Improving the safety and mobility of vulnerable road users through ITS applications [VRUITS] D7.3 Final Exploitation Plan

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IMPROVING THE SAFETY AND MOBILITY OF VULNERABLE ROAD USERS THROUGH ITS APPLICATIONS

Grant agreement n° 321586

Deliverable D 7.3
Final Exploitation Plan

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### Project coordinator

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<tr>
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### Partners

![VRUITS consortium partners logo]

[http://www.vruits.eu]

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## Version history

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<td>European Commission</td>
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<td>EU</td>
<td>European</td>
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<td>FP</td>
<td>Framework Programme</td>
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<td>HMI</td>
<td>Human Machine Interface</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transport System</td>
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<tr>
<td>ITS-G5</td>
<td>Cooperative ITS communication on 5.9 GHz band</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<td>VRU</td>
<td>Vulnerable Road User</td>
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EXECUTIVE SUMMARY

This document is the final version of the “Final Exploitation Plan” as created in WP7: Dissemination and Exploitation. The document gives an overview of the exploitable results of the project, analyses the stakeholders interested in the results, and gives the preliminary plans for several partners to exploit the results.

Chapter 2 briefly gives an overview of the project results as produced in the other work packages. Chapter 3 lists the stakeholders of the VRUITS project result exploitation. Based on these chapters, in chapter 4 the exploitation details are explored based on three target areas for exploitation of the results; being industrial activities, academic interests, and regulatory norms and standards.

From the perspective of industrial activities, one of the benefits of the VRUITS project is the extensive cost-benefit analysis, which can guide specific development activities. In the conclusion, a link is made to the Impact Analysis describing a collection of systems with a positive benefit-cost ratio, as potential starting point for such development activities. Combined with the results from the pilots in the Netherlands and Spain this leads to technical research and developments for devices specifically targeting vulnerable road users. Examples mentioned of concrete developments triggered by the VRUITS project include technologies for portable beacons for VRU’s, and VRU-prepared traffic management equipment.

From the academic point of view, the expertise gained will be used by the partners through scientific publications, offered as expertise in future offerings, and used when developing future products. The pilot analysis and measurement tools as created in WP3 and WP4 will not be offered as separate products, but these and the setup and results as reported in WP5 also can be used in subsequent (follow-up) projects.

Norms and standards are relevant for all stakeholders, as to enable a sufficiently large market to make developments economically feasible. The VRUITS project has triggered several initiatives with respect to standardisation, however the process of standardisation will continue beyond the life time of the VRUITS project. Here both follow-up projects (e.g. XCYCLE) and industry interest are expected to be sufficient to drive the progress of the standards beyond VRUITS. Next to norms and standards, also other actions at EU level are identified in the VRUITS project, helping towards exploitation of the VRUITS results. These are not covered in this deliverable, but are detailed in deliverable D6.2 “Recommendations for actions at EU level and their assessment”.
1. **INTRODUCTION**

This deliverable D7.3 contains the final exploitation plan for the VRUITS project. As such, it is input in the final deliverable D1.2. It is constructed in two phases:

1. A draft version of D7.3, which was submitted to the Commission in May 2015.
2. The final version (this document), with updates and adjournments associated to the results of VRUITS, as updated at the end of the VRUITS project.

D7.3 is based on two earlier deliverables: D7.1 and D4.2.

- **D7.1** is created in the first months of the project. In it, an initial dissemination and exploitation plan is created with the identification of the project’s expected results to be disseminated and exploited. It identifies the different means and timing for the dissemination and exploitation activities within the VRU domain. As such, it contains input from all Consortium partners, in relation also to their geographical regions.

- **D4.2 Architecture for integration of VRUs and draft recommended practices for usability and user acceptance.** This document describes the architecture of cooperative ITS services for VRUs, guidelines for the data to be transmitted and the communication media; assessment of different methods to provide critical information; and recommended practices for the development of HMIs for VRU ITS applications.

This final exploitation plan of the project results can be presented to the internal end-users (design and safety engineers, human factor experts) and to manufacturers/suppliers without restrictions.

Measures regarding the introduction of the products into the market especially related to non-commercial exploitation, as standardisation and measures to be taken at EU level, are addressed in detail in T6.1 and T6.2 and described in D6.1 and D6.2.
2. PROJECT RESULTS

2.1 Results

The project results both in a set of tangible results, as well as in an increased knowledge on the different aspect of VRU safety. The tangible results coming out of the project are:

- **WP5:** Helmond pilot system, consisting of a Road Side Unit with capability of detecting and classifying cyclists and transmitting cyclist data; an in-vehicle system able to assess collision risk between the vehicle and cyclists, and to send warnings especially to the cyclists, the vehicle also being equipped with an AEB-system; and an intelligent bike application with haptic and visual warning to the cyclist. Owner: TNO.

- **WP5:** Valladolid pilot system, consisting of a pedestrian detection system able to establish the number of pedestrians waiting for green light and send the information to a traffic controller which decides whether to extend green phase for pedestrians. An illumination module capable of highlighting the crossing and its surroundings when the presence of pedestrians is detected is also implemented. Owner: CIDAUT.

- **WP5:** Alcala de Henares pilot system, consisting of an upgraded traffic controller able to transmit warnings to drivers, detect pedestrians willing to cross over Bluetooth, and detect pedestrian crossing using camera with additional illumination; as well as of an app for pedestrians providing them information on traffic light status. Owner: SICE.

- **WP3:** several software tools supporting the calculation of the quantitative impact assessments. These tools will not be exploited as separate products, but used in future assessment offerings. Owners: VTT, LTU, ECORYS.

- **WP4:** measurement tools updated for performing the tests: the reaction time measurements for cyclists and the QoS measurements for ITS-G5 communications. These tools will not be exploited as separate products, but used in future offerings by VTT.

For detailed descriptions of the pilot systems, please see the deliverables D5.1 up to D5.3 of WP5. For a description of the software tools and measurement tools, please refer to project deliverable D3.2 (Impact assessment update) and D4.2 (Architecture for integration of VRUs and draft recommended practices for usability & user acceptance).

In addition to these tangible products, during the project expertise and knowledge has been gained by the partners involved in different fields, such as:

- **WP2:** Accident analysis for VRUs; user needs of VRUs; ITS applications for VRUs; safety trends for VRUs; mobility trends for VRUs.

- **WP2 & WP3:** assessment method for safety, mobility & comfort of ITS applications for VRUs; Cost-Benefit assessment of ITS applications for VRUs.

- **WP3:** impact of ITS applications on VRU safety, mobility & comfort.

- **WP4:** interaction between VRUs and cooperative transport systems; Human-Machine interaction for VRUs.

- **WP5:** evaluation of the piloted applications for VRUs.

- **WP6:** recommendations for ITS applications; assessment method and Multi-Criteria analysis of recommendations.
The expertise gained will be used by the partners through scientific publications, offered as expertise in future offerings, or used when developing future products.

Table 1 gives an overview of the different results. The sections 2.1.1 and following introduce the different results briefly. More information on the exploitation plans of the different partners is in chapter 4.
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<th>Foreseen embargo date</th>
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2.1.1 Helmond pilot system

- Its purpose. In Helmond, an Intersection Safety application with Cooperative AEB was demonstrated. The Helmond pilot system consists of a Road Side Unit with capability of detecting and classifying cyclists and transmitting cyclist data; an in-vehicle system able to assess collision risk between the vehicle and cyclists, and to send warnings especially to the cyclists, the vehicle also being equipped with an AEB-system; and an intelligent bike application with haptic and visual warning to the cyclist.

- How the foreground might be exploited, when and by whom: The different components of the systems are still proof of concept.
  - Car – CAEB: Automatic EmergencyBraking (AEB) available on new cars, and has to be extended towards Cooperative AEB. This requires larger scale tests / simulations, investigate business case (impact, CBA).
  - RSU: requires further development required to improve performance, decrease size and costs
  - Bicycle: requires further development to investigate on needs cyclists, and to decrease size and costs of equipment
  - Communication: standardization of the communication messages is an ongoing activity in ETSI.
  - Ongoing; Standardization of communication messages for VRU’s

- IPR exploitable measures taken or intended
- Further research necessary, if any: see above
- Potential/expected impact (quantify where possible)

2.1.2 Valladolid pilot system

- Its purpose: In Valladolid, an intelligent crossing was demonstrated. The Valladolid pilot system consists of a pedestrian detection system able to establish the number of pedestrians waiting for green light and send the information to a traffic controller which decides whether to extend green phase for pedestrians. An illumination module capable of highlighting the crossing and its surroundings when the presence of pedestrians is detected is also implemented.

- How the foreground might be exploited, when and by whom: The Intelligent Pedestrian Detector will be commercialised as a commercial product, Countrust. The actuation of the traffic lights can be adapted to the specific requirements of each crossing.

- IPR exploitable measures taken or intended: none

- Further research necessary: actuation of traffic lights can be adapted to the specific conditions of each crossing, although in-depth analysis of these conditions will be required. Different potential actuations (not covered within VRUITS project) could be enabled with the data provided by the IPDs if more research is performed: these actuations include extension, shortening and cancellation of pedestrian green phase according to the number of pedestrians waiting or approaching. Finally, additional research is deemed to be necessary for smarter global traffic lights actuation, which can integrate additional systems as vehicle detectors.

- Potential/expected impact (quantify where possible): -
2.1.3 Alcalá de Henares pilot system

- Its purpose: In Valladolid, an intelligent traffic controller was demonstrated. The Alcalá de Henares pilot system consists of an upgraded traffic controller able to transmit warnings to drivers, detect pedestrians willing to cross over Bluetooth, and detect pedestrian crossing using camera with additional illumination; as well as of an app for pedestrians providing them information on traffic light status.

- How the foreground might be exploited, when and by whom: The expertise gained from the pilot system allows the improvement of SICE’s range of solutions in urban traffic: State of the art traffic controller MFU-3000 (http://www.sice.com/sites/default/files/dc-hr-tu-mfu_v05.pdf). Work in the VRUITS project has helped to the development of the new SAFECROSS 2.0 (http://www.sice.com/es/safecross-20) platform that pools most of the elements of the Alcalá de Henares Test Site

- IPR exploitable measures taken or intended
- Further research necessary, if any
- Potential/expected impact (quantify where possible)

2.1.4 Tools for quantitative safety and mobility & comfort assessment

- Purpose: In WP3 tools were developed for the quantitative assessment of safety and mobility & comfort, based on the method developed in WP2 and to perform the quantitative assessment.

- Exploitation: the tools developed in the project will be used by the partners in WP3 work packages in their future offerings, such as consultancy activities, for performing further assessments.

- IPR exploitable measures taken or intended: none
- Further research necessary: needs for further research were identified during assessment activities in WP3 and are reported in D3.1 and D3.2.

- Potential/expected impact (quantify where possible): -

2.1.5 Measurement services for ITS-G5

- Purpose: in WP4, VTT used the Qosmet tool, which was developed prior to the VRUITS project by VTT, for measuring the performance of ITS-G5 communications. The tool allows to measure the range, latency and packet delivery rates of ITS-G5 communications. VTT also developed a system for measuring the reaction times for cyclists in WP4.

- Exploitation: VTT will use the expertise gained in their commercial offerings.

- IPR exploitable measures taken or intended: none
- Further research necessary: none

- Potential/expected impact (quantify where possible): -
2.1.6 **Accident analysis for VRUs, user needs, ITS applications and their impact, safety and mobility trends**

- **Purpose:** Work in WP2 and WP3 resulted in an increase in knowledge regarding both the safety of VRUs (critical scenarios, underreporting, accident trends) and mobility and comfort of VRUs (factors affecting comfort and mobility, trends), as well as in how, in which ways and to which extent ITS applications can improve safety, mobility and comfort of VRUs.
- **Exploitation:** the experience gained in the work will be used by the partners in WP2 and WP3 in their future offerings, such as consultancy activities.
- **IPR exploitable measures taken or intended:** none
- **Further research necessary:** the research performed has assisted in identifying gaps in current research and shortcomings of current data collection methods.
- **Potential/expected impact (quantify where possible):**

2.1.7 **Assessment methods for safety, mobility & comfort**

- **Purpose:** In WP2 methods were developed for the assessment of safety and mobility & comfort of ITS applications.
- **Exploitation:** the methods developed in the project will be used by the partners in WP3 work packages in their future offerings, such as consultancy activities.
- **IPR exploitable measures taken or intended:** none
- **Further research necessary:**
- **Potential/expected impact (quantify where possible):**

2.1.8 **Cost-benefit assessment methodology**

- **Purpose:** In WP2 methods were developed for the cost-benefit assessment of ITS applications.
- **Exploitation:** the methods developed in the project will be used by the partners in WP3 work packages in their future offerings, such as consultancy activities.
- **IPR exploitable measures taken or intended:** none
- **Further research necessary:** needs for further research were identified during CBA activities in WP3 and are reported in D3.1 and D3.2.
- **Potential/expected impact (quantify where possible):**

2.1.9 **Integration of VRUs in Cooperative ITS systems**

- **Purpose:** In WP4 research has been performed on how VRUs can be integrated in cooperative systems. An architecture has been developed, and the requirements for devices have been outlined. The work is continuing with the standardisation of C-ITS for VRUs by ETSI in TR 103 300.
- **Exploitation:** the experience gained in C-ITS will be used by the research partners (VTT, TNO) in their future offerings. The industrial partners (NXP) will use the knowledge gained by the project in the design of their future products.
• IPR exploitable measures taken or intended: none
• Further research necessary: during the work the requirements for future devices and the needs for further research were identified. These are reported in D4.2 and D6.1.
• Potential/expected impact (quantify where possible): -

2.1.10 Human-Machine interaction of VRUs
• Purpose: In WP4 research has been performed on requirements on HMI for VRUs (elderly drivers, pedestrians, cyclists).
• Exploitation: the experience gained on HMI and user requirements will be used by the partners (VTT, TNO, CIDAUT, KITE) in their future research and offerings.
• IPR exploitable measures taken or intended: none
• Further research necessary: during the work the challenges regarding HMIs for VRUs and the needs for further research were identified. These are reported in D4.2 and D6.1.

2.1.11 Evaluation of ITS applications for VRUs
• Purpose: In WP5, the system trialed were evaluated. Both technical performance evaluation and user evaluation was performed.
• Exploitation: the experience gained in evaluation and the increased knowledge collected will be exploited by the partners (VTT, TNO, CIDAUT, SICE, ECORY) in their future research and offerings.
• IPR exploitable measures taken or intended: none
• Further research necessary:

2.1.12 Recommendations regarding ITS applications for VRUs
• Purpose: In WP6, recommendations on how to improve safety and mobility of VRUs were analysed.
• Exploitation: the increased knowledge collected will be exploited by the VRUITS partners both in their future offerings and in strategic planning.
• IPR exploitable measures taken or intended: none
• Further research necessary:

2.1.13 Update of traffic control products
• Purpose: Update of PEEK’s traffic control products EC-2 and Imflow based on the findings of the VRUITS project.
• Exploitation: product will be brought on the market in 2017.
• IPR exploitable measures taken or intended: none
• Further research necessary: none
2.1.14 Requirements for VRU chip definition

- **Purpose:** Definition of a new VRU-targeted chip
- **Exploitation:** The foreground will be exploited to define the requirements for a new VRU-targeted chip development, based on the findings of the VRUITS project (CBA, field trials). The resulting product (chip) may be brought on the market around 2020, depending on study outcome and market development. It can then be used by system integrators/device makers into VRU devices.
- **IPR exploitable measures taken or intended:** none
- **Further research necessary:** definition of VRU-specific standard extensions, technology for accurate VRU positioning
- **Potential/expected impact:** availability of a dedicated chip for system integrators covering the specific requirements for VRU’s, like low power consumption, small form factor, integration capability with already available devices as cell phones and fitness trackers for HMI. This will make the technology available to a larger group of VRUs compared to the more bulky and power-hungry devices resulting from today’s general purpose chips.

2.2 IPR coming out of the project

No applications for patents, trademarks and registered designs

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<th>Confidential Click on YES/NO</th>
<th>Foreseen embargo date dd/mm/yyyy</th>
<th>Application reference(s) (e.g. EP123456)</th>
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3. STAKEHOLDERS FOR EXPLOITATION

The target groups of VRUITS activities and results can be divided in 7 major families, namely: General public, Research Institutions, VRU organisations, Vehicle manufactures, OEMs and ITS application Developers, Standardisation bodies, Cities & authorities.

Each target group shares with some of the others a number of subjects of interest and attention, but shows also peculiar goals due to the nature of the group itself. As an example, general public is very much interested in the cost, benefit and safety aspects and in the impact in everyday life of new technologies, as well as are the vehicle manufacturers and OEMs. On the other hand, the general public is less interested in the actual implementation means and methodologies, which are the primary interest of R&D institutions. The Cities and Authorities are very much focused on safety issues and on means of implementation in the current regulation systems, whereas they are less focused on methodological issues.

The target groups that are interested in all aspects of the implementation of new technologies for VRUs are the vehicle manufactures, OEMs and ITS application developers. This is quite understandable as their products have to be: 1) implemented in vehicles and infrastructures according to clear specifications and design principles, 2) utilised by the general public, 3) implemented in vehicles and systems approved by the authorities, cities municipalities and standardisation bodies.

Moreover, the issues that are of most interest to all target groups are safety impact and usability, whereas certain aspects such as methodology, means of implementation and applicability are shared only amongst very specific parties.

Table 2 gives an overview of potential interest of the target groups for the different project results.
Table 2: Interest of the stakeholders in the VRUITS results.
Legend: x: general interest; X: major interest in using the project result; XX: major interest in procuring the result.

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4. EXPLOITATION PLAN

4.1 Overview

Transportation is a primary element in every aspect of daily life. Modern commercial activities are strongly connected with efficiency in goods and people moving. With the term ‘efficiency’ several meanings are implied that can vary according to the final environment of implementation. The most common aspects are:

- **Speed**: minimizing the time spent travelling is a key issue for all the activities that need a fast and constant supplying.
- **Punctuality**: delays in deliveries are a source of additional costs and inefficiencies.
- **Safety**: both people and goods must be assured a high level of safety to avoid them to be damaged. Other than avoid threats to people, damaging goods usually results in money loss.
- **Comfort**: passengers and driver optimal travelling conditions have to be taken into account. In fact not optimal driving condition can lead to a lowering of the driving performances and increase the accident probabilities.
- **Cost**: this is an essential aspect of any mode of transportation, routing efficiency and fuel consumption etc.

For these purposes exhaustive studies are performed in this domain aiming to improve the overall functioning. The thematic area is a very wide research domain, which offers several opportunities of deepening, development, theoretical advance and practical application. Therefore, both industrial and academic organizations have the opportunity to focus on different aspects, exploiting respective interests and goals. These are all coherent with the general scope of the project and results can lead to complementary contribution and overall advance in technology and safety.

The major business opportunities for the domain are linked to the development of means of compliances to be implemented in appropriate tools and instruments. Safety represents the harmonizing and crucial aspect that all parties are expected to include in their developments. The depending business opportunities resulting from the research work carried out in VRUITS are described and detailed hereafter. These include market-oriented considerations and research priorities.

In more detail, VRUITS operates following three main targets, representing relevant usage of results:

1. Industrial orientated activities, more interested in results easily transferable to a market context and profit making from their actual implementation.
2. Academic interests, focused in finding results applicable to studies, supporting research activities and development of new theoretical methods and methodologies.
3. Regulatory, norms and standards generation. This potential exploitation of the results, equally important and relevant for the specific themes dealt with by this project, is at present only foreseeable in terms of potential improvement and modification of current standards for design and modelling approaches. Therefore, it will not be included in the current document, as it is considered too speculative at this stage of development of the work. However, the topic is handled in detail in document D6.1 “Recommended practices for improving usability and user acceptance of ITS applications”, section 5 “Standardisation”, and is also linked to document D6.2 “Recommendations for actions at EU level and their assessment”.

At the level of the final exploitation plan, when concrete tools and means of compliance with the proposed approaches for VRU modelling and design of safety measures will be formulated in detail, also their potential impact in the development of norms and standards will be considered.
For these reasons, this chapter will start presenting an analysis of the market related to transportation domain according to different typologies addressed by the project and together with the partners’ specific area of competence.

Afterward, a description of the academic and research activities that will benefit from the VRUITS outcomes will be provided. Also, the position of the partners within the project will be clarified, their mid and long term strategies and goals will be discussed. The purpose of this is to:

- Share among partners a common view of the project expected outcomes;
- Identify possible priorities of the project;
- Determine guidelines, strategies, and business model for their achievement.

The exploitation processes described hereafter have been obtained from a Questionnaire that was circulated amongst the partners of VRUITS with the aim of collecting information about dissemination actions and exploitation plans. The replies collected from all partners with opinions and intentions in relation to dissemination and exploitation activities, are summarised in the following chapters of this Deliverable. In particular, the essential aspects of the exploitation plans of each partner are reported in relation to National Market analysis, Research and Development activity and Partners objectives.

### 4.2 Market analysis

Road transportation is a very important sector of modern societies, and several organisations have conspicuous interests in it. These include both public departments dedicated to the monitoring of transportation systems, organisation dedicated to the integration of infrastructures and private companies operating in the people and goods transportation domain.

Improvement of quality and competitiveness is one of the highest priority elements when dealing with market domains. In addition, safety assessment is a topic which is gaining growing attention by safety authorities and general public, and, consequently, all involved organisation (private, industries and academic institutes) are very active in this aspect. The industrial approach of VRUITS aims at proposing to such stakeholders effective solutions derived from the project activities in order to meet these expectations.

For the different partners of VRUITS the analysis of the market goals and opportunities depend on the specificity of the type of organization. Therefore, these visions of each Partner are left distinguished even if a grouping by nation is applied. All partners share, obviously, the focus of their market analysis on VRU related issues and the importance that different VRUs play in the national markets. In principle, all Nordic countries give high relevance to bicyclists, whereas in the Southern’ European markets, motorcyclists represent somehow a more “relevant” issue. All countries concentrate on pedestrians and, in particular, on the population of elderly and disabled persons.

#### 4.2.1 VTT – Finland

VTT is heavily involved in transport related research and assists authorities and companies in the various phases of analysis, design, specification, development and evaluation of transport systems and services. Safety and mobility of Vulnerable Road Users is a high priority both on national and European level. VTT plans to use the methodologies developed during the project regarding safety and mobility assessment in other national and international projects. In addition, the work regarding the safety assessment, as well as the performance measurements of ITS-G5 have been disseminated. VTT is a large organisation with a wide area of expertise, such as sensor development and communications. The research team involved in VTT will assist other teams within VTT to adapt innovative projects to the needs of VRUs and to bring these products closer to the market. The approach used for performance measurement will be exploited in other projects.
4.2.2 ECORYS, TNO, NXP and PEEK – The Netherlands

As shown in recent statistics (see VRUITS newsletter #1), compared to other EU countries in the Netherlands, next to pedestrians, especially bicyclists are the most vulnerable road users.

TNO is heavily involved in transport related research and assists authorities and companies in the various phases of analysis, design, specification, development and evaluation of transport systems and services. Safety and mobility of Vulnerable Road Users is a high priority issue, both on national and European level. TNO plans to use the methodologies developed during the project regarding safety and mobility assessment in other national and international projects and will use the expertise gained through assessment of HMI and performance of ITS applications in national and international projects and in contract work. The project development matches with our initial expectations.

NXP is active in various semiconductor markets, amongst which are automotive and consumer electronics markets. Within the automotive market, NXP wants to be the leading company offering basic components covering all aspects of wired and wireless connectivity, as shown in the ‘NXP connects the car’ campaign.

Based on the expertise gained in VRUITS, NXP will be able to better serve the VRU market especially by developing semiconductor devices (chips) for ITS, suitable for affordable mass production in low size and low power embedded applications. Using these devices, not only VRUs with vehicles generating electrical energy (as motorcycles) but also for example pedestrians can be equipped with a wearable ITS device, e.g. as an extension on a mobile phone used as HMI. The devices can both be used to broadcast their own position and velocity, and be used to receive information relevant for the VRU.

ECORYS is an economic and policy consultancy firm providing services to national and international clients. ECORYS will use the work done in VRUITS especially related to development of socio-economic impact assessment methodology for VRU and recommendations and conclusions for different stakeholders in future national and international projects, which are related to road safety, both in The Netherlands and in Europe. ECORYS especially worked on developing a CBA methodology, which can be applied for ITS applications for VRUs, as part of the overall VRUITS impact assessment methodology. This CBA methodology will be used for future consultancy and research projects. Work done on recommendations will especially be used in future policy related consulting activities with public sector clients.

Peek Traffic, currently also known as Dynniq, is a solution provider for infrastructure systems. One of the main products is the traffic light controller, which has safety as most important function. Knowledge built during the VRUITS project will be used in new traffic control configurations and with the design of new products. Both the traffic light controller and the cooperative applications developed for the RSU play an important role for VRU safety. Dynniq/Peek is also proceeding with more research in the field of VRU safety, for instance with its involvement in the XCYCLE project.

4.2.3 FACTUM – Austria

As FACTUM is a research facility solely focusing on social sciences and traffic research applications of developed products or other benefits, a market analysis of these products do not apply. However participation in the development process of assessment methodologies focusing on safety, mobility and comfort is in line with FACTUM’s involvement in research projects focussing on vulnerable road users on both national and international levels. Results and expertise gained in course of the project will be directly applied in other research initiatives in ITS domain.

The project development matches with initial expectations.
4.2.4 CIDAUT and SICE – Spain

CIDAUT supports the business sector as regards technology monitoring to contribute to the transfer of technology and innovation as a way to stimulate the development and growth of the transport sector by accessing the know-how and expertise of technological research, innovation and development groups. Projects with companies are the main channel for transferring results to the industrial sector. There is an increasing European and national focus on VRUs, and one of the priorities of CIDAUT is oriented towards the development of ITS aiming to improve safety and mobility. Furthermore, CIDAUT will bring expertise obtained in the field of VRU and ITS systems within the VRUITS project to its daily work with industry.

The progresses made in the VRUITS project match with initial expectations of CIDAUT and enable the establishment of contacts with industrial partners as well as with entities from the public sector. Specifically, the VRUITS project has allowed the implementation of specific ITS targeted to VRUs where CIDAUT has provided its technological expertise with the aim of improving the safety and mobility of VRUs in urban environments. The know-how in accident analysis, user studies and usability studies was applied in the initial phase of the project. In addition, CIDAUT expertise on system evaluation studies has been applied to project activities where innovative ITS applications have been assessed in real environments, specifically as part of the Spanish test sites.

SICE’s innovative and technological capacity, together with extensive experience within the more diverse markets, let SICE offer specific solutions to common problems in different fields such as traffic, communications, process control, lighting, tolling, parking, environment (quality of air and water), transportation, security and access control. For the development of this plan, SICE has offices in 28 countries in the five continents, and it has a wide national chain, with 16 points distributed among central services in Madrid, regional locations, subsidiaries, delegations and technical assistance centres, which ensure complete commercial coverage. The promotional activities or the marketing campaign of the VRUITS projects’ progress and results will be developed in two ways:

1. Commercial: through SICE’s National and International chain, giving information to potential clients.
2. Technical and commercial: through the regular participation of SICE at relevant events related to transportation and traffic such as technical forums, seminars and exhibitions (see Appendix).

For this reason we have participated in several conferences, covering different regions in Spain, in three of the main cities: Madrid, Valencia and Barcelona. These conferences were aimed at public authorities, companies, associations and researchers where the design and implementation of an Intelligent Pedestrian Traffic Signal through VRUITS project have been promoted as an initiative for the improvement of VRUs’ safety.

4.2.5 POLIS – Belgium

By promoting the results of the VRUITS project to cities and regions across Europe Polis will contribute to highlight the importance and relevance to invest in systems (ITS) which can support the safety of vulnerable road user and thus contribute to achieve the other policy objectives of increasing the number of cyclists and pedestrians on the local transport networks.

The project development matches with initial expectations.

4.2.6 LU - United Kingdom

Loughborough University Design School has a particular focus on transport related research in terms of design, human factors and safety aspects. Safety and mobility of Vulnerable Road Users is a par-
ticular key priority area within the UK generally but is also a focus for Loughborough since it has knowledge and expertise in the subject matter through participation in a number of in-depth studies. At a European level, Loughborough will use the methodologies developed during the project regarding accident analysis and safety within developing projects.

We also intend to exploit some of the data analysis conducted within the project for teaching purposes within our University teaching programmes. The data are very informative with regard to the challenges experienced by VRUs and the emerging solutions are very much state-of-the-art from a technology perspective. We intend to highlight the issue holistically within both our ‘Transport Safety’ module and Driver and Vehicle Ergonomics Module so that the issue of VRU safety is understood by undergraduate and graduate students.

Overall, the project development has exceeded our expectations, as we did not foresee the Impact Assessments for both Safety and Mobility and Comfort to be so extensive and detailed. We are very happy with the progress, as we have learned much, and we would like to apply this enhanced expertise to other on-going activities in the field of VRU safety, where possible.

Another positive development is the acquired knowledge about the CARE accident database, on how to analyse it, as well as on the numerous limitations in using this sort of information at a pan-European level. Our overall focus on VRU accidents at Loughborough remains strong.

4.2.7 KITE – Italy

Transportation, in Italy, represents an important sector in the market development and competitiveness involving several organisations with conspicuous financial interest. Focusing on road transport, these organisations include:

1. European and Italian authorities for road transport. These stakeholders aim at implementing method that enables to audit rapidly and efficiently the technology proposed by the industry for certification and to define a set of requirements which could structure technical and productive, as well as employment and safety aspects.

2. Organisations dedicated to integration of infrastructures. The prime interest of road administration comes from the need to test and approve systems that are introduced in vehicles and in infrastructures primarily from the safety perspective of vulnerable road user. Moreover, they look at the enhancement of roads management in terms of efficiency through innovative, stand-alone or cooperative technologies, which foster the streamlining of the ordinary traffic, the protection of all roads’ users and the supporting of their needs and duties.

3. Private companies. Industries and OEMs develop tools and systems supporting all road users in their everyday usage of different transport modes. At first, major improvement regarding the vehicle industry, which was interested in tools that make prototyping and testing quicker, more efficient, and thereby cheaper. In the latest years, attention is more pointed at developing supporting as well as protective systems for Vulnerable Road Users, also in consideration to the environmental benefits that not-motorized transport means can generate.

In addition, safety assessment is a topic of primary attention by the general public and by the representatives of users’ categories (e.g., European Cyclists’ Federation, International Federation of Pedestrians, etc.). Finally, further improvements in both comfort and mobility features could promote a cultural change, convincing more people to prefer more sustainable, but safe, comfortable and agile transport modes rather than private cars only.
Consequently, all involved organisations (private, research institutions, industries and authorities) are very active in this aspect. The industrial approach of VRUITS aims at proposing to such stakeholders’ effective solutions and practical recommendations derived from the project activities in order to meet these expectations.

As the techniques proposed by VRUITS aim at improving the safety assessment of advanced support systems, these are of interest to all stakeholders of the automotive domain.

Thanks to the participation in the VRUITS project, KITE Solutions had the opportunity of acquiring an overview of possible new markets, possible new clients and partners, in a sector of the transport domain usually not included among its usual activities. As for KITE Solutions core competences, these have been improved in terms of understanding the current technology level of available ITS systems and their possible market spread, as well as recognizing the safety issues currently struggling VRUs.

Therefore, the initial expectations have been matched as far as the expansion of KITE’s new competence and expertise, whereas the precise identification of new markets remains to be further strengthened.

4.2.8 LTU – Sweden
At Luleå University of Technology safety and mobility of Vulnerable Road Users is a high priority subject within the overall research on transport and urban planning. Based on the expertise gained in VRUITS LTU will be able to better plan for and serve the needs of VRUs.

The knowledge developed within VRUITS about transport safety in relation to ITS and about mobility, comfort and safety, and design, for VRUs has been addressed in lectures at the university. So far, LTU has been part of one scientific paper presented in conference proceeding and it is also part of three submitted papers to conferences. Participation in the development process of assessment methodologies focussing on mobility and comfort is in line with LTUs research, focussing on vulnerable road users on both national and international levels. LTU plans to use the methodologies developed during the project regarding safety and mobility assessment in other national and international projects, and use the expertise gained through assessment of performance of ITS applications in national and international projects. The project development matches with initial expectations.

4.3 Research and Development Activity
Summarising the outcome of main goals of VRUITS partners in R&D are to expand knowledge, methods and methodologies already existing and previously developed in a variety of projects. This leads to the generation of new tools and instruments that will eventually become market products. Already now, several companies are using the results of VRUITS as input into current developments (e.g. section 4.3.10, 4.3.11).

4.3.1 VTT
In the VRUITS project, VTT has exploited its expertise on safety assessment of ITS applications, usability assessment evaluation, and expertise in cooperative traffic systems and in communication systems.

VTT has developed further the assessment methodology for safety related ITS applications, and adapted it to Vulnerable Road Users. VTT has been involved in developing an architecture for the integration of VRUs in cooperative traffic systems, and used the Quality of Service measurement tool to assess the technical performance of communication systems for VRU safety applications. VTT was also involved in the process for defining the recommendations of the project. During the project VTT
has gained knowledge on the needs of VRU and the possibilities of ITS for VRUs, and on impact assessment.

VTT is a large organisation with a wide area of expertise, such as sensor development and communications. The knowledge gained within the VRUITS project will be exploited through increased collaboration between the transport team and other areas by applying their expertise to ideas from other teams. Examples are the development of sensors for vehicles, intelligent lighting and integration of wireless communications in devices for VRUs, such as intelligent reflectors and intelligent rollators.

The knowledge gained in VRUITS will be further exploited in future projects and offerings.

### 4.3.2 ECORYS

ECORYS has mainly contributed to the development of the overall IA methodology specifically applicable for VRU, and especially to the development of the socio-economic assessment/CBA methodology, which is an important element of it.

In addition, ECORYS contributed to the development of a methodology for assessment and ranking of the recommendations for improving VRU safety and mobility. The knowledge gathered during the project will be used in future research activities, projects and consultancy activities.

### 4.3.3 FACTUM

Due to the involvement in the basic research phase of the project the applied methodologies (including focus group discussions in four European countries, expert interviews on a European level and literature studies) a number of benefits will arise for Factum as a research facility besides the found and produced qualitative data.

The applied methodologies can be adapted and improved based on experiences gathered in course of the research process leading to processes that are more efficient, especially in view of transnational application of the research methods including organization and administration processes.

A comprehensive research plan covering all relevant fields of the topics of VRUs and ITS is developed to guarantee the collection of quality data in course of the basic research phase as well as ensure a user centred design approach in the development phase based on the integration of both experts form tangent fields and representatives of identified user groups.

### 4.3.4 LTU

In the VRUITS project, LTU has deepened its expertise on mobility and comfort assessment of ITS applications, and usability for specific user groups, expertise in cooperative traffic systems and in communication systems.

LTU has developed the assessment methodology further for mobility and comfort related to ITS applications, and adapted it to Vulnerable Road Users.

### 4.3.5 CIDAUT

Within VRUITS project CIDAUT has made use of its experience on the evaluation and analysis of driving assistance systems, assuring safe, attractive and effective interfaces. In-depth research has been carried out on the involvement of the vehicle, the influence of the road infrastructure and its interrelation with the human factor in order to obtain information to draw valid, efficient conclusions for designing safer vehicles, systems, and road infrastructures. CIDAUT has taken part in several tasks of the project: CIDAUT has contributed to the analysis of accidents involving VRUs, and to the definition of
the needs of different groups of VRUs with respect to mobility, safety and comfort. CIDAUT has also participated in the identification of current and future ITS oriented to VRUs as well as to the prioritization, selection and assessment of ITS performed within VRUITS project.

In Valladolid test site, CIDAUT has adapted a camera vision system for automatic pedestrian detection, and has defined the architecture and communication aspects of cooperative systems, specifically covering the ITS application implemented. After conduction of the Spanish pilots, CIDAUT has drawn major conclusions from the statistical analysis of the data collected during pilot tests. Local site-based dissemination actions have been organised involving local and national authorities as well as industrial partners.

Regarding recommendations obtained in the project, CIDAUT has compiled recommended practices regarding to usability and user acceptance for the improvement of ITS applications.

CIDAUT plans to exploit the experience on needs of VRUs in terms of mobility, safety and comfort and the potential of ITS applications in covering these needs gained during VRUITS project in future national and international projects. In particular, CIDAUT will contact with local authorities of European cities having shown interest in Valladolid test site in order to advise them in case of implementing the same technology.

## 4.3.6 SICE

This expertise developed by SICE in various projects, primarily, from the design of complete centralized Urban Traffic Control Centre (UTC) projects incorporating its own products and applications, has been employed to improve the pedestrians’ mobility, introducing innovative algorithms to the traffic control in cities and suburban areas, developing Smart Traffic Lights controllers for urban intersections, with cooperative functionalities, thanks to the pedestrian detection based on advanced vision systems.

SICE is placed at the forefront of applying the latest technology to the traffic control in cities and suburban areas. Its mission in this sector is to reduce congestion, improve travel times, reduce the environmental impact of road traffic, and overall to maximize the safety of urban traffic.

As ITS developer and integrator, SICE has focused its participation mainly on the adaptation and integration of applications and systems in the Spanish test site, and on the setting-up and conduction of the pilots. SICE has taken part on various activities in different work-packages: contribution to definition of technology potential of ITS for VRUs needs, cost assessment of ITS systems deployment, support of the definition and development of the cooperative system architecture and information system, and has actively contributed to project dissemination activities and exploitation plan and strategy.

The expertise gained in VRUITS allows the improvement of SICE’s range of services in urban traffic business area. Safety of VRUs draws the attention of many municipalities and VRUITS is part of the path to provide effective services for elderly and disabled persons. In fact, VRUITS has helped to the development of the new SAFECROSS 2.0 platform that pools most of the elements of Alcalá de Henares Test Site and was awarded in the Innovation Gallery of the Traffic 2015 (The International Safe and Sustainable Mobility Exhibition).

## 4.3.7 LU

Loughborough University Design School has a special interest in the methods developed to evaluate new systems designs and their effectiveness in accident prevention. Particularly relevant in this regard will be the Impact Assessment methodology and how it can be utilized within other projects for accident countermeasures and system development. Loughborough University Design School has established the scenarios which are relevant for Vulnerable Road User accidents and how these may be
avoided through system development and deployment. This will be linked to other on-going projects within the UK but will also be of interest to new programs that are likely to eventuate within the Horizon2020. Loughborough will look for opportunities to exploit the methods and data analysis as and when they arise.

We recognise that the challenge of vehicle automation is very broad and we consider that VRU safety following the widespread introduction of autonomous vehicles needs to be recognised as an issue where the evidence is not yet mature. We hope to exploit the results of the VRU-ITS project to indicate where VRU safety needs may therefore be overlooked by the rapidly increasing movement towards vehicle automation. Our aim is that the research community should never lose sight of the fact that there are many broad-ranging road-user scenarios involving VRUs which may not be addressed by autonomous vehicle technologies. We aim to undertake further research following on from VRU-ITS to examine how such vehicles react in extreme (urban) conditions in which large numbers of VRUs may be present.

4.3.8 **KITE**

Inside VRUITS project, KITE experience in modelling and field data analysis has been further developed especially for the assessment of user-acceptance and usability of existing ITS services for VRUs. The field study carried out during the initial phases of VRUITS in order to evaluate and assess safety and comfort/mobility of existing systems has further expanded KITE’s expertise in this area.

In addition, a very important goal of KITE in participating in VRUITS was to improve its own knowledge and expertise in the basic methodological instruments dedicated to deal with VRU safety issues. Indeed, the expertise gained in performing the research work in which KITE has been involved has been instrumental in creating competence in risk analysis in the domain of VRU. In fact, this competence previously existed in KITE, but it was focused on different technological and transport domains. The participation in the VRUITS project allowed KITE to enlarge and transfer its offer also to the specific domain of vulnerable road users. This has turned out already very useful and productive, as we have been involved in new successful projects in the area, which settle their basis on VRUITS outcomes themselves or which involve partners from the VRUITS Consortium.

4.3.9 **TNO**

TNO focuses in VRUITS on a number of aspects. The main focus is on the Impact assessment, the improvement of HMI for ITS applications and the Dutch pilot.

For the Dutch pilot, TNO developed among others a Road Side Unit (RSU) including radar classification software for VRU’s. The performance of this detection and classification was evaluated as well. Communication via WiFi-p between RSU, vehicle and bicycle was successfully established. The Cooperative Automatic Emergency Braking (CAEB) system on the vehicle was improved to enable processing of the location information about the bicycle detected and sent by the RSU.

A haptic and visual HMI was implemented on the bicycle and evaluated during the Dutch pilot. The experiences build and knowledge gained by TNO within this project can be applied in subsequent research and improvement of ITS applications for Vulnerable Road Users. The HMI of the system was positively evaluated by the users in the trial. Some users objected to the display on the bicycle stating that it distracts too much from looking at their surroundings. This indicates that visual information on an instrumented bicycle should be kept at a minimum e.g. only show system status (on/off). The haptic feedback via vibrating handle bars of the bike was perceived as an intuitive way to warn for danger, users understood the meaning of this warning immediately. The calculated Time-to-Collision (TTC) between the warning on the bicycle and the point of collision with the car was between 2 and 3 seconds in the trial. Literature states that to avoid an accident the critical cut-off point is a TTC of <1.5 s.
(van der Horst, 1990). Therefore, it is understandable that most users stated in the evaluation that they would prefer to be warned earlier.

TNO strengthened its knowledge of impacts of C-ITS in its work in three work packages covering Impact Assessment (which TNO led), the user evaluation of the Dutch pilot, and the recommendations and conclusions for accelerated deployment of C-ITS for VRUs. The integration of VRUs in C-ITS as well as the need to increase soft mode use in the EU has expanded the application area in which TNO has carried out impact assessments. VRUITS offered the unique opportunity to carry out both ex-ante and ex-post safety, mobility and comfort assessments, using real-life pilot data. This knowledge will be exploited both at the EU-level and at the Dutch regional level. A major Dutch program on C-ITS deployment includes (assessment of) VRU applications. The development of recommendations to all relevant stakeholders – public bodies at local, national and international levels, industry, user group representatives and research organisations – will enable TNO to advise these stakeholders in effective research, testing, and deployment of C-ITS applications for VRUs.

4.3.10 NXP

NXP has extensive experience in automotive communication devices. For example, ITS G5 communication devices used in several pilots were based on the first generation ITS G5 chipset of NXP (‘RoadLINK’ chip set), offering best-in-class communication even at high speed and in difficult non-line-of-site situations. These first generation units are currently being designed in by several vehicle manufacturers. The findings in amongst others the VRUITS project will be taken into account in the definition of the 2nd generation RoadLINK chip set for automotive use.

More relevant in the context of the VRUITS project, these findings are (amongst others) currently also being used as input in a dedicated study within NXP, with focus especially at the definition of new chips for vulnerable road users. This study will take into account the unique requirements of the various VRU categories.

Several types of devices are considered:

- A transmit-only G5 tag signalling the availability of a VRU (e.g. school kid).
- An extension of a mobile phone handset where resources (e.g. GPS, CPU) already available in the handset can be shared with a VRU device based on G5 C-ITS communication. Such extension can either be by integrated into a handset (e.g. as peripheral to a cellular chip), or used as an accessory connected to the handset via for example Bluetooth Low Energy.
- A passive NXP RF-ID based tag, used in several events where VRU detection based on these tags is being tested and demonstrated. Compared to the G5 units, these tags will be short-ranged (maximum 20 meters) which as indicated in VRUITS is sufficient for a number of relevant use cases, such as the VRUITS IPTS case. The advantage of passive RF-ID tags is simplicity, as well as the extreme low cost, making it suitable for widespread adoption in e.g. garments and bags.

A key item for a VRU-optimised solution is power consumption. This is especially true for VRUs like pedestrians, as they have to rely on (small) batteries within the VRU unit. It is expected that significant steps can be made in the architecture. Based on work already started in VRUITS, we expect further adaptations in the C-ITS/G5 standard are required for ultra-low power requirements, e.g. reduced transmit frequency according to dedicated rules for specific VRU classes.

4.3.11 PEEK

In the field of intersection control, Peek does a lot of autonomous research, which recently has resulted in a new urban traffic control systems (ImFlow). One of the characteristics of ImFlow is the extreme
flexibility for safely accommodating VRU phases in the control program. Short waiting times for VRU’s leads to low red light negation, thereby improving safety.

Peek will use its knowledge on international intersection control to implement novel approaches to VRU safety as developed in VRUITS in the real world.

For cooperative ITS the Greenflow product has various applications for traffic safety, traffic management and emission reduction implemented according to the latest standards. During VRUITS, it was identified that certain VRU related safety data could not be put in these standards. This knowledge was summarised in a draft paper and submitted to the ITS Europe conference of 2016 for publication. The work will also continue in the XCYCLE project to continue efforts to extend the standards to fully support all VRU safety information.

The knowledge is already used for the current Greenflow product version to support disseminating such VRU safety information on an architecture level. Once the standard is available, few actions will be required to implement such message.
5. CONCLUSION

As identified in section 4.1, there are three main target areas for exploitation of the results, being industrial activities, academic interests, and regulatory norms and standards.

From the perspective of industrial activities, one of the benefits of the VRUITS project is the extensive cost-benefit analysis as described in deliverable D3.2, which can guide specific development activities. In the VRUITS presentation ‘Impact Assessment’ (see references), a collection of systems with a positive benefit-cost ratio is presented, which is a good starting point for such activities. Combined with the results from the pilots this is leading to technical research and developments for devices related to vulnerable road users, such as portable beacons for VRU’s (section 4.3.10) or VRU-prepared traffic management equipment (section 4.3.11). Commercial deployment will also depend on market development and business use cases for example with respect to involvement of non-industrial stakeholders like cities. For this purpose, alignment with the VRU roadmap as presented in deliverable D6.1 section 4.13, and general ITS application roadmaps as for example the Car2Car Communication Consortium roadmap (Buburazan, 2016), is recommended.

From the academic point of view, the expertise gained will be used by the partners through scientific publications, offered as expertise in future offerings and consultancy activities, or used when developing future products. The pilot analysis and measurement tools as created in VRUITS WP3 and WP4 will not be offered as separate products, but these and the setup and results as reported in WP5 also can be used in subsequent (follow-up) projects. For example, a comprehensive research plan is developed by Factum, covering all relevant fields of the topics of VRUs and ITS to guarantee the collection of quality data (section 4.3.3).

As result of the Cost-Benefit Analysis, we can conclude a system with a high NPV in itself does not per se also result in a good Benefit-Cost ratio, as demonstrated for the PCDS+EBR system (deliverable D3.2 and presentation ‘Impact Assessment’). Only if the system can share the underlying implementation with other systems, a benefit-cost ratio larger than 1 can be achieved.

Based on this, we conclude norms and standards are relevant for all stakeholders, as to enable a sufficiently large shared market to make developments economically feasible. The VRUITS project has triggered several initiatives with respect to standardisation (section 4.1), however the process of standardisation will continue beyond the life time of the VRUITS project. Here both follow-up projects (e.g. XCYCLE, section 4.3.11) and industry interest are expected to be sufficient to drive the progress of the standards beyond VRUITS.

Next to norms and standards, also other actions at EU level are identified in the VRUITS project, helping towards exploitation of the VRUITS results. These are not covered in this deliverable, but are detailed in deliverable D6.2 “Recommendations for actions at EU level and their assessment”.
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