand for the time of the storage service within the terminal (the percentage of possibilities to reduce customer expectations regarding the number of container storage days expressed in decimal numbers)

The model provides for the possibility of calculating the terminal component capacity by two methods. Having data on the number of designated storage positions for intermodal units at the terminal, it is possible to calculate the storage capacity. It is the product of the mentioned storage positions and the possible average number of container storage layers. In the absence of information on the number of designated storage positions for intermodal units at the terminal, it is possible to calculate the storage capacity according to the average occupancy of the square by cargo units (20 ", 40", semi-trailers, dangerous or isothermal cargoes). Then the result is the capacity of storage yards in one layer and the product of the number of possible layers of container storage. The capacity of storage yards in one layer is

the quotient of the storage yards (less technological roads and manipulation plots for transshipment facilities) and the average occupancy of UTI/TEU. An important element is the proper determination of the area of the square excluded from the possibility of storage which depends to a large extent on the type of reloading devices used.

Calculation of transshipment possibilities according to the conditions for transshipment devices

Included data:

Rigid:

- number of loading devices and their type (self-propelled handling equipment, RTG or RMG cranes),
- technological break in the operation of devices,

Scalable and variable:

- percentage of the type of wagon reloading - wagon / car-wagon,
- percentage of the wagon/car reloading type - square,
- percent of the square wagon/car reloading type,
- number of working hours of the terminal within 24 hours,

The following work times taking into account the work organization of the terminal:

- average reloading time by self-propelled loading equipment/overhead crane,
- average time of unloading wagon/car - square,
- average loading time of the wagon/car - square,
- additional difficulties expressed in the average working time of a self-propelled loading device/crane.

The handling capacity of devices on the terminal is one of the most important parameters for the handling capacity of the entire terminal because they significantly affect both the conditions of transshipment capabilities of the track infrastructure as well as indirectly on the conditions of reloading capacity of storage yards.

The result expressed in the UTI handled per day is the sum for the same time interval of the average number of operations possible to be performed by all transshipment devices (overhead cranes and self-propelled handling equipment). The number of device operations per day results directly from the terminal operation time decreased by the average technological break time for transshipment facilities (8 hours per day) and the average duration of one transshipment operation.

The duration of one transshipment operation of a given device, taking into account the organization of work at the terminal, is the weighted average of reloading times according to adopted in the type model (type 1 is a wagon - wagon or car wagon, type 2 is wagon - square or car - square, type 3 is square - wagon or square - car) taking into account the percentage share of a given type of reloading and time of additional external difficulties and internal for each transshipment operation.

The role of the terminal location in the calculation model of reloading capabilities

It should be remembered that there are many different handling possibilities for a terminal that handles containers, swap bodies, and semi-trailers. Both semi-trailers and swap bodies require different reloading technology. For handling large streams of semi-trailer loads, specialized terminals are built to service them in various systems, we also use specialized wagon rolling stock and loading facilities. This model is useful in the design of terminal networks as capacity simulations An important issue when building a network of logistic infrastructure facilities such as terminals and choosing a place for a potential investment

should be guided by a number of criteria. The basic conditions of choosing a terminal's location are the potential of a given market, organizational and legal conditions as well as technical and spatial conditions. However, the most important premise is the market criterion, and therefore the current and forecasted flows of cargo in the environment of the planned investment. When assessing the weight of individual criteria, we can say that the share of market potential is about 60-70% of the total weight. However, the other criteria when choosing a location, such as spatial, environmental and technical conditions are of lesser importance. It is estimated their impact on the decision on the location selection not exceeding in total 30% -40% of the weight in the decision. Considering that the terminals working in the network system should support loads flows coming from seaports or border crossings, especially at our eastern border, the analysis of the reloading capacity of terminals operating in the network system allows for proper network design.

1. Criteria for choosing a location for an intermodal terminal. Source: Own study

The analysis of transshipment capacity both for the newly built terminal infrastructure and for existing terminals in the event of their expansion is an important element of the optimization of investment outlays in Figure 2

Summary

Increasing competition on the market of transport services makes the reliability, speed, and timeliness of logistics services more and more important. In the intermodal transport segment, there are currently the most advanced organizational solutions in the field of rail transport. Further development of intermodal transport, and at the same time their profitability, taking

into account the large competition of car transport, depends on a number of factors, but one of the most important is the proper technical condition of intermodal terminals, taking into account their size and equipment for the streams of cargo. Barriers resulting from insufficiently prepared infrastructure hamper the growth of transport and logistics services. Infrastructural investments should be ahead of needs, as infrastructure investment processes are long-lasting. Therefore, we should conduct a number of analyzes, including in the scope of calculating optimal transshipment capacities for intermodal terminals, both for a specific location and those working in a network system, which is one of the conditions for obtaining positive economic effects and adjusting adequate investment outlays to current and planned needs.