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Project Coordinator: **CTL – Centro di Ricerca per il Trasporto e la Logistica – Roma (Italy)**

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Summary: A synopsis of transferability audits in similar fields and experienced problems in Technology Transfer from Europe to Emerging Economies, in particular with respect to Road Safety of Vulnerable Road Users

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Table of Contents

1. Introduction .......................................................... 6
2. Considerations about transferability ................................ 6
   2.1. The meaning of transferability ................................... 6
   2.2. The philosophy behind the transferability studies: the “road safety space” qualitative concept for transfer .................. 7
3. Enlarging the Concept of Transferability: From Measures to Policies .... 9
   3.1. The TRANSPLUS approach ...................................... 10
   3.2. The LEDA approach .............................................. 13
   3.3. The CIVITAS approach .......................................... 16
4. Customizing the TS to SaferBrain ..................................... 23
5. Human Factors Issues in Road Safety .................................. 26
   5.1. Introduction ........................................................ 26
   5.2. User State ......................................................... 27
   5.3. Experience and Levels of Knowledge .......................... 29
   5.4. Behaviour .......................................................... 30
   5.5. Road User Behaviour in Real-World Situations .................. 31
   5.6. Conclusions ...................................................... 33
6. Collecting the knowledge for the Transferability Study process ......... 33
   6.1. Matching the TS to the real user needs .......................... 33
   6.2. The definition of the objectives for the TS ...................... 36
7. Developing a Model for Evaluating the Role of Human Factors in Determining the Efficient Transferability of VRU Safety Measures .... 37
   7.1. Human Functional Failure (HFF) Methodology ................ 38
   7.2. Adapting the HFF Methodology to Use as a Model for Evaluating VRU Behaviour ...................................................... 42
8. Sample of common European Road Safety Measures which have not been extensively transferred, yet .................................. 43
   8.1. What has already been transferred? .............................. 43
9. Summary and Conclusions ................................................. 53
10. References ..................................................................... 54
11. Appendix A: Road Safety Measures for Vulnerable Road User Safety .... 58
   11.1. Pedestrian focused measures .................................... 58
   11.2. Pedal Cycle Focused Measures ................................. 66
   11.3. Motor Vehicle Focused Measures Which Benefit VRU Safety .... 69
Index of Tables

Table 1: Horizontal transferability matrix
Table 2: The Objectives/Problems Matrix
Table 3: Typical variables for the characterization
Table 4: Classification of the target cities according to the variables of the origin city
Table 5: The Contexts/Variables Matrix
Table 6: The Complementarities Matrix
Table 7: Main safety concepts less used in the target contexts
Index of Figures

Figure 1: The Road Safety Space
Figure 2: The Road Safety Space in the motorcycle helmet case
Figure 3: Horizontal transferability
Figure 4: Horizontal transferability – different levels
Figure 5: Vertical transferability – different levels
Figure 6: Combination of Measures and Target/Origin Cities in the LEDA TS
Figure 7: Characteristics of the Origin Cities in the LEDA TS
Figure 8: Variance values for the Origin Cities in the LEDA TS
Figure 9: Scores and variance values for a given Target City in the LEDA TS
Figure 10: Comparison per characteristics between Origin/Target Cities in the LEDA TS
Figure 11: Final comparison per measures
Figure 12: The CIVITAS algorithm for transferability
Figure 13: The Complementarities Matrix: an example
Figure 14: The Measures/Packages Matrix
Figure 15: Prioritizing HLOs
Figure 16: The TS process
Figure 17: Adaptation of the TS in respect to the human and behavioural factors
Figure 18: Phases leading to an accident
Figure 19: Functional chain involved in driving activity
## List of Terms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>Transferability Study</td>
</tr>
<tr>
<td>HLO</td>
<td>High Level Objective</td>
</tr>
<tr>
<td>VRU</td>
<td>Vulnerable Road User</td>
</tr>
<tr>
<td>HFF</td>
<td>Human Functional Failure</td>
</tr>
<tr>
<td>OTS</td>
<td>UK On The Spot accident study</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
</tbody>
</table>
1. Introduction

Road infrastructure design and professional land use planning came into existence before 6,600 years (Lamm et al, 1999). Since that time human mobility increased consistently in terms of annual average distance travelled as well as in importance for managing daily life.

However, increased mobility involves also increased exposure to those risks associated with mobility like road accidents and pollution due to traffic. Every year, almost 1.2 million people are killed in road accidents around the globe (WHO, 2004). Accidents are particular prevalent in low and middle income countries (e.g. Emerging Economies and Developing Countries) where 85 percent of the world's road fatalities occur (World Bank, 2009a).

At such rapid national economy growths, as it can be observed in Emerging Economies like India and Brazil, the number of motor-vehicles as well as fatalities and injuries from traffic accidents are likely to increase too, since motorized traffic competes with slower moving non-motorized and more vulnerable traffic for road space, especially if measures are not taken to mitigate the problem.

Most of the victims of road accidents are not even in a motor vehicle. Pedestrians, cyclists and motorcycle riders are the most vulnerable road users and account for the majority of traffic fatalities in Emerging Economies. In Delhi, India, pedestrians and bicyclists account for around 61 percent, and pedestrians, bicyclists and motor cyclists account for over 87 percent of the total traffic fatalities (Mohan, 2009).

The human and economic damage caused by traffic accidents is largely preventable. Flaws in applying safety measures, coupled with inappropriate road user behaviour, can be overcome with concerned effort.

In particular, crucial are behavioural habits of road users in Emerging Economies having a different social / cultural background and safety awareness experience that can be commonly expected from Advanced Economies in Europe, North America or Japan. So it makes it difficult simply to transfer already tested safety measures from Europe or other advanced regions to those Emerging Economy regions or countries.

Therefore, WP2 will identify the performance efficiency of practices and methodologies intended to be applied in Emerging Economies compared to their application in Advanced, e.g. European, countries taking into account available experience with those measures e.g. in Europe. The main outcome of WP2 will be the development of a generalized transferability audit allowing to check the applicability and acceptability of available Road Safety Measures, Guidelines and Tools from European countries to Emerging Economies.

The Deliverable D2.1 explains the Transferability Concept and how Human Factors issues influencing Transferability and road safety in general. It includes the developing of a model for evaluating the role of Human Factors in determining the efficient Transferability of VRU Safety Measures as well as an Appendix for Road Safety Measures for Vulnerable Road User Safety.

2. Considerations about transferability

2.1. The meaning of transferability

Generally speaking, “transferability” means the quality of being transferable or exchangeable, which, for road safety problems, becomes the possibility to implement in a given context measures successfully adopted elsewhere. The basic assumption behind is “what proved to be effective in a place may confirm to be useful again, in another place” but the translation of the concept into practice is more challenging and in some cases even tricky.

Indeed, “transferability” is often mistaken for the selection of measures which could be fit a given situation, whereas it is a process in which the feasibility of implanting measures from an origin city to a receptor city is assessed; in other words, the former is just a kind of
recommendation of transferable best or good practice, the latter deals with both the selection of measures to transfer and an evaluation of the efforts and resources required for the measures to succeed (including also an analysis of the barriers to overcome). Consequently, "performing a transferability exercise requires not only some discipline in following a suitable methodology but, ultimately, also a wise judgement on its overall fitness" (Macario and Marques, 2004:6).

The WHO (2004:12) statement "in high-income settings, new strategies and programmes for traffic injury prevention generally require considerable analysis and planning before implementation. In developing countries, though, because of the scarcity of resources, the priority should be the import and adaptation of proven and promising methods from developed nations, and a pooling of information as to their effectiveness in the imported settings among other low-income countries" sheds a light on another important facet of the transferability issue, i.e. the proper knowledge of both origin and receptor contexts, which are of the utmost importance for the definition of the above mentioned barriers (and drivers, too). Factors influencing origin and/or receptor contexts belong to three different domains:

- the institutional domain (i.e. the totality of legal, regulatory and standardization tools which authorize the enforcement of a given measure and which may markedly differ from one Country to another);
- the funding availability (i.e. the amount of money, personnel and technical know-how required to implement a given measure);
- the society (i.e. the cultural status which makes a community aware of the need to adopt a given measure and willing to accept it);

Each factor can affect the others, can have both a local (case study, pilot study, urban area) and a general (state, nation) influence, may involve more study areas than the usually involved ones (i.e. safety and mobility): from psychology to anthropology, from public health to security, etc.

Moreover, for the evaluators’ sake, such factors are, whenever possible, translated into indicators, which makes very difficult to frame such three factors within a univocal and comprehensive approach, especially if the focus is to perform the transferability assessment relying solely on quantitative indicators.

It is also worth noticing that the three above-mentioned domains are also essential arenas for the endorsement and implementation of further road safety policies, according to the transferability audit or better Transferability Study – TS directions and usual goals.

It is clear, then, that there is no “original recipe” to start a TS, due to the great amount of variables to deal with. So far, many experiences have provided a wide palette of concepts for the transferability process, depending on different goals, contexts of application, measures / policies to transfer, actors involved, etc.

2.2. The philosophy behind the transferability studies: the “road safety space” qualitative concept for transfer

It is clear that the deeper the three main factors are analyzed, the easier will be the identification of drivers and barriers to support the transfer feasibility; at the same time the impossibility to deal with the three factors according to a univocal, quantitative point of view prompted King (2005) to address the problem by the elaboration of an innovative concept: the “road safety space”, i.e. a kind of “environment” where, theoretically, a TS can take place and where all the mutual influences among the three above mentioned domains occur (Figure 1). Indeed “Each road safety issue in a given country exists in a space defined by the economic, institutional, social and cultural factors which influence it. The factors include both broad and specific influences. The road safety space varies from one road safety issue to
another, and from country to country, although some factors may be shared across road safety issues or across countries” (King, 2005:97).

A typical example of this could be the introduction of traffic calming devices to improve safety at intersections: improving conflict areas by traffic calming solutions will entail a “road safety space” where economic, regulatory and cultural issues which affect the final outcome effectiveness can be considered.

Such a concept originates from a metaphor of the biological adaptation, according to which a “road space” is an ecosystem. In other words, “The transfer of a road safety measure to the country in the hope of making an impact on the road safety problem is analogous to introducing an outside species in the hope of changing some of the features of the ecosystem” (King, 2005: 98).

The lesson learned from this creative concept is important since the metaphor of the ecosystem describes properly the multidisciplinary vision, i.e. the importance of approaching a given road safety issue under the three domains (institutions, economy and society), along with the actions needed to elaborate a TS: a) the comprehension of the road safety space itself, i.e. how such an ecosystem can operate before and after the introduction of a given measure/ policy, in terms of current status and consequences on the three domains and b) an assessment of how such an introduction process can be operated. The success of a TS and the reliability of its outcome depend on these aspects.

The logical process is therefore based on the following steps:

- Use the “road safety space” concept to identify the factors belonging to the three domains which can affect the safety issue in hand
- Select which are the effective measures likely to be transferred among those available from the origin context
- Use the “road safety space” concept to identify the factors which made the transferable measures successful in the origin context
- Assess whether, according to the target context, the measures to be transferred are likely to be successful as they were in the origin case study or need to be adjusted to the new local situation; the option that they may be of no use (with or without amendments) may be contemplated.
In Figure 2, an example of such process concerning the introduction of the motorcycle helmets safety measure in Thailand is shown.

**Figure 2: The Road Safety Space in the motorcycle helmet case (King, 2005: 240)**

### 3. Enlarging the Concept of Transferability: From Measures to Policies

The road safety space concept is focused on the transferability of single measures or of package of measures and may be appropriate to contexts where road safety is already a consolidated practice (even though with “flaws”) and just one or more actions are needed to improve the safety level. In this case the road safety space, due to its multidisciplinary approach, is a suitable tool to assess the effectiveness of measures and above all the feasibility of their implementation.

However, in some contexts with very low local safety levels, such concept may turn to be unsuitable since single measures / interventions would be too a poor response to meet the safety requirements and a more “bulky” approach may be required, such as the introduction of comprehensive safety policies.

Thinking in terms of policies or “safety concepts”, rather than single measures, actually is a key element to promote effective safety measures, which moves the focus from the transferability of single measures to the transferability of a course of actions, guiding criteria, or procedures to create “road-safe” environments.

Examples of transferability of road safety policies do not abound, and in many cases they deal with simple recommendations of best practice to transfer, whereas the literature on transferability of transportation policies is rather rich and consolidated results from TSs are available, although they mostly concern transfer of policies from/to contexts in developed countries. Theoretical principles and standard procedures can be borrowed from such an expertise area and adjusted...
to the issue in hand, with special attention to methods to identify general perspectives and goals which usually support the transferability process of transportation policies.

Among the TSs on transportation policies, some relevant EC-funded research projects are worth to be analyzed:

- TRANSPLUS - transport planning, land use and sustainability.
- LEDA - legal and regulatory measures for sustainable transport in cities.
- CIVITAS Initiative (METEOR, MIRACLES).

They can serve as cases in point to single out general criteria, recurring structures and implemented models useful for the transferability of comprehensive policies to improve road safety.

Furthermore, as better described in the next sections, such examples are coherent with the road space concept, since they take in due consideration the legal and regulatory aspects, the available economic resources and the social issues as factors influencing the transferability process on its whole.

3.1. The TRANSPLUS approach

The core of the EC research project TRANSPLUS was to assess how transportation and land use issues must be integrated to create exportable best practice. Main findings on transferability can be synthesized according to the following key-concepts:

1) **Compatibility** – It is important to assess not only whether the policy tool itself is exportable to the target city, in terms of technical contents, goals, timeframe, etc. but also how it may be compatible to the target context; hence the need to look for comparable cities in terms of “relationships between institutions and territories”.

2) **Scope** – Such relationships call for a univocal identification of the level of transferability, which can be considered in terms of:

   a) **Horizontal transferability**, i.e.: the translation of a tool at the same scale of generation and application across territorial boundaries (Figure 3).

![Figure 3: Horizontal transferability (Macario and Marques, 2004:10)](image-url)
The three types of horizontal transferability from Figure 3 may form a sequence: first, measures / policies can be transferred at local level (type 1), then among cities (type 2) and eventually across countries; on the contrary, for what concerns the scope of the project in hand, the process may be differently directed: first the import of safety policies from abroad to India and Brazil, then the application at a local scale and, if appropriate, a subsequent domestic “enlargement”. Within such a general frame possible combinations are those described in Figure 4 and Table 1, where:

- Translation T12 could be from one city to another in the same metropolitan area or from one sub-national context to another in the same country.
- Translation T13 could be from city to another in the same region.
- Translation T14 could be from one city to another in the same sub-national context.

![Figure 4: Horizontal transferability – different levels: I – Intervention/measure/policy; T – Translations; A – Area (Macario and Marques, 2004:11)](image_url)

In any case, horizontal translation of a policy means that a policy can be transferred from one institution / territory to another, without changing the scale of application.

**Table 1: Horizontal transferability matrix (Macario and Marques, 2004:12)**

<table>
<thead>
<tr>
<th>Scale of territorial transfer (translation)</th>
<th>SCALE OF POLICY APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Locally applied policy e.g. Weerter; traffic calming</td>
</tr>
<tr>
<td>TYPE 1 Transferability within a city</td>
<td>T11 – the transfer of a local policy within a city</td>
</tr>
<tr>
<td>TYPE 2 Transferability between cities (in the same country)</td>
<td>T12 – the transfer of a local policy between cities</td>
</tr>
<tr>
<td>TYPE 3 Transferability between Countries</td>
<td>T18 – the transfer of a local policy between countries</td>
</tr>
</tbody>
</table>
b) **Vertical transferability**, on the contrary, is the case when a given policy may be *scaled up or down*, according to different degrees. Therefore zooming out (or in) may be synthesized as in Figure 5, where

- Transfer Z12 could be from one city to one metropolitan area or sub-national to national level.
- Transfer Z13 could be from one city to one regional level or regional to national level, etc.
- Transfer Z14 could be from one city to sub-national level.

![Figure 5: Vertical transferability – different levels: I – Intervention/measure/policy; Z – Zoom; A – Area (Macario and Marques, 2004: 13)](image)

The vertical transferability in the SaferBrain project can be seen as a kind of premium achievement; indeed up scaling would entail that the safety policies / measures implemented in the demonstration cases have been successful and hence the lessons learned are worth to be exported at a larger scale.

3) **The 3-steps approach** – The transfer process can be applied according to three phases:
   1) The identification of the best practice in the origin city (Demonstration Phase); 2) The analyses of drivers and barriers for transferring the best practice to the target city (Test Phase); 3) The implementation of the best practice contents in the target city, which concludes the TS. (*Implementation Phase*).

**Multidisciplinary support** – Gleaning information can rely on very different sources and mechanisms, from official statistics, site visits, desk research, even to data provided by NGOs or collected by phone interviews, etc.

4) Even though not contemplated during the TRANSPLUS project, the role of the Web and social networks in general can be central in the dissemination of ideas and results.

5) **Osmosis** - Such an open procedure gives way to “a general osmosis effect where cities learn from each other and ideas filter through either from cities in the same country or from a city in another country” (Macario and Marques, 2004:14).

### 3.1.1 The lesson learned from TRANSPLUS

The TS according to the TRANSPLUS directions may present some pros and cons. Among the former, the identification of the Transferability Scope (i.e. vertical and horizontal transferability concepts) is the most important one since it stresses the possibility to "stretch" and "move" the transferability focus in a very broad way. The assessment of the possibilities due to the so-called osmosis effect can be of some importance, since any positive outcomes...
the pilot projects may achieve can enlarge the transferability extent far beyond the SaferBrain lifetime. The poor flexibility of the 3-steps approach, on the contrary, may be difficult to adapt: the process is straightforward, but in the case of the SaferBrain pilot projects more intermediate phases could be required.

3.2. The LEDA approach

The final task of the LEDA project was to assess the transferability of a series of 20 “less well-known but effective measures” to some receptor cities in Europe, selected according to the project evaluators’ expertise. The concept was simpler than the TRANSPLUS’ one, since the TS was focused on the transfer of just single measures, namely under the legal and regulatory points of view. Each measure was eligible to be tested by more than one target city, if possible, and the combination of measures and Origin / Target cities is shown in Figure 6.

![Figure 6: Combination of Measures and Target/Origin Cities in the LEDA TS (Langzaam Verkeer, 1999)](image)

As a pre-requisite to the TS itself, a study of possible correlations between the two sets of Target/Origin Cities was developed by the LEDA participants. The profile of Origin Cities was drawn by a questionnaire submitted to the LEDA participants; typical questions have been: “Does the measure reflect specifically the modal split in this city?”; “Does the measure reflect specifically the nature of transit in this city?”; “What resources did this measure require to be available for enforcement in this city?; etc. Questions were created to provide information about drivers and barriers for the TS strictly under the regulatory point of view (coherent with the LEDA general scope) and therefore in terms of:

- Urban structure
- Legal framework
- Political will
- Public acceptance
- Role of enforcement

For any answer, responses available were based on a 3-point Lickert Scale: A, B, C; each point corresponded to a score (-1, 0, 1), where 0 is meant as neutral, i.e. the midpoint.
Accordingly, for each response mean, mode and variance values have been calculated (Figure 7); in particular variance values of each Origin City allowed assessing the “distance” of the City from a hypothetical “model city”, in which every answer was scored 0.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does the measure in this City form an important part of a strong local or regional transport strategy which consists of several closely linked interlocking measures?</td>
<td>None</td>
<td>Strong</td>
<td>0.30</td>
<td>0</td>
<td>0.43</td>
</tr>
<tr>
<td>2. What level of social sustainability in respect of relevant elements of traffic management, land-use planning, or public transport law or regulation making in the City did this measure require in order to be generated?</td>
<td>Local</td>
<td>Central</td>
<td>-0.46</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. What level of integration of traffic management &amp; public transport management &amp; land-use planning, &amp; functions in the City, does this measure require in order to be effective?</td>
<td>None</td>
<td>Integrated</td>
<td>0.66</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. In order to be effective does this measure require local City responsibility for enforcement of traffic management?</td>
<td>City</td>
<td>Not City</td>
<td>-0.45</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>5. What resources did this measure require to be available for traffic management enforcement in the City?</td>
<td>Low</td>
<td>High</td>
<td>-0.20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6. In order to be effective does this measure require local City responsibility for enforcement of specific parking controls?</td>
<td>City</td>
<td>Not City</td>
<td>-0.40</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>7. What resources does this measure require to be available for parking control enforcement in the City?</td>
<td>Low</td>
<td>High</td>
<td>-0.15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8. How is public transport owned &amp; controlled in this City?</td>
<td>Private</td>
<td>Public</td>
<td>0.50</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9. Does the measure specifically reflect the nature of public transport control in the City? (Measures appropriate to locally owned public transport monopolies might not transfer to the UK's deregulated bus market, and vice versa)</td>
<td>Yes</td>
<td>No</td>
<td>0.30</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>10. What proportion of local journeys are already made by sustainable 'green modes' (walking, cycling and public transport) in the City?</td>
<td>Low</td>
<td>High</td>
<td>0.65</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11. Does the measure specifically reflect the modal split in this City? (Measures appropriate to a City with a high level of cycling may not transfer to a City with a low level of cycling)</td>
<td>Yes</td>
<td>No</td>
<td>0.30</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12. Did this measure require private motorists to willingly accept measures which restrict their freedom of action in the City?</td>
<td>Non-restrictive</td>
<td>Compliant</td>
<td>0.15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13. What is the nature of the road system in the City?</td>
<td>Narrow</td>
<td>Wide</td>
<td>-0.05</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14. Does the measure reflect the nature of the City’s road system?</td>
<td>Yes</td>
<td>No</td>
<td>0.66</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15. Is the density of population and pattern of urban development in the City?</td>
<td>Dispersed</td>
<td>Compact</td>
<td>-0.20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16. Does the measure reflect the urban development pattern in the City?</td>
<td>Yes</td>
<td>No</td>
<td>0.16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17. What level of consultation was needed to introduce the measure in the City?</td>
<td>Little</td>
<td>Extensive</td>
<td>0.35</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 7: Characteristics of the Origin Cities in the LEDA TS (LEDA, 1999)

The Origin Cities list in Figure 8, classified per increasing variance values, provides information of the quality of mix of characteristics typical of each city; to the highest variance values correspond cities with the more mixed characteristics patterns.

<table>
<thead>
<tr>
<th>No.</th>
<th>Measure</th>
<th>Origin City</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bicycle priority street / bus lane</td>
<td>Legua</td>
<td>0.75</td>
</tr>
<tr>
<td>2</td>
<td>Increasing accessibility in residential areas</td>
<td>Lisbon</td>
<td>0.69</td>
</tr>
<tr>
<td>3</td>
<td>Parking policy</td>
<td>Fvora</td>
<td>0.68</td>
</tr>
<tr>
<td>4</td>
<td>Limited access to the city centre on Saturdays</td>
<td>Bruxt</td>
<td>0.68</td>
</tr>
<tr>
<td>5</td>
<td>Quality bus corridors</td>
<td>Dublin</td>
<td>0.68</td>
</tr>
<tr>
<td>6</td>
<td>Air quality legislation</td>
<td>Lyon</td>
<td>0.68</td>
</tr>
<tr>
<td>7</td>
<td>Licensing of accessible taxis</td>
<td>Edinburgh</td>
<td>0.68</td>
</tr>
<tr>
<td>8</td>
<td>ASC location policy</td>
<td>The Hague</td>
<td>0.65</td>
</tr>
<tr>
<td>9</td>
<td>Public transport finance levy on companies</td>
<td>Strasbourg</td>
<td>0.65</td>
</tr>
<tr>
<td>10</td>
<td>Traffic calming measures</td>
<td>Bologna</td>
<td>0.52</td>
</tr>
<tr>
<td>11</td>
<td>Access-parking</td>
<td>Oslo</td>
<td>0.50</td>
</tr>
<tr>
<td>12</td>
<td>Car sharing parking space</td>
<td>Wiener Neustadt</td>
<td>0.50</td>
</tr>
<tr>
<td>13</td>
<td>Bus priority scheme</td>
<td>Budapest</td>
<td>0.50</td>
</tr>
<tr>
<td>14</td>
<td>System of two-stage parking charges</td>
<td>Ghent</td>
<td>0.49</td>
</tr>
<tr>
<td>15</td>
<td>Global parking policy</td>
<td>Luxembourg</td>
<td>0.43</td>
</tr>
<tr>
<td>16</td>
<td>Bhutanese bus parking</td>
<td>Ghent</td>
<td>0.40</td>
</tr>
<tr>
<td>17</td>
<td>Environmental zones</td>
<td>Lund</td>
<td>0.38</td>
</tr>
<tr>
<td>18</td>
<td>&quot;Getting business in the right place&quot;</td>
<td>The Hague</td>
<td>0.35</td>
</tr>
<tr>
<td>19</td>
<td>Bi-directional bus lane</td>
<td>Zug</td>
<td>0.24</td>
</tr>
<tr>
<td>20</td>
<td>Pedestrian street</td>
<td>Copenhagen</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Figure 8: Variance values for the Origin Cities in the LEDA TS (LEDA, 1999)

The list of Target Cities and their characteristics has been created, using the same criteria and the trying to pursuing the same goals of the study on Origin Cities, i.e. to find out which were the cities with the highest level of characteristics mix, as reported in Figure 9 where a template for just one case is shown.
Once that the profiling process of both Origin and Target cities was over, it was possible to start the comparison phase, considering options both of close matches and differences and using a correlation coefficient; a typical table of comparison per characteristics is reported in Figure 10.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Response</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Strength of local/regional transport strategy</td>
<td>None</td>
<td>0</td>
<td>0.46</td>
</tr>
<tr>
<td>2. Level of local autonomy</td>
<td>Local</td>
<td>-0.20</td>
<td>0.17</td>
</tr>
<tr>
<td>3. Level of integration of traffic management</td>
<td>None</td>
<td>-0.13</td>
<td>0.27</td>
</tr>
<tr>
<td>4. Responsibility for the enforcement of traffic</td>
<td>City</td>
<td>-0.33</td>
<td>0.24</td>
</tr>
<tr>
<td>5. Resources made available for traffic management</td>
<td>Low</td>
<td>0.20</td>
<td>0.31</td>
</tr>
<tr>
<td>6. Responsibility for the enforcement of parking</td>
<td>City</td>
<td>-0.73</td>
<td>0.21</td>
</tr>
<tr>
<td>7. Resources made available for parking control in</td>
<td>Low</td>
<td>0.13</td>
<td>0.41</td>
</tr>
<tr>
<td>8. Control of public transport in the City</td>
<td>Private</td>
<td>0.47</td>
<td>0.55</td>
</tr>
<tr>
<td>9. Proportion of local journeys already made by</td>
<td>Low</td>
<td>0.37</td>
<td>0.64</td>
</tr>
<tr>
<td>10. Willingness of motorists to accept measures</td>
<td>Reluctant</td>
<td>-0.20</td>
<td>0.31</td>
</tr>
<tr>
<td>11. Nature of the road system in the City</td>
<td>Compact</td>
<td>0.50</td>
<td>0.00</td>
</tr>
<tr>
<td>12. Density of population and urban development</td>
<td>Dispersed</td>
<td>-0.07</td>
<td>0.35</td>
</tr>
<tr>
<td>13. Established level of consultation carried out</td>
<td>Little</td>
<td>0.40</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Figure 9: Scores and variance values for a given Target City in the LEDA TS (LEDA, 1999)

The comparison phase paved the way for major analyses on the profiles of Origin/Target Cities but the final goal was to determine the least / most transferable measures; accordingly, a final assessment was made considering the average Origin City score for a given measure and same score for the Target City, as in Figure 11 (where 0.8 is the score of the most transferable measures and -0.29 is the score of the least transferable ones).
Transferability scores can be divided also according to the relevance:

- "low scorers": those measures that require some form of restriction or perceived risk to be imposed above and beyond what is "typical". Consequently these measures are assessed as creating a problem from either the public acceptability or the political standpoint.

- "medium scorers": those measures that can typically be done under existing powers, but are not perceived as providing significant benefits either publicly or politically, or in respect of the City’s objectives.

- "high scorers": those measures that can be implemented using existing powers, and which are relatively easily enforceable, and which are perceived to provide benefits for the City or to the public” (Macario and Marques, 2004:24)

3.2.1. The lesson learned from LEDA

In general the evaluation process was rather time-consuming because of the calculations. Basically, positive aspects to consider are a) the possibility to outline characteristics of the cities in the most flexible way and according to the most different goals (for instance, all the LEDA partners participated in the definition of the questions, which have been deeply elaborated); b) the provision of a method easily usable by decision makers (calculations can be easily made by spreadsheets); c) the possibility to have a kind of quantitative control of the TS; d) the avoidance of data search and desk research in general, since characteristics are determined according to the TS participants’ expertise. At the same time, it is worth reminding that the LEDA focus was just on single measures and the application of such a method enlarged to policies may turn to be not that straightforward.

3.3. The CIVITAS approach

The CIVITAS approach differs from the above mentioned ones because aimed at providing a general methodology for transferability, easily adaptable to different kinds of research projects and the related measures implementation process. The need to provide a general framework is due to the CIVITAS nature itself, since it is an initiative (now at its 3rd edition) in which EC funded projects to promote sustainable mobility are clustered. The implementation of very different measures targeted to improve sustainability in many cities across Europe (from access restrictions, to pricing, to traffic calming, to ITS, to car sharing / pooling, to clean transit fleet, to awareness campaign, etc.) is one of the main goals of CIVITAS, along with their evaluation and the assessment whether they may be transferable or not. On this purpose, since the CIVITAS 1st edition, special supporting projects, and namely METEOR (Monitoring and Evaluation of Transport and Energy Oriented Radical Strategies for Clean Urban Transport), have been in charge to develop a common methodology to steer the
involved cities towards comparable qualitative outcomes and quantitative results. Indeed, the assessment of the efficiency of the planned measures (according to an ex ante/ ex post comparison) and the comparability of results were considered as pre-requisites for transferability of good/ best practices achieved during the CIVITAS program.

3.3.1. The pre-requisites for transferability

Being the transferability process customized to such different case studies (and cities) the METEOR methodology for the TS was based on simple steps according to an algorithm further described. However, before starting the transferability process it was necessary to consider some basic, but unavoidable, issues:

a) Being transferability aimed at exporting successful measures / policies, how “success” can be defined?

b) Once assessed the drivers which contributed to the success of a given measure / policy in the origin city, it is necessary to evaluate their importance in the target city as well, or in other words whether they may be as decisive in the new context as they have already been in the origin one.

c) Implementing mobility measures requires a deep knowledge not only of the environments the measure / policy was / will be implemented, but also of the quality and quantity of data and information available to support the TS.

Solutions to such matters have not been univocal, but they are worth to be analysed since they can provide useful directions for the SaferBrain TS.

For what concerns the definition of success, the lesson learned from CIVITAS stresses the need to use indicators to assess measures efficiency, according to some evaluation categories. Coherently, values from such indicators can be used also to determine measurable criteria for success, a kind of threshold values for transferability, to meet some agreed transferability requirements (or goals). For example, a given safety policy which contributed to decrease the accidents rates in a given area can be assessed as successful only if such decrease meet the n-% value required by the TS (which could be the translation of a political goal, a value coming from specifications, etc.).

Same considerations can be done about the second issue, i.e. the need to assess the relevance level of the key drivers for the success of a given measure in the implant context, too. Also in this case, it is necessary to quantitatively assess such importance, according to the experts’ knowledge, which could be done by rating each key driver. Matching relevance for any driver in both origin and target contexts is a good marker for successful transferability.

The last issue is maybe the most important. It is not only a problem of availability of data but above all of their reliability. Indeed, quantitative information or data directly monitoring the effects of a given implemented policy / measure are not always available and even when available they cannot be trusted as unique element to decide whether the policy / measure is exportable or not, since as said before, the conditions for transferability may not match. As a consequence, to start a TS it is important to have a study session in which available data and information are scanned and assessed whether they may usable to support the TS. Such assessment should be made by consultations. Such phase should occur both at a political level in the target context, to have decision makers aware of the starting level of the TS (and avoid further disappointing results as “garbage in – garbage out”), and at a technical level, to have transferability planners aware of what still misses to perform a TS and how such gap(s) can affect the transferability results.
3.3.2. The CIVITAS methodology for transferability

As already said, the CIVITAS approach for transferability was rather “universal” because of the very different palette of contexts it was meant to guide during the TS phase.

The methodology is based on an algorithm (Figure 12) which takes into consideration some of the aspects already dealt in TRANSPLUS and LEDA.

The approach is based on the following 10 steps:

- **STEP 1** – Diagnostic of the problem
- **STEP 2** – Characterisation of the city
- **STEP 3** – Analysis of the city context and implications of problems identified
- **STEP 4** – Look around for similar contexts
- **STEP 5** – Selecting examples of source urban contexts
- **STEP 6** – Identify measures with potential for transferring
- **STEP 7** – Packaging and dimensioning the measures for transferring
- **STEP 8** – Ex-ante assessment of measures to transfer
- **STEP 9** – Identify need for adjustment
- **STEP 10** – Implement measures and steer results

Figure 12: The CIVITAS algorithm for transferability (Macario and Marques, 2004:36)
This is meant to steer a theoretical transferability process in which some measures / policies under implementation have their potential for transferring assessed, in light of some general goals of the TS itself and in consistency with the involved cities characteristics. The tasks planned for each step are described as follows:

**Step 1 – Diagnostic of the problem.** In this phase it is recommended to run an analysis of the target context, taking into due consideration which are the recurring problems and which are the strategic goals, also called HLOs – High Level Objectives, the target city is oriented to achieve. It is recommended to draw a matrix to have global visions of HLOs, problems – Ps.

The matrix is made of a number \((n)\) of high level objectives \([HLO_n]\) and a number \((m)\) of problems \([P_m]\), where matching relationships \((R)\) are depicted using a scale, \(R_{mn} = \{1; 2; 3\}\). The impact of \([P_m]\) on \([HLO_n]\) is represented as follows:

- \(\{1\}\) Neutral impact
- \(\{2\}\) Slight impact
- \(\{3\}\) Strong impact

**Table 2: The Objectives/Problems Matrix**

<table>
<thead>
<tr>
<th></th>
<th>HLO1</th>
<th>HLO2</th>
<th>HLO3</th>
<th>HLO.</th>
<th>HLOn</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>(R_{11})</td>
<td>(R_{12})</td>
<td>(R_{1,3})</td>
<td>…</td>
<td>(R_{1n})</td>
</tr>
<tr>
<td>P2</td>
<td>(R_{21})</td>
<td>(R_{22})</td>
<td>(R_{2,3})</td>
<td>…</td>
<td>(R_{2n})</td>
</tr>
<tr>
<td>P3</td>
<td>(R_{31})</td>
<td>(R_{32})</td>
<td>(R_{3,3})</td>
<td>…</td>
<td>(R_{3n})</td>
</tr>
<tr>
<td>P.</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>P_m</td>
<td>(R_{m1})</td>
<td>(R_{m2})</td>
<td>(R_{m3})</td>
<td>…</td>
<td>(R_{nm})</td>
</tr>
</tbody>
</table>

Hence, the matrix allows assessing which problems are more relevant in pursuit of the HLOs.

**Step 2 – Characterisation of the City.** The “Characterisation” is aimed at defining some local features (Variables) which will be used to identify the context needed by the target city to “receive” a given measure typical of a certain Origin City. Variables can be divided into physical, institutional and socio economic ones and should be referred to very simple data or information to collect, as for instance Population density, Area of city, Number of households, Number of cars, Motorization rates, Accident rates, etc. as in Table 3.

**Table 3: Typical variables for the characterization**

<table>
<thead>
<tr>
<th>Physical</th>
<th>Institutional</th>
<th>Socio-Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population in the area</td>
<td>Number of public transport operators</td>
<td>Number of households</td>
</tr>
<tr>
<td>Area of the city</td>
<td>Institutional complexity – current types of directly involved authorities</td>
<td>Number of registered cars</td>
</tr>
<tr>
<td>Land use</td>
<td>Political commitment</td>
<td>Average income</td>
</tr>
<tr>
<td>Network length</td>
<td>Public awareness – level of enlightenment of the population and acceptance of changes</td>
<td>Cars per household</td>
</tr>
<tr>
<td>etc</td>
<td>etc</td>
<td>etc</td>
</tr>
</tbody>
</table>
Once the characteristics have been listed, the CIVITAS methodology recommends to draw an assessment matrix of the types of characteristics of the target city as in Table 4, as operated in the LEDA Transferability process.

**Table 4: Classification of the target cities according to the variables of the origin city (Macario and Marques, 2004:37)**

<table>
<thead>
<tr>
<th>ORIGIN CITY VARIABLES (single measure)</th>
<th>Classification of Target City</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1 Presence of a strong local or regional transport strategy in the City, consisting of several closely linked limiting measures</td>
<td>No local or regional transport strategy in place. Measures are assessed locally on an independent basis</td>
</tr>
<tr>
<td>2 High level of local autonomy in respect of traffic management / land use planning / public transport law or regulations making in the City</td>
<td>Complete local autonomy in these areas</td>
</tr>
<tr>
<td>3 Mixed level of integration of traffic management / public transport management / land use planning / ... functions in the City. Does one body have overall responsibility for all of the above?</td>
<td>Entirely separate legislative framework and implementation structures for different functions</td>
</tr>
<tr>
<td>4 Local responsibility for the enforcement of traffic management in the City</td>
<td>Mostly City powers</td>
</tr>
</tbody>
</table>

**Step 3 - Analysis of the city context and implications of problems identified.** This is the phase where outcomes from steps 1 and 2 are put together so to have a more detailed characterisation of the HLOs considered, a revision of the related problems identified and above all to start “a preliminary political decision on which HLOs and problems should remain the focus of the discussion”. It is also stated that “For a city to assume its condition of target city will depend on having concluded from these initial 3 steps that there are indeed problems that require measures to be undertaken. Measures that should be taken from previous examples discussed with other cities where similar situations were identified” (Macario and Marques, 2004:39).

**Step 4 - Look Around for Similar Contexts.** The core of such phase is to profile contexts very close to the target city, hence with similar characteristics, so to find out proper conditions of comparability, according to a series of indicators and evaluation categories (as those belonging to areas such as “land-use”, “socio-economy”, “transport supply”, “travel demand”, “impact indicators”, “local policy” and “cultural indicators”). It must be reminded that CIVITAS is aimed at implementing very different measures and therefore good numbers of evaluation categories are required.

Also in this case it is requested to study how a Context [C] can match the variables [V] which describe the target cities. “Hence, a matrix characterised by a number (n) of Contexts [C] and a number (m) of variables [V] can be developed, where matching resemblance is assessed”. This will allow to determine the similarity coefficient $S_{mn}$. 

March 2009
Page 20 of 73
A+S, LOUGH, CTL
It is recommended to assess quantitative variables in terms of variation of the selected indicators (for instance indicator “GDP per capita” might be assessed as the percentage on the same indicator on the target city, e.g. source city “A” is +15% richer than target city, while source city “B” is -5% less rich), whereas qualitative variables can be evaluated according to perceived resemblance in a 1-3 points scale, being 3 the best match. It is important to stress that quantitative indicators should be seen as direct clues on the similarity level.

Step 5 - Selecting Examples of Source Urban Contexts. This is the moment where similar contexts turn into real case studies or real origin cities where from the TS begins. Indeed variable, general features and similarities (or differences) from the previous steps can be described according to some core indicators which enable to identify real “Source Urban Contexts”.

Step 6 – Identify measures with potential for transferring. Once defined criteria for success, as discussed in the previous section, in this phase it is possible to look for candidate measures for the TS, by selecting from all measures adopted in the Source Urban Contexts, those which have reached success thresholds; such a list calls for a review by all the involved participants in the TS so to have a final a list of Candidate Measures, including specific remarks on crucial conditions of applicability identified by the reviewers.

Step 7 – Packaging and Dimensioning the Measures for Transferring. This is a very important step since the TS is aimed at transferring not just single interventions but coherent packages of measures with constitute appropriate policies. Also in this case, a matrixes-based process is recommended to build such packages:

The first matrix to draw is a matrix of measures complementarities [C], where the complementarity of each Measure (M) is set against others, by using a Likert scale as follows:

- 3 – Crucial
- 2 – Significant
- 1 – Limited
- 0 – Neutral
An example of such a matrix is reported below.

“The most effective packaging will result from the analysis of the above-suggested matrix. Below is presented a suggestion for a simple automatic MS EXCEL analysis regarding a set of 9 measures [C (9,9)]. While the top part of the matrix shows the assessed complementarity of measures using the suggested scale, the bottom part translates that in coloured impact, adding up at the bottom of each column for a “complementing factor”. This number allows ranking measures against their crossed importance in the success of all others.”

Figure 13: The Complementarities Matrix: an example

“The next step would then be to set up best suiting packages of measures, as suggested below. At this stage, it will also be possible to set up second best packaging choices, should a given measure need e.g. to be kept on hold. Independent measures that have no crossed impact are identified, in view of any possible implications of their total suppression” (Macario and Marques, 2004:43)”
Step 8 – Ex-ante Assessment of Measures to Transfer. Once defined what transfer and where, the knowledge of what would happen in the target cities in case of “transfer” or “no transfer” may be a useful hint to assess whether the real transfer process is worth to be carried out. In this case it is recommended to simulate do-something and do-nothing scenarios, according the indicators already selected.

Step 9 - Identify Need for Adjustment. If results from the previous phase support the feasibility of the transfer process, this is the phase where revisions, adjustments, new options have to be taken into consideration before proceeding to the next phase.

Step 10 - Implement Measures and Steer Results which is the moment where the real transfer of measures takes place and programs for monitoring the appropriateness of the transferability process and the effectiveness of the transferred package of measures are planned.

3.3.3. The lesson learned from CIVITAS

The sequence and the process above described is too complex and long to govern a TS like the SaferBrain one, being the scope of the project in hand very different from that of CIVITAS. Moreover, measures, indicators and implementation programs were already decided within the CIVITAS framework, which facilitated and directed the whole TS. The sequence, however, is flexible enough to: a) be adapted to both horizontal and vertical transferability options; b) start the process either from target cities and looking for candidate origin cities or vice versa; c) jump some steps if needed (for instance step 8 can be skipped in case of poor resources or information to create the scenarios); d) use indicators coherent with the road safety space concept and useful to be considered in safety audit process.

4. Customizing the TS to SaferBrain

The CIVITAS algorithm, as just stressed above, is a very comprehensive and flexible tool to run a TS oriented to export sustainable mobility best practices and a simplified sequence can be easily adapted to the SaferBrain TS. A first proposal is hereby presented switching from such general focus to the safety one, in order to have a transferability audit suitable to the pilot projects in hand.

Also in this case there are some pre-requisites to consider: the gist of the TS is to study how to import best practice on road safety from abroad to the pilot experiences. Accordingly the following questions arise:

- If the process is just importing, in the case studies, safety policies, which level will be considered for the TS: horizontal or vertical? Both?
- How to define “success” in these cases? Indeed, quantitative values describing success of best practice, for instance in Europe, can be far from what achievable in the pilot projects. Real positive outcomes can be blurred by not realistic, ambitious goals or miscalculated ones.
Road safety measures are manifold and their outcomes can be enhanced by implementing other supporting measures. Which are the main categories of eligible measures for the pilot cases: pure infrastructural, pure regulatory, educational, ITS-based, road-user-targeted (just for vulnerable users, motorized ones, elderly, children, all of the above), a mix, ....? This is not secondary, since transferring measures which can be perceived as supportive of individuals mobility will probably result easier to implant than the restrictive ones.

However, even though the replies to the questions above are pending, it is possible to draw a general structure for a Transferability Audit, according to the following sequence:
Step 1 - Characterisation of the Target City and related HLOs

A characterisation of the target contexts, according to the road space safety concept, is recommended which requires the description of the contexts under the three points of view (by using regulatory, economic and social indicators). Safety problems emerging from this picture will be codified into a series of HLOs. Matrixes and questionnaires can be borrowed from the CIVITAS algorithm steps 1 and 2. The goals of this step are: to have a good snapshot of the contexts in hand and to have a priority list of HLOs to pursue. Such prioritization can result from calculations as Macario and Marques (2004:39) suggest (Figure 15).

The prioritisation of problems is suggested to following the criteria (m number of problems and n number of HLOs):

\[ \text{Rank } (P_{1..P_n}) \text{ according to } \sum_{i=1}^{n} P_{mi} \]

The acknowledgement of the High Level Objectives that may be more at risk is suggested to following the criteria:

\[ \text{Rank } (\text{HLO}_{1..\text{HLO}_m}) \text{ according to } \sum_{i=1}^{m} \text{HLO}_n \]

Figure 15: Prioritizing HLOs

They can also be derived from questionnaires submitted to all the involved experts (the importance of qualitative recommendations is great, since many studies on transferability are largely based on consultations; see for instance Buchanan, 2003).

Step 2 - Looking Around for useful solutions – SaferBrain will provide a list of efficient safety measures (already successfully adopted), which grouped together will form comprehensive safety policies coherent with the contexts of application and hence with HLOs. Expertise from the partners involved in the task will be required to decide quantity, quality and validity of such measures (Delphi process or simple questionnaires according to the LEDA examples could be useful to carry out the selection). It will be of the utmost importance to select measures easy to monitor by the indicators developed in the step 1. Such a selection must be consistent with the technical and economical affordability of the target contexts and their desire towards some category of measures rather than others; this is the reason why consultancies are required to have shared decisions and solutions.

Step 3 - Selecting Origin Cities – This step goes in hand with the previous two, since it is necessary to know, when looking for exportable successful measures (step 2), where they have been implemented (origin cities) and if such origin contexts are close to the target ones (step 1). A characterisation of the origin cities similar to the target ones is necessary, in order to have comparable results.

Step 4 - Identify measures with potential for transferring and Step 5 – Packaging and Dimensioning the Measures for Transferring. The selection of measures will be coherent with
the characterization of the target / origin cities, local HLOs; the measures will be liable to be monitored by the selected indicators. Packaging and dimensioning of the measures will be decided according to directions provided, at target cities level, during step 2.

Step 6 – Directing the transfer (creating the transferability audit). Once decided what and how has to be transferred to the target contexts, criteria to carry out the transfer process can be provided (time horizons, level of involvement of users in the process, resources to be involved in the process, etc.). If possible, it will be sensible to create do-something / do-nothing scenarios to estimate the level of efficiency of the selected safety measures and hence to have a set of useful ex ante / ex post indicators, once the measures will be really implemented.

5. Human Factors Issues in Road Safety

5.1. Introduction

Human factors are known to be implicated in the majority of accidents. According to Sabey and Taylor (1980) human error is a factor in almost 95% of accidents.

Petridou and Moustaki (2000) suggest that behavioural factors collectively represent the principal cause of three out of five traffic accidents and contribute to the causation of most of the remaining. They distinguish between a number of different types of behavioural factors according to the duration of their effect on the road user:

- those that reduce capability on a long-term basis (for example, inexperience, ageing and other health issues);
- those that reduce capability on a short-term basis (for example, alcohol impairment, fatigue, psychological stress or temporary distraction);
- those that promote risk taking behaviour (speeding, disregard of traffic, failure to use protective systems).

In addition, they identified short term risk-taking for example, criminal acts and suicides. However, suicides and criminal acts have been determined not to be outcomes of the operation of the traffic system, and hence are outside the scope of the issue under consideration here.

In low income countries, a number of other factors may contribute to the accident problem, including the failure to design motorised vehicles which are less hostile to vulnerable road users (Roberts, Mohan et al. 2002) high proportion of non-motorised traffic and the presence of locally designed para-transit vehicles (Mohan, 2002).

This chapter examines the human factors and road user behaviour issues which may hinder the transfer of road safety methodologies, measures and tools from Europe to Brazil and India. A particular emphasis is placed on measures to improve safety for vulnerable road users, as this is the main area of concern for the SaferBrain project.

The following sections address differences between high-income countries and newly motorised ones in terms of human factors. These human factors have been categorised according to whether they are related to “User state”, “User Experience” or “User Behaviour”.

It is recognised that less motorised countries often have a significant fleet of alternative local transport vehicles. However, these have few parallels in the high-income countries, and as a consequence are little studied. Nevertheless, they may have an impact on the effective transfer of some road safety methodologies, measures and tools which must be considered.
5.2. User State

As has been discussed in section 5.1, the physical and mental state of the road user can affect their performance in a number of ways. This section will discuss in turn factors leading to long and short term capability reductions. Conclusions will be drawn about the likely impact of these various human factors on the transferability of road safety measures, methods and tools.

Factors related to the user state which lead to long term reductions in road user capability include poor health and age-related factors. Factors related to the user state which lead to short term reductions include fatigue and alcohol impairment.

5.2.1. Health problems and ageing

A number of studies have assessed the impact on driver state of various medical conditions. According to Sagberg (2006) the most notable health conditions are:

- stroke and myocardial infarction, and underlying cardiovascular disease;
- affective or psychological disorders (including anxiety, depression and related conditions);
- sleep disturbances;
- visual deficiencies, especially myopia.

The incidences of health problems which have road-user safety implications is likely to vary in different countries. In addition, it is likely that screening for and treatment of the health conditions mentioned would also vary.

Linked to the question of health, is that of ageing. Whilst older drivers do not have anything like the accident involvement-rate of young and novice drivers, they are, nevertheless over-represented in accident statistics. In addition, according to Brace et al. (2006) changes related to the ageing process (such as reduced bone density) make them more at risk than other road users of sustaining a serious or fatal injury once involved in an accident. According to the United Nations, one out of every ten persons is now 60 years or above; by 2050, one out of five will be 60 years or older; and by 2150, one out of three persons will be 60 years or older.

The older population itself is ageing. The oldest old (80 years or older) is the fastest growing segment of the older population. They currently make up 13 percent of the 60+ age group and will grow to 20 percent by 2050. The number of centenarians (aged 100 years or older) is projected to increase 14-fold from approximately 265,000 in 2005 to 3.7 million by 2050.

In some developed countries today, the proportion of older persons is already one in four. During the first half of the 21st century that proportion will be close to one in two in some countries.

As the tempo of ageing in developing countries is more rapid than in developed countries, they will have less time than the developed countries to adapt to the consequences of population ageing (http://www.un.org/esa/socdev/ageing/popageing.html).

The specific changes which occur as part of the ageing process which may impact on road safety include (Hakamies-Blomqvist et al., 2004):

- Stiff joints and weak muscles making it difficult to turn to look, to apply force to the brakes or to manoeuvre the vehicle;
- Deterioration in eye sight and hearing, loss of peripheral vision and medical problems such as glaucoma and cataracts;
- Dulling of reflexes and reduced attention span, leading to increased reaction times and difficulty processing information;
• Memory loss;
• Disorientation;
• Poor or decreased judgement;
• Loss of initiative;
• Increased use of medication.

Maintaining safe mobility for older people has been shown to be linked to other physical and mental health outcomes (Brace, Elliman et al. 2006), so it is essential that the implementation of road safety measures is not undertaken without consideration being given to the age profile of the population. Similar trends can be observed in Emerging Economies, in particular in large cities with higher income and raised living standard.

5.2.2. Fatigue

Fatigue affects driver performance in the short term a number of ways. It is associated with a reduction in alertness, longer reaction times, memory problems, poorer psychometric coordination, and less efficient information processing. It also has an effect on task motivation and driver mood. These factors in turn lead to deteriorations in the driver’s ability to steer, to maintain lane discipline and appropriate speed, and to maintain headway in car-following situations (www.erso.eu).

Estimates of the incidence of fatigue-related crashes vary due to the difficulty of determining driver state immediately prior to the crash, but are thought to be higher on certain road types (for example, those with lower driver work-load and more monotonous conditions such as motorways) at certain times of the day (generally during times when the driver would normally be asleep, and late afternoon to early evening), and for certain types of driver (Horne and Reyner, 1995)

5.2.3. Alcohol Impairment

Alcohol is well documented factor in accidents, affecting drivers in a number of ways in the short term. According to research published by the European Commission the driving task can be divided into three different levels. The lowest level includes tasks like maintaining speed and keeping course (steering, accelerating, braking, etc.). The intermediate level involves decisions about dealing with traffic situations (for example, gap-acceptance, and right-of-way). At the highest level are decisions about whether or not to drive at all. Alcohol affects all of the skills related to the different levels of driving, in some cases impairing performance even at blood alcohol concentrations of less that 0.5g/l.

There is a strong positive correlation in more motorised countries between alcohol impairment and pedestrian accident involvement (Irwin, Patterson et al. 1983), (LaScala, Gerber et al. 2000). However, even across Europe there are wide variations in drink-drive legislation, from a zero-tolerance approach in Romania, Slovakia, Czech Republic and Hungary to a limit of 0.8 mg/ml in the UK. Within countries there are sometimes variations in the limit for novice drivers, or for accident-involved drivers (as opposed to drivers in general traffic) (Vis and Eksler (Eds) (2008)).

Approaches to enforcing the existing drink-drive limits also vary; in some countries (including the majority of European countries) random breath-testing is allowed, whereas in others the police can only test drivers for the presence of alcohol where they have reason to suspect it. The possibility of being tested for alcohol also varies considerably between different countries.

2 http://ec.europa.eu/transport/road_safety/specialist/knowledge/alcohol/measures/police_enforcement.htm
Similarly, attitudes to alcohol consumption and legislation controlling sales vary significantly, even between European countries, and could be expected to do so to an ever greater extent between countries with more widely differing social, cultural and behavioural characteristics.

5.3. Experience and Levels of Knowledge

The road user’s experience of the road environment, their vehicle and routes will tend to affect the levels of road user capability to deal with their surroundings on a long term basis. “Smeed’s Law” which was first postulated in 1949, predicts that as motorisation levels increase, fatalities per head of population rise, but fatalities per vehicle fall (Smeed, 1949). Smeed interpreted this to suggest that road-users have a given level of perceived risk that they are prepared to tolerate, and will adjust their behaviour when they are uncomfortable with traffic conditions. However, Adams (1987) felt it more likely that the reductions in crashes per vehicle that were associated with increases in levels of motorisation could be attributed to a learning process on the part of road users. He suggested that differences in accident rates between countries with different levels of motorisation could be “explained by myriad behavioural adjustments in response to perceived increases in the threat of traffic.”

This suggests that road-users’ levels of experience in traffic and knowledge of road safety could be a significant determinant of accident rates.

The Global Road Safety Partnership (2001) argues that one of the reasons for the high level of injuries to child pedestrians in lower income countries is that “children do not have the necessary knowledge and skills that allow them to deal with the hostile traffic environment.”

In a study published in 1983, (Jacobs and Sayer, 1983) found that children in Jamaica, Pakistan and Thailand demonstrated lower levels of knowledge about safe crossing-behaviour than their counterparts in the UK. Only 1% of Jamaican children and 38% of children from Pakistan mention that one should stop before crossing. In addition, only 53% of children in Thailand had received advice on road safety compared to 95% in the UK. However, it is difficult to identify and quantify the benefits of road-user education, even in countries like the UK where it is a long-established part of road safety strategies. Jacobs and Sayer (1983) go on to say that in general, whilst there were some important aspects of safe behaviour that the children failed to mention, when they were asked to demonstrate how they crossed roads, using a simulated road environment on a playground, performance on the practical task was far better than on the knowledge questions. It is therefore difficult to establish the extent to which lack of knowledge about safe-behaviour translates into accidents.

Khan et al. (1999) highlights a number of behavioural factors which increase the risk for pedestrians which may be linked to inexperience or lack of knowledge. For road-crossing behaviour these include:

- Crossing multi-lane roads one lane at a time rather than all at once
- Crossing without looking in both directions
- Crossing in a group, without any member of the group ensuring the road is safe
- Using non-designated crossing points

Using non-designated crossing points is also associated with increases in risk in more motorised countries (Evans and Norman 1998)

Studies of pedestrian behaviour in Europe suggest that social norms and internalised moral norms may have a strong influence on crossing behaviour (Evans and Norman 1998). In other words, the presence of other pedestrians waiting for the safe pedestrian phase before crossing makes other people less likely to cross against the signals. Conversely, it may be
the case in less motorised countries that high volumes of pedestrians who exhibit the types of unsafe behaviours described above (walking on the road edge, crossing in groups) make it less likely that people will exercise due caution.

Inexperience and/or lack of knowledge can also be a factor in driving behaviour, having two effects; firstly, it influences the driver’s ability to perceive and respond to hazards, but secondly, it affects the “mental workload” which a particular traffic situation imposes on the driver.

According to Deery (1999), novice drivers detect hazards less quickly and efficiently than experienced drivers. As a result, they tend to underestimate the risk of an accident in a variety of hazardous situations. At the same time, they overestimate their own driving skill. Young drivers are also more willing to accept a given level of risk while driving than experienced drivers.

Patten and Kircher et al. (2006) showed a large and statistically significant difference in cognitive workload levels between experienced and inexperienced drivers. Inexperienced, low mileage drivers had on average longer reaction times to a peripheral stimulus, than experienced drivers.

Whilst in reality the two are often the same, a distinction must be drawn between inexperienced drivers and young drivers. Inexperienced drivers may suffer from poor hazard perception and increased mental workload, but in the case of young drivers, these issues are exacerbated by problems of immaturity, higher likelihood of driving at riskier times of day (such as the early hours of the morning), and a higher propensity to drive whilst impaired by drugs, alcohol or fatigue (www.erso.eu). This combination results in a significant increase in accident risk for young drivers, who are overrepresented in crash statistics in Europe. Figures from CARE³ suggest that young drivers are at two to three times the risk of dying in a traffic accident when compared to the experienced drivers. This suggests that the number of young and/or inexperienced drivers within the traffic system is likely to be a factor in levels of crashes, and in the appropriate policy measures that should be implemented.

Conversely it can also be the case that over-familiarity with the road layout can lead to complacency and a lack of concentration on the driving task. (Teran-Santos, Jimenez-Gomez et al. 1999) Simulator studies undertaken as part of the RISER project (de Ridder et al., 2006) suggest that drivers modify their behaviour as they become more familiar with the road layout. This may have implications if changes to infrastructure are proposed.

5.4. Behaviour

5.4.1. Distraction

As the number of electronic devices and vehicle technologies increase in the driving environment the human machine interface grows in complexity. These devices can lead to distractions for all road users by reducing the attention and concentration given to the task in hand. The technologies can relate to both the driving task (e.g. satellite navigation) and unrelated (e.g. phones, mp3 players). The later is also an issue with pedestrians and cyclists, who may use mp3 players and as a result can’t hear their surroundings (Young et al, 2003).

Distraction from the road environment can result from a number of factors; information overload by too many road signs, misleading information by incorrect signage or ineffective, missing signage and roadside features not related to driving (shops or previous accidents) (The Automobile Association Limited, 2009).

³ http://ec.europa.eu/transport/care/index_en.htm
Other factors which can lead to the distraction of the road user whether it is a driver or a vulnerable road user include internal distraction, mental load or distractions due to companions or passengers (ROSPA, 2007).

There appears to be very few studies regarding pedestrian distraction (e.g. crossing the road while using mp3 players), often because it is difficult to deduce at crash scenes whether pedestrian distraction has played a contributing role in a collision. However, this is still an issue to be considered, as the use of music players and mobile phones by pedestrians while walking along the street is widespread.

5.4.2. Risk taking

5.4.2.1. Speeding

Speed, both ‘exceeding speed limit’ and ‘inappropriate speeding’ (i.e. too fast for conditions) are both highly prevalent in accident causation (Schick et al, 2007; Naing et al, 2009).

According to Elvik et al. (2004) “there is a strong statistical relationship between speed and road safety. When the mean speed of traffic is reduced, the number of accidents and the severity of injuries will almost always go down. When the mean speed of traffic increases, the number of accidents and the severity of injuries will usually increase.”

According to Auerbach-Hafen et al. (2007) speed affects accident risk in a number of ways, though the relationship is complicated by a number of factors including environmental ones (such as the effect of a wet or icy road surface), infrastructure elements (grade separation of opposing traffic flows) and factors such as the pattern of energy dispersal in a crash.

5.4.2.2. Failure to use protective systems

Protective systems include seat belts, air bags, child restraints and cycle helmets. According to Auerbach-Hafen et al. (2007) use of seat belts is the single most effective measure in reducing fatal and non-fatal injuries in motor vehicle crashes. However, seat belt wearing rates vary, not only across countries, but also within individual countries for different categories of vehicle and for different seating positions within the vehicle (Auerbach-Hafen et al. 2007). This variation exists despite the fact that seat belt use is now mandatory across Europe. Measures to increase belt use may need to take account of differing conditions in different countries, with levels of enforcement and the perceived likelihood of being caught likely to be important determinants of compliance.

Use of protective headwear for motorcyclists and cyclists is not an uncontroversial measure, as some studies suggest their impact on safety has not been established (Macpherson et al. 2002). Moreover, the effectiveness of legislation on increasing rates is also open to debate (LeBlanc, Beattie et al. 2002). As with seat belts, enforcement is likely to be an important determinant of the effectiveness of legislation.

5.5. Road User Behaviour in Real-World Situations

As has been mentioned, vulnerable road users are a particular concern in less motorised countries, due to their relatively higher numbers. In addition, vulnerable road users in less motorised countries have different characteristics to those in highly motorised ones. In the case of pedestrian safety for example, in less motorised countries a different focus is required to that in Europe (Khan, Jawaid et al. 1999). This is because in Europe the main issues are children and the very elderly, where the physical vulnerability and probable lack of alternative modes are factors. In less motorised countries young adults are at significant risk because of their higher exposure to risk.
A number of studies have examined vulnerable road user behaviour. These behaviours can be categorised as being those which relate to general use of the infrastructure, and those which are particularly pertinent in the case of accidents.

5.5.1. Pedestrians

In terms of using the street itself, identified issues included;

- Walking on the street (road) edge, even where a pavement (sidewalk) is available.
- Walking in the road, not facing the oncoming traffic.

Khan et al. (1999) suggests a number of possible explanations for these behaviours, including encroachments on the pavements which blocked an average of 67% of the available space. These encroachments included parked vehicles, advertising, street vendors and cafes.

In addition Evans and Norman (1998) also found that pedestrians are more likely to engage in risky behaviour when it is perceived as being the easiest thing to do.

Lack of provision of crossing facilities means pedestrians do not form the habit of looking for them when deciding where to cross (Khan, Jawaid et al. 1999). Where pedestrian provision has been made it may be arduous and poorly designed, so pedestrians may choose not to use it (Khan, Jawaid et al. 1999).

In real world accident, studies such as the UK On The Spot (OTS) accident research project\(^4\) a number of common accident scenarios or more specifically the actions and behaviour of pedestrians during the accident have been identified. Factors which can lead to conflicts between vehicles and pedestrians include restricted visibility between the vehicle and pedestrians, pedestrians emerging from behind obstacles such as parked vehicles or vegetation, reduced visibility due issues with lighting or the pedestrian wearing dark clothing. Unexpected pedestrian behaviour such as running out into the road or walking along the carriageway where no pedestrian facilities are provided.

Common behavioural issues observed in pedestrian accidents include the incorrect use of pedestrian facilities, pedestrians running into the carriageway without looking correctly or the pedestrian not crossing at designated areas but taking the shortest route following pedestrian desire lines.

Common reasons for not using a pedestrian crossing correctly include:

- not crossing within the designated area
- being on the wrong side of the pedestrian barriers
- crossing on a red light for pedestrian traffic (green light for vehicular traffic)

5.5.2. Cyclists

Common scenarios leading to conflicts between pedal cyclist and vehicles identified in real world studies can be split into two distinct groups: actions by the pedal cyclist and actions by the vehicle driver.

Actions by the pedal cyclist can include pedal cyclists travelling along the footway. The cyclist does not perceive any risk towards other traffic and is in collision with vehicles turning into or out of minor roads. The pedal cyclist enters the carriageway from the footway without looking or giving any consideration for other modes of transport, this may include a gradient for the pedal cyclist and as a result a higher speed of entry to the carriageway.

Actions by the vehicle which can include a vehicle overtaking the pedal cyclist and turning in front of the pedal cyclist into a minor road, which results in a conflict and a collision. Other

\(^4\) The UK On-the-Spot accident research project [http://www.ukots.org/](http://www.ukots.org/)
scenarios include vehicle sight obstructions, where the pedal cyclist is obscured in the vehicle's blind spot when the vehicle is starting a manoeuvre or a lane changing manoeuvre.

5.6. Conclusions

As has been established, human factors are known to be factors in a majority of accidents. This study has identified a number of relevant issues which affect accident involvement, and which must be considered when assessing the transferability of road safety expertise and knowledge between different countries. User state has been shown to be important, as both long term and short term reductions in capability can be generated by certain influences on user state. In addition, human behaviour, such as risk-taking or ingrained social norms and habits may impact on the transferability of measures.

There will be variations between different countries in relation to:

- the levels of knowledge and experience of road users;
- incidence of health problems which have road safety implications, and the availability and effectiveness of screening programs to identify them;
- the numbers of older road users;
- incidence of the factors which impact on driver fatigue;
- levels of alcohol impairment amongst road users;
- levels of road user distraction;
- speeding;
- protective systems use.

These variations must be taken into account when determining road safety priorities, designing and implementing programmes, and assessing outcomes.

6. Collecting the knowledge for the Transferability Study process

6.1. Matching the TS to the real user needs

From the sections above it is clear that the need to customize the TS to the cases studies in hand is due to the unfeasibility to simply transfer safety concepts typical of developed countries to developing contexts.

This is the reason why in section 4 a simple, but reliable, TS process has been presented in which the six steps (Figure 16), planned to steer the transfer of safety concepts, allow decision makers to assess what is more appropriate for the target contexts. Such a sequence, which becomes a kind of SaferBrain-adapted version of similar ones applied in previous EC-funded projects, is coherent with the two main directions a TS study can be oriented to: the horizontal transferability (i.e. moving safety measures/policies to one context to another without changing the scale of application) and the vertical transferability (i.e. up/downscaling elsewhere safety measures/policies implemented in a given origin context). The presented TS process is also consistent with another theoretical concept, i.e. the Road Safety Space which postulates to take in equal consideration institutional, social, economic and cultural factors when assessing the transferability of safety concepts from developed to developing Countries.

The requirement to assess the transfer feasibility of safety concepts according to different expertise areas is generally acknowledged, but rarely met, being in many cases transferability assessed only under the operative point of view.

However, the need to expand TS beyond the technical limits becomes unavoidable when transferability deals with the levels of acceptance and awareness the measures to transfer
are likely to achieve in the target context, especially in case of innovative solutions. The outcomes from section 5 concerning the relevance of human factors and road user behaviour issues in causing road accidents do call for such multitask approach, and consequently users needs analyses and behaviour appraisals become paramount in this process.

It is also worth considering that so far, scientific literature on safety and users needs in developed countries is rather rich, but not the same can be said for Emerging Economies especially in sensitive areas (both urban and rural) and under specific circumstances (night hours, home-to-school/work travels, platoons at conflict areas, etc.). Such a lack of knowledge makes not possible just to transfer safety measures starting from needs typical of users from developed countries, being contexts and safety perceptions different; typical examples of differences have been extensively described and, for the sake of brevity are shortly synthesized:

a) the aforementioned amount of alternative fleets of transportation vehicles available in less-motorized countries have no corresponding patterns in the high-income ones; the not proper assessment of such variety of four-three-and-two-wheelers may decrease the efficiency of safety solutions transferred from car-dominant contexts (moreover it is to be noted that even in high-income countries the role of apparently minor modes as two-wheelers is little studied, too).

b) Road users experience traffic (and related dangers) in a different way, resulting into different knowledge of road safety as well. Such (in)experience becomes unbearable when data concerning the most vulnerable users are analyzed; children from low-income Countries are poorly schooled in road safety issues which makes them dramatically exposed to traffic risks. Lack of knowledge or inexperience is also ascribable to typical careless behaviours recurring in less motorized countries (as walking on the road edge, group or solo jaywalking, etc.).

c) Health and aging problems are important factors to consider, especially when transferring measures for non-motorized users (but not only). In Europe and in the US great emphasis is placed in promoting measures to plan safe walking for children, keep the elderly mobile and improve accessibility options for physically challenged users whose

Figure 16: The TS process
abilities can be very close to those of the elderly in terms of mobility problems. But the amount of elderly population may vary markedly between developed and developing countries; on the contrary, the amount of young adult road users (with problems due to novice drivers and riders) may result to be more important to consider than the number of senior drivers. As a consequence it is highly recommended to assess the age profile of both origin and target contexts to determine which priorities related to such problem remain valid in the TS process. The change of the population patterns introduces also another issue: design criteria for infrastructures are generally not able to meet specific requirements of elderly population (and children), since they are often conceived considering male, young and healthy people as typical users; at the same time “specific measures” are provided for those who are impaired, resulting thus into a series of ghettoizing solutions. A revision of such parameter it is also recommendable and its validity check through on-the-spot analyses and questionnaires in the target context.

d) Fatigue it is another important issue to consider since it can lead to deteriorate driving skill and reduce the level of alertness. It is related to individual situations while driving and hence there should be no difference between developing and developed Countries, as it should be for problems related to distraction. However, specific factors for fatigue and distraction can be individuated in low-income Countries, where vehicles poor maintenance, misleading road environments (bad signage, roadside features not related to driving), not comfortable on-board environments can contribute to make driving a stressful experience.

e) Alcohol is a well-known cause for accidents. According to OECD (2006) the percentage of fatal crashes where drunk driving was a reported factor is a common feature in road accidents statistics of many developed countries. In spite of national drink-driving laws enforced all over the world (with few exceptions, among them: Indonesia, Morocco and the Philippines according to WHO 2009), the phenomenon is hard to fight and also in this case it can be recommendable to assess the proportion of road traffic deaths attributable to alcohol as an exogenous cause affecting road safety, along with the level of enforcement of the related legislation.

Many of the issues above described can be better understood if considered under the behavioural point of view, and namely that of not-motorized road users as pedestrians and cyclists. Already mentioned problems as jaywalking or walking along the road edge can occur in developing Countries not only because of the lack of safety facilities to mitigate the driver/not-motorized user conflicts, but also because of different ways of using the road environments and in particular sidewalks, where encroachments due to different activities may be recurring. As a consequence, what in developed countries are simply described as risk factors (crossing with red light or not at the designated areas, poor quality of public lighting, taking shortcuts according to the individuals desire lines, etc.) must elsewhere be re-interpreted according to local social and cultural patterns. Same conclusions can be drawn when considering conflicts between drivers and cyclists: blind manoeuvring, cycling on sidewalks etc. are improper behaviours due in many cases to a peculiar way of using the road.

Also other behavioural problems, as risk taking and namely the failure to use protective systems, have to be analysed through a different lens; the World Bank (2009a) recognizes poverty as a limit to improve road safety: a barrier which could prevent road users not only from wearing helmets, but also having proper education, knowledge and skill about the road risks. Same attention must be paid when assessing other causes for distraction, either
because poorly investigated so far (scientific literature on the role of electronic devices while driving, in developed nations, abound but results are not fully consolidated, yet; hence the relevance of the same problem in a not developed context may differ) or because very difficult to elaborate (a typical example is the so-called “misleading environment”: a mix of stop-and-go traffic, motorized and non-motorized modes, noise, too much confusing information from the roadside, from which it is very difficult to single out the most distracting cause).

6.2. The definition of the objectives for the TS

The TS suggested in section 4 is based on the assumption of managing the whole process within the conceptual frame of the Road Safety Space, which means that for any of the 6 steps planned, equal consideration must be paid to whatever social, technical and economical issue in hand during the TS itself.

As a consequence, tasks namely concerning the individuation of objectives for the TS in the target cities (step 1), adoptable solutions (step 2) and their packaging (step 5) can be rather simple if considered under the regulatory, technical and/or economical points of view, since related local constraints, barriers and drivers to support the implant of packages of measures are easy to individuate and assess. For instance, too expensive solutions can be easily discarded as those that require specifications, rules or laws currently not in force in the target contexts and for which no changes are planned by short-term horizons. Not the same can be said when such tasks come to consider human factors and road user behavioural issues, which call for a more in-depth assessment to ascertain whether they may hinder the transfer of road safety measures from one context to another.

Such an awareness requires an enlarged vision to support the TS, in which the evaluation of regulatory, technical and economical issues becomes a general pre-requisite for the transferability of measures (a kind of go/no-go step), but the real transfer feasibility is assessed through the proper knowledge of the role human and behavioural factors may play in the acceptance of the safety measures.

This kind of approach (Figure 17) means that, whatever the package of measures or safety concepts to transfer, the TS will deal both with technical and behavioural domains (meaning the former the whole set of regulatory, technical and economic aspects, i.e. the “Economy” and “Institutions” domains of the Road Safety Space concept, and the latter its “Society” arena) but with different extents. Technical solutions to transfer, indeed, can have direct relationships with economic and institutional issues, whereas per se cannot markedly affect the local social patterns; on the contrary, how people perceive and assess the proposed technical solutions to transfer is of the utmost importance for their final acceptance and proper use. In its turn the behavioural domain, which reflects the cultural and social acceptance of the proposed solutions due to stated human and behavioural factors, may strongly influence decision makers and planners in their final assessments.

This means that the so-called HLOs (or objectives to be individuated during the step 1 of the proposed TS process) must be divided into two categories: economic-institutional goals and the social ones. The fulfilment of the former will represent an accomplishment of the “technical” exportability of the safety measures/policies in hand and of their efficiency under the operative point of view; the achievement of the latter will represent the full acceptance of such measures/policies by the target users. From the lesson learned from the LEDA project four out of five topics can be selected to frame the economic-institutional HLOs, i.e.

- “Urban structure”
- “Legal framework”
- “Political will”
whereas the remaining issue “Public acceptance” will be the pivotal concept the social HLOs will be based upon.

Figure 17: Adaptation of the TS in respect to the human and behavioural factors

7. Developing a Model for Evaluating the Role of Human Factors in Determining the Efficient Transferability of VRU Safety Measures

The Human Functional Failure (HFF) methodology was developed by the EC funded project TRACE (TRaffic Accident Causation in Europe) to address the issue of ‘human error’ in road accidents. This ‘error’ was conceptualised as a failure of human function. It enables the identification of factors that contribute to crashes and how the resultant human functional failures occur.

Although the methodology described in this section was developed to evaluate failures (i.e. errors) experienced by drivers in road accidents, it could also be used as a basis for a model to evaluate the behaviour of other road user types (e.g. pedestrians, cyclists). It also has the potential to be used to evaluate not just road accidents, but also the effects of road user behaviour on the safe and correct usage of road safety measures.

This section outlines the HFF methodology and finishes with an explanation of how this methodology would be of benefit to use as a model to evaluate the cause and effect chain in terms of road user safety, particular for Vulnerable Road Users (VRUs).
7.1. Human Functional Failure (HFF) Methodology

7.1.1. Introduction

The Human Functional Failure (HFF) methodology makes a clear distinction between human failures and human factors. Human factors are defined as ‘characteristics of the system which have weakened its capacity to function safely’, whereas human failures are defined as ‘the unwanted outcome of a confrontation of the driver with a task in which a difficulty was met’. Human failures are not defined as ‘faults’, as failures can also be found for ‘not at fault’ road users. The aim is to use the failures to identify the limits (physical and mental) of human capacity and therefore be able to understand better the types of countermeasures (i.e. safety systems) that would assist in overcoming these human limitations.

The theoretical basis of the method is that driving is a dynamic system where humans, vehicles and the road infrastructure interact. An accident occurs as a result of an incorrectly adjusted interaction between system components.

An accident scenario for a driver can be described as a sequence of events. The first is the driving phase. This phase is before a problem arises. The driver is driving ‘normally’ i.e. there are no unexpected demands and the driver is in control of speed and manoeuvres. This means that there is a balance between the demands and ability of the system components to respond one to another. The second is the ‘rupture’ phase. This is when an event occurs that the driver did not expect (also known as a ‘conflict’), for example a manoeuvre of another road user or the road sharply bends, which leads to the driver’s work load to rise potentially beyond their ability. This in turn leads to the ‘emergency phase’. During this phase the driver may attempt to carry out an emergency action in order to avoid an accident. The demands on the driver are to solve a problem quickly within the limits of the system as a whole. If the driver is unsuccessful in solving this problem, s/he enters the Impact phase. The impact phase comprises the crash and its consequents and determines the severity of both material damage and injury. Each of these phases should be considered specifically within the context of the driving system, with the purpose of not generating hazards for the driver. Figure 18 illustrates the four phases.

<table>
<thead>
<tr>
<th>Driving phase</th>
<th>Rupture phase</th>
<th>Emergency phase</th>
<th>Impact phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviour on approaching the place</td>
<td>Meeting an unexpected event</td>
<td>Avoidance manoeuvres and dynamic demands</td>
<td>Nature of impact</td>
</tr>
</tbody>
</table>

Figure 18: Phases leading to an accident

The HFF method particularly focuses on first 2 phases where the normal driving situation goes wrong and becomes an impaired one. It specifically explains the place and role of the driver in the driving system.

7.1.2. Types of Human Functional Failures

The aim of the HFF methodology is to be able to clearly define the types of functional failures that human experience in road collisions. It defines five main stages that the road user goes though when undertaking the driving task (perception, diagnosis, prognosis, decision-making
The HFF method does not use ‘failure’ to indicate fault, instead it aims to use the failures to identify the limits (physical and mental) of human capacity and therefore be able to understand better the types of countermeasures (i.e. safety systems) that would assist in overcoming these human limitations. Figure 19 illustrates the stages of the driving task.

**Figure 19: Functional chain involved in driving activity**

### 7.1.2.1. Perception

In order to react appropriately to the various situations encountered while driving, the driver first has to detect the relevant information in the environment. This is the perception stage of the driving task and requires the driver to physically see and attend to what they see. Failures here will disrupt the whole chain. The HFF method identifies a number of potential failures at this stage:

- The information is not adequately visible to the driver e.g. because of a sight obstruction or glare;
- The driver is focussed on one event or problem resulting in lack of awareness of other aspects e.g. driver focussing on a road sign might not see another vehicle indicating to turn;
- The driver reduces to a minimum the time and attention they devote to the search for information e.g. because it is routine or because the situation causes their work load to be particularly high;
An additional task diverts the driver’s eyes and/or attention from the road – this can be either related to driving task e.g. checking blind spots or unrelated either outside or inside of the vehicle;

The driver has a limited attention on the driving task resulting from other cognitive activity such as being lost in thought or anxious about being late.

7.1.2.2. Information processing (Diagnosis and Prognosis)

The next stage in the driving task is for the driver to process the information s/he has perceived. This is the Diagnosis and Prognosis stages of the driving task and failures can occur at either stage. The driver has to work out the significance of what they perceive.

Failures in Diagnosis include making errors in the evaluation of:

- the difficulty involved in negotiating the road infrastructure e.g. how sharply the road bends;
- speed and path of other vehicles e.g. when there is a big enough gap to pull out of a junction;
- The conventions about negotiating a particular section of road e.g. who should give way at an intersection;
- Another road user’s intended manoeuvre e.g. another vehicle makes a turn without indicating.

Based on their diagnosis of the situation, the driver will make a judgement about what is going to happen next.

Failures in Prognosis are when the following expectations are not met:

- Expecting another road user not to perform a manoeuvre e.g. a vehicle without priority giving way;
- Expecting another road user to perform a certain manoeuvre based on the driver’s understanding of the correct thing to do in a situation;
- Entering the space of another road user with the expectation that another road user will not occupy it. E.g. entering the opposite carriageway to overtake a vehicle.

7.1.2.3. Decision-Making

The fourth stage is for the driver to decide what manoeuvre to perform based on his/her prognosis of the situation. Failures in the Decision Making stage are considered to be ‘violations’ that is deviations from the behaviours which could be expected from the majority of road users:

- Due to the characteristics of the roadway environment, the driver is forced to decide on a risky manoeuvre to negotiate the specific situation e.g. a driver has to decide to pull out of a junction with restricted view due to a sight obstruction;
- Deciding to perform a manoeuvre despite the safety risks involved e.g. speeding due to lateness or driving less carefully due to the influence of friends;
- Deciding to perform a manoeuvre without taking necessary precautions due to relying on another road user e.g. a passenger states that a road is clear.

7.1.2.4. Taking Action

The last stage of the driving task is to correctly execute the planned manoeuvre by correctly operating the controls of the vehicle. Two types of failure are identified for this stage:
The driver is unable to control his/her vehicle due to environmental events such as an icy road or a wasp in the passenger compartment or mechanical defect such as defective brakes;

The driver allows the vehicle to take an incorrect trajectory due to the distraction of another activity such as tuning the radio or talking to a passenger.

7.1.2.5. Overall Capacities

The HFF method also defines failures that directly relate to overall capacities of the human. The affect the whole function chain and include loss of psycho-physiological capacities (e.g. falling asleep, loss of consciousness), the alteration of the sensory-motor and cognitive capacities (e.g. drug/alcohol impaired) and overstretching of the cognitive capacities (e.g. infrequent driving, age).

7.1.3. Degree of Involvement

The HFF method also distinguishes between the different degrees of involvement of the road users. The Primary active road user is the road user whose action triggers the sequence of events or actions which lead to the crash. The Secondary active road user although not initiating the conflict, has direct involvement by not taking action to prevent the conflict. In this case the context of the situation should have given the secondary active road user enough information to predict the conflict. A Non-active road user is one who is confronted with the action of an active road user and this action could not have been easily predicted given the context of the situation. The final type of road user is ‘Passive’. This road user is part of the crash scenario but was not able to play any active role as they had no opportunity to predict the actions of others e.g. if a driver was stationary at traffic lights and was hit from behind by another road user.

7.1.4. Linking Contributory Factors to Failures

Grids of contributory factors were also developed as part of the TRACE study, to be used alongside the classification model of human functional failures to determine typical failure generating scenarios. The grids were developed using current accident causation systems included in existing data collection systems from countries across Europe. Three categories of factors were addressed:

- User (Human);
- Environment;
- Vehicle (Tool).

The User category of factors is described as any factors related to the individual and personal demographic. This includes any physical and psychological disorders that may be of relevance or any psychosomatic states that the user may have incurred through alcohol or misuse of drugs or emotional/motivational states. The user is defined as any human in charge of a vehicle within the accident (e.g. driver, motorcyclist, cyclist) or any pedestrian injured in the accident, and is described as a ‘road user’.

Three main subcategories of user factors were identified, as follows:

- User State;
- Experience;
- Behaviour.

The environment category encompasses all aspects related to the users’ surroundings (i.e. external to the vehicle and road user). Six categories of environment-related factors were defined:
– Road Condition;
– Road Geometry;
– Traffic Condition;
– Visibility Impaired;
– Traffic Guidance;
– Other Environmental Factors.

The Vehicle category involves the equipment or devices the user is interacting with in the task. The subcategories developed to deal with the vast array of tools were:

– Mechanical: Vehicle failures which directly affects vehicle control;
– Maintenance: Anticipated vehicle fault, indirectly affects control of vehicle;
– Design: Design of vehicle affects safe/efficient operation;
– Load: Did a vehicle load affect ability to control vehicle?

The vehicle category was developed within the remit of the TRACE project which focused on motorised vehicles and cars in particular. However if would be possible, perhaps with slight modifications, to apply the ‘tool’ category to other vehicles such as powered two wheelers and bicycles.

7.1.5. Typical Situations

Typical pre-accident driving situations were also identified and developed into a grid of situations in TRACE. These were defined as the type of task being performed (e.g. going ahead, turning, overtaking…) and the location the task was performed in (e.g. bend in road, at intersection…).

Closely related to the pre-accident driving situation is the ‘conflict’, which is also identified for each road user in each accident analysed. This is defined as the initial conflict that the road user was faced with prior to an accident (e.g. another road user or object in the road). It is possible for a road user to have no conflict (e.g. losing control of vehicle when falling asleep or unconscious, or being distracted by another task or person).

7.2. Adapting the HFF Methodology to Use as a Model for Evaluating VRU Behaviour

Although this methodology was initially developed mainly to consider drivers in accidents, it could also be adapted to be used as a basis for a model for evaluating vulnerable road user behaviour and its effects on being able to efficiently transfer safety measures, methods and policies to other countries.

For each road safety measure, method or policy identified, a list of potential failures (i.e. potential failure to use properly and therefore increase risk to safety) could be compiled, using the categories outlined in the HFF methodology for each type of road user:

For example:

– Pelican crossing. Potential failures:
  - Perception - crossings may not be able to be seen by car drivers from a distance because of excessive visual clutter in vicinity of crossing, e.g. signs, larger vehicles…;
  - Decision making - pedestrians may not wait for red light to cross; pedestrians may ignore crossings and cross at other locations.
On-road cycle lanes. Potential failures:

- Perception - cyclists may not be seen by other road users because of large numbers of HGV's (heavy good vehicles) which use the road;
- Information processing - even when the vehicle traffic lanes are slow moving, cyclists may expect the cycle lane to stay clear and therefore travel at faster speeds, not realising that the cycle lane cuts across minor side roads, therefore increasing the risk of side collisions at the entrance to these minor roads;
- Decision making - drivers may intentionally drive in cycle lanes to overtake slower lanes of traffic.

This is just a small number of examples of how the concepts outlined in the HFF methodology could be used to evaluate VRU issues when considering the transferability of common used European safety measures.

This will be considered further in the remaining tasks in Work Package 2, and discussed in more detail in SaferBrain Deliverable 2.2.

8. Sample of common European Road Safety Measures which have not been extensively transferred, yet

8.1. What has already been transferred?

The level of transferability of a given measure depends on many aspects, belonging to the three main arenas already described, i.e.: the institution, the society and the availability of funding; indeed, the above mentioned “road safety space” concept (King, 2005) is quite conclusive in assessing the relevance of such three areas when importing best practices from developed Countries to the developing ones.

However, examples of good practice gone bad, once transferred, abound because it can be difficult to take into due account such three areas contemporarily. Recurring reasons for such misinterpretation rely on different factors:

- poor safety policies do not steer in direction of consolidated assessment of transferability procedures, resulting thus into a simple transfer of recommended good practices with no assessment at all;
- some measures, being already successfully transferred elsewhere, prevent decision makers from elaborating further local evaluation;
- in many cases transferability deals only with single measures and therefore considerations on transferability under the technical and economic points of view prevail on the assessment of the community acceptance and awareness; in some cases, for some measures transferability assessment seems to be even unnecessary.

The first two issues can be explained because in not “mature” contexts transferability of technologically-advanced measures is often saluted for its potential of progress, but the reality is that being such contexts often compelled to play the role of mere recipients of technologies not locally-developed, they have poor control over them (on the contrary, developed Countries are able both to design and control safety measures). Needless to say, this is an “implant” of measures / know-how and not a transfer, and as long as such an implant process will be reiterated there will be no end to the dependency on developed countries technologies, which can partly explain some criticisms about the from-west-to-east transferability process itself (Mohan and Tiwari, 1998).
The third factor is more difficult to defend since usually affects pure-technological measures, which because of their complexity should call for more careful assessments; for instance transferring ITS measures is usually judged just as matter of technological feasibility and economical affordability. Indeed, since the mission ITS are designed for is to prevent dangerous human actions that can cause crashes at the earliest possible stage, it is taken for granted that end-users will unconditionally accept them. This is typical of developed Countries, where local decision makers “copy and paste” safety technical measures as they expect their communities to be educated enough to acknowledge the need for them. In some cases it works, in some others it doesn’t. For example, in Italy debates on speed camera detectors are endless since drivers consider them as a kind of “fines machines”, not reminding that speeding tickets are the consequences of their behaviours. Quoting such a case is just an example of how still in western Countries, even the most effective safety measures can be misjudged if they are merely “imported” in one place, despite the positive outcomes they could have achieved elsewhere.

From the issues above described it is possible to single out some principles which can help clarifying the “object” of transferability.

Any single measure can be theoretically transferred from one place to another, provided to be affordable and technically/legally feasible in the receptor context; but outcomes can be very unpredictable. There is a plenty of scientific literature of single measures transferred from one city to elsewhere, but even in the successful cases there is no certainty of further positive “replicability”, which paves the way for two general principles:

a) any measure is theoretically transferable, but what makes it potentially transferable is the full availability of technical data about its performance, implementation costs, enforcement of regulatory drivers/barriers and above all information about the level of acceptance among the end-users, which enable decision makers to assess whether the measure has been successful or not. This is the reason why, in the previous section on the definition of the objectives for the TS, the High Level Objectives - HLOs have been divided into two categories: the economic-institutional goals and the social ones.

b) provided to have enough information about the success of a given measure, such a measure can be eligible to be transferred only if consistent with the “road safety space” of the receptor context, which moves the focus on the importance of consistency.

Indeed, consistency calls for a logical coherence among the three domains which constitute the “road safety space”, that is the already mentioned economic resources, institutions and society, between the origin and the target contexts; such a coherence provides a third transferability principle:

c) it is necessary not only to transfer single measures but the concepts behind them, i.e. the political visions supporting them, which means exporting not only technical know-how but also consensus building and (if necessary) fundraising techniques, along with procedures for the long-term assessment of the transferred policies/measures.

Hence, such three principles lead to the importance of thinking about transferability not in terms of single, successful, road safety measures to implant somewhere, but in terms of visions or concepts for road safety whose practical translation is the implementation of packages of multitask measures. Such an approach has been shared since long time by the Asian Development Bank - ADB (1998), which issued the Road Safety Guidelines for the Asian and Pacific Region, recommending direct actions to adopt, according to the following 14 topic areas.

- Coordination and Management of Road Safety
- Road Accident Data Systems
• Road Safety Funding and the Role of the Insurance Industry
• Safe Planning and Design of Roads
• Improvement of Hazardous Locations
• Road Safety Education of Children
• Driver Training and Testing
• Road Safety Publicity and Campaigns
• Vehicle Safety Standards
• Traffic Legislation
• Traffic Police and Law Enforcement
• Emergency Assistance to Road Accident Victims
• Road Safety Research
• Road Accident Costing

For each area, ADB presents specific aspects along with some good practice examples (from both Eastern and Western Countries) envisioning possible improvements consequent to the adoption of funding concepts and itemizing which are the priority actions needed. It is clear that the mentioned measures have been, more or less, already implemented in Europe or in the US but the emphasis is not on the single measure itself but on benefits that a cluster of them can provide the adopting community with. It is also worth stressing that the grey literature available presents a huge amount of case studies with a vast array of safety solutions transferred from developed to developing Countries, which allows to assert that more or less a raft of measures has been transferred or simply implanted, but the problem is to consider the gist and the extent of what has been transferred.

Therefore, it is worth analyzing, starting from the taxonomy proposed by ADB, which are the most relevant road safety actions in Europe, less applied elsewhere but effective, and the related pros and cons of their transferability, with respect to the SaferBraIn tasks. The focus, hence, will be on those ADB topics more affecting safety, namely under the infrastructural point of view; for each of the ADB topic considered, Transferability Study Issues – TSIs will be raised, in order to steer the TS in coherent directions with the SaferBraIn goals, and a general assessment of the topic in terms of Transfer Opportunity to the Case Studies in hand, i.e. Opportunity for the TS – OTS, will be provided. To be noted that the following considered ADB topics and related safety concepts may either have a direct influence on the SaferBraIn TS or just affect it indirectly; in any case, any of the issues further described are able to enlarge the vision of the TS itself.

8.1.1.  Coordination and Management of Road Safety

It is acknowledged that the coordination and the management of road safety, from central to local levels, are crucial to optimize efforts and achieve sound results. In western Countries, national agencies are active since long time and the lesson learned from some of the most advanced experience is to have comprehensive visions behind political choices and technical solutions.

Examples as the Swedish Vision Zero (Vägverket, 2006) or the French Ville plus sûre, quartiers sans accidents (Greze, 1994) are expressions of political will and technical expertise merged into one coordination and management program, at national level and applied diffusely across each Country, so to have nationwide results.

In developing Countries, national and local bodies involving in the management of road safety are active, too but the World Bank (2009a) advises: “In South Asia, governments so far have been slow to cope with the growing level of traffic. Setting up agencies with a separate budget and the power to enforce regulations to address road safety at an institutional level would be an important step forward”. But such a concern is not limited to South Asian regions as the World Bank (2009b) in promoting its World Bank Global Road
TS1. Manifold best/good practice examples are available in the SaferBrain Case Studies Countries, which are worth to be considered when importing innovative safety concepts, given the importance of the recipient context features in the TS. But what has been already done “in house” and what is going to be transferred from abroad must be coherent with the national road safety common trends and ascribable within national Coordination and Management of Road Safety programs. A goal for the SaferBrain Case Studies could be to contribute updating national visions (or creating new ones) and fostering the national safety agencies’ role.

OTS1. Under the theoretical point of view, transferability of measures on coordination and management of road safety would be highly appropriate, but under the practical point of view, the need of time and resources for the whole process could not be compatible with the SaferBrain tasks.

8.1.2. Road Accident Data Systems

Dealing with data is a sensitive task because of its two-pronged scope: on the one hand, to collect the biggest amount of data and information on accidents and, on the other, to process such information in order to produce reliable indicators to monitor the accidents trends.

The first scope is centred on information collection and related data entry which constitute the accident recording and storage systems; the second scope is generally focused on data processing and analyses elaboration, whose optimal consequence should be the dissemination of the outcomes among planners and decision makers.

For what concerns the first issue, the most relevant problem is to have reliable and comparable data which calls for a standardization of procedures concerning technical tasks as data recording and storage. In Europe, such a standardization is an on-going process: it started with mere practical aspects (as, for instance the recording forms homogenization, the agreement on what kind of data were to collect or the training of the recording officers, etc.) among the different Countries, to proceed towards more advanced issues, as the need to use GIS to improve the quality of information.

The core of the second issue is the use of indicators to monitor safety trends; even in developed Countries very advanced safety indicators (as for instance those from the SUNFLOWERS program, as reported by Morsink et al., 2007), cannot be used because there are no reliable data to “feed” them or it is too complex to process them; so, typically, very basic safety indicators are used, providing only general information. Such uncertainty leaves the problem of selecting reliable and shareable indicators still unsolved.

Data process standardization among non EU-Countries can be considered as a non relevant issue unless specific demands have to be met; this explains why, on the one hand, current data available are enough to feed general comparative statistics (as for instance in WHO, 2004), but on the other their total inappropriateness when the focus is on events occurring on different kinds of roads, environments, specific periods, etc. And of such unsuitability ADB (1998) is particularly aware since it stresses not only the importance of standardization, but also the scarcity of related good practices in the Asian regions. Planzer (2005) is on the same page for what concerns the need of standardization for Latin American Countries, and
she raises two further interesting issues: that accidents rates may differ among Latin American Countries also because of difference in the data collection and that there are different calculation parameters for social costs between developing and developed Countries, which remind the problems of the not comparability among advanced indicators; indeed Planzer states that in developing countries, the valorization of accidents social costs is based on the “Human Capital Method”, whereas in developed Countries is used the “willingness to pay” approach, which assesses social impacts starting from higher costs both for injured and dead victims. Consequences in terms of underestimation of the amount of events are clear, also if the problem of under-reporting (Baguley, 2001) is considered; in many European Countries under-reporting, especially in case of minor accidents, is still strong and no direct countermeasures are available to transfer.

TSI2. Standardization is a long-time process, but it can start from apparently minor issues as the import of recording forms, already used in Europe, and an assessment whether they match to the locally used ones, as a measure to ensure comparability of results, especially in the event of cross-cases comparison.

OTS2: under the technical point of view, transferability of measures on safety data collection (namely forms to be used, training of recording officers, data analysts) should be highly recommendable.

8.1.3. Road Safety Funding and the Role of the Insurance Industry

Road safety funding is a multifarious domain since involves very different bodies (public and private) and may be based on very different methods (from national levies to charity programs). In Europe the most important roles are played by single nations, which fund national safety programs, and the European Commission, which does the same for all the Member States. Insurance companies seem to keep a very low profile on that and in general are not willing to draw any attention; not to mention that it could be very difficult to obtain any kind of data from them, which on the contrary could turn to be very important to improve the usual “accidentology” analyses. That’s why insurance companies role in safety issues is limited to few actions, many of them one-off, as provision of money to support research and advertisement campaigns or lobbying for change. Not to mention that the problem of insurance increasing costs due to the occurrence of an accident induce many drivers to avoid reporting the event, contributing to the above mentioned under-reporting problems

However, besides some isolated cases (for instance in Finland, a road safety tax has been levied on compulsory vehicle insurance for about 40 years) funds raised are used to finance many activities in the field of road safety and because of a very strong but peculiar body as the European Commission, the consequent concept to export is to create a regular practice for fundraising either at public or at private levels.

TSI3. The problem of road safety funding is beyond the SaferBrain tasks, but the funding options according to which the Case Studies could be in future maintained and managed should be at least theoretically envisaged.

OTS3: Even the possibility to introduce safety-dedicated taxes should be very careful assessed by local/national decision makers.

8.1.4. Safe Planning and Design of Roads

In many European and North American Countries the long time design practice and implementation of infrastructural measures planned to solve safety problems contributed to consolidate a series of safe planning concepts most of them based on the modification of the infrastructure features, by a plethora of very different measures. Key concepts of safe planning are:

- Road hierarchy
Coherence with land use development patterns
Provision of facilities for any mode
Management of conflicts among modes

which are focused on turning roads into safer environment, both in urban and rural areas.

The translation of such concepts into practical measures is based on design solutions which take care of the following infrastructural aspects:

- Speed limits
- Cross-section design
- Sight distance
- Road signs and markings
- Safety fencing and barriers
- Lighting
- Management of roadside obstructions (vegetation, signage, urban furniture, etc.)

All of them are strictly interrelated since the bad/good design of one aspect may affect the efficiency of the others or, in other words, from the performance of the one depends the performances of the others; such considerations are valid both for links and nodes of the road network. The synergic consideration of all these aspects is strictly a matter of road design, but other devices as Intelligent Transport System – ITS or Decision Support Systems – DSS may integrate such traditional road design practice.

For what strictly concerns the infrastructural design, the traffic calming concept includes all these aspects and this explains its success across Europe and North America, where it started to be implemented on a regular basis more than 20 years ago, with the aim of slowing down car traffic, increase collective and non motorized modes and eventually improve liveability in residential areas. The core of the design is to modify the vertical and the horizontal alignment of roads to decrease cars speed, avoid through-traffic, accommodate non-motorized modes by providing appropriate facilities and re-design conflict areas; accordingly ITE (quoted by Lockwood, 1997) defines traffic calming as “the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users”.

Traffic calming measures can be focused either on motorized modes or on vehicles (as in the U.K. taxonomy described in Appendix A) and in some cases they prove to be really effective but not accepted by the people (which is typical, for example, of footbridges or underpasses in secluded, residential areas, where pedestrians tend to avoid them because of security reasons); in some other cases they may rise conflicts among the different users (as, for instance, some kind of low bollards which are not detectable by white canes, turning thus into obstacles for blind users).

Such problems prompted infrastructure designers and traffic planners to assess the suitability of each measure under the point of view of the different road users and progress toward more efficient and advanced multi-measures schemes, including dedicated regulations and design specifications, combined urban rehabilitation and traffic management programs, along with user participation processes. Nowadays traffic calming has become a real design philosophy to tame traffic and create non-motorized modes realms (the so-called Woonerven, Zone 30s, Zone 20s, Home Zones, shared spaces, etc.), to which corresponds high levels of acceptance among the end-users and political willingness, being not only the accident reduction a reality, but also the improvements of air quality and of security not negligible. Traffic calmed environments (which never exceed the neighbourhood size) are usually recognizable by drivers who have the perception of being guests in a place where pedestrians and cyclists are the hosts. It is clear that the stronger such feelings have to be, the highest should be the level of beautification of the road environment. Indeed, infrastructural solutions to slow car speed may have their performance enhanced by
appropriate placing of vegetation, urban furniture, different quality of lighting, etc. Hence the motto could be "basic design ensures safety but coupled with streetscaping ensures liveability". The successful experience of the so-called Community Streets in Japan (Odani and Yamanaka, 1990:392) can prove that.

Ewing (1999), Wegman and Aart (2006) and many others stress however that to have successful stories the "3Es - education, enforcement and engineering" approach is unavoidable, which raises again the issues of the expensiveness of most of traffic calming programs (at least at their initial stages of implementation) and link them to other topic areas listed by ADB as the "Road Safety Education of Children" (further detailed) and "Traffic Police and Law Enforcement". Enhanced police enforcement, speed displays, community speed watch programs are typical examples of accompanying measures, along with other activities as submission of questionnaires or, creation of focus groups among the residents.

The up-scaling at urban level of traffic calmed areas calls for a general revision of the safety programs at city level, namely to avoid congestion, which upgrades the level of intervention to the traffic management field, entailing more complex activities as traffic control, parking and transit management, traffic monitoring, etc. ITS role in this field is very important, since the possibility of improving safety by properly managing the traffic flows across the whole city network is enhanced by two points of strength of ITS: flexibility (as adaptation to circumstances) and dynamicity (as changes in real time).

By ITS the possibility to improve safety is obviously at a different level, from that of the simple infrastructural design. Wegman and Aart (2006:100) describe three levels of automation ITS may be involved into: the intervening ITS (concerning on-board operations, with part of the driving task is taken over by ITS devices and the driver informed accordingly); the warning ITS (still mostly for on-board operations, when the system alerts the driver and in case of no-reply the alert is magnified) and then the informing ITS (i.e. the provision of information both on-board and on-street). It is clear that as long as the focus is on the infrastructure the most relevant ITS for safety are the informing ones and especially those aimed at solving conflicts between motorized and non-motorized modes as count-down green at traffic lights, sensors to adapt green/red phases according to pedestrians walking speed; at homogenizing travel speed (as Variable Message Signs – VMs, Split Cycle Offset Optimization Technique – SCOOT or dynamic advisory speeds, also known as "green waves"); at preventing illegal behaviours (as the cameras system in Singapore, the so-called J-eyes - Junction Electronic Eyes)

But when it comes to more comprehensive solutions as those to prevent risky road use (as drink driving or seat belt interlocks smart cards applications) or dangerous actions in the traffic (as the Lane Keeping System – LKS or Intelligent Speed Assistance – ISA, just to mention some of the most well-known ones) the level on involvement switches from infrastructure to individuals and vehicles, and the complexity of implementation raises as well. This is the reason why ITS in Europe are limited only to "mature" contexts as it is for DSS which require not only skill and expertise for their use but also advanced road management and design practice.

TSI4a. Planning and design safer roads is maybe the most difficult task since it entails very different aspects; from what described above main features are the design of roads to slow down traffic, namely by traffic calming programs at local level (neighborhood) and the increase of the safety level by upscaling such interventions at city level and combining them with more complex ones as streetscaping, traffic management, use of ITS and DSS.

For what concerns the possibility to transfer one or all of the above, it is useful to consider some not negligible factors.

Traffic calming measures are based on traffic patterns typical of western urban areas, very different from those of the developing Countries, which tend to be used by more
diversified fleets (and namely more two/three-wheelers and animal traction vehicles) and in a more mixed way among motorized and non-motorized modes. Design specifications based on vehicles size and hierarchy of roads based on motorized traffic flows typical of industrialized Countries are to be taken into account, too.

Accordingly, a first issue to consider is, hence, the need to adapt specifications and design prescriptions to traffic patterns typical of developing Countries and check whether traffic calming measures may be still be applicable. This could allow to switch from the trial level, typical of many traffic calming implementations (see for instance the Jaipur case studies in Hyder et al., 2008) to the development of more comprehensive traffic calming programs; but above all, it may allow to upgrade from single safety measures to more comprehensive safety concepts, also fostered by educational and enforcement activities. Scarcity of available resources (already mentioned when dealing with the problem of funding) is another important issue to consider, since traffic calming requires interventions at a larger scale than on-the-spot solutions; and moreover, even though considering single measures as some pedal cycles or pedestrian focused measures based on the use of traffic lights (pelican/puffing/toucan crossing), resources for maintenance may be difficult to find (for instance Kings, 2005:100 advises against the transfer of traffic lights devices in contexts where traffic light compliance and enforcement are poor, if not integrated by an enlargement of aims, namely change to enforcement priorities due to the new signal installation, as an adaptation to the local context).

A third issue to assess whether traffic calming program may be transferable or not is to consider the contexts of application: is streetscaping possible in the receptor context? This is not only a matter of resources usable for re-shaping streets but a matter of coherence and safeguard of the receptor built environments.

TSI4b. Same problems for transferability are valid when dealing with ITS, too. Van Niekerk, Anderson and Vorster (2005) advise against the use of ITS as long as priorities are different: “The deployment of ITS in an environment where poverty and other social needs (education, health and housing) will always be given priority, presents specific challenges. If ITS deployment agencies do not ensure that their ITS programme create job opportunities and lead to other social benefits, their initiative is likely to fail. Specific care should be taken that the introduction of technology does not lead to any loss in jobs”. Indeed, ITS seem to be replicable everywhere under the technical point of view, unless of problems related to the collection of timely, reliable and accurate data about traffic flows and road conditions. But their recurring deployment in “mature” contexts may raise more than one objection when it comes to their implementation in other areas with different priorities which could steer decision makers towards less sophisticated and expensive safety countermeasures.

The use of DSS may be debated in the same way; DSS have a wide range of applications and unless of technical problems are transferable everywhere; there are no lessons to be learned about their transferability, but sound reasons are needed to fund such systems when local priorities steer in other directions.

OTS4. It is highly recommended to envisage the possibility to import comprehensive traffic calming programs (not single solution) since they represent, at a basic level, one of the less expensive countermeasure to mitigate safety conflicts, provided to resolve the above mentioned design standardization problems. On the spot traffic surveys, questionnaires among drivers and residents may help adjusting such specifications.
8.1.5. Improvement of Hazardous Locations

Outcomes from two of the above mentioned issues, i.e. “Safe Planning and Design of Roads” and “Road Accident Data Systems” merge in such topic area. Indeed a good analysis of accidents recurring locations may reveal black spots across the road network and prompt road planners and designers to implement suitable countermeasures, which are usually based on the revision of the road features (by traffic calming techniques or by the implementation of traditional devices as for instance traffic lights) or even by the deployment of more advanced tools as ITS.

In past time, the improvement of hazardous location was a “step-by-step” process: starting from single sites, then considering more sites with common problems (typically along a route), now intervening according to area-wide schemes, for which also constant monitoring activities are planned too.

**TS15a.** Black spots analyses become more and more important but even more important is to plan a set of countermeasures with common “qualities”: a small palette of recurring solutions, equal levels of perception for the drivers, same level of enforcement in order to have likeness of treatment at city level. This is very difficult to achieve and hence very difficult to transfer as well. In Europe, very few urban areas reached such level of homogeneity and among them it is worth mentioning the Chambery (France) case.

**TS15b.** The integration of results coming from a “traditional” analysis of black spots (i.e. under the infrastructural point of view) with those coming from the application of the HFF methodology for evaluating the VRUs behaviors at those hazardous locations could provide an improved knowledge of the failure patterns.

**OTS5.** Area wide treatments of hazardous location is recommended at least at district level for the SaferBrain Case Studies in hand.

8.1.6. Road Safety Education, User Needs Analysis and Participation Process

Needless to say, educational programs are of the utmost importance to raise the public awareness of safety problems, especially if dedicated to the most vulnerable categories of users. In many European Countries inclusion of road safety in the school curriculum appropriate to each age group is a long time reality and the development of classroom materials or training of teachers are regular activities. But educating children should be part of a more comprehensive participation process in which end-users and decision-makers partake solutions, starting from the analysis of the real user needs, which is the only way to assess whether what planned or designed may meet the actual users requirements.

Involving road end-users (motorized or not) is a difficult task since it requires skill in sampling, continuity of contacts, information, explanations, but above all the search of the appropriate medium to make the exchange of opinions a fruitful measure. Indeed, not all users are keen to participate in group activities nor may be able to properly express their needs (which are typical of children, teenagers, elderly people, and physically challenged users). Therefore, it is necessary to make end users at ease while expressing their needs and confident that what they say will be really taken into account. Usually focus groups, interviews (either vis-à-vis or by phone), questionnaires, residents panels are the most recurring procedures to detect what people expect; but the “have-your-say” approach may be difficult in case of secluded users groups, i.e. people who do not have a central role in the community life but are more exposed to traffic risks.

This is the reason why usual procedures as interviews and focus groups have been more and more integrated by other techniques as mental maps and “walkability” lists (the latter designed first in the US since the 1990’s) dedicated to users who may prefer “solo” medium to express their need. Mental maps are easily usable both by children and elderly who may
find easier to sketch their way home/school and highlight the aspects they perceive as more
dangerous or safer; the walkability lists are actually multiple answers checklists in which
users choose the more appropriate answers to define problems characterizing their everyday
walks, and therefore is more appropriate to analyze non-motorized users requirements.

A recent technique which mixes traditional way of collecting information and innovative
assessment of the people needs has been developed during the recent EC-funded project
MIRACLES in Rome (Musso and Corazza, 2006); even though the project was aimed at
assessing how Romans perceived sustainability and not safety, the procedure may be easily
adaptable. One of the MIRACLES tasks was to organize a survey among the Romans to
collect preferences and opinions on the project sustainable measures implemented in the
city; usual interviews and focus groups activities have been supported by a theoretical model
based on a psychosocial approach, the Emotional Text Analysis - E.A.T. methodology. According
to this approach, users while expressing their opinions tend to use recurring terms
(the so-called “dense words”, with a “strong” emotional meaning) which reveal their personal,
emotional involvement in the problem in hand. The psychologist team in charge of analyzing
such “dense words” and translating them in useful information for the decision makers
provided interesting and non conventional interpretations of some recurring traffic
phenomena, which proved to be very useful to local administrators.

**TSI6.** User needs analysis and participation process are unavoidable activities to
customize transferred issues to local situations. Even activities on a small scale,
whatever the medium, may turn to be seminal when solving problems in sensitive
areas

**OTS6.** The use of innovative measures as walkability lists and mental maps could be
an added value to the usual user needs analysis.
Table 7: Main safety concepts less used in the target contexts.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Main actions/concepts</th>
<th>Lesson learned from Europe</th>
<th>Positive influence for SaferBrain case studies</th>
<th>Negative influence for SaferBrain case studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination and Management of Road Safety</td>
<td>Fostering strong, self-standing national bodies in charge of creating general road safety policies</td>
<td>Creation of national visions for road safety endorsing choices and actions</td>
<td>Coherence of contents and comparability of results at national level</td>
<td>None</td>
</tr>
<tr>
<td>Road Accident Data Systems</td>
<td>Data recording, Data storage, Data process for indicators, Dissemination activities</td>
<td>Importance of data standardization</td>
<td>Data standardization helps comparing results</td>
<td>None</td>
</tr>
<tr>
<td>Road Safety Funding and the Role of the Insurance Industry</td>
<td>Fundraising for road safety</td>
<td>Road safety tax</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Safe Planning and Design of Roads</td>
<td>Traffic calming, ITS, DSS</td>
<td>Importance of planning a mix of measures, supported by enforcement, education and engineering activities</td>
<td>Possibility to switch from the single countermeasure implementation to a more comprehensive packages of solutions in order to create safer environments</td>
<td>Traffic calming may not be used if not adapted to local traffic patterns and built environment features, ITS and DSS may not be accepted</td>
</tr>
<tr>
<td>Improvement of Hazardous Locations</td>
<td>Black spot analyses</td>
<td>Importance of area-wide assessment, HFF methodology to list potential failures</td>
<td>Possibility to consider not just spot events but to run analyses at district level</td>
<td>None</td>
</tr>
<tr>
<td>Road Safety Education of Children</td>
<td>User need analyses (mental maps, walkability lists)</td>
<td>Design starting from user needs</td>
<td>Possibility to &quot;customize&quot; transferred safety concepts to the local &quot;road safety space&quot; features</td>
<td>In case of no check/participation with end users, acceptance could be very low</td>
</tr>
</tbody>
</table>

9. Summary and Conclusions

The Deliverable D2.1 – Interim Report on Transferability shows the status of the Work Package 2 development up to date. It reveals in very detail the meaning of transferability including the philosophy behind and the "road safety space" qualitative concept for transfer.

Furthermore, it shows the concept of transferability in the policy related context with practical implications and a customization to the needs of SaferBrain.

Moreover, a model for evaluating the role of human factors in determining the efficient transfer of Vulnerable Road User Safety Measures has been introduced.

This gives a sound theoretical and technological approach for further research and development in Work Package 2 which will finally lead to a commonly accepted Transferability Audit and a associated curriculum respectively.
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11. Appendix A: Road Safety Measures for Vulnerable Road User Safety

11.1. Pedestrian focused measures

The following safety measures are aimed predominantly at all pedestrian. These safety measures are usually found at locations where high pedestrian / motor vehicle conflicts are likely. The safety measures are installed at a road network to assist vulnerable road users in crossing the carriageway.

11.1.1. Tactile paving

Designed to assist visually impaired pedestrians, tactile paving is used on the pavement to highlight crossing facilities on the carriageway. There are standard specifications for installing tactile paving which the target pedestrians are aware of to assist them further. The colours vary but there is a requirement for a contrast between the tactile paving surface and standard paving material, along with the unique textured surface this is usually used with dropped kerbs.

Advantages / Disadvantages

- Aimed at visually impaired pedestrians.
- Various range of colours available to compliment different urban themes / designs.
- Must be installed correctly by a standard method so visually impaired pedestrians know what to expect and also to prevent trip hazards or difficulty with wheel chairs.
- Very little if any continued maintenance required.

11.1.2. Footway build-outs / Kerb extensions
Ideally footway build outs are positioned as near to a line of desire for pedestrians as possible as this safety measure offers little obvious assistance to pedestrians. The major benefit of this design is to increase visibility for both pedestrians and motorists. The main benefit for motorists is by increasing the vision afforded to the driver of any pedestrians potentially crossing the carriageway. Footway build outs are commonly found where on-street parking is permitted or as part of a chicane or priority narrowing systems as this decreasing the width of carriageway pedestrians are required to cross and in turn the potential for conflicts.

**Advantages / Disadvantages**
- Increases visibility of traffic on the carriageway and vice versa.
- No routine maintenance required.
- Ideally used in conjunction with bollards to prevent parking on the build out.
- Can use a lot of space and care should be taking in the positioning.

### 11.1.3. Dropped kerbs

![Dropped kerbs](https://www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm)

Used in conjunction with a variety of safety measures, dropped kerbs can also be used on there own for crossing points or private driveways. They increase the ease of access for wheeled items, such as wheelchairs, pushchairs or shopping trolleys.

**Advantages / Disadvantages**
- Aimed at especially vulnerable pedestrians, wheelchairs and prams.
- Also advantageous for pedal cycles where appropriate.
- Can create trip hazards for pedestrians continuing along the footpath and not intending to cross, especially in icy conditions.
11.1.4. Pedestrian refuges

(Source: www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm)

The intention of a pedestrian refuge is to break up the carriageway into multiple parts, allowing pedestrians to stop and wait for traffic to pass in each section. Usually installed with dropped kerbs and tactile paving, pedestrian refuges can only be installed on wide carriageways. This safety measure also relies on good visibility for both pedestrians and motorists, although the narrowing effect created on the carriageway tends to naturally slow motorists down.

Advantages / Disadvantages
- Pedestrians can be masked by the lit bollards especially during the hours of darkness.
- If there are large numbers of pedestrians or cyclists attempting to use the facility, there can be a lack of space on the central refuge.
- Other than replacing bulbs in the lit bollards the only maintenance issue is the high damage record expected from overtaking motor vehicles or large good vehicles.

11.1.5. Zebra crossing

(Source: www.idgo.ac.uk/.../Pedestrian_Crossings.htm)

Zebra crossing are non-enforced crossing points, the crossing is highlighted by Belisha Beacons (orange flashing lights) the motor vehicle is required to stop for any pedestrians wanting to cross the carriageway. Zebra crossings are usually found where the pedestrian traffic volume is not especially high and the carriageway speed is fairly low. The design of the
crossing relies on both parties using it correctly. These crossing can also be broken by a pedestrian refuge in the centre of the carriageway allowing traffic to flow until pedestrians reach the associated section.

Advantages / Disadvantages
• Vehicles are prevented from parking on the zig zag lines either side of the crossing, meaning this style of crossing requires a large amount of space and should not be used where parking is limited.
• Simple to install and maintain.
• Limited safety for pedestrians as it is drivers’ judgement to stop.

11.1.6. Pelican crossing

A traffic control and automatically controlled pedestrian crossing system, a pelican crossing eliminates vehicular and pedestrian conflicts by restricting traffic flow. The red and green pedestrian signal located on the opposite side of the carriageway indicates when it is safe for pedestrians to cross, as vehicular traffic will have been stopped by a red signal. When the green pedestrian signal flashes it is not safe for pedestrians to begin crossing. The pelican crossing was the first signalised crossing to be used in the UK and provides a safer environment for all crossing pedestrians.

Advantages / Disadvantages
• Where there are two staggered crossings separated by a refuge there is a possibility a pedestrian could look at the far crossing and step out into moving traffic.
• Fitted with a turning knob on the underside to allow the visually impaired when it is safe to cross.
• The traffic control signals for drivers give a very definite place to stop and this prevents drivers looking for pedestrians outside of the crossing, therefore a high proportion of pedestrian/motor vehicle conflicts take place within a short distance of a crossing as pedestrians take a short cut and drivers fail to see them as they are looking at the crossing.
11.1.7. Puffin crossing

A similar system to the Pelican crossing where traffic enforcement of red lights allowing vehicle movement through the crossing. The more modern design of the puffin crossing is slowly replacing the older pelican design. The puffin again uses red and green pedestrian signals to show when it is safe for pedestrians to cross, but these are located on the same side as the pedestrians intending to cross. The intelligent user-friendly crossing, using infrared is able to detect the speed of the crossing pedestrians and appropriately match the length of time for the safe signal.

Advantages / Disadvantages
- More modern crossing.
- Fitted with a turning knob on the underside to allow the visually impaired when it is safe to cross.
- Certain pedestrians, particularly older pedestrians which maybe more used to the older design of pelican crossing may be confused by this crossing and attempt to cross on a red signal.

11.1.8. School crossing patroller

The main role of a school crossing patroller is to assist children crossing the road on the main desire lines on route to school. They can be located to assists and educate children at existing
crossings or to create a safe crossing where there previously isn’t a crossing or possibly where they are a high number of crossing children where it would not be possible to install a crossing.

Advantages / Disadvantages
- Aimed at young pedestrians.
- Only tend to work for 30mins in the morning and again in the afternoon.
- Drivers often fail to see or disregard the patroller resulting in collisions with motor vehicles.

11.1.9. Footbridges and Underpasses

(Source: [www.bridgeandtunnelclub.com/.../footbridge/](http://www.bridgeandtunnelclub.com/.../footbridge/))

Both footbridges and underpasses are generally used to allow pedestrians and cyclists to cross major road networks safely. They are more commonly found when the carriageway consists of several lanes in each direction and installing a crossing would create massive traffic flow problems. It is more common to find slopes down to underpasses and up to footbridges as opposed to steps as this allows access for disabled pedestrians and cyclists.

Advantages / Disadvantages
- Aimed at pedestrians and cyclists.
- Expensive to install
- Underpasses can create other dangers to pedestrians due to the secluded nature of the construction.
- Allows traffic to continuing flowing and easy congestion

11.1.10. Pedestrian barrier

(Source: [www.tcf-fencing.com/pedestrian_guardrail.htm](http://www.tcf-fencing.com/pedestrian_guardrail.htm))
Coming in two varieties, standard and hi-visibility, pedestrian barriers or guardrail is used to prevent pedestrians entering the carriageway outside of a crossing.

Advantages / Disadvantages

- Aimed at pedestrians
- Prevents cyclists exiting the carriageway to avoid danger
- There is a debate on the effectiveness of pedestrian barrier with main councils removing it with the view motorists will naturally slow down if there is an increased risk of pedestrians stepping into the carriageway.
- If this barrier is used excessively or on a desire line a certain percentage of pedestrians will climb over the barrier which drivers will not be expecting resulting in serious collisions.

11.1.11. High visibility pedestrian crossings

To obtain a higher visibility of the white strips on the road surface, the background can be treated with paints of different colours (generally red or blue). The results of an Australian study (Corben et al. 2004, in Martin, 2005) an increase of the Time-to-Collision indicator for the conflicts between pedestrians and vehicles was observed, indicating a lower risk for the pedestrians.

Using such pedestrian crossings is recommended in complex environments with many interactions between pedestrians and vehicles, like road with high commercial density.

Particular applications also exist that, using different paint colours, create a tri-dimensional effect.

(Source: www.premark.com)

11.1.12. Lifted pedestrian crossings

The main effect of the lifted pedestrian crossings in the intersections is, like for the speed humps, to reduce the average speed of the vehicles approaching. A secondary effect is instead the traffic reduction on the road where they are placed, with consequent increase of traffic flow on the parallel roads.
The effect on road safety is an average reduction of the accident rate (ratio between number of accidents and traffic entity) equal to about 49% (Elvik e Vaa, 2004). The estimated reduction is not very reliable because in the studies some aspects falsing the real benefits are neglected.

11.1.13. Other measures

- Enlarging the pedestrian pavements
- Installing SOS columns for assistance and emergency
- Verification of the position of the bus stops in order to guarantee a suitable area for the stop
- Verification of the road curvature radius
- To convert the intersection to a roundabout
11.2. Pedal Cycle Focused Measures

The following safety measures are aimed predominantly at cyclists. These are usually found at locations where high pedestrian / cyclists / motor vehicle conflict is likely with these safety measures designed to assist vulnerable road users to either cross the carriageway or keep them safer whilst travelling along the carriageway.

11.2.1. Toucan crossing

![Toucan crossing image](http://www.warwickshire.gov.uk/web/corporate/pages.nsf/Links/1DCC12C3F2E7F61380256C6804B9F9E)

This modern design of crossing is very similar to puffin crossings with the addition of also permitting cyclists to ride across the carriageway.

**Advantages / Disadvantages**
- Aimed at pedestrians and cyclists.
- Can cause conflict with large numbers of pedestrians and cyclists crossing in opposite directions.
- Certain pedestrians, particularly older pedestrians who maybe more used to the older design of pelican crossing may be confused by this crossing and attempt to cross on a red signal.

11.2.2. Pegasus crossing

![Pegasus crossing image]
Another modern design of crossing, the pegasus crossing is very similar in operation as a puffin crossing but are only generally found in conjunction with bridleways.

**Advantages / Disadvantages**
- Will be situated within 3 meters of a Puffin or Toucan crossing.
- Can sometimes be found with high fences on either side of the crossing to prevent the horses stepping into the road whilst waiting for the traffic to stop.
- Not very common and can therefore create confusion with users or none users.

### 11.2.3. On-road cycle lane

![On-road cycle lane image]

Segregated with a broken white line, it is not illegal for motorists to enter or even park within a cycle lane. However, the idea of a cycle lane is to provide cyclists, where the width of the carriageway allows, a lane for them. The cycle lanes tend to extend out further at a traffic control signal to allow cyclists to move further to the offside if they wish to turn right at a junction.

**Advantages / Disadvantages**
- Highlights the increased possibility of encountering cyclists to other carriageway users.
- The network of cycle lanes does not tend to meet up thus forcing cyclists to incorrectly use the pavements or normal carriageways.
- Presents increased dangers when motor vehicles park in the cycle lanes forcing pedal cycles to enter the carriageway or attempt to squeeze past with the live traffic.
11.2.4. Shared foot/cycleway

These schemes remove cyclists completely from the carriageway thus creating a safer environment for VRU. Usually integrated by tactile paving in an attempt to reduce collisions the three lanes are for bi-directional cyclists with the third lane for pedestrians.

Advantages / Disadvantages

- No test/training required for cyclists before use therefore there is the very real possibility they could wander out of their lane resulting in collision with other cyclists or pedestrians.
- Both pedestrians and cyclists in small groups tend to travel side by side, spilling over into other lanes, resulting in conflicts and collisions.

11.2.5. Shared roadway

The general concepts covered by this category of countermeasures are geared toward providing safe, smooth surfaces, good visibility, and appropriate, safe and easy access for bicyclists on all roadways that bicyclists are allowed to use. Appropriate use of this group of tools helps to manage traffic and vehicle speeds suitable to the roadway type and area the roadway serves, outcomes that benefit bicyclists and other road users.

The countermeasures discussed under Shared Roadway will remain applicable in most riding circumstances, even for specialized bicyclist facilities such as bike lanes. Lighting, attention to surfaces and other countermeasures are also important with respect to shared-use pathways. Attention to all of these measures will help to ensure that bicyclists have safe places to ride.
11.2.6. On-road Bike facilities

Bicycles are vehicles and need to be safely accommodated on the streets and roadways. Streets should be designed to accommodate all modes, including motor vehicles, transit, bicycles, and walking. Facilities that are safe, accessible and aesthetically pleasing attract bicyclists. Evidence is increasing that bicyclist safety improves as more bicyclists are part of the traffic stream.

(Source: http://www.bicyclinginfo.org/bikesafe)

11.2.7. Other measures

- Advance of the stop line or spaces reserved to the cyclists at the intersections with traffic lights allowing the cyclists to stop behind the other vehicles

11.3. Motor Vehicle Focused Measures Which Benefit VRU Safety

The following safety measures are aimed predominantly at motorists. These are usually found at locations where there has either been a high collision rate or the average speed is required to be reduced.

11.3.1. Speed tables

(Source: www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm)

As the name would suggest this safety measure consists of a raised level area on the carriageway with a slope either side to allow traffic to enter and exit. They achieve significant speed reduction as well as making ideal crossing areas for pedestrians, is it therefore not uncommon to find zebra crossings on top of the speed table.

Advantages / Disadvantages

- Aimed at all carriageway traffic.
- It is also not uncommon to find zebra crossings on top of speed tables.
• Can create a noticeable level of noise from traffic especially on busy routes or with large numbers of goods vehicles.
• Creates a negative attitude in all motor vehicle users due to the damage caused to vehicles suspension by this design of speed calming measure.

11.3.2. Speed humps and Speed cushions

(Sources: www.streetsblog.org/.../ )

Speed humps coming with various names are full width humps on the carriageway which dictate that all vehicles are required to slow down. Speed cushions are a very cost effective and therefore commonly used way reducing speed in an urban environment. Speed cushions come in a variety of materials some of which can simply be bolted to the carriageway or they can be constructed from asphalt.

Advantages / Disadvantages
• Aimed at motor vehicles, although motorcycles are able to drive between the cushions and larger vehicles tend to straddle the cushions allowing them to maintain speed.
• Can create unnecessary noise in an urban environment
• Cushions are preferred to humps by emergency vehicles due to them being able to straddle the cushions.

11.3.3. Chicanes / Priority Narrowing

(Sources: www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm )
Chicanes can either consist of a series of build outs merely directing two way traffic around a couple of bends or a set of priority narrowing's which give priority to a certain direction. This can depend on the visibility for each direction, although chicanes should only be positioned where there is high visibility for both directions and a lack of driveways.

This safety measure relies on fairly even traffic flows in each direction to reduce the overall speed. Depending on the design it can also be possible to leave a gap in the build out to allow cyclists to continue unaffected and not have to ride around the hazard.

**Advantages / Disadvantages**

- Generally increase the number of collision, albeit damage only or slight injury collisions.
- Can create unnecessary traffic flows problems, especially during rush hour, school leaving times or in busy housing estates.
- Care must be taken in the design to allow space for large goods vehicles to navigate through.

**11.3.4. Vehicle activated sign (VAS)**

( Source: [www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm](http://www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm) )

Unlike static signs that motorist become used to and tend not to see, VAS’s light up and grab most carriageway user’s attention. When triggered the signs can display a plethora of responses from the independent speeds of motorists to warnings of corners or hazards ahead.

The electronic signs are intended to supplement existing static signs and not replace for the simple reason if the electronic sign were to fail there would be a lack of warning to motorists.

**Advantages / Disadvantages**

- Very effective
- Speed displaying signs should only display up to slightly over the limit as motorists can compete to get the highest figure.
- Only useful for localised speed control, for example on a sharp bend or outside a school.
- Speed displaying signs allow motorists to check their own speedometers within the vehicle and this can have a negative effect as manufactures tend to set speedometers a little fast for safety.
11.3.5. Safety / Speed cameras / red light cameras

(Source: www.bbc.co.uk/cambridgeshire/content/articles/2005/03/09/speed_versus_safety_cameras_feature.shtml)

Enforcement cameras are usually in the UK a highly visible device combining a camera with a vehicle monitoring system. These are used to identify the independent speeds of motorists and record the vehicles which are breaching the post speed limit for the carriageway or some other legal requirement such as a red traffic signal.

Advantages / Disadvantages
- Aimed at Motor vehicles
- Forward facing cameras are unable to take pictures of motorcycle number plates
- Very susceptible to being vandalised
- Local motorists soon learn the camera location and only slow down for the camera speeding up in between.

11.3.6. Bollards

(Source: www.leics.gov.uk/index/highways/road_pathway_maintenance/road_schemes/road_safety_gallery.htm)

Bollards have a variety of uses and can be used in conjunction with several other safety measures should as kerb built outs. They are used as a physical barrier to protect pedestrians and highlight where they are likely to be crossing from.

Advantages / Disadvantages
- Aimed at motorists
- Comes in a variety of shapes and materials, some designed to prevent trailers and the rear wheels of long vehicles ‘cutting the corner’ and entering the footpath.
- Can create additional hazards for both footpath users in terms of wheelchairs and buggies users and carriageway users in terms of increasing severity in the event of a collision/loss of control.

11.3.7. Other measures
- Improve road lighting
- Realising sounding bands