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RAILWAY NETWORK OF ROMANIA'S CENTRAL DEVELOPMENT REGION: CURRENT SITUATION AND EVALUATION OF DEVELOPMENT PLANS BASED ON GRAPH THEORY MODEL

ABSTRACT

The present study focuses on the Central Development Region in Romania and attempts to highlight the deficiencies of the regional railway network, as well as to scientifically analyse the impact of new lines designed in the region. The current regional rail network is greatly determined by the historical development process of the railway, and therefore, in the first section, the most notable causes, milestones, and historical factors have been summarized. The goal of this paper has been to evaluate the current situation of the Central Region's rail network and investigate the potential processes entailed by the line designed between Tîrgu Mureş and Sighişoara. For this, at first, some quantitative and qualitative analyses as well, including traffic and travel speed measurements have been carried out. Finally, using the analysis capabilities offered by the application of graph theory, we had the opportunity to perform a simulation with the planned rail line. Our conclusion is that the improvement of the Tîrgu Mureş rail accessibility toward Braşov could be considered as a real option, especially, as in the near feature, the motorway connection between these two important Transylvanian cities will be built, which will represent a huge challenge for the rail transport on this axis.

KEY WORDS

railway network, new railway line, graph theory, regional development, rail accessibility

1. INTRODUCTION

In these days the recurring theme of the railway related transportation geography research is confined to the analysis of the importance and efficiency of high-speed rail [1, 2, 3], as well as the rail transportation [4, 5, 6]. The issue of conventional railway construction may be interesting in special situations. In Romania the development of railway network came several decades later than in other Western-European countries, and this was further affected by the outbreak of two World Wars. Due to those circumstances, the Romanian railway network has not reached an optimal development level, and therefore nowadays many missing rail connections cause problems. Therefore, the building of new lines has been an issue in the transport policy practically since the beginning of the railway construction; however, no major advance has been made. Generally, these planned lines would serve regional or even micro-regional interests, and therefore their likelihood is pretty low; nevertheless, they are included into the spatial planning act. In Romania, the major problem in this topic is given by the extremely low competitiveness of rail transportation in the current technological state of the network. As the likelihood of developing high-speed rail lines across the country is also reduced (only a speed limit upgrade up to 160 km/h of the conventional trunk lines is planned), in some cases, the building of new conventional lines could be considered. In the literature treating the Romanian rail system, some papers discuss the aspects of modernizing the signalling and controlling infrastructure [7, 8], others focus on the development projects alongside the European transport corridors [9, 10], and yet few others deal with the history and functionality of the rail network [11, 12, 13]. Papers modelling effects of new lines in Romania are

very rare [14, 15]; therefore, theory models had to be created. In this case, a regional point of view was adopted by evaluating the potential benefits, which could be achieved due to a new conventional rail connection.

Due to its geographical position, the Central Development Region is adjacent to six development regions. In addition, its geostrategic position is further increased by the orientation of the main lines in the transportation system, which is due to the capital's peripheral location. Bucharest is connected to the western parts of the country and the EU's core area mainly through the Central Region. The importance of this relationship is well reflected by the national infrastructure development strategy, which gives a central role to the construction of the A3 (Bucureşti – Braşov – Oradea – Hungary) motorway, as well as the modernization of the main railway line No. 300. Beyond that, the railway and motorway component of the Pan-European Corridor IV also crosses this region, which plays an essential role in the transport policy of the EU.

2. FORMATION OF THE CENTRAL DEVELOPMENT REGION AND ITS CHARACTERISTICS

The proximity of Romania's integration to the European Union at the end of the 1990s has initiated the difficult process of limiting the development regions. The purpose was the creation of territorial units adequate to such NUTS II levels, which are able to control regional development, to collect structural funds, and to totalize and convey compatible statistical indices for EUROSTAT. For the limitation of regions many different conceptions have been developed, which were subject of a serious political argument. The first document, which made between 1996 and 1998 a proposal to limit the regions, was prepared from PHARE funds and named as "Green Paper". The division into eight regions, suggested in the document, came into existence according to Law 151/1998 (modified by Law 315/2004) by the "voluntary" association of county councils. In fact, the theory of the central administration prevailed. The newly created regions could not be considered administrative units and they do not have a legal entity, therefore their activity is coordinated by the Territorial Development Agency according to Law 315/2004. In 2011 the regional reorganization came to be a political argument issue again.

The eight regions were named by their geographical position to the country's geometrical Centre. The Central Development Region is formed by six counties – Alba, Braşov, Covasna, Harghita, Mureş, Sibiu, and the administrative Centre of the region is located at Alba Iulia (Alba County). Considering Romania's historical regions, the Central Development Region is formed by central and south-southeast Transylvania, while Cluj and Bistriţa-Năsăud counties belong to the neighbouring North-West Development Region.

The area of the region is 34,100km^2, which covers 14% of the country's territory, and is therefore the 5th largest region in Romania. According to statistical data, the region had 2.5 million inhabitants (11.8% of the total population) in 2010. Its average population density (74/km^2) is below the national value. The highest population density was registered in Braşov county (116.6/km^2), while the lowest was in Covasna (60/km^2), Alba (59.6/km^2) and Harghita (48.9/km^2) counties below the national average.

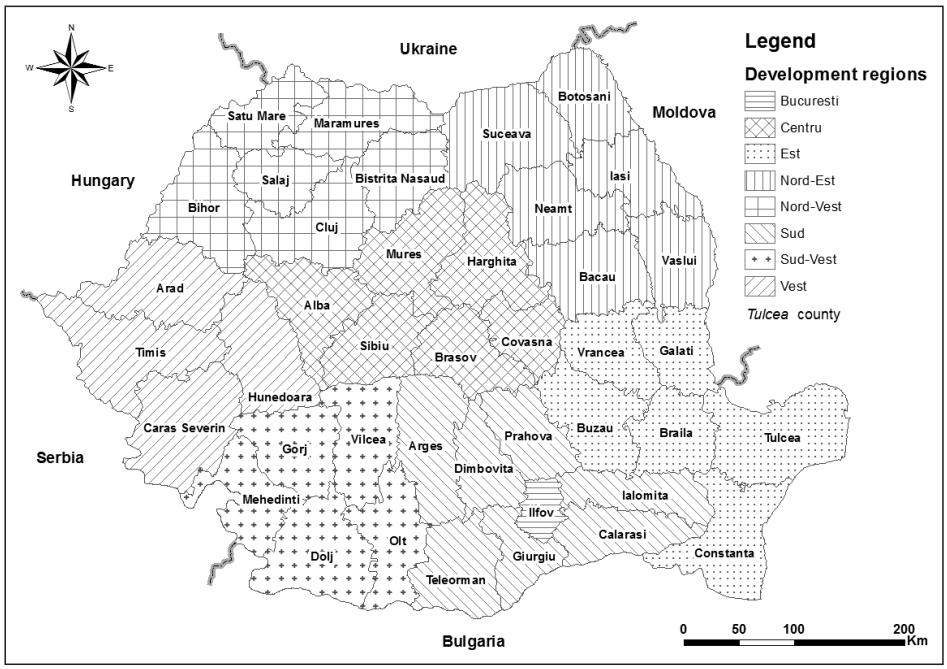

Figure 1 - Development Regions in Romania (own edition)

In 2011 the settlement network of the Central Development Region was formed by 57 towns (out of which 20 municipalities), 357 rural localities and 1,788 villages, which concentrated into 414 administrative units. The urban population ratio in 2010 was 59%, this placing it in the third position following Bucureşti and the West Development region. However, the level of urbanization of the region is considered to be low, which is further aggravated by high ratio of small towns. In the Central Development Region only Braşov's population is higher than 250,000, and there are only two towns with a population between 100,000 - 200,000 – Sibiu and Tîrgu Mureş. Considering Transylvania as a single historical-geographical territorial unit, it is necessary to take into account Cluj Napoca, as the entity with the strongest polarization in the area. As a result, the transport infrastructure of the region, and within this the railway network - beyond the national interests (international connections, connection of distant locations with the capital), serves the accessibility and connectivity of these four towns. Considering the rail connectivity of the main cities, however, significant differences may be observed. The case study presented here discusses the position of Tîrgu Mureş in the railway network, as well as the development possibility of the rail connection of the Tîrgu Mureş – Braşov axis.

3. HISTORICAL BACKGROUND AS A FACTOR IN THE CURRENT SPATIAL CONFIGURATION AND ACTUAL DEVELOPMENTS OF THE RAIL NETWORK IN ROMANIA

The development of the railway infrastructure in Romania started in the latter half of the 19th century. The first railway line was inaugurated on 20 August 1854 between Oravița and Bazias to transport coal from the Anina Mountains to the Danube. The peripheral location of Transylvania, as part of the Austro-Hungarian Monarchy, affected to a great extent the development of the railway network. In consequence, it came several decades later as compared to the core area of the monarchy. It was also delayed by the tense political situation after the revolution of 1848/49; hence considerable advance was only possible after the historical compromise of 1867 [16]. The state's interest was to connect the large towns of Transylvania (Cluj, Braşov, and Sibiu) with the capital by railway lines that contribute to the economic development, as well as to build connections across the Carpathian Mountains to the Kingdom of Romania in order to enhance the export trade [17]. As a result of a Budapest-centric development policy, the rail lines entered Transylvania from two directions and ran gradually toward the East. In the South, along the Mureş Valley, the (Budapest -) Arad – Alba Iulia – Teiuş line was built, while to the North, the (Budapest -) Oradea – Cluj-Napoca – Războieni – Teiuş line. Basically, there were two major interest spheres, which tried to join Sibiu and Braşov to the railway network. In the era of railway building, next to the state's engagement, civil assemblages became an important factor as well, which mostly represented local and microregional interests [18].

The development of the rail network in Transylvania took place in various stages. In the period between 1867 and 1873 the Cluj-Napoca-Braşov trunk line and additional railway branch lines were built; therefore, Sibiu (1872) and Tîrgu Mureş (1871) joined the railway network [19]. The railway construction was interrupted for a couple of years due to the rising worldwide crisis. Thereafter the Trans-Carpathian international connections to the Kingdom of Romania, which were of strategic importance, were gradually developed. The condition was that the lines would reach the border zone. Foremost, Transylvania was connected with Muntenia from the Braşov – Predeal direction (1879); and thereafter, following the construction of the south Transylvanian Deva – Vinţu de Jos – Sibiu line (1892), the transport along the Olt Valley commenced [20]. The connection between Transylvania and Moldova was created in 1899 with the Ciceu – Ghimeş – Adjud line, while the plan of extending the Braşov – Breţcu line through the Oituz valley toward Moldova was discarded. Until the inauguration of the line linking Transylvania with Bucovina in 1938, this was the only connection between these two historical regions.

Another particularity of the historical development of the railway network was the spreading of narrow gauge lines, which served mainly economically the less developed areas [21]. Around Tîrgu Mureş, in the ethnographic area called Transylvanian Plain, a smaller narrow gauge network was developed at the beginning of the 20th century. In addition, in the Arieş Valley, the 90km long line between Turda and Abrud was used between 1892 and 1999. The country's longest narrow gauge line (123km) once was operating between Sibiu and Sighişoara; then, after 1965, the Agnita – Sibiu (62km) section was in operation until 2001. The annexation of Transylvania to Romania led to the re-evaluation of the regions geopolitical situation, but since its railway network was more developed than in the other parts of the country, after 1920 only the Hărman – Întorsura Buzăului branch line was built (1924-31). Eventually, following the Second Vienna Award - due to strategic considerations - Hungary considered necessary the construction of the Deda – Sărăţel connecting line, that later became part of the main line No. 400 [12]. In the second part of the 20th century, towards the powerful industrialization demand, the emphasis was on the modernization of main lines with electrification and duplication of the trunk lines [13].

Romania's entry into the European Union (and consequently the pre-accession instruments financed by the EU) gave a new chance for developing the country's railway infrastructure after a few decades of missing investments in this field. Especially in the 1990s and the first years of the new millennium, the railway was highly disadvantaged in comparison to public roads. This led in the passenger and mainly freight sector to dramatic changes of the modal split. Since no investments were made in the motorway network in the communist era nor in the transition period (the decades after 1989), the existing road network did not have enough capacity to handle the increased traffic volume. From logistic point of view, the simultaneous development of the road and railway infrastructure is a very important aspect (considering the still low-level transport network).

As previously mentioned, the condition of the railway infrastructure represents the weakest link of rail transport. In terms of quality, it has shown a strong downward tendency in the last 20-30 years, especially in the case of branch lines, this process leading to the necessity of introducing speed limits. Consequently, according to the situation in August 2010: 579 speed limitations were adopted while 5,596km railway lines, 12,026 bridges, 67 tunnels (of 170), 8,805km wiring (of 10,407km), 10,209 telecommunication units (of 12,071), and 96 transformer stations (of 186) were in need of repair.

Using EU resources, the rehabilitation of the railway lines along the Pan-European Corridor IV has been initiated. Accordingly, the initial phase included the opening of the Fundulea-Bucharest-Comarnic (211km) and the Feteşti-Constanța (84km) section. Presently, the Comarnic-Predeal (48km) and the Fundulea-Feteşti (104km) sections are under construction, whose deadlines are the second trimester of 2012 and mid-2013, respectively. As consistent with the schedule of the Ministry of Transport, the rehabilitation of the first section of the Simeria-Coşlariu-Sighişoara (167km, intended deadline: 2014-15) and the Simeria-Curtici route (41km, intended deadline: 2014) starts in the year 2012. The next stage will include the rehabilitation of the remaining sections of Corridor IV: Sighişoara-Braşov (130km, intended deadline: 2019), Braşov-Predeal (26.9km, intended deadline: 2020), the 2nd and 3rd sections of the Simeria-Curtici route (144km, intended deadline: 2020), and the Arad-Craiova-Calafat route (488km). Full rehabilitation of the northern axis of Corridor IV is expected by 2020, which will allow a 160km/h speed limit for local trains and a maximum of 140km/h in case of freight trains. At the same time, several railway stations will also undergo necessary renovations: according to the plans, twenty-one towns altogether will have their railway stations modernized in the period between 2011 and 2014. The renovation of the Târgu-Mureş railway station will also take place in the same period – the total costs of the works amount to 11,781,678 euro, funded by the state budget and the ERDF funds.

In line with the EU policy (White Paper), the issue of rapid transit system in Romania has made its way again onto the agenda. Its draft plan was also sketched out (without the specification of lanes) in the National Spatial Plan sanctioned by Act 71/1996 and its repealing Act: 363/2006. According to the Com-

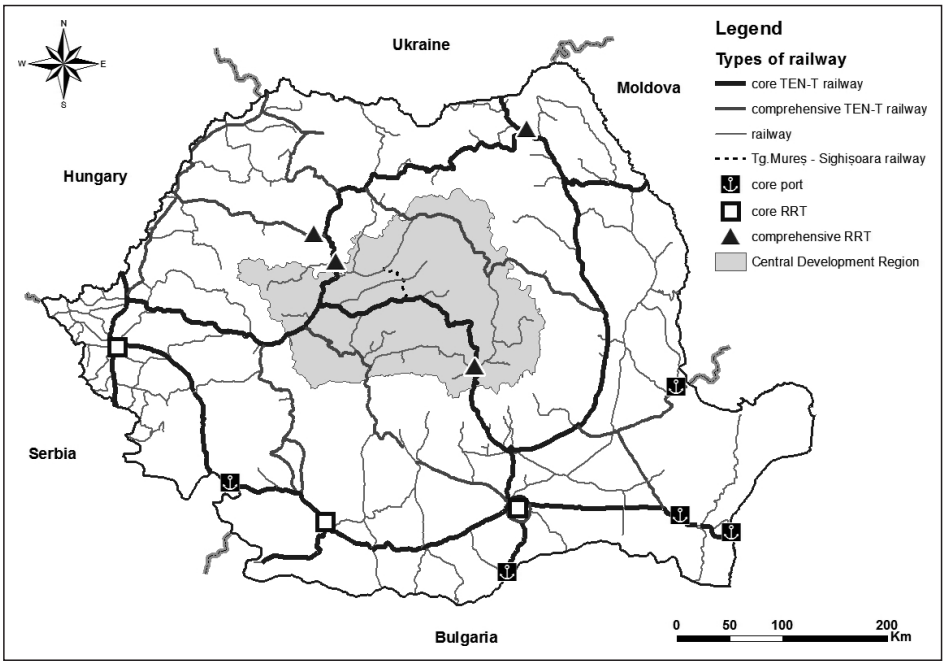

Figure 2 - TEN-T rail network, ports and rail-road terminals (RRT), after the enlargement of the TEN-T network in 2012 (own edition)

bined Transport Strategy approved by the Ministry of Transport in 2011, the high-speed rail line between Budapest and Constanța will be accomplished after 2015, in accordance with the negotiations carried out with the countries directly concerned. This high-speed rail line would be connected with the Paris – Strasbourg – Stuttgart – Vienna – Bratislava – Budapest high-speed rail network, thus creating a highly competitive transport option between the Black Sea and Western Europe. Its designed speed limits would fall between 250km/h and 300km/h.

In the context of the liberalization of the rail transport in 2001, a few private operators (mainly in freight sector) were established, as for example GFR, Servtrans or Transferoviar Group. In a very short time period, these new companies took over a huge volume of freight rail transport, primarily targeting the profitable block-train traffic. These measures led to CFR Marfa losing its absolute monopoly.

The joint influence of historical factors, terrain conditions, as well as economic development rate of the region led to a low connectivity level of the railway network. The large number of branch lines (dead-end lines) and the underdevelopment of connections in the north-south direction affect negatively the competitiveness of the railway. Considering the global devaluation of the rail transport, there is little chance for improvements in the near future.

4. CURRENT SITUATION OF THE REGIONAL RAIL NETWORK

Due to its favourable geographic position, three main lines cross the region (No. 200, 300, 400), branching off to additional rail lines. The main junctions are Braşov, Teiuş, Ciceu, Vinţu de Jos, Podu Olt, Copşa Mică and Războieni. In 2010 the total length of the rail lines in use was 1,336km. In the past two decades, however, dramatic changes occurred. In 20 years 426km of railway lines were withdrawn from circulation, which meant a 24% decrease of the total length of the railway. Regarding the Central Region's counties, only in the case of Braşov and Covasna the length of the lines did not decrease. The narrow gauge lines (282km) were withdrawn from use at the turn of the millennium, due to their low competitiveness and utilization. The same happened to most industrial railway lines. It is worth mentioning that the current situation would be even more alarming without the involvement of private carrier companies, which by 2001 gradually took over the operation of branch lines considered to be associated with a loss by the Romanian Railways Company (CFR), mainly branch lines serving micro-region interests. During this period only the North-East (139km) and the South-East (439km) regions have increased the total length of their railway network. The ranking list of regions showing a downward trend was led by the Central Development Region, and in consequence it fell from the third to the fifth position. Paradoxically, since most of the lines withdrawn from circulation were not electrified, the ratio of electrified lines increased from 37.4% (1990) to 50% by 2010, which exceeds the national ratio (37.1%). Among the counties making up the region (NUTS 3 level) there are significant differences regarding the state of railway supply. Concerning the railway line density showing the area-expanding degree of the rail network, the Central Region is found below the national average (45.2km/1,000km^2). Among the counties of this region only Braşov's railway density (66km/1,000km^2) has exceeded the national average, which is result of its status of a very important railway junction, being a "gateway" between Transylvania and areas across the Carpathians.

Regarding the quality of rail lines, Covasna and Mureş counties have the most unfavourable position because they have no multiple track lines, and the electrified line ratio is below 40%. The territorial rate of modernized lines essentially depends on the main line track. The entire main line No. 300 (Predeal – Braşov – Sighişoara – Teiuş – Războieni), the Vinţu de Jos – Şibot section of the main line No. 200, and the No. 200A line, which connects these two, are electrified and double tracked. The main line No. 400, branching off at Braşov to the North, is electrified but it is a single track line, as well as the No. 501 branch line of this

Table 1 - Railway lines by category, 2010

Counties	Railway lines (km), from which:			Railway density (km/km^2)
	Total	Electrified	Double track	
Alba	230	136	139	36.8
Braşov	353	184	135	65.8
Covasna	116	44	–	31.3
Harghita	209	174	2	31.5
Mureş	283	87	–	42.2
Sibiu	145	44	44	26.7
Central Region	1,336	669	320	39.2

Source: Romanian Statistical Institute, edited

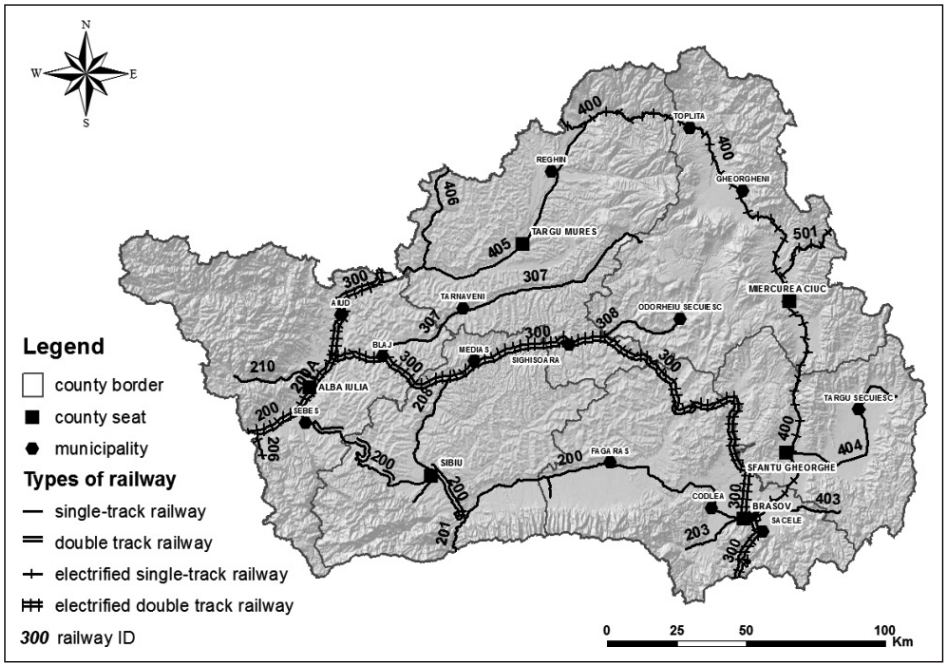

Figure 3 - Railway network of the Central Development Region (own edition)

branching off at Siculeni to Moldova [22]. Finally, on the Podu Olt – Sibiu – Şebeş portion of the main line No. 200 several short sections are double tracked. Another curiosity of the railway network of the Central Development Region is that the highest altitude train station is located there - Predeal (1,040m), as well as Romania's longest rail tunnel - Teliu (4,300m), which is located on a branch line of little importance. Additionally, the rail line between Predeal and Braşov was the first electrified section in Romania, inaugurated in 1961.

The spatial distribution of the electrified and double track lines highly influences the organizational process of rail transportation by the necessary usage of different types of locomotives, as well as the highest possible loadability of the system (the number of railway vehicles on a given line). All this further worsens the high average travel time resulting from the poor technical condition of the railway infrastructure, and thereby negatively affecting the competitiveness of the rail transport [23]. The average travel speed value achieved by passenger trains, taking into account the standing time at stations, could be placed between a 28-58 km/h interval. In case of express trains, the average speed values are mostly 20km/h higher; however the 66km/h maximum average speed value obtained on the Copşa Mică –Sibiu (No. 208) line is still far from the competitive value.

The current regional rail network usage is well reflected by the sum of trains travelling daily in both directions on a given rail line segment. The data used here was provided by the official railway timetable showing regularly running passenger trains on weekdays. As a result, the most loaded lines are the following: Podu Olt – Tălmaciu – Sibiu, the Copşa Mică – Mediaş, Vânători – Sighişoara, and Şibot – Vinţu de Jos – Teiuş – Războieni, on the average 50 - 65 trains/day. Essentially, the usage of main lines No. 300 and No. 200, as well as the No. 200A line connecting these two are the most significant ones. However, the utilization of branch lines and, especially, dead-end lines is very low, typically 10 to 15 trains/day traffic.

In topological sense, the biggest problems of the region's railway lines are caused by the large number of dead-end lines and the underdevelopment of the north-south oriented rail connections; and therefore, in some cases of stations located geographically close to each other, there is a multiple network distance as compared to the bee-line distance. This question mainly affects the central and eastern parts of the region due to its unfavourable terrain and hydrological network. In fact, there is a lack of branch lines making the connection among the three main lines; which otherwise, spatially, cover well the region. Only the Copşa Mică –Sibiu, and the No. 200A lines have this function, but both are located on the western part of the region. The No. 200A line is nationally significant, since it connects the two trunk lines crossing the country's western border.

The greatest deviation from the ideal bee-line distance takes place between Odorheiu Secuiesc and Miercurea Ciuc, where the rail connection length is 528% greater than the air distance between the two cities. Considering the rail connections of the county seats compared to the ideal theoretical distance, a 10 – 132% increase in distance occurs. In the most unfavourable situation is the region's third biggest city, Tîrgu Mureş, since it is affected by all four most

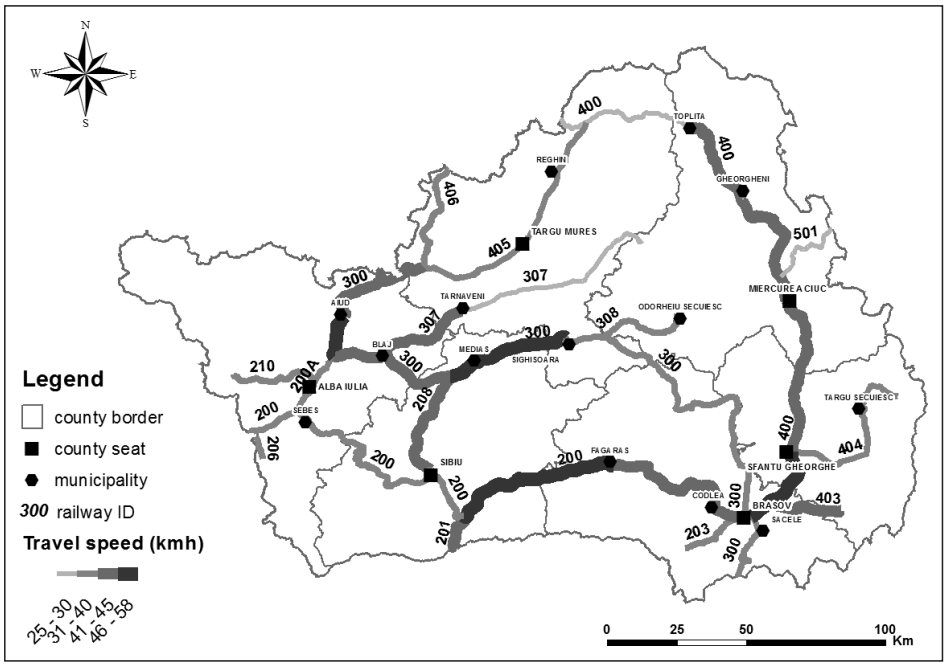

Figure 4 - Average travel speeds of passenger trains
(own edition, based on data from the official railway timetable)

puzzling connections: Sibiu (132%), Braşov (122%), Sfântu Gheorghe (107%) and Miercurea Ciuc (93%). In the same way, significant extra distances are created between settlements located on parallel branch lines.

Responsible for this situation is principally the cost-effective development policy used for the railway network extension. Evidently, the extra distance as compared to public roads, affects negatively the competitiveness of the railway. The partial solution for this problem would be the construction of new rail connections. As result of a similar idea, new railway line projects appeared in the regional development plans; however, in practice, these have not been materialized. For instance, the 71/1996 spatial planning act of Romania, which lapsed in the meantime, contained the construction of 8 new rail lines. The currently valid act (Law 363/2006) contains only two new lines: Tîrgu Mureş - Sighişoara and Gheorgheni – Bicaz. Out of these two railways the former has grounds; however, due to the national economic situation, and

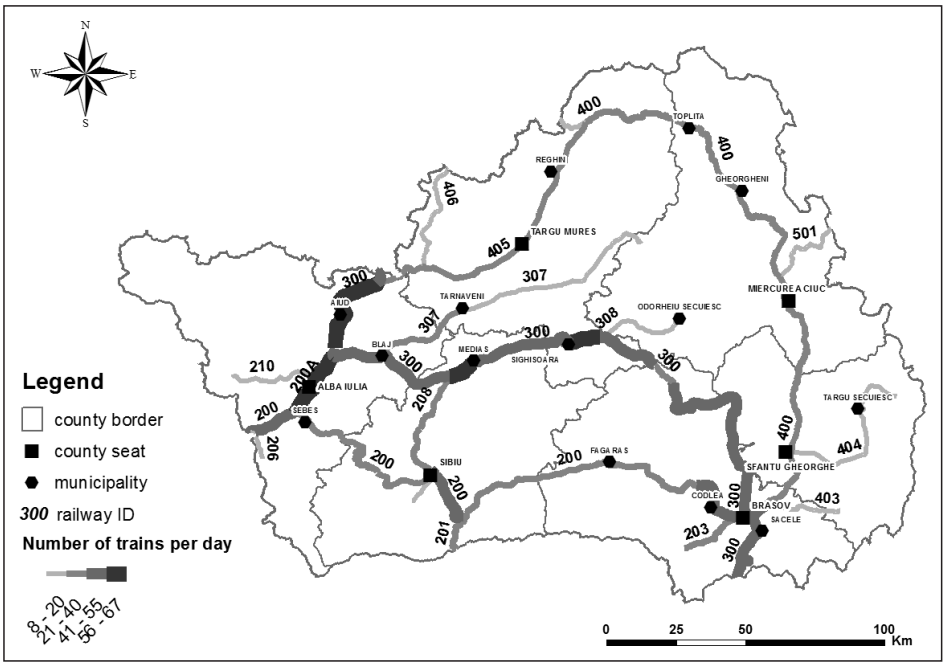

Figure 5 - Number of trains per track segments per day
(own edition, based on data from the official railway timetable)

since the utmost priority of the transportation network development was shifted to the construction of new motorways, the chance for realizing such railway projects decreased. Nevertheless, the fact that the plan appeared in the new law leaves reason for hope. Of course, the top priority in the railway network development is the rehabilitation of the main lines with the purpose of achieving the 160km/h maximum velocity in the case of passenger trains, and the 120km/h speed in the case of freight trains [24]. In addition, the objective is to put in operation the ETCS system on trunk lines, which serves the rail interoperability. The modernization works in the Central Development Region will affect the northern branch of Corridor IV formed by the (Curtici – Arad -) Şibot – Vinţu de Jos – Coşlariu – Sighişoara – Braşov – Predeal (- Bucharest) section, the main line No. 400 and the (Bucharest -) Olt Valley – Sibiu - Sebeş section [9, 10, 25].

5. INVESTIGATION OF THE SIGHIŞOARA – TÎRGU MUREŞ PLANNED BRANCH LINE

In order to make a deeper analysis of the rail network of the region, the graph theory was applied in this research. Graph models reduce the complexity of systems and offer the possibility to evaluate the extent to which the connections between the components of the graph are developed. On the basis of the conventional procedure [26, 27, 28] a software called "Start Utility" was created for this survey, which exploits the capacity of the computers to perform complex mathematical operations. In our graph the vertices shall be the towns the railway goes through, the railway junctions, the border stations and the last station of the railway dead ends, while the edges shall be the network distance (km) between the stations. The graphic presentation of the graph containing the 55 vertices established in the above mentioned manner is as follows.

On the basis of the network length the journey from each station to all the other stations was simulated. The calculated values for each station were summarised receiving 525,560km as the total length of the network. Among the analyzed 55 nodes the best positioned station with the easiest access is the Copşa Mică station located on the main line No. 300 (7,389km). In the accessibility top ten there are stations in the Sighişoara – Teiuş and Copşa Mică – Sibiu sections. The best situated from among the county seats is Sibiu (4), followed by Alba Iulia (15), Braşov (23), Sfântu Gheorghe (32), Tîrgu Mureş (35) and finally Miercurea Ciuc, which is the 46th in line. From among the main junction stations the most accessible are Teiuş (7), Podu Olt (9) in the first third of the hierarchy, Vinţu de Jos (17), Războieni (20), Braşov (23) in the middle section, while junctions Deda and Siculeni have quite disadvantaged positions. Naturally, on the last positions we find the final stations of the dead ends.

The results show that there is a difference of 5,714km between the aggregate accessibility of the first and last station in the hierarchy, which means a 77% excess of distance compared to the most advantageous value. The difference between the first and the last position in the top ten is only 624km, which means an excess of just 7.8%. Accessibility calculated based on distances in the network reflects clearly that the optimal position is a little to the west from the geometrical Central. Main line No. 400 is the most isolated, which is a consequence of its underdeveloped

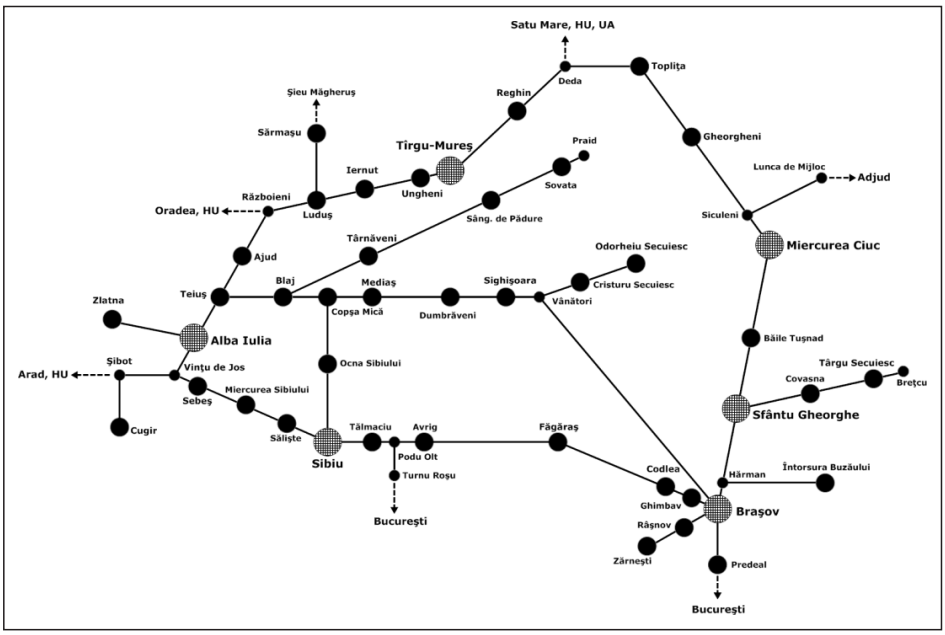

Figure 6 - Graph model of the Central Development Region railway network

connection with the main line No. 300. The global accessibility values are weakened greatly by dead-end lines. A good example of this is the Mediaş – Praid branch line, where Mediaş is the second globally most accessible town, while Praid is the last in the accessibility hierarchy. Also, in the case of other dead-end lines there is a significant difference between the accessibility of the junction and the dead-end station. It is obvious that if lines No. 307 (Praid) and No. 308 (Odorheiu Secuiesc) would provide a connection between main lines No. 300 and No. 400, and if there was a north-south oriented rail connection between these lines, the connectivity of the regional railway network would be far better as well as the accessibility of the railway stations. This is another reason for the importance of the Sighişoara – Tîrgu Mureş railway line mentioned in the regional planning act.

In order to evaluate the impact of the planned railway line in the context of this research, the existing graph was completed with the 45km long fictive Sighişoara – Ungheni (which is located on branch line No. 405 at 11km distance from Tîrgu-Mureş) railway line, thus making the change within the railway accessibility of the stations measurable. The result of the program simulation was that the total distance necessary to travel through the entire network was shortened by 24,848km, which means a decrease of 4.7% compared to the actual situation. Due to their population number and the state of their economy, the settlements are of varied importance in the economic-social system of the region and therefore the importance of the railway connections between these settlements is varied as well. So the impact of the planned railway line would be not only a slight improvement in global accessibility, but rather a greatly improved railway connection between the various towns. The two towns gaining the most from this project would be obviously the two above mentioned towns, and also the accessibility of the settlements on branch line No. 307 would be enhanced. The new line would alter the accessibility hierarchy, the first five being Sighişoara, Dumbrăveni, Vânători, Mediaş, Copşa Mică, which means that the central position would move to the East compared to the present situation. The railway access of Sighişoara would improve greatly; it would advance by 11 positions in the hierarchy, and viewed from this starting point the route necessary to travel through the entire network would be shortened by 1,088km. Furthermore, Tîrgu-Mureş would advance by 19 positions in the hierarchy to position 26 and the total distance necessary to travel through other stations would be shortened by 1,445km.

With the new railway line the divergence of the railway connections compared to the air distance between several important towns would be significantly decreased. The railway distance between Tîrgu Mureş and Braşov would decrease by 101km, which is a difference of 43% compared to the air distance and an improvement of 79% compared to the present situation. In case of Tîrgu Mureş – Sighişoara connection there would be an even more spectacular improvement where the network distance would be decreased by 141km with an improvement of 353% compared to the ideal railway route (air distance). The route between Tîrgu Mureş and Odorheiu Secuiesc would decrease by 142km, which would be an improvement

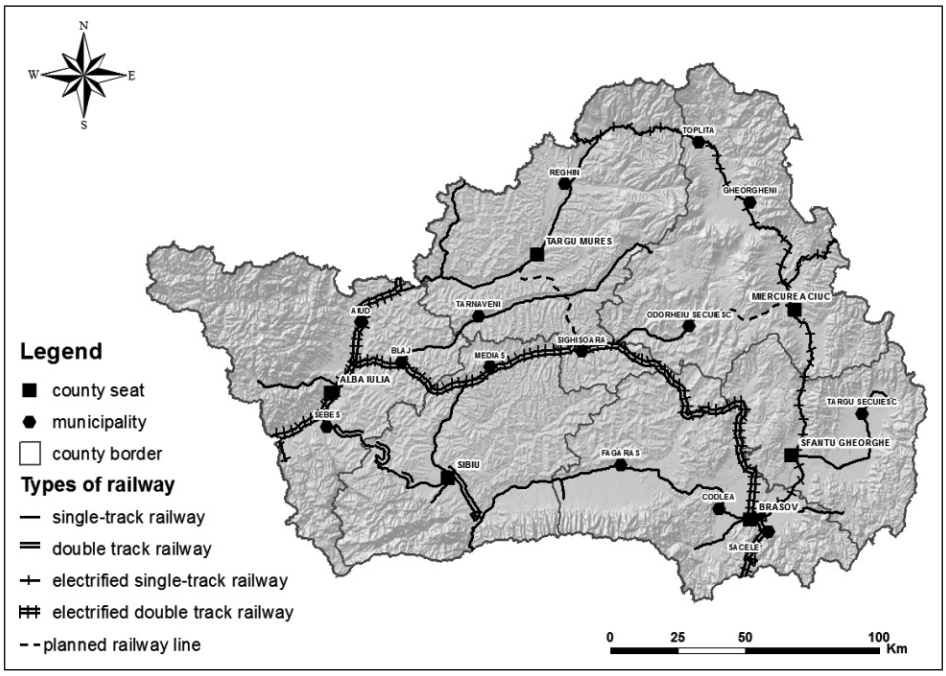

Figure 7 - Planned railway lines in the Central Development Region according to Law 363/2006 (own edition)

of 229% compared to the air distance between them. The results reflect the fact that the new railway line would have a positive impact on the railway accessibility of Tîrgu Mureş and it would greatly improve its connection to the Braşov – Bucharest – Constanța axis. It is also important to mention that by the connection of the main line No. 300 with the branch line No. 405 a new, alternative axis would be formed on the Sighişoara – Ungheni (Tîrgu Mureş) – Războieni route; which would be even shorter by 37km compared to the Sighişoara – Teiuş – Războieni route used at present, and it would relieve the latter when necessary.

Giving it more thought, a second simulation was made, where the initial model was extended with two lines: Sighişoara – Tîrgu Mureş and Odorheiu Secuiesc – Miercurea Ciuc. The latter – although it was proposed in the 71/1996 regional planning act and its construction was an issue more than once in history [13, 20] of the railway of the region –is no longer relevant today. The reasons are the high construction costs needed to cut through the Harghita Mountains, the lower classification of line No. 308 as a second class line and its poor technical state, as well as the low competitiveness of the railway transport. Despite these facts, these two lines would solve the majority of the network topological problems caused by missing rail connections. If we add to the graph a 50km long railway line between Odorheiu Secuiesc and Miercurea Ciuc, the route necessary to travel through the entire network would take 45,936km, which would be an improvement of 8.7% compared to the present situation. Besides, Miercurea Ciuc would advance 18 positions in the accessibility hierarchy, while Odorheiu Secuiesc 22. The divergence from the ideal railway route in the case of the Odorheiu Secuiesc - Miercurea Ciuc route would improve by 503% and in case of the Odorheiu Secuiesc – Gheorgheni route by 394%. The connection of Miercurea Ciuc with Sibiu (37%), Tîrgu Mureş (38%) and Alba Iulia (51%) would improve as well, even if at a lesser extent. The new line would enhance also the railway connection between Transylvania and Moldavia, which is at present realized in this region by travelling through either Braşov or Deda.

6. CONCLUSION

Although the need for the development of the transport infrastructure is one of the most urgent problems of Romania, there are significant differences between the various ways of transportation. Governments in the last ten years have unanimously concentrated mainly on the development of the public road network, especially of motorways. Since there were no adequate investments after the fall of the Communist regime, the competitiveness of the railway transportation, being in an increasingly difficult situation, has dramatically decreased. Thus, reality contradicts the plans for development regarding various railway lines presented in various strategic development documents. One example is the National Development Plan elaborated for 2007-2013, which states that the percentage of the railway transport should be kept at the present level. This expectation seems quite utopistic considering the international trends, as unrealistic as the cause of the construction of new railway lines consistently included in the National Development Planning Act since 1996.

Compared to this, the goal of enhancing the technical state of the existing railway lines, which would result in the increase of the average speed, is a more realistic aim. Such modernization would concern mainly the main lines, especially the elements of the TEN-T network. The target would be to assure an average speed of 160km/h in the case of passenger service and 120km/h in the case of freight transport. A key issue is the financing for the project, which is the greatest impediment in the present economic situation despite the financial aid offered by the European Union. The railway development project also contains the renovation of several important railway stations in the region - Sighişoara, Braşov, Sibiu, Alba Iulia, and Tîrgu-Mureş, Sfântu Gheorghe in the near future – and the inauguration of ERTMS -ETCS (level 2 on the corridor and level 1 on the trunk lines).

In this context it is certain that the construction of the railway line between Tîrgu-Mureş and Sighişoara (mentioned in Law 363 of 2006) will certainly not take place. And yet, considering the railway network morphology of the region and the social-economic status of Tîrgu-Mureş in the Central Transylvania, there are solid arguments for building the line. The results obtained with the help of the model showed that the new line would create a competitive railway axis on the Tîrgu-Mureş – Braşov – Bucharest – Constanța line. At present this route can be travelled only with a significant detour, and taking into consideration that a motorway will be built on this route within the next years, the competitiveness of railway transport shall continue to decrease both in the case of passenger service and of freight transport [29]. Besides, the secondary importance of this line would be that a viable alternative to the railway connection between Sighişoara and Cluj-Napoca would be created. Arguments against the project are, among others, that in order to build the line two watersheds need to be cut through, and since there is a great inclination angle tunnels would also be needed. Moreover, bridges would need to be constructed on two rivers. All these led to an enormous increase of construction expenses on this quite short section.

On the other hand the largest artificial fertilizer producing plant of Romania (even compared to international facilities), Azomureş, is located in Tîrgu-Mureş, which has a great need for transportation. The Council of the County of Mureş initiated in 2003 the creation

of the Mureş industrial park at an 18km distance from the town. The industrial park lies immediately next to the international airport "Transilvania" and the Tîrgu-Mureş – Războieni railway line. In the industrial park, covering a total area of 40.9 hectares, 22 companies have plants and further investors are expected. All this leads to the conclusion, that the need for transportation in the immediate surroundings of Tîrgu-Mureş will remain high in the future and it may even increase. The question is whether this need will be met at a greater extent also by the more environment-friendly railway transportation, or primarily by the public road transport.

The importance of developing secondary railway lines is often underestimated in transport policy, leading to huge regional disparities. Such developments are characteristic of Romania, as well. So-called boom-towns and their direct surroundings, as the Bucharest, or the Timişoara region, are in opposition with spacious rural areas, such as the north-eastern region. The main focus of the European transport policy is on strengthening the traffic development projects along the Pan-European Corridors to connect the agglomerations of the European Union. One of them, Corridor IV, crosses the Central Development Region. Through its geopolitically important position, Romania is the gate to the Caucasus and Central Asia with its significant raw material deposits and growth markets. In this context, the construction of road, railway, and waterway infrastructure along these corridors is gaining more and more importance for Romania.

The other side of the coin regarding these traffic development projects is the concentration on large-scale projects. Consequently, the economically underdeveloped regions will be disregarded, leading to emigrations from these areas to regions along the more developed corridors. Therefore, sustainable investments in rural areas counteract regional disparities. The Central Development Region is rurally coined. As shown, the planned railway connection between Târgu-Mureş and Sighişoara would have a positive effect on underdeveloped regions. Secondary railway lines are essential for having enough traffic volume (in passenger and freight transport) on the main lines, as well. They are gradually taking over the collecting role in the region and bring additional volume to the main lines. Traffic volume cannot be generated just along the main corridors. Main lines that serve exclusively to connect different agglomerations, without collecting an additional number of passengers and additional amounts of freight from the secondary lines, cannot be operated economically. Finally, the construction of a new railway line between Târgu-Mureş and Sighişoara will give way to the appearance of new markets promoting the products of local industry, such as the products of Azomureş. Creating a better-connected railway network in Central Romania will allow the railway system to take over the transport of raw materials as well as final products due to the reduced transport costs. Less truck traffic on the roads is not only a positive economic effect but it also allows better quality of life by offering better accessibility to other regions and a reduced number of trucks on the roads. Therefore, freight traffic on railways should have a higher priority in the traffic policy of Romania if they are to fulfil these aims. The impact of infrastructure development in rural areas should not be underestimated, especially in the European context.

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KIVONAT

ROMÁNIA KÖZÉP FEJLESZTÉSI RÉGIÓJÁNAK VASÚTHÁLÓZATA: JELENLEGI HELYZETKÉP VALAMINT A HÁLLÓZAT FEJLESZTÉSI TERVÉNEK ELEMZÉSE A GRÁFELMÉLET SPECIFIKUS ALKALMAZÁSÁVAL

Tanulmányunkban Románia Közép Fejlesztési Régiójának vasúthálózatát elemeztük, kitérve a meglévő diszfunkciókra, a hálózat szűk keresztmetszeteire, valamint kísérletet tettünk a régió vasúthálózatát érintő fejlesztési tervek hatásának felmérésére. A régió vasúthálózatának jelenlegi konfigurációját a hálózat történelmi fejlődése nagymértékben befolyásolta, ezért a tanulmány első szakaszában áttekintjük a legmeghatározóbb okokat, eseményeket és mérföldköveket. Célunk a régió vasúthálózatának jelenlegi felmérése mellett, a Segesvár és Marosvásárhely között tervezett új vasútvonal hatásának modellezése képezte. Ennek megfelelően minőségi és mennyiségi elemzéseket végeztünk el kitérve a vonalak forgalmára, a szerelvények átlagsebességére, végül a gráfelmélet alkalmazásán alapuló módszerrel modelleztük a hálózati kapcsolatok fejlődését a tervezett új vonal megépülése következtében. Az eredmények arra engednek következtetni, hogy Marosvásárhely vasúti elérhetőségének Brassó irányában történő javítása egy életképes lehetőség, amelynek szükségességét indokolja az a tény hogy a közeljövőben megépülő Marosvásárhely – Brassó autópálya ezen a tengelyen komoly konkurenciát fog jelenti a vasúti szállítás számára.

KULCSSZAVAK

Románia Közép Fejlesztési régiója, új vasútvonalépítés, vasúthálózat, gráfelemzés, vasúti szállítás elérhetősége

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