

## ERGONOMICS AND ACCESSIBILITY IN PASSENGER TRAINS

Lucian CUCU<sup>1</sup>, Ionel SIMION<sup>2</sup>, Marina PUYUELO CAZORLA<sup>3</sup>, Gina Florica STOICA<sup>4</sup>, Sorin CANANAU<sup>5</sup>

*The purpose of this paper is to establish the current state of comfort and accessibility in public transportation by railway and how they interfere with the choices for transportation of the passengers and they're well-being when using this services. This study is based on surveys made across Europe by various companies specialized in this field and on field data gathered in the past 3 years studying the behaviour of the passengers and time tables on various train routes in Romania. The research is focused on elderly people, people with disabilities and in some extent on normal travellers. The results of this paper will be relevant in the future development and design, regarding ergonomics, accessibility and comfort, in the public transportation area. The users of the railway transportation services were asked questions regarding their comfort, safety, security and accessibility to this services.*

**Keywords:** train, ergonomics, modular design, accessibility

### 1. Introduction

A major concern in the passenger railway transportation services is the customer satisfaction level. This satisfaction level is influenced mostly by the following factors: comfort, accessibility and security. Although these factors have been improved in the past 20 years, according to the information presented in the following study there are still major issues that needs to be addressed and situations that need improvement. The study is based on research gathered from various surveys, concerning customer satisfaction level across Europe, and field data research, made directly studying the railway transportation service providers. The study shows various situations in Europe regarding passenger comfort, accessibility

---

<sup>1</sup> Machine Design and Tribology Mechanical Engineering and Mechatronics, University POLITEHNICA of Bucharest, Romania, e-mail: Lucian.dsg@gmail.com

<sup>2</sup> Engineering Graphics and Industrial Design- Aerospace Engineering, University POLITEHNICA of Bucharest, 313 Splaiul Independentei, Bucharest, Romania, e-mail: ionel.simion@upb.ro

<sup>3</sup> Universitat Politècnica de València, Spain, email: mapuca@ega.upv.es

<sup>4</sup> Machine Design and Tribology Mechanical Engineering and Mechatronics, University POLITEHNICA of Bucharest, Romania

<sup>5</sup> Machine Design and Tribology Mechanical Engineering and Mechatronics, University POLITEHNICA of Bucharest, Romania

and security and the areas that need improvement in the railway transportation services.

The impact of passengers' dissatisfaction with the railway transport services could be far reaching with operational and financial costs on the immediate parties involved and ripple effects extending to unrelated parties. This situation, if extended, could destabilize the train service infrastructure forcing people to adopt different ways of transportation, directly affecting the local economy[1]. This situation could also relate to future environmental issues in the scenario that more people will use their personal vehicle to travel, more frequently. This will involve a larger carbon footprint and more congestions on the roads, resulting in more accidents and problems to the environment just to name a few.

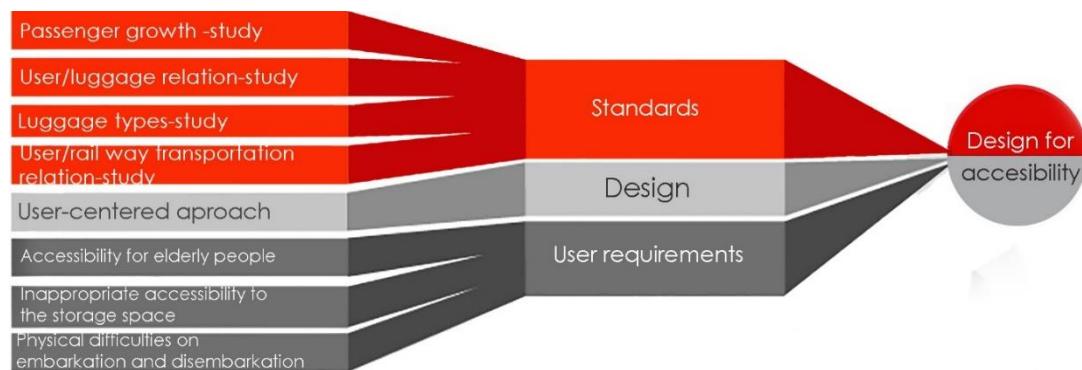


Fig. 1 Study approach

## Materials and Methods

Information has been gathered through field data research, measuring the time required for various types of passengers to embark and disembark the train. Through the field data, passengers with ages from 15-18 to 60-70 years old, with heavy or light luggage, were monitored at embarkation and disembarkation in order to observe if they encountered any difficulties, and in what time frame they could perform that task. Also data was acquired during several journeys with the train, travelling with a large luggage and experimenting with the storage solutions offered inside the train.

According to speciality literature the main components composing the comfort or discomfort of the train passengers are mainly postural, mental and micro-environmental. These components are dependent on the journey purpose, age of the passengers, car-type and journey length. These factors are increased when crowding exceeds a certain level, due to improper luggage storage, or passenger capacity overload.

Human behaviour takes a leading role in a proper ergonomically correct environment. In order for the environment to work for the user, from an ergonomic

point of view, psychological, behavioural and physical factors must be analytically examined in a scientific way, determining how these factors are influencing the comfort of the passengers [2]. Ethnographical methods can be employed as insights into passenger behaviour so that the user will not feel constrained in any way when travelling. It is very important how the passenger works with the design offered to him through his behaviour. Another factor influencing the passenger behaviour is the constant changing technology. This factor can be used to inform, influence and direct the passengers to better use the solutions accommodating him through the journey.

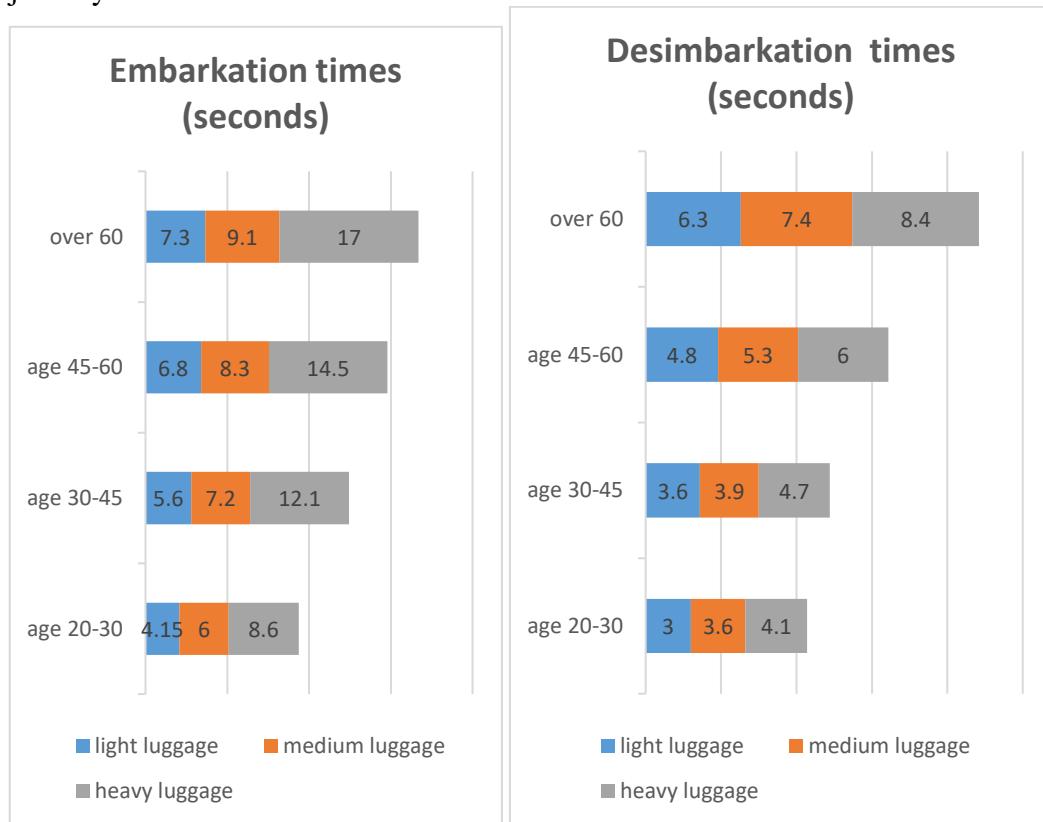


Chart1 Embarkation and Desimbarcation times

A different approach to determine the efficiency of the accessibility and ergonomics features of the train in relation to the human behaviour was to measure the time required for different passengers to embark and disembark the train [3]. The process of time measuring was performed during different hours of the day, including the rush hours. By analysing these times, adjustments can be made to the access ways and interior of the train in order to obtain a better flow of passengers during the embarkation and disembarkation process.

The average time to disembark for people between 20 and 35 years old was 4.54 seconds and to embark 4.91 seconds, with medium luggages and large luggages, and for people between 35-70 years old was 8.4 seconds with similar luggage to disembark and 8.4 seconds to embark. For younger people the time to embark or disembark was around 2.5 seconds and for elderly people between 7 to 15 seconds depending on their luggage.

In order to keep the information in check for this study, speciality literature has been used, based on the Flash Eurobarometer “Survey on passengers’ satisfaction with rail services” (Flash No 326), which was conducted to examine EU rail passengers’ satisfaction with various features of the rail services, including the trains themselves, railway stations and the rail network in their country [4]. The surveys were conducted in March 2011, via telephone interviews, with nationally representative samples of rail passengers (aged 15 and older) living in 25 of the 27 EU Member States, according to “The Gallup Organization”.

The results obtained from the field data were mostly confirmed by the results of the surveys conducted by several specialized companies in Europe. Through these surveys is possible to observe the current state of comfort, accessibility and security in trains in Europe, and is possible to form a general idea for the passengers satisfaction level.

According to the survey’s results, a large majority of rail passengers surveyed said they mostly used the train to commute to work, school or university. Some of the respondents took the train either daily (4%) or regularly (once and three times per week). The largest proportion (56%) of rail passengers, however, said that most of their journeys by rail were for leisure purposes. The largest proportions of respondents who used the train regularly to commute to work were seen in Portugal, Denmark and Belgium and for business travellers were in Sweden, Italy and Greece. Based on the field data gathered most of the people using the train for commute are travelling with light baggage’s or backpacks which do not impose difficulties on embarkation or debarkation and neither to store them during the journey. However the passenger that are travelling for leisure are carrying large luggages or at least one backpack and a large trolley. For the passengers with large luggage’s it is difficult to embark and disembark and also to find a large enough storage space. Another problem is manoeuvring inside the train with the heavy and large luggage[5].

Accessibility was one of the most important subject in the surveys regarding the ability to access and benefit from the railway transportation services. Topics like a universal design of the features integrated in the trains and in the train stations were discussed in order to establish if the services provided are usable by the people with the widest possible range of abilities, operating within the widest possible range of situations including people with disabilities or without.

According to Flash No 326 results, three countries – Poland, Bulgaria and Romania – were the ones where rail passengers were the most likely to be very or rather dissatisfied with the rail services in their country. These countries were joined by Germany for the items related to seating capacity in railway carriages, the punctuality and reliability of trains, the information provided in case of delays and the availability of staff on trains.

In the public transportation area services, comfort is a highly debated subject. It is the balance between good ergonomics, cost effective materials, and the maximum use of the available space. Comfort in passenger trains is usually considered for a predetermined travel time, so accordingly to the use of the train, a seat for example, is calculated to ensure an ergonomically correct position for the time frame of the journey. However, these travelling time frames can expand very quickly due to the misuse of the train, delays or passenger related problems like injuries or disabilities. The level of dissatisfaction of the rail passengers with the seating comfort on trains reached 33% in Bulgaria and 47% in Poland and in Romania the level of very dissatisfied reached 12%. In this section also joined countries like Italy, Estonia, Hungary and Slovakia with levels of dissatisfaction between 21% and 28% [6].

Another area of the customer satisfaction level with the railway services is the level of security offered by the service provider. Rail passengers in Romania, Bulgaria and the Visegrád Group were not only the most likely to be dissatisfied with their personal security in railway stations (31%-41%), they were also among the most likely to say that they were very or rather dissatisfied with their security on board trains (for example, 40% in Poland, 37% in Bulgaria and 32% in Romania) [7].

The public security measures taken by the railway transportation providers in order to keep the passengers and employees' safe has become a major issue around the world since the September 11 attacks, and especially the 2004 Madrid train bombings. This area needs an extra security screening of passengers and their bags to prevent weapons or bombs on public transport. However, this would also have a number of negative side effects, which could outweigh the benefits, among them:

- increased (and prohibitive) costs
- reduced public transport convenience, leading to more car travel (and thus road deaths)
- making the queues of people waiting for screening vulnerable to attacks
- creating a sense of fear and a call for further measures and reduced civil liberties

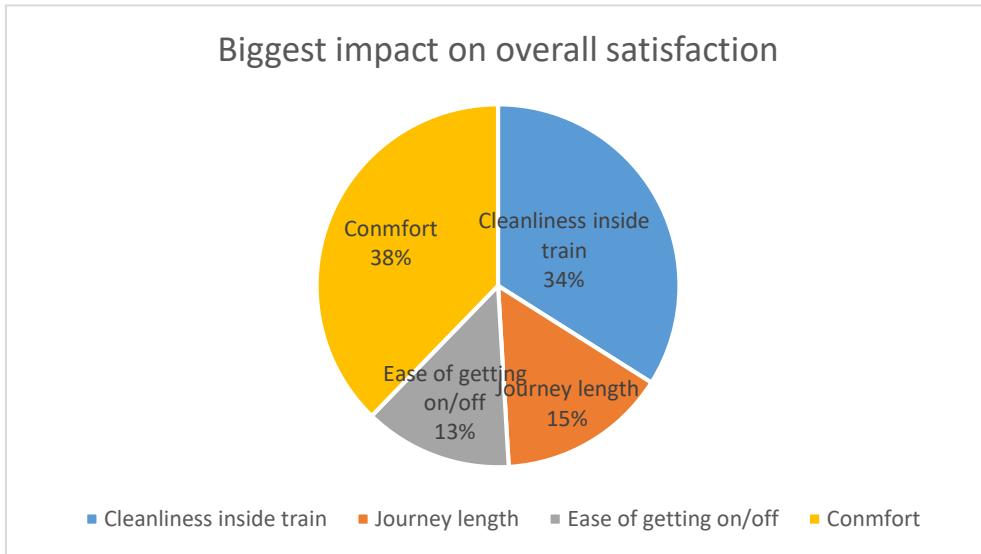


Chart 2- Passengers satisfaction levels

Therefore, most experts recommend against such methods. Like random or profile-based searches of public transport users, they are often considered security theatre, because random searches will be unlikely to catch the particular terrorist, and profile-based searching allows the terrorist to reverse engineer the search system, using attackers which are unsuspicious [8].

The results of the surveys shows that respondents found it difficult to express an opinion about the provision of information and assistance for disabled and elderly rail passengers on trains and in stations in their country. Those interviewees who responded said that more than half of them were very or rather satisfied with assistance and information for disabled and elderly passengers. The total level of satisfaction remained below three-quarters in all countries surveyed.

## 2. Results

The results of the study are based on the data gathered from the personal field research and confronted with the surveys of the Gallup Organization. The number of respondents satisfied with the provision and assistance for disabled and elderly passengers was between 41% and 44% which suggests that a very alarming majority of the people using these services are having problems when traveling by a public transportation service. For this study 11% of respondents in 2015 described themselves as having a conditions/illness expected to last 12 months or more

(disabled). 52% of those said that their condition/illness had an adverse impact on their journey. 24% of those with a listed condition were over the age of 65. The following list shows the difficulties that passengers with or without disabilities encounter when travelling by train.

Data gathered from the surveys of the Gallup Organization:

- Passengers with mobility (75%) or dexterity (73%) difficulties were most likely to say their journey was adversely impacted.
- Passengers with a disability were more likely to be visiting friends and relatives than other passengers: 18% vs 12%
- Those with a mobility (23%) or visual (22%) impairment were most likely to be travelling with another adult. Those with a disability were most likely to be travelling with baggage/additional items (26%)
- Those with a mobility impairment were most dissatisfied with the station (19%), whilst those with a condition related to dexterity were most dissatisfied with the train (22%)
- Satisfaction with train attributes, amongst those passengers with a disability, is generally on a par with other passengers. However in two areas satisfaction was considerably lower: Ease of getting on and off of the train (71% vs 79%). Personal security on board the train (72% vs 77%)
- Passengers were asked if they had cause to worry about personal security when travelling by train in the last six months. Concern was much higher (double!) amongst disabled passengers (18%)

Various problems were found after gathering the field data research results, obtained in the train station, after observing and analyzing the passengers embarking and disembarking the train.

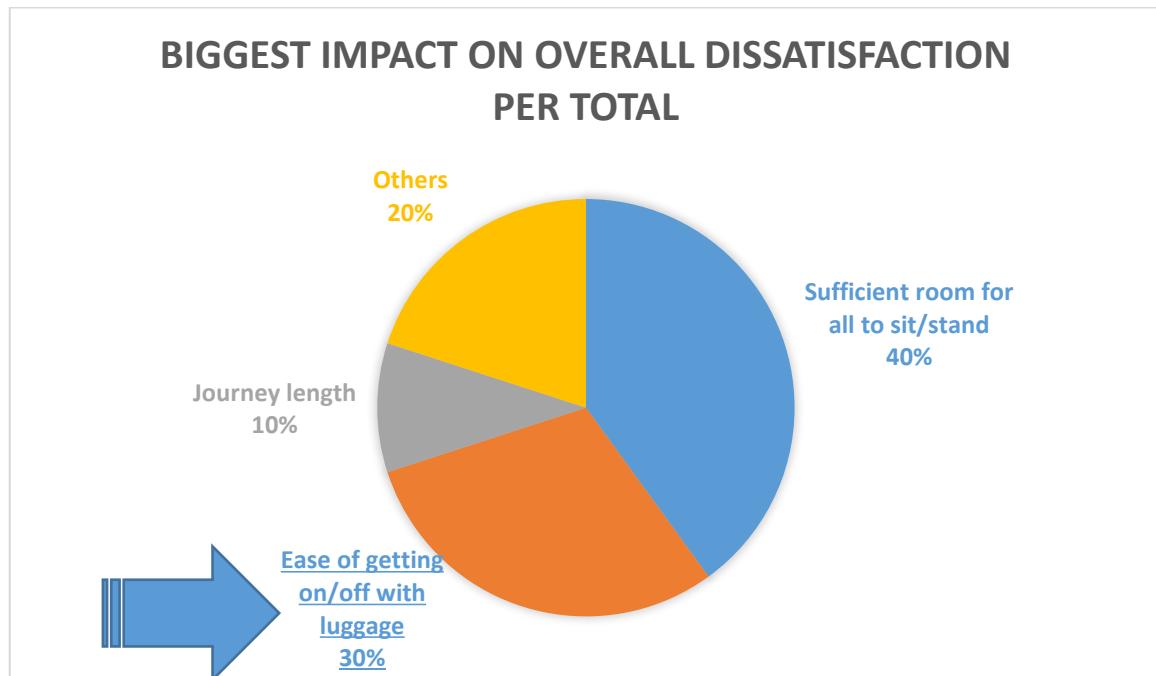


Chart 3- Passengers dissatisfaction levels

Data gathered from the field research:

The following conclusions are the result of the field research provided with direct information from the users of these services and on personal experience regarding the rail way transportation. These conclusions provide an insight with the most common problems existing in this public transportation area which can affect the future of public transportation

- **Difficult embarkation in train wagons:**

Access a train is difficult for the elderly and / or disabled people. Boarding can be difficult for young people as well based on traveling condition such as luggage number or weight or health problems at that time (medical conditions like fractures etc.) Level of difficulty faced by an elderly person when entering into a train depends on the wagon design and the degree of accessibility, number and volume of baggage. The level of difficulty increases especially if that person has a disability.

- **Difficulties in finding the booked seat:**

30-40% of passengers on a train have difficulties finding the seat booked when purchasing the ticket. These difficulties are caused by two factors. The first factor that causes this problem is the hard reading of the number for the wagon or seat because of their incorrect positioning, the use of inappropriate colours, lack of maintenance causing the numbers to fade out. This factor is caused by the owner of the train. Another factor that makes it difficult to read the seat or wagon number is the disability that the passenger may have like poor eyesight or blind people.

- **Difficult access to storage areas:**

The current location of storage in a passenger coach, made accessing them difficult for most of the train passengers. The size and location of these spaces make it almost impossible for large baggage storage.

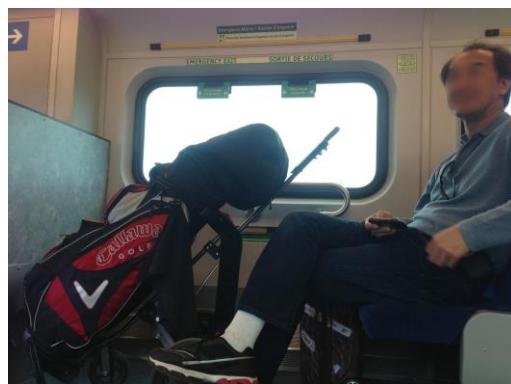


Fig. 2 Insufficient storage example (<http://www.paulstravelblog.com/wp/?cat=>)

Storage of large luggage is very difficult, depending on luggage size, their weight and the person performing the task. In these situations most passengers prefer to store these large luggages on the aisle making it almost impossible to move inside the wagon or under the seats where already the space is insufficient for a comfortable ride.

- **Reduced mobility inside the wagon:**

60% of the train travellers have difficulties with mobility after they embark into a wagon. The problem is often caused by the aisle size and spacing between seats. Although the size of these spaces is determined according to the area standards where the train is running, these dimensions do not allow optimal mobility for the elderly, disabled or for people with luggage dimensions above

average. About 10% of the passenger of a train cannot reach the place reserved for large luggage.

- **Uncomfortable seats:**

Most journeys exceeding 30 minutes become very uncomfortable due to the design of passenger seats [9]. To make maximum use of the interior space of a wagon, their producers have tried to introduce as many seats as possible, sacrificing the space required and optimal ergonomics of the seats[10].



Fig. 3 Passenger train interior (<http://economytraveller.com/five-train-trips-six-trains-europe>)

Passengers are forced to bear an ergonomic position calculated correctly for a short period of time, but incorrect for a longer period of time, greater than 30 minutes, thus creating discomfort.

- **Lack of adequate storage security:**

70% of the train passengers complain that there isn't a security system for luggages. The bags must be supervised at all times by passengers making mobility difficult, creating a state of anxiety throughout the journey. There is no system to protect your luggage if a person forgets his luggage on the train or in case of having health problems during the journey.

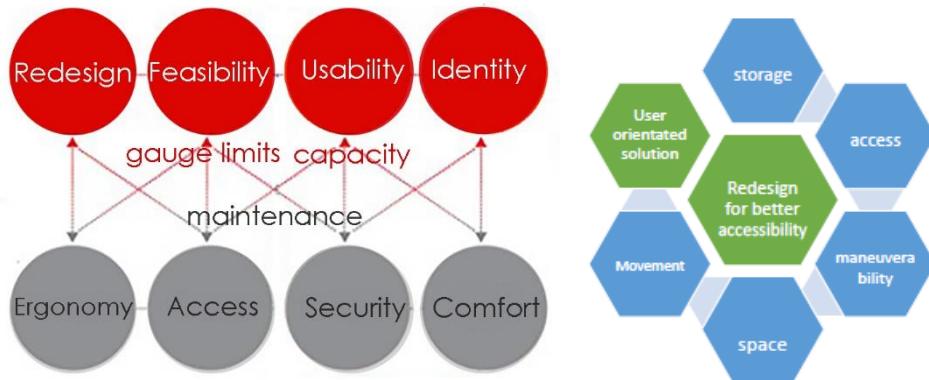


Fig. 4-5 Future research directions

### 3. Conclusions

Improving the current state of comfort, accessibility and security in the passenger trains would increase the number of users for this service and reduce the number of vehicles on the public roads. This increase in users for the public transportation services will have a positive impact on the local economy for the respective area of use.

In order to improve on the resulting situations presented in this study, regarding the customer satisfaction level, these areas: comfort, accessibility and security must be upgraded. To make these upgrades possible, a redesign should be considered. Passengers can be influenced through a good ergonomic design to proper use the internal facilities of the train. Improving the passenger train interior design with aspects considering better ergonomics and better accessibility features would improve the travelling quality for the user. This would make it a more preferable way of transportation, increasing the desirability for these services, resulting in a safer method for people to travel from point A to point B.

Considering the limited space inside the train wagon, improvements can be achieved through a modular design language for luggage storage that could take care of the passenger luggage from the embarkation process and giving it back at the disembarkation stage. The system can be adapted through an exterior mount solution that is not to interfere with the train behaviour or can be implemented directly from the factory. This type of storage can offer security through the storage solution, offering screening and monitoring devices that can be implemented in the system.

## Acknowledgement

This research is based upon work supported by the Sectorial Operational Programme Human Resources Development, POSDRU/159/1.5/S/132397, co-financed by the European Social Fund and the direct collaboration between Politehnica University of Bucharest, Romania and Politehnica University of Valencia, Spain.

## R E F E R E N C E S

- [1] *Niclas A. Krüger* -Estimating traffic demand risk – A multiscale analysis- Swedish National Road and Transport Research Institute, VTI, Box 55685, SE-102 15 Stockholm, Sweden- Transportation Research Part A 46 (2012) 1741–1751
- [2] *Pieter Coenen, Idsart Kingma, Cécile R.L. Boot, Paulien M. Bongers, Jaap H. van Dieën* Detailed assessment of low-back loads may not be worth the effort: A comparison of two methods for exposure-outcome assessment of low-back pain- Applied Ergonomics, Elsevier
- [3] *Arthur Stewart, Robert Ledingham, Graham Furnace, Alan Nevill*- Body size and ability to pass through a restricted space: Observations from 3D scanning of 210 male UK offshore workers- Applied Ergonomics, Elsevier
- [4] *The Gallup Organization* -Survey on passengers' satisfaction with rail services- - Flash EB Series nr.326- Publication: June 2011
- [5] *Jace Drain, Daniel Billing, Daniel Neesham-Smith, Brad Aisbett*- Predicting physiological capacity of human load carriage – A review- Applied Ergonomics, Elsevier
- [6] *Chris Nash* -Passenger railway reform in the last 20 years – European experience reconsidered - Institute for Transport Studies, University of Leeds, Leeds, UK, Research in Transportation Economics 22 (2008) 61–70
- [7] *Chris Nash* -European rail reform and passenger services e the next steps - University of Leeds, Leeds, United Kingdom- Research in Transportation Economics 29 (2010) 204e211
- [8] *Passenger Focus* -Rail Passenger Satisfaction at a glance: Great Britain - Autumn 2014-
- [9] *Pascale Carayon, Sarah Kianfar, Yaqiong Li, Anping Xie, Bashar Alyousef, Abigail Wooldridge*- A systematic review of mixed methods research on human factors and ergonomics in health care- Applied Ergonomics, Elsevier
- [10] *Kristina M. Gruevski, Michael W.R. Holmes, Chad E. Gooyers, Clark R. Dickerson, Jack P. Callaghan*- Lumbar postures, seat interface pressures and discomfort responses to a novel thoracic support for police officers during prolonged simulated driving exposures- Applied Ergonomics, Elsevier