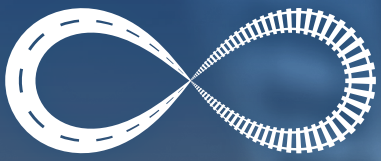

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

# Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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Department of Transportation

CETRA 2018
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

TITLE
Road and Rail Infrastructure V, Proceedings of the Conference CETRA 2018

EDITED BY
Stjepan Lakušić

ISSN
1848-9850

ISBN
978-953-8168-25-3

DOI
10.5592/CO/CETRA.2018

PUBLISHED BY
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE
minimum d.o.o.
Marko Uremović · Matej Korlaet

PRINTED IN ZAGREB, CROATIA BY
"Tiskara Zelina", May 2018

COPIES
500

Zagreb, May 2018.

Proceedings of the
5th International Conference on Road and Rail Infrastructures – CETRA 2018
17–19 May 2018, Zadar, Croatia

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CETRA 2018 17–19 May 2018, Zadar, Croatia
5th International Conference on Road and Rail Infrastructure

# THE PROCESS OF CONSTRAINTS EVALUATION AND COMPARISON USING THE SOFTWARE APPLICATION

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## Abstract

For transport companies, it is necessary to ensure the expected level of freight transport services focused on the needs and possibilities of customers to succeed in today's highly competitive transport market. The final level of logistic chain can be negatively influenced by an unexpected constraints. To avoid of this, it is necessary to identify and calculate the level of possible constraints that may have negative impact on the final efficiency of realised logistics chain. Based on the research realised at University of Žilina, Department of Railway transport, there was created a Microsoft Excel application that evaluates and compares the level of constraints in different variants of logistic chain realisation. The comparison is realised by using of a criteria that represent the possible constraints. The evaluation process is realised by setting of weights of the criteria and the comparison of their level in two different variants of logistic chain realisation. The software comparison allows easily to choose the more efficient variant of realisation of logistic chain.

*Keywords: constraints, evaluation, comparison, efficiency, software application*

## 1 Introduction

The intermodal transport system can be the solution to ensure the sustainability of freight transport as a part of logistic chain. To be efficient, the transport companies has to provide the transport services on required level and strongly focused on the customer´s expectations and needs. Because of this it is necessary to identify, calculate and compare the level of possible constraints that may have the negative impact on the efficiencies of whole realised logistics chain. Chen says that an appropriate performance measurement system is an important requirement for the efficient management of a logistic chain realisation [1]. It is important to say that in the sense of efficiency evaluation and comparison, the constraints are not only elements with low capacity or performance, but also elements with disproportionately high capacity or performance. The disproportionately high performance or capacity of element compared to other logistics system elements are inefficient. This fact significantly influence the increase of the final costs of logistic chain realisation. Cibulka says that the transport capacity utilisation, the final efficiency of passing the distance and efficiency of time indicators are analysed in the process of achieving of logistics goals to ensure that customer requirements for goods and services (logistics efficiency) are met [2]. Based on the research realised at Žilina University, Department of Railway transport , there was set the methodology and created the software application for evaluation and comparison of constraints in different variants of logistic chain realisation. The software application provides to logistics operators, freight forwarders, carriers and other entities the tool for logistic chain realisation decision making.

## 2 The comparison process using the software application

The process of constraints comparison in different variants of logistic chain realisation with using the excel application is realised in the following four steps:
- Setting the criteria that represents possible constraints in logistic chain
- Software calculation the criteria weights
- Software comparison of the criteria levels in two different variants of logistic chain

### 2.1 Setting the criteria

As the first, set of 20 relevant criteria was created with the cooperation of logistic operators and transporters and academic community [3]. Then the criteria were divided into the three groups and seven subgroups. A detailed division of the criteria is shown in the Figure 1.

| | I. level | II. Level | III. Level |
|---|---|---|---|
| Basic flows | | Flow categories | Criteria |
| Logistics chain | Material flow | Fluency of mater. flow | 1.Time of transport<br>2. Customs proceedings conditions<br>3.Flexibility of operators<br>4.Referencies of reliability |
| | | Suitability of Intermodal transport unit | 1.Capacity of ITU<br>2.Possibilities of ITU use |
| | | Safety of mater. flow | 1.Level of accidents<br>2.Political situation |
| | Financial flow | Level and conditions of financial flow | 1.Total costs<br>2.Terms of payment<br>3.Financial losses protection<br>4.Credibility of operators |
| | | Safety of financial flow | 1.Safety of financial transactions<br>2.Illegal charges |
| | Information flow | Level of information flow | 1.Delivery time information<br>2.Process information<br>3.Speed of change information<br>4.Communication with operators |
| | | Safety of information flow | 1.Internal safety of information<br>2.Safety of information transfer |

**Figure 1** Set of the criteria

### 2.2 Software comparison and calculation of weights of the criteria

The calculation of weights of the criteria is realised using the SAATY method. The calculation of absolute weights of the criteria is realised in three following steps:
- Setting weights of basic groups – I. level (material, financial and information flow)
- Setting weights of subgroups inside of the group – II. level (fluency of material flow, sustainability of intermodal transport unit, etc.)
- Setting relative weights of criteria inside of the subgroup – III. Level

The calculation of weights is realised by pair comparison. It means that the importance of each group, subgroup or criteria is compared with the importance of another groups, subgroups or criteria using the scale in the Table 1 [4]. Note: The values 2, 4, 6, 8 can be used for a finer resolution of the significance of the criteria pairs.

**Table 1** The importance evaluation scale

| The importance evaluation scale | | | | |
|---|---|---|---|---|
| 1 | 3 | 5 | 7 | 9 |
| Both equally important | Little more important | More important | Much more important | The most important |

For example, setting of weights of basic groups is realised by pair comparison of following pairs:
- Material flow compared to Financial flow;
- Material flow compared to Information flow;
- Financial flow compared to Information flow.

The same process is realised when setting the weights of the subgroups and the criteria. The comparison of the importance of groups, subgroups and the criteria in the software application is realised graphically. The user just moves the indicator closer to criterion with higher importance. In the Figure 2 is shown the comparison of criterion Total price of transport and criterion Terms of payment. The used data are modeled to describe the functionality of the software. In this case, the criterion Total cost of transport is much more important than the criterion Terms of payment.


**Figure 2** The comparison of two criteria

The importance of all criteria pairs is gradually being compared by user based on his preferences. There are compared the criteria of Material flow with the following rank of importance in the Figure 3. The used data are again modeled to describe the functionality of the software:
1) Time of transport;
2) Customs proceedings conditions;
3) Flexibility of operators the same as References of reliability.

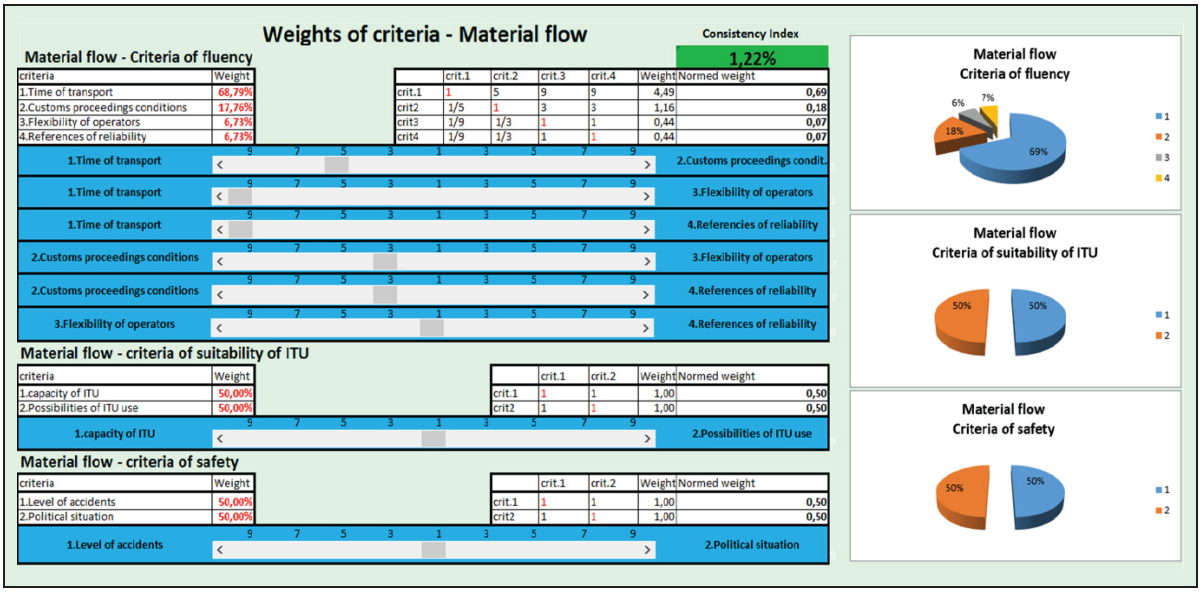


**Figure 3** Setting of weights of the criteria of Material flow

The software application automatically transform the graphic evaluation into the numbers using the scale in Table 1 and put these numbers into the matrix using the Saaty method. It

means, that these values are stored by software application into the table, in which rows and columns are written criteria in the same order. The writing of values by this application is realised as follows. If for example in the line of criterion 1, in the column of the criterion 3 is written value 5, then the criterion 1 is much more important than the criterion 3. Adequate to be in the line of criterion 3 and column of the criterion 1 written inverse value, the value of 1/5 [4]. In the rows and columns with the same number will always be written value 1 [4]. If we denote the matrix S, then for all the elements will be applied the following relations (1) and (2) [4].

$$s_{ii} = 1 \tag{1}$$

$$s_{ij} = 1 / s_{ji} \tag{2}$$

The software application then calculate the weights of each criterion by using geometric average of lines of Saaty matrix (Fig. 4). The final absolute weights of criteria are calculated using the following formula [5] (3):

$$w_{abs} = w_g * w_{sg} * w_{rel} \tag{3}$$

Where:

$w_{abs}$ – absolute weight of a criterion;
$w_g$ – weight of the group;
$w_{sg}$ – weight of the subgroup;
$w_{rel}$ – relative weight of a criterion.

## 2.3 The comparison of level of the criteria

The first, the level of each criterion is evaluated separately for each variant using mathematic and verbal evaluation [6]. The comparison of criteria level in different variants of logistic chain is realised using the SAATY method. The level of each criterion in different variants is compared using the scale in the Table 2.
There is the comparison of Material flow criteria level in two variants in Figure 4. The used data are again modeled to describe the functionality of the software:

**Table 2** The comparison scale

| The comparison scale | | | | |
|---|---|---|---|---|
| 1 | 3 | 5 | 7 | 9 |
| Both on the same level | Little better | Better | Much better | The best |

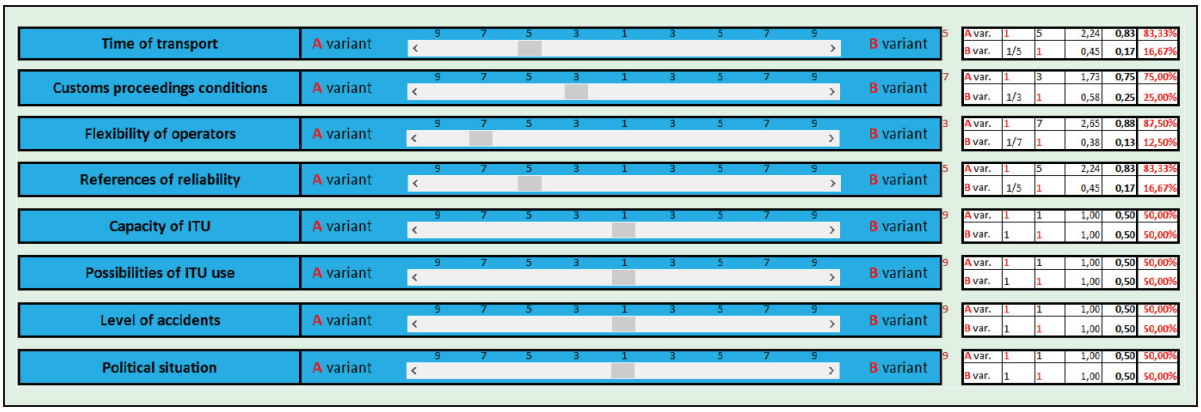


**Figure 4** The comparison of Material flow criteria level

The following results of levels of the criteria (Table 3) follows from the comparison in Figure 4.

**Table 3** The comparison of levels of the criteria

| The comparison of levels of the criteria | |
|---|---|
| 1. Time of transport | Better level in A variant |
| 2. Customs proceedings conditions | Little better level in A variant |
| 3. Flexibility of operators | Much better level in A variant |
| 4. References of reliability | Better level in A variant |
| 5. Capacity of ITU | The same level in both variants |
| 6. Possibilities of ITU use | The same level in both variants |
| 7. Level of accidents | The same level in both variants |
| 8. Political situation | The same level in both variants |

## 2.4 Final comparison of variants

In the end, all the criteria weights and the results of criteria levels comparison are entered in the final summary [7]. The final result is calculated in percent and evaluates efficiency of variants realisation (Figure 5). The final evaluation of variants is realised using the following formula (4):

$$L_e = \left( \sum_{n=1}^{6} W_n * L_n \right) * 100 [\%] \tag{4}$$

Where:
$L_e$ – level of efficiency;
$W_n$ – weight of criterion n;
$L_n$ – level of criterion n;
n – number of criterion.

Based on the criteria division of Figure 1, the result shows the efficiency of variants compared even at level of subgroups. This provides more detailed comparison of different variants of logistic chain realisation.

| Criteria | Weights of criteria | | Level of criteria | | Parcial results | | Results of flow categories | | Final results | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Relativ | Absolut | A variant | B variant | A variant | B variant | A variant | B variant | A variant | B variant |
| 1.Time of transport | 68,79% | 7,64% | 83,33% | 16,67% | 6,37% | 1,27% | | | | |
| 2. Customs proceedings conditions | 17,76% | 1,97% | 75,00% | 25,00% | 1,48% | 0,49% | 82,13% | 17,87% | | |
| 3.Flexibility of operators | 6,73% | 0,75% | 87,50% | 12,50% | 0,65% | 0,09% | | | | |
| 4.References of reliability | 6,73% | 0,75% | 83,33% | 16,67% | 0,62% | 0,12% | | | | |
| 1.Capacity of ITU | 50,00% | 5,56% | 50,00% | 50,00% | 2,78% | 2,78% | 50,00% | 50,00% | | |
| 2.Possibilities of ITU use | 50,00% | 5,56% | 50,00% | 50,00% | 2,78% | 2,78% | | | | |
| 1.Level of accidents | 50,00% | 5,56% | 50,00% | 50,00% | 2,78% | 2,78% | 50,00% | 50,00% | | |
| 2.Political situation | 50,00% | 5,56% | 50,00% | 50,00% | 2,78% | 2,78% | | | | |
| 1.Total costs | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | | | | |
| 2.Terms of payment | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | 50,00% | 50,00% | 53,57% | 46,43% |
| 3.Financial losses protection | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | | | | |
| 4.Credibility of operators | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | | | | |
| 1.Safety of financial transactions | 50,00% | 8,33% | 50,00% | 50,00% | 4,17% | 4,17% | 50,00% | 50,00% | | |
| 2.Illegal charges | 50,00% | 8,33% | 50,00% | 50,00% | 4,17% | 4,17% | | | | |
| 1.Delivery time information | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | | | | |
| 2.Process information | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | 50,00% | 50,00% | | |
| 3.Speed of change information | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | | | | |
| 4.Communication with operators | 25,00% | 4,17% | 50,00% | 50,00% | 2,08% | 2,08% | | | | |
| 1.Internal safety of information | 50,00% | 8,33% | 50,00% | 50,00% | 4,17% | 4,17% | 50,00% | 50,00% | | |
| 2.Safety of information transfer | 50,00% | 8,33% | 50,00% | 50,00% | 4,17% | 4,17% | | | | |
| | | 100,00% | | | 53,57% | 46,43% | | | 100,00% | |

**Figure 5** The final result

## 3 Conclusion

The final efficiency of transport services is crucial for ensuring the sustainable system of freight transport. To ensure the efficiency of transport services as a part of logistic chain, it is necessary to analyse whole logistics chain and identify and evaluate the level of possible constraints that may have the negative impact on the final level of its realisation. The software application in Microsoft Excel, created at University of Žilina, Department of Railway transport, provides to logistics operators, freight forwarders, carriers and other entities the user friendly interface and objective information about the efficiency of realisation of different variants of logistic chain. This application evaluates the efficiency of different variants of logistics chain by level comparison of selected criteria that represent the possible constraints in proposed logistics chain. The result of the software evaluation helps easily to choose the better variant of realisation of logistics chain and to ensure its efficiency.

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