Final Report Summary - 2-BE-SAFE (2-WHEELER BEHAVIOUR AND SAFETY)

Executive Summary:
Up to 2008, the research relating to PTWs’ safety focused mainly on sociological aspects, training, accidentology and primary safety systems design. Based on the fact that it is crucial to base countermeasures on scientific evidence relating to riders’ behaviours and practices, the purpose of 2-BE-SAFE was to contribute to filling the knowledge gap on PTW riders’ behaviour. The 2-BE-SAFE project, started on January 1st 2009, is a focused 36 months research collaborative project, co-funded by the EC, Theme 7 – SST. It involved 27 partners from 11 countries, and was organised in 7 research work packages.

The aim of Work Package 1 was to identify the factors that contribute to PTW crashes across Europe focusing on road infrastructure and weather conditions. 20 prevailing scenarios in 5 European countries that account for most fatal PTW accidents, and the causal factors contributing to crashes have been identified.

Innovative tools have been designed within Work Package 4: 6 instrumented PTWs, an instrumented car, 2 riding simulators, a driving simulator, and a video-based tool for investigating motorcyclists’ risk awareness.

A pilot naturalistic riding study was conducted within Work Package 2, using the instrumented motorcycles from partners. This naturalistic riding study was a première at pan-European level. The studies successfully tested the proposed naturalistic riding methodology, and developed new knowledge and recommendations for future larger studies. Different approaches to perform automatic event detection of safety critical events were developed, applied and evaluated.

The study implemented in Work Package 3 was focused on PTW riders’ hazard perception and acceptance of risk, and how these characteristics influence their acceptance of new technologies designed to enhance their safety. Significant differences were observed between commuters and sport-riders: commuters tend for example to underestimate the criticality of riding situations. The result of the online survey revealed two groups based on overall acceptance of assistive systems. Levels of acceptance are much lower than for equivalent systems in passenger cars, the study suggests that riders will accept systems that they perceive to be useful, reliable and effective.

Work Package 5 aimed at a better understanding of rider’s behaviours and of critical factors influencing PTW safety. Several experiments focussed on PTWs conspicuity. Results indicated, for instance, that varying riders’ clothing (bright clothes, reflective warning vests, and dark clothes) can enhance riders’ conspicuity in certain situations but the effects are strongly mediated by the background conditions (e.g. lighting conditions) and by the characteristics of the driving situation (e.g. urban vs. rural traffic environment). Variations of specific frontal light configurations were found as promising solutions to enhance PTWs conspicuity. It is proposed to provide a unique visual signature/signal pattern for PTW to other road users Results revealed advantages in terms of a better detection and faster identification for yellow coloured headlights, ABLS (‘Alternating Blinking Light System’) and additional lights on the fork and handlebars for motorcycles (T Light configuration). The feasibility of the use of riding simulators for the behavioural studies has been evaluated. As a result, one can consider that these tools can be reasonably used for studies in extra-urban situations, but is still problematic for the study in urban and complex situations. Last, in WP5, a Cognitive Work Analysis (CWA) has been conducted, based on face to face interviews with riders. The knowledge derived from the riders interviewed was used to formulate some options for enhancing the safety of motorcycle and scooter riders.

2-BE-SAFE has applied a large variety of scientific research methodologies. Some of these methods have been applied for first time; some of them were not applied on the field of PTW safety before. Last, some methodologies also received significant improvement within the project. All the experience and knowledge acquired within the research activities conducted have been analysed and then summarized into a set of guidelines and policy recommendations (Work Package 6). Two main documents have been produced. The first document summarizes experiences and issues particularly relevant for the observation of driver behaviour of PTW riders with respect to PTW safety. Based on feedback on the various research studies conducted within the project, it proposes improvements in tools and
methodologies. It also proposes new topics for PTW safety research. This guideline is intended to be used by researchers and research stakeholders for future research programs. The second document consists in a comprehensive list of PTW safety measures, with indication on their advantages, shortcomings, potential implementations barriers and key success factors. The measures are assessed, based on their expected impacts, costs and benefits, and transferability. The guidelines presents each of the identified PTW safety measure assessed and ranked. It is intended to be used by stakeholders and practitioners.

Dissemination and exploitation plans of 2-BE-SAFE project results have been achieved within Work Package 7. One can find on the 2-BE-SAFE website (www.2besafe.eu) dissemination materials including, for instance, posters and leaflets distributed to interested parties, stakeholders, and related activities. One will also find the three newsletter issued and a list of the publication and communications.

Project Context and Objectives:

Rationale

Up to 2008, the research relating to PTWs road safety focussed mainly on sociological aspects, training, accidentology and primary safety systems design. These aspects were critical due to an over-involvement of PTWs riders in fatal crashes, this in a context of a strong increase of the number of PTWs on the road. The PTW related research was however poor compare to car ones, and undertaken with delay. One can consider that the car related research was far in advance, with several researches focussing, for example, on the understanding of drivers' behaviours and on the design of driving aid devices.

Based on this analysis, and on the fact that it is crucial to base countermeasures on scientific evidences related to rider behaviours and practices, the purpose of 2-BE-SAFE was to participate to filling-in the knowledge gap on PTW rider behaviour. The project targets the behavioural and ergonomic factors cited in the MAIDS study as contributing ones to PTW crashes. Supported by accidentology findings and by the development of new research tools and platforms and tuning existing ones, the idea was to focus on 3 main items: risk perception and rider acceptance of assistance systems, riding practices and interactions with other road users, and last, PTWs conspicuity issue. The expected final output was the production of guidelines and policy recommendations for improving PTW road safety, as well as the identification of research questions for the improvement of methodological tools that contribute to the "understanding" of PTW riding behaviour.

Project Results:

Work achieved within the project

The 2-BE-SAFE project, started on January, 1st 2009, is a focused 36 months research collaborative project, co-funded by the EC under the 7th FP, Theme 7 – SST. It involved 27 partners from 11 countries. It specifically addressed two topics in the work program: "...vehicle conspicuity with special attention to Powered Two Wheelers..." (SST.2007.4.1.1. Safety and Security by Design), and "interaction between innovative technologies and drivers and vessels pilots' actions in emergency situations, cognitive and behavioural differences based on needs and abilities of drivers, age, gender, culture, education and disabilities..." (SST.2007.4.1.2.Human Physical and Behavioural Components).

In the following sections, the objectives of the various 2-BE-SAFE work-packages are presented and the respective findings are illustrated. More detailed information can be found in the public project deliverables, which can be downloaded at the 2-BE-SAFE website (www.2besafe.eu).

The aim of Work Package 1 was to identify the factors that contribute to PTW crashes across Europe, including rider / driver factors and characteristics of the road environment (road infrastructure and weather conditions). The analysis has been conducted at two levels: at a macroscopic level, using accident statistics from national accident databases; and at a microscopic level, using appropriate models, interviews and in-depth accident data. The key results of this research activity are:

- the identification of 20 prevailing scenarios in 5 European countries that account for most fatal PTW accidents, and of the causal factors contributing to accidents
- a list of the most relevant critical factors related to infrastructure (roadway design and maintenance defects, road surface conditions and so on). The analyses conducted provided the opportunity to thoroughly evaluate critical infrastructure parameter (curve radii, cross-fall, texture, unevenness and skid resistance) combinations.
- a predictive model of the relation between precipitation and PTW accidents, with a limit due to the lack of exposure data for PTW riding.

Work Package 4 was dedicated to the development of several tools that were necessary for conducting experiments related to rider and driver behaviour that would be performed in the other Work Packages of the project. Innovative tools have been designed:

- 6 PTWs have been instrumented accordingly to fulfll the requirements set in WP2 of the 2-BE-SAFE naturalistic riding pilot study, which was also conducted within WP2.
- an instrumented car has been modified to enable it to be used to study the behaviour and performance of PTW riders interacting with car drivers (WP 5).
- 2 riding simulators have been tuned iteratively and partially validated (objective and subjective validation) within WP5.
- a driving simulator has been modified by adding a blooming effect that improves the realism of the rendered situations, and the conspicuity of objects which emits lights. The rear view rendering system has been redesigned, that uses the car rear mirrors location and real mirrors to let the driver see the rear scene. This allows the driver to search for information by moving his/her head. The driving simulator has been used to study the conspicuity of riders passing cars (WP5).
- a video-based tool for investigating motorcyclists' risk awareness (critically assessment) has been designed and developed. It has been used within WP3.
- A pilot naturalistic riding study (NRS) was conducted within Work Package 2, using the instrumented motorcycles (as described in the WP4 section). This naturalistic riding study was a first pan-European attempt (worldwide only one NRS was undertaken in Australia at the same time with the 2-BE-SAFE one). The NRS was undertaken in Italy, Greece, the UK, and France with the objective of validating the PTW instrumentation and the methodological approach of the experiment. Additional objectives involved the identification (using the collected data) PTW riding behaviours and the development of suitable algorithms that could detect PTW riding patterns and conflicts automatically.
- A state-of-the art review on naturalistic riding studies was performed.

The NRS experiment was undertaken based on the aforementioned review while taking into account the distinct PTW characteristics, riding behaviour and attitudes and PTW accident characteristics.
The studies tested successfully the proposed naturalistic riding methodology, performed an assessment of the instrumentation used and developed new knowledge and recommendations for the performance of future large scale NRS. Through the analysis, different approaches to perform automatic event detection of safety critical events were developed, applied, evaluated and were proven to be successful. In addition, an initial database of events including several of their elements was created, demonstrating the potentiality of the results achievable with the naturalistic riding methodology.

Figure 1: Example of instrumented motorbike for pilot naturalistic study

The study implemented in Work Package 3 was focused on PTW riders’ hazard perception and acceptance of risk, and how this characteristic influences their acceptance of new technologies designed to enhance their safety. A state of the art review on contextual parameters and riders’ diversity has been completed, and a common methodological tool (motorcyclists’ profile questionnaire) has been developed and translated in 6 languages. A study on riders’ risk awareness has been completed, using a common video-based tool (criticality assessment) in association with a verbal method among two samples of motorcyclists (i.e. a group of riders with sport profile versus a group of commuters) in 6 European countries. Last, an on-line survey (completed with focus group) has been implemented for investigating relationships between riders’ profiles and openness towards ARAS/OBIS (i.e. Advanced Rider Assistance Systems / On Bike Information Systems).

Figure 2: Video-based tool developed for criticality assessment and associated descriptive scales (CRITIC)

The main differences observed between the commuters and the sport riders also concern (1) motivations for using a motorbike (commuters main motivations are “saving time”, “easier parking” and “advantage costs”, against “pleasure of riding”, “riding bend” and “acceleration feeling” for sport riders), (2) potentially risky manoeuvres implemented when riding (for example, more frequent overtaking between lanes or filtering between cars on highway for sport riders, against more frequent use of bicycle lanes and of hard-shoulder for commuters), and (3) speeding attitudes (sport riders having a more positive attitude towards speed than commuters).

The result of an online survey revealed two groups based on overall acceptance of assistive systems. Riders in the high acceptance cluster reported higher mean levels of fear worry and upset and were more likely to nominate “risk” as the greatest downside to riding. These results suggest that riders who are more risk aware are more accepting of assistive systems. Acceptance is higher for systems that do not interfere with the riding task and for systems that are well-known and/or considered reliable (e.g. ABS, airbags). Adaptive cruise control, lane keeping assistant and intelligent speed adaptation received the lowest acceptance levels. In general, the greatest barriers to acceptance relate to the perceived effectiveness, usefulness and cost-effectiveness of systems. Although levels of acceptance for PTW assistive systems are much lower than for equivalent systems in passenger cars, the study suggests riders will accept systems that they perceive to be useful and effective.

Work Package 5 aimed at a better understanding of rider’s behaviours and of critical factors influencing PTW safety. A cognitive work analysis of motorcycle riding has been conducted as well as a conflict studies. As one of the most prominent safety factor relies to a lack of PTW conspicuity, several experiments focussed on this question and improvement were performed.

Figure 3: Studies on effects of background conditions & traffic situations

Figure 4 - Proposal for different light configurations for enhancing PTW conspicuity

A conflict study has been conducted in 9 European countries (Austria, Czech Republic, Finland, France, Germany, Greece, Italy, Portugal and Spain), as well as Focus Group interviews. The key findings of these studies are that:
- the assumption that sports bike riders have a riskier riding behaviour couldn’t be confirmed with the present analyses
- riders in groups had a safer riding behaviour than PTW riders who ride alone
- no relation between the conspicuity of the helmet and the clothing, and the number of conflicts could be demonstrated. The conflict study results showed either that riders without a conflict more often rode a dark motorcycle (it was not possible to explain this fact, which is contradictory with common hypothesis, further research should focus on this issue)
- the riders consider critical behaviour (under certain conditions) as a normal (typical) behaviour, although they are aware of the criticality. Several critical behaviour patterns have been mentioned and justified by an attentive and skilled riding behaviour and certain circumstances
- riding a motorcycle is not necessarily combined with special protection clothing.

Several research activities addressed phenomena related to PTW visual conspicuity as a critical factor in between-vehicle interaction. The effects of motorcycle low-beam headlights during daytime were evaluated by assessing driver’s decision making in a driving simulator study of gap acceptance. Results showed that for short time gaps ahead of a PTW, the odds of accepting the gap and turning in front of the PTW are lower for PTW with headlights on than for PTW with headlights off. Results from further experiments indicated that varying riders’ clothing (bright clothes, reflective warning vests, and dark clothes) can enhance riders’ conspicuity in certain situations but the effects are strongly mediated by the background conditions (e.g. lighting conditions) and by the characteristics of the driving situation (e.g. urban vs. rural traffic environment).

Variations of specific frontal light configurations were found as promising solutions to enhance PTWs conspicuity. Due to the distinctive features of such a frontal light configuration, the studies showed that the proposed naturalistic riding methodology, performed an assessment of the instrumentation used and developed new knowledge and recommendations for the performance of future large scale NRS.
light configuration, it is proposed to provide a unique visual signature/signal pattern for PTW to other road users, and thus, to facilitate recognition and identification processes. So, distinctive frontal light configurations are intended to make PTWs clearly distinguishable from the background and from other road users. Variation of the light colour (yellow headlights), additional helmet lights ('Alternating Blinking Light System' or ABLS) and specific frontal light arrangements with additional lights installed on the front of the PTW (as T shaped, V shaped, FACE design) were considered as possible approaches to implement such a visual signature. Results revealed advantages in terms of a better detection and faster identification for yellow coloured headlights, ABLS and additional lights on the fork and handlebars for motorcycles (T Light configuration).

Driving simulators are nowadays of common use for the behavioural studies. Riders simulators are emerging, but much more difficult to design due to the particular dynamics of PTWs and to the complex interactions between the riders and the PTWs. It is why we studied the current feasibility of behavioural studies using riding simulators. As a result of the conducted studies, one can consider that these tools can be reasonably used for studies in extra-urban situations, with few traffic interactions. It is still problematic to use riding simulators for the study of riders' behaviour in urban and complex situations. The perceived speed, the control of the virtual motorbike and simulator sickness syndrome are factors which limit the feasibility of the studies for such situations and the validity of the results.

Last, in WP5, a Cognitive Work Analysis (CWA) has been conducted, based on face to face interviews with riders. In road safety, is the general lack of communication with end users in designing the road transport system. This is not always the case in other domains, such as aviation, in which operators perform complex tasks in high risk environments, where it is common to formulate options for risk and harm minimization that derive, at least in part, from expert opinion identified using CWA technique. Within 2-BE-SAFE the knowledge derived from the riders interviewed was used to formulate some options for enhancing the safety of motorcycle and scooter riders. The options are based not on crash or incident data, but on the expert knowledge of experienced motorcycle riders operating in a variety of domains. As such, some options for countermeasures may not be justifiable on moral or scientific grounds. For example, advanced rider training focusing on vehicle mastering, which are identified as relevant for riders, may for some riders have unintended side effects, such as encouraging them to become overconfident in their ability and exposing themselves more to risky situations to test their limits.

Dissemination and exploitation plans of 2-BE-SAFE project results have been achieved within Work Package 7. The 2-BE-SAFE website (www.2besafe.eu) was launched early in the project and included an internal repository area. Dissemination materials including posters and leaflets distributed to interested parties, stakeholders, and related activities. Three newsletter issues were released across the project's lifespan and over 20 participations in journals, European and International Conferences, seminars, and workshops were recorded. Two User Forum events were held targeting potential users from diverse stakeholder groups (e.g. researchers, policy makers, OEMs, developers, engineers, automotive industry representatives, social scientists, etc.) because of the diversity and breadth of the project itself. The first User Forum event was organized by FEMA in conjunction with the first International Motorcyclists’ Conference and was held on June 29, 2010 at AUTOWORLD Museum in Brussels. The final User Forum took place on December 14th 2011 at the Cité Internationale Universitaire in Paris (almost 100 people attended each User Forum event).

The 2-BE-SAFE project held an Exhibition booth during the TRA Conference 2010 that took place on June 7-10, 2010 in Brussels, Belgium as shown in the figure below.

Figure 5: Participation of 2BESAFE project (Exhibition booth) at TRA Conference 2010

An extensive market analysis and exploitation planning led to the identification of 8 2-BE-SAFE products identified (2 primary and 6 secondary). The two primary outcomes of the 2-BE-SAFE project were the 2-BE-SAFE methodological framework handbook and the 2-BE-SAFE implementation guide.

2-BE-SAFE aims to contribute and be adopted by relevant standardisation committees and, in the long-term horizon; it may lead to mandatory and legally enacted principles regarding training, validation and transport of PTWs. Despite the global economic crisis, 2-BE-SAFE may indeed create a competitive advantage for industries and a breakthrough in research and development in Europe and beyond.

Conclusion

The aim of the 2-BE-SAFE project was to design and implement a broad-ranging research program that produces fundamental knowledge on PTW riding behaviour, performance, and safety - alone and when interacting with other road users - that can be used to inform and the development of a broad and integrated package of countermeasures/public policies for improving the safety of PTW riders in Europe.
The project consisted of an innovative program of research, involving partners from Europe, Israel and Australia, that directly targets those behavioural and ergonomic factors cited in the MAIDS study as contributing to PTW crashes.

Guidelines and recommendation have been drawn for the observation of PTW behaviours and for the determination of countermeasures towards improvement of PTWs’ road safety, based on the fundamental knowledge acquired in the project's research work packages. A set of countermeasures have been proposed that cover the safety problems that were identified during the in-depth studies related to: infrastructure and weather conditions, riders’ behaviour and interactions with other road users and conspicuity issues. The potential impacts of each proposed countermeasure, as well as its expected costs, implementation barriers as well as acceptance have been assessed. The proposed countermeasures have been ranked and key success factors have been proposed.

Potential Impact:
Dissemination impact

Dissemination activities inform various stakeholders about the potential activities of a multi-facet project such as 2BESAFE. Diffusing information and knowledge to various interested groups could yield unpredictably interested future research opportunities. For example, the potential for creating countermeasures and guidelines for methodologies and tools could serve as a basis for future research activities or continuation of the work undertaken with 2BESAFE.

Both User Forum events targeted potential users from diverse stakeholder groups (e.g. researchers, policy makers, OEMs, developers, engineers, automotive industry representatives, social scientists, etc.) because of the diversity and breadth of the project itself. Therefore, diverse needs might be covered by information that leads to the creation of a methodology handbook that could be potentially be available in different forms. In addition, publications encourage researchers across Europe and over the Atlantic to have an overview of both the “State-of-Art” and know-how on different fields in one project. For example, researchers will be able to get input for visual conspicuity and PTW rider attitudes resulting from work conducted within the same project.

Exploitation impact

The “Exploitation plans” described the exploitation and sustainability opportunities of the products of the 2BESAFE project. In specific, the document lists and discusses the possible products, target groups and exploitation models that can be implemented within the context of 2BESAFE and after its completion. The outcomes of the project are either services (provisions of know-how) or products (i.e. handbooks, s/w). Two of those products are primary and the rest six of them are secondary.

In general the period of which the 2BESAFE outcomes will be ready for market exploitation varies from 3 up to 24 months after the end of the project, while the potential users of those cover a broad range of stakeholder categories, which are the ones following:

- Research institutes
- Authorities
- Industry
- Legislators
- Standardization committees
- PTW manufactures
- PTW and car suppliers
- Training schools
- Infrastructure manufacturers
- Insurance companies
- Rider/cars simulator developers and manufacturers
- Human factor experts
- Bodies dealing with agricultural issues
- Bodies dealing with workplace accidents

Finally, all products, especially at their early stage, apply to the 1st Business Case of those that have been identified by the Market Analysis, which refers to the exploitation of the products on voluntary basis. However, some of the 2BESAFE outcomes, such as the 2BESAFE Implementation Guide, can be applied to all 3 Business Cases, concerning both exploitations on voluntary and on mandatory basis. In the cases of those products both the target sales and target prices are being multiplied from the first Business Case to the second and the third one. Nevertheless, actions on following also all 3 business cases have already been initiated by 2BESAFE partners and some have already leaded to their adoption by national standards and driving license procedures (i.e. Austria through KFv).

Societal impact

Probable societal impact would be indirectly affected by advancements in gaining insight in PTW interaction with drivers and naturalistic observation of PTW riders. These, among others, are first time findings leading to first time inferences that could prove valuable information to be diffused to not only stakeholders but to the general public and PTW riders through various motorcycle groups and organisations. Leading research institutes and associations are involved in 2BESAFE project. In other words, exploitation of know-how created within 2BESAFE could be easily diffused to general public by the partners themselves on first basis and later moving on to using the developed handbook for training purposes. Countermeasures also would directly affect society with both expert ratings that are easily transferable to common, general, flexible, understandable translation of knowledge by both riders and policy makers. The reciprocal benefit could accelerate benefits for road safety and decrease accidents related to PTWs and riders –drivers’ interaction.

List of Websites:
www.2besafe.eu