Metro, light rail and tram systems in Europe

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METRO SYSTEMS IN EUROPE – 2009

1. INTRODUCTION

For the scope of this study, metro has to be understood along the UITP definition: "Metropolitan railways are urban, electric transport systems with high capacity and a high frequency of service. Metros are totally independent from other traffic, road or pedestrians. They are consequently designed for operations in tunnel, viaducts or on surface level but with physical separation. Metropolitan railways are the optimal public transport mode for a high capacity line or network service. Some systems run on rubber-tyres but are based on the same control-command principles as steel-wheel systems. In different parts of the world metro systems are also known as the underground, subway or tube." This results in a high degree of freedom for the choice of vehicle width and length, and thus carrying capacity (above 30,000 passengers per hour per direction [pass/h/dir] is possible). Intervals between stations would be typically more than 1 km for new systems and because the alignment does not have to follow existing streets, curve radii and section gradients can be more generously dimensioned and permit for an overall higher commercial speed than light rail systems. Metro systems require heavier investment than light rail and can be implemented as the preferable option for large cities where demand justifies the high capital cost. The reality shows however that due to specific circumstances like high demand on main routes or huge expectations for a high quality of service (allowed by technologies like UTO [Unattended Train Operation]) also smaller cities and municipalities launch metro systems.

The aim of this study is to give a general overview of the networks (in operation, in construction and planned) and of the rolling stock (fleet sizes and age) in order to sketch some general trends for the future development, both for replacements as well as new needs (extensions or new lines require additional rolling stock to maintain service level). The research is based upon a questionnaire sent to all metro systems as well as upon additional information originating from the most viable sources currently available, mostly first hand, or via secondary literature.

In this study the collected data is presented in an aggregated way at the level of a country or a group of countries. There are three country groups:

- Former EU 15 countries (**EU-15**)[1]
- Countries of the last extensions of EU (Poland, Czech Republic, Bulgaria, Hungary, Romania, Slovakia, Estonia, Latvia) (**NMS**)[2]
- Other countries beyond EU-27 and candidate countries (Norway, Switzerland, Bosnia Herzegovina, Serbia, Croatia and Turkey) (**B-27**)

[1] Without Luxembourg and Ireland as there are no metro systems

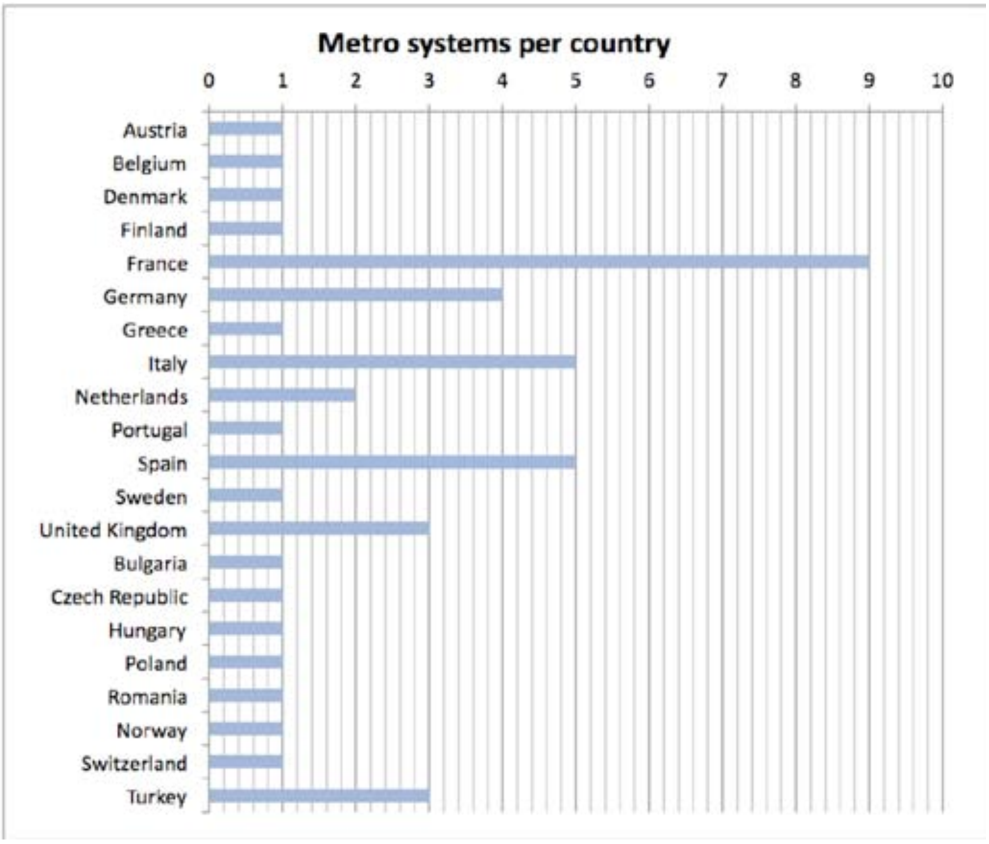
[2] New member states not mentioned do not possess metro systems

2. SYSTEM DATA: EUROPE-WIDE OVERVIEW

OVERALL PICTURE

Within Europe there are 45 metro systems: 35 (78%) can be found in the former EU-15 countries, 5 (11%) in the NMS and another 5 (11%) beyond the borders of the current European Union.

Chart 1



Out of the 169 metro lines, 146 lines (86%) with a network extent of 2,335 km (87% of the total) can be found in the EU-15 country group. The comparison with the 2004 study shows that there are 9 more systems in the three country groups; this means an increase of 25% of the total number of networks in five years. A more detailed look reveals that since the 2004 survey 8 new networks opened in EU-15 and one in B-27. The guideway structure from the responding parties has the following distribution: 4% are elevated, 24% are at grade and 72% are running underground.

Chart 2

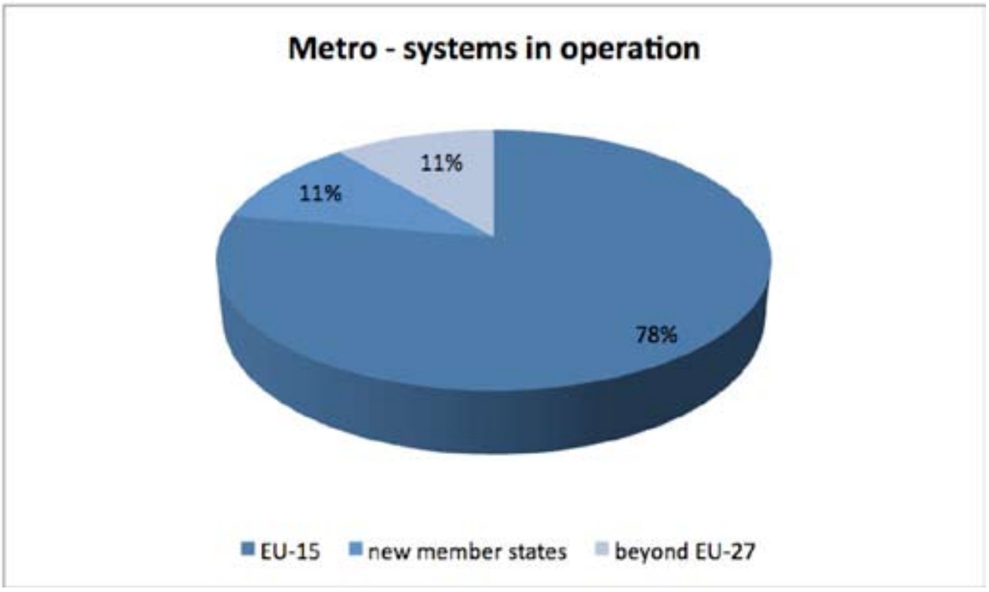


Chart 3

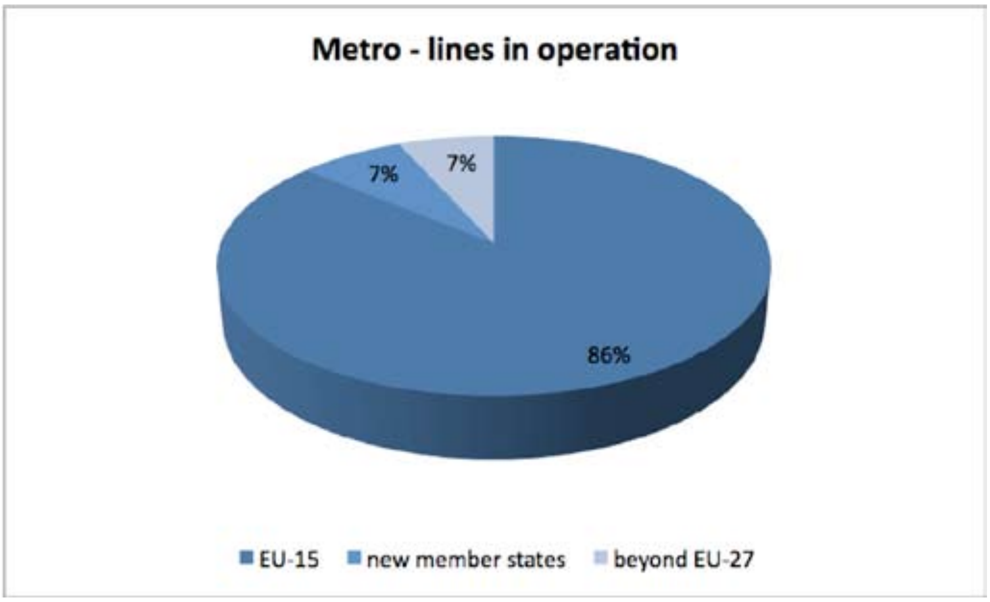
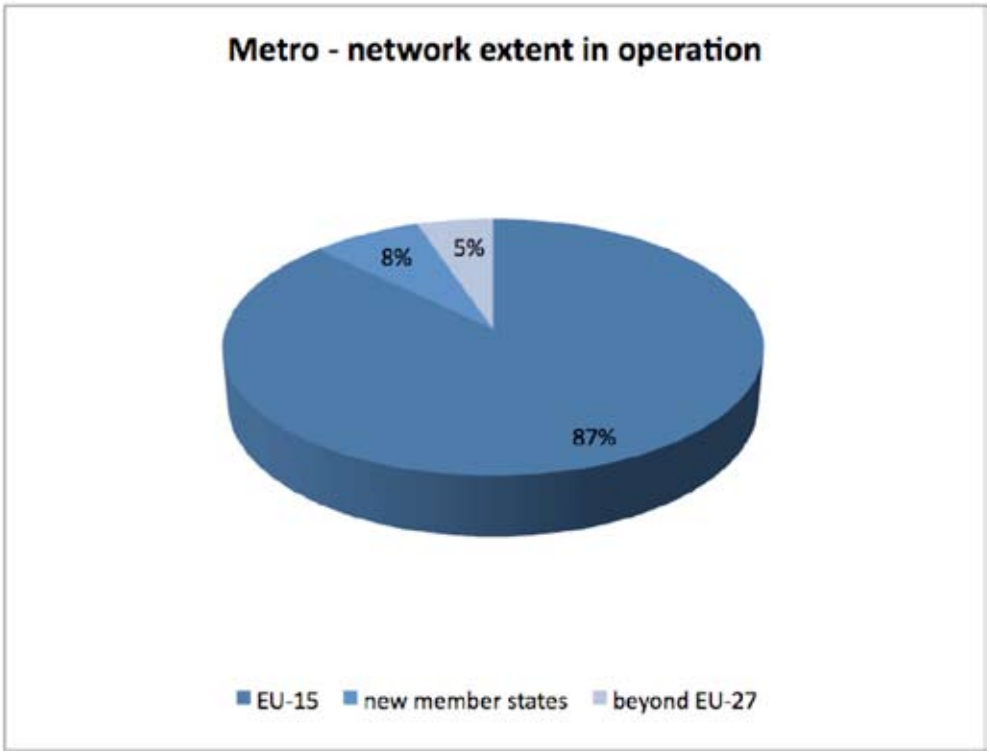


Chart 4



From 23 replying networks possessing in total 1,946 metro stations (EU-15 1,766; 91% and NMS 180; 9%) only 422 are unstaffed; which equals 21.6%. 1,021 stations (52.5%) are accessible for wheelchairs, however the EU-15 countries provide an average of 55 stations per network accessible for wheelchairs whereas the NMS can offer only 17 such stations. The average distance between the stations accounts for 1.02 km; i.e. 0.96 km in the EU-15 countries, 1.14 km in the NMS and 1.42 km in B-27. This shows that for new systems there is a trend to increase the distance between stations.

Table 1

	Number of responding networks	Lines	Network extent (km)	Average number of lines per system	Average length of line (km)
EU-15	35 (78%)	146 (86%)	2,335 (87%)	4.1	17.4
NMS	5 (11%)	12 (7%)	200 (8%)	2.4	16.5
B-27	5 (11%)	11 (7%)	140 (5%)	2.2	15.4
TOTAL	**45**	**169**	**2,675**	3.7	17.2

The average ratio of lines per system and network extent per system shows the following picture: almost 4.1 lines per system and 71 km network extent per system are the average inside the EU-15 country group against 2.4 lines and 40 km in the NMS. In the B-27 country group these figures reach 2.2 lines per system and 33.8 km network extent per system. These indicators show the large differences in the structural system characteristics according to the country groups: the EU-15 countries contain nearly the double amount of lines per system in comparison to the NMS and B-27 countries. However the average length of line is quite identical for all the three country groups with around 16 km.

3. NUMBER OF STAFF

Only 22 metro operators replied to the question about the company profile in the survey. Based on the collected data as a whole for these companies 45,329 persons are working daily in the operation and maintenance of the metro systems, whereof 11,312 are drivers (25%).

Correlating these figures with the network extent of these systems the average amount of staff per average network kilometre is 17 for B-27, 23 in the EU-15 and 61 in the NMS. Taking into account the passenger numbers for the networks which replied to this question the following result is obtained: one staff member is on average "responsible" for 156,741 passengers in EU-15, 103,842 passengers in NMS and 236,000 passengers in B-27.

4. ANNUAL NUMBER OF PASSENGERS

This question has been answered by all but one system (Izmir, Turkey) and the consolidated replies show the impressive number of 9.9 billion passengers being yearly moved within metro systems in all three country groups; i.e. 224.5 million passengers per year per network on average. France ranks first in terms of yearly passengers with about 2 billion (20% of the total), followed by Germany with 1.5 billion (15%), Spain with 1.3 billion (13%) and the United Kingdom with 1.1 billion (11%). Paris is carrying nearly 1.5 and London nearly 1.1 billion passengers a year; followed by Madrid with nearly 700 million. The network with the smallest amount of yearly passengers carried is Genoa with 8 million and it is also the smallest in network extent with 5.5 km.

Table 2

	Inhabitants (Mio.)	Annual number of passengers (Mio.)	Average number of trips per inhabitant	Passengers/year/ number of networks
Total	**561**	**9,877**	**18.3**	**235.2**
EU-15	383	8,364	21.8	261.4
NMS	88	1,246	14.2	249.3
beyond EU-27	90	266	3.0	53.2

The average number of passengers carried per network inside NMS is only 2/3 of the amount within EU-15 countries whereas the networks from B-27 countries transport only 13% of the passenger numbers from the EU-15 group.

Chart 5

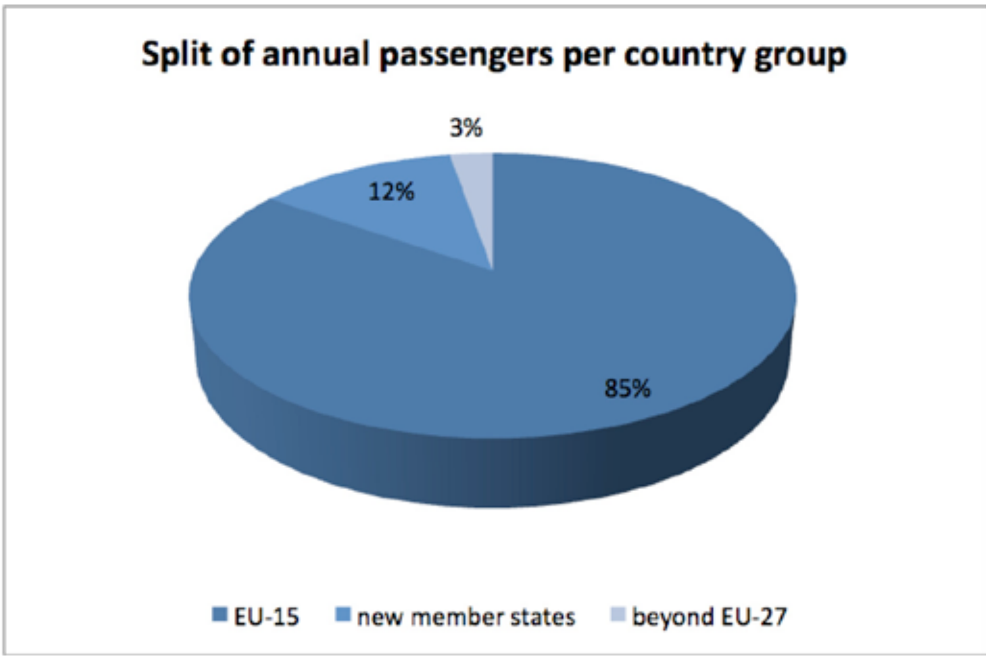
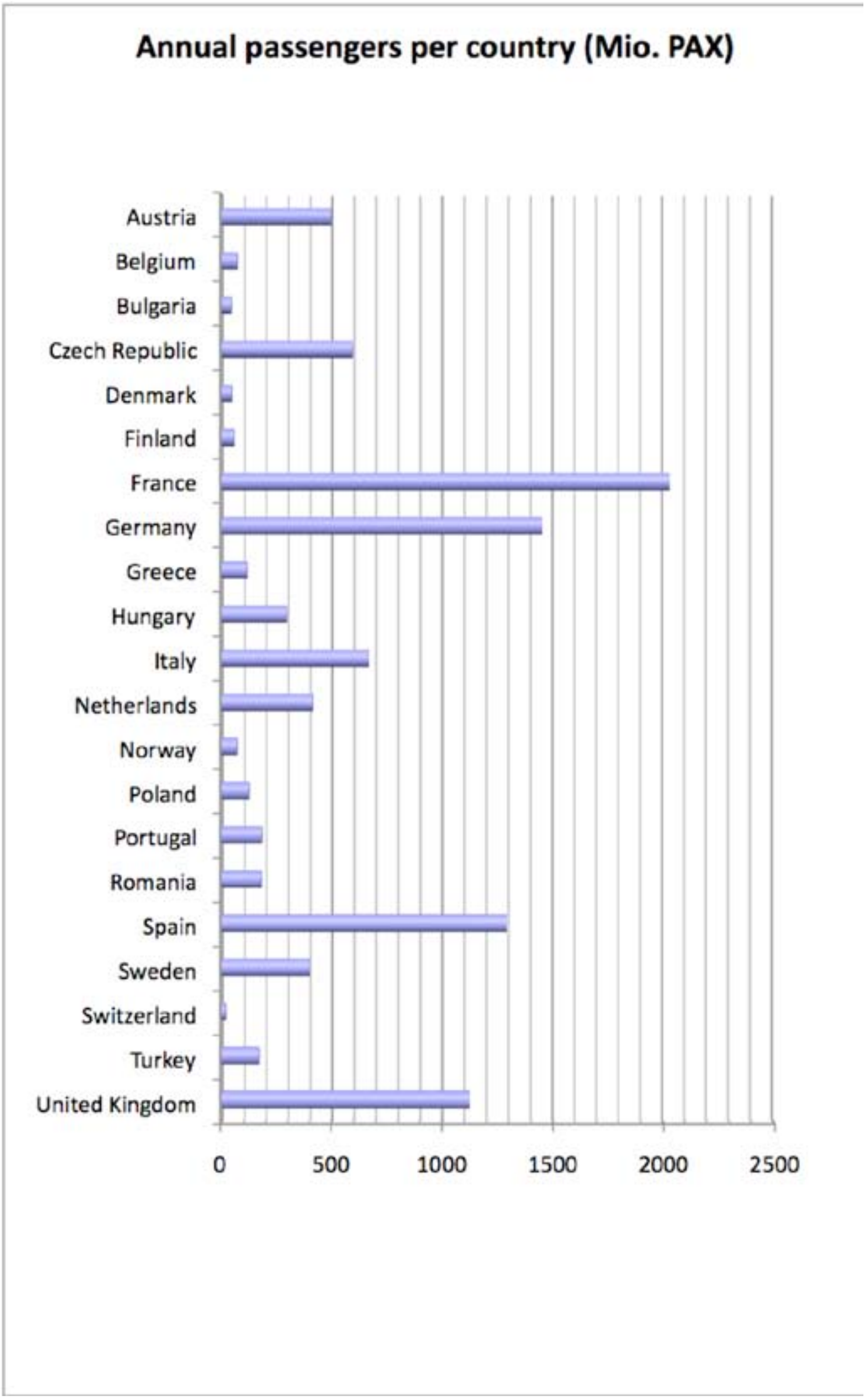


Chart 6


Annual passengers per country (Mio. PAX)
Austria
Belgium
Bulgaria
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Italy
Netherlands
Norway
Poland
Portugal
Romania
Spain
Sweden
Switzerland
Turkey
United Kingdom
0
500
1000
1500
2000
2500

COMPARISON TO LIGHT RAIL AND TRAM SYSTEMS

The 189 LR and tram networks carry approximately 10.4 billion passengers per year to be compared with 9.9 billion for 45 metro systems one clearly sees the high capacity of metro systems.

The figures in table 3 below show the amount of passengers being carried yearly in metro and in light rail and tram systems in relation to their network extent. One clearly sees the different functions of metro and light rail/tram systems with much higher traffic for metro systems generally serving major cities and/or dense areas.

Table 3

	Metro: Passengers (in Mio)/network extent (in km)	Light Rail and tram: Passengers (in Mio)/network extent (in km)
Total	**3.44**	**1.43**
EU-15	3.33	1.00
NMS	6.30	1.97
beyond EU-27	1.57	1.36

For EU-15 and NMS one kilometre of metro carries as average three times more passengers than a kilometre of light rail or tram. For B-27 countries three networks responded: for Switzerland and Turkey one find similar figures about 3.5 million passengers per kilometre of network; however for Norway the value is 0.9, due to the large extent of the Oslo network compared to the population served.

5. NETWORK DEVELOPMENTS

Network developments should be understood as: (i) line extensions or new lines under construction, or (ii) line extensions or new lines, which are planned.

DEVELOPMENTS UNDER CONSTRUCTION

At the time of the elaboration of this study 391 km of network extensions were **under construction** in 28 European cities and municipalities:

- 22 of all extensions (79%) with a length of 269 km (69%) are performed within the EU-15 country group;
- 4 extensions (14%) with a length of 52 km (13%) are taking place within the operators of the NMS; and
- 2 network extensions under construction (7%) with a length of 70 km (18%) are implemented beyond the EU-27.

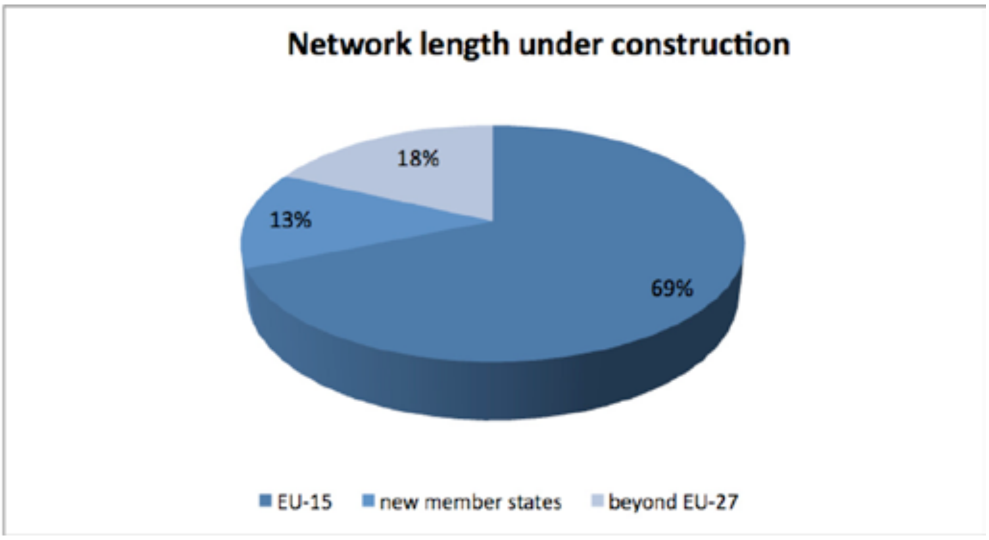
In comparison to the 2004 study with 149 km under construction, this means a total increase of 262% whereof 240% for the EU-15 country group, 743% for NMS and 233% for the group beyond EU-27.

From the figures which have been collected the following changes have occurred between 2004 and 2009:

- for EU-15, a clear priority is given to extensions of existing networks (2009: 114 km against 2004: 36 km), but the construction of new lines is also considerable (2009: 155 km against 2004: 76 km)

- for NMS, there is also an increase in network extension (2009: 16 km against 2004: 7 km) as well as in new lines (2009: 37 km against 2004: 0 km)
- for B-27, the construction of new lines is higher than in the last study (2009: 64 km against 2004: 15 km), but the extensions on the other hand are lower than in 2004 (2009: 7 km against 2004: 15 km)

Chart 7



PLANNED DEVELOPMENTS

For all the three country groups 23 cities **are planning** to create new metro systems or to extend their metro network by creating new lines or extensions with a total length of 396 km:

- 16 cities in EU-15 (70%) by a total of 202 km (51%);
- 4 cities (17%) within the NMS by a total of 73 km (18%); and
- 3 cities beyond EU-27 (13%) by by a total of 121 km (30%)

The collected figures show the following in comparison to the previous study in 2004:

- for EU-15, far less line extensions are planned (2009: 87 km against 2004: 146 km) and the similar situation applies to new lines (2009: 116 km against 2004: 158 km)
- for NMS, there is a focus on planned line extensions (2009: 44 km against 2004: 13 km), however the new lines show a more stagnant development (2009: 30 km against 2004: 32 km)
- for B-27, there is also a clear trend towards extensions (2009: 41 km against 2004: 4 km), but a decline can be noticed regarding new lines (2009: 80 km against 2004: 127 km)

Comparing the total length of planned extensions, new lines and planned lines with the previous study in 2004 a slight decrease can be identified in planned extensions in EU-15 (minus 33%) and in the countries B-27 (minus 8%) and an increase in the NMS (162%).

Chart 8

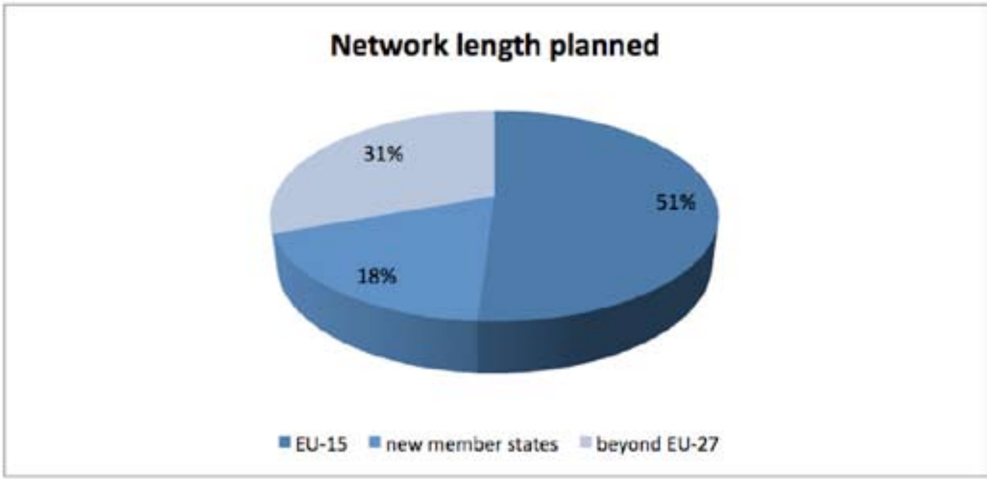
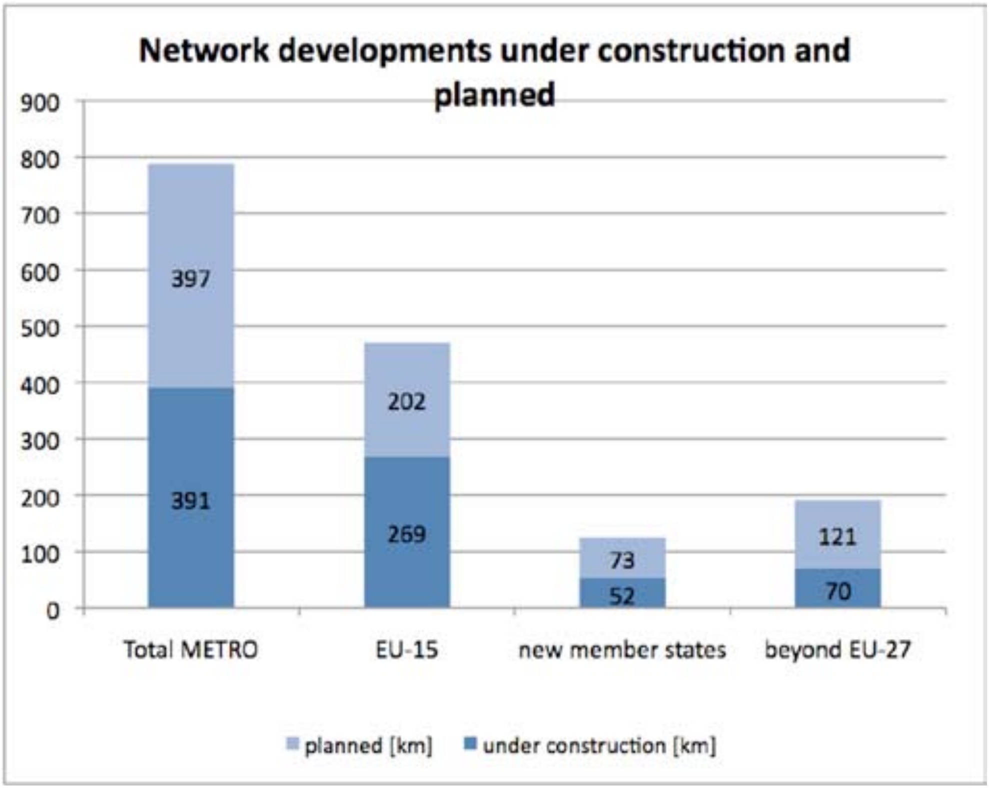


Chart 9



NETWORK DEVELOPMENT FOR UNATTENDED TRAIN OPERATION

Unattended Train Operation (UTO) is provided in 12 systems on 17 lines with a total length of 166 km; all systems besides one in Switzerland are situated in the EU-15 countries. In total there are 73.1 km under construction (53.3 km EU-15 and 19.8 km in NMS) and 51.5 km planned (41 km EU-15 and 10.5 in NMS). The financing of the planned and extensions under construction usually involves state's budget, EU grants and city and municipal budget. In two cases a project is developed in the form of public-private-partnerships.

COMPARISON TO LIGHT RAIL AND TRAMS

Table 4

	Metro under constr. (km)	LR under constr. (km)	Metro planned (km)	LR planned (km)
Total	**391**	**488**	**397**	**1086**
EU-15	269	425	202	810
NMS	52	17	73	48
B-27	70	46	121	228

Table 5

	Metro under constr. (in % of existing network)	LR under constr. (in % of existing network)	Metro planned (in % of existing network)	LR planned (in % of existing network)
Total	**13.6%**	**6.7%**	**13.8%**	**14.9%**
EU-15	10.7%	9.9%	8.1%	16.5%
NMS	26.3%	0.8%	36.9%	2.3%
B-27	41.7%	17.5%	71.8%	80.6%

Table 4 presents an overview of network developments in kilometres for both metro and light rail/tram systems which are currently under construction and which are planned. In table 5 these developments are given in percentage in relation with the current network extent of the related mode in the three different country groups.

Regarding metro systems under construction the B-27 countries are investing heavily into the contstruction of networks developments and are adding nearly one half of the existing infrastructure to the current networks. For the EU-15 countries the value lies slightly over 10% which is also related to the fact that the networks in these countries are already well extended. A similar result is visible regarding light rail extensions in NMS: with their already very large networks it is logical that there are hardly any (0.8%) needs for further extensions.

Huge network developments are planned in B-27 countries with over 70% increase for metro and over 80% increase for light rail and tram systems in comparison with the existing network extent. Indeed, these countries have still a huge development potential and are planning to allow for it.

Also the metro systems planned in NMS are outweighing the planned light rail and tram extensions by the factor 1.6; these countries also recognise the higher potential of metro systems for serving a high number of public transport passengers.

These ambitious plans especially for NMS and B-27 countries can only be achieved if sufficient resources are available as well as if a strong political support is given towards holistic urban mobility policy and planning.

6. METRO FLEET IN EUROPE

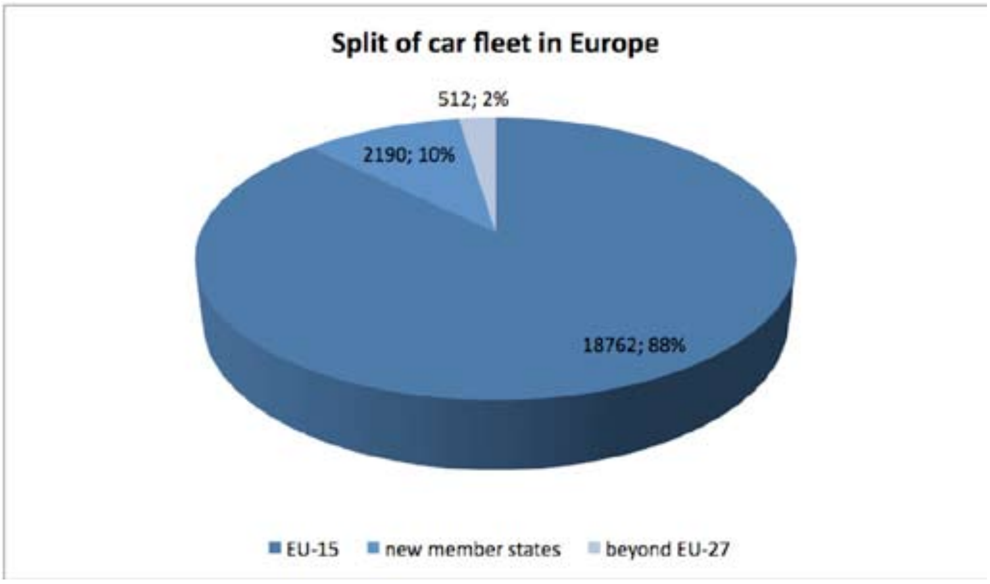
METRO FLEET OVERVIEW

A metro car is the smallest independent and inseparable unit that is coupled to train formations. Cars can be motorised or not and in many cases the smallest operating unit consists of two cars.

The total fleet in Europe amounts to about 21,500 cars. The EU-15 countries account for 88%, the NMS for 10% and B-27 for 2 % of the total fleet (see chart 10).

In relation to 2004 there is an increase of 12% in the amount of cars in EU-27 which could be explained by the entry of Romania and Bulgaria into the NMS and by the development of some new systems in the EU-15, like in France, Italy and the United Kingdom.

Chart 10



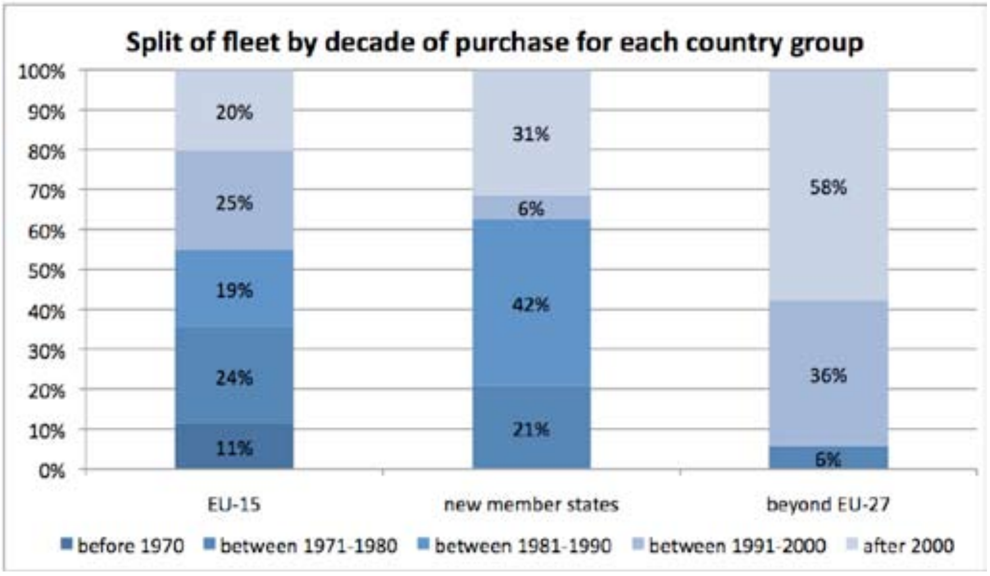
There are also some changes in the split of the purchase per decades for the metro fleet in Europe. Whereas in 2004 still 25% of the fleet in the EU-15 was purchased before 1970 it changed to 11% in 2009. At the same time the share of newly purchased vehicles (younger than 10 years) increased from 3% to 20% in the EU-15, from 10% to 31% in the NMS and from 17% to 58%.

The increase of new cars beyond EU-27 is the result of the fact that Romania and Bulgaria are now counted in another country group and the systems in Turkey and Switzerland were built quite recently.

For large companies, like in London or Paris it is hard to renew the oldest vehicle fleet at once due to limited investment funds. Therefore there are still some old cars in operation within the EU-15, but which are in most cases at least modernised.

It can be concluded that 35% (2004: 48%) of the EU-15 fleet, 21% (2004: 33%) of the NMS fleet and 6% (2004: 28%) of the B-27 fleet are over 20+ years and need to be replaced in the next decade (see chart 11 below).

Chart 11



ROLLING STOCK REPLACEMENTS

Estimating perspective car purchase market volumes one has first to consider the future needs for replacements of the fleet on the basis of the. The current situation is shown in chart 12 below.

The target life cycle of metro cars is usually 40 years. However, thanks to modernisation some metro cars can stay under operation one or event two decades longer. It has been assumed that one metro car among five would be modernised and last 10 years more in order to calculate the expected replacements as realistically as possible.

According to the surveyed data the expected replacements in the decade 2010-2019 will reach 1,707 vehicles; however nearly only inside EU-15 countries (2004: 4,300). The expected vehicle replacements will constantly rise over the decades: 2021-2030: 4,465 (2004: 3,385), 2031-2040: 4,610 (2004: 6,419) and 2041-2050: 4,895 (see chart 13).

Chart 12

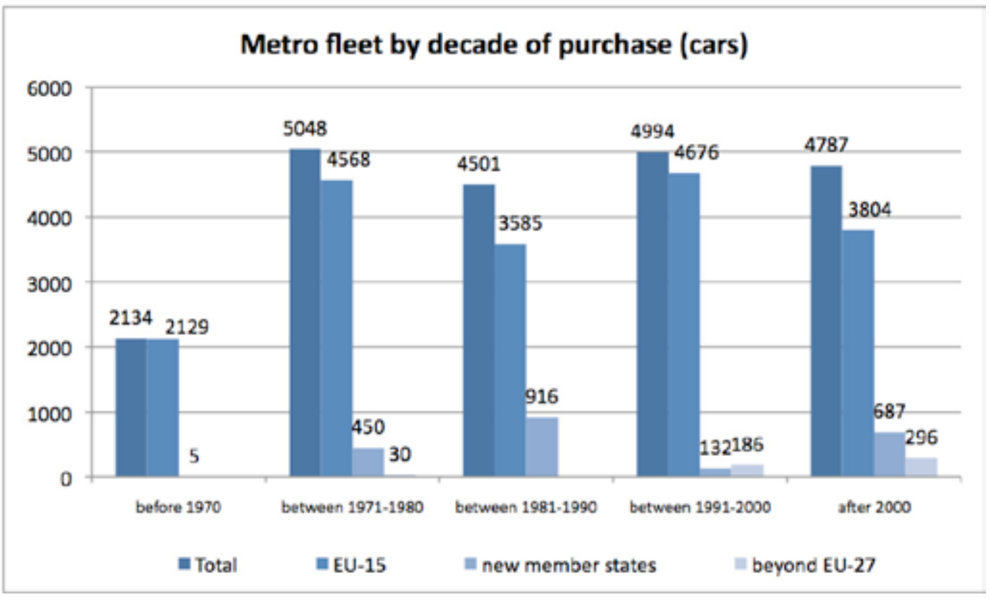
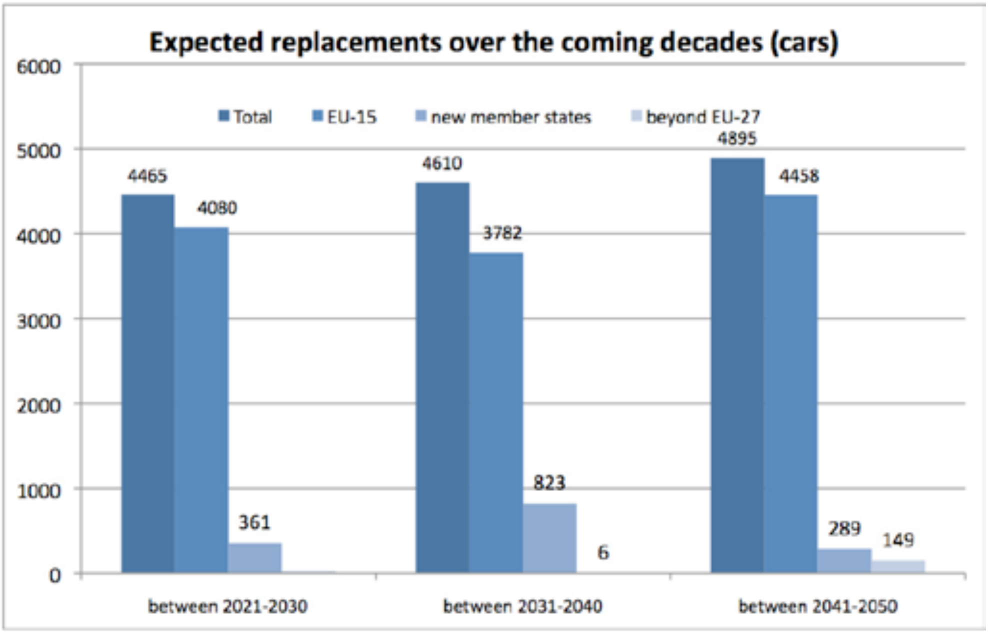


Chart 13



ROLLING STOCK NEEDS FOR NETWORK DEVELOPMENTS

Similary to the chapter on the light rail and tram market, forecast on the future needs of vehicles for network developments can be deducted from a basic ratio of vehicle per network-km. As mentioned this method is just an approximate trend indication and will not reveal the real situation, which is difficult to predict due to the influence of many economic and political factors. In the following table the used calculation ratios for each country group are given and a summary on the final expectations of metro car needs you can be found in chart 14.

Table 6

	Total	EU-15	new member states	beyond EU-27
metro cars	21,464	18,762	2,190	512
operated [network-km]	2,675	2,335	200	140
current cars/ network-km		**8.04**	**10.95**	**3.66**
under construction [km]	391	269	52	70
cars for constructions	**2,987**	**2,161**	**569**	**256**
planned [km]	396	202	73	121
cars for planning's	**2,865**	**1,623**	**799**	**443**
Total	**5,852**	**3,785**	**1,369**	**699**

In total 6,323 vehicles will be needed for network developments in the coming years, whereof the EU-15 countries will have the lion's share with 65%, the NMS 23% and the countries beyond EU-27 12%. Chart 15 shows the current metro car orders, which could be found within the literature and UITP sources.

Chart 14

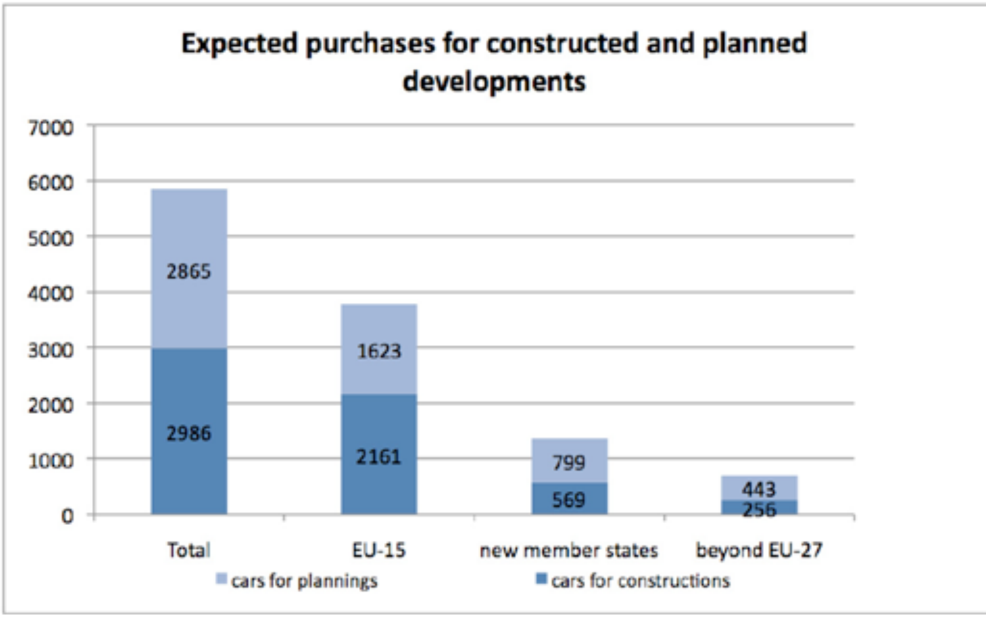
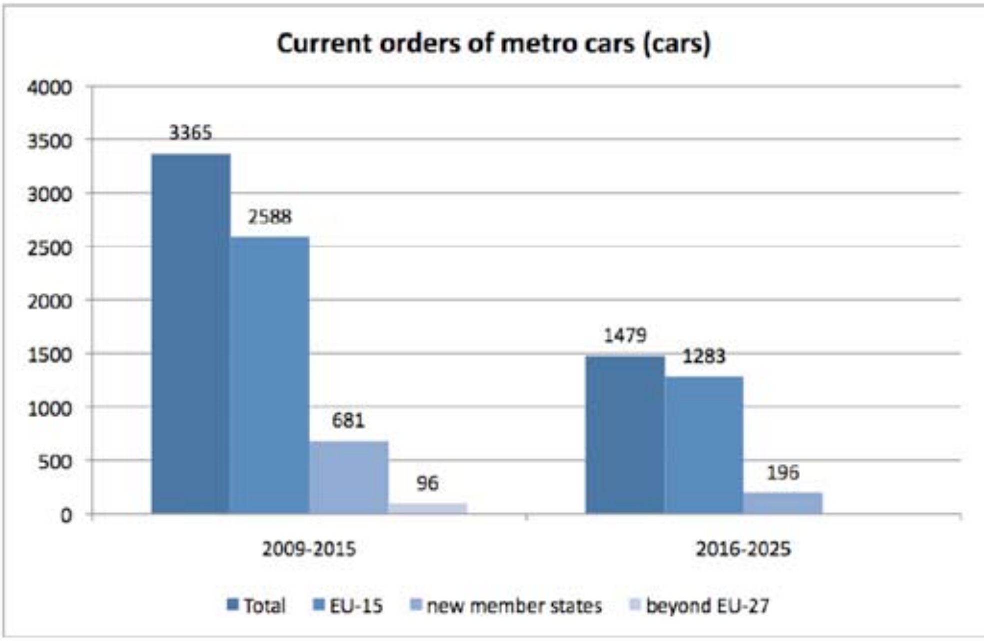


Chart 15



7. CONCLUSIONS

The market for metro is characterised by an enormous development potential for both infrastructure and rolling stock.

Concerning infrastructure in total 787 km are or will be being built (391 in construction [2004: 135 km] and 396 in planning [2004: 503 km]): this is an overall increase to 2004 of 23.4% (construction: 190% and planning: minus 78.7%).

Assuming an average construction cost of 130 million EUR/km (without rolling stock), the monetary evaluation of the market equals around 100 billion EUR over the next 20 years: around 50 billion EUR for lines in construction (2004: 17 billion EU) as well as 50 billion EUR for planned lines (2004: 65 billion EUR).

The difference regarding the planned lines between 2004 and 2009 is remarkable, but might be linked to a more conservative planning due to the economic crises rather than a saturation effect. Furthermore in the four years between the two studies many new metro lines or extensions have been constructed.

Taking into account the research on infrastructure activities ranges between 1% and 2% of the construction costs the investments in R&D would be between 1 and 2 billion EUR.

In terms of rolling stock the forecast for the period 2010-2030 including both replacements and developments can be estimated around 15,000 vehicles (2004: 14,000). A turnover of 22.5 billion EUR (2004: 21 billion EUR) is calculated when taking into account the average cost of 1.5 million EUR per car. Assuming that R&D expenditures related to rolling stock account for 1.5% an investment of 340 million EUR is to be assumed.

LIGHT RAIL AND TRAM SYSTEMS IN EUROPE – 2009

1. INTRODUCTION

For the scope of this study, light rail has to be understood along the UITP definition, i.e. as a public transport system permanently guided at least by one rail, operated in urban, suburban and regional environment with self-propelled vehicles and operated segregated or not segregated from general road and pedestrian traffic. This broad definition includes all possible forms inside the continuum from a classical tram (not segregated) to a metro (fully segregated).

Basis for the study has been an extensive questionnaire sent to the existing light rail and tramway systems as well as additional data collected through further UITP channels. The replies to the questionnaire have been sometimes very different in number depending on the question. As a whole in this study the collected data is presented in an aggregated way at the level of a country or a group of countries. There are three country groups:

- Former EU 15 countries (**EU-15**)[3]
- Countries of the last extensions of the EU (Poland, Czech Republic, Bulgaria, Hungary, Romania, Slovakia, Estonia, Latvia) (**new member states; NMS**)[4]

[3] Without Denmark and Luxembourg as there are no light rail or tram systems

[4] New member states not mentioned do not possess light rail or tram systems

- Other countries beyond EU-27 and candidate countries (Norway, Switzerland, Bosnia Herzegovina, Serbia, Croatia and Turkey) (**beyond EU-27; B-27**)

It was decided not to aggregate the current EU-27 countries because the light rail and tram market features are still too heterogeneous and would have weakened the interpretation of the results.

The objective of this study is first to give an update of the situation displayed in the 2004 version of the "Light Rail and Metro System in Europe" study. **Besides comparing the situation in 2004 and 2009 this study also provides additional information concerning passenger traffic and infrastructure characteristics including the grade of separation from general road traffic.**

2. SYSTEM DATA: EUROPE-WIDE OVERVIEW

Out of the total existing 189 tram or light rail systems for the three country groups 169 systems are located inside the current EU-27, which stands for nearly 90% of all systems; 126 systems (66%) belong to the EU-15 and 43 systems (23%) to the NMS. The comparison with the 2004 study shows that there are 16 more systems as a whole in the three country groups; this means an increase of almost a 10% of the total number of networks in five years. A more detailed look reveals that since the 2004 survey two systems were closed in the NMS, two were opened in the B-27 and 18 were opened and two were closed in the EU-15 countries. A more detailed overview between the three country groups is provided in table 3.

Chart 1

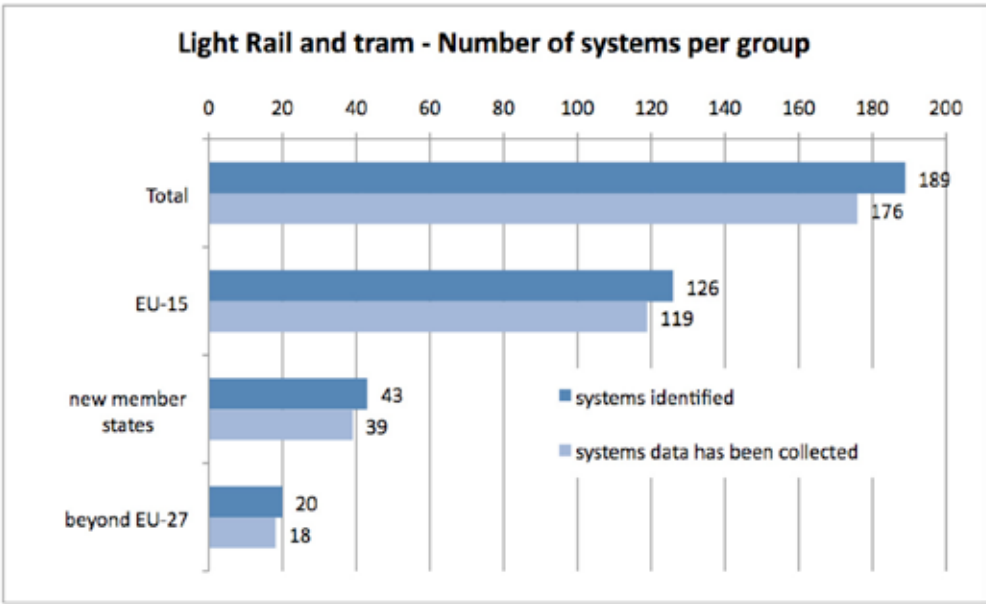
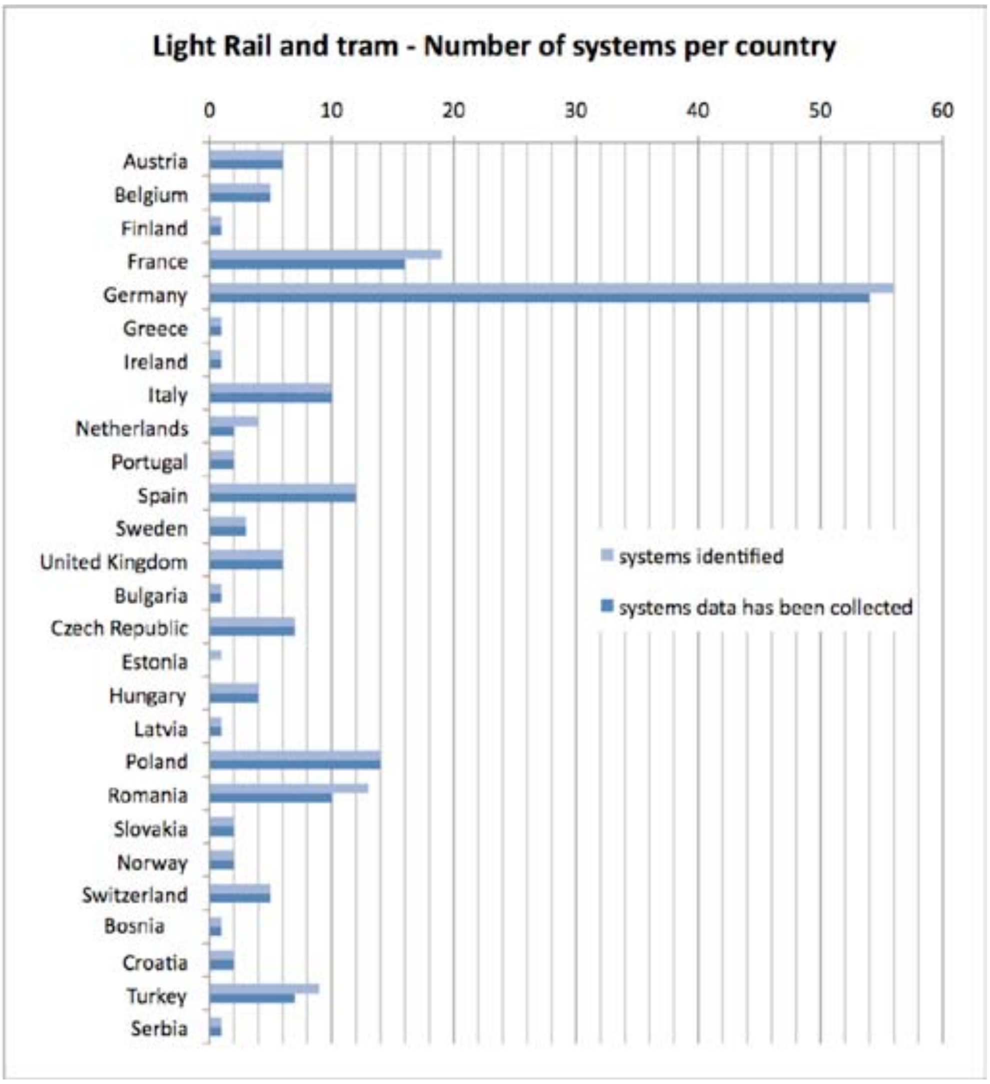


Chart 2



In whole Europe, based on 176 systems, which were responding to the questionnaire there are 1,149 lines operated over a total accumulated length of lines of 14,676 km. Out of this total 1,064 lines with a length of 13,924 km are operated within the EU-27, which means that nearly 92% of all lines and 95% of the total line length are located within EU-27.

Table 1

	Number of responding networks	Lines	Line-km	Average number of lines per system	Average length of line (km)
EU-15	119	636	8,348 (57%)	5.3	13.1
NMS	39	428	5,576 (38%)	11.0	13.0
B-27	18	85	752 (5%)	4.7	8.8
TOTAL	**176**	1,149	14,676	6.5	12.8

The above table shows a significant difference between the average numbers of lines per system; with the NMS containing in average 11 lines which is about twice the lines per system compared to the two other country groups. However the average length of line is quite identical for the NMS and the EU-15 with 13 km, while it is only 2/3 of it for the B-27 (9 km).

Information was also collected on network extent. Contrary to the line length which is related to operating conditions the network length is a physical characteristic of the layout of the system. Each part of the network can accommodate one or more tracks and each track can be used by one or more lines. From a total of 132 replying networks, which are gathering a total network extent of 7,303 km, the average network length is 54.9 km over which are operated in average 1.65 lines per kilometre. Concerning each of the three country groups the following table shows the distribution of these figures:

Table 2

Country group	Number of responding networks	Total network extent (km)	Average network length per network (km)	Average number of lines per km of network
EU-15	98	4,918 (67%)	50.2	1.48
NMS	26	2,122 (29%)	81.6	2.37
B-27	8	263 (4%)	32.8	1.32
TOTAL	**132**	7,303	55	1.65

Table 2 shows a significant difference concerning the average network length per network as per country group. In the NMS the average network is 1.6 times longer than in the EU-15. Similarly the average number of lines per km of network is 1.6 times higher than in the EU-15. This shows that there are probably different approaches to the operation between both country groups especially regarding the dilemma of extension/concentration of the network layout in relation with the investment and maintenance expenses as well as of the diversification/simplification of the lines in relation to the easiness of use for the passenger. NMS need to reconsider the most viable layout of their networks also in regard of level of priority which can be provided for light rail systems against general road traffic; see below.

Chart 2 (189 systems)

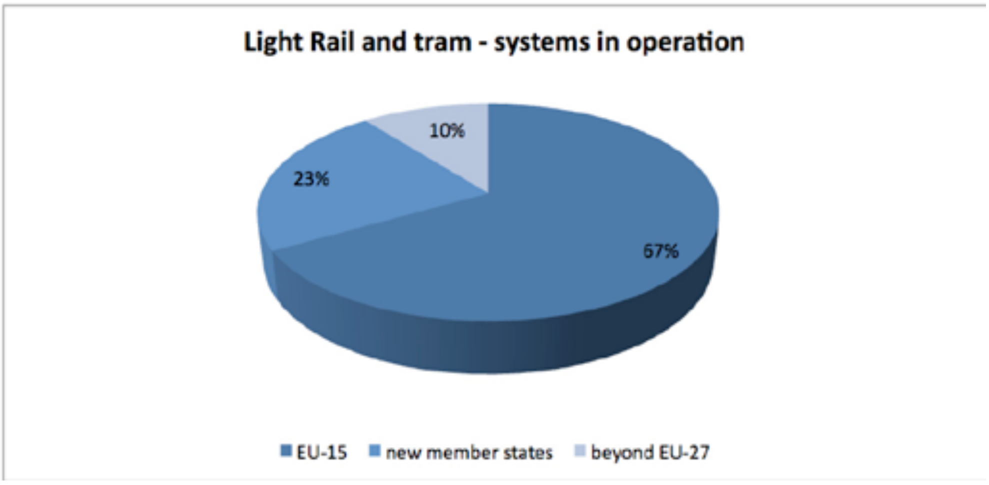


Chart 4 (176 systems)

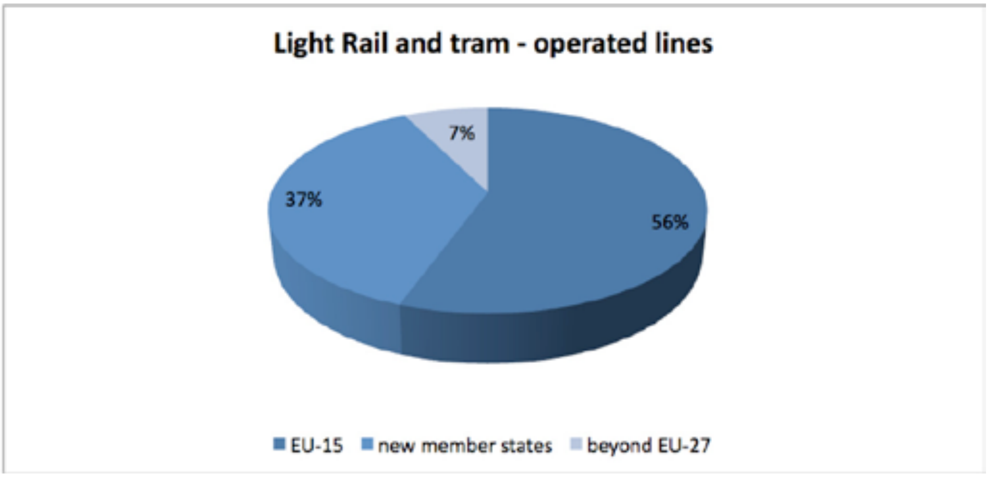


Chart 5 (176 systems)

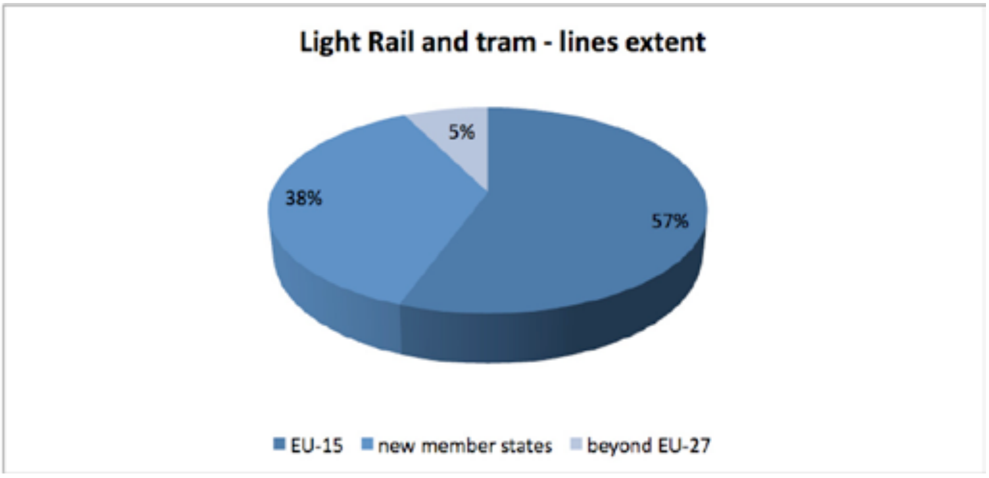
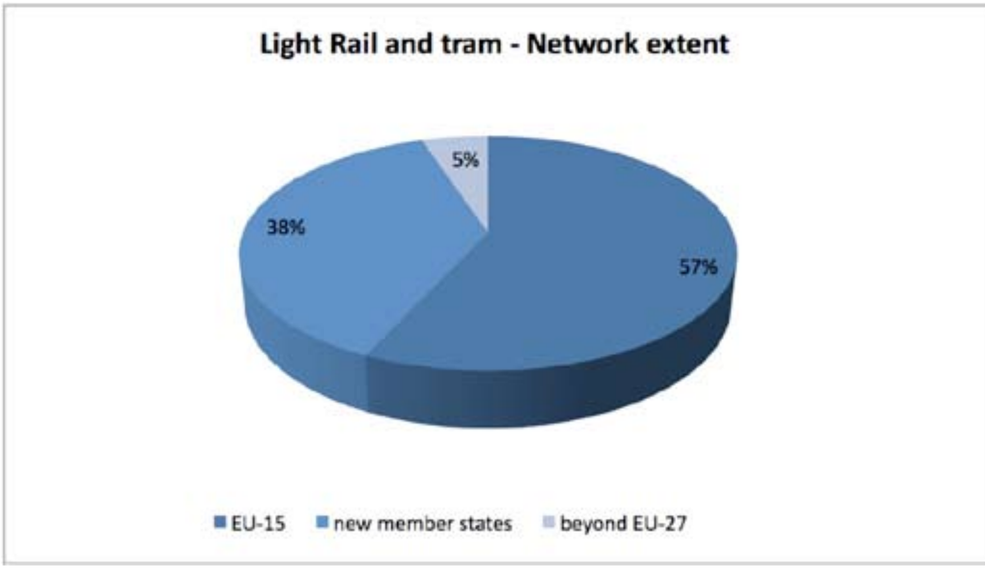


Chart 6 (176 systems)



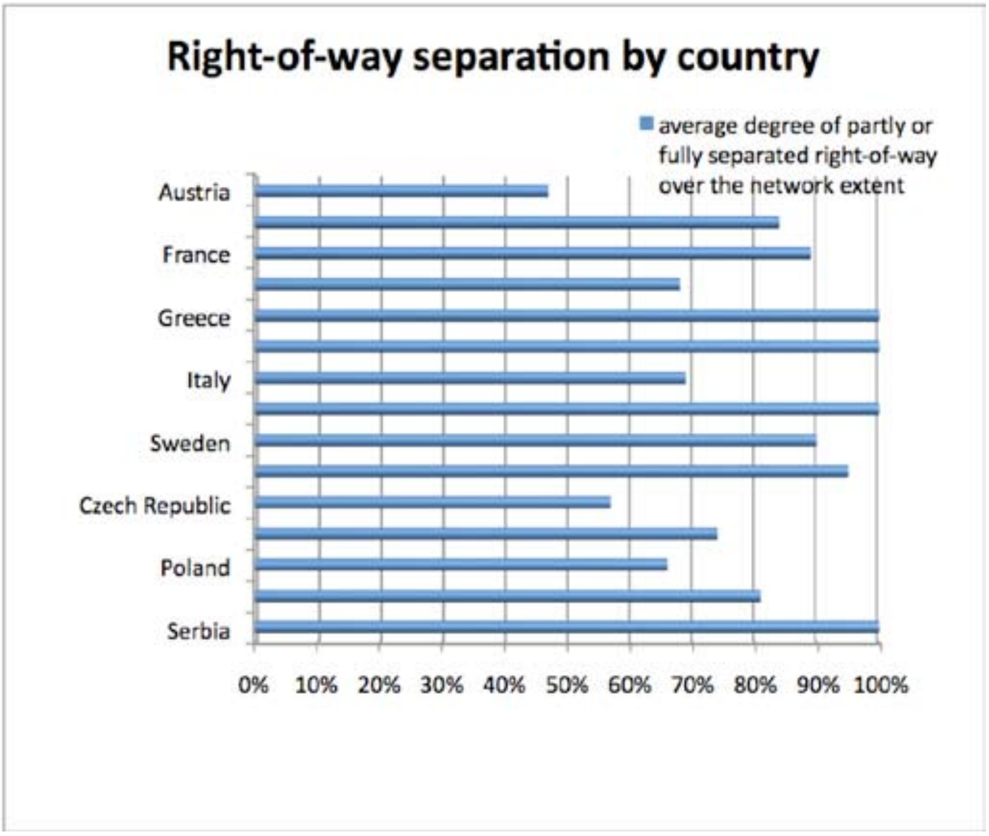
3. PHYSICAL PRIORITIES FOR LIGHT RAIL SYSTEMS AGAINST THE GENERAL ROAD TRAFFIC ("SEPARATION FROM GENERAL TRAFFIC")

OVERALL FIGURES

The separation from general road traffic can be achieved either through the reservation of lanes (identified by road marking or flat kerbstones), or through the creation of separated right of ways (ROW) which can be either partially separated except at crossings or fully separated through grade separated infrastructure (elevated or underground).

Depending on the specific question only up to 74 networks have replied to the questions about the level of track protection. Regarding the network length these networks show an overall average of 75% of separated ROW operation whereof the following percentages account for the different country groups: EU-15 74%, NMS 63% and B-27 87%; however only the companies (representing 20 networks) from four countries out of the group of NMS provided the required information: a degree of separation could be calculated for the Czech Republic 57%, for Hungary 74%, for Poland 66% and Romania 50%. Beyond the EU-27 it can be pointed out that Turkey as an upcoming light rail country has a very high separation of the tracks from the normal road and pedestrian traffic and offers a high commercial speed (see chart 7). It is evident that there is some leeway for enhancing the state of separation for systems in all these countries; especially Romania as well as the Czech Republic.

Chart 7 (73 systems)



The chart above provides information about the level of protection of the network from general road traffic in the percent of network extent benefitting from any kind of separation as stated above. It is proven that the efficiency of the operation of a network in terms of commercial speed and regularity is fully correlated to the level of protection of the network. The chart shows that in several countries the level of protection is most often 100%[5]. Most of these countries had abandoned their tram systems in the 1950s and decision makers have understood that a high level of separation is a prerequisite for a successful operation and that in order to achieve this, a novel approach of land-use policy and space allocation between transport modes as well as urban activities is mandatory. The implementation of new systems is especially demanding and needs a strong and persistent political will (especially before and during the construction phase) due to long existing city traffic environments favouring private car use.

COMPARISON OF THE EU-15 AND THE NEW MEMBER STATES

Based on the indicator “number of systems per 1 million inhabitants” the situation in NMS is very similar to that of the EU-15: it ranges between 0.14 to 0.77 for the NMS and between 0.09 and 0.68 for the EU-15.

In terms of network extent per 1 million inhabitants the customers inside the NMS profit from a high factor: it ranges from 13.5 to 60.0; whereas for the EU-15 the factor lies between 2.22 and 38.7.

Concerning the number of systems per 1 million inhabitants the Czech Republic (0.68) and Estonia (0.77) can be compared with Germany (0.68). Three other NMS countries (Romania, Latvia and Hungary) have a higher factor than 0.4 in this category and can be compared with Belgium.

The NMS country, which has the lowest number of systems per 1 million inhabitants, is Bulgaria with 0.14; but it is however in terms of network extent per 1 million inhabitants with 42.8 in the leading ranks. UK and Greece are on the lowest levels of both before mentioned indicators in the EU-27.

Concerning the factor “network extent per 1 million inhabitants” there is a clear difference between the countries which closed down their networks in the 1950/60s (e.g. Spain, France, Italy, etc.) and the ones which kept their systems running (e.g. Austria, Germany, Poland etc.); however in the latter case several NMS (like Bulgaria, Latvia or Czech Republic) display clearly a higher level of infrastructure coverage than any of the EU-15 countries.

[5] Data for networks with 100% ROW do not take into account cross-roads and street-crossing

Table 3

	Systems	Network extent (km)	Population (2009 in Mio.)	Systems / 1 Mio. inh	Network extent (km) / 1 Mio. inh
Germany	56	3184	82.3	0.68	38.7
Belgium	5	314	10.4	0.48	30.2
Spain	12	194	40.6	0.30	4.8
France	19	490	64.1	0.30	7.6
Italy	10	372	58.1	0.17	6.4
United Kingdom	6	155	61.1	0.10	2.5
Netherlands	4	345	16.8	0.24	20.54
Sweden	3	122	9.1	0,33	13.41
Ireland	1	24	4.3	0.23	5.58
Austria	6	314	8.2	0.73	38.29
Portugal	2	85	10.7	0.19	7.94
Greece	1	24	10.8	0.09	2.22
Finland	1	91	5.3	0.19	17.17
Czech Republic	7	422	10.3	0.68	50.0
Romania	13	661	22.2	0.59	29.8
Latvia	1	123	2.2	0.45	60.0
Hungary	4	337	9.9	0.40	34.0
Slovakia	2	74	5.5	0.36	13.5
Poland	14	905	38.5	0.36	23.5
Bulgaria	1	308	7.2	0.14	42.8
Estonia	1	39	1.3	0.77	30.00

4. COMPANY PROFILE

COMPANY OWNERSHIP

In comparison and addition to the 2004 study this document provides the reader also with some information about the grade of privatisation of the sector based on 79 responses to this question.

Within this sample 68 represent public companies, 4 private companies and 7 operate within a shared ownership. In detail 83% of the operators inside EU-15 and beyond the borders of the current EU-27 and over 90% for the NMS are public companies. This information is probably not representative for the real situation of the private ownership of companies due to the low response rate in countries like France where the private sector is largely represented.

Chart 8 (79 systems)

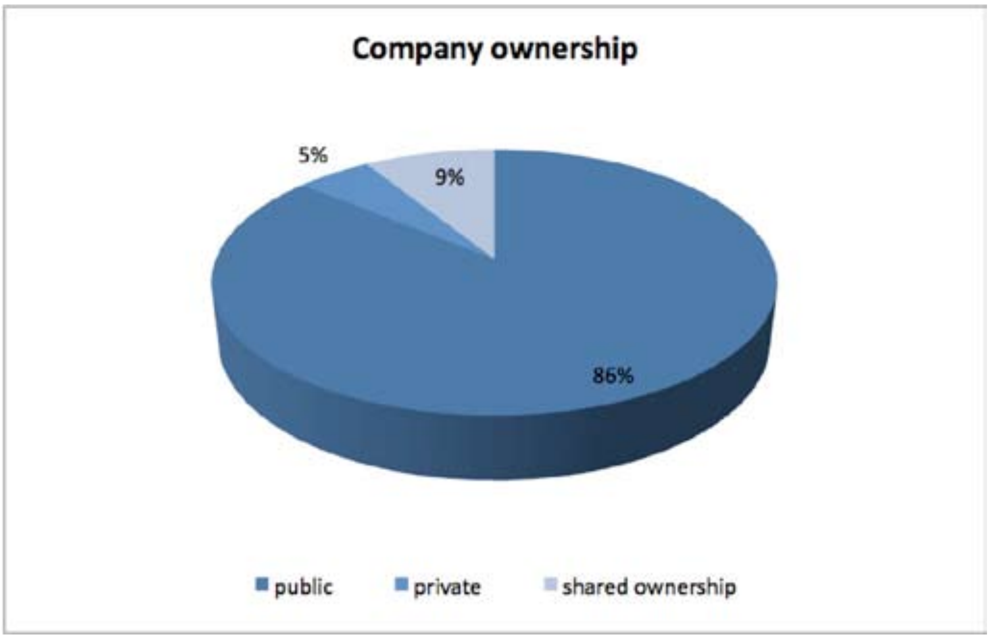
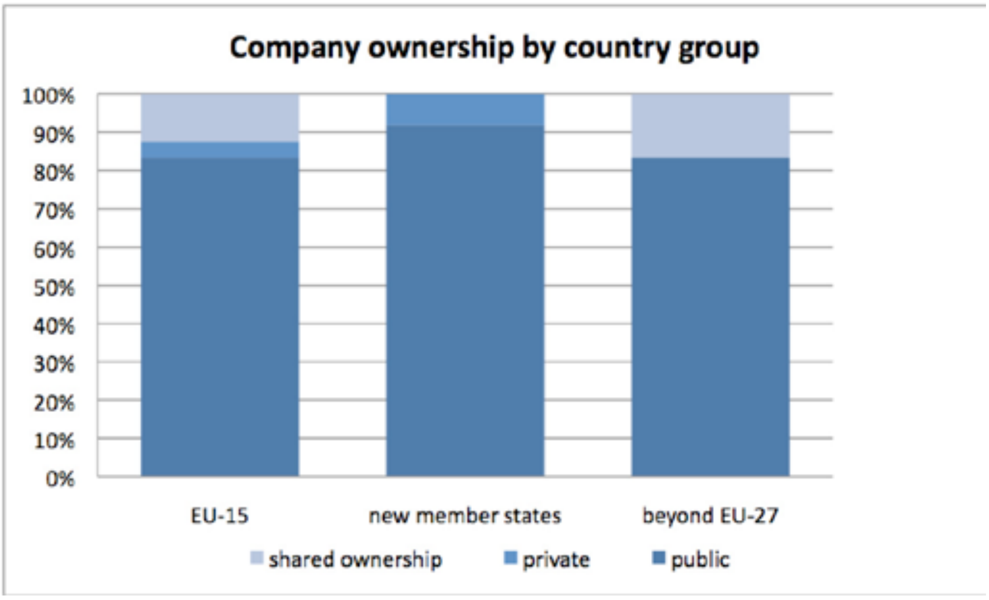


Chart 9 (75 systems)



OWNERSHIP OF THE ASSETS OF THE COMPANY

Out of 75 replies around 60% of the infrastructure and 75% of the rolling stock is owned by the operators. From the sample it appears that the situation is very diverse; e.g. in Hungary and most of Belgium networks the companies are the owners of both infrastructure and rolling stock while in Germany or Poland the situation is much more different. Replies from Romania showed a large public ownership of the networks' assets.

Chart 10 (75 systems)

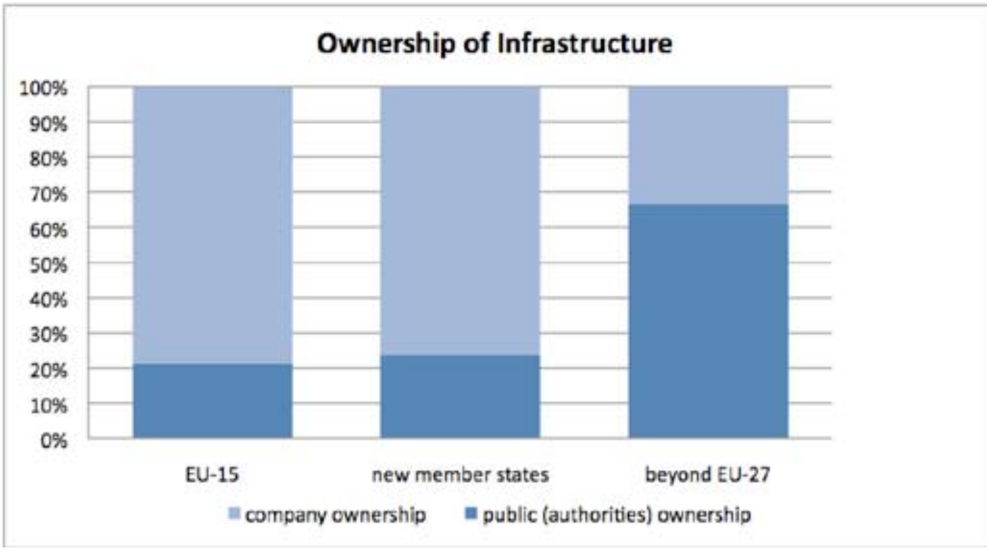
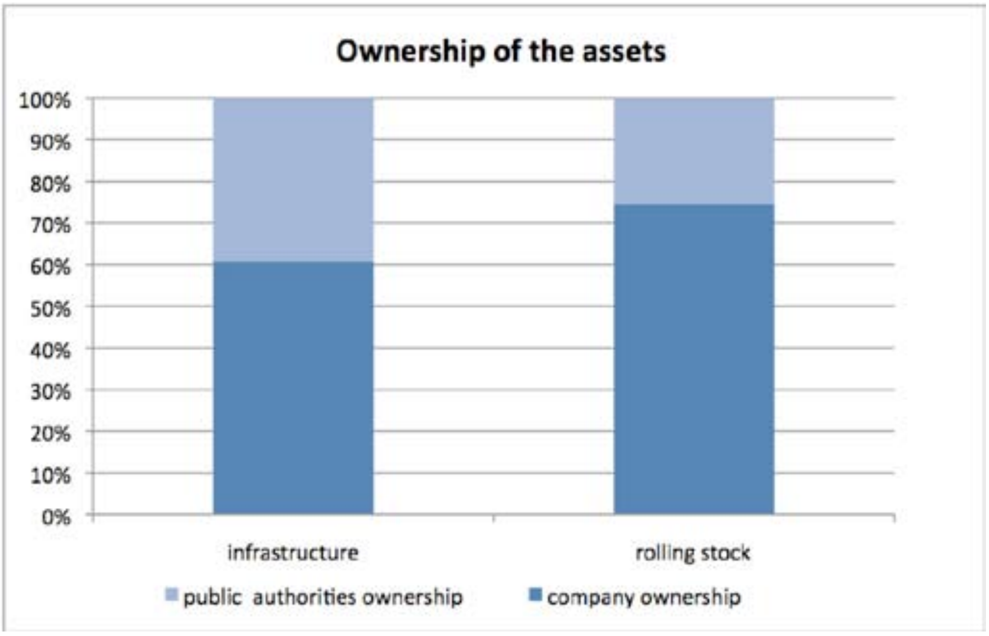


Chart 11 (75 systems)



PUBLIC SERVICE CONTRACT

Among 69 replies 71% of the public service contracts are directly awarded while only 12% are awarded by a call for tenders and the remaining networks (17%) have no public service contract.

Independently from the received answers one can say that the application of call for tenders is closely linked to the “tradition” of each country in terms of tendering public services in general (e.g. in France such tenders have been commonly used since decades). However the situation is about to change considerably in the coming years; especially for the 17% “no contract” cases. This is due to the enforcement of the Regulation (EC) 1370/2007 on public service requirements, which demands the signature of a contract once final compensation and/or exclusive rights are involved. Call for tenders are often used for the “brand-new” light rail systems, e.g. in UK, Spain, Italy or Turkey.

Chart 12 (69 systems)

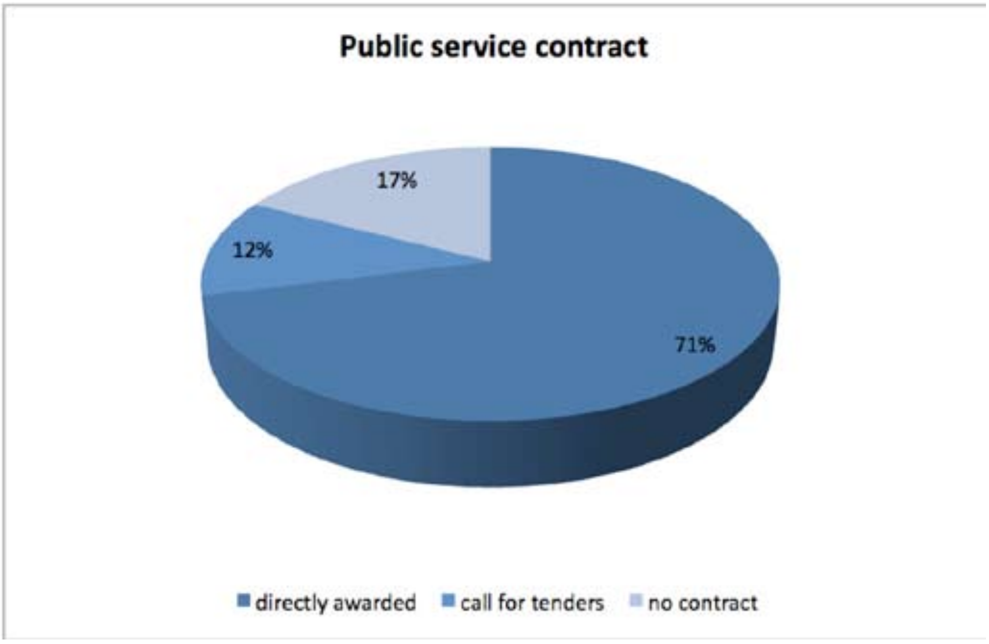
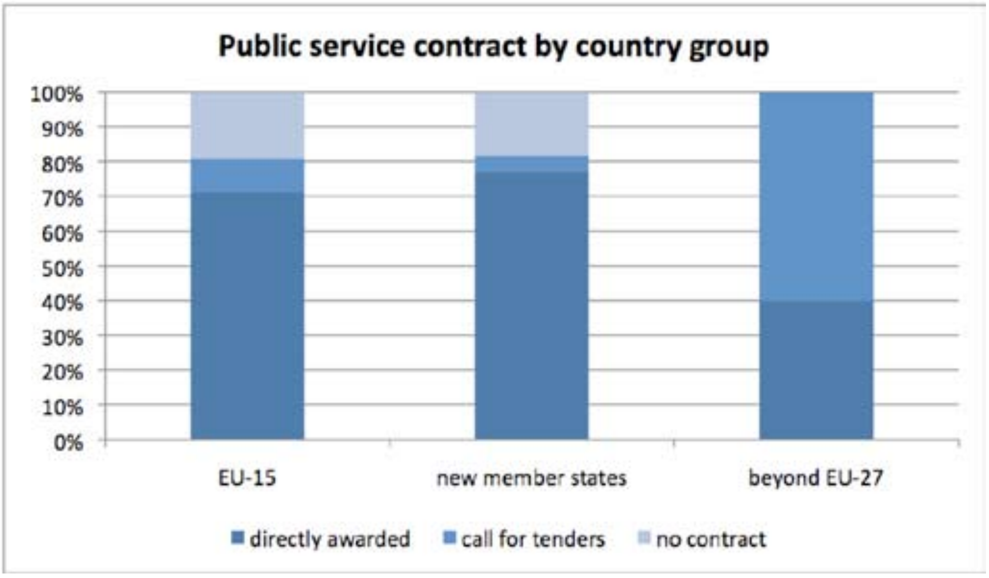


Chart 13 (69 systems)



NUMBER OF STAFF

The staff employed for the operation of tram and light rail services from the 97 replying networks amounts to 52,675 persons devoting their daily work on the running and maintaining tram lines. Out of these 44% are from the NMS, 53% from the EU-15 and 3% from the B-27. Correlating these figures with the network extent of these systems the average amount of staff per average network kilometre is 7 in the EU-15, 13 in the NMS and 14 for B-27.

Taking into account the passenger numbers for the networks which replied to this question one staff member is on average "responsible" for the following amount of passengers in the concerned country groups: 94,133 passengers in EU-15, 142,244 passengers in NMS and 126,592 passengers in B-27.

5. TRAFFIC DATA

This chapter is providing information, which was not collected in the 2004 survey.

ANNUAL NUMBER OF PASSENGERS

This question has been answered by 158 (84%) out of 189 LR systems (108 out of 126 for EU-15, 34 out of 43 for NMS and 16 out of 20 for beyond EU-27). These 158 networks carry 8.743 billion passengers per year (55.3 million passengers per year per network on average). **This leads to an estimate of about 10.4 billion passengers for the 189 networks.** It is interesting to note that the average number of passengers carried per network is 3.14 times higher for NMS networks than for EU-15 systems (average 97.5 million passengers per year per network for NMS countries and 40 million passengers per year per network for EU-15). The countries beyond EU-27 lie in between, carrying as an average 66 million passengers per year per network, i.e. 1.11 times more than the average for EU-15 networks.

This figure of 10.4 billion passengers per year for tram and light rail systems can be compared to the yearly passengers of the suburban and regional railways, which was estimated at 6.8 billion passengers per year in 2006).[6] This means that tram and light rail networks in Europe would carry considerably more passengers than suburban and regional rail systems.[7]

With a more detailed view on the yearly number of passengers Germany ranks first, with about 2.28 billion passengers for 46 replying networks (on average 49.6 million per network), which equates almost 26% of the total amount of passengers from the 158 replying systems, and 53% of the total for the 111 replying systems from EU-15. The second country is Poland with 1.7 billion passengers for 13 systems (on average 55.3 million per network) representing 19% of the total number of passengers for all 158 replying sytems and 50% of the total number of passengers for 34 replying NMS systems. The third in rank is the Czech Republic (681 million for 7 networks; i.e. on average 97.3 million per network), followed by France with 576 million for 16 systems (on average 36 million per network). Romania with 511 million is ranked fifth, but only 7 out of 11 networks replied (on average 73 million per network) from this country.

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[6] Suburban and Regional Landscape in Europe – ERRAC study 2006

[7] The figures can also be compared with the approximate number of 800 million air passengers per year in Europe and 1,000 million rail passengers using long distance national and international services in Europe.

Table 4

	Inhabitants (Mio.)	Annual number of passengers for 158 responding networks (Mio.)	Estimated annual number of passengers for all 189 systems (Mio.)	Average number of trips per inhabitant
EU-15	382	4,278	4,920	11.2
new member states	97	3,411	4,190	35.2
beyond EU-27	107	1,055	1,320	12.4
TOTAL	**586**	**8,743**	**10,430**	**14.9**

Chart 14 (158 systems)

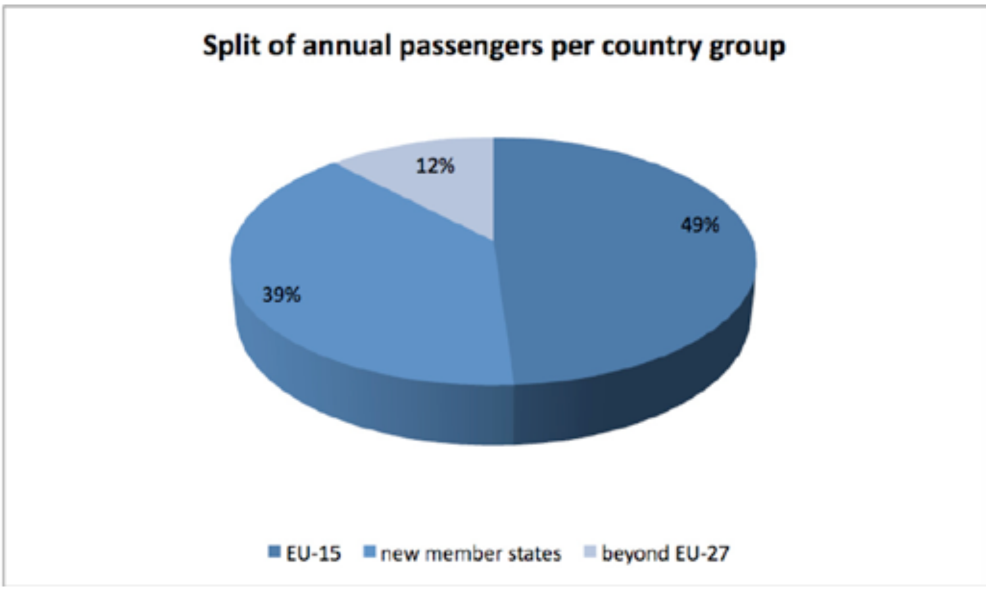
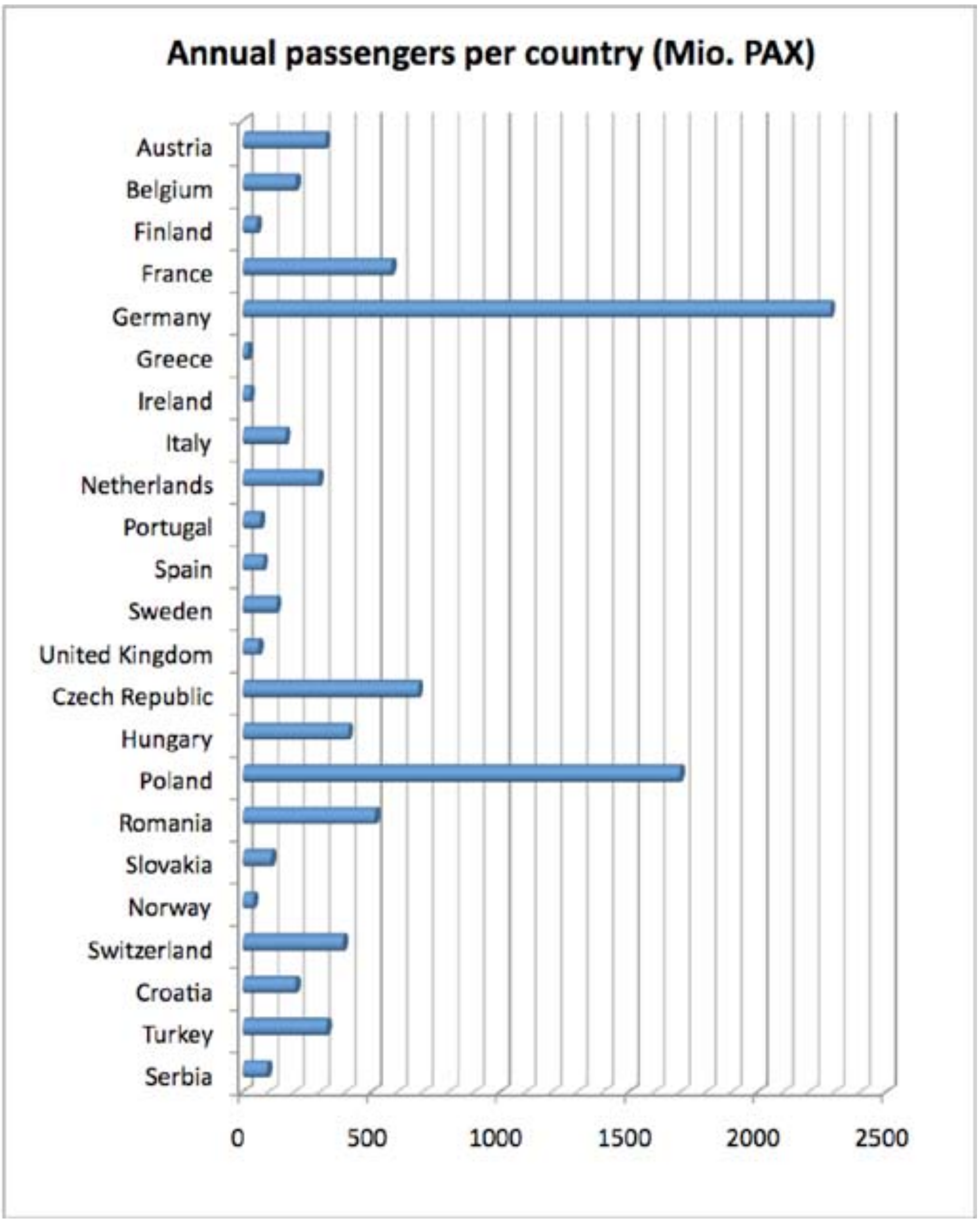


Chart 15 (158 systems)



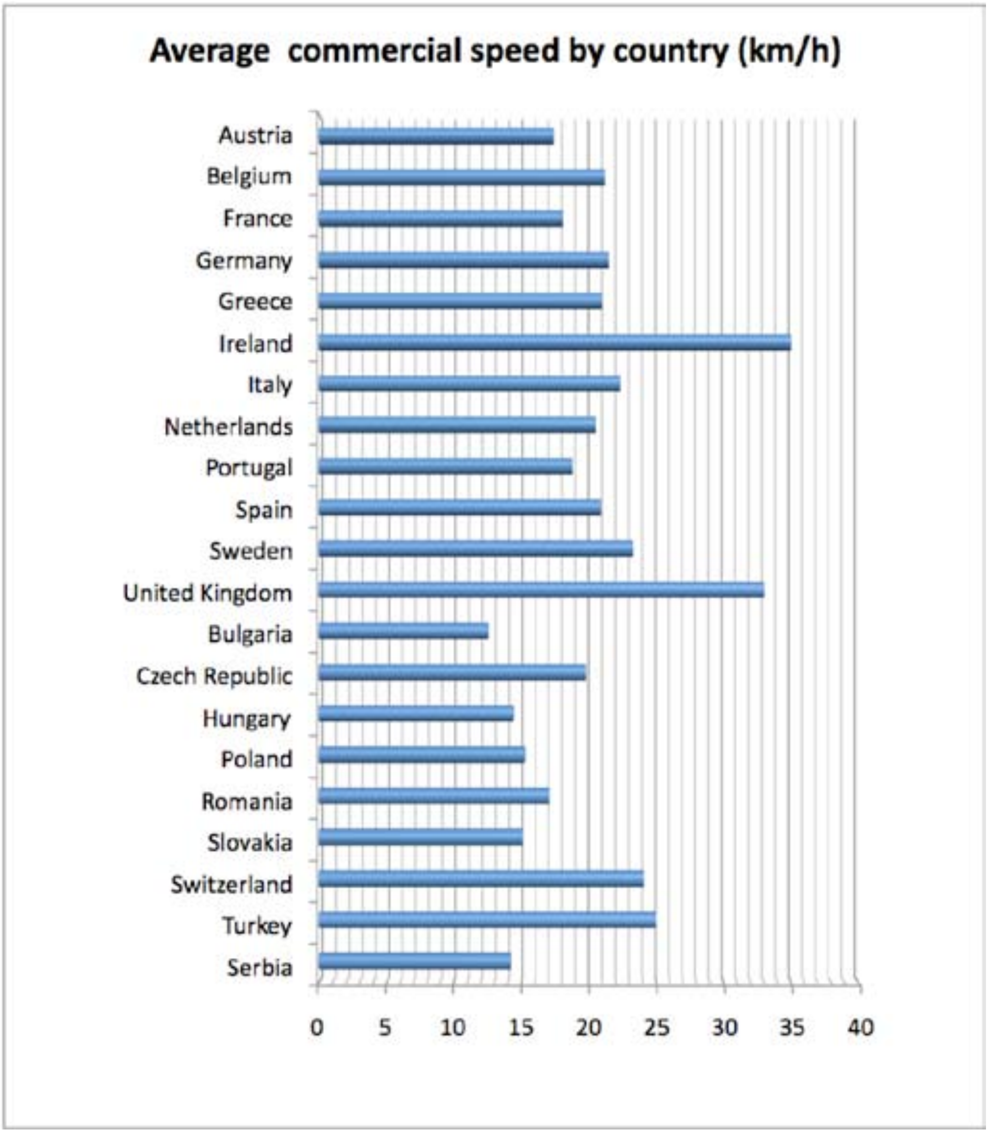
AVERAGE COMMERCIAL SPEED

One indicator to quantify the quality of a tram or light rail service is the average commercial speed, which indicates the average speed with which passengers are carried. This factor helps drawing tentative conclusions on the quality of the separation of the ROW and the acceleration (in terms of the priority on crossroads) of the tram or light rail system. However, the commercial speed is also influenced by the distances between the stops, the boarding/alighting time at stops and other factors.

Table 5 (105 replying systems)

	Average commercial speed (km/h)
EU-15	22.76
NMS	15.71
beyond EU-27	21.10
TOTAL	19.86

Chart 16 (105 replying systems)



From the sample above one can notice that in the former EU-15 the commercial speed is much higher (by 45%) than in the NMS. Hence, based on the figures it seems that there is still a huge potential for the NMS to raise the attractiveness of their tram and light rail systems by increasing the commercial speed through improved priorities for light rail against general road traffic by means of protection of ROW as well as traffic light prioritisation at cross-roads.

6. NETWORK DATA

NETWORK DEVELOPMENT

Network developments should be understood as: (i) line extensions or new lines under construction (including municipalities introducing a tram or light rail system for the first time or reintroducing it after a time of absence); (ii) line extensions or new lines, which are planned.

OVERALL FIGURES

At the time of the elaboration of this study 40 cities and municipalities in the EU-15 have a total length of 488 km **under construction**; this figure includes 16 new systems under construction (total length of 226 km).

A further 55 cities and municipalities have **planned** a total length of 818 km of network extensions whereof 15 **new** systems are **planned** with a total extent of 268 km.

DEVELOPMENTS UNDER CONSTRUCTION (LINE EXTENSIONS OR NEW LINES)

From the figures which have been collected it seems that a change has occurred between 2004 and 2009:

- for EU-15, a clear priority is given to extensions of existing networks (2009: 199 km against 2004: 154 km) against a dramatic decrease in the construction of new systems (2009: 226 km against 2004: 455 km)
- for NMS, extensions are underway (17 km), but similar to 2004 no new networks are being constructed
- for B-27 (46 km), there is an increase in the development of the existing networks, but contrary to 2004 no entirely new systems are currently built
    - Planned developments (line extensions or new lines)

The figures that have been collected show that there is a similar trend for planned network developments:

- for EU-15, there are far less new systems planned (2009: 268 km against 2004: 859 km) and a bit more extensions of existing systems (2009: 542 km against 2004: 478 km)[8]
- for NMS, it seems that the amount of planned extensions is increasing (2009: 48 km against 2004: 5 km)
- for B-27, there is a global increase in the length of extensions (2009: 228 km against 2004: 131 km), but in 2009 no new system is planned while in 2004 four were foreseen

In the 2004-2009 period several new systems have been constructed (especially inside B-27), for which extension are currently planned in order to serve the increased ridership.

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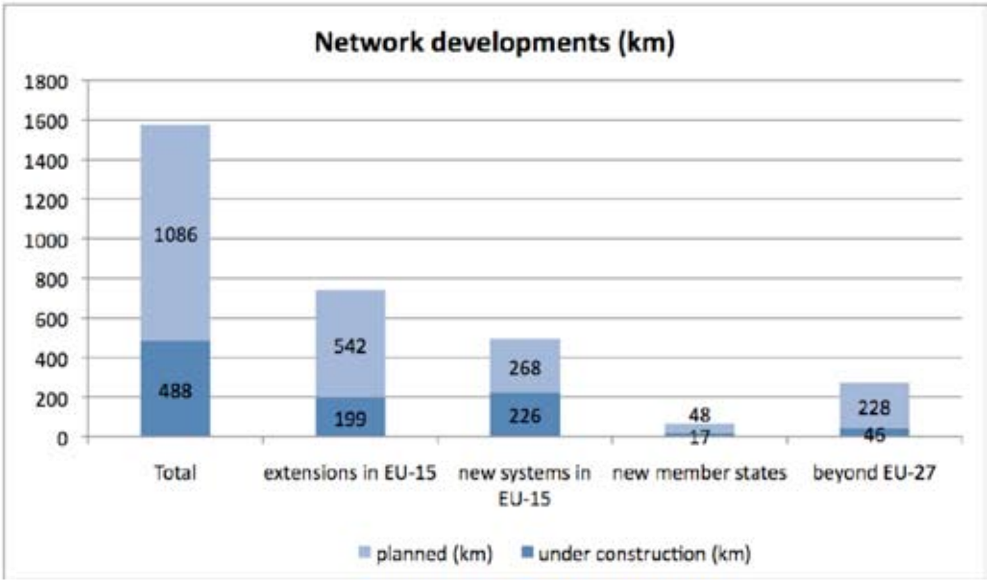
[8] The above mentioned differences for new systems – both in construction and planned – within EU-15 might be linked to the fact that in the period 2004-2009 the then new systems have been built and there is simply no need for further new systems, but the focus lies now more on extensions.

Chart 17



INVESTMENT COSTS

Regardless the low response rate concerning the current and planned expenses (43 and 51 networks) the study provides some information about investment costs as well. From all 33 replying networks 3.68 billion EUR are estimated for all infrastructure constructions of new lines, line extensions and modernisations (rolling stock excluded): 85.6% are related to the EU-15, 7.4% to the NMS and 7% to B-27. This leads to an average price per kilometre of infrastructure in construction of 15.8 million EUR for both the EU-15 and the NMS and of 5.6 million EUR for the countries beyond EU-27. The NMS have planned the least of the three country groups for the next decade; only 0.9 billion EUR. This stands in stark contrast to the need of these systems to keep them in operation and sustain a high modal share of public transport within this country group.

Table 6

	million EUR/construction km
EU-15	15.80
NMS	15.80
beyond EU-27	5.56

7. TRAM AND LIGHT RAIL FLEET IN EUROPE

ROLLING STOCK OVERVIEW

The European light rail and tram fleet amounts about 20,000 vehicles at the time the survey was conducted.

As shown in chart 18 below, the former group of the EU-15 countries count for a bit less than a half, the NMS for 43% and other European countries outside the EU-27 for 8% of the overall fleet with 10,000 vehicles.

In contrast to 2004 there is a slight increase in the percentage for the NMS and a decrease for countries beyond the EU-27. This is the result of Romania and Bulgaria joining the European Union, which have been included in this study within the NMS group.

The important decrease of the fleet in whole Europe since 2004 by about 5,000 vehicles is very probably linked to a strong trend towards longer, multi-modular vehicles in the EU-15. The higher request for these vehicles originates from both passengers (comfort,…) and operators (less drivers,…).

Chart 18

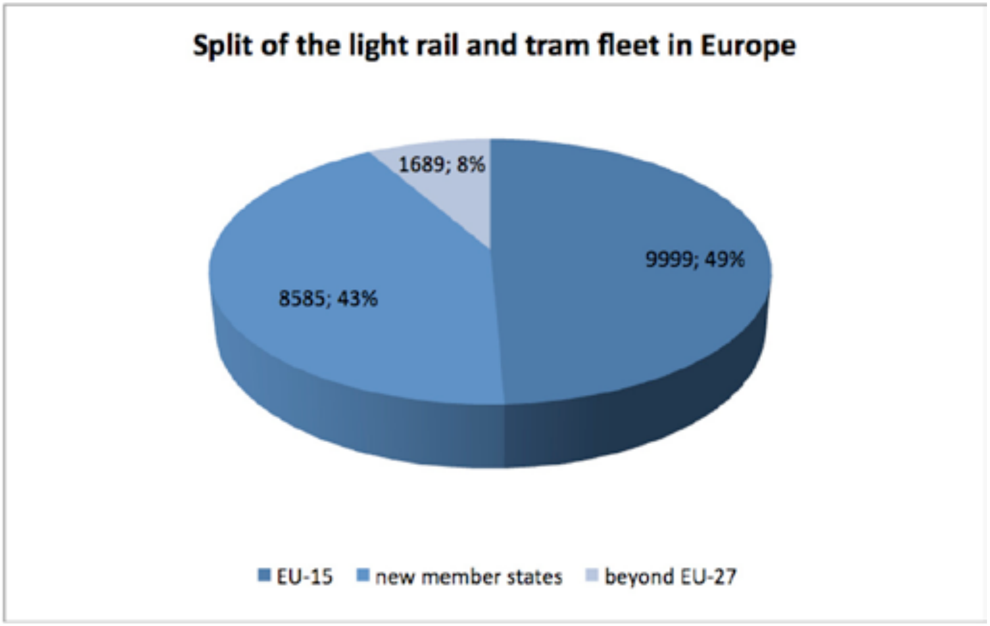
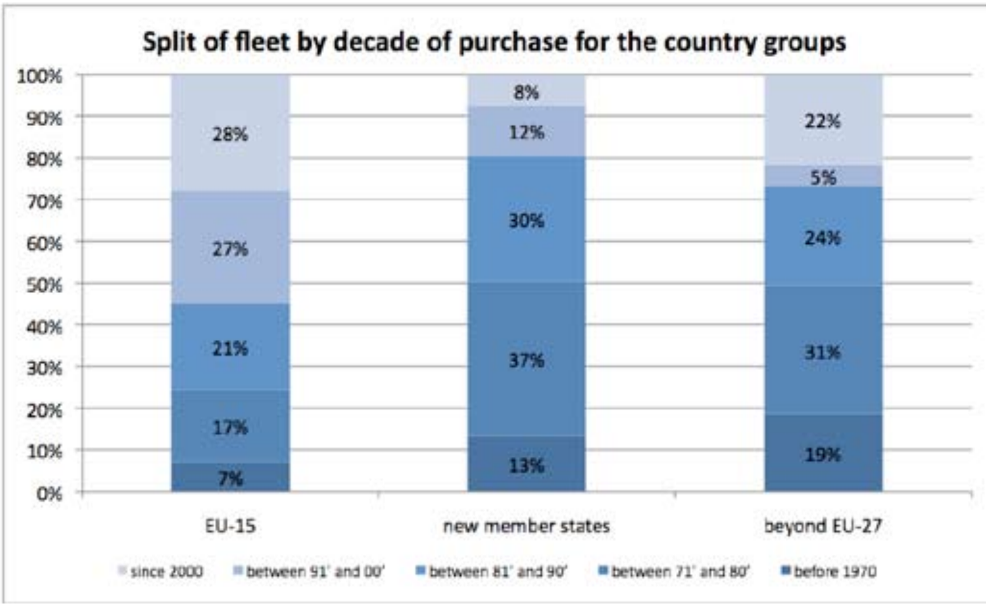


Chart 19



The current distribution of vehicles by decade of purchase in each country group shows that the EU-15 fleet is more modern than the ones in the two other country groups. Compared with the 2004 survey there is a strong development in terms of purchasing new vehicles in all country groups. This is clearly visible when comparing the percentage of vehicles which were built before the 70's and after 2000, e.g. in EU-15: built before 1970: 26% (2004) against 7% (2009); and built after 2000: 8% (2004) against 28% (2009).

ROLLING STOCK REPLACEMENTS

For a rough estimate of prospective market volumes for light rail vehicles purchase it is useful to consider the future needs for replacements of the fleet on the basis of the vehicle purchase in the past decades. The current situation is shown in chart 20 below.

In general in the EU-15, Norway, Switzerland and B-27 countries a vehicle's life cycle of 30 years is assumed and 40 years in the NMS; however in practice there might be vehicles which operate one or two decades longer, e.g. after a modernisation. To take this into account it has been assumed that one vehicle among five would be modernised and last 10 years more. Additionally a replacement rate of 2:3 is assumed for vehicles purchased before 1980, which considers that two modern articulated light rail vehicles will replace three old classic trams taking into account the enhanced capacity of new vehicles.

Chart 20

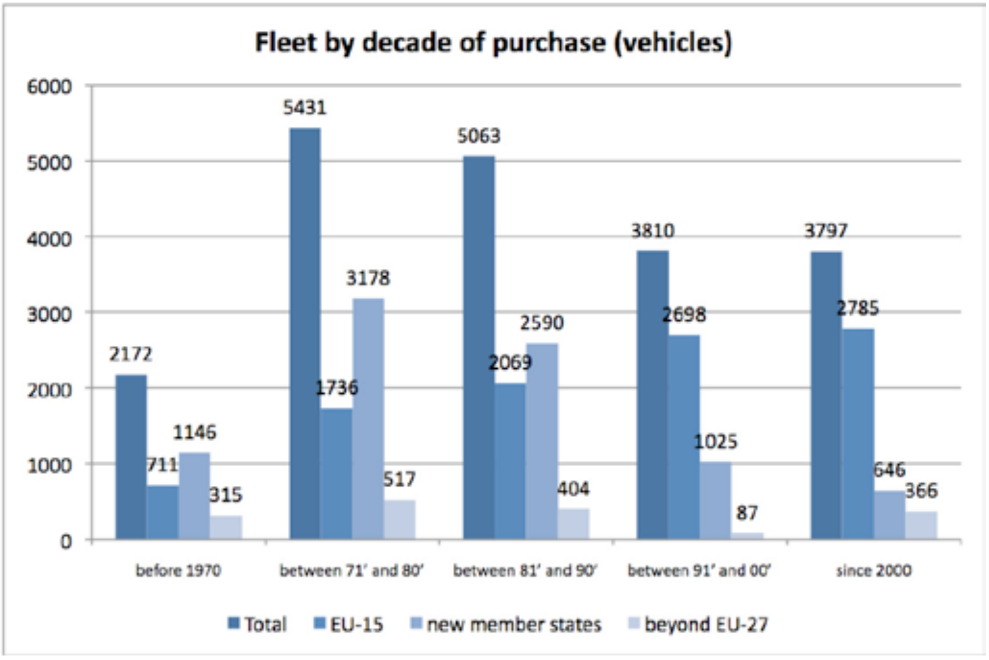
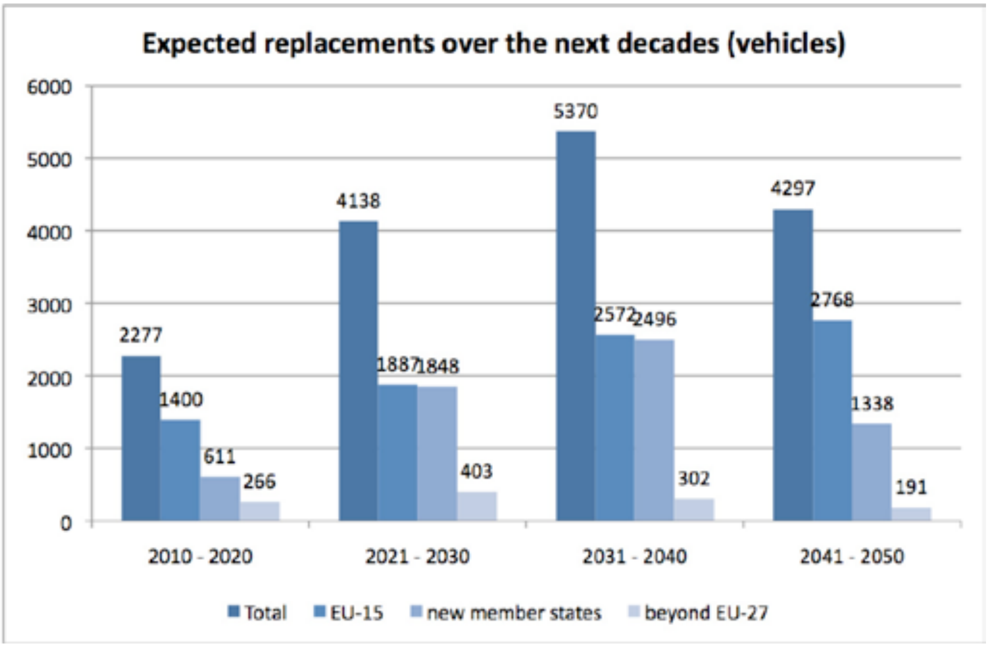


Chart 21



In comparison to the 2004 survey the overall number of expected vehicle replacements for the decade 2010-2020, 2021-2030 and 2031-2040 are lower. This leads to the assumptions that either a longer life cycle period is taken into account for the current vehicles or that funding is lacking for the acquisition of vehicles; however this stands in clear contradiction to the results obtained concerning the development priorities (final chapter): 70% of the tram and light rail operators in EU-27 have estimated the purchase of new vehicles with “very high” and “high”.

ROLLING STOCK NEEDS FOR NETWORK EXTENSIONS

Forecasts on the future need of vehicles for network extensions can be calculated on a basic ratio of vehicle per network extent in kilometres. This forecast will be approximate due to the variation of service levels (interval chosen for the line, network) and because the vehicle itself and its capacity are not sufficient indicators, e.g. classic tram car against modern multi-articulated light rail vehicle.

Due to the variable indicators the following factors have been calculated: for the EU-15 a ratio of 1.77 is applied, for the NMS it is 3.04 and for the countries beyond the borders of EU-27 a ratio of 2.95 has been taken into account. These factors are approximate, but they are sufficient to give a trend of vehicles needed for network extensions; both currently under construction and planned ones.

The current orders of light rail vehicles which could be found in the literature and UITP sources are given in chart 23.

Table 7

	EU-15	new member states	beyond EU-27	total
Network extent (km)	5,659	2,829	573	9,062
Fleet	9,999	8,585	1,689	20,273
Current vehicles/km	**1.77**	**3.04**	**2.95**	**2.24**
Extensions under constr. (km)	416	17	46	479
Needed vehicles	**736**	**52**	**136**	**922**
Planned extensions (km)	810	48	228	1,086
Needed vehicles	**1,431**	**146**	**672**	**2,249**

Chart 22

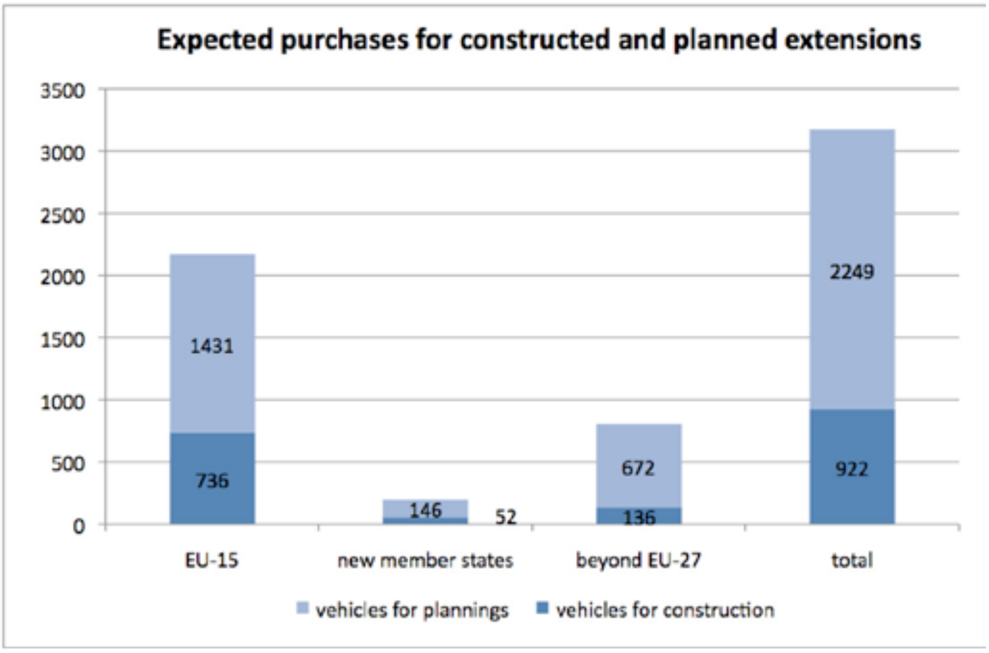
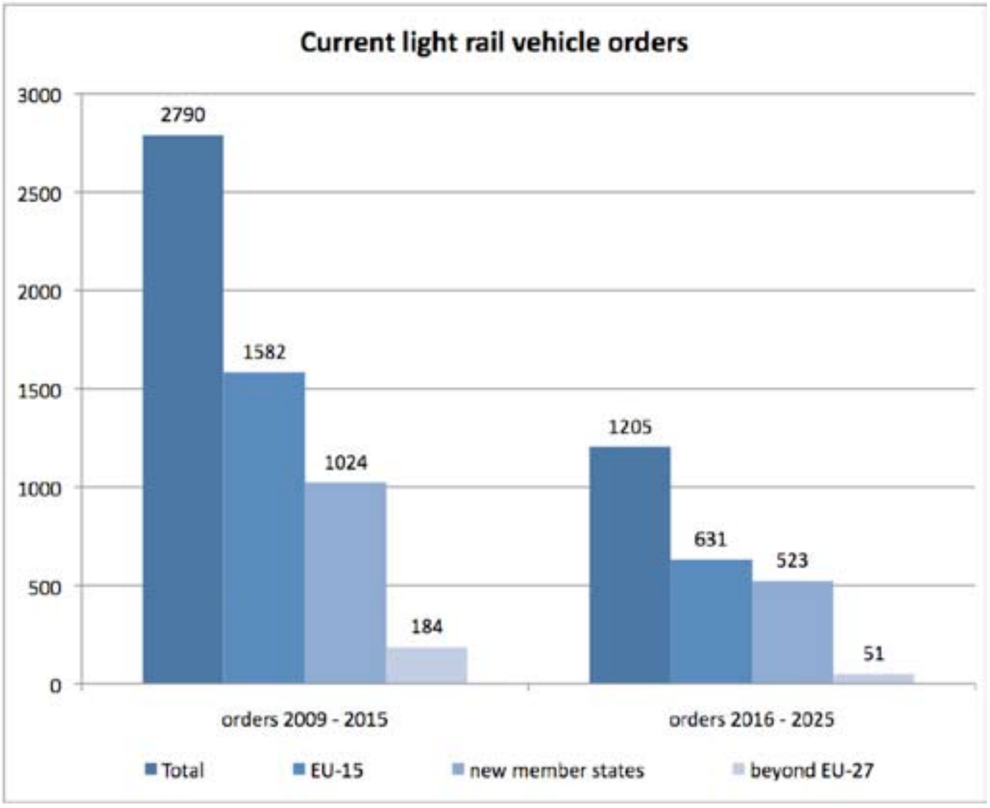


Chart 23



8. DEVELOPMENT PRIORITIES

The question concerning primary development targets has been replied by 70 operators. They were asked to evaluate, with the importance from 1 (very low/does not agree) to 5 (very high/fully agree), the following mayor development goals:

a) Concentration on heavily used lines

b) Construction of new routes

c) More efforts on right-of-way protection

d) Purchase of new vehicles

e) Modernisation of the current fleet

f) Integration of catenary-free track-sections

g) Future projects are secure financed

h) The tram/LR system is supported by local politics

The highest priority, i.e. being valued with either "4" or "5" for both country groups lies with the local political support to tram/light rail systems (h); 76% for the operators in the EU-15 and 78% in the NMS. At almost the same level of priority EU-15 countries focus on objectives related to infrastructure (a) and vehicles (d); followed by the construction of new routes (b). For NMS the priorities lay mainly on vehicles upgrade (e) or purchase (d); however all other topics are regarded as important with more than 50% except the integration of catenary-free track-sections (f), which for both country groups is the lowest priority.

EU-15	Concentration of heavily used lines	Construction of new routes	More efforts on right-of-way protection	Purchase of new vehicles	Modernisation of the current fleet	Integration of catenary-free track-sections	Future projects are secure financed	The tram/LR system is supported by local politics
very high	36%	30%	9%	33%	7%	0%	14%	30%
high	40%	24%	22%	35%	16%	2%	20%	46%
medium	13%	13%	16%	20%	30%	0%	48%	17%
low	11%	20%	36%	2%	20%	21%	14%	7%
very low	0%	13%	18%	11%	27%	76%	5%	0%

NMS	Concentration of heavily used lines	Construction of new routes	More efforts on right-of-way protection	Purchase of new vehicles	Modernisation of the current fleet	Integration of catenary-free track-sections	Future projects are secure financed	The tram/LR system is supported by local politics
very high	35%	33%	29%	39%	18%	10%	33%	30%
high	25%	29%	24%	35%	50%	10%	19%	48%
medium	30%	14%	10%	22%	23%	0%	19%	17%
low	5%	14%	24%	0%	5%	24%	14%	0%
very low	5%	10%	14%	4%	5%	57%	14%	4%

9. CONCLUSIONS

In comparison to the 2004 study the market for light rail is still strong and has a high development potential. There are 16 more systems in Europe; however the current trend goes towards the extension of existing systems rather than the creation of new ones. In total 488 km of double track are being built and 1,086 km are planned, which means a decrease of ca. 20% in comparison to 2004.

If an average construction cost of 15 million EUR/km (without rolling stock) is assumed, the monetary evaluation of the market is in the range of EUR 24 billion over the next 20 years (EUR 7.5 billion for lines in construction and EUR 16.5 billion for planned developments). On the infrastructure side, we can estimate research into civil engineering activities is rather moderate and could be range between 1 and 2 %, i.e. between 240 and 480 million EUR.

As far as rolling stock is concerned, the forecast both for the replacement and the network developments is in the range of 9,500 vehicles for the period 2010-2030. If we take two average cost hypothesis of 1.2 and 1.5 million EUR/vehicle, we find a turnover ranging between EUR 11 and 15 billion; research and development (R&D) expenditures dedicated to rolling stock can be estimated at least 1.5% of this value that is EUR 170-210 million.

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SEVENTH FRAMEWORK PROGRAMME

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