Report

Report

Obstacles to Internal Market in Rail Mass Transit

Final Report

Volume 1

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AEA TECHNOLOGY RAIL

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Abbreviations

AEA	AEA Technology Rail is a business name of AEA Technology plc
ALRT	Automated Light Rail
AFNOR	French Standardisation Institute
BAV	Federal Transport Authority (Switzerland)
BOStrab	German tramway design and operating requirements
CEI	Italian Electro Technical Committee
CEN	European Standardisation Committee
CENELEC	European Electrotechnical Standardisation Committee
CFL	Luxembourg Railways
CPT	Confederation of Passenger Transport (UK)
CPTSHO	Civil Protection and Traffic Safety Head Office (Spain)
DETR	Department of the Environment, Transport and the Regions (UK)
EBO	German railway design and operating regulations
EC	European Community
EFTA	European Free Trade Association
ETSI	European Telecommunications Standards Institute
EU	European Union
GAMAB	Globally at least equivalent (safety) principle
GLT	Guided Light Transit
HMRI	Her Majesty's Railway Inspectorate (UK)
HSE	Health and Safety Executive (UK)
INTF	National Transport Institute (Portugal)
ISO	International Standardisation Organisation
KHVM	Ministry of Transports, Communication and Water Management (Hungary)
LNT	Light railcar Regulations (Germany)
LRT	Light Rapid Transit
LRV	Light Rail Vehicle
MARIE	Mass Transit Rail Initiative for Europe
NERA	National Economic Research Associates
PKP	Polish Railways
POLIS	An association of European cities and regions with interests in transport and the Environment

RATP	Paris Regional Transport
RENFE	Spanish National Railways
RHK	Finnish Rail Infrastructure
RSP&G	Railway Safety Principles and Guidance
SZ	Slovenian Railways
TTK	Transport Technologie-Consult Karlsruhe GmbH
TVR	‘Transport on reserved track’ – French term for GLT
UIC	International Railway Association
UITP	International Public Transport Association
UK	United Kingdom
UNIFER	Rail regulation body, Italy
VAL	‘Light automatic vehicle’ – see Glossary
VDV	Association of Transport Operators, Germany

Executive Summary

The European Commission placed a contract with AEA Technology Rail in January 2000 to undertake a study of the obstacles to the completion of the internal market for rail mass transit systems. The origin of this study was the formation of the MARIE (Mass Transit Rail Initiative for Europe) industrial forum in March 1998. This was set up by European urban rail operators and the railway industry under the auspices of the European Commissioners for industry and transport. The objectives of MARIE are further to integrate the Single Market in this segment and to improve competitiveness.

The EC considered that divergent requirements for the construction and operation of urban rail systems and related product acceptance procedures vary strongly across Member States and that they contribute to market fragmentation and high costs.

Rail mass transit vehicles are defined as 'trams, light rail, metros' therefore the prime area of interest for the study has been urban rail transit systems that generally do not form part of a national rail network.

The countries covered were the Member States of the European Union, Norway, Switzerland and the first wave continental enlargement countries (Poland, Hungary, Czech Republic, Estonia and Slovenia).

The key elements of the project were:

- **Assessment of National Requirements**
- **Assessment of Local Requirements**
- **Discussions with Suppliers**

It was necessary to overlap these activities in order to provide sufficient time for responses and analysis of material within the project timescale. The timescale was however extended by about two months in the light of the slow responses that we obtained from many of the bodies that were consulted.

The following table summarises the institutions and bodies which define and manage safety requirements in each country of the study area.

Country	Regulations set by	Standards set by	Management by
Austria	Federal Government	CEN/cities	Federal Government and cities
Belgium	Provinces	CEN/National government/cities	Provinces and cities
Czech Republic	National Government	National Government /CEN	National Government
Denmark	National Government and Railway Inspectorate	National Government /CEN/cities	Railway Inspectorate
Estonia	National Government	Cities	Cities
Finland	Cities	CEN/cities	Cities

Country	Regulations set by	Standards set by	Management by
France	National Government	CEN/cities	Départments
Germany	Federal Government	Federal Government	Länder
Greece	Cities	Cities	Cities
Hungary	National Government	National Government	National Government/Cities
Ireland	National Government	CEN/cities	Railway Inspectorate
Italy	National Government	National Government	National Government
Luxembourg	National Government	CEN/cities	Railway Inspectorate
Netherlands	National /Provincial Government	Cities	National Government
Norway		Cities	Railway Inspectorate
Poland	National Government	National Government	National Government
Portugal	Cities	CEN/cities	National Government
Slovenia	National Government	Slovenian Railways	Slovenian Railways
Spain	Regional Government/Cities	Regional Government/ CEN/cities	Regional Government/Cities
Sweden	Cities	CEN/cities	Railway Inspectorate
Switzerland	Federal Government	Cities	Federal Government?
UK	National Government	National Government	Railway Inspectorate

Virtually all regulation is at national or sub national level. Euronorms are generally only applicable where the national government has adopted them, very few of any relevance to mass transit have been the subject of EC Directives and those will be on issues of detail, such as wiring.

Of the 22 countries being studied, 14 manage the application of standards at national level. Usually this is done by a 'Railway Inspectorate' or an equivalent body as part of their overall function for supervising the rail networks of a country as a whole. Sometimes the Railway Inspectorate may be part of a wider body with other responsibilities.

Many of the existing Railway Inspectorates are relatively new and have been established as a result of the process of opening up national railway networks to open access operation.

In three countries regulation is the responsibility of state, provincial or local government, namely Belgium, France and Germany. This is also the case in the United Kingdom, but only in Northern Ireland.

As part of the remit we were asked to consider defined key safety areas. The table below summarises the various safety standards actions that we are proposing as a result of our analysis of these topics.

Each topic can be considered in terms of the benefit to industry and the cost to society of standardisation. If we then consider these simply in terms of 'high' or 'low', then an action, which has high benefits and low costs, is worth doing quickly and vice versa.

We have listed the actions recommended:

- 'Existing standards' Standards exist now that could be applied to this area.
- 'New standards' Standards are being prepared that could be applied to this area.
- 'Standards required' New standards should be prepared for this area.
- 'Harmonise' Harmonisation only, no standards are required.

We gave these a priority:

- S Short term
- M Medium term
- L Long term

These priorities derive from the cost/benefit considerations and the effort and time required to achieve harmonisation.

We also noted where flexibility is required in any harmonisation process, i.e. new standards will cover issues such as interfaces, tests and options but not state exactly what should be provided.

Topic	**Industry benefit**	**Society cost**	**Action**	**Flexibility required**	**Priority**
Fire safety	High	Low	New standards		S
Crashworthiness	High	Low	New standards	Yes	S
Derailment	High	Low	Standards required		M
Doorway dimensions	High	Low	Standards required		M
Traction & control	High	Low	Existing standards	Yes	S
Train protection systems	Low	High	Standardise the systems	Yes	M
Emergency brake	High	Low	New standards		S
External lighting	Low	High	None	Yes	
Coupling type	Low	High	None	Yes	
Couplings retracting	High	High	Harmonise		L
Cab layouts	Low	High	None	Yes	
Cab equipment	Low	Low	Standards required	Yes	M
Emergency Equipment	Low	Low	Harmonise	Yes	M
Track gauge	Low	High	No action	Yes	
Gauging	High	Low	Standards required		M
Vehicle width	Low	High	Standards required	Yes	L
Vehicle height	Low	High	Standards required	Yes	L
Vehicle length	Low	High	Standards required	Yes	L
Internal layout	Low	High	No action	Yes	
Disabled person provision	High	Low	Standards required		M
Loading parameters	High	Low	New standards		S
Noise/EMC	High	Low	Existing standards		S
Other environmental	Low	Low	Standards required		M
Information interfaces	Low	Low	Harmonise	Yes	M

Topic	Industry benefit	Society cost	Action	Flexibility required	Priority
Information presentation	Low	Low	Standards required	Yes	M
Lighting	Low	Low	New standards	Yes	S
Heating and ventilation	High	Low	Standards required	Yes	M
Air conditioning	High	Low	New standards	Yes	S

This process is relatively ‘black and white’; some action is probably justified even where we have said ‘no action’ and actions we have suggested may be varied as a result of further work. The objective here is to provide an overview of the extent to which actions will be needed in order to achieve a single market, rather than be precise about detail.

The *major* obstacles to a Single Market that we have identified are:

- Variations in tender documents
- Language
- Infrastructure
- Risk
- Image
- Lack of expertise
- Competitive tendering
- Changing roles for mass transit

The conclusions of the study were:

1. The main scope for Single Market activity is Light Metro, Light Rail and Tramway systems.
2. There is little attraction to promoters and operators of new LRT systems to use standardised vehicle designs.
3. The largest market is for vehicles for existing and extended systems, rather than for entirely new systems.
4. There is a case for some ‘education’ to avoid the problems caused by political decisions at local level when priority is given to making systems individual in order to express a city image.
5. To assist in overcoming these problems we are suggesting the production of standardised format and terminology vehicle specifications.
6. A trial of this process would be needed.
7. Improved guidelines would be of value, in association with this process.
8. Coupled with this, the possibility also exists of producing standardised tender documents so as to create common procedures for procurement processes.
9. The ‘new approach’ to standardisation, adopted by the EC, is preferable, in terms of overall benefits, to having vehicles of totally standard dimensions.
10. Testing and acceptance procedures are perhaps more important than specified values.
11. The Single Market needs to consider a wider area than just Europe. The market for metro system vehicles will probably be important in developing countries.

Our recommendations are based on acceptance of the principle that a Single Market for Mass Transit vehicles would be worth developing. As required in the remit, we have defined these as short, medium and long term actions.

- Short term work is actions that might start virtually immediately and begin within two years.
- Medium term work might commence in the period 2003-2010.
- Long term work might begin beyond 2010 and depend on success in the earlier stages.

Short term:
1. Investigate how to establish in more detail the processes recommended .
2. Establish a process for producing guidelines that cover best practice in Mass Transit and for making these widely available and accepted.
3. Establish a process for informing city authorities, government bodies and scheme promoters of the advantages of harmonisation and the move towards a Single Market.
4. Produce harmonised vehicle specification documents.
5. Produce standardised tender documents.
6. Encourage use (partly by the above processes) of existing or currently planned Euronorms in specifications covering the following topics: Fire safety, crashworthiness, traction and control, emergency braking requirements, vehicle loading parameters, noise, Electro Magnetic Compatibility, internal lighting and air conditioning. Modify work on existing planned standards, if necessary, to take account of this issue.
7. Address the problem of lack of expertise to work on international standards and related issues, by investigating the issue and methods of overcoming it.
8. Devise a process where work towards the Single Market takes account of other work in related areas.
9. Investigate the extent to which the requirements of the European Single Market match those of potential export markets, e.g. North America, Far East, Australasia and rapidly developing overseas countries with large urban populations.

Medium term:
1. Carry out a trial using the harmonised specification and standardised tender documents with a small number of systems and assess the results. Modify the process accordingly.
2. Publish the Guidelines and generally promulgate the benefits of the Single Market approach.
3. Develop new Euronorms to cover derailment and other suspension related issues, doorway dimensions, train protection systems, cab equipment, gauging, disabled persons provision, environmental impact, information presentation and heating and ventilation. These Euronorms should cover mass transit generally and include street tramway operation.
4. Investigate and encourage harmonisation of the emergency equipment carried and of the interfaces required for information systems.
5. Reconsider the value of Internal Market Directives in the light of experience.

Long term:
1. Encourage full use of the harmonised specifications, the standardised tender documents and the processes and guidelines developed earlier and if necessary or appropriate issue Directives and/or encourage national legislation in order to enforce this.
2. Introduce new standards (Euronorms) for key vehicle dimensions for new systems (e.g. vehicle width, length and height). Where appropriate, seek modifications to any other legislation or requirements that inhibit this.
3. Resolve a specific issue associated with retractable couplers.

Overall benefits are estimated at around 20 Million Euros annually after 10-20 years if these recommendations were implemented.

Contents

Appendices (Volume 2)

1 Introduction

1.1 BACKGROUND

The European Commission concluded a contract with AEA Technology Rail in January 2000 to undertake a study on the obstacles to the completion of the internal market for rail mass transit systems. The remit is attached (Appendix A).

This document is the final report of that study.

A Work Plan[1] was agreed with the Commission and published on 17th February. The Intermediate Report[2] was also agreed and published on 5th July.

The origin of this study was the formation of the MARIE (Mass Transit Rail Initiative for Europe) industrial forum in March 1998[3]. This was set up by European urban rail operators and the railway industry under the auspices of the European Commissioners for industry and transport. The objectives of MARIE are further to integrate the Single Market in this segment and to improve competitiveness.

The EC considered that in rail mass transit, the clients (either urban operators or local authorities) usually specify design parameters of new systems in great detail. As a result they also considered that rolling stock, such as trams, light rail vehicles and metro cars, built to local specifications could not be used in another city, minimising residual value and limiting scope for vehicle leasing and other innovative financing methods. They saw the lack of technical harmonisation as resulting in small production runs and relatively high costs for the supply industry.

The EC considered that divergent requirements for the construction and operation of urban rail systems and related product acceptance procedures vary strongly across Member States and that they contribute to market fragmentation and high costs.

1.2 OBJECTIVES AND STRUCTURE OF THIS REPORT

The objective of the study is to provide an overview and analysis of the nature of, and reasons for, the current fragmentation of the Single Market for rail mass transit systems in Europe. To pursue this objective, we have studied in particular the extent to which regulations and product acceptance/certification procedures in place in the countries being studied are diverging. The study has included an assessment of the economic impacts of the existence of diverging requirements both on operators and on the railway industry, as well as an estimation of the likely benefits of actions towards technical harmonisation. We have developed recommendations for appropriate actions to overcome the market fragmentation due to diverging requirements for rail mass transit.

Rail mass transit vehicles are defined as 'trams, light rail, metros'[4]. Therefore the prime area of interest for the study has been urban rail transit systems that generally do not form part of a national rail network. So for example commuter rail services provided by a national rail authority, or by a private railway company, where the city or any sub-national government has little or no influence on specifications, have only been of secondary interest.

The scope therefore included tramways and light rail systems, urban metros, underground railways, light and automated metros, people mover systems, and systems such as GLT/TVR (guided light transit) that use rail for guidance only, that are planned at regional and local level. The standards and requirements of national rail systems have been relevant however, especially where interworking occurs between national and urban systems.

1.3 KEY ISSUES

In assessing the nature and reasons for the obstacles to the completion of the Single Market we were asked to address the following specific questions:

- What institutions or bodies act in the definition and management of the requirements, in particular in the area of urban rail safety?
- What actual procedures are used for management of the various areas of requirements and in particular the urban rail safety process?
- To what extent do operators of systems set the requirements (e.g. safety standards related to both operation and equipment) themselves?
- To what extent are the requirements and, in particular, safety regulations, based on economic considerations (i.e. risk assessment where the cost of safety measures is balanced against the risk associated with likely hazards)?
- How do the philosophies underlying the requirements (in particular related to safety) differ between the countries being studied?
- To what extent are diverging requirements driven by liability standards for rail mass transit operations?

We were also required to ensure that the assessment covered all significant safety and other characteristics that determine vehicle design including:

- Fire safety and measures to eliminate the hazards associated with electrical arcing.
- Crashworthiness, structural requirements and standards to minimise the effects of collisions.
- Wheel and rail profiles and geometry, suspension design, bogie performance and other measures to prevent derailment.
- Measures associated with the safe operation of door systems by staff and passengers, including accessibility and the need to cater for people with disabilities.
- Traction specifications and control methods.
- Train protection systems.
- Emergency braking standards and measures, the circumstances in which they are used and the accessibility of the brake controls to drivers.
- Head and tail lamps, marker lights and all forms of external lighting.
- Couplings.
- Driving cabs.
- Emergency equipment.

- Comparative overall dimensions, in particular track gauge, vehicle maximum widths and lengths, floor and platform heights, and restrictions on throwover when curving.
- Vehicle layout, including door locations, methods used for assessing number of standing passengers in various conditions and the mixed use of space for seating, standing or other purposes.
- Environmental impact.
- Visual and audible information systems.
- Heating, cooling and lighting.

The study focussed on the rolling stock and on major system interfaces (including power supply, track and structures, highway operation of street tramways, signalling and train control, communication and information).

The study also provided an overview of planned or prepared new requirements; in particular related to safety, in the countries covered.

We were asked to make a survey and an analysis of the existing product acceptance/certification procedures in the countries covered. Special emphasis needed to be placed on product testing procedures, quality assurance and the linkages between acceptance procedures and existing industry standards.

We assessed the economic impact of existing differences in requirements, in particular safety regulations/practices and product acceptance/certification procedures, on the rail mass transit supply industry and on urban rail system operators.

We developed recommendations for appropriate actions to overcome the obstacles to the completion of a Single Market for rail mass transit systems related to different requirements and in particular safety regulations. We distinguished recommended actions in terms of ‘Short term’, ‘Medium term’ and ‘Long term’.

1.4 STUDY AREA

The countries to be covered were the Member States of the European Union, plus Norway, Switzerland and the first wave continental enlargement countries (Poland, Hungary, Czech Republic, Estonia and Slovenia)[3].

1.5 METHOD OF APPROACH

The basic method of approach was agreed as part of the Work Plan.

The study covered 22 countries, with the possibility of standards and other documents being written in at least 17 languages.

Information was collected from all these countries and enquiries and discussions were necessary in some cases to determine facts that are not written down. The amount of information and experience available in each country does however vary. For example urban rail transport systems are much more extensive and developed in countries such as Germany, Switzerland and Austria than say Slovenia, Ireland and Greece.

The project team was set up so as to have the means to cover all the 17 languages and collect information and interview authorities in all the 22 subject countries.

The key elements of the project were:

- **Assessment of National Requirements**: This was split into two: an initial broad assessment to identify key issues and then a more detailed study. It included International Standards where appropriate and covered all countries.

- **Assessment of Local Requirements** such as are set by regional or city authorities. It would not have been feasible to study all of these, and instead we proposed approaching a large sample of authorities to obtain information, both directly and through a questionnaire. The selection of cities was based on obtaining a representative sample.

- **Discussions with Suppliers**: Major suppliers were contacted to ascertain their views on how differences between national and local requirements affect their ability to supply the same product to different markets. We also sought to establish which differences in requirements have significant effects on the price of equipment.

It was necessary to overlap these activities in order to provide sufficient time for responses and analysis of material within the project timescale. The timescale was however extended by about two months in the light of the slow responses that we obtained from many of the bodies that were consulted

1.6 PROJECT TEAM

This report has been compiled by AEA Technology Rail but includes input from the other project team members mentioned in this section. Team members responsible for information gathering were:

- **AEA Technology Rail**: A major player in the UK and Irish rail consultancy markets in particular, with broad experience including light rail studies and the formulation and application of safety standards. A subsidiary company in Madrid is active in Spain and Portugal, and a Polish member of staff was responsible for gathering information from that country.

- **TTK**: TTK is very active in light rail consultancy and project work in many European countries, and was responsible for information gathering in Germany, Austria, Slovenia, Luxembourg, Holland, Scandinavia, France and Italy.

- **Gradimir Stefanovic**: An independent consultant, Gradimir originates from the Balkans and works on light rail projects there and elsewhere. In this study he has been responsible for information gathering in Hungary, the Czech Republic, and Estonia, as well as some of the work in Slovenia.

Additionally, the team included several experts in rail technology and safety who contributed by addressing specialist topics and reviewing the conclusions. The report was put together by AEA Technology Rail with support from the team members listed above, and also from:

- **David Catling**, an independent consultant and member of the UITP Light Rail committee, with long experience of light rail systems and standards.

- **Major (retd) C B Holden**, who was formerly with the UK railway safety authority. He took a leading role in putting together the UK safety regime for light rail, including reviewing best practice from other countries, and has also been involved in rail safety in Ireland.

1.7 INFORMATION SOURCES AND CONSULTATION

1.7.1 International, national and regional

Information on ISO standards has been taken from publications.

We had meetings with Dee Razdan, Chairman of CEN Committee TC256, which covers all the rail standards produced by that organisation. He supplied various material as requested. AEA Technology Rail is itself a provisional 'Notified body' that in future may be involved in the certification process; the authors of this report have consulted with the Technology Director, R.Gostling, who has been fully involved in the negotiations for the company to achieve this status.

We identified the principal authorities responsible in each country of the study area for producing regulations and standards and for safety management. These are listed in Appendix B. All were contacted with requests for information.

In addition a meeting was arranged by the EC in Brussels on March 15th 2000 which was attended by representatives of the national rail standards organisations of the following countries:

- Belgium
- France
- Germany
- Netherlands
- Portugal
- Sweden
- United Kingdom

This meeting was convened specifically to discuss this study and the national representatives made presentations of the procedures that applied in their countries and provided background information.

Information has been obtained from various sources concerning the regulations and standards that apply in all countries of the study area. In some, for example Greece and Spain, there is little information available but this reflects the fact that these countries do not have regulations and standards in place.

We also made use of the NERA report[4] on Safety Regulations and Standards for European Railways, which had a section covering their application to secondary railways, including ‘metros and light railways (tramways)’. This report was published in February 2000. We have used it as a ‘cross check’ and guide, not as a direct source.

Major (retd.) C.B.Holden, who was a member of the study team, was also able to contribute significant knowledge and experience of both UK and certain overseas requirements as a result of his previous career within HMRI as a Principal Inspecting Officer of Railways.

1.7.2 Cities

We also collected local standards and the specifications produced by individual city authorities. There are nearly 180 cities and towns with rapid transit systems in the study area. The EC agreed that it would not be feasible to study all of these within the constraints of the project. Instead they agreed that we approached a selection of authorities based on the following factors:

- The number and size of urban systems in each country.
- The variety of types of urban system in each country.
- The extent to which cities have developed comprehensive standards of their own.
- Countries where special conditions prevail, e.g. use of non-standard track gauge, existence of older systems which inhibit standardisation, domination by markets outside of the EC and extreme climatic conditions.

The selection covered about 20% of the 180 systems. There has been continuing debate about the list and substitutions have been made. The table below shows the cities that were agreed in the approved Work Plan[1]. Contact details are given in Appendix C.

Country	Cities
Austria	Vienna
Belgium	Antwerp, Brussels
Denmark	(Copenhagen)
Finland	Helsinki
France	Paris, Nantes or Grenoble, Strasbourg
Germany	Berlin, Cologne/Bonn, Karlsruhe, Zwickau, Kassel
Greece	Athens
Ireland	(Dublin)
Italy	Milan, Rome, Naples
Luxembourg	(Luxembourg)
Netherlands	Amsterdam
Portugal	Lisbon
Spain	Madrid, Valencia
Sweden	Stockholm, Göteborg
UK	London including Croydon, Midland Metro, Sheffield, (Sunderland)
Norway	Oslo
Switzerland	Geneva, Zurich
Poland	Warsaw, Krakow
Hungary	Budapest
Czech Republic	Prague
Estonia	(Talinn)
Slovenia	(Ljubljana)

Cities shown in (brackets) are at an early stage of implementation or were considered to be less relevant to the aims of the study, and hence less likely to require a detailed examination.

Figure 1 shows the geographic spread of the cities that were initially consulted.

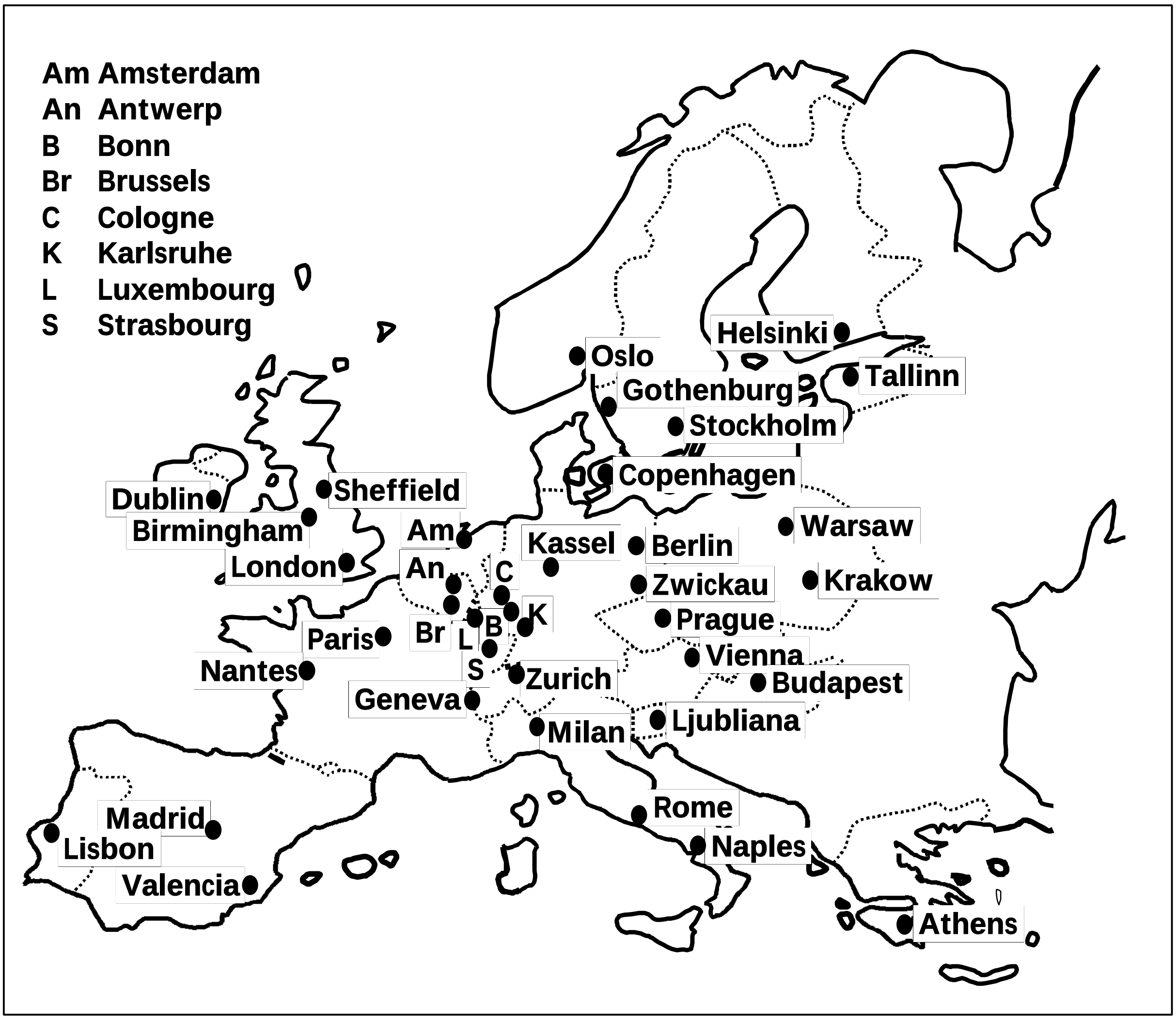


Figure 1: Cities Consulted

During the course of the study two issues arose that resulted in us discussing changes to this list with the EC:

1. Certain city authorities refused to co-operate.

2. Marc Girardot of MARIE expressed the opinion that the emphasis of the study should be on new LRT systems because this is where the benefits of harmonisation will be greatest. He did not see many new metro systems being built.

Some cities have refused assistance . To cover the possibility of an eventual lack of information we also contacted a number of 'replacement cities'. The situation is explained in detail in Appendix G.

In terms of the shift in emphasis, this has meant that for example in London, we have collected more information concerning Croydon Tramlink than on the London Underground. The same pattern has been followed elsewhere.

In addition to formal requests, we had already access to considerable information on many of these systems or had experience of working with them, so this has supplemented what we have specifically collected.

A second meeting was organised by the EC on March 15th to discuss the project with representatives of industry, both operators and suppliers. The operators represented were:

- Merseyside (Liverpool)
- Rheinbahn (Düsseldorf)
- RATP (Paris)
- London Transport

Other attendees included representatives of the following associations of operators or organisations with an interest in city transport:

- UITP
- POLIS
- EUROCITIES
- VDV
- The Association of Finnish Local and Regional Authorities

Subsequently further discussions took place with UITP, VDV and the Finnish association in order to facilitate the process of informing and obtaining information from specific cities.

We also gave the same presentation that was given to the two meetings on March 15th to the UITP Light Rail Committee on the 7th June. The following city authorities and operators were represented at the second meeting:

- Belgium: Brussels, De Lijn
- Bosnia-Herzegovina: Sarajevo (not in study area)
- France: Paris, Rouen, Transdev,
- Germany: Berlin, Cologne, Rheinbahn (Düsseldorf), Stuttgart
- Hungary: Budapest
- Italy: Milan, Palermo
- Netherlands: The Hague
- Portugal: Lisbon
- Romania: Bucharest (not in study area)
- Sweden: Gothenburg
- Switzerland: Zurich
- Tunisia: Tunis (not in study area)
- UK: London, Manchester

TTK, at the same time as working as part of this project team, have coincidentally also been working as part of the Cross Rail project, with the objective of developing a standard European 'Tram Train'. They have also been working with Semaly and Systra on a standard French LRV. This experience, plus their considerable work experience for other cities throughout Europe, has been an additional source of information.

1.7.3 Industry

We have been in dialogue with each of the five major firms which together dominate the European vehicle supply industry:

- Adtranz
- Alstom
- Ansaldobreda
- Bombardier
- Siemens

We asked all five firms for information on their 'platform products' i.e. vehicle designs based on modular concepts and ranges of options so as to encompass the variations in specification encountered within Europe.

We also asked them to complete a questionnaire, the purpose of which was to identify which safety and other requirements, in their opinion, fundamentally affected vehicle design.

During August 2000, it was announced that Bombardier is to purchase Adtranz (subject to regulatory approval), but for the purpose of this study we have considered them as separate firms.

Other discussions were held on various supplementary topics with these firms and also with Kiepe of Germany, another notable supplier. Contact details of the firms that we have been in contact with are listed in Appendix D.

In addition to this consultation, we have made extensive use of published material and our own knowledge of the supply industry. In particular David Catling and Gradimir Stefanovic have undertaken considerable previous studies of the supply industry as part of their role as members of the UITP Light Rail Committee.

2 The Current Situation

2.1 THE RAIL MASS TRANSIT INDUSTRY

2.1.1 Growth and Types of System

The rail mass transit industry that we are studying consists of urban rail transit systems that generally do not form part of a national rail network. Tramway and metro systems (the latter usually underground metropolitan railways) have existed in Europe since the 1860s. Tramway development in particular intensified once electric traction became the norm from 1890-1914 but thereafter suffered a sharp decline in many countries due to vulnerability to competition from buses and trolleybuses, and due to increased use of private transport. Metro development also accelerated with electric traction, but the high cost and disruption of building this type of system has limited their number and rate of growth; many systems are relatively recent in origin. Unlike tramways, high-capacity Metro routes are less vulnerable to competition and, once opened, few routes have been abandoned.

To meet the high demand for high quality public transport from the 1960s onward, existing tramways were modernised or replaced by new Light Rail or Light Metro. These modes are characterised by modern high productivity vehicles, largely segregated from road traffic wherever possible to increase regularity and reduce journey time. Continuing experimentation has resulted in the emergence of a few Automated Light Rail systems (ALRT) and more novel solutions of which the French VAL automated people mover is perhaps the most significant.

More recently Light Rail systems have tended to adopt characteristics closer to those of traditional tramways, for example extensive street operation so as to achieve high visibility and meet improved access expectations. However, although operation in pedestrian areas is attractive in city centres, the newer systems tend to be segregated from motorised general traffic.

Because of the differences between countries, and because the light rail modes in particular have evolved from existing tramways, there is no agreed means of categorising the modes. A definition is included in the glossary and has been used here to categorise systems.

Into the ‘other’ category we group all mass transit system which are either driverless or do not use ‘conventional’ steel wheel on steel rail. All these systems are totally segregated from other modes.

The table below shows the number of cities and towns that have urban rail transit systems in the countries of the study area by type (a city will appear more than once if it has more than one type of system):

Country	**Metro**		**Light Metro**		**LRT/Tramway**		**Other**	
	No	route-km	No	route-km	No	route-km	No	route-km
Austria	1	38.5	0	0.0	5	286.6	0	0.0
Belgium	1	40.5	0	0.0	5	296.0	0	0.0
Czech Republic	1	43.6	0	0.0	7	339.0	0	0.0
Denmark	0	0.0	0	0.0	0	0.0	0	0.0
Estonia	0	0.0	0	0.0	1	39.0	0	0.0
Finland	1	16.9	0	0.0	1	75.0	0	0.0

Country	Metro		Light Metro		LRT/Tramway		Other	
	No	route-km	No	route-km	No	route-km	No	route-km
France	2	226.1	0	0.0	7	98.6	4	64.2
Germany	4	342.6	7	284.1	53	2477.6	1	13.3
Greece	1	25.8	0	0.0	0	0.0	0	0.0
Hungary	1	30.8	1	176.0	4	186.0	0	0.0
Ireland	0	0.0	0	0.0	0	0.0	0	0.0
Italy	3	111.6	3	165.4	5	402.6	0	0.0
Luxembourg	0	0.0	0	0.0	0	0.0	0	0.0
Netherlands	2	120.3	2	37.6	3	333.1	0	0.0
Norway	1	49.6	1	48.4	2	136.8	0	0.0
Poland	1	11.2	1	29.0	14	907.5	0	0.0
Portugal	1	30.0	0	0.0	1	72.0	0	0.0
Slovenia	0	0.0	0	0.0	0	0.0	0	0.0
Spain	3	251.6	2	270.6	3	15.4	0	0.0
Sweden	1	110.0	1	5.7	2	130.6	0	0.0
Switzerland	0	0.0	5	112.7	5	229.6	0	0.0
United Kingdom	2	402.4	1	59.5	5	128.9	1	21.7
TOTAL	**26**	**1851.5**	**24**	**1189.0**	**123**	**6154.3**	**6**	**99.2**

Figure 2 shows the cumulative growth in the number of new systems since 1970. As noted above the growth has most recently been in the LRT/tramway sector. However many of the new systems categorised as Light Metro or 'Other' modes also use significant elements of LRT/tramway technology.

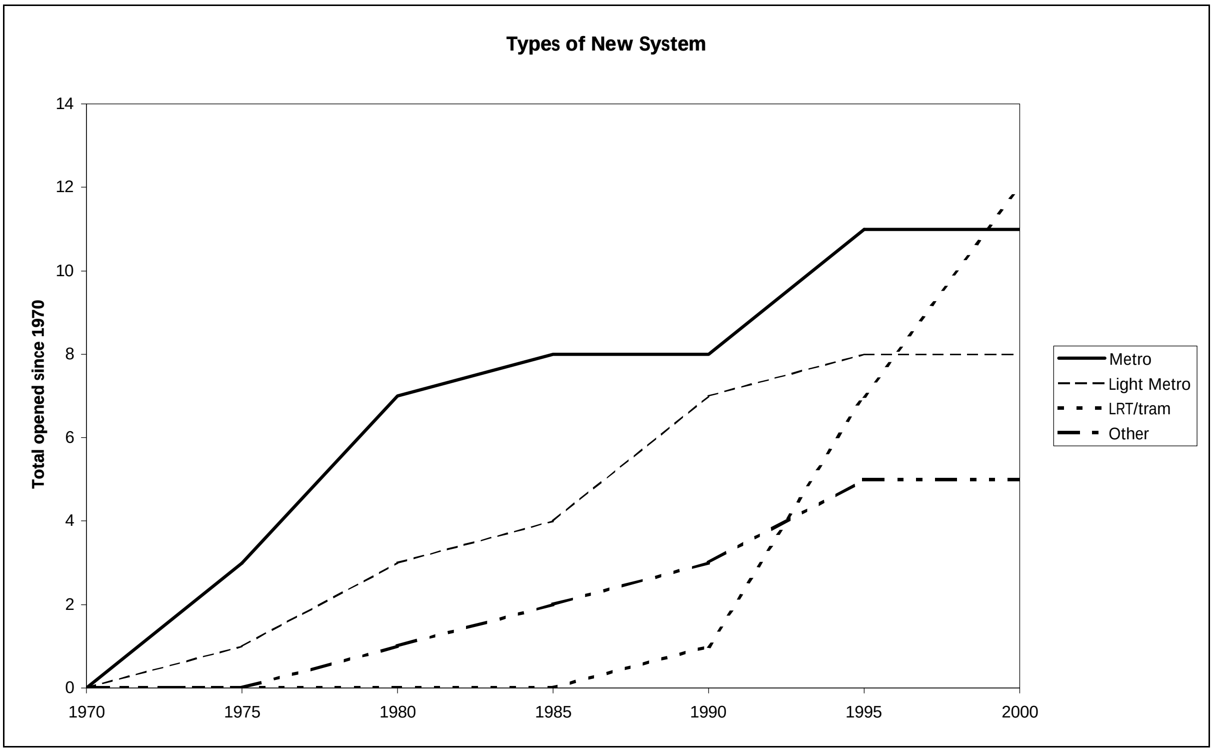


Figure 2: New systems since 1970

Not all countries in the study area have mass transit rail systems at present. However there are plans for new systems in Denmark, Ireland, Luxembourg and Slovenia.

The source of the data in the above table is mainly the Light Rail Transit Association[5], and is correct to 1998 with some more recent updates. We have used our judgement in categorising systems into the four mode groups, and in excluding systems which are predominantly rural, or which only serve a tourist or museum role.

2.1.2 Trends

In strategic terms the following trends that affect rail mass transit in the study area are of significance to this study:

- The increasing interest in rail mass transit as a solution to reducing congestion, protecting the environment and stimulating local economies.
- The trend to make public transport more accessible to all.
- Interest in reducing the costs of constructing and operating systems so as to extend their potential.
- Concern about the safety of rail systems.
- Concern about personal security when using public transport.
- Substantially increased interest in ‘shared track’ systems, which will break down the distinction between conventional railways and mass transit systems and have significant safety implications.

2.1.3 Technical Developments

The following technical developments have influenced the industry in recent years and are of importance to this study:

- The development of complete or partial low floor Light Rail Vehicles and trams, so as to improve access. Complete low floors in particular have given rise to a whole range of fundamentally new designs.
- The use of platform doors on metro, light metro, people mover and automated systems.
- Development of ‘Tram train’ vehicles with higher crashworthiness and compliance with certain railway standards so as to achieve shared track operation between light and heavy rail.
- Development of ‘modular’ vehicles and ‘platform’ product strategies, so as to provide a range of options within a more standardised product offer.
- Use of computer controlled systems to provide simpler but more effective control, higher levels of safety, fault diagnostics and improved passenger information systems.

- Interest in alternatives to electric traction such as diesel, gas turbine, LPG and in the longer term fuel cell powered vehicles.

2.1.4 The Suppliers

The rail mass transit industry in Europe is characterised by a relatively small number of major suppliers. Adtranz, Alstom and Bombardier each have major manufacturing facilities in several European countries. Siemens is based in Germany and Ansaldo-Breda in Italy but both market their vehicles throughout Europe and the world.

A large number of other firms operate as sub-contractors to the vehicle suppliers, providing components such as complete traction packages, braking systems, control systems, body structures, bogies and door equipment.

The concentration of the supply industry among a small number of firms should, in theory, facilitate standardisation and progress towards a single market.

2.1.5 Modular Designs

One response by suppliers to the problems of variations in requirements has been the adoption of modular vehicle designs. By this process, one basic design can be adapted so that it fits into the geographical conditions of virtually every city. This approach is especially valuable in allowing flexibility of dimensions, which is one feature that most cities cannot afford to standardise on.

The table that follows indicates the flexibility that is possible by application of three typical modular designs:

Options available	**Length (m)**	**Width (mm)**	**Other key options**
Incentro (Adtranz)	18.6-49.4	2300/2400/2650	Gauge One/two cabs Cab end design Type of seats
Citadis (Alstom)	20-50	2300/2400/2650	Partial or full low floor Aluminium/steel or stainless steel bodies Shared track version 750/1500V /15kV/25kV
Combino (Siemens)	18/21/26/30/34/38/42	2200-2650	Installed power Passenger information Air conditioning Seating arrangement and type Door types

The Incentro and Combino designs are all 100% low floor. Citadis can be supplied as 100% low floor or in a variant with high and low floor sections.

3 Standards Bodies

3.1 INTERNATIONAL

The principal international body is the International Organisation for Standardisation (ISO), a worldwide federation of around 130 national standards bodies. ISO publishes international standards.

At the European level there are three international standards bodies that are relevant to mass transit railways:
- The European Committee for Standardisation (CEN)
- The European Committee for Electrotechnical Standardisation (CENELEC)
- The European Telecommunications Standards Institute (ETSI)

CEN Technical Committee 256 is responsible for railway applications, including mass transit systems. It works together with CENELEC and ETSI via a special joint rail programme currently chaired by David Moss.

The fundamental methods of working of these three European standards organisations is as follows:

- They work solely to apply EC directives. Those that currently apply to CEN TC256 cover procurement, machinery, construction and interoperability.

- They plan, daft and arrange adoption of standards through procedures that respect the principles of openness and transparency, consensus, national commitment and technical coherence at the European and national level.

- Administration is financed by the EC, EFTA and national members. The costs of technical expertise, which are much higher, are financed directly by industry and society.

The following table shows the member status within CEN of each country in the study area.

Country	**Membership status**	**National standards body**
Austria	National	ON (Österreichisches Normunginstitut)
Belgium	National	IBN/BIN (Institut Belge de Normalisation/Belgisch Instituut voor Normlisatie)
Denmark	National	DS (Dansk Standard)
Finland	National	SFS (Suomen Standardisoimisliitto r.y.)
France	National	AFNOR (Association française de normalisation)
Germany	National	DIN (Deutsches Institut für Normung e.V.)
Greece	National	ELOT (Ellinikos Organismos Typopoiisis)
Ireland	National	NSAI (National Standards Authority of Ireland)
Italy	National	UNI (Ente Nazionale Italiano di Unificazione)
Luxembourg	National	ITM (Inspection du Travail et des Mines)
Netherlands	National	NNI (Nederlands Normalisatie-institut)
Portugal	National	IPQ (Instituto Português da Qualidade)

Country	Membership status	National standards body
Spain	National	AENOR (Asociaciôn Española de Normalzaciôn y Certificaciôn)
Sweden	National	SIS (Standardiseringskommissionen i Sverige)
United Kingdom	National	BSI (British Standards Institution)
Norway	National	NSF (Norges Standardiseringsforbund)
Switzerland	National	SNV (Schweizerische Normen-Vereinigung)
Poland	Affiliate	PKN (Polski Komitet Normalizacji)
Hungary	Affiliate	MSZH (Magyar Szabvanyugyi Hivatal)
Czech Republic	National	COSMT (Czech Office for Standards, Metrology and Testing)
Estonia	Affiliate	ESK
Slovenia	Affiliate	SMIS (Standards and Metrology Institute (Slovenia))

The basic process is that when a European Standard is created the equivalent national standards are made identical wherever possible. Members are obliged to implement European Standards by giving them the status of national standards. They must also withdraw any conflicting national standards. This occurs provided more than 71% of countries vote in favour of the adoption of the standard.

The existence of a standard does not of itself require that applications should follow that standard. For a particular mass transit system, compliance to a particular standard may be made mandatory by EC Directive, national or local legislation or the terms of the procurement contract. Alternatively a supplier may demonstrate or warrant compliance to a standard as evidence that their product is suitable. CEN standards can therefore offer a route to harmonisation of requirements, while remaining optional if not appropriate for a particular application.

Less than 20 European Standards apply to railways and only one exclusively to mass transit systems (EN50206-2 Pantographs for metros and light rail vehicles).

Most of the CEN standards relating to the railway industry cover sub-systems of vehicles. Sometimes it will be appropriate for vehicle procurers to specify compliance of these sub-systems to the relevant standards, for instance if a failure of a sub-system can have an effect on the safety of passengers. In other circumstances, a vehicle manufacturer will require individual subsystems to comply with relevant standards, as part of the process of supplying a vehicle that meets the overall requirements of a particular application.

Clearly, where it is practicable to do so the use of harmonised standards is to be encouraged, since it will minimise the chances of suppliers having to demonstrate compliance with a number of different requirements.

An issue is the time it takes to produce a European Standard, currently about seven years. CEN TC256 aims to reduce this to four and the current work programme involves the publication of 107 new rail standards.

Clearly the role of the European Standards Organisations is growing rapidly in the railway industry sector and they could have a significant role in developing a Single Market for mass transit vehicles.

The International Railway Association (UIC) is another international body that produces standards pertaining to railways. Its fundamental objective in doing this is to facilitate international transport by rail. Mass transit systems, as defined in this study, would not normally be members of the UIC and the emphasis of the organisation is on heavy rail. However reference to compliance with certain UIC standards can be useful in certain circumstances.

The International Public Transport Association (UITP) is the world's largest trade association for the public transport industry. Its Light Rail Committee has produced many publications, and is currently preparing guidelines based on the practical experience and research of its members over a long period of time. These present best practice and suggestions for the design of vehicles, including factors to be considered. UITP has no official function so far as producing guidelines is concerned, but this work has considerable potential value. It is currently producing a set of planning guidelines for transport authorities considering a light rail system for the first time.

Within Germany, the Association of Transport Companies (VDV), has produced many publications over a long period of time that are guidelines of best practice in rail mass transit. They are aimed at operators but much of the subject matter is of value to suppliers. VDV recommendations are not binding but are widely accepted as 'state of the art' not only in Germany but also in Austria, Switzerland, the Scandinavian countries, Luxembourg and Estonia. Because Germany has the greatest extent of Light Rail and tramway systems within the study area, and because of its long and continuous history of engineering and operational development in this field, VDV recommendations have also been used to help create guidelines and standards in other countries as well. e.g. the UK.

VDV publications 150 'Type recommendations for light rail vehicles' and 153/2 'Recommendations for developing performance specifications for Light Rail' are of special interest, since they are aimed at promoting standardisation.

The VDV is mentioned here rather than in section 3.2.6 because its publications are in use internationally.

3.2 NATIONAL

3.2.1 Austria

The Federal Ministry for Science and Transport has general responsibility for transport legislation, this includes metro and tram systems.

Tramways and LRT systems have been covered by the Railways Act of 1957 but from 1st July 2000 new regulations were introduced to cover these systems.

Each system creates its own internal regulations, based on the Railways Act, for approval by the Ministry. Each company is responsible for enforcing its regulations[4].

Regulations have been based on Germany's BOStrab (see 3.2.6). VDV publications are used as guidelines by the systems within Austria.

3.2.2 Belgium

Essential requirements were laid down in a national regulation of 1976; transport operators are responsible for meeting these.

In 1987 the three provinces were made responsible for regulation of mass transit systems. This is facilitated by the fact that the systems that exist coincide with the provincial boundaries. This control includes fairly detailed intervention, for example the testing of braking systems.

The Ministry supplied our study team with a copy of the regulations.

3.2.3 Denmark

Responsible bodies are the Ministry of Transport and the Railway Inspectorate.

Activities are controlled by the Railway Safety Act of 1996. This allows the Minister to:

1. Establish railway safety regulations
2. Establish regulations pertaining to the application or fulfilment of EU regulations and EU directives concerning railway safety.
3. Authorise the Railway Inspectorate to partially exercise the first of these activities.

The Act set up the Railway Inspectorate.

The legislation covers all 'railways' and railway operations, so seems to apply to new metros, including LRT. It replaced the Act of 1919 that supervised the Private Railway companies.

The Copenhagen Metro, now under construction, is an automated 'Light Metro', and vehicles have certain LRT characteristics. As a new underground railway it presumably will come under the above Act.

3.2.4 Finland

Finnish Railways are responsible for the standards for rail vehicles.

Finland has created standards relating to railways.

There are no specific LRT and tramway standards at national level in Finland. Helsinki Metro and Tramway are responsible to the City Authority for their self-regulation. In future however, these and any new systems might be regulated by the Finnish main line infrastructure owner RHK. This is a civil service agency under the Ministry of Transport and Communications. It was separated from the state railway, VR, in 1995. RHK is also the safety regulator[4].

3.2.5 France

The only general national regulations in France for tramways or light railways is the Ministerial decree No.730 of 1942 for regulation of railways, which applies to all rail systems. It is a legal document that provides the broad principles and outline requirements for safety on these systems. However, while this document still has status in terms of overall safety regulation the detailed technical requirements are no longer observed. An example is the requirement that the grooves in tram rail must be no wider than 35mm - recent systems have used wider grooves. The process by which this occurs has not been identified.

The state is ultimately responsible for public transport safety. It establishes regulations and checks compliance. General regulation and safety standards are established by the DTT (Directorate for Land Transport).

The DTT is in charge of the supervision of public enterprises and of the relationship between the state and local authorities, local transport authorities and professionals within the land transport industry.

Local transport, including metro, LRT and tramways, is the responsibility of the ‘sous direction des transports collectifs’ (mass transport sub-directorate). This body establishes national regulations.

The individual Départments (local administrations) are responsible for safety on LRT and tramway systems. This involves:

- Issuing permits for operation (new systems, new lines, new rolling stock)
- Approving the safety rules of operators
- Monitoring traffic
- Investigation of minor accidents (major accidents are a State responsibility)

This situation is likely to change. Two decrees are being formulated, one on safety on the national rail network and the other on land guided public transport. French Railways have commissioned Systra, Semaly and TTK to prepare the terms of reference for a tender for a standardised French dual-mode (shared track) LRV, this includes a review to see how applicable the design would be to the wider European market.

The general principle that is being applied in safety assessment is that an extended rail network should be no less safe than the existing one. Use of more rigorous safety processes is considered to be especially important where technical innovation occurs.

France has other standards that relate to detailed aspects of mass transit systems issued by AFNOR and CEI. These mainly cover fire prevention, external finish, safety, reliability, maintainability, access doors, and pantographs.

Several totally new systems have been constructed in France and there have been attempts to produce a French ‘standard’ tram. A significant number of the new systems have been developed by the same private build and operating company, creating an element of standardisation by default.

3.2.6 Germany

The Federal Ministry of Transport, Building and Housing is responsible for regulations that apply to the design and operation of LRT systems including Metro and tramway but not any operation on main lines. Shared track operation comes under railway safety legislation created to cover the operation of light passenger rail cars and vehicles on the national network (LNT-Richtlinien).

There are three types of regulatory documentation:

- Federal legislation
- Federal design and operation regulations - statutory instruments.
- Technical guidelines covering these regulations.

The same pattern applies to both railway and metro/LRT/tram regulations.

Rail regulations derive from the General Rail Transport Act (referred to as AEG). The design and operation regulations are 'Eisenbahnbau- und Betriebs-ordnung' (EBO).

Metro/LRT/tram regulations derive from the Passenger Transport Act (referred to as PbefG). The design and operation requirements are 'Strassenbahnbau- und Betriebsordnung' (BOStrab), which has been examined in detail as part of this study. The most recent version is dated 11/12/1987. This regulation was submitted to the EU as a technical standard in that year in compliance with international law, and still applies without modification. It includes safety requirements and design practices.

The previous BOStrab (dated 1965) was much more specific but this did not significantly inhibit the development of new systems. There was provision for exemption subject to safety risk assessment.

The view of the Ministry was that risk assessment must not become the norm because this would create legal proof difficulties and significantly increase administrative costs. On the other hand, the speed of technical change might result in regulations needing to be changed at shorter intervals and this would also create legal problems. The outcome was that the later regulations are as free as possible of technical details and concentrate on essential principles. This had applied in 1965 but was developed more fully later.

Guidelines have been prepared with the assistance of the governments of each federal state and professional associations. The process is facilitated by using 'generally recognised technical rules', which are continuously updated. They allow the responsibilities of each party to be identified without severely limiting their discretion.

The following basic rules are laid down in section 2 of BOStrab:

1. Infrastructure and vehicles must be built so as to meet safety and performance requirements. These requirements are deemed to be met when there is conformity with these regulations, to the requirements of the responsible technical supervisory authority and planning and or licensing bodies, and to generally recognised best technical practice.

2. Variation from the generally recognised best technical practice is permissible, provided that the same level of safety can be guaranteed.

Paragraph 1 in detail also refers to the basic safety and regulatory requirements that are contained in other regulations issued by Federal and state governments. This is essential because otherwise it would not be possible to cover all the aspects that have to be covered in a rapidly changing legislative environment.

The second paragraph extends the freedom available to suppliers, designers and operators, especially where new technology is involved. In this case the generally recognised best technical practice simply becomes a reference guide.

The Federal Government issues regulations but does not control their application. This is the responsibility of the state governments. They may draw on other experts or expert bodies to assist them and may also require operators and promoters to provide evidence of a safety case or technical nature.

There is also no central authority for vehicle acceptance and inspection of system safety for systems that come under the BOStrab regulations. The individual state governments undertake these functions.

State governments continue to be responsible for control because of the historic differences in systems.

Individual states do not create regulatory legislation for transport systems; they may however interpret Federal legislation differently.

The German Public Transport Association (VDV) co-ordinates activities and responses to changes in public transport policy and important regulations (especially BO Strab). As mentioned previously, VDV publishes guidelines to assist its members (VDV Richtlinien).

3.2.7 Greece

The Ministry of Transport and Communications is responsible for existing systems.

The new Athens Metro was procured by the Ministry of Environment, Physical Planning and Public Works, which provided its detailed requirements in the form of tender documents. When the system is fully operational, it will transfer to the control of the other Ministry.

There are currently no national standards for mass transit systems. All rail systems are self-regulating. There has been some recent adoption of international standards (ISO/Cenelec) and there are plans to introduce modern legislation to cover the regulation both of the national rail network and secondary lines (including metros etc)[4].

3.2.8 Ireland

There are no existing systems but a light rail system is under construction in Dublin. There are no Irish national standards for either heavy or light rail but there is a Railway Inspectorate.

The only safety regulatory provision in the Act under which the Dublin LRT is being constructed is that no part of the system is to be brought into service unless approved by a Railway Inspecting Officer.

The Department of Public Enterprise has overall responsibility for rail safety and legislation, including Dublin Light Rail, and proposes setting up an independent Inspectorate and to introduce a safety case regime. The safety case regime will apply to both heavy and light rail and the onus will generally be on the developer or promoter to demonstrate safety validation and compliance and in so doing to adopt appropriate safety standards/guidance/best practice.

The safety standards of the Dublin LRT have so far largely followed best UK practice. Both Irish Railways and Dublin LRT have adopted the UK Railway Safety Principles and Guidance, modified where necessary to cater for the difference in track gauge and for compatibility with the existing railway system.

3.2.9 Italy

Mass Transit systems are the responsibility of the Ministry of Transport.

UNIFER, the Rail Regulation division of the Italian Government Standardisation body, develops standards for LRT and tramway systems. A draft new frame standard was issued to cover LRVs and trams in January 2000. This standard will replace six earlier vehicle standards.

CEI, the Italian Electro Technical Committee, also sets standards[4].

The aim of the new standard is to define principal requirements including safety features. It is a requirement that these standards must be referred to when any significant project for a new or modernised LRT system is taken forward.

The new standard refers to 12 other UNIFER standards which cover interactions between vehicles and infrastructure (e.g. definition of track gauge and rail profiles) or rail systems in general (e.g. protection measures against electrical hazards).

3.2.10 Luxembourg

In the past, railway safety and legislation was purely the responsibility of the national railway (CFL). Gestion Réseau was established recently, and will have a railway inspectorate function. Luxembourg does not have any rail standards of its own. In recent years proposals were developed for a LRT network in Luxembourg, involving shared running on parts of the rail network. The requirements for the proposed vehicle were created specially, making use of the German VDV recommendations.

3.2.11 Netherlands

Provincial governments are responsible for safety on LRT systems, the exception being Utrecht where the LRT route is in effect part of the rail network. Shared track developments will also probably fall outside the responsibilities of the provinces.

Regulations are produced at both national and local level. Railway safety is controlled mainly by specific laws defined by the Ministry of Transport. There is a separate law for metros and tramways[4]. The administrations responsible for rail safety also examine safety cases.

The safety processes are based on risk assessment with a table of risk factors for people at individual risk in certain situations and the ‘social’ risk that applies to the line as a whole. Guidelines on these risk factors were expected to be published in summer 2000.

Up to 400 local authorities might be involved in this process; they may use national government principles, but this is not enforced. However this may be changed when the 1875 Railway Act is replaced by new legislation.

It is recognised that there are considerable difficulties in translating risk factors back into specific standards, for example wheel profiles.

The principle applied in the Netherlands is that the market makes its own standards. Guidelines are being created for new LRT systems.

3.2.12 Portugal

The Instituto Nacional do Transporte Ferroviário (INTF) was set up in 1998; it is part of the Ministry of Public Works and deals primarily with accident investigation. Metro and LRT systems will come under its scope in future.

The INTF has statutory safety responsibilities, including the approval of safety systems submitted to the promotion of technical safety improvements, and the maintenance of technical records of accidents[4].

There are no national regulations for metro, LRT and tramway systems. The Lisbon Metro has created its own safety regulations, which are contained in seven volumes and cover various topics including operation, signalling, track workers, communications, policing and infrastructure. The Porto Metro has yet to produce the equivalent documents.

Tramways, such as those in Lisbon, Porto and Sintra have no safety regulation.

3.2.13 Spain

Each system is self regulating and creates its own standards. This is mainly because Spain is broken down into 13 autonomous self-governing regions and these regions have authority for developing transport infrastructure in the cities. If there is a project in a particular city, the transport departments of the local government in question and the city authorities issue a public tender for technical assistance to define the system. There are a number of local companies that specialise in this sort of support. There is little or no intercourse between the different regional governments on these matters.

There is at present no external regulatory body governing operations in the Spanish Railway network. Each operator manages its own safety functions and formulates its own regulations. This is carried out according to regulations prepared and applied by RENFE (the national railway system). The Civil Protection and Traffic Safety Head Office (CPTSHO) of RENFE is responsible for the formulation and enforcement of technical traffic standards[4].

3.2.14 Sweden

There are no specific standards. Each system is considered by the Swedish Railway Inspectorate on a ‘case by case’ basis. Each applicant must prove the value of any proposed new system.

There is a perceived need to clarify this process. A review is under way to establish regulations.

The principle adopted is that industry must adopt technical standards, which may be internationally accepted ones, and Sweden has no wish to create its own. The focus is on risk assessment rather than specifications.

Infrastructure operators have in law the main responsibility for railway activities; they therefore produce traffic safety rules for approval by the Railway Inspectorate. These rules may be very different for railway systems that do not share traffic with each other or with the state lines[4].

The Railway Inspectorate is the only body that deals with safety approval; it deals with the whole rail sector.

New requirements are likely to be ‘high level’. Approval processes will concentrate on the vehicle manufacturer rather than the operator to achieve a ‘type approval’ approach.

In general, designs that are acceptable elsewhere in Europe will be considered suitable in Sweden. Even in terms of weather, a vehicle that is suitable for operation in Germany should be suitable at least in the southern parts of Sweden.

3.2.15 United Kingdom

The relevant standard setting and regulatory bodies for LRT in Great Britain are the Department of Transport, Environment and the Regions (DETR), the Health and Safety Executive (HSE) (via Her Majesty’s Railway Inspectorate (HMRI)) and the Confederation of Passenger Transport (CPT). These are all national organisations.

Great Britain has the advantage of mostly new, modern systems and a consistent national approach.

Key elements of the safety regime in Great Britain are derived from legislation and comprise:

- Need for approval of a Safety Case for railways (as defined) but not for tramways.
- Compliance with the Safety Critical Work Regulations which cover the competency and fitness of staff and their working hours.
- Various regulations including the requirement to report accidents and others on communications.
- HMRI’s ‘Rail Safety Principles and Guidance’, which are guidance, not standards as such. Alternatives are acceptable providing a case can be made.
- The requirement for new systems and significant enhancements to be approved by an Inspector from HMRI. The published guidance gives an indication of what is likely to be acceptable, and on recent projects HMRI inspectors have been involved throughout the development in order to provide advice on what is acceptable.

Policy is under review at the moment in the light of serious rail accidents but may not significantly affect the procedures for mass transit and tramways.

There are no mass transit systems in Northern Ireland; there has been a project for a Light Rail system in Belfast but this is not currently being taken forward. The railways of Northern Ireland adopt HMRI’s Railway Safety Principles and Guidance, modified to suit the different track gauge and the need for interworking with Irish Rail.

The Northern Ireland Act, 1998, provides for responsibility for road and rail safety to be transferred to the new Northern Ireland Assembly and Executive[4].

3.2.16 Norway

Railway Safety is the responsibility of the Norwegian Railway Inspectorate.

There are no specific LRT or tramway standards. Each system will create its own specifications. Oslo has made use of German VDV recommendations.

3.2.17 Switzerland

The Federal Transport Authority (BAV) is responsible for rail safety and legislation. Use is made of German VDV standards.

There are a large number of private railways, light railways and tramways in Switzerland, which presumably come under this authority. Tramways have to meet certain railway regulations.

3.2.18 Poland

The three relevant bodies responsible for setting railway standards and regulations in Poland are as follows in order of priority:-

The Polish Parliament: The Construction Law (Prawo Budowlane) is set by the parliament and signed by the president of Poland.

Ministry of Transport (Ministerstwo Transportu): The regulations passed by the ministry specify the technical conditions for the location and construction of railways. There are other non-railway specific regulations which can effect the railways, e.g. 'Technical requirements for level crossings'. The regulations issued by the ministry are signed by the minister.

Polish State Railways (Polskie Koleje Panstwowe - PKP): There are numerous instructions issued directly by the PKP e.g. 'PKP Signalling Instructions'. These are increasingly being redrafted and re-issued as regulation directly by the Ministry of Transport.

Poland is going through an exercise of bringing all its 7,000-plus technical standards in line with those in the European Union countries. This has been ongoing for the past few years. Some standards, including some affecting the construction and operation of tramways, are still in production and may therefore not yet be available.

In the meantime, Krakow is undergoing a redevelopment of its tram system. Similarly, Warsaw is undertaking a smaller scale, partial renovation of its system. The Warsaw Metro is planning to finish building Line 1 and then to construct Lines 2 and 3. Following recent local government reforms there is some uncertainty as to the future of direct line responsibility with respect to standards and regulations.

In general terms, the standards tend to be national rather then local.

3.2.19 Hungary

Commissioning and operation of the safety systems of railway networks are subject to the OVSZ I and OVSZ II regulations. The current authority responsible for these is the Ministry of Transports, Communications and Water Management (KHVM). OVSZ I covers national railways, and OVSZ II covers local railways including urban mass transit systems.

In order to introduce a new technical feature or operation the railway authority must produce a specification. This is then approved by an authority that issues a railway construction permit. If the specification includes the import of overseas products then these have to be licensed by means of a permit issued by the same authorities. The specification will in many cases include cross references to international standards that apply in Hungary.

Urban systems, such as those in Budapest, are also subject to regulation by city authorities. For example, the Independent Roads and Railways Department of the Budapest Traffic Inspectorate has this role in the capital.

3.2.20 Czech Republic

The Czech government regulates the safety of rail transport and rail networks, the responsible body being the Ministry of Transport.

The basic safety requirements and regulations are set out in the Railways Act No.266 of 1994. This Act regulates all railways including mass transit, LRT and tramways. This Act is currently being revised.

We have identified five important Czech Standards that apply to mass transit:

- CSN 281300 Tramway vehicles - Technical requirements and tests
- CSN 280337 Tram profiles
- CSN 280318 Tramway track gauge
- CSN 736425 Bus, trolleybus and tramway stops.
- CSN 333516 Tramway and trolleybus overhead electrification

The first of these has to form part of any tendering process initiated by a city. It is relatively prescriptive and makes reference to other Czech standards covering noise and vibration, electrical safety and track design. Other standards also apply to more detailed aspects.

Safety regulations, standards and requirements are formulated in more detail at city level. Individual operators are responsible for the safety of their systems.

Policy has recently changed. In future activity will concentrate on disseminating or implementing EC standards. The Czech standardisation Institute will focus on procedures for adopting such standards rather than updating existing Czech standards.

Government currently checks and supervises that safety requirements are being met. In future, more initiatives in creating standards, implementation directives and control of their application will be transferred to local authorities and public transport operating companies.

The drive for the change in policy has been the need to cut costs and to make better use of limited professional staff resources.

3.2.21 Estonia

The Estonian National Standardisation Office (Standardiamet) is responsible for standards that apply to public transport systems in the country. In the past, development and operation was covered with Soviet Union National Standards (GOST). The only standards now being produced are very specific and not directly relevant. General strategy is based on the dissemination or full implementation of EC standards, some transport-related standards having already been adopted.

German standards are recommended, especially to fill the gaps where there are no appropriate national or EC standards.

The only mass transit system is the Tallinn Tramways, which has reported that it is self regulating. Historically it based its standards on technical requirements issued by the Soviet Union, but recently it has developed new standards based on the 1987 version of the German BOStrab.

3.2.22 Slovenia

A specific body with responsibility for railway safety and regulation is being established as part of the Ministry of Transport. At present the relevant tasks are dealt with by the rolling stock section within Slovenian Railways (SZ).

Vehicles must be designed and built in accordance with current UIC and EU regulations.

3.3 LINKAGES BETWEEN NATIONAL STANDARDS

The chart (Figure 3) is a graphical representation of the existing links between standards relating to rail mass rapid transit in different countries. It does not show those countries where there are no standards.

A solid line represents a ‘direct’ link, where the standards are the same in whole or in part.
A dotted line represents an ‘indirect’ link, where the standards are based on those in the origin country (these links will be historic - but only recent links are shown).

The arrow indicates the direction of the flow.

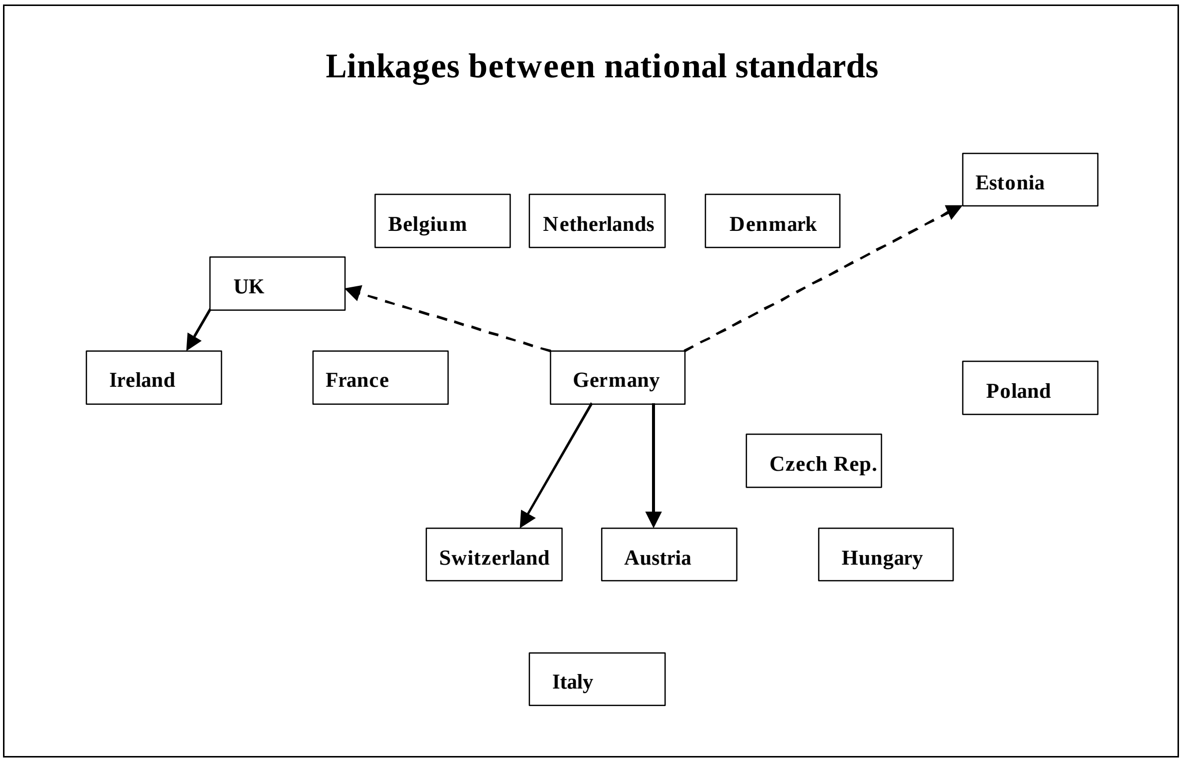


Figure 3: Simplified derivation of national standards

The influence of German standards is very significant.

In effect these linkages reduce the effective 'bodies of standards' to only 10 in the 22 study countries:

1. Belgium
2. The Czech Republic (being superseded by international standards)
3. Denmark (not significant as no LRT at present)
4. France
5. Germany with Austria, Switzerland and Estonia
6. Italy
7. Hungary
8. Netherlands (Guidelines only)
9. Poland
10. UK and Ireland

Or one could say that there are only seven significant groups of standards that need to be considered in terms of harmonisation and achieving the Single Market.

In addition, there are probably linkages between the standards in the former Soviet bloc countries although we have not investigated these in detail. These may affect Poland and Hungary and to a minor extent, Estonia.

3.4 APPLICABILITY OF NATIONAL STANDARDS

Certain key international and national standards are analysed in Appendix E.
The national standards can be categorised as follows:

- Class A. Up to date standards that are applicable to modern mass transit and LRT systems
- Class B. Standards that are applicable but that are in the course of revision.
- Class C Standards that are applicable but that require revision.
- Class D Some standards exist but they do not cover LRT particularly well.
- Class E Standards do not exist

The following table summarises the position for the individual study countries:

Class	**Countries**	**Number**
A	Austria, Belgium, Germany, Poland ,Switzerland, UK	6
B	Czech Republic, Hungary, France, Italy, Netherlands	5
C		0
D	Denmark, Estonia	2
E	Finland, Greece, Ireland, Luxembourg, Norway, Portugal, Slovenia, Spain, Sweden	9

4 Extent that Operators set Requirements

For the purpose of this study, local standards are defined as standards that apply to specific systems as distinct from those that might apply to a number of systems in a country, region or local area.

Our findings on local standards are derived from the operator questionnaire, from other material supplied by operators and others as part of this study, or from other information to hand. In general the information applies to the selected city list but in some cases, information from other cities has been included. The comments apply to the study area as a whole.

Our surveys suggest that standards do exist at local level but that in general they are not published or permanent in nature. The usual practice is for specifications to be produced associated with a particular order for vehicles. This is important, because even where such documents do exist, they do not necessarily represent what might be issued if new orders were to be placed in future.

In compiling our questionnaire we were careful to ask the recipients to consider the procedures and standards that would apply should a new LRT system be built in future. Many of these cities may have specifications on the shelf, but what matters is their relevance to the specific situation in which the single market approach is most likely to have an effect.

Therefore many existing local standards will be of no real interest to this study.

The following city authorities stated that they would not set standards at all: Amsterdam (in future), Athens, Copenhagen, Ljubljana, Milan (other than for rolling stock), Rome, Stavangar, Venice.

5 The form of Local Standards

The form of the standards is dictated by the tendering procedure. This was investigated in question B1 of the operator questionnaire.

Cities will either build a system themselves or award a concession to a private company. On the basis of the responses, the countries most likely to do the former might be the three Benelux countries, the Czech Republic, Hungary and Finland. This will also be the process in Ireland for the Dublin system.

All other countries are more likely to use the private sector approach. Exceptions to this were Germany where systems gave a mixed response, and Spain where Metro de Madrid has its system extensions built for it by the regional government, and other cites contemplating LRT systems are considering a mixture of public, private and concession based systems.

The decision between private and public depends on political policy at national and local level and historic factors. In some cases it is perhaps inconceivable that an entirely new system in a city that already has a very extensive network would be created other than by the existing authority. This might explain the mixed response from Germany.

Copenhagen was unusual. There is no law covering the construction of LRT systems in Denmark, neither are there any city standards. The Copenhagen Metro is following German standards (BOStrab) and EN5026, the only approval process being final authorisation by the Danish Railway Inspectorate.

In Amsterdam the operator is owned by the City and has a concession to operate the system. In future the city will build new infrastructure, in consultation with the operator, and the operator will specify the rolling stock.

In Gothenburg the city sets standards and operation may be carried out either by a private or public sector company based on a tendering process.

The responses suggest that where the private sector is taking the lead, the most usual situation is that the city authorities do set very specific detailed technical standards. The performance specification route is less common.

In a few countries the private sector would set its own standards and be free of interference provided they complied with the law. This would probably happen in Greece. It might also occur in some locations in Italy where the national regulations for LRT are fairly specific. Based on experience, it would probably also apply in Portugal. Because of the system used in Spain where the regional and city authorities contract studies to define the systems, the standards are usually ‘all relevant national and international standards’ plus data taken from manufacturers.

Where cities are procuring vehicles for a system owned by the city itself the performance specification route does appear more common. Only Brussels, Prague and Helsinki stated that they would issue very detailed vehicle specifications and of these Prague stated that their specifications were ‘somewhere between these two extremes’.

Appendix F is an analysis of city standards, covering a range that we received from many of the cities contacted in the study area countries. As well as summarising key characteristics of each standard it also shows to what extent the key safety areas of interest to this study are covered.

Appendix G is a further analysis of the questionnaire results and explains this in the context of the system types, their characteristics and plans for extensions and new lines.

Finally Appendix H provides additional information on key parameters that apply to the systems studied, mostly supplied by the cities themselves.

6 History and origin of standards

The origin of standards on the rail network in the last century was perhaps threefold:

Strategic
Governments were concerned that investment, originally by the private sector but very soon by the state, would be wasted if systems did not eventually inter-connect and form networks. Partly this wish was driven by a wish to have use of railway infrastructure for military purposes. It was usual for Railway Inspectorates to be formed by military personnel. There was considerable early attention to fundamental issues such as gauge for this reason, but this often overlooked equally important issues of interchangeability such as coupler height and type.

Secondary railways and tramways were often exempted from this process, but even here there were attempts to standardise narrow gauges as in Italy and Ireland. In some smaller countries, where the possibility of national networks of tramways existed, detailed standardisation was applied - the best example being Belgium.

In recent years the possibility of linked rail mass transit networks, or any military interest, has faded into the background. However the ‘shared track’ concept has created another route by which systems might be linked or at least adopt a common vehicle design. This possibility is recognised in the German LNT-Richtlinien, in UK Railway Group Standards for Light Rail and also by current initiatives in France.

Safety
Safety regulation began as a result of public concern that governments were allowing private companies to exploit them to a dangerous degree, and was a reaction to the horrific accidents of the early days which were the consequence of conveying large numbers of people using untried technology. Early requirements were fairly basic but quickly developed based on the experience gained from accidents and technical development.

This approach built up considerable bodies of material, but suffered from the fact that the cycle began again every time new technology was introduced. The more fundamental principle of safety risk assessment was introduced recently as a more reliable and flexible way of achieving acceptable levels of public safety.

Commercial
The commercial incentive to create standards so as to make national products more saleable was perhaps the last aspect to be addressed. Until recent times, and the formation of the EC, this interest was principally applied to national markets and the overseas markets provided by the foreign possessions of colonial European powers.

7 Key Safety Requirements

7.1 OVERVIEW

As part of the study we have looked in detail at certain safety topics that were specified in the remit. We have first considered how these topics are covered by existing international standards and national requirements and we have also noted any significant points relating to these topics that have arisen form our study of local requirements. Secondly we have considered what aspects of these topics create the most significant problems for the Single Market approach and what might be done to overcome these.

Requirements can be set in a framework that follows through logically from basic principles. e.g.:

Basic principles that apply to rail and other guided systems
Requirements that apply to the vehicles that operate on all such systems.
Additional requirements or dispensations that apply to the vehicles that operate on specific types of system (e.g. Tramways)

As a base for analysis, we have chosen to use the UK Railway Safety Principles and Guidance (RSP&G) issued by the HMRI[6]. These documents include a clear list of principles, along with factors relevant to each one. It is also relevant in making this choice that the UK regulations have been updated in recent years, and are based in part on a review of best practice in other countries. For clarity, we have slightly modified the UK terminology, so for example we tend to refer to ‘vehicles’ rather than ‘trains’ as being more appropriate when discussing mass transit systems. Figure 4 on page 78 shows how these safety principles inter-relate.

After stating the principles we then state the factors that need to be considered that are appropriate to mass transit applications. For simplicity we assume that mass transit systems do not carry any goods traffic, although this will not always be the case.

We then look at a selection of the principal national requirements identified in section 3.3, i.e. the national standards of the Czech Republic, Belgium, France, Germany, Hungary, Italy and the UK, to see how they they cover these issues and in particular to highlight any significant variations. In doing this we did not examine all the standards, in particular those of Hungary and Italy, in as much detail as others but in these cases we have reported on the coverage. As part of this we identify key international or national standards that are cited in these requirements.

We have looked at a selection of local standards as well, the extent to which they covered these issues is reported in Appendix F. We have not reported in detail on what each of these actually said since much of this information is historic and might not be applied in future. But it has coloured the recommendations that we have made.

For each topic we have included a final discussion and some conclusions.

Finally we have summarised the possible actions that could contribute to the single market, classified in terms of priority.

7.2 FIRE AND ELECTRICAL ARCING

Principles:

'The interior of vehicles should provide a safe environment for people carried' (RSP&G Principle 24).

'The electrical and other powered systems and equipment on board vehicles should not endanger other systems or people' (RSP&G Principle 28)

Factors to be considered:

- Limitation of fire load, ignition sources, fire spread and smoke and fumes.
- The provision and marking of emergency and safety equipment to deal with incidents.
- Intended passengers and their behaviour.
- Access and egress arrangements.
- Foreseeable actions by people that may lead to injury to others.
- Unauthorised access to equipment.
- Bonding and short circuit protection.
- Avoiding contact with electrical conductors and other possible causes of electrical shock e.g.metallic parts of a vehicle becoming 'live' in fault condition.
- Effect of the loss of power supply.
- Effect of the loss of safety critical systems.

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic. This is probably due to the fact that safety responsibilities rest with the individual undertakings and are supervised at provincial level.

France

AFNOR requirements NF F 16-101/103 cover materials, electrical equipment and protection against fire in a general fire safety context. They are specifications and apply to all rail mass transit systems as defined in this study.

Germany (BOStrab)

There are four regulations that involve this topic:

- Materials and components must reflect the current state of fire prevention technology (no standards are cited) (33-3).
- Passengers are to be protected against fires (33-12).
- Communication with fire service in tunnels (23-4)
- Vehicles must withstand thermal stresses (1-3)

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 9 and 13. Reference is made to other Italian railway rolling stock standards and to EN 50126 and EN 50153 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are 12 general requirements covering fire (36-47), two on fire barriers (48,49), three on ignition sources (50-52), one on fire detection (53) and two on fire extinguishers (54,55) in the trains section. A role is cited for standards in requirement 38 but none are referred to.

The tramway requirements add:
- Fire stopping around electric traction power cables (297)
- Toxic fumes from fires in electrical cabinets must not vent into passenger areas (299)
- Fire extinguishers are required (268)
- Electricity at work regulations of 1989 apply (288/9)

Czech Republic

Many cross references are made in the basic tramway vehicles requirements (CSN 28 1300). The electrical safety standards (CSN 33 2000) are relevant.

There are requirements for the number of emergency exits related to the numbers of passengers but otherwise requirements are very vague.

The overhead contact lines regulation (CSN 33 3516) has some vague fire requirements and some specific requirements relating to electrical arcing.

Hungary

In Hungary the following standards are applied with regard to fire protection:
- IEC 332-1-3 Installation of electric cables
- UIC 895 Types of acceptable cables
- DIN 5510-2 Fire proof seating and materials
- DIN 4102 Fire protection
- MSZ 14800/9-85 Materials of low combustibility
- NF F16-101 Materials used in railway tunnels
- UIC 564-2 Materials for interior trim of rail vehicles

No particular regulations or specifications are thought to cover electrical arc hazards.

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general. EN 50153 covers protective provisions relating to electrical hazards on rail rolling stock.

The ‘Fire Protection in Railways’ (FTP) committee was formed in 1997. It has not published any standards as yet but has six in preparation covering:

- General considerations
- Fire behaviour of materials and components
- Fire resistance of barriers and partitions
- Fire safety requirements for rolling stock design
- Additional fire safety measures
- Flammable liquid and gas installations
- Electrical equipment fire safety (specifically includes ‘trolley buses, track guided buses and magnetic levitation vehicles’)

Industry Views

Industry consider that the materials used in the structure of vehicles, wiring standards and methods of protecting electrical equipment are fundamental to vehicle design, so fire safety standards are crucial. The elimination of fire hazards due to electrical arcing might be achieved by design modification and is therefore slightly less critical.

Manufacturers varied in their opinions on providing evacuation routes; some suppliers will be able to offer variations in vehicle layout.

Interior trim materials can be changed as part of the design process and smoke detection can also be added in, if a requirement, at this stage.

Opinions vary totally on whether or not warning systems are critical to vehicle design - again this reflects variation in design philosophy.

There was general agreement that provision of extra or different fire extinguishers was not a problem and they could be retro-fitted to existing vehicles.

Operator views

This topic was the subject of a questionnaire question. We asked operators and city authorities to comment on the statement, ‘An internationally accepted standard for the fire safety of vehicles in various applications would be an acceptable basis for ensuring safety in this area.’

54% of the cities that responded thought this was true and another 41% thought that this was possibly true. Only 5% thought that it was untrue.

Discussion/conclusions

Clearly fire safety is fundamental to vehicle design. The overall principle seems to follow through into all the more specific regulations, requirements and specifications.

The principle has to be fairly broad. The way of protecting people depends very much on circumstances. So for example for a street tramway the emphasis will be on getting people out quickly (e.g. the Czech requirements) and for a metro in tunnel there will be more emphasis on fire barriers, smoke prevention etc..

The requirements do not appear to conflict significantly, especially in the critical areas of materials, wiring and electrical equipment protection. References are made to different standards but the work of the CEN FTP group will provide coverage for the most critical areas and can replace equivalent national documents.

The economic aspects of variations are more in the existence of differences than in the differences themselves. Fairly advanced requirements are made for trams in terms of detection and warning systems and other measures because they carry a lot of people and often there is only one member of staff present. Industry will accept that vehicles that operate in tunnels require more onerous standards in certain respects. So there is some uniformity in terms of principles and how these are applied.

The more detailed requirements, in particular those that apply in the UK, are of the nature of guidelines and should collectively form the basis of European guidelines on this topic.

7.3 CRASHWORTHINESS

Principles:

‘The structural integrity of vehicles should be maintained in normal operations and afford protection to people carried in the event of an accident’ (RSP&G Principle 24).

Factors to be considered:

- The loadings that arise on the structure.
- The effects of collision.
- The structural compatibility of all trains on the same track unless other arrangements exist to further reduce the risk of collision.
- Side impact from road vehicles when street running.
- Prevention of over-riding.
- Level of containment of wheelchairs, luggage and loose objects.
- Protection from and containment of fire.
- Integrity of equipment attachments.
- Range and compatibility of couplings.
- Compatibility with buffer stops/arresting devices.
- Arrangements for lifting vehicles.
- Glazing.

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic, probably due to the fact that safety responsibilities rest with the individual undertakings and are supervised at provincial level.

France

There do not seem to be any specific national requirements.

Germany (BOStrab)

The only regulation is a very general one that does not directly cover crashworthiness:

'*The design of vehicles must take into account all the static and dynamic loads to which the structure will be subject, including tare, payload, acceleration and braking stresses, coupling forces and any other stresses arising from the operating conditions.*' (33-1)

Light Rail Vehicles that operate on shared track services will in future be subject to the Light Railcar EBO regulations (LNT). Provided the operation and vehicles meet certain other requirements these specify crashworthiness in terms of a 60t end load static strength, as against the 150t required in the UIC regulations for multiple units on railways.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 6,9 and 11. Reference is made to other Italian railway rolling stock standards and to prEN 12663 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are 13 general requirements covering crashworthiness and related issues (124-131 and 134-138) in the trains section, no standards are referred to. In addition to the strength of the vehicle these cover issues such as obstacle deflection and minimising over-riding. No specific end strengths are quoted.

The tramway requirements add:

- Mitigation against collision as part of underframe, body and articulation joint design (243).
- Collision protection against vehicles and large obstacles (under-run protection and obstacle deflectors) (244).
- Collision protection for pedestrians (245).

The guidelines state that the end loading standard should be compatible for all trams on a system and that the impact speed of a collision may be taken as 25mph (40km/h).

Czech Republic

The basic tramway vehicles requirements (CSN 28 1300) states that the static force between two cars or two vehicles in the opposite direction must not exceed 110kN.

Hungary

OVSZ II (Safety of urban railways) covers this topic and makes reference to VDV Guideline 152 and UIC standard 566. An end load strength of 500kN applies to metro rolling stock, although certain older stock only attains 250kN.

Relevant CEN standards

PrEN 12663 is in preparation, it will cover the structural requirements of railway vehicle bodies and shall include mass transit and tramway vehicles.

Industry views

The suppliers confirmed, as would be expected, that the structural strength of the vehicle and the exact locations at which this strength is required are fundamental to the design of the vehicle. This is also true of side impact protection wherever this is specified for tramways in street traffic. Suppliers generally considered that coupler strength and the amount of energy absorption provided could be varied within the basic design of a vehicle.

Passenger safety in collisions can also be improved by ‘secondary measures’. These could include softer seats and trim, number and design of handrails and grab rails, and luggage and wheelchair retention measures. Generally, suppliers saw these as being features that they could vary within the basic vehicle at the design stage.

Discussion/conclusions

Primary crashworthiness is fundamental to vehicle design. Requirements for main line systems are well mapped out in UIC regulations and can be adopted by metros, but those for LRT and tramway systems tend to be vague. This may partly reflect the facts that most systems are self-contained and vehicles therefore tend to be of uniform crashworthiness, and also that in street running high vehicle strength is actually a hazard to other road users as well as being unnecessary.

Secondary crashworthiness is perhaps less of a problem in standardisation terms because few authorities have so far identified this as a requirement. The fact that many users of mass transit will be standing is fundamental to any consideration of this approach. Standees are more vulnerable but at the same time need the features, such as grab poles, that may cause serious injury in the event of a crash.

The cost of meeting different requirements is associated with variations. The cost difference between structures meeting different requirements, within the range normally considered appropriate for mass transit, may only be marginal.

Since the existing national requirements appear relatively vague; it would be worth developing an approach that builds on the proposed CEN standard. Special consideration also needs to be given to shared track operation.

7.4 DERAILMENT

This includes wheel/rail profiles and suspension geometry.

Principle:

‘The running gear should guide the vehicle safely along the track’ (RSP&G Principle 30).

Factors to be considered:

- Wheel/rail interface geometry
- Range of speed
- Compatibility with track geometry
- Track maintenance tolerances

- Switching (points and crossings)
- Effects of traction and braking forces
- Effects of permitted forces
- Risk and effect of component failure
- Effect of collision with obstacles
- Wheel unloading
- Noise and vibration
- Integrity of the attachment of equipment to the running gear.
- Bonding

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic, probably due to the fact that safety responsibilities rest with the individual undertakings and are supervised at provincial level.

France

AFNOR requirements NF F 00-800 cover this topic in a general sense. They are specifications and apply to all rail mass transit systems as defined in this study.

Germany (BOStrab)

There are four regulations that involve this topic:
- Track curve radii and gradients must be dynamically favourable (15-2)
- Track and vehicle dimensions must be matched to minimise derailment risk (17-2)
- Curves to be laid out to minimise lateral acceleration (17-4)
- No risk of derailment at maximum permitted speed, including when suspension system damage has occurred (35).

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 4 and 19. Reference is made to other Italian standards including:
- UNI 3648 Grooved rail tramways. Track gauge, normal and narrow gauge.
- UNI 8350 Metros. Calculations to verify wheel-sets.

and to EN 50126 and prEN 13479 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are 12 general requirements covering this topic (82-92) in the trains section. Other than requirements to show certain information these are basically guidelines and broad performance criteria, with no references to standards.

The tramway requirements add (242):
- The need to reduce noise in sensitive residential areas.
- Taking account of grooved rail and flange tip running.
- Obstacle deflection equipment is required.

Czech Republic

Many cross references are made in the basic tramway vehicles requirements (CSN 28 1300). The standards related to track design, from CSN 73 onwards, are relevant. There are some specific references to derailment and suspension.

CSN 28 0318 is a requirement for the dynamic characteristics of tramway track, which is relevant but not very specific.

Hungary

Operators use a figure of between 4% and 8% as the allowable loading difference between a pair of bogie wheels, based on the German VDV guidelines 153-157. Wheel and rail profiles tend to be specified locally.

Relevant CEN standards

ENV 12299 covers ride comfort for passengers, measurement and evaluation.

Standards in preparation are:

- CEN/TC 256 N368, which will cover vehicle dynamics testing.
- PrEN 131103/4, design guides for axles, wheelsets and bogies.
- PrEN 13232, which will cover, track, switches and crossings including wheel/rail interaction.
- PrEN 13260/1/2 covering wheelsets and bogies, axles and wheels.
- PrEN 13749, methods of specifying the structural requirements of bogie frames.
- PrEN 13715, wheel profiles
- Others covering specific suspension components and track systems

Industry views

Suppliers consider that suspension characteristics and derailment prevention measures are fundamental to the basic design of the vehicle, so specification variations in these areas will be critical.

The minimum curvature, both horizontal and vertical, is also crucial.

Variations in wheel diameter will usually be crucial to vehicle design but variations in wheel profile or the back to back dimensions of wheels is not as critical.

Generally all elements associated with topic must be sorted out at the design stage, retrospective changes being very difficult or impossible to achieve.

Discussion

There is a tradition of specifying wheel and rail profiles in detail because this is a key interface on rail systems. This is reflected in the proposal by CEN to issue a large number of new standards. Rail profiles are reasonably standardised, in that not that many profiles are in common use (see Appendix H).

The basic principle is clearly fundamental and must be the basis of whatever detailed requirements exist now and in the future. The topic is linked with that of passenger comfort and issues such as noise and vibration, wheel and rail wear. Again these are all issues where the fundamental objective of the end user is unlikely to vary significantly, especially where new systems are concerned. There is some trade off between suspension and track quality but in general for mass transit systems the track quality should be better than that of rail systems in general.

In economic terms, variations in requirements in this area will cause significant problems for the supplier with little benefit for the operator. We therefore strongly recommend that this is one area where standardisation, along the lines already being followed by CEN, is appropriate and that international guidelines should then be based on these fundamental parameters, design processes and test procedures.

There is an interaction between this topic and the issue of rail profiles, especially for tramway rail.

7.5 DOOR SYSTEMS

Principles:

‘Vehicles should have a safe means of access, egress and retention of people carried’ (RSP&G Principle 26).

Factors to be considered:

- Stepping distances
- Size, number and arrangement of doors
- Door control arrangements
- Prevention of doors opening on the move or on the wrong side of the vehicle
- Prevention of departing with door open
- Hazards associated with moving doors
- Protection against trapping fingers, limbs etc
- Emergency evacuation
- Emergency services access

Belgium

Article 12 of the 1976 regulations states that control of doors is confined to the staff, but that at least two doors in every vehicle must be capable of being opened by passengers in an emergency.

France

AFNOR requirement NF F 31-054 covers the passenger access doors for urban and suburban rail systems. It specifies key dimensions and requirements that apply to all rail mass transit systems as defined in this study.

Germany (BOStrab)

Section 44 covers this topic, the requirements are:

- Rapid boarding and alighting
- Clear passage of at least 650mm with one on each side of at least 800mm
- Means of preventing people being trapped
- Moving footboards must be linked to door operation
- Driver must know that doors are closed
- Doors on each side to be released separately
- On automated lines, train cannot start without all doors detected closed
- Doors must be kept closed but with emergency opening unless there is an alternative exit

Other regulations that involve this topic are:

- Maximum horizontal gap between platform and vehicle floor not to exceed 250mm (31-7)
- Hand holds to be provided in doorway areas (33-11)

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 9 and 12. Reference is made to other Italian railway rolling stock standards, in particular UNI 8882, which covers door safety, and to EN 50126 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are eight general requirements covering doors (227,228-236), twelve on door operation (236-247) and one on requiring emergency door release (248).These are very similar to BOStrab requirements in terms of subject and level of detail although they are more onerous (requiring audible door closing warnings for example). There are no significant conflicts.

The tramway requirements add:

- Minimising trapping injury (270)
- Compliance with disability access regulations (271)
- Level access through at least one door, adjacent to a wheelchair space (272)
- Interlocking of folding steps/sliding plates with door operation (273)
- Measures for preventing vehicles moving with doors open (274)
- Signing of door controls (275)
- Emergency door release by passengers (276)
- Safe evacuation through doors (277)
- Requirements for passenger controls, including that they should be between 900mm and 1400mm above the surface that the passenger is standing on (278)
- Emergency door release activates brake but only at low speed (279)
- Means of releasing doors from outside in an emergency (280)
- Identification of which doors have been opened in an emergency (281)

These requirements duplicate both the Trains requirements and the factors contained in the Principles to some extent. This perhaps emphasises the relative importance of door operation to tramway safety.

The Rail Vehicle Accessibility Regulations 1998 had the objective of improving access, especially for persons with disabilities. The requirements are very detailed, of a specification form, and while not directly related to safety, do impinge on safety considerations. Particular ones worth noting on the topic of doors are:

- Doors must be painted in a distinctive colour
- Audible warning devices must be fitted
- The control device must be between 700mm and 1200mm above the floor (contradicting the HMRI figure given above)
- Doorway widths must not be less than 850mm, if used by wheelchair passengers.
- The gap between the platform and door edges must never be greater than 75mm horizontal and 50mm vertical, if wheelchair passengers are to board without a boarding device.

Infringement of these regulations carries severe penalties although and it is not yet known whether enforcement of every detail will be practical.

Czech Republic

The basic tramway vehicles requirements (CSN 28 1300), state that:
- Closed doors cannot exceed vehicle contours and open doors must not exceed contours more than 250mm.
- Some specific requirements on door systems are included in CSN 73 6425 which covers bus, trolleybus and tramway stops.

Hungary

Door control requirements are based on the regulations that apply to metro vehicles and contained in 990.902/1980. The following factors are expected to be considered in technical specifications:
- Simple opening of doors
- Remote control
- Control of doors on one side only.
- Doors locked when vehicle moving
- Protection against being trapped in doors.
- Forced opening by passengers.
- Inter-vehicle access.
- Reduced gap and level difference for disabled passengers

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general.

Work is proceeding on a standard to cover external doors on railway vehicles.

Industry views

Although some manufacturers can offer a choice within a standard vehicle design of the width, height and position of doorways and whether or not there is level access, in general these will be critical areas.

In general every aspect of the door control systems and associated safety features were seen as something that could be varied at the design stage, and as not being fundamental to the vehicle design. But one supplier saw interlocking with traction and braking systems as being fundamental.

A few safety features were seen as having potential for late or retrospective modification. These included the operating instructions, grab rails, footstep surface materials and the colour of the doors.

Discussion/conclusions

Although there is general agreement on principles the degree to which measures are required does vary. This will result form variations in expectation, the age and complexity of systems and operating conditions.

The topic is tied in to the question of access for the mobility impaired, which has resulted in some very specific requirements.

International agreement on doorway dimensions would seem appropriate. The contrast between the 800mm width required in Germany and the 850mm in the UK is an example of how problems arise. Wheelchairs will not be any narrower in Germany.

The CEN work should focus on these issues and there is a need for the detailed but inconsistent requirements of the various countries, as listed above, to be set down and unified in a logical sequence with less sophistication for simpler and basically safer systems.

7.6 TRACTION SPECIFICATIONS AND CONTROL METHODS

Principles:

'The electrical and other powered systems and equipment on board vehicles should not endanger other systems or people' (RSP&G Principle 28).

Factors to be considered:

- Interference with other powered control systems
- Avoiding contact with equipment and conductors
- Effect of loss of power supply
- Effect of loss of safety critical systems
- Limitation of fire load and its protection, ignition sources, fire spread, smoke and fumes.
- Unauthorised access to or use of equipment
- Availability of powered systems in degraded operations or emergency situations
- Bonding and short circuit protection
- Electro-Magnetic fields - effects on people

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic, probably due to the fact that safety responsibilities rest with the individual undertakings and are supervised at provincial level.

France

There are no specific regulations.

Germany (BOStrab)

There are four regulations that involve this topic:

- Gradients and traction and braking performance must be matched so that trains can be brought to a halt and a failed train can be assisted. (17-5)
- Traction motors and transmission must be designed to be appropriate to conditions and take account of maximum stresses due to various braking situations and sudden changes in line voltage. (37)
- The control of traction and braking must be designed to:
  1. Give braking precedence over traction commands
  2. Minimise jerk
  3. Monitor braking commands on automatic systems.(38-1)
- Passenger vehicles must be provided with a vigilance system to automatically brake if the driver is incapacitated. (38-2)

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 8 and 13. Reference is made to other Italian railway rolling stock standards and to EN 50121 and EN 50153 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are clauses in the Trains section on:

- Compatibility of electric traction supply systems
- Arc protection, earthing and bonding
- Electromagnetic Interference
- Fail safe traction systems with alarms
- Need to have full control of power source.
- Protection for flexible connectors
- Coupling and uncoupling powered systems during operation
- Isolating devices
- Pressurised systems
- Protection against high voltages and electrical shock
- Siting of electrical pick ups/overhead wires
- Isolated power sockets
- Short circuit protection
- Speed regulation
- Design of controls and alarms

- Making over-ride controls difficult to access in normal operation
- Interlocking of controls
- Protection against controls being locked or easily knocked into unsafe positions.

The tramway requirements add:
- Recovery to avoid blocking a highway (277)
- Battery emergency lighting (278)
- References to the Electricity at work regulations of 1989(288/9)

Czech Republic

Many cross-references are made in the basic tramway vehicles requirements (CSN 28 1300), and the electrical safety standards regarding traction equipment (CSN 33 series) are relevant.

Hungary

The traction system and design of controls tends to be covered by system specifications rather than any central standards as such.

Relevant CEN standards

- EN 286-3 and 4 cover pressure vessels used as part of traction and control systems.
- EN 50121 series cover Electromagnetic compatibility.
- EN 50125-1 covers the environmental conditions for on-board equipment.
- EN 50126 covers the specification and demonstration of safety measures in general.
- EN 50153 covers protective provisions relating to electrical hazards on rail rolling stock.
- EN 50155 covers electronic equipment used on vehicles.
- EN 60130 covers traction transformers and inductors.

Industry views

The choice of AC or DC, return current arrangements and the basic power supply voltage were seen to be fundamental to vehicle design. Most of the safety related features were seen to be features that could be provided as an option at the design stage, i.e.:
- Disabling controls in empty cabs
- Circuit breakers
- Over current protection
- Power supply isolators
- Lightning surge arrestors
- Combined traction and braking controls
- Traction interlocks.

Discussion/conclusions

Traction equipment is a potential area for greater standardisation. It is significant that there are already a number of EN standards covering this topic and that EMC, in particular, is well covered. The reason for this is that the problems associated with electrical machines and their effects are common to a large part of industry therefore mass transit can benefit from the concerns and work of other industries in this area. Andrew Foster of Adtranz pointed out that electrical traction equipment represents something like 40% of the cost of a tram. Traditionally it accounted for about 50% of the cost of London Transport Underground trains. So it is not only practical but also worthwhile to have a more uniform approach.

The addition of different types of safety system to protect traction systems do not cause fundamental problems and the standards referred to above simply list features required rather than specify requirements.

The cab is crucial in terms of being the place where the control of the vehicle takes place. In general, ergonomic and safety principles should apply across borders and there is scope for sensible guidelines that benefit from the experience that designers have created in this important area.

7.7 TRAIN PROTECTION SYSTEMS

Train protection systems are defined as systems that assist the driver not to pass signals at danger. They can be of varying complexity, e.g.:

- A vigilance system, to help check that the driver is not incapacitated or asleep.
- A warning system that repeats external signals, visually, audibly or both.
- The same but it has to be cancelled to prevent a brake application.
- Irrevocable braking if a signal is passed at danger.
- Speed control, plus irrevocable braking if a signal is passed at danger.

The requirement for these varies. Metros will tend to have them because of the severe consequences if a lone train driver misses a signal when in charge of a packed train, particularly in tunnel. At the other extreme, trams that always drive on sight, will not have them. They will usually be a requirement for any shared track system, where the vehicles are operating in an environment where they do not meet crashworthiness standards.

Principles:

‘The signalling system should provide for the safe routing, spacing and control of vehicles’ (RSP&G Principle 20).

Factors to be considered:

- Prevention of collisions
- Protection against human error
- Types of vehicles.
- Effect of the electric traction system.
- Type of track and condition.
- Interfaces with communication and other systems
- Protection in event of partial or complete signalling failure.
- Avoidance of the degradation of the signalling system.
- Changeover from signalled to line of sight sections.
- Effects of modifications
- Compatibility with level crossings.

- Interference from electrical sources.

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic.

France

There do not appear to be any specific requirements at national level.

Germany (BOStrab)

The regulations state that passenger vehicles that operate on lines equipped with train safety systems must be fitted with these supplementary train safety devices. (38-3)

Train safety systems are the signalling system plus automatic train protection or automatic train operation systems. They must be reliable and fail safe. (22)

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock section 9.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

The trains section states that they must be compatible with the signalling equipment. On-board systems should be self-checking and provide fault detection warnings. They should fail safe and not provide false signalling information to the driver. They should not prevent the driver taking over in emergency but isolation switches should be sealed or alarmed.

Sections 334-336 cover this area. Either Automatic Train Protection shall be fitted or an Automatic Warning System or a trip cock system is required.

The tramway requirements only add a requirement for a compatible form of automatic train protection for mixed shared track operation.

Czech Republic

There are no specific requirements in the tramway regulations.

Hungary

Based on OVSZ II, Metros can only be constructed with a train control function. National Regulations for Railways I and II are relevant as are certain other Hungarian standards. In addition to the EN standards referred to below, IEC 571 (which covers electronic systems) and IEC 60721/98 (which covers the classification of environmental conditions) are considered to apply. In addition two UIC leaflets are applied, namely UIC 736 'Relays of safety appliances' and UIC 738 'processing and transmission of information attached to the safety aspect'.

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general.

Work has taken place on two further standards: prEN 50128 on the application of software to railway control and protective systems, and prEN50129 on safety orientated protective systems.

Industry views

Generally industry saw the fitting of any protection system as something that can be achieved at the design stage as an add-on option. They are therefore not fundamental to basic design.

This was also true of the detection method (mechanical trip, magnetic sensor, inductive loop sensor, Balise etc.)

Discussion/conclusions

Even though there may be a variety of train protection systems:

- They will not always be required, e.g. on street tramways.
- On most systems only one type will be required.
- Suppliers can fit these if they are specified for a given system.

In the few cases where a system operates over routes that have more than one type of protection then it may be possible to dual fit vehicles. This already happens for example, in Karlsruhe.

7.8 EMERGENCY BRAKING

Principles:

‘The speed regulation system of the vehicle should meet the operational requirements of the system without endangering people’ (RSP&G Principle 29).

Factors to be considered:

- Braking must be continuous, capable of stopping a divided train and holding fully-loaded vehicles indefinitely on the maximum gradient.
- Harm caused by rapid deceleration
- Performance under various adhesion conditions
- Incapacity of the driver
- Availability on demand.
- Overall braking performance of all systems.
- Transitions between different types of system.
- Gradients
- Compatibility wit the track and forces imposed on the track.
- Compatibility with the electric traction system.
- Minimising the risk of dragging brakes.
- Harmful substances emitted from brake blocks.
- Speed monitoring.
- Controlled release of brakes to permit safe movement in failure conditions

Belgium

Article 7 of the Rail Transport regulations of 1976 specifies a that a deceleration of at least 1.5m/s^2 must be attained on level track at 40km/h when the emergency brake is applied. Emergency braking must occur automatically if the driver is incapacitated. No vehicle may be introduced into service without the braking system being tested by the regulatory authority.

France

Article 32 of the Decree 730 of 1942 requires that all trains must have continuous brakes and Article 45 specifies braking performance for trams on various gradients.

Germany (BOStrab)

Requirements are stated in section 36:

- Vehicles must have two independent braking systems, which shall work if traction current fails
- Risk of harm to passengers and jerk rate must be minimised
- Maximum use of available adhesion must be made
- Rating must be appropriate to the route
- Performance is specified, see table below
- This must be attained even if one braking system has failed
- On tramways - one of the braking systems shall not rely on adhesion, the other must be assisted by sanding, both brakes must achieve the emergency rates specified
- These requirements apply to multiple units
- If trains divide unintentionally, at least the unmanned section must come to a stand automatically, and this must be indicated to the driver
- Emergency brake application must be available to passengers but this may be over-ridden in sections without places of safety, such as tunnels

Speed at start of braking (km/h)	**Average minimum braking admissible (m/s^2)**	**Maximum stopping distance (m)**
20	1.71	9
30	2.04	17
40	2.29	27
50	2.47	39
60	2.57	54
70	2.73	69

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 7, 8 and 9. Reference is made to other Italian railway rolling stock standards, including UNI 9153 that covers braking systems, and to EN 50126 and prEN 13452 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are ten general requirements covering braking systems (313-322), two on electric brakes (325-326) and one (323) on emergency brakes. This states that the emergency brake must be capable of reliable control from the cab and should be effective at all times. It should be designed to optimise train retardation and should not be degraded by wheel slide protection equipment.

The tramway requirements add:

- Track brakes if insufficient braking force is available via the wheel/rail interface.
- Deceleration rates similar to those of other vehicles operating on the highway, i.e. about $3m/s^2$ for the emergency brake.
- The rate of change of deceleration should not exceed $0.8m/s^3$ and definitely should not exceed $1\ m/s^3$.
- The jerk rate should not endanger standing passengers.

Czech Republic

Braking capabilities and methods for testing brakes are developed in broad details. For each type of braking system minimum performances are prescribed or linked with other safety standards (CSN 28 1300).

Hungary

The regulations for the acceptance and operation of metro vehicles issued by the Ministry of Posts and Telecommunications cover this topic (990.902/1980).

- Emergency brake controls must be easy to access.
- Allowable maximum braking distances are given in a tabular form.

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general.

PrEN 13452-1 will cover the performance requirements for the braking systems of mass transit vehicles, PrEN 13452 - 2 the testing methods. Other work is covering performance calculations, vocabulary and components.

Industry views

The emergency braking rate is a fundamental issue for suppliers but other issues, such as the design of track brakes, location and design of the control are not.

Discussion/conclusions

The basic principles are simple and well established. There seems to be agreement between the various national authorities.

There are differences in the way the emergency braking rate is specified but the planned work of CEN should overcome this and each country could then make reference to these figures and testing processes in its own requirements without significant compromise.

Clearly tramways operate in a different environment but the issues involved seem to come through in the existing requirements.

7.9 EXTERNAL LIGHTING

Principles:

External lighting is required for the following purposes:

- To illuminate the track ahead
- To identify trains/vehicles to signalling controllers
- To distinguish the direction of travel and the integrity of the train.
- To warn track workers, people on level crossings or tramways.
- To identify the vehicle as a tram to other road users on a tramway.
- To mark the extent of the vehicle for passing traffic on a tramway.
- To indicate if doors are open/closed/locked or available for use.

Unlike other safety features listed above, external lighting is a means of achieving safety rather than a fundamental safety issue.

Factors to be considered:

- Intensity of headlamps in relation to speed
- Hazards of intense headlamps
- Direction of headlamps on sharp curves
- Reflections
- Dazzling passing drivers of train/trams, road vehicles
- Confusion with other types of train, road vehicle etc.
- Visibility of external lighting
- Ability of people to distinguish colours
- Logic associated with lamps used to indicate if doors are locked
- People with disabilities
- Lamp failure
- Effect of the loss of power supply
- Effect of the loss of safety critical systems

Belgium

Article 9 of the 1976 Regulations stipulates that information about the destination and route must be carried on vehicles and that this must be illuminated when necessary.

In Article 15 the following requirements exist for trams:

- A white headlamp that can illuminate the track in front for a distance of 20m under normal conditions.
- Two front white marker lights, one at each side

- Two back red marker lights, , one at each side
- Two stop lights, one at each side
- Two front direction indicator lamps, one at each side
- Two back direction indicator lamps, one at each side

and for metro vehicles:

- Two white headlamps that can illuminate the track in front for a distance of 20m under normal conditions.
- Two red lights and two stop lights (to indicate braking) at the rear of the train.

Lights must be at least 400mm above ground level, and must be lit when visibility is below 200m. Lamps of different function may be combined into single lighting units. Trains must always allow control of lighting at extremities.

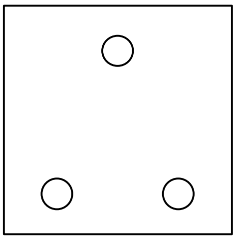
France

Article 32 of the Decree 730 of 1942, as modified by a further decree in 1960, gives fairly detailed requirements for external lights on trams.

Germany (BOStrab)

Paragraph 40 makes the following requirements:

- Warning and indicator installations must meet operational needs, be clear and unambiguous and not rely on availability of traction current.
- Headlamps for street running must be dippable.
- Yellow flashing direction indicators on each side.
- Yellow flashing hazard indicators on both sides , which must flash in unison.
- Cab repeaters for direction, hazard and headlamps.
- Two red tail lamps on street running vehicles.
- A triangle of white headlights (the top one may include the route indicator):



- Two red or yellow brake lights at the rear.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 9, 12 and 13. Reference is made to other Italian railway rolling stock standards and to prEN 13272 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There is a requirement (69) that train ends should remain conspicuous at all times and that front and rear ends should be identified separately. However this may be achieved by colour, not necessarily lamps.

Tail lamps are required and headlamps may be required on trains but there are no other requirements for external lighting other than for vehicles that operate on tramways.

The tramway requirements are based on complying with the Road Vehicle Lighting Regulations of 1989 so far as they are appropriate to trams and to key objectives:

- Identifying the vehicle as a tram.
- Providing for bi-directional running.
- Lights and reflectors on the side in accordance with requirements for large goods vehicles rather than buses.

Actual requirements are:

- Two white dippable headlights and a third located centrally above them.
- Two white position lights facing forward and two red facing the rear.
- Two white outline marker lights facing forward and two red facing the rear.
- Two amber direction indicators facing forward and two facing the rear, and combined with side marker lights.
- At least 3 amber side marker lights, per side, for a full length tram (30m).
- Reflectors which may be combined with the direction indicators above, the side ones to be 1m above road level. For double ended trams, the reflectors must be amber.
- Two red brake lights or clusters (facing the rear).
- Two high intensity red fog lights (facing the rear).

Relatively precise requirements are made about lamp positions and lamp outputs.

For tramways that do not have street running but use line-of-sight operation, the only requirements are for a single long-range dippable headlamp, front and rear position lights, brake lights and rear fog lamps.

Where more than one lighting arrangement has to be provided for use on a system then a single selector switch in each cab, to change modes, is required.

There is also a requirement (268) to fit a lamp bracket so that the drivers hand lamp may be used in an emergency as a tail light.

Czech Republic

The basic tramway vehicles requirements (CSN 28 1300) gives very detailed requirements on external lighting.

Hungary

External lighting is defined in the specification for acceptance and operation of metro vehicles (990.902/1980) of the Ministry of Post and Telecommunications. This makes reference to UIC leaflet 555 to cover lighting intensity.

The following also apply:

- MSZ-07-5018-82: ‘Lighting and external lighting of the passenger carriages of public railways and metros’
- Ministerial Decree 28/1971: ‘Licensing of the construction and operation of vehicles of local public railways’ (This is to be replaced by new specifications, ‘Design and licensing of the operation of passenger vehicles of public railways ‘)
- KPMSZ Kk17: ‘Regulations for lighting and external lighting of local public rail vehicles.’
- Ministerial decree 1/1975 (II.2): ‘Regulation of public road traffic.’

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general. Otherwise this is not a topic currently being covered.

Industry views

In general the suppliers believed that external lighting variations were within the range of options that could be settled when a system issued a specification and were not fundamental to vehicle design. One supplier did say that lamp position is fundamental, in that it affects the design of the vehicle end. Some variations, such as lamp colour, can be varied by modification. Bombardier thought that a system that provides an automatic change of lighting between ‘railway’ and ‘tramway’ modes is a fundamental vehicle issue. This is interesting in view of their experience with the Tram Train concept.

Discussion/conclusions

There are very distinct differences in external lighting requirements, especially for street running. This derives from the variations in highway requirements for the different countries. Total standardisation might be difficult to achieve.

On the other hand, the variations will be at national level, so a particular supplier should be able to cope with them much easier than for variations at city level. There is a degree of commonality and suppliers could design a system for future designs that is adaptable for each country without too much difficulty. It is noted that some manufacturers would be unable to adapt their current designs to meet various national standards. The cost differences of such variations should not be that great.

7.10 COUPLINGS

Principles:

Couplings are provided to link vehicles together:

- ‘Semi-permanently’ to link vehicles that normally operate together in a fixed set or multiple unit. Such couplings may be solid and only removable within a workshop.

- To link vehicles, sets or multiple units together, or with a locomotive, to form a train. Such couplings are normally permanently attached to the vehicle ends and are operated in service, either automatically or manually.
- To link vehicles, sets or multiple units together, or with a locomotive, for the purpose of recovering a failed unit. In these circumstances the vehicle may not be fitted with a coupler. The coupler may be carried on the vehicle or on a recovery vehicle and fitted manually when required.

Unlike other safety features listed above, couplings are a means of achieving safety rather than a fundamental safety issue.

Factors to be considered:

- Buffer locking on tight curves
- Over-riding and rotation in collision
- Strength
- Strength and integrity in an accident
- Compatibility with other vehicles and buffer stops etc
- Hazards associated with manual couplings
- Hazards associated with handling and lifting temporary couplers
- Hazards associated with projecting couplers on a street tramway

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic, probably due to the fact that safety responsibilities rest with the individual undertakings and are supervised at provincial level.

Germany (BOStrab)

The only requirements (section 42) are that couplings must match and that a means of recognising that automatic couplers are engaged and locked is provided.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 9 and 12. Reference is made to other Italian railway rolling stock standards . This includes UNI 8881 that covers automatic couplers for heavy rapid transit, light rapid transit and tramways.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

The Trains section states the requirements that we have listed as the first five ‘factors to be considered’ above.

The Tramway section adds:

- A requirement that couplers used in service on trams in street operation should fold away or retract when not in use
- Protection from couplers in a collision

There is also a guideline that couplers should be designed with a safety factor of 10% above the maximum loading they will experience.

Czech Republic

The basic tramway vehicles requirements (CSN 28 1300) make some specific requirements about couplings.

- Couplers have to be extended if trams operate coupled together.
- They must be protected against disconnection.
- They must be covered and protected when not in use.

Hungary

We do not have information on this topic.

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general. Otherwise this is a topic that is currently not being covered.

Industry views

The view was that coupler height is fundamental to vehicle design. This is also mostly true of the requirement for retractable couplers. Adtranz pointed out that the ‘gathering range’ i.e. angle of lateral movement available is also fundamental. On the other hand the actual coupler itself can be changed, possibly retrospectively.

Discussion/conclusions

The requirements for couplers are fairly basic. Industry can cope with different types and the firms that manufacture the couplers themselves are already producing a wide range that is likely to meet all requirements.

The issue of retracting couplers is more serious. There is a difference of philosophy between countries here. Ideally designs produced for a future Single Market should allow for either retractable or fixed couplers to be fitted, unless agreement can be reached on this issue.

7.11 DRIVING CABS

Principles:

‘The interior of vehicles should provide a safe environment for people carried’ (RSP&G Principle 24).

‘The electrical and other powered systems and equipment on-board vehicles should not endanger other systems or people’ (RSP&G Principle 28)

Factors to be considered:

- Compatibility with the body shell of the vehicle and the access and egress arrangements.

- Foreseeable events which may lead to injury and the arrangements which may be taken to mitigate against injury
- The provision and marking of emergency and safety equipment to deal with incidents.
- The integrity of fixtures and fittings
- The conditions and ergonomics to enable the crew to operate safely
- Heating, ventilation and lighting
- Train borne noise
- Interaction of security with safety arrangements
- Unauthorised access to equipment
- Avoiding contact with electrical conductors
- Effect of the loss of power supply
- Effect of the loss of safety critical systems

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic other than Article 13 that requires that the driver's view must be through perfectly transparent safety glass.

France

There do not appear to be any specific requirements at national level.

Germany (BOStrab)

The General Requirements (Paragraph 3 - 3) states that means must be taken to reduce to a minimum unavoidable danger caused by unauthorised operation. This applies to apparatus and devices.

Paragraph 44 covers driver cabs:

- The driving position must allow the vehicle to be driven safely. Field of vision, weather and draught protection, interference by passengers, ergonomics and the seat are all specifically mentioned as factors to be considered.

- Rapid escape must be possible.

- Speedometers and tachographs must be provided.

- Rear view mirrors are a requirement for street running.

- These conditions need not apply in failure modes.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 9 and 12. Reference is made to other Italian railway rolling stock standards.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are three requirements covering access and egress (209-11), four on cabs (212-215), and one each on cab lighting and heating and ventilation. There are also requirements on noise, hot surfaces, and stowage . None of these are specific, except that the noise requirement is that the Noise at Work Regulations of 1989 are met.

The tramway requirements add:
- Cab design on ergonomic principles.
- Optimum external and internal visibility for the driver.
- Tram signals and signs must be readily visible.
- Mirror may be provided to view passengers boarding.
- A traction and braking controller with an emergency braking position.
- A drivers safety device.
- An emergency brake button (additional)
- A speedometer
- A tachograph for off street tramways (recommended for street tramways).
- An emergency ‘pantograph down’ button.
- Switches to operate the main power circuit breakers.
- Means of disabling controls at non-driving end.

Czech Republic

Very detailed requirements are made in the basic tramway vehicles requirements (CSN 28 1300). There are many cross-references.

Hungary

The system specification will cover visibility distance, fittings, methods of evacuation, accessibility zones etc.. This topic is covered by 990.902/1980 and OVSZII and also by:
- Ministerial Decree 28/1971: ‘Licensing of the construction and operation of vehicles of local public railways’ (This is to be replaced by new specifications, ‘Design and licensing of the operation of passenger vehicles of public railways ’)

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general. There are no general standards applying to cabs, either existing or planned, for any type of rail vehicle. However a number of standards will apply to some specific details. Work is taking place on developing standards for air conditioning in driving cabs.

Industry views

In general most of the design variations that are possible in driving cabs were not thought to be fundamental to vehicle design. One exception was the extent of the area visible to the driver, ahead of the vehicle. Cab size, pay on entry provision and shielding from the passenger area also might come into this category for some suppliers.

The driver's seat is one feature that generally can be varied without great difficulty although Adtranz did point out that there are issues associated with how different types of seat interface with the vehicle design.

Discussion/conclusions

The fundamental issue of left hand or right hand driving position will remain so long as conditions vary on the railways and roads of Europe.

Systems will want to keep the flexibility of either having single ended or double ended vehicles and suppliers are willing to offer these options.

In general there must be scope for harmonisation outside of these two issues, because the fundamental requirements are the same. Where this is not possible then variations in controls required and other relatively minor details should be accommodated within product ranges.

7.12 EMERGENCY EQUIPMENT

Principles:

Emergency equipment is carried as a means of mitigating risk.

Factors to be considered:

- Functions to be covered
- Appropriateness of equipment
- Reliability
- Safe Storage
- Easy access versus security
- Safety when using equipment
- Availability of trained staff
- Ease of checking that equipment is available
- Keeping equipment in safe and reliable condition

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic.

France

Article 56 of the Decree 730 of 1942 has a vague requirement that all vehicles must carry essential emergency equipment.

Germany (BOStrab)

Paragraph 48 states that vehicles must have:
- A first aid box (unless these are available at all stations).
- A fire extinguisher
- A warning triangle, for street operation.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock section 9. Reference is made to other Italian railway rolling stock standards.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

Section 225 states that 'Conductor rail electric traction current short-circuiting devices, track circuit short-circuiting devices and other emergency equipment should be provided appropriate to the traction and signalling systems in use. Where provided, it should be securely stowed to prevent unauthorised use but be readily accessible when required'

Section 54 requires fire extinguishers.

First aid boxes are not essential (207).

The tramway requirements overlap these :

- A fire extinguisher.
- Other emergency gear, including track circuit clips if needed.
- A first aid kit

Czech Republic

There are some specific requirements listed in the basic tramway vehicles requirements (CSN 28 1300).

Hungary

Specifications are expected to cover this provision. There are also requirements in:

- Ministerial Decree 28/1971: 'Licensing of the construction and operation of vehicles of local public railways' (This is to be replaced by new specifications, 'Design and licensing of the operation of passenger vehicles of public railways ')

Relevant CEN standards

EN 50126 covers the specification and demonstration of safety measures in general. Otherwise there do not appear to be any standards, existing or planned, that cover this topic.

Industry views

Variations in this area do not seem to cause significant problems for industry. The storage space and provision for carrying emergency couplers have to be covered at the design stage - this may also be true of fixed first-aid boxes and an external hand lamp bracket. However the loose fittings themselves can easily be varied.

Discussion/conclusions

The variations at national level are not significant. Providing harmonised vehicles allow adequate stowage space for what is likely to be required, such variations do not seem to present a barrier to this approach. With an increase in anti-social activity by passengers in certain cities the issue of the desirability of requiring fire extinguishers has arisen.

7.13 VEHICLE DIMENSIONS

Principles:

'Vehicles should be dimensionally compatible with the infrastructure' (RSP&G Principle 32).

'The electrical and other powered systems and equipment on-board vehicles should not endanger other systems or people' (RSP&G Principle 28)

Factors to be considered:

- Safe clearances under static and dynamic conditions
- Influence of track geometry on dynamic performance
- Centre and end throws on curved track
- Clearances between structures and vehicles
- Clearances between vehicles on adjacent tracks
- The lengths of platforms
- Stepping distances at platforms
- Operation in degraded mode with failed suspension, doors stuck open, etc

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic, probably due to the fact that safety responsibilities rest with the individual undertakings and are supervised at provincial level.

France

Article 45 of the Decree 730 of 1942 provides that overall vehicle length of trams is established by the authorities on a system by system basis.

Germany (BOStrab)

Paragraph 18 defines a clear area that approximates to the UK concept of a 'kinematic envelope'.

Specific requirements for vehicles are contained in paragraph 34:

- Contact between vehicles and objects is not allowed under all operating conditions.
- Throwover on curves must not be more than 650mm outside that on straight track.
- For street operation, width is limited to 2650mm up to 3400mm above rail and 2250mm higher than that.

- The width does not include indicator and marker lights, open doors, rear view mirrors, retractable footsteps when extended.
- Maximum height over the lowered pantograph must not exceed 4m.
- Floor height and platform height must ‘enable passengers to board and alight comfortably’. Floor level must never be below platform level.
- Clear height in passenger areas must be at least 1950mm or 1700mm above seats, but exception is made for vehicles without standing areas and where there is no rush to board and alight.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock section 3 and 13. Reference is made to other Italian railway rolling stock standards. UNI 7156 covers kinematic gauge issues.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

Trains must be compatible with the size allowed by the infrastructure including allowances for safe clearances under static or dynamic conditions (81). The size of the infrastructure is not specifically constrained for new lines.

More detail is given in the Tramways section where clearances are defined. The UK traffic lanes allow trams of 2650mm width to meet these requirements.

Other dimensions are not specified. In particular cities HMRI might not approve trams above a certain length but there is no general rule. Platform height is not standardised for new systems.

Czech Republic

There are some specific requirements in the basic tramway vehicles requirements (CSN 28 1300). Vehicles must not:

- Exceed 2650mm wide
- Exceed 3700mm high
- Be longer than 18m, or 40m if articulated.

CSN 28 0318 includes very specific tram gauging information.

Hungary

OVSZII and the design principles for underground railways (257.712/1972) both provide structure gauge information that together cover mass rapid transit applications. Specifications and data for track construction and the maintenance of underground railways are also relevant. Overall vehicle dimensions derive from these.

OVSZII suggests that a 120m platform length is considered when vehicle length is determined. This presumably means that lengths will be based on sub-divisions of this figure.

Floor and platform heights are only specified in terms of compatibility with existing routes.

The Ministerial Decree 28/1971, ‘Licensing of the construction and operation of vehicles of local public railways’ also covers this topic. This is to be replaced by new specifications, ‘Design and licensing of the operation of passenger vehicles of public railways ‘.

Relevant CEN standards

There do not appear to be any CEN standards existing or planned that set limits on the dimensions of any type of rail vehicle.

So far as operation over main line railways (shared track) is concerned, the UIC leafllets that cover gauging issues could provide a basis for international standards and harmonisation.

Industry views

Track gauge variations are possible between 1000m and wider than 1435mm within product ranges but not always as options of specific vehicle designs. Anything below 1000m gauge would be treated as ‘special’.

2650mm is the maximum width that suppliers are building street running vehicles to and variations down to 2500mm do not present problems. But vehicles in the width range 2000-2500mm would be special designs for most suppliers.

Some suppliers see overall length as something they can offer as an option but others see this as fundamental to vehicle design. Clearly vehicle length does affect many other design elements of a vehicle but suppliers are at least able to offer a range of ‘popular’ lengths to choose from. The same is true of floor height. Many current LRV designs are based on relatively short modules connected by articulations; this approach allows many different lengths to be supplied, and also reduces throwover on curves.

The popular low floor height is 350mm, other heights are ‘specials’. More serious are the tolerances on floor height, which derive from access considerations. Some suppliers see these as fundamental.

Discussion/conclusions

There are significant variations, not only in the requirements but also in the way they are defined.

A good example of the latter is that in Germany clearance is defined in terms that vehicles must not come into contact with other objects, whereas in the UK a ‘safety margin’ space is defined.

The 2650mm maximum width specified in a number of countries is not accepted in Italy. If a ‘lowest common denominator’ approach was taken to harmonisation, this would result in many systems losing useful passenger space (2650mm is considered to be the minimum width at which a vehicle can contain two seats either side of a central aisle). In this case a change to the Italian requirements would be desirable.

It should also be noted that where stepping distances are limited, the infrastructure effectively defines the width of the vehicle at the height of the entrance step.

In Germany certain objects can project outside the maximum width whereas in the UK they might not be allowed to.

Harmonisation of the procedures for gauging and the principles involved would be valuable because this is a relatively complex area for suppliers to deal with. To be sure a vehicle will 'fit' one has to know the exact performance of its suspension and of the throws over specific infrastructure in some cases. Some simplification would be of value. Some measure of agreement on clearances should also be possible.

The maximum height variations e.g. Germany 4m and the Czech Republic 3.7m could also present difficulties.

Previous work by MARIE[3] has shown that there is international acceptance of the idea that standardisation of key dimensions should be possible for new systems but that it will not be for new vehicles on existing or extended systems. The reason for this can be appreciated by studying the wide variations that exist, in combination terms, as shown in Appendix H.

7.14 VEHICLE LAYOUT

Principles:

'The interior of vehicles should provide a safe environment for people carried' (RSP&G Principle 25).

Factors to be considered:

- Intended passengers and their behaviour.
- Compatibility with the bodyshell and access and egress arrangements
- Foreseeable events which may lead to injury, and the arrangements which may be taken to mitigate against injury.
- Foreseeable actions by people that may lead to injury to others.
- Unauthorised access to equipment.
- The stowage of luggage and equipment and their retention in normal operation and during an accident.
- The integrity of fixtures and fitting.
- Heating, ventilation and lighting.
- Trainborne noise.
- The retention of toilet and other waste.
- The interaction of security arrangements with safety arrangements.
- The provision and marking of emergency or safety equipment to deal with accidents.

Belgium

Article 12 of the Rail Transport regulations of 1976 includes a requirement for emergency exits from vehicles.

Germany (BOStrab)

Some requirements are included in paragraph 33:

- Sufficient emergency exits.
- Passengers can travel in the articulation areas.
- Seats and passenger spaces must be so designed and arranged so that injury is unlikely to occur.
- Hand holds and grab rails must be provided.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock section 3. Reference is made to other Italian railway rolling stock standards .

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are three requirements covering walkways (170-172) and seven covering emergency access routes (248-254) that will affect layout.

The tramway requirements add only one requirement i.e. that internal steps and stairways should meet current regulations for passenger carrying road vehicles.

Requirements for wheelchair spaces and grab rail are specified in some detail in the Rail Vehicle Accessibility Regulations 1998. These also make ‘priority seats’ a requirement and specify their dimensions. They also specify that if toilets are provided, a specified proportion must be accessible versions, which are specified and large.

Czech Republic

There are some requirements associated with this topic in the basic tramway vehicles requirements (CSN 28 1300). There are requirements for the number of emergency exits related to the numbers of passengers.

Hungary

OVSZ II defines the number of doors, their positions and opening widths, and the number of seats in relation to standing accommodation.

The same specifications as mentioned in the previous section also apply here.

Relevant CEN standards

Vehicle layout issues are only covered by CEN standards, future and planned, indirectly. This might cover metros but is unlikely to cover lighter forms of mass transit.

Industry views

The provision of a toilet was seen as fundamental to vehicle design as is the position of doorways. One supplier saw seating as fundamental, because they were making use of the spaces under seats.

Most other features that might be required were seen as the sort of options they would expect to have to provide. This includes wheelchair spaces.

Discussion/conclusions

National requirements tend to be vague other than on issues associated with the number of exits. Suppliers should be used to dealing with these variations, and flexibility of internal arrangements would seem to be a selling point.

Provision of a wide range of features for the accommodation of the mobility impaired may become more of a problem unless harmonisation and a measure of standardisation occur in this area. In general the requirements for people with disabilities should be the same across Europe and consistency would also be of value from the public's point of view. In this case where passengers may be less well equipped to deal with variations.

7.15 LOADING PARAMETERS

Principles:

The issue here is the variation in the way that passenger loadings are estimated and calculated.

Factors to be considered:

- Masses assumed for each individual passenger.
- Which seats are included in the calculation.
- Ratio of passengers to standing area.
- Which standing areas are included in the calculation.
- The load cases assumed.
- Factors assumed for dynamic effects.

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic.

Germany (BOStrab)

Paragraph 33 (2) states that the payload of passenger vehicles should be based on:
- A load of 750N per seat.
- A load of 5000N per m^2 standing area.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock section 6. Reference is made to CUNA NC 581-20 that defines the available space for seated passengers in all public service vehicles.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There is nothing specific in the trains section. There are two relevant references in the Tramways section:

- The density of standing passengers should not normally exceed 4 passengers/m^2 of standing space (261).
- Gross laden weight calculations and floor strength requirements should be based on double this figure (262).

Czech Republic

This is covered by the basic tramway vehicles requirements (CSN 28 1300). Maximum passenger loads are calculated on the basis of maximum capacity and an average weight per passenger of 70kg. The number of standees is calculated at 8 per m^2 and includes the whole available area for standing passengers.

Hungary

Ratios of standing and seated passengers are covered (see previous topic 7.14).

Relevant CEN standards

EN 50215 covers the testing of rolling stock after completion of construction and before entry into service.
EN 50126 covers the specification and demonstration of safety measures in general.

PrEN12663 will cover the structural requirements of railway vehicle bodies, this should cover issues such as the weight per passenger, the number of standing passengers in a given floor space and load cases.

Industry views

The weights assumed for passengers are fundamental to vehicle design. Issues about standing density and use of space are also relatively important, although suppliers probably assume worst cases.

Discussion/conclusions

This is an area where any disbenefits that might be considered from standardisation are easily outweighed by benefits to industry. People generally weigh the same and crowd together consistently. The variations in requirements between countries are not significant. A standard approach could be easily achieved.

This could be done by making reference to PrEN12663 and expanding and augmenting it as necessary

7.16 ENVIRONMENTAL IMPACT

Principles:

'The design and construction of new and altered works, plant and equipment should, so far as is reasonably practicable, ensure the safety of any people who might be affected' (RSP&G Principle 1).

Factors to be considered:

- The interactions between the particular works, plant and equipment and those of other railways and other guided transport systems.
- The interactions between the system and its adjacent environment including physical interfaces, noise, vibration, and electrical and magnetic interference..

Belgium

The Rail Transport regulations of 1976 do not make any specific references to this topic.

Germany (BOStrab)

This document does not contain any general environmental requirements.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock section 5. Reference is made to other Italian railway rolling stock standards and to EN 50121 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are vague (non-specific) requirements in the Trains section covering:

- Minimising impact (57)
- Safety of people and property adjacent (58)
- Smell, fumes and smoke in populated areas (61)
- Preventing noxious substances affecting people (62).
- Control of exhaust emissions (63)
- Leaks and spills (64)
- Noise and vibration (65)
- Hazardous materials (66)
- Changes in properties of materials over time (67)

The Tramways requirements add:

- Minimising stray currents (178).
- Need to reduce noise in sensitive urban areas (242)

The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996 will also apply and use is made of ‘The Calculation of Railway Noise’ published by the Department of Transport in 1995.

Czech Republic

Some detailed specifications are contained in the basic tramway vehicles requirements (CSN 28 1300). Reference is made to CSN ISO 2631-1, which deals with the exposure of people to vibration.

Noise outside of the vehicle is limited to 65 dB when stationary and 80dB when moving.

Hungary

There are a number of requirements and standards that are applied in Hungary:

- EN50081 and EN50155 (see below)
- ISO 3095 and ISO 3381, covering noise
- Act LIII, 1995: 'Protection of the Environment'
- Government Decree No.102/1996 (VII.12) concerning hazardous waste
- MSZ 18159-1975: 'Noise emissions of rail vehicles'
- MSZ-07-3720-1990: 'Noise level calculations for railway traffic'
- MSZ-07-2904: 'Noise level calculations for road traffic'
- Decree No.12/1983 (V.12): 'Noise and vibration abatement'
- MSZ 17-011/9: 'Electrical Traction for Transport. Allowable levels of disturbance. Methods of investigation.'
- MSZ-07-8204/10-76: Radio Interference'

Relevant CEN standards

EN 50121 covers Electromagnetic Compatibility

ISO/DIS 3095 is planned to cover the measurement of noise emitted by rail vehicles.

Industry views

Vehicle noise requirements are fundamental to vehicle design. Other requirements are less onerous or are in areas where industry is used to meeting them.

Discussion/conclusions

Noise is becoming a key issue throughout Europe. Concern on this topic is leading to mapping of noise levels. Squeal of wheels on tramway curves is now taken more seriously because it is not sufficient to quote a general noise level. It is also a parameter of the tramway system itself, not specifically of the vehicle.

International standards on Electromagnetic Compatibility are becoming established and the same will occur in respect of noise.

This is an area where harmonisation of requirements is fully justified. This assists industry in simplifying tendering and acceptance processes and also benefits society as a whole.

However in respect of EMC, compliance with international standards may not be sufficient to ensure safety. On the heavy rail network in Britain, it is necessary for manufacturers of new electric trains to demonstrate that the return currents cannot cause hazards to signalling equipment, under normal or any credible fault condition. The necessary testing and analysis has caused significant delay to the service introduction of several fleets. This also became an issue on Croydon Tramlink, where although the vehicles do not run on the railway their proximity leads to some electrical coupling of return currents. The tram was demonstrated to comply with the relevant parts of the EN50121 standard, but its traction package operates at the same frequencies as the railway signalling equipment. A significant amount of work was necessary to demonstrate that railway safety would not be compromised.

7.17 VISUAL AND AUDIBLE INFORMATION SYSTEMS

Principles:

'There should be an effective means of communicating safety messages to, from and within vehicles' (RSP&G Principle 27).

Factors to be considered:

- Communications between vehicles, staff and control centres
- Communications between staff on board vehicles
- Communications between staff and passengers
- Passenger alarm facilities
- Availability of communications systems in degraded conditions
- People with disabilities

Belgium

The Rail Transport regulations of 1976 Article 11 forbids the placing of notices on windows. Trams and metro vehicles must be fitted with passenger emergency alarms that are easily accessible (Article 10). These are the only references to this topic, except that information must be provided on the exterior to identify the route and destination (Article 9).

France

There do not appear to be any specific requirements at national level.

Germany (BOStrab)

The following requirements are made:

- Paragraph 23:
    - Suitable information technology systems to provide communications between vehicles and control, with priority for safety messages.
    - Rapid communication from tunnels to control and emergency services.
- Paragraph 46:
    - Line and destination indicators on the front (unless given by platform indicators).
    - Route indicators, destination and route description (if appropriate) on the boarding side.
    - Line description on the rear.
    - System map or line diagram, line description where necessary
    - Stop and necessary operational announcements
    - Confirmation of request stops
    - Voice communication between drivers and control
    - Passenger communication with control on automated systems

  Some of these do not apply to Personal Rapid Transit systems in which passengers themselves select the destination.
- Paragraph 47:

- Instructions for passengers associated with the operation (signs)
- Pictograms identifying seats reserved for the mobility impaired etc
- Notices concerning emergency equipment

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 12. Reference is made to other Italian railway rolling stock standards.

UK Railway Safety Principles and Guidance (Trains and tramway sections)

Passenger compartments, including toilets, must be fitted with an ‘efficient means of communication between the passengers and the servants of the company in charge of the train’ (205). This results from the Regulation of Railways Act of 1868, which still applies.

Chapter 8 of the Trains section covers communications:

- General points covering integrity, failure, public address, and use of radio and synchronisation (256-261)
- Between crew and passengers (262-265), includes public address
- Between train and the control centre (267-268), including a recommendation that covers situations on one man operated trains and automated railways.

The Tramways section adds recommendations for alarm points and request stop advice (282-283).

All mass transit in the UK must meet the requirements of the Rail Vehicle Accessibility Regulations 1998. In terms of passenger information this **requires**:

- Public address, both audible and visual.
- Announcements of the destination (on the exterior)
- Announcements of the next stop, delays of more than 10 minutes, diversions and emergencies.
- Lettering sizes and the use of mixed case rather than all capitals are specified.
- That visual announcements are visible from the majority of seats.

An operator would be breaking the law in the UK if this was not provided on new vehicles, unless he had obtained an official exemption.

Czech Republic

Very detailed requirements are made in the basic tramway vehicles requirements.

Hungary

Requirements will be specified with reference to the following:

- MSZ-07-5010: Public service vehicles. Passenger information announcements for trams, trolley buses and buses’
- KPMSZ Kk103: Passenger Information and warning announcements for vehicles used for urban (local) public transport and for long distances buses’

The Ministerial Decree 28/1971, 'Licensing of the construction and operation of vehicles of local public railways' also covers this topic. This is to be replaced by new specifications, 'Design and licensing of the operation of passenger vehicles of public railways '.

Relevant CEN standards

This topic is not covered by any existing or planned CEN standards.

Industry views

Information systems were not seen as fundamental to vehicle design but they mostly do have to be sorted out at the design stage.

Discussion/conclusions

There is a lot of variation here that probably reflects historic developments and cultural differences. It is an area where requirements can be very specific, especially in terms of meeting the needs of people with hearing and sight difficulties. Conversely, it is possible for suppliers to provide variations without too great difficulty. What is actually provided does depend very much on local circumstances. Even within each set of requirements there are variations.

The approach here may be to harmonise interfaces so that different types of system can be fitted, and linked if necessary to other on-train communication and control systems.

Standardising on types of public address and visual displays would not add very much as long as the logic is consistent. Simple measures like standardising the format and symbols used on system maps would probably be more effective so far as the public were concerned.

7.18 HEATING, COOLING AND LIGHTING

Principles:

'The interior of vehicles should provide a safe environment for people carried' (RSP&G Principle 25).

'The electrical and other powered systems and equipment on board vehicles should not endanger other systems or people' (RSP&G Principle 28)

Factors to be considered:

- Heating, ventilation and lighting in both normal and degraded condition. Limitation of fire load, ignition sources, fire spread and smoke and fumes.
- Intended passengers and their behaviour.
- The integrity of fixtures and fittings.
- Foreseeable actions by people that may lead to injury to others.
- Unauthorised access to equipment.
- Avoiding contact with electrical conductors.
- Effect of the loss of power supply.
- Effect of the loss of safety critical systems.

Belgium

The Rail Transport regulations of 1976, Article 14 states that the interior lighting of the vehicle must give a uniform illumination of at least 100lx in the centre aisle at 1m above floor level. Lighting can be reduced in the area close to the driving position so as not to affect the view of the driver. If the lighting fails, emergency lighting must be sufficient to permit passengers to exit in safety.

There are no requirements associated with heating or ventilation.

Germany (BOStrab)

Paragraph 45 makes the following requirements:
- Passenger compartments must have 'adequate lighting'.
- Lighting must not be capable of being switched off by passengers.
- Interior lighting must not interfere with driver's vision.
- Footsteps must be lit.
- Emergency lighting, activated by failure of normal lighting, at least in doorways and emergency exits.
- Passenger compartments and drivers cabs must be adequately heated and ventilated.

Italy

This topic is covered by the new draft standard for tramway and light rail rolling stock sections 4, 12 and 13. Reference is made to other Italian railway rolling stock standards and to prEN 13272 (see below).

UK Railway Safety Principles and Guidance (Trains and tramway sections)

There are six requirements associated with heating and ventilation in the trains section, these cover (192-197):
- Adequate air changes
- Simple means available if passengers control ventilation
- Heating, ventilation, air conditioning to be applied as appropriate
- Environment must be maintained under all conditions and in event of failures
- Over riding of automatic controls
- Air intake siting
- Release of air conditioning refrigerant

There are two covering lighting (198-199):
- Lighting to remain operational, reduced level OK in an emergency. Emergency lighting must cover escape routes and signs.
- The same for passageways, steps and exits.

The tramway requirements add:
- Matching illumination to that in other passenger carrying road vehicles (264)

Czech Republic

Very detailed requirements are made in the basic tramway vehicles requirements (CSN 28 1300). Internal lighting has to be equally spread with a minimum of 75lx measured 1m above floor level. In an emergency the illumination must not fall below 10lx in door areas.

Hungary

Requirements are specified in OVSZ II.

The following are also applicable:

- MSZ 21875-1990: 'Employee safety requirements associated with the heating and ventilation of work places'
- Ministerial Decree 28/1971: 'Licensing of the construction and operation of vehicles of local public railways' (This is to be replaced by new specifications, 'Design and licensing of the operation of passenger vehicles of public railways ')

Relevant CEN standards

PrEN 13272 will cover electrical lighting for rolling stock in public transport systems. Work is also taking place on standards for the comfort parameters and type tests for air conditioning systems in urban and suburban rolling stock and driving cabs.

There are no other standards directly relevant to heating and ventilation.

Industry views

One supplier saw lighting levels as fundamental to vehicle design but generally lighting provision was seen as something that they could vary.

Ansaldo-Breda saw the provision of air conditioning and heating as fundamental to vehicle design but other suppliers saw these features and ventilation as being within the range of options they would expect to supply with specific vehicle designs. Adtranz saw as fundamental the decision on whether or not windows needed to be opened to provide ventilation.

Discussion/conclusions

The detail of requirements for lighting varies but the overall objectives are probably the same. It would be possible to simply implement prEN 13272 in future.

The European standards for air conditioning could also be applied comprehensively to mass transit. Heating and ventilation could be similarly treated.

In each case, what is provided can be varied, the issue is consistency of specification, testing and measurement techniques.

7.19 OTHER SAFETY TOPICS

The preceding subsections have been confined to considering in detail the specific topics agreed in the Work Plan, however there are many other basic safety topics that could be considered in the same way. Figure 4 shows all the safety principles that are applied in the UK as a guide and initial 'check list' to the full range of topics that eventually should be covered.

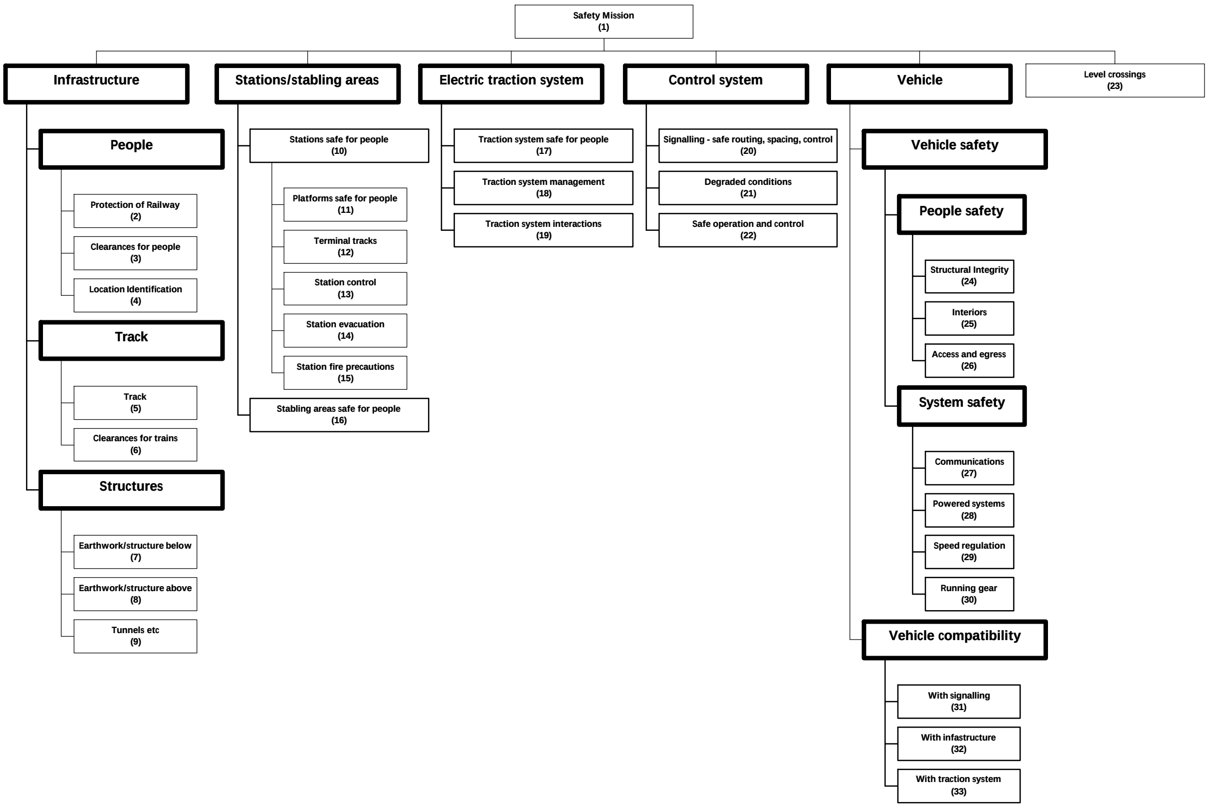


Figure 4: Structure of safety principles (simplified version of that in reference [6])

Some other areas that industry identified as crucial to vehicle design were:

- Requirements for obstacle deflectors (due to the need to provide sufficiently strong attachments in the vehicle structure)
- Requirements for high impact windscreens.

Variations in the following areas associated with safety were not seen as significant:

- Traffic signal control detection
- Route request and point operation systems
- External mirrors
- Horns and bells
- Shrouding to rail level.

7.20 SUMMARY

The table below summarises the various safety standards actions that we are proposing as a result of our analysis.

Each topic can be considered in terms of the benefit to industry and the cost to society of standardisation. If we then consider these simply in terms of ‘high’ or ‘low’, then an action, which has high benefits and low costs, is worth doing quickly and vice versa.

We list the actions recommended:

- ‘Existing standards’ Standards exist now that could be applied to this area.
- ‘New standards’ Standards are being prepared that could be applied to this area.
- ‘Standards required’ New standards should be prepared for this area.
- ‘Harmonise’ Harmonisation only, no standards are required.

We give these a priority:

- S Short term
- M Medium term
- L Long term

These priorities derive from the cost/benefit considerations and the effort and time required to achieve harmonisation.

We also note where flexibility is required in any harmonisation process, i.e. new standards will cover issues such as interfaces, tests and options but not state exactly what should be provided.

Topic	**Industry benefit**	**Society cost**	**Action**	**Flexibility required**	**Priority**
Fire safety	High	Low	New standards		S
Crashworthiness	High	Low	New standards	Yes	S
Derailment	High	Low	Standards required		M
Doorway dimensions	High	Low	Standards required		M
Traction & control	High	Low	Existing standards	Yes	S
Train protection systems	Low	High	Standardise the systems	Yes	M
Emergency brake	High	Low	New standards		S
External lighting	Low	High	None	Yes	
Coupling type	Low	High	None	Yes	
Couplings retracting	High	High	Harmonise		L
Cab layouts	Low	High	None	Yes	
Cab equipment	Low	Low	Standards required	Yes	M
Emergency Equipment	Low	Low	Harmonise	Yes	M
Track gauge	Low	High	No action	Yes	
Gauging	High	Low	Standards required		M
Vehicle width	Low	High	Standards required	Yes	L
Vehicle height	Low	High	Standards required	Yes	L
Vehicle length	Low	High	Standards required	Yes	L

Topic	Industry benefit	Society cost	Action	Flexibility required	Priority
Internal layout	Low	High	No action	Yes	
Disabled person provision	High	Low	Standards required		M
Loading parameters	High	Low	New standards		S
Noise/EMC	High	Low	Existing standards		S
Other environmental	Low	Low	Standards required		M
Information interfaces	Low	Low	Harmonise	Yes	M
Information presentation	Low	Low	Standards required	Yes	M
Lighting	Low	Low	New standards	Yes	S
Heating and ventilation	High	Low	Standards required	Yes	M
Air conditioning	High	Low	New standards	Yes	S

This process is relatively 'black and white'; some action is probably justified even where we have said 'no action' and actions we have suggested may be varied as a result of further work. The objective here is to provide an overview of the extent to which actions will be needed in order to achieve a single market, rather than be precise about detail.

8 General Issues

8.1 MANAGEMENT OF REQUIREMENTS

The following table summarises the institutions and bodies that define and manage safety requirements in each country of the study area. This information is derived from that given in section 3.2.

Country	Regulations set by	Standards set by	Management by
Austria	Federal Government	CEN/cities	Federal Government and cities
Belgium	Provinces	CEN/National government/cities	Provinces and cities
Czech Republic	National Government	National Government /CEN	National Government
Denmark	National Government and Railway Inspectorate	National Government /CEN/cities	Railway Inspectorate
Estonia	National Government	Cities	Cities
Finland	Cities	CEN/cities	Cities
France	National Government	CEN/cities	Départments
Germany	Federal Government	Federal Government	Länder
Greece	Cities	Cities	Cities
Hungary	National Government	National Government	National Government/Cities
Ireland	National Government	CEN/cities	Railway Inspectorate
Italy	National Government	National Government	National Government
Luxembourg	National Government	CEN/cities	Railway Inspectorate
Netherlands	National /Provincial Government	Cities	National Government
Norway		Cities	Railway Inspectorate
Poland	National Government	National Government	National Government
Portugal	Cities	CEN/cities	National Government
Slovenia	National Government	Slovenian Railways	Slovenian Railways
Spain	Regional Government/Cities	Regional Government/ CEN/cities	Regional Government/Cities
Sweden	Cities	CEN/cities	Railway Inspectorate
Switzerland	Federal Government	Cities	Federal Government?
UK	National Government	National Government	UK: Railway Inspectorate

Virtually all regulation is at national or sub national level. Euronorms are generally only applicable where the national government has adopted them, very few of any relevance to mass transit have been the subject of EC Directives and those will be on issues of detail, such as wiring.

Of the 22 countries being studied, 14 manage the application of standards at national level. Usually this is done by a 'Railway Inspectorate' or an equivalent body as part of their overall function for supervising the rail networks of a country as a whole. Sometimes the Railway Inspectorate may be part of a wider body with other responsibilities.

Many of the existing Railway Inspectorates are relatively new and have been established as a result of the process of opening up national railway networks to open access operation.

In three countries regulation is the responsibility of state, provincial or local government, namely Belgium, France and Germany. This is also the case in the United Kingdom, but only in Northern Ireland.

In other countries city administrations or operators are self-regulating. In some cases these bodies have a role in the process.

The principal ways in which this regulation can be managed are:
1. Providing guidance at the design and construction stages of new lines or vehicle types.
2. Approving Safety Cases.
3. Approving new lines and vehicles (or vehicle types) prior to entry into passenger service.
4. Monitoring safety, both on specific systems and in overall terms.
5. Investigating accidents
6. Making recommendations for new legislation where this is proved necessary.

The extent to which these functions are performed will vary but this is perhaps not significant. The reasons for such differences tend to be historical and we do not anticipate great resistance to harmonisation of process. Our reasons for saying this are:
- Many regulations are relatively modern or still being developed.
- Many are based on the application of European Standards and procedures.
- In the countries where the structures are long established there is also the greatest pressure for change, in Germany because of the large expanding networks, in France and the UK because of the number of entirely new systems.

Another issue is that of cost and resources. To provide a comprehensive system costs money or else delay at crucial times for approval processes to go through. The impact of a delay in opening of six months to a year on a newly built Light Rail system can have a significant impact on the viability of the scheme as a whole. The tendency of regulating authorities is either to cut back services or to charge for them. The initial advisory role may become a consultancy service. The policy change of the Czech Government is perhaps typical of what might happen as other small countries are faced with more and more demands from expanding rail networks.

Standards need not be obligatory for these processes to be effective. For example in the UK the 'Requirements' are not mandatory in the strict legal sense. In this way the Regulating Authority remains responsible, through the approval process, for the final decision as to whether in a specific circumstance something is safe or not. This avoids the hypothetical problem, 'This is how I will do it because that is what the law says, even though you are telling me that it is unsafe'.

Well-developed arrangements exist in Germany for managing the application of standards. Approval for operating a system is only granted to organisations if they and their staff are reliable and technically qualified. The issuing of licences and the supervisory role are undertaken by public agencies appointed by the Länder, and these bodies also award the planning permission required for any new works. Among other activities they will carry out acceptance of materials and parts, carry out acceptance tests on vehicles (see below) and can demand all the information and assistance required in order to undertake this work.

This is more complex system than that followed in the UK, where licensing of railway operators and assets was introduced in 1992. Existing operations were exempted. Exemption could also be obtained for new systems either by application or if they fulfilled certain conditions. A key criteria for licensing was whether or not the system might ever be physically connected to the national rail network. So for example, a narrow gauge tramway system would automatically fall outside this legislation.

8.2 PHILOSOPHIES BEHIND NATIONAL STANDARDS

The functions of standards as applied to rail systems, in particular mass transit, can be summarised as follows:

1. They are the means whereby the regulating authority sets the requirements that it will continue to monitor in order to maintain safety, performance levels etc.

2. They represent a record of best practice so that the quality of systems is maintained and every new one does not have to develop technology and practices from scratch.

3. They impose uniformity to achieve interworking and interchangeability, and improve marketability of products.

Many standards only define the most important basic principles and are therefore kept clear of technical details. This is true of BOStrab and the UK RSP&G.

The extent to which standards are of importance and are being developed in each country would appear to be related to the extent of development of new rail mass transit systems. The countries where national standards do not exist are clearly ones where the development of new systems is non-existent, minimal or at an early stage.

The philosophy derives from key issues such as where the liabilities lie and how the process is managed, as discussed in the next section.

8.3 PHILOSOPHIES BEHIND LOCAL REQUIREMENTS

Cities may need to create standards because national standards do not exist. The answers to this question (B2) should logically have been consistent between countries but this was not the case. The reason for this is probably that in some countries, some cities will consider the national standards to be adequate and others will not. The lack of national standards resulting in new city standards, should new LRT systems be promoted, might occur in Finland, Luxembourg, the Netherlands and Poland.

Of those cities that would use national standards, only a few would consider them to be sufficient. This seems to be the case in Belgium, some cities in Italy and Germany, and Estonia where the German VDV would probably be used in preference to an Estonian standard. Strasbourg has used VDV requirements as well.

Many cities seem to base their standards on national standards but add their own requirements. Nine of the consulted cities stated that they did this. Other cities known to do this are Bern (Switzerland), Bremen (Germany) and Graz (Austria). The reasons given for adding to national standards, in order of importance, are as follows:

- To achieve compatibility with existing systems in the city 92%
- A desire to procure a high quality system 66%
- To allow for technical advances and more flexibility 58%
- Due to a tradition of producing detailed specifications 33%
- A desire for higher than standard safety requirements 33%
- Due to peculiar local conditions 25%

These results are some of the most interesting from the study. Clearly compatibility is an issue and is key to consideration of future standardisation. The quality issue may reflect political whims, as held by the operator or local politicians, but in general one would expect specifications to require more than the minimum so this figure might have been higher. It suggests that political whims may not be as significant an issue as is imagined - although the low level of agreement might also be explained by the survey covering established mature systems. Specifying technically advanced products is important and this reflects the problem that existing wider based requirements do have a tendency to ossify.

Only a few systems claim the practice is due to tradition or older policies that are out of date, these systems being Naples, Gothenburg, Prague and Budapest. Likewise, perhaps surprisingly, only a few systems consider that national standards are inadequate in safety terms. This suggests that national standards bodies are generally meeting public expectations in this respect. In the case of Zwickau, the need to go beyond national standards this may have been due to the novel form of track sharing.

Zwickau is one of the few cities that claims it has peculiar local conditions that justify improved standards. The others are Prague, that states it has a technically complex systems, and Gothenburg. Gothenburg has been the only significant developing LRT system in Sweden for a number of years and this must partly explain why it has had to look after itself.

Question C2 of our questionnaire explored this issue further. The full results are tabled in Appendix G. The responses of the 37 cities which provided answers are summarised in the following table:

Criteria	**Very important**	**Relevant**	**Not applicable**	**Don't know**	**Common standards would help**
Attracting investment	**11**	**19**	**4**	**3**	**10**
Providing safer transport	**19**	**16**	**2**	**0**	**13**
Minimising initial cost	**6**	**23**	**4**	**4**	**12**

Criteria	Very important	Relevant	Not applicable	Don't know	Common standards would help
Providing affordable transport for all	**22**	**12**	**1**	**2**	**7**
Reducing pollution	**23**	**14**	**0**	**0**	**14**
Minimising risk for the city authority	**20**	**5**	**9**	**3**	**9**
Expanding existing Light Rail system	**12**	**12**	**8**	**4**	**5**
Providing access for the disabled	**25**	**9**	**1**	**0**	**18**
High quality distinctive system to make an 'image' statement	**13**	**14**	**4**	**6**	**4**
Tailored to meet specific requirements of market research	**7**	**19**	**4**	**5**	**2**

8.4 SAFETY PRINCIPLES EMPLOYED IN NATIONAL STANDARDS

There are two main principles:

1. Standards are set so that safety is assured provided these are met. This principle is based on the concept of 'absolute safety' i.e. everything possible should be done to avoid any deaths or injuries at all.

2. The principle of risk assessment is applied. The hazards associated with any particular innovation are identified, quantified and assessed. Measures are introduced to alleviate these hazards to an acceptable safety standard. The 'Safety Case' is then approved as a whole. This is based on the concept that safety measures are applied to the extent that they are reasonably practical, i.e. there is no need to introduce costly measures if the risks are extremely low.

The second principle is more recent and generally being applied more extensively. Both have their advantages and disadvantages, the most significant being:

1. Absolute safety is what the public expects but the cost can be so high, as more is learnt about potential risk, that rail systems become so expensive to use that people are forced to use other, more dangerous forms of transport.

2. The first principle relies on experience. In a fast changing world, one cannot afford learning the lesson the hard way from studying the aftermath of accidents. It is much better to predict what might happen in advance.

3. The discipline of predicting and quantifying hazards makes operation intrinsically safer through involving the people directly responsible, and enables different aspects of safety related expenditure to be prioritised.

4. The process of risk assessment is very costly and time consuming.

Some countries are currently applying a mixture of these two principles and in all cases where the second is applied there will be some reliance on the first. For example a tramway operator in a city should be able to state in their Safety Case that they intend to use a well established wheel profile and rail profile without identifying and quantifying any general derailment hazards associated with their use.

There is also a third principle, i.e. that existing safety levels should be maintained and accidents from the same cause should be avoided. This is referred to here as the 'Globally at least equivalent principle' - GAMAB.

The following table indicates the countries that are applying the different principles, in broad terms, so far as mass transit is concerned:

Principle	Countries	Number
Absolute safety	Austria, Belgium, Czech Republic?,Denmark, Estonia, Finland*, Poland? , Slovenia	8
Risk assessment	Ireland, Italy, Netherlands, Sweden, UK	5
Mixture	Germany, Switzerland?	2
GAMAB	France	1
None of these	Greece, Hungary, Luxembourg, Norway, Portugal, Spain	6

*Likely to move to Risk Assessment in future.

In general, countries that are revising their standards are moving towards the use of risk assessment and this trend will probably continue. A harmonisation leading to the Single Market should be able to build on this tendency.

8.5 SAFETY PRINCIPLES EMPLOYED IN CITY STANDARDS

At the local level, 17 cities of those surveyed provided information on this topic.

Only two (Paris and Naples) stated that the standards it produced were sufficiently detailed so as to assure safety provided that the supplier met them in full without variation.

Six other cities used the same principle but the supplier was allowed to make variations provided he could prove that he could attain the same level of safety.

Three cities only set safety performance requirements, and would require the supplier to prove he can meet them. These include Amsterdam and Warsaw. Amsterdam commented that their safety performance requirements would be linked with specific and detailed technical safety specifications (presumably there is reference to complying with Euronorms etc).

Six other cities also set safety performance requirements, but in this case the supplier is simply responsible for meeting them - he does not have to prove this.

Based on this sample, the split between detailed specifications to assure safety and suppliers having responsibility is about even.

Birmingham commented that that safety is assured by compliance with UK safety legislation and the advice and guidance given by the Railway Inspectorate, which has issued safety principles.

8.6 POLITICAL INFLUENCE

As noted above, 66% of our sample of operators who set their own requirements do so because they want high quality systems. Other evidence of the political influence, by city authorities, at local level on systems includes:

8.6.1 Interest in 100% low floor vehicles

Most people, including those with mobility impairments, have no problem in entering and leaving a mass transit rail vehicle by the same pair of doorways. In fact, moving along the vehicle to another pair of doorways is both inconvenient and difficult when there are crowds. The public appreciates some segregation, young people sit in groups on raised seats with a better view, older people and families with young children prefer low floor areas with easy access. So unless there are emergency exit or pay-on-entry issues, and providing any internal steps and ramps are well designed, a vehicle with varying floor heights is very acceptable. A partial low floor vehicle can have level access at all doorways. Despite this, many cities are demanding 100% low floor, despite all the technical difficulties and costs, this must reflect a political wish to have the 'latest technology'.

8.6.2 Interest in making an 'image statement'

In question C2 of our questionnaire we asked the city authorities how important they thought it would be for a new Light Rail system to make an image statement.

37 cities responded. The answers they gave were:

- Very important 35%
- Relevant 38%
- Not applicable 11%
- Uncertain 16%

This suggests that image is important to cities, as is commonly believed. There is evidence from several cities that light rail is a key element of their image. Perhaps the best-known examples for new systems come from France, with cities such as Grenoble and Strasbourg placing weight on a distinctive image, and taking the opportunity to make environmental improvements. In Spain the first 'Modern' LRT System, in Valencia has been an important contributor to a significant change in the city's image over the last few years. It has been introduced together with major developments in parks and innovative public buildings. It has become the 'role model' for other cities contemplating or installing systems, like La Coruña, Granada, Bilbao, San Sebastián and Irun. Even in Croydon, where no measures have been taken to make the vehicle distinctive and no environmental improvements have taken place outside the immediate vicinity of the tracks, early evidence indicates that the citizens are proud of their tramway and see it is an important contribution to the community.

The vehicle is the part of the system that the user sees most of, it is the most significant factor in the journey experience, therefore it is not surprising that emphasis is placed on making it as attractive as possible compared with other elements such as track, stops and electrification.

8.7 EFFECT OF ECONOMIC CONSIDERATIONS

Our questionnaire results suggested that operators are not that keen to minimise initial cost. It is an issue that ranks surprisingly low down the list in terms of importance. This may be because we have selected larger cities with established networks, making it unattractive to use lower-cost technologies which often have lower carrying capacity and are likely to be incompatible with existing systems. These cities may also be less likely to go for cheaper technology which they perceive as being risky.

Providing affordable transport, on the other hand, was seen as important. Notably most of the cities in eastern Europe saw this as very important, reflecting the resistance that might be expected in those economies to high fares.

It might be perceived that achieving common standards will add costs, especially for less sophisticated systems. Our discussions with CEN identified that their requirements are developed so as not to impose undue costs. In making decisions on what standards to adopt, CEN applies the practice of 'weighting' opinions of organisations with most to lose.

There are other indirect effects of economic considerations:

1. Where large populations have been traditionally poorly served by public transport the demand will be for high capacity systems.

2. In countries where the car has become the normal form of transport, making the system attractive by means of high performance and modern image will be a driving force.

3. Where cities are expanding beyond the range of buses and trams and yet have existing rail systems the interest will grow in shared track forms of mass transit.

4. In very wealthy cities, the availability of land for any form of public transport infrastructure will be limited, issues such as electromagnetic compatibility, interference and visual intrusion will be acute.

For existing systems the costs of modifying infrastructure to suit new vehicles could be very high indeed. The actual costs have to be added to those associated with disruption or else increased so that somehow the changes are made while the service continues to operate. Such changes also have to be introduced over a large part, or possibly the whole of the system, in one go to be effective. Even quite minor changes, such as altering the heights of platforms, become extremely expensive in these circumstances.

For new systems the cost savings of standardisation will be considered in the context of the cost of procuring the system as a whole. A typical LRT line might cost 15 Million Euro per route kilometre to build, and for each kilometre a typical fleet would have one vehicle costing 2 Million Euro. If standardisation saved 25% of the cost of the vehicle, which would be a difficult target, then the overall saving in the cost of the system as a whole would be 3%. On this basis we do not think that a Single Market for vehicles would have a significant impact on increasing the number of LRT systems that are promoted and built in Europe.

Whole life costs should be the basis of decision making, even though this is not always the case. One benefit of working towards the Single Market should be that experience, that results in minimised whole life cost, can be built into the harmonisation and standardisation processes.

8.8 LIABILITY

CEN are careful to point out that they accept no liability for their standards and this will be true of all Euronorms. International standards are interpreted by national laws, and liability may vary from country to country. We believe however that liability might be accepted by whichever international, national, regional or local body legislates for them to become mandatory as part of its regulatory role. We would advise any authority to take legal advice on this

Throughout the study area, the liability for compliance with standards and other requirements generally seems to lie with the transport infrastructure owner or operator.

The German Ministry for Transport and Housing stated that if a case went to court then the findings could influence subsequent versions of BOStrab.

It is certainly true in Austria, Belgium, Denmark, Finland, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, the UK, Hungary, Poland, the Czech Republic and Estonia.

As long ago as 1879, following the Tay Bridge disaster, it was made clear in the UK that the responsibility for safety must lie with the infrastructure owner. In this case the railway company had met the requirements in terms of carrying out specified tests but had badly managed the construction and maintenance process so that obvious faults had not been acted upon. The same underlying principle remains true today.

In the event of an accident where compliance with standards was an issue, we would expect the infrastructure owner/operator to be responsible where it had not complied with the standard and the regulatory body to be responsible where the standard was proved to be inadequate.

Many modern standards and requirements are vague or shift the onus onto the operator etc. - this is one method regulators can apply to limit their liability. In the UK there are no mandatory requirements for safety only ‘Principles and Guidelines’, but this still places liability onto the approving body. This issue is currently being debated following recent major railway accidents.

Cities were asked to comment on the issue of where they saw the liabilities resting as a result of setting standards. 14 of those surveyed gave their views:

- 35% stated that the liability remains with the city authority provided that the supplier meets their standards or an approved variation.
- 35% stated that liability was transferred to the supplier. Bern, Bremen and Essen also considered that this was the case.
- One authority (London) said that liability was not an issue until a specific problem arose.

- 21% said that they didn't know, neither did Graz.

Birmingham commented that they do not set any safety standards themselves so as not to incur any liabilities.

In Prague, safety is the responsibility of the authority that is supported by an independent attestor. Liability is shared between the authority, the supplier and the operator.

Clearly this is a topic where there is some diversity of opinion and understanding.

8.9 PLANNED OR PREPARED NEW REQUIREMENTS

The accelerated work of CEN has been mentioned already and section 3.1 describes many of the new standards that are planned.

The UITP Light Rail Committee is currently revising its planning guidelines.

At the national level new bodies of requirements are planned as follows:

- **Austria** - New regulations for LRT and tramways introduced July 2000.
- **Germany** - New VDV recommendations are planned in order to assist in clarification , unification of techniques within the Association, and to make a 'bridge' with new European Standards.
- **Italy** - more standards that fit into the new framework are to be expected.
- **Netherlands** - Guidelines on risk factors and on LRT.
- **Slovenia** - the new regulatory body will possibly create some high level regulations.

In general the growth in requirements is not significant. It is either catching up with changes in procedure e.g. Netherlands, or modifications so as to make better use of European Standards.

The environment seems to be appropriate for change.

We checked if the situation that exists in cities regarding local standards is likely to change. 15 of those surveyed replied.

- 60% had no plans to change.
- 27% had plans to change
- 13% expected changes in future

8.10 EXISTING PRODUCT ACCEPTANCE PROCEDURES

In countries that use or have adopted the BOStrab procedures, product acceptance is bound up with the regulatory process. The Technical Supervisory body appointed by the Länder approves new vehicles, including carrying out specified tests. These tests derive from the technical requirements contained in BOStrab, some of which are described elsewhere in this report (e.g. compliance with pre-determined braking curves).

In other countries the process is less rigorous and more informal. In the UK the Railway Inspectorate have in the past examined new vehicles for Light Rail systems during the design and construction processes and concentrated purely on areas where they might have concern.

Occasionally this will result in tests, and the final approval of a type of vehicle will nearly always involve some basic test running including gauging runs over new infrastructure.

In a number of countries compliance with standards is a pre-requisite of obtaining funds for a project. This is true in Germany and in Italy. In France the government used this process to introduce a standard tram design, but the design was only applied in Nantes, the requirement was relaxed and other cities went their own way leaving Nantes with a vehicle that was not optimised for its own conditions.

The EC Directive on Interoperability of rail networks has resulted in work on technical standards and the establishment of 'Notified bodies'. These organisations will have two roles:

1. The approval of 'sub-systems', which could include complete vehicles.
2. The approval of suppliers

The establishment of this process has been delayed. Pre-notified bodies have been appointed, these include organisations with an established role in vehicle safety approval processes at national level, for example AEA Technology Rail. One cause of this delay is that it depends on legislation being passed by the governments of the EU member states. The intention had been to set up the organisations by law and define their roles later, but this causes difficulty in some states including the UK.

The extent of interoperability is defined as a network that will include part but not all of the national networks of each country, so the scope of Notified Bodies will not extend to Rail Mass Transit systems. On the other hand, as part of this same process it is the intention that Euronorms will replace national railway standards, which might apply to all rail systems in a country and therefore lead to some interaction.

Nominated Bodies are responsible for checking compliance; they are not liable for safety.

The vehicle acceptance process now being initiated for the European rail network could be applied to rail mass transit systems. This would create uniformity in this area of the market and could supplant the existing processes such as those that derive from the BOStrab requirements. However we believe that this might unduly penalise smaller scale systems of local interest and a system of exemptions based on well defined criteria is needed. The vehicle approval process for lighter systems (including tourist tramways, ultra light rail, guided bus and certain other novel forms of guided transport) should be no more onerous than that which might in the future apply to buses.

Nine cities provide information on the way in which they ensure compliance with their standards:

- **Amsterdam**: The operator checks compliance by vehicle suppliers

- **Birmingham**: Detailed tender assessment and supervision of construction, utilising appropriately qualified specialist consultants.

- **Gothenburg**: The city authority makes regular checks on operator compliance.

- **London**: A combination of the detailed performance specification being part of the contract documents, activities of a monitoring and approvals team during construction and commissioning and performance monitoring during operation.

- **Luxembourg**: Inspection by civil service department

- **Milan**: By the City reviewing proposals in detail and by final tests before the service begins.

- **Paris, Cologne**: External audits by specialised companies.

- **Strasbourg**: Railway Inspectorate liaison and a legal agreement in advance of construction.

In addition the following cities provided comments on their practice:
- **Bern**: Periodic controls by the city administration
- **Essen**: Long term legal agreement with option to include specifications
- **Graz**: Controlling activity

Although these comments vary, they reflect the different situations of the various administrations. For new LRT systems the following process would probably be generally accepted:
- Review of proposals by the authority that went out to tender.
- Detailed specifications added to the legal contract documents.
- Checks during construction and commissioning by an inspector appointed by the authority that invited tenders.
- Final inspection by a body representing the ultimate standards or regulatory body.
- Periodic checks during operation by an independent organisation appointed for this purpose.

8.11 EXTENT TO WHICH OPERATORS' VIEWS ARE TAKEN INTO ACCOUNT WHEN STANDARDS ARE FORMULATED

International standards are compiled by representatives of the industry. This applies to Euronorms and the UITP Guidelines. It is also true of other standards and guidelines produced by trade associations, principally VDV.

In Germany the cities considered by the VDV to have mostly influenced moves towards standardisation of the vehicle market have been[8]:
- **Metros**: Munich, Nuremberg, Berlin and Hamburg.
- **Light Rail**: Cologne, Dusseldorf, Essen, Dortmund and Hannover.
- **Tramway**: Frankfurt, Karlsruhe, Stuttgart, Bremen, Magdeburg, Leipzig, Dresden and Rostock.
- **Track Sharing**: Karlsruhe

There has been much less influence by cities over BOStrab[9].

In the UK the Railway Safety Principles and Guidance, Guidance on Tramways was produced in draft and then circulated widely through the industry. Individual cities, Public Transport

Executives, operators, suppliers and consultants suggested changes and improvements. This was considered to have been an extremely worthwhile exercise.

Crossrail, a EU Fifth Framework Programme project, started on 1st January 2000 and will last 16 months. The project considers shared track issues at a European level, including cross border issues and their influence on vehicle design and equipment. The consortium consists of Scan rail Consult of Denmark, SYSTRA (France), NEI (Netherlands), Halcrow (UK), Transurb (Belgium), Trademco (Greece), DE-Consult and TTK (Germany). Adtranz, Siemens and Altom are represented on the project advisory board.

8.12 ECONOMIC IMPACT ON INDUSTRY AND URBAN RAIL OPERATORS OF EXISTING DIFFERENCES IN REQUIREMENTS

Section 7 considered the economic impact on industry of specific variations in requirements for safety, and also of variations in key dimensions.

In general where a variation is fundamental to the design of a vehicle this will mean that in order to meet that requirement a vehicle from the standard product range will not be acceptable. So unless there is agreement internationally on this issue, all vehicles would have to be built in small batches.

The typical ‘start up’ order for a new Light Rail system is 25 vehicles or less. This is also a typical number for replacing part of a fleet or of a larger system or the maximum number likely to be required for a system extension. Based on a vehicle life of 30 years the total European market for Light Rail vehicles and trams will be about 250 a year. So the ratio of design activity to production run size will clearly be top heavy. This is the root problem of the industry, especially in the Light Rail and tramway field.

On the other hand an order for 25 Light Rail vehicles represents a significant investment for a city or operator, of the order of 50 Million Euros. For existing systems the core issues will be:
- The costs of modifying the system if new vehicles are not compatible.
- The risks of diverging from established practice that could result in added costs.

These have to be balanced, in money terms, against:
- Cost savings from using a more ‘standard’ product.
- Improved features of the new vehicles.

One option that might be attractive would be to produce standardised, modular vehicles on which components can be changed or added later, possibly as a scheduled half life refurbishment or rebuild. This allows vehicles to be upgraded as requirements change or more investment becomes available. It could be attractive to countries such as those of Eastern Europe.

Time is also crucial in money terms. If the specification is too demanding the supplier suffers from the long period required for design, negotiation and testing, before he receives full payment. Conversely, if an operator is faced with a standard product there may be more design delays associated with adapting the system and approval processes.

Few operators use second hand vehicles Those that do are not apparently hindered significantly by lack of standardisation since there tend to be plenty of vehicles available of different types.

Standardisation might facilitate the leasing process, but the costs of leasing as against purchasing vehicles outright is not always attractive and depends on circumstances and the way individual systems are funded. However leasing costs are influenced by the fact that there is no significant residual value in non-interchangeable vehicles. Lessors must recover their costs quickly in these circumstances.

This question can also be considered by examining the experience of previous standardisation attempts in Europe, we have looked in some detail at the case of the French standard tram.

In 1975, in response to the fuel crisis and the rapid growth of car traffic, the then French Minister of Transport encouraged French transport authorities and manufacturers to develop national tramway standards jointly. The objective was to help promote the establishment of new systems initially in five cities, starting with Nantes and Grenoble. This initiative led to a jointly funded project to develop a French standard tram. The design was based on established technology, probably since the key criteria would have been acceptability, reliability and economy. It was a 6-axle twin articulated unit of welded aluminium construction.

The chosen width was 2300mm, relatively narrow, but taking account of the need to ‘fit’ into specific cities. This increased acceptability but at a cost, a loss of capacity and hence economy.

The first application of the design was in Nantes in 1985. Although Nantes had examined possible ways of providing access for the mobility impaired they considered at that time that the development of a new design of low floor vehicle was incompatible with their policy of only using fully tested designs.

Initially the Grenoble authority SEMITAG proposed using the French Standard tram. However, by 1982, increased pressure to provide full level access for the disabled (including those in wheelchairs) necessitated a review. Initially SEMITAG looked at adapting the French Standard tram design by adding a low floor central body section (as adopted in Nantes later). But they settled on a fundamental review instead that resulted in what was in effect an entirely new design of vehicle. The new design improved accessibility and acceptability and also improved the external appearance. But there was a cost, the vehicle was now heavier and additional safety measures were required to protect the passengers in the low floor vehicle from side impacts.

About 60 of the second version of the standard tram have now been built for Grenoble, Paris and Rouen. However 10 years later, the design is ‘redundant’ again in the sense that it is overtaken by developments such as 100% low floor vehicles, wider higher capacity vehicles, new ideas on external appearance and modular concepts. While the commonality will have produced economies in production costs, clearly 60 vehicles is not a significant number to justify a standardised design that might incur economic and other penalties for the user.

9 Obstacles To a Single Market

9.1 OBSTACLES IDENTIFIED

The *major* obstacles are identified below:

9.1.1 Variations in tender documents

Very few cities issue 'local standards' as such. The major barrier to the single market appears to be variations in documents issued with invitations to tender. These will generally include some form of specification, which may be performance based. In this case suppliers have a problem in knowing if their products will meet the requirements or how they will be tested. At the other extreme some very detailed tender specifications are issued. Often these are inappropriate, in that the city might have simply copied earlier requirements and more up to date solutions would perform as well, or better. This usually arises because the firms or individuals that put them together do not have the appropriate experience to realise the implications of what they have assembled. Our surveys have shown that the split between detailed and performance based specifications is about equal.

The type of tender document and the amount of detail are usually related to the procurement process being used.

Language (see below) further compounds the difficulties associated with variations in tender documents, not only because of translation issues but because different languages inevitably inhibit communication and lead to different practices in the way documents are put together in each country.

9.1.2 Language

Language is a significant barrier. Both tender documentation and the specifications that these refer to have to be understood by suppliers. It is insufficient to simply have them translated; many technical terms do not translate exactly. Suppliers need to take great care so as not to make significant mistakes due to this cause.

There is also the need to respond in a specific language, which to some extent will disadvantage suppliers in countries where that language is not in common use.

9.1.3 Infrastructure

Even with the best intentions, cities cannot easily change the key parameters of systems, for example:

- track gauge
- formation and road lane widths and clearances
- gradients and curvature
- structure and tunnel dimensions
- platform heights and lengths
- electrification supply

While the variations between these individual parameters are not great, the combinations that have been created necessitate a multiplicity of variations in overall system design (this can be appreciated by looking at the table that forms Appendix H).

These variations are not a significant barrier to standardisation provided one is talking about the 'new approach' adopted by the EC as distinct from a classic approach that required common parameters. However such variations clearly limit the possibilities for creating standard products and this will continue to be a problem for industry.

9.1.4 Risk

Operators and city authorities believe that if they continue to use what they have used in the past then they will minimise risk. Anything that is untried or new, or in an environment where it has not been used before, will inevitably cause problems. This will happen simply because staff are not familiar with the different technology and the public may also react adversely. What works in what city does not always work in another. Hence, although some risks might be reduced by having a 'tried and tested' standard product, other risk issues remain and might indeed be exacerbated.

9.1.5 Image

City authorities and some operators place high value on image, including employing the latest technology. By adopting standard solutions they are tending to deny themselves this objective.

The Strasbourg Light Rail project had as a major objective acting as a catalyst for changes to the city centre. In 1990, none of the manufacturers designs that were available met the requirements of the Strasbourg Transport Authorities (CTS). A working group consisting of CTS, engineering consultants Metram and Philippe Neerman and the design agency IDPO produced the concept design for a new vehicle (Eurotram). Many later LRT projects were 'visually' promoted using the Eurotram image.

Vehicles procured for Lille in 1991, and delivered in 1993/1994 represented an early attempt to provide passengers with maximum percentage of low floor. Anssaldo Breda offered a new design that gave 77-80% low floor utilisation for passengers. 25 vehicles were manufactured but despite very attractive image and interior seat arrangements, there have been no more orders or similar developments from other manufacturers.

In France, or in countries where French consultants assisting in developments of new light rail systems, one finds that 8-10% of the consultants works in specifying the new LRT systems is spent on architecture and industrial design.

9.1.6 Lack of expertise

A significant barrier is finding available expertise to undertake the tasks required to create a single market on this scale, and the funds necessary to support. Current standards work is sponsored by industry but is restricted by the availability of resources and other commercial considerations. Experts are often specialists and lack the vision to appreciate all the interactions between each element of a LRT system. The speed of technological development in this field is increasing, and much stronger professional interaction between industry, operators and the standards bodies is required.

9.1.7 Competitive tendering

Competitive tendering, where the supplier has to prepare detailed specifications, means that co-operation between supplier and operator to achieve best results is not always possible. Detailed specifications have commercial value. Operators and promoters are unwilling to share information. This is a barrier to single market development.

9.1.8 Changing roles for mass transit

Mass transit systems are beginning to take on new roles:

Urban rail systems are being extended into the regions by use of track sharing. Vehicles used on such systems must be able to interwork over national rail systems. They will have features that are unnecessary for systems that do not include track sharing.

Mass transit is attempting to better fill the gap that exists between conventional rail (including Light Rail and Tramway) and the bus, so as to provide high quality but more economic transport over wider areas. The solutions involve ‘intermediate systems’ that employ novel technology.

This diversity will in theory make achieving a single market more problematical.

9.2 ECONOMIC IMPACT OF OBSTACLES

9.2.1 Variations and language in tender documents

It is very difficult for suppliers to respond properly to detailed specifications, working from scratch every time. A supplier who has worked with the authority before may be in a favoured position; the specification may even be one that he has produced that describes his own vehicles! On the other hand, an experienced supplier may consider that he is handicapped by putting in a realistic price based on his understanding of the customer’s real needs and preferences, which may not always be covered in the specifications.

Simple things can cause major problems such as translation and inconsistencies in how tests are described. In general cities might accept a standard requirement for say passenger comfort but at the moment all are expressing it and measuring it differently.

9.2.2 Infrastructure

This is probably the most significant obstacle in economic terms. The costs of replacing infrastructure will nearly always significantly outweigh any benefits to the operator from standardisation of vehicles and related systems. This is more so in the case of underground lines. In most cases the overall costs mean that the concept is not feasible.

For new lines the constraint will not exist. However systems must work within three basic constraints:

1 The existing physical infrastructure of the city to be served.
2 Regulations concerning rail and mass transit systems (where there is scope for change)
3 Other regulations, for example highway restrictions, that are more difficult to change.

In general a system can usually be built in any given city given a *flexible* set of standards to work to. Where conditions prevent this, for example hills are extremely steep or streets exceptionally narrow, then in the single market case, such systems would no longer be feasible. This might have some economic impact in that it would restrict the number of systems that are created, and also add to initial cost.

Other regulations might be changed if there was a good reason, e.g. incompatibility with regulations and standards accepted Europe wide for mass transit.

9.2.3 Risk

This makes obtaining funding more difficult and hence raises the costs of borrowing money or means that schemes do not happen. Where risks turn into reality the disruption and unreliability is both a social and economic cost.

9.2.4 Image

This has little direct economic impact except that in most of Europe it seems that mass transit systems have to be attractive in order to be effective in terms of modal shift. How much this depends on the overall attractiveness of the mode, as against the shape of the cab and the colour of the seats has to be tested, but we suspect it is not a serious factor.

9.2.5 Costs imposed by these obstacles

In terms of language and variation in tender documents the costs can be estimated. A supplier will easily spend 1 Million Euros bidding for an order for 25 vehicles for a new system. Say three firms compete to this level, then the total expenditure will be 3 Million Euros. The saving from standardised tender documents could be 25%, i.e. 750,000 Euros. The annual market might be ten times this figure, so the costs of this obstacle are of the order of 7.5 Million Euros per year. Similar savings might be achieved by overcoming other obstacles that result from competitive tendering, such as not sharing information (9.1.7)

If there were no problems due to infrastructure, risk or image then standard designs of vehicle could be used throughout Europe. The costs saving would be about 10%. The annual market is for about 250 vehicles at 2 Million Euros each (8.12), so these three barriers are collectively costing around 50 Million Euros per year.

In 9.1.8 we identified the changing role of mass transit as an obstacle. This could be seen as a fourth problem to add to the list of infrastructure, risk and image that are barriers to a standard design. However these changes are also associated with market growth, so would have a neutral effect provided specialised technologies, such as shared track and guided bus systems, were excluded from this process. At the present time these systems are relatively novel so there is more scope for applying harmonisation and achieving early benefits provided that they are recognised as separate categories of transport system. There is little if any cost at present but there could be savings in future depending on how these markets develop.

9.3 SIGNIFICANCE OF OBSTACLES

The major issue is that existing systems offer far less scope for the Single Market process than new ones. But this difference is diluted by the fact that the standardisation process that would be applied would follow the ‘new approach’ and therefore common dimensions would not be an essential overall requirement.

The lack of expertise available to develop new European standards is a real problem. Industry needs help to overcome this very serious issue if a single market is to be achieved.

A change of climate is needed:

- Where operators and suppliers co-operate
- Where the value of the single market is appreciated

10 Achieving a Single Market

A single market would be of most benefit to suppliers who experience difficulty in selling across borders due to variations in requirements. The variations in requirements exist at national and local level. European standards exist but are only enforced if adopted at national level.

National requirements vary considerably in level of detail between European countries. This partly reflects the extent to which LRT systems are being developed in each country. So for example, Germany, which has the most developed set of standards, is the country with the largest number of LRT systems (even though most are well established rather than new). In general, national standards are not too prescriptive. They often simply set principles or performance criteria. Individual regulations that override LRT specific requirements can be a problem, for example regulations that define, in detail, the facilities required on public transport vehicles to make them accessible to people with various disabilities. In due course national LRT standards could be replaced by European standards with common acceptance procedures. This process can already be seen happening in many countries, including some not yet within the EU, namely the Czech Republic, Poland and Estonia.

During the period that this study has taken place the issue of standardisation of Light Rail vehicles has been discussed within the UK at Government level. The Environment, Transport and Regional Affairs Committee published a report on 'Light Rapid Transit Systems' on 8th June 2000[10], after extensive consultation.

Paragraph 64 recommended that:
'The cost of light rail schemes could be reduced by adopting common designs for vehicles and other equipment. We recommend that the Government bring together local authorities and other promoters of LRT projects to ensure that where possible vehicles and other equipment are standardised in order to realise economies of scale.'

The Government's reply was published on 26th July 2000[11]. It stated:

'Local authorities and other promoters of light rail schemes already liaise with each other in developing their plans. They are best placed to discuss with suppliers the scope for using standardised vehicles and other equipment, with any consequent cost savings. Since the market is a European one, it would not be effective to seek to bring together only the UK purchasers of equipment'

This response reflects the fact that LRT initiatives in the UK are all taken at local level, there is no 'central planning' or significant intervention. It does emphasise the need to consider standardisation at a European level. An early attempt at UK standardisation, made by the Passenger Transport Executives, failed, possibly partly for this reason.

The VDV recommendations in Germany provide a model of what might be possible throughout Europe. Compliance with VDV recommendations is, to some extent, a pre-requisite for obtaining funding in Germany.

10.1 STANDARDISED VEHICLES

There are two basic methods of achieving standardisation considered here:

1 A standard vehicle that will fit most systems. Previous examples of this approach include the American President's Conference Committee (PCC) vehicles and CKD Tatra vehicles, both of which were very successful in their time and for the role they were designed to perform. Another example was the German high floor 'Stadtbahn' vehicle, used by several systems there and also exported to the USA.

2 Vehicle designs in which it is possible to use different components through common interfaces and a harmonised approach.

Our thorough and representative enquiries have revealed, not unexpectedly, that there is currently wide diversity in regulations and requirements and that the goal of achieving a standard vehicle (option 1), that would be suitable for most systems, appears to be neither achievable or desirable. The concept would not necessarily be welcomed by manufacturers, who, with the growth of modular construction, make a virtue and selling point of their ability to supply vehicles in different versions.

Vehicles with completely standard dimensions might be acceptable to all but might not be very attractive; there would be no incentive to do better. An obvious example is that a vehicle narrow enough to run on the majority of LRT systems would have much less carrying capacity than the wider vehicles used by cities which have suitable infrastructure.

Option 1 would tend to ossify progress, option 2 would tend to encourage it.

We therefore recommend that the second option, which is the principle of the EC 'new approach' product directives, is the one that is pursued.

10.2 HARMONISATION

One option that might be attractive would be to produce standardised, modular vehicles on which components can be changed or added later. This allows vehicles to be upgraded as requirements change or more investment becomes available. It could be attractive to countries such as those of Eastern Europe.

Standardisation will cover all aspects of vehicles. The principal concern of the EC is those standards that relate to safety. In general we feel that there is scope for overcoming problems in this area because expectations of safety should not vary through Europe in the longer term and common standards and test procedures should be acceptable in this context. We see no reason why basic safety principles for LRT could not be standardised and this is one area where an EC Directive might be worthwhile. This would allow economies of scale in areas such as seats, doors, trim features and braking system components to be achieved quickly. Once in place, technological change could be taken on board much more quickly throughout Europe as a whole.

The main problem for standardisation of safety measures may be defining the context properly; safety measures for a high-speed light metro in Germany may be excessive for a slow street tramway in the Czech Republic. It will be worthwhile breaking safety measures down according to the conditions in which systems operate so as not to over-burden certain systems with unnecessary costs.

There is a 'short cut' to achieving some measure of quick standardisation. Electrical standards are already relatively harmonised for conventional rail and some of this could be transferred to rail mass transit. Success in the rail industry in this area derives from the fact that the electrical industry in general serves a much wider market where harmonisation is very important indeed. Since the total cost of electrical equipment on a tram represents about 40% of the total cost, and about 50% for a metro car, this could be very valuable.

Certain areas do present problems, in particular variations in braking standards, emergency escape and disabled access requirements. LRT systems that have street operation are also subject to highway requirements, the way that road safety is dealt with in different countries varies considerably and results from the way people behave. This is something that cannot be changed very easily.

Infrastructure standards will impact on the system as a whole, including vehicles. Variations between countries in highway standards etc. are therefore an issue that needs to be dealt with at a higher level.

Vehicles often need to meet Railway requirements as well. The requirements for Mass transit vehicles cannot be considered in isolation. Future vehicle designs may need to take more account of the requirements for shared track operation (LRT operation in mixed traffic with conventional trains) because of the growing interest in these applications. However railways are more divergent than on highways; while most road vehicle can travel into any European country, the same is not true of a rail vehicle. Barriers on the rail system include incompatible signalling sytems, electrification, EMC, structural dimensions and even track gauge. While EC or national initiatives seek to address may of these, significant differences will remain for the foreseeable future.

10.3 CONTRIBUTION THAT NATIONAL STANDARDS MAKE TO THE SINGLE MARKET

The national standards that already exist can make a significant contribution to the single market. Although there are variations and they place different emphasis on specific issues, they do represent a considerable body of practical experience and should be the basis for new international requirements. Our investigations suggested that the underlying principles, especially in the area of safety, are nearly always the same, even though expressed and interpreted differently.

Even standards that are being replaced, such as those of the Czech Republic, should not be ignored, since they represent a considerable body of detailed technical expertise in an environment that is more typical of certain regions of Europe.

No one national standard should be applied universally without careful consideration. There are regional differences, and sometimes even more local issues to be considered.

It also has to be remembered that the more complex and widely applied requirements, such as those of BOStrab and the VDV work in the context of the legislative structure and social context of particular countries.

On balance however we have no doubt that international standards cannot sensibly ignore what has gone before.

10.4 INTERNAL MARKET DIRECTIVE

In due course an EC Directive would be appropriate to endorse certain of the key measures proposed in this report (see recommendations in section 12).

The extent to which the Directive would get into detail depends very much on how this process develops and the support that it gets from industry.

At a late stage in this study we were alerted to the existence of a European Directive that relates to cableways, i.e. transport systems used principally in mountain areas to convey tourists by means of cars suspended from cables[12]. In studying this we found that it matched the proposals made in this report, in that it provides a framework to overcome problems that would inhibit a single market and emphasises the need to define essential safety and other requirements on a Community-wide basis rather than proceed immediately with standardisation. It could be considered as a ‘model’, in principle, for the process that we have recommended independently.

EC directives may be necessary to achieve interoperability between national rail networks but this type of issue is generally irrelevant to LRT. However the Cross Rail study (referred to earlier) has identified eight European cities with interests in cross-border LRT links.

10.5 OTHER MEASURES RECOMMENDED

There are significant and acceptable short-term measures that can be taken to achieve harmonisation of vehicle safety requirements, making it less difficult and costly for manufacturers to comply with special requirements on a small order:

1 Harmonisation of basic safety performance requirements
2 Harmonisation of the specification process
3 Harmonisation of the approval process.

The existing processes for establishing and introducing Euronorms can form the basis of this initiative.

The harmonisation of the specification process might involve:

1 Use of common terms that are internationally accepted and readily translatable.
2 Use of a limited number of languages.
3 Common document structure with paragraphs numbered, so that if a particular topic is irrelevant that section is missed and there is no entry against the number. This is seen on a small scale in the format of notices in the Official Journal.
4 Uniform references to European Standards.
5 Uniform references to European wide testing procedures and approval processes.

This activity would require considerable resources but this needs to be considered in the context of the benefits to be achieved. It should be a joint activity of industry and operators/city authorities. The first step should be discussions by MARIE, perhaps with the EU providing high level co-ordination and back up in terms of encouraging any necessary legislation.

There is also a considerable role for guidelines. New European-wide guidelines for Light Rail and Tramway systems are required. These should also cover other light transit technology with growth potential, for example guided bus, guided light transit, ultra light rail, automated light rail, but perhaps less comprehensively at first. They should be based on the experience of existing recommendations, standards and guidelines producing bodies. In particular they should embrace VDV and perhaps HMRI, AFNOR, UNIFER and Czech concepts and proposals. This work might be co-ordinated as a part of the activities of the UITP Light Rail Committee and its members.

There is also a fundamental need to convince industry that the single market concept is important.

11 Conclusions

1. The main area of interest is Light Metro, Light Rail and Tramway systems (‘LRT’). Relatively few entirely new Heavy Metro systems are likely to be built in Europe in the near future. The cost of modifying existing underground systems to accept standard vehicles is likely to outweigh any cost advantages that standardised vehicles might have. On the other hand, entirely new LRT systems are being built so both the scope for standardisation and the risk of diversification exists.

2. There is little attraction to promoters and operators of new LRT systems to use standardised vehicle designs. The cost savings are relatively low and at the same time this will inevitably involve a compromise on what they would really like or added costs in other areas.

3. The largest market is for vehicles for existing and extended systems, rather than for entirely new systems. Most customers will therefore be less inclined to accept standardised vehicles, because of issue of incompatibility and the potential need for changes to the existing infrastructure.

4. Individual cities like to display their own image and express this by making their rapid transit systems unique. This could be considered to be an obstacle to the Single Market. Suppliers have found some ways around this, for example the Incentro can be supplied with different styled cab ends to provide individuality. It has to be accepted that LRT is successful because of image issues, so this aspect cannot be ignored. However there is also an issue of education, so that local politicians may be unaware of the economic consequences of such actions.

5. To assist in overcoming these problems, we are suggesting the production of standardised format and terminology vehicle specifications. For example sections would be numbered in a consistent sequence, so that even if the document was in an unfamiliar language the relevant section can easily be found. Each section might have options that the promoter/operator might select from, but the terminology, testing processes etc. would be standard. These might be co-ordinated as a part of the activities of the UITP Light Rail Committee and its members.

6. A trial of this process would be needed. This could begin with one or two systems using it and the standardised approach would be developed based on this experience. If successful, use could be made compulsory through an EC directive. MARIE has already considered the concept of a trail of new processes.

7. Improved guidelines would be of value, in association with this process. The work of the UITP could assist this. Guidelines are of more value than International Standards in terms of working towards a Single Market because agreement is not required before introducing them and they can be developed and modified more quickly.

8. Coupled with this, the possibility also exists of producing standardised tender documents so as to create common procedures for procurement processes. The VDV have already done some work towards this objective.

9. The ‘new approach’ to standardisation, adopted by the EC, offers a greater overall benefit than having vehicles of totally standard dimensions. Although totally standard dimensions would be of benefit in a production sense they would probably be a disaster in commercial terms.

10. Testing and acceptance procedures are perhaps more important than specified ‘pass criteria’, since variations in these cause greater problems for the designer, and hence cost for the supplier and operator.

11. The Single Market needs to consider a wider area than just Europe. For example, the LRT market is very strong in North America. Concentration on European conditions could result in suppliers losing business in overseas markets. The overseas market in developing countries may be biased towards full metro systems, with their capability to handle large numbers of people, and this issue needs to be recognised in the harmonisation process recommended here.

12 Recommendations

Our recommendations are based on acceptance of the principle that a Single Market for Mass Transit vehicles would be worth developing. As required in the remit, we have defined them as short, medium and long term actions.

- Short term work is actions that might start virtually immediately and begin within two years.
- Medium term work might commence in the period 2003-2010.
- Long term work might begin beyond 2010 and depend on success in the earlier stages.

We do not claim that these recommendations are exhaustive, they are based on the remit and the information and opinions we have gained from working on the study. Other measures may be needed. However we do believe that they are representative of the total scope and type of actions that are required to achieve the Single Market objective.

12.1 SHORT TERM

- Investigate how to establish in more detail the processes recommended here in more detail, in particular discussions with European Standards bodies, UITP etc.
- Establish a process for producing guidelines that cover best practice in Mass Transit and for making these widely available and accepted.
- Establish a process for informing city authorities, government bodies and scheme promoters of the advantages of harmonisation and the move towards a Single Market.
- Produce harmonised vehicle specification documents (section 11, conclusion 5).
- Produce standardised tender documents (conclusion 8).
- Encourage use (partly by the above processes) of existing or currently planned Euronorms in specifications covering the following topics: Fire safety, crashworthiness, traction and control, emergency braking requirements, vehicle loading parameters, noise, Electro Magnetic Compatibility, internal lighting and air conditioning. Modify work on existing planned standards, if necessary, to take account of this issue.
- Address the problem of lack of expertise to work on international standards and related issues, by investigating the issue and methods of overcoming it.
- Devise a process where work towards the Single Market takes account of other work in related areas, e.g. Cross Rail.
- Investigate the extent to which the requirements of the European Single Market match those of potential export markets, e.g. North America, Far East, Australasia and rapidly developing overseas countries with large urban populations.

12.2 MEDIUM TERM

- Carry out a trial using the harmonised specification and standardised tender documents with a small number of systems and assess the results. Modify the process accordingly.

- Publish the Guidelines and generally promulgate the benefits of the Single Market approach (this activity would be carried out by the bodies involved in producing them).

- Develop new Euronorms to cover derailment and other suspension related issues, doorway dimensions, train protection systems, cab equipment, gauging, disabled persons provision, environmental impact, information presentation and heating and ventilation. These Euronorms should cover mass transit generally and include street tramway operation.

- Investigate and encourage harmonisation of the emergency equipment carried and of the interfaces required for information systems.

- Reconsider the value of Internal Market Directives in the light of experience.

12.3 LONG TERM

- Encourage full use of the harmonised specifications, the standardised tender documents and the processes and guidelines developed earlier and if necessary or appropriate issue Directives and/or encourage national legislation in order to enforce this.

- Introduce new standards (Euronorms) for key vehicle dimensions for new systems (e.g. vehicle width, length and height). Where appropriate, seek modifications to any other legislation or requirements that inhibit this.

- Resolve the issue of retractable couplers.

In section 9.2.5 we considered the costs imposed by obstacles to a Single Market. It is difficult to predict what financial benefits might result from the process recommended above but after 10 years annual savings equivalent to the 7.5 Million Euro cost of language and other variations in tender documents should be realised by the supply industry. This figure should be substantially higher if one takes into account the added benefits to suppliers of components and sub-systems.

The cost due to other obstacles, roughly estimated at 50 Million Euros per year, would only begin to be reduced after 10 years and would depend on many factors, including growth of market size. It is perhaps reasonable to expect benefits worth around 10 Million Euros annually from this process after 10-20 years, assuming a continuing steady growth in new systems.

13 Glossary

The terms used on this report are explained below. The report is written in English and the terms have the meanings that generally apply in Europe in countries where English is used.

Automated Light Rapid Transit
Driverless Light Rail systems using automated centralised control.

Electronic Guided Bus
Guided bus system where the guidance is provided by a cable buried in the road that is detected by the vehicle and its position used to control steering.

Guided Bus
A passenger transport system using buses that are guided for all or part of the route, or the buses that operate on such a system.

Guided Light Transit
A passenger transport system using vehicles that run on rubber tyres on a roadway and that are guided by means of a device that locates in a slot in the roadway.

Harmonisation
I.e. Legislative harmonisation - European Community legislation that lays down essential requirements for safety, health etc. that occurs exceptionally in those areas where the objectives of national legislation are not equivalent. It is up to producers to choose by what means they wish to comply with these requirements.

Heavy Rail
Conventional railways that operate as national networks and are capable of accommodating large passenger and freight trains.

Kerb Guided Bus
A guided bus system where the guidance is provided mechanically by means of rollers that sense the position of kerbs on either sides of the bus.

Light Metro
Rail Mass Transit system that does not form part of the national or long distance rail network and that uses Light Rail Vehicles.

Light Rail
An urban passenger transport system that has tramway sections and accommodates smaller trains than metros.

Light Rail Vehicle
A passenger rail vehicle specifically designed to operate on a Light Rail system.

Light Rapid Transit
An alternative name for Light Rail.

Mass Transit

Public transport systems that regularly carry large numbers of people, typically in urban and suburban areas.

Metro
Rail Mass Transit system that does not form part of the national or long distance rail network and that uses heavy rail trains.

Railway
Guided transport system using parallel rails, which provide support and guidance for vehicles carried on flanged wheels.

Specification
Formal description of a component, assembly or process that facilitates its replication and provides a record of what has or will be done.

Standardisation:
The application of standards, i.e. technical specifications approved by a recognised standardising body for repeated or continuous application, with which compliance is not compulsory.

Tram
A passenger rail vehicle specifically designed to operate on a tramway.

Tramway
A railway used wholly or mainly for the carriage of passengers which has been designed to have a significant element that operates on line of sight on a highway.

VAL
French automated rapid transit system using rubber tyred vehicles.

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