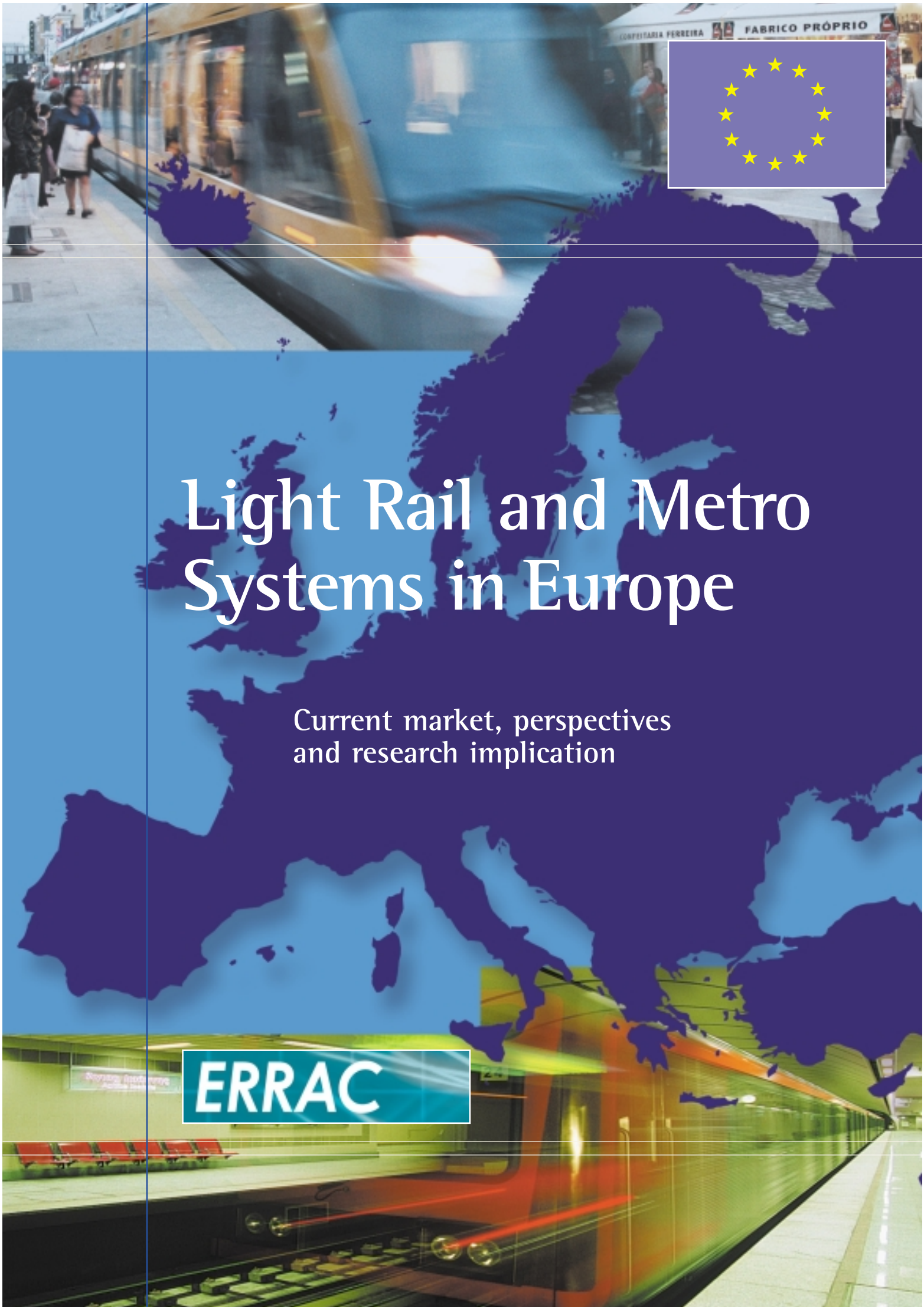

Light Rail and Metro Systems in Europe

Current market, perspectives and research implication

ERRAC

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Members list

ERRAC

Foreword

The wide collaborative approach on rail transport research fostered by the set-up and launch of ERRAC, the European Rail Research Advisory Council, in September 2002 has already delivered less than two years later significant results, notably improvements in the way rail research is organised and perceived by third parties.

Since the early stage of ERRAC, urban and regional rail passenger transport has been considered in the scope of the activities. Through months of intense exchange between the stakeholders, the importance of this market segment was not only confirmed, but an order of magnitude could be found. Rail product suppliers reckon that trams, light rail and metro systems, as well as regional and suburban railways make up around 50% of their total turnover, estimated at 36 billion _ per annum (world-wide "accessible" market including all rail supplies and excluding infrastructure). The improvement of urban and regional rail public transport supply is therefore of paramount importance for the manufacturers, as it is also for the authorities, the operators and above all for the European citizens.

This stunning market share certainly helped to convince the ERRAC stakeholders that some specific analysis on urban railway systems would be of great value and interest for the railway community. These studies were performed in the framework of the ERRAC working group 2 (WG2) chaired by Jonathan ELLIS, from the UK Strategic Rail Authority. The WG2 objectives are to co-ordinate and assess the rail research and development programmes underway in Europe in line with the ERRAC SRRA, the Strategic Railway Research Agenda. Rail research and development must be upgraded to the proper level required by the business and investment needs of the European railways.

The present studies were performed by UITP, the worldwide association of urban and regional passenger transport operators, their authorities and suppliers. They are made of two parts and cover (i) light rail and (ii) metro systems, in 35 European countries. They feature a state-of-the-art review of present and future (in construction or planned) systems and fleet. They provide indicative target figures in terms of R&D funding needs for light rail and metro systems as derived from the overall investment plans.

We are confident that these information and recommendations will raise further awareness of the importance of the urban rail sector among decision-makers, especially those with responsibilities in research.

Philippe RENARD
ERRAC Chairman

Wolfgang MEYER
UITP President
ERRAC member

1 Tram and Light Rail Systems in Europe

Current Market, Perspectives and Research Implications

1. Introduction

For the scope of this study, light rail (LR) has to be understood along the UITP definition, i.e. "a tracked, electrically driven local means of transport, which can be developed step by step from a modern tramway to a means of transport running in tunnels or above ground level. Every development stage can be a final stage in itself. It should however permit further development to the next higher stage." This broad definition encompasses a wide array of situations, from conventional tramway, to tram-train solutions.

Light Rail systems are thus flexible and expandable. It is not absolutely necessary to have an independent bed track over the whole route; however, the highest degree of segregation from private traffic should be aimed for. LR systems can be developed from traditional tramway systems or planned and built as entirely new systems. The former option being likely to happen in many central and eastern European cities, and the latter option mostly in Western European countries.

In total, 170 systems are represented in this LRT overview in Europe – 107 can be found within the current EU-15, 30 within the new Member States joining the EU in May 2004 and 31 within the countries beyond the EU-25 (including Norway, Switzerland but also candidate countries for the EU membership such as Bulgaria, Romania and Turkey, or the 2nd enlargement wave, as well as Western Balkan countries). This group of countries, however heterogeneous as it may seem, has been constituted in order to simplify and ensure a better understanding of results. Hence, one should bear in mind, that light rail situation in Romania is very different from the one in Norway, Switzerland or Turkey.

The aim of this study is to give a general overview of 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 requiring additional rolling stock). The research is based upon vigorous data research from the most viable sources currently available, mostly first hand, and direct primary sources provided by the operators or the cities themselves.

	Systems	Lines	Track length (km)
EU-15	107	448	4793 (59%)
New Member States	30	349	2240 (28%)
Beyond EU-25	33	144	1027 (13%)
Total	170	941	8060

Chart 1. General figures

2. System data : Europe-wide overview

2.1 Existing systems

Among the 170 tram and LRT (941 lines), 63% of systems (107), 48% of lines (448) and 60% of track*km[1] (4793) are **in operation** within the EU-15 (See chart 2). Germany alone accounts for more than half of these (56 systems and 2768 track*km). The first wave of the Enlargement will bring another 30 systems (349 lines and 2240 km) into the EU, increasing the total system length of the EU-15 by 46%. Most of the systems are in operation in Poland, the Czech Republic and Hungary. Another 31 systems can be found in countries that will remain outside the borders of the enlarged EU after 2004 (144 lines and 1027 km). There are plans for extensions of the existing, as well as for several new systems, in well-off and tram-friendly Switzerland and in demographic booming Turkey.

[1] *Marginally, some systems have single track sections, or sections with over 2 tracks, but in this report 1 track*km is to be understood as 1 km of double track*

Fig. 1. LRT - networks in operation (systems)

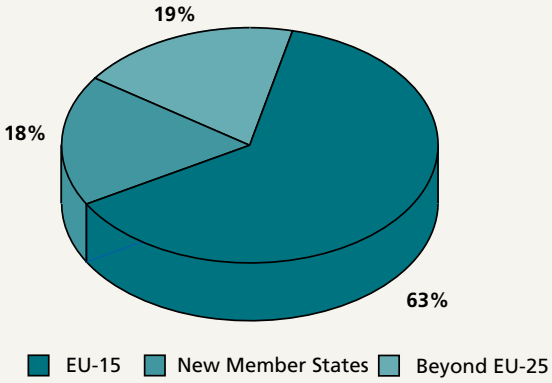


Fig. 2. LRT - networks in operation (lines)

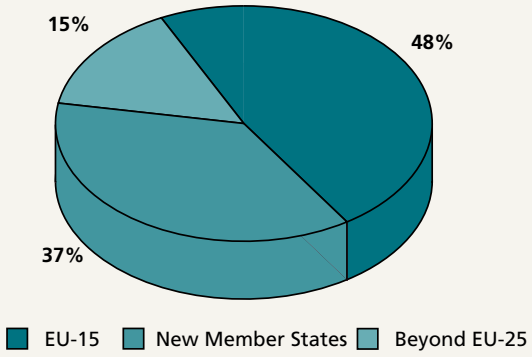
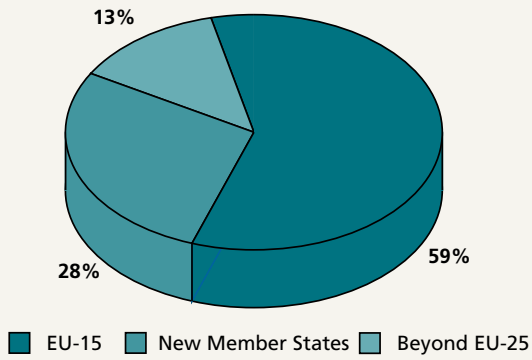


Fig. 3. LRT - networks in operation (track*km)



	Systems	Lines	Track*km
Austria	6	47	313
Belgium	5	33	332
Finland	1	11	76
France	11	20	202
Germany	56	231	2768
Greece	0	0	0
Ireland	0	0	0
Italy	7	37	209
Luxembourg	0	0	0
Netherlands	5	34	280
Portugal	2	6	65
Spain	4	5	206
Sweden	3	14	186
UK	7	10	156
Total	**107**	**448**	**4793**
Czech Republic	7	71	333
Estonia	1	4	39
Hungary	4	34	188
Latvia	1	8	167
Poland	14	204	1445
Slovakia	3	28	68
Total	**30**	**349**	**2240**
Bosnia and Herzegovina	1	2	16
Bulgaria	1	6	208
Croatia	2	15	57
Norway	2	9	47
Romania	14	69	461
Switzerland	7	26	112
Turkey	5	6	66
Serbia and Montenegro	1	11	60
Total	**33**	**144**	**1027**

Chart 2. Existing systems by group of countries

2.2. Growth of LRT systems in Europe - 15

New lines can mean: (i) cities introducing LRT for the first time or reintroducing them after a short hiatus or absence, or (ii) additional lines being build next to existing ones.

In 35 cities of the EU-15, new lines are being built or existing lines are being extended by some 609 km. In a further 74 cities, new lines or extensions are planned (1337 km) (See chart 3)

Among these schemes, 18 are being built and 41 are planned in cities which do **not** currently offer light rail provisions for a total of 59 new LRT systems (See chart 4).

According to the ERRAC business scenarios (2002), LRT development is expected to double the length of existing systems and increase by 50% the number of LRT systems in Western Europe by 2020[2]. This study demonstrates strong evidence of an increase of roughly 40% of the track length; this figure should be considered as a minimum as research so far was unable to find length data (new lines or extensions) for some 30 cities that already have plans at their disposal, and new projects may arise in coming years. On the contrary, major occurrences such as economic downturn or recession and difficulty in funding (financial engineering) may stall or postpone some projects. This data on system extensions will provide ratios to assess additional needs in rolling stock.

If we have a look at the number of cities with LRT, then the increase amounts to 55%.

Still this evidence demonstrates that the initial ERRAC forecast for the track length may have been over-optimistic. On the other side, figures show that the ERRAC forecast for the number of cities equipped may have been slightly conservative.

[2] For this forecast see ERRAC: Strategic Rail Research Agenda 2020. First Report of the European Rail Research Advisory Council, September 2002, p. 8

	Construction				Planned			
	Ext.		New		Ext.		New	
	Cities	km	cities	km	cities	km	cities	km
Austria					1	4		
Belgium	1	5			4	104		
Finland							1	15
France			6	135	8	113	9	190
Germany	7	15			10	127	3	
Greece			1	48			1	15
Ireland			1	22				
Italy	3	14	4	62	1	26	5	65
Luxembourg							1	15
Netherlands	3	41	1	20	1	7		
Portugal	1	70			1	44	2	89
Spain			5	104			14	277
Sweden			2	50	1	5		
UK	1	9	1	14	3	48	11	193
Total EU-15	16	154	21	455	30	478	44	859
Czech Republic					1	5		
Total New M S					**1**	**5**		
Norway							1	15
Switzerland	1	4						23
Turkey	2	11	1	15	1	4	3	89
Total Beyond EU-25	**3**	**15**	**1**	**15**	**1**	**4**	**4**	**127**

Chart 3. LRT Lines - In construction and Planned

Fig. 4. LRT - track*km in construction

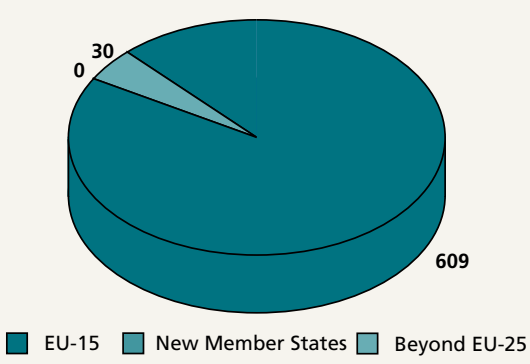
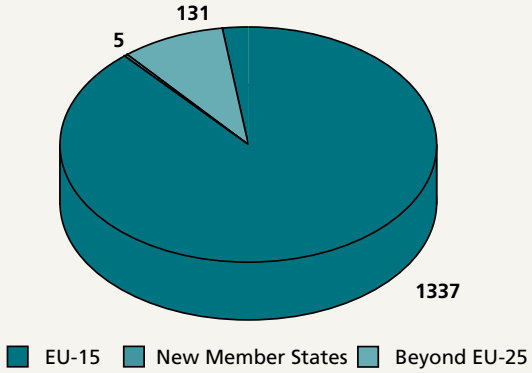


Fig. 5. LRT - track*km planned



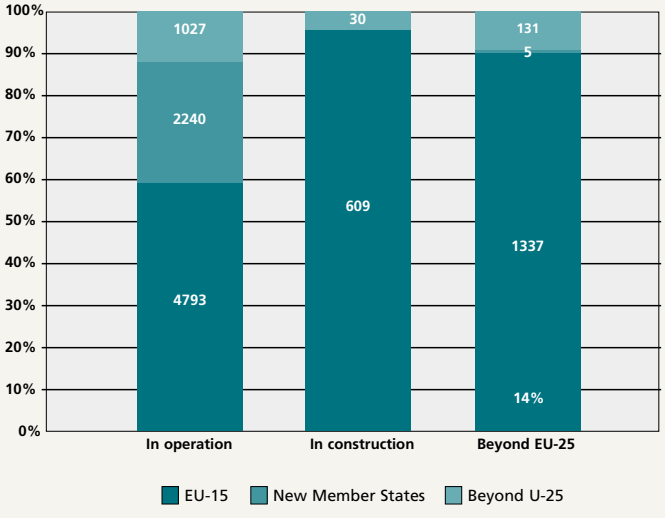
	Construction		Planning	
	Systems	Line *km	Systems	Line *km
Austria				
Belgium				
Finland			1	15
France	5	84	6	130
Germany			3	
Greece	1	48	1	
Ireland	1	22		
Italy	4	62	4	57
Luxembourg			1	15
Netherlands	1	20	2	7
Portugal			1	40
Spain	5	104	12	258
Sweden				
UK	1	14	10	140
Total	18	354	41	662

Chart 4. LRT construction or plans in cities without LRT

2.3. Growth of LRT systems in the new Member States

No new systems are in construction in the new Member States (see figure 6) and the only extension of an existing system is currently being carried out in Prague while there is a plan for tram-train in Brno. In Central and Eastern European Countries (CEECs), the objective is rather to keep the system running and avoid line closures. Once political support is gained, the next step is to deploy investments to turn tramways into sheer light rail standards, to increase commercial speed and reliability, such as maximum segregation from private traffic, priority at traffic lights, short interval. A good indicator of qualitative progress for LRT in these countries would be to investigate the percentage of track*km segregated from general road traffic.

Fig. 6. LRT - Length of LRT networks (km) - in operation, in construction, and planned



2.4. Comparison of EU-15 and new Member States

Several factors may explain this relative lack of schemes for systems in construction and planning in CEECs. The funding shortage is one of them but it is confident to say that the already high density of systems in these countries is an even more relevant factor. Systems in the new member states are relatively dense in terms of number of systems per million inhabitants (average of 0.5 system/1M inhabitants) and in terms of track*km per million of inhabitants (with an average of 31km per 1M inhabitants). These average ratios are fully comparable to the German or Belgian average. Two countries of a similar population size, the Czech Republic and Belgium, have similar track length.

However, one should bear in mind that within the EU, Germany and Belgium are untypical countries in terms of light rail deployment. The situation in France, United Kingdom, Spain or Italy, where the old systems were drastically closed down in the 1950s and 1960s and are being rebuilt today, is more common for the EU-15. The system/1M inhabitants does not reach 0.20, compared with over 0.36 in the new Member States, and 5 track*km/1M inhabitants, compared with over 12.6 km also for the new Member States. Chart 5 shows that there are about 10 times more track*km per 1M inhabitants in Germany and Belgium than in France, Spain, Italy or UK. This leaves space for considerable growth in the forthcoming decades.

Judging upon the available projects for new systems and extensions of current systems, the current EU-15 member states are likely to evolve towards higher density of systems while the immediate priority in the new Member States remains current systems maintenance and upgrade; while extensions and new systems are more difficult to construct due to lack of funding.

In addition, if we consider the average route length and the average system length in EU-15 (respectively 11 km and 44 km) and in the new Member States (respectively 6 km and 75 km), we can reasonably assume that LRT operators in the new Member States are most likely to restructure their systems to (i) offer longer routes on heavy loaded corridors, and (ii) probably close down some unproductive lines or sections. However realistic this scenario may be, it is extremely difficult to quantify those trends.

	Systems	Track*km	Population (in M inh.)*	System/ 1M inh.	Track*km/ 1M inh.
Czech Rep.	7	333	10.3	0.68	32.3
Estonia	1	39	1.4	0.71	27.9
Hungary	4	188	10.2	0.39	18.4
Latvia	1	167	2.4	0.42	69.6
Poland	14	1445	38.6	0.36	37.4
Slovakia	3	68	5.4	0.56	12.6
Germany	56	2768	82	0.68	33.8
Belgium	5	332	10.2	0.49	32.5
France	11	202	60.4	0.18	3.3
UK	7	156	58.6	0.12	2.7
Spain	4	206	39.4	0.10	5.2
Italy	7	243	57.6	0.12	4.2

Chart 5. Comparison between some accession and EU countries

** Source: http://europa.eu.int/abc/index_en.htm*

2.5. Tram-train specific case

Cologne-Bonn (1980s) and Karlsruhe (1992) offered a pioneering experience with tram-train systems and gained recognition as a worldwide reference. Saarbrucken followed these two shortly after. Since then, these systems have been commercially successful. For the coming decades, tram-train projects in the EU member states represent one of the most important trends. Currently, 17 systems have been proposed in 6 countries of the EU (Finland, France, Germany, Italy, the Netherlands and Spain), including 5 systems already in construction (Mulhouse and Dunkirk in France, Kassel in Germany, Sassari in Italy, Gouda-Leiden in the Netherlands and Alicante in Spain).

Clearly, a priority axis in LRT research and development should focus around such systems. The present lack of (or little) regulation makes it possible to favour a European approach from the outset, and would avoid market fragmentation, thus leading to substantial economies of scale.

3. Tram and LRT Fleet in Europe

The total fleet in Europe amounts to about 25,000 vehicles. The current EU-15 member states account for 46% of the rolling stock, new member countries for 35% and countries beyond the EU an additional 19%. The largest share of the fleet was built in the 1970s in the EU-15 and the new Member States and in the 1980s for the second wave of enlargement. Within the EU-35, the current EU-15 accounts for more than 59% of currently operated networks in track*km (fig. 3) but only for 46 % of the rolling stock (Fig. 7). This discrepancy can be explained through the trends towards longer multi-articulated vehicles up to 45 m in length for single-units, against rigid or bi-articulated trams with sometimes trailers in most CEECs. Thus, these fleet figures do not necessarily reflect the nominal capacity. Moreover, modern and reliable LRVs reduce the necessary reserve vehicles required to operate a system in decent conditions. For example, DVB in Dresden managed to increase patronage between 1991 and 2001 even though it reduced its fleet by half and added longer vehicles.

In particular, the share of the newly purchased rolling stock in the new member states is rather low (See figure 8). While the share of the fleet built after 1990 accounts for 33% in the EU-15, it represents only 6% for the first wave enlargement countries and 10% for countries staying beyond the EU after 2004. It can be supposed that there will be a need for the renewal of the fleet in those countries in the upcoming years (See all charts in this section). However, financial constraints for rolling stock replacement are likely to take the form of general overhaul and modernisation or second hand rolling stock acquisition for a large part of the needs.

As a whole, it appears that 42% of the EU-15 fleet, 67% of the new Member States fleet and 48% of the Beyond EU-25 fleet is over 20 years old and should be replaced before 2020.

Fig. 7. LRT Fleet (Europe) number of vehicles

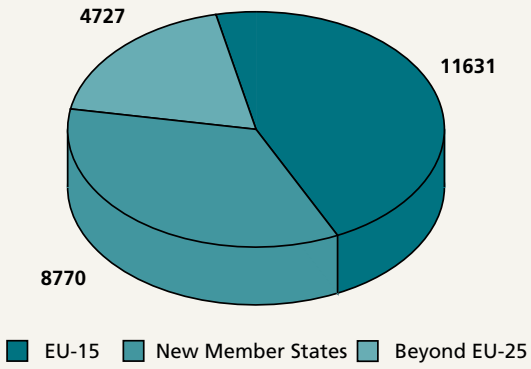
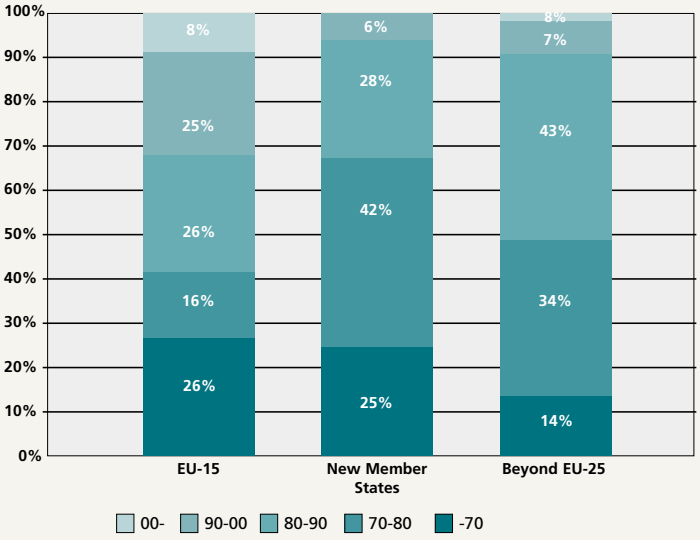


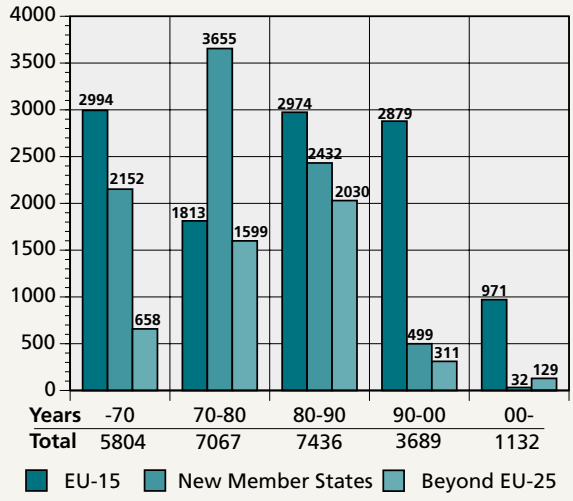
Fig. 8. Fleet size by decade of purchase



3.1. Rolling Stock: Prospective Market Volumes

When addressing the issue of prospective market volumes, a distinction between the needs for replacement of existing fleets and the new rolling stock needs for new lines or extensions has to be made. The current situation is shown in figure 9.

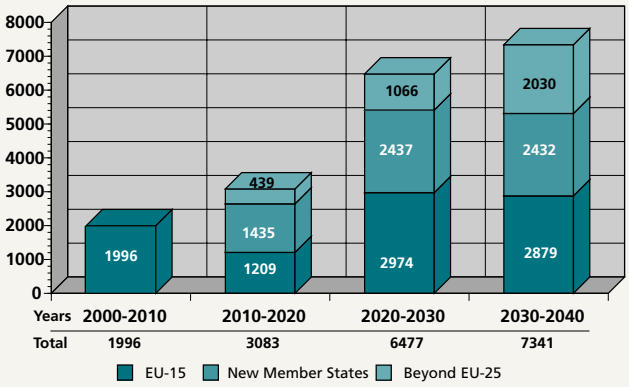
Fig. 9. LRT fleet by age (number of vehicles)



3.2. Rolling stock replacements

In EU-15, a life-cycle of 30 years is generally assumed, but reality shows that rolling stock can operate from 30 to 40 years. The rolling stock operational period in post-communist CEECs can eventually be one or two decade longer. It is likely that about 3170 vehicles built before 1970 will be replaced by 2010 in the EU-15. In the period 2010-2020, further replacement of 3900 trams built during the 1970s is expected. Europe-wide rolling stock replacement forecast – with the 30 years life-cycle in the EU-15 and 40 year life-cycle for the rest of Europe – is shown in figure 10. **For rolling stock built before the 1980s, a 1:1.5 replacement ratio was assumed** (i.e. 2 new vehicles to replace 3 old ones) to take into account the increased LRV length and capacity.

Fig. 10. Rolling stock expected purchase for replacement market (number of vehicles)



Until 1980: replacement ratio 1:1.5
After 1980: replacement ratio 1:1

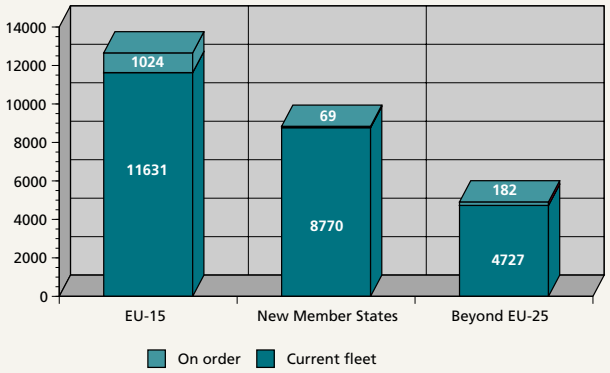
If a ratio of 1:2 is assumed[2], which is also a possible scenario, total figures would be 1497, 2312 and 5602, respectively for 2000-2010, 2010-2020 and 2020-2030.

[2] *1 new vehicle to replace 2 old ones.*

3.3. Rolling stock needs for new lines and extensions

Sources on planned rolling stock orders are scarce and the following chapter is bases on the most complete data found in the literature and in UITP sources.

Fig. 11. LRVs in Europe – current fleet and orders (identified in the literature)



With this information, forecasts can be deducted from a basic ratio of vehicle needed per track*km. The forecast will be broad because of variation of service levels (interval chosen) and because vehicle is not a sufficient indicator for capacity (light rail vehicle or LRVs can range from 15 to 45 m in length).

This can be done both for systems in operation and in construction. The apparent ratio difference between systems operated and in construction (2.43 vehicle per km of track vs. 1.66) can be partially explained by the trend towards longer multi-articulated vehicles, and by partial availability of data for LRVs currently ordered.

From a methodological viewpoint, it is therefore proposed to calculate a range of vehicle needs, based on two ratios of 1.66 and 2 in EU-15, and on 1.66 and 3 in Beyond EU-25.

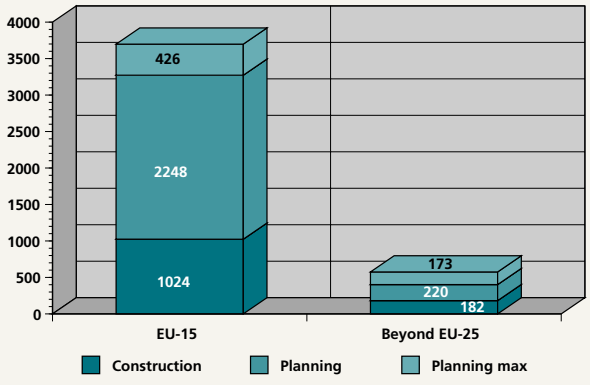
For the 1st wave of the EU enlargement, there is little need to show for a fleet size forecast, as there are only few plans for new systems and little information on extensions available.

We are aware that such estimates are approximate, but they are sufficient to give a general trend indication.

EU-15	Operation	Construction	Planning	
track length	4793	609	1337	1337
fleet	11631	1024	2224	2674
fleet/km	2.43	1.68	1.68	2
Beyond EU-25				
track length	1027	30	131	131
fleet	4727	182	220	393
fleet/km	4.60	6.07	1.68	3

Chart 6. Rolling stock needs forecast

Fig. 12. Rolling stock expected purchase for lines in construction and planning



4. Conclusions

The light rail market has a high growth potential ahead.

In terms of **infrastructure** expressed in track*km, a 40% growth is confirmed. In terms of number of European cities equipped with LRT, the growth has reached 55%. 739 km of double track are being built, and 1473 km are in planning stages. 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**30 billion over the next 20 years** (EUR9.5 billion for lines in construction and EUr22 billion for planned lines). These figures do not include expenditures on infrastructure refurbishment and/or segregation, which is expected to boom in the new Member States. 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 300 and 600 million euros.

As far as **rolling stock** is concerned, the forecast both for the replacement and the new markets ranges between 7500 (conservative figure) and 9300 (maximalistic figure) for the period 2000-2020. If we take two average cost hypothesis of 1.2 and 1.5 million EUR/vehicle, we find a turnover ranging **between EUR9 and 14 billion** (7500 * 1.2 and 9300 * 1.5). Research and development (R&D) expenditures dedicated to rolling stock can be estimated at 1.5% of this value (EUR170 million) and should be increased to 3% (as encouraged by European Commission). **It is thought that this increase in R&D to EUR340 million could generate return on investment between EUR450 and 1400 million through a decrease in cost between 5 and 10 %.**

5. Specific recommendations

In all countries, the fight against pollution and congestion should be tackled vigorously in urban areas, among others through the promotion of efficient mass rail transport.
Some countries of the EU-15 should drastically expand their LRT activities, since they have 10 times less offer expressed in track*km per million inhabitants.

In CEECs, the objective is to keep the system running and reorganise networks around structuring corridors. Political support is needed to deploy investments to turn tramway into sheer light rail standards.

In these countries, cohesion fund resources should be dedicated also to local and regional projects, not only to national (mostly) road infrastructure projects.

If this can be achieved, these resources should be carefully spent on both rolling stock renewals and infrastructure refurbishment. "Easy" investment programmes focussing on rolling stock should be avoided.

2 Metro Systems in Europe

Current Market, Perspectives and Research Implications

1. Introduction

For the scope of this study, metro has to be understood along the UITP definition, "a tracked, electrically driven local means of transport, which has an integral, continuous track bed of its own (large underground or elevated sections)." This results in a high degree of freedom for the choice of vehicle width and length, and thus a large carrying capacity (above 30,000 passengers per hour per direction – pass/h/dir.). Intervals between stations would be typically more than 1 km, and because the alignment does not have to follow existing streets, curve radii and section gradient can be more generously dimensioned and permits for an overall higher commercial speed.

Metro systems require, therefore, heavier investment than light rail, and can be implemented only in large cities where demand justifies the capital cost.

In total, there are 36 systems in Europe – 27 can be found within the current EU-15, 3 within the new member states joining the EU in May 2004 and 6 within the countries beyond the EU-25 (including Norway and Switzerland but also candidate countries for EU membership such as Bulgaria, Romania and Turkey as par of the second enlargement wave). This group of countries, however heterogeneous it may seem, has been constituted in order to simplify and ensure a better understanding of results. Hence, one should bear in mind, that the light rail situation in Romania is very different from the one in Norway, Switzerland or Turkey.

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 vigorous data research from the most viable sources currently available, mostly first hand, direct primary sources provided by the operators or the cities themselves.

	Systems	Lines	Track*km
EU-15	27	117	2072 (88%)
New Member States	3	7	93 (4%)
Beyond EU-25	6	14	181 (8%)
Total	36	138	2346

Chart 1. General figures

2. System data: Europe-wide overview

2.1. Existing systems

Chart 2 shows that among the 36 metro systems (138 lines), 75% of systems (27), 85% of lines (117) and 88% of track*km[1] (2072) are in operation within the EU-15. The first wave of the Eastern enlargement will bring another 3 systems (7 lines and 93 km) into the EU. Another 6 systems can be found in countries that will remain outside the borders of the enlarged EU after 2004 (14 lines and 181 km).

Few cities in Central and Eastern European Countries (CEECs) invested in metro systems. They have, instead, expanded their tramway systems.

[1] *Marginally, some systems have single track sections (or sections with over 2 tracks), but in this report, 1 track*km is to be understood as 1 km of double track*

	Systems	Lines	Track*km
Austria	1	5	61
Belgium	1	3	84
Finland	1	11	76
Denmark	1	2	17
France	6	27	322
Germany	4	22	361
Greece	1	2	18
Italy	2	8	144
Netherlands	2	4	127
Portugal	1	4	28
Spain	3	20	349
Sweden	1	3	110
UK	3	15	480
Total	**27**	**117**	**2072**
Czech Republic	1	3	50
Hungary	1	3	32
Poland	1	1	11
Total	**3**	**7**	**93**
Bulgaria	1	1	6
Norway	1	5	80
Romania	1	4	63
Switzerland	1	2	10
Turkey	2	2	22
Total	**6**	**14**	**181**

Chart 2. Existing systems by group of countries

Fig. 1. Metro - systems in operation (track*km)

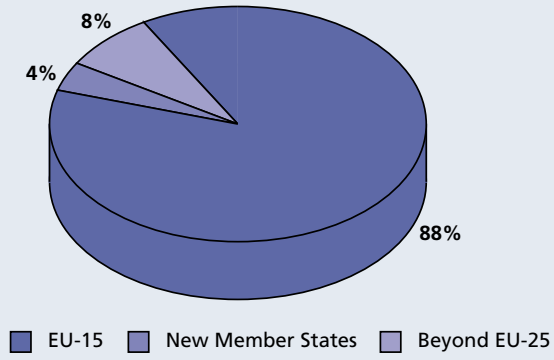


Fig. 2. Metro - networks in operation (systems)

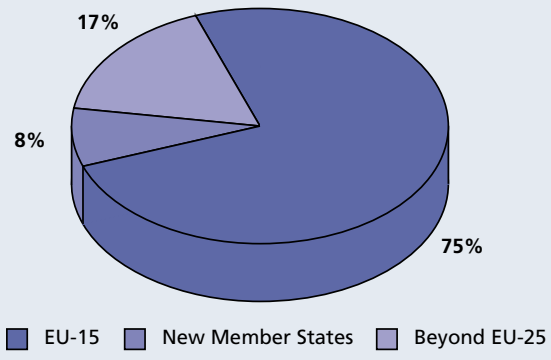
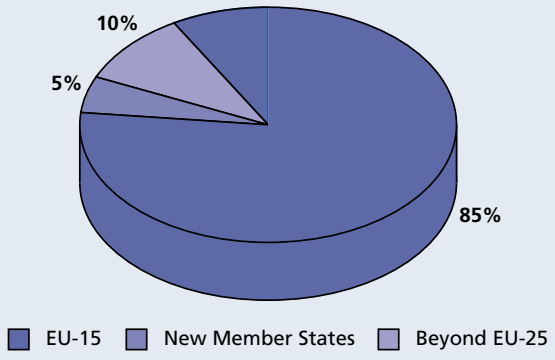


Fig. 3. Metro - systems in operation (lines)



2.2. Growth of Metro systems in Europe

New lines can mean (i) cities introducing a metro system for the first time, or (ii) additional lines being built next to existing ones.

In 20 cities (of which 14 are in the EU-15), new lines are being built or existing lines extended – that is an increase of 55% of existing systems (of which 52% of these systems are in the EU-15). This represents 135.3 km, of which nearly 112 km are in the EU-15. In a further 33 cities, 503.9 km of new lines or extensions are planned (See Chart 3).

Cities in EU-15 have the lion's share of metro development with approximately 83 % of all new construction, while new Member States and Beyond EU-25 cities account for only 5 % (7 km) and 12 % (16.5 km) in the construction of extensions. For planned metro system growth, cities in EU-15 account for 60% of all planned schemes, with an additional 9 % (45 km) in the new Member States and 31 % (155 km) in the Beyond EU-25 countries. Please note the dominant role of Turkey. Among these schemes, 3 systems are being built and 5 are planned in cities which do **not** currently offer metro services (See Chart 4).

This data on system extensions will provide ratios to assess additional needs in rolling stock.

	Construction				Planned			
	Ext.		New		Ext.		New	
	Cities	km	cities	km	cities	km	cities	km
Austria					1	14		
Belgium	1	4						
Denmark	1	4						
France	2	2.5			4	25.5		
Germany	1	7.3	1	7	4	16.4		
Greece	1	14	1	10	1	26		
Italy	1	2.5	3	18	2	5	5	104
Netherlands							1	10
Spain	1	1.5	1	41	1	35	1	44
Sweden					1	5		
UK					1	19	1	N/A
Total EU-15		**35.8**	**6**	**76**	**16**	**145.9**	**8**	**158**
Czech Republic	1	4			1	5		
Hungary					1	8		
Poland	1	3						
Slovakia							1	32
Total New M S	**2**	**7**	**0**	**0**	**2**	**13**	**1**	**32**
Bulgaria	1	2.3					2	47
Norway	1	3				1	15	
Switzerland							1	11
Turkey	2	11.2			1	16	1	76
Total Beyond EU-25	**3**	**15**	**1**	**15**	**1**	**4**	**4**	**127**

Chart 3. Metro Lines in construction or planning (in km)

Fig. 4. Track*km in construction

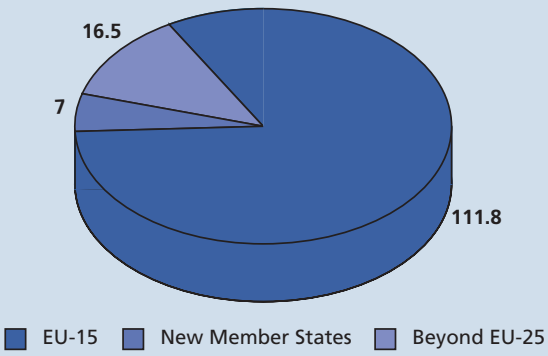
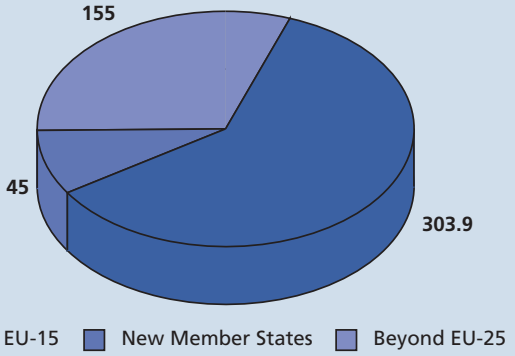


Fig. 5. Track*km planned

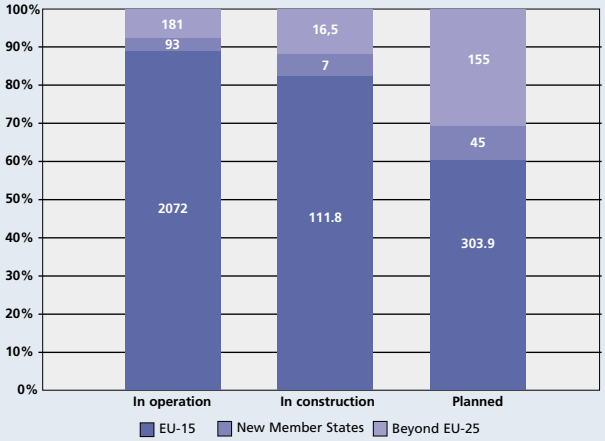


	Construction		Planning	
	Systems	Line *km	Systems	Line *km
Greece	1	10		
Italy	2	18	3	47
UK			1	N/A
Total	3	28	4	47
Slovakia			1	32
Total	3	28	5	79

Chart 4. Construction or planning in cities without Metro

Few new systems are in construction in the new Member States. Several factors may explain this relative lack of schemes for systems in construction and planning in CEECs: the fund scarcity, the relative limited number of large cities in the new Member States, or the good public transport provision of LRT.

6. Length of metro networks - in operation, in construction, and planned



In addition, there are large differences in the structural system characteristics according to country groups. Systems and lines tend to be longer on average in EU-15 countries. The average **route length** and the **system length** in EU-15 (respectively 18 km and 76 km) differs from the typical values in the new Member States (12 km and 29 km respectively) and in the Beyond EU-25 countries (13 km and 30.5 km respectively). Similarly, systems in EU-15 have an average of 4.3 lines against 2.3 in new Member States and Beyond EU-25 countries.

However, a deeper analysis highlights that the relevant criteria is the city size expressed in terms of population. Among all cities equipped with a metro system, 10 have over 2.5 million inhabitants, all but 2 (Istanbul and Ankara) are in the EU-15[2]. In these large cities, systems are on average 117 km long, with an average route length identical as the EU-15 average (18km). The difference is thus due to the average number of lines per system: 6.5 in cities with over 2.5 million inhabitants vs. 2.3 in new Member States and Beyond EU-25 countries.

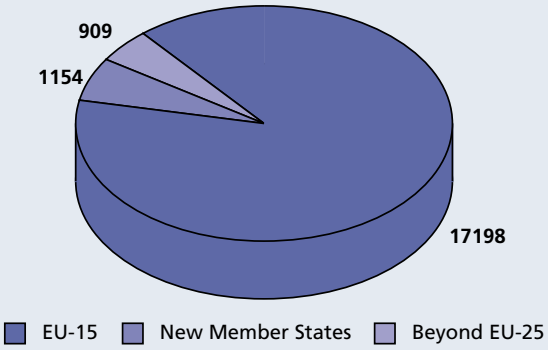
[2] *in decreasing order : Paris, Istanbul, London, Madrid, Berlin, Barcelona, Ankara, Athens, Lisbon and Rome (source : www.citypopulation.de).*

3. Metro Fleet in Europe

The unit chosen is the metro car, i.e. an independent unit that is coupled to others as variable train formation, depending on transport demand.

The total fleet in Europe amounts to about 19,200 vehicles. The current EU-15 member states account for slightly below 90% of the rolling stock, new Member States for nearly 6% and countries Beyond EU-25 for about 4%. This reflects the infrastructure situation described in chapter 1: 88% of track*km in EU-15.

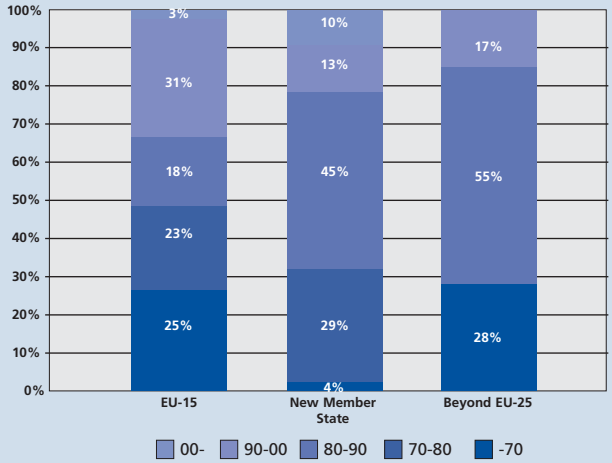
Fig. 7. Metro fleet in Europe - number of cars



In particular, the share of the newly purchased rolling stock is rather low (See figure 8): the share of the fleet built after 1990 accounts for 34% in the EU-15, 23% for the new Member States and 17% for the countries Beyond EU-25. It can be supposed that there will be a need for the renewal of the fleet in those countries in the upcoming years. However, financial constraints for rolling stock replacement are likely to take the form of general overhaul and modernisation or of second hand rolling stock acquisition for a large part of the needs.

As a whole, it appears that 48% of the EU-15 fleet, 33% of the new Member States fleet and 28% of the Beyond EU-25 fleet are over 20 years old and should be replaced before 2020.

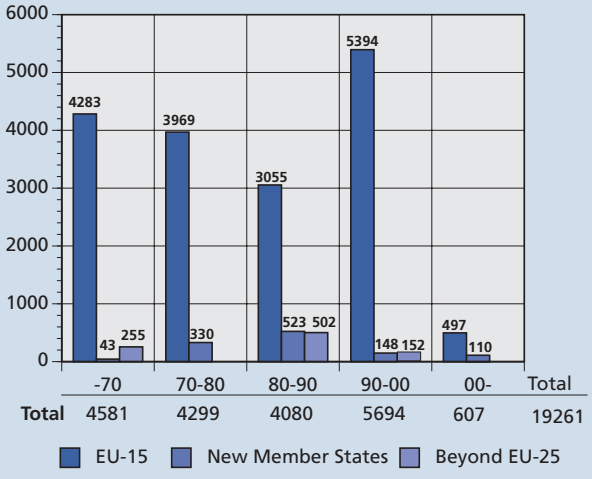
Fig. 8. Metro fleet by decade of purchase



3.1. Rolling Stock: Prospective Market Volumes

When addressing the issue of prospective market volumes, we have to distinguish between the needs for replacement of existing fleets and the new rolling stock needs for new lines or extensions. (See figure 9)

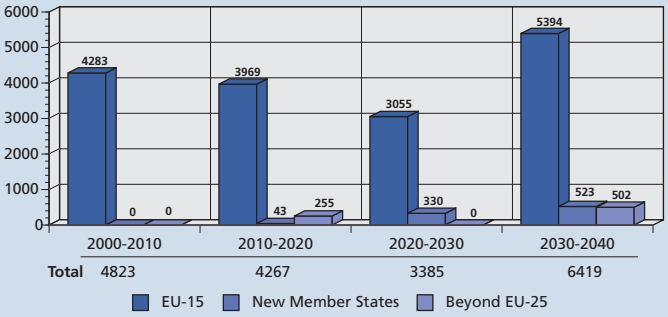
Fig. 9. Metro fleet by decade of purchase (number of cars)



3.2. Rolling stock replacements

In EU-15, a life cycle of 30 years is generally assumed, but reality shows that rolling stock operate between 30 and 40 years, especially in times of scare investment money. **The rolling stock operational period in post-communist CEECs can eventually be one or two decade longer.** It is likely that the some 4,600 cars built before 1970 will be replaced by 2010 at latest in the EU-15. In the period 2010-2020, a further replacement of 4,300 cars built during the 1970s is expected for all European countries. Europe-wide rolling stock replacement forecast – with the 40 years life cycle in the EU-15 and 50 years life cycle for the rest of Europe (See figure 10). For the next two decades, 9,000 metro cars should be replaced in the whole of Europe.

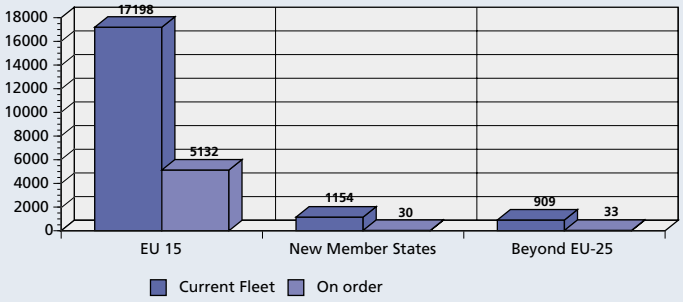
Fig. 10. Metro car replacement over coming decades



3.3. Rolling stock needs for new lines and extensions

Sources on planned rolling stock orders are scarce and following chapter is based on the most complete data found in the literature and in UITP sources.

Fig. 11. Current metro fleet and orders

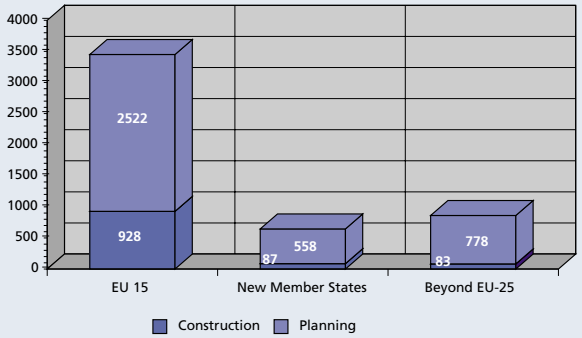


Similarly to the survey on light rail market, forecasts for rolling stock needs for system extensions are based on an assumption that a basic ratio of cars needed per track*km can be used. However, the estimate cannot be fine-tuned as for LRT (variation of service levels, interval chosen, lower service on extended terminal branches, etc.) because collected data is less detailed. However, it is sufficient to give a general trend indication by using the same ratio of cars needed per track*km. The following table is an attempt to quantify the future needs on the basis of a ratio "fleet size/track*km in construction" available for the EU-15.

EU-15			
	In Operation	In Construction	Planned /ext.
Track length	2072	111.8	303.9
Fleet size	17198	928	2522
Fleet/km	8.30	8.30	8.30
New Member States			
Track length	93	7	45
Fleet size	1154	87	558
Fleet/km	12.41	12.41	12.41
Beyond EU-25			
Track length	181	16,5	155
Fleet size	909	83	778
Fleet/km	5.02	5.02	5.02

Chart 6. Rolling Stock Needs Forecast

Fig. 12. RS expected purchase for lines in construction and planning



4. Conclusions

The metro market has a high growth potential ahead, especially for rolling stock.

In terms of **infrastructure** expressed in track*km, the growth is more moderate than for LRT, but still rather substantial with a 21% increase (135 km in construction and 503 km in planning). If we assume average construction cost of 150 million EUR/km (without rolling stock), the monetary evaluation of the market is in the range of **EUR95 billion over the next 20 years** (20 billion for lines in construction and 75 billion for planned lines). These figures do not include expenditures on infrastructure refurbishment and line automation. Refurbishment is expected to boom in the new Member States and automation in EU-15 countries. **Automation of conventional lines should be a major research area in the coming years.** On the infrastructure side, we can estimate that research into civil engineering activities is rather moderate and could range between 1 and 2 %, i.e. between EUR950 and EUR1900 million.

As far as **rolling stock** is concerned, the forecast both for the replacement and the new markets is assessed at around 14,000 units (cars) for the period 2000-2020. If we take an average cost hypotheses of EUR1.5 million/car (average between motorised car and trailer), we find a turnover of **about EUR 21 billion.** R&D expenditures dedicated to rolling stock can be estimated at 1.5% of this value (EUR315 million) and should be increased to 3% (as encouraged by the European Commission). **It is thought that this increase in R&D to EUR630 million could generate return on investment between EUR1.05 and EUR2.1 billion through a decrease in cost between 5 and 10%.**

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