

EUROPEAN COMMISSION DG RESEARCH

SIXTH FRAMEWORK PROGRAMME

THEMATIC PRIORITY 4.3

FP6 – 2005 – Transport – 4

Specific Targeted Project– CONTRACT N. TST5-CT-2006-031360

FINAL Publishable Activity Report

1 June 2006 – 31 March 2010



PISa

Powered Two Wheeler Integrated safety

Deliverable no.	D34 - FINAL Publishable Activity Report
Dissemination level	Public
Task Package	Task 1.2 reporting
Author(s) and Partner name	C. van der Zweep (UNI), J. Vandenhoude (TNO)
Co-author(s) and Partner name	All partners
Status (F: final, D: draft)	FINAL – date
File Name	D34 – FINAL – FINAL Publishable Activity report -PISA.docx
Project Start Date and Duration	01 June 2006 - 31 March 2010
Approved by coordinator	J. Vanderhoude, TNO 31/07/2010

Table of Contents

1	<i>Project Execution</i>	3
1.1	PISA project Objectives	3
1.1.1	Main objective / mission	3
1.1.2	Scientific and technical objectives	3
1.2	Contractors involved	4
1.2.1	Co-ordinator Contact details	4
1.3	Work performed and end Results achieved	4
1.3.1	Work package 2: User needs and requirements [LU-VSRC]	4
1.3.2	Work package 3: System specifications [TRL]	11
1.3.3	Work package 4: System development [IBEO]	12
1.3.4	Work package 5: System integration [CARVER]	14
1.3.5	Work package 6: Evaluation and validation [TRL]	21
1.4	Degree to which the Objectives were reached	29
1.5	Methodologies and Approaches employed	30
1.6	Achievements of the Project in relation to the State of the Art	30
1.7	Impact of the Project on its Industry or Research sector	30
2	<i>Dissemination and it use (Publishable results) – Annex I</i>	31

1 Project Execution

1.1 PISA project Objectives

1.1.1 Main objective / mission

The aim of this project was to develop and use new technologies to provide integrated safety systems for a range of Powered Two Wheelers. The systems were developed, in order to improve primary safety and so that they could be linked to secondary safety devices. The project aimed to develop reliable and fail-safe systems which offer improved safety.

The rationale for the PISa project was that the research would contribute to the general EU target of 50% reduction in road accident fatalities; the PISa objectives were aligned with this ambition. PISa also contributed to India's automotive policy by enhancing the safety of PTW designs.

The quantified objectives for the integrated system were to combine sensors and an advanced braking and suspension system to:

- a) Avoid 50% of accidents where a collision was not inevitable;
- b) Reduce the impact speed, and hence reduce the injury severity by one MAIS integer for 50% of accidents where a collision was inevitable;
- c) Prevent 50 % of the single vehicle loss of control accidents.

The PISa project will assess the objectives in controlled tests to replicate the

1.1.2 Scientific and technical objectives

The scientific and technical objectives were to:

- Identify the most frequent causes – precipitating factors and contributory factors - of PTW accidents and how the rider interacted with the PTW during the pre-crash phase by analysing PTW accident data and video tapes recorded at dangerous junctions.
- Examine rider and bike interaction when riding along known accident sites using an instrumented PTW
- Assess and measure rider behaviour in dangerous manoeuvres identified from the accident analysis and instrumented PTW by using computer models, including human muscle activity, that replicate the interaction between a rider and a PTW.
- Assess and measure the PTW behaviour and response in dangerous manoeuvres, identify potential areas for improvement by use of triggered control mechanisms on for instance suspension, brakes, steering.
- Identify existing technologies and safety systems in passenger cars and assess their usability in PTWs.
- Develop a PTW safety system that integrates sensors, warning devices – visual, acoustic, and/or mechanical – an intelligent braking system and automatically variable suspension that will reduce the incidence and severity of PTW accidents.
- Assess the costs of the PTW safety system and the benefits in terms of reduction in accidents and injuries.
- Fit the prototype integrated safety system to at least two PTWs and evaluate the PTWs on a test track and road using a range of subjects (riders).

- Invite various dignitaries to observe the behaviour and hence the benefits of the integrated system during track and road tests.

1.2 Contractors involved

List of participants				
No.	Participant organisation name	Short name	Country	Type of organisation
1	Netherlands Organisation for Applied Scientific Research	TNO	NL	RES
2	Università degli Studi di Firenze	UNIFI	IT	HE
3	Loughborough University - Vehicle Safety Research Centre	VSRC	UK	HE
4	Ludwig-Maximilians-Universität	LMU	D	HE
5	Transport Research Laboratory	TRL	UK	RES
6	IBEO	IBEO	D	IND
7	Paioli Meccanica	PAI	IT	IND
8	Malaguti Spa	MAL	IT	IND
9	TVS Motor Company Ltd.	TVS	INDIA	IND
10	Uniresearch bv	UNI	NL	IND/SME
12	Carver Engineering	CARVER	NL	IND/SME

1.2.1 Co-ordinator Contact details

The technical coordinator role of Dr. Ard de Ruiter has been taken over by Jeroen Vandenhoude (TNO). The first of June 2009.

Coordinator name	Jeroen Vandenhoude
Coordinator organisation name	Netherlands Organisation for Applied Scientific Research TNO
Coordinator e-mail	Jeroen.vandenhoude@tno.nl
Coordinator Telephone	+31 40 265 2664
Coordinator Fax	+31 40 265 2601

1.3 Work performed and end Results achieved

1.3.1 Work package 2: User needs and requirements [LU-VSRC]

Context and objectives of the work of WP2

The activities proposed in WP2 were planned to make efficient use of existing data and information and, only where needed, collect new information. WP2 therefore used the outputs of other projects to provide in-depth accident cases and analysis of motorcycle

accident statistical data in order to both understand all of the relevant issues and to determine and prioritise the potential for active and integrated safety solutions.

The intention of WP2 was that real-world information would form the basis of the recommendations for the subsequent development and implementation of the PISa systems within WPs 3, 4 and 5.

The original objectives of WP2, together with the planned outputs were as follows:

1. Identify and prioritise from existing statistical PTW accident data those accidents where integrated safety systems will make a positive contribution to accident/injury reduction. Public deliverable D2: Powered two-wheeler Integrated Safety (PISa): Review of current PTW accident data.
2. Identify knowledge, issues and techniques from existing motorcycle and integrated safety literature, which will assist in the definition and evaluation of integrated safety systems for motorcycles. Public deliverable D3: Powered two-wheeler Integrated Safety (PISa): Review of PTW safety technologies and literature.
3. Review in-depth PTW accident data to identify relevant scenarios and to fully understand the issues of accident causation and outcome. Restricted deliverable D10 and D15
4. Review video data of driver/rider behaviour at road junctions (of known accident sites) to further understand accident scenarios. Restricted deliverable D11 & D15.
5. Identify the issues considered important to users (and experts) in relation to the performance of integrated safety systems. Restricted deliverable D12.
6. Prioritise potential integrated safety systems in the context of accident reduction/user behaviour/ technological possibilities. Restricted deliverables D13 & D14 and D16.
7. Define the requirements of specific potential integrated safety system(s) in terms of the system performance and user needs. Restricted deliverable D13 & D14.

Work performed

The work within WP2 was undertaken according to the Description of Work under a series of tasks and the majority of activities were completed in line with those planned. The tasks, and the results of the work completed within each, are described below.

Task 2.1 Accidentology

Task 2.1.1 Accident Statistics

A number of major European PTW accident studies were reviewed including: APROSYS (Advanced PROtection SYStems), MAIDS (Motorcycle Accident In Depth Study), SafetyNet, TRACE (Traffic Accident Causation in Europe), as well as various national studies. Each study was reviewed and data assimilated regarding the PTW market, accident data (trends, risk, scenarios and causation), injury data (distribution, type/outcome and causation), accident factors (time of day/year, weather/light conditions, speed, engine size and hardware and traffic control methods), crash test scenarios and design implications. In addition, accident data from India were reviewed.

The findings were presented in the context of the future work packages of the PISa project to provide direction and guidance concerning the key factors to be considered. The most important information which was carried forward in WP2 was the summary of the most frequent and severe PTW accident configurations identified by the APROSYS

project, represented by 7 crash scenarios as shown in Table 1. The data from India indicated that these scenarios were also relevant to Indian traffic conditions.

Table 1 The most frequent and severe PTW accident configurations identified by APROSYS

Importance	Location	PTW type	Struck object	Junction
1	Urban	Moped	Car	Intersection
2	Urban	Moped	Car	Straight
3	Urban	Motorcycle	Car	Intersection
4	Urban	Motorcycle	Car	Straight
5	Non-urban	Motorcycle	Single vehicle	Not stated
6	Non-urban	Motorcycle	Car	Straight
7	Non-urban	Motorcycle	Car	Intersection

Task 2.1.2 Literature (State of the Art) Review

A review was made of available literature relating to PTW technologies and safety. Information was reviewed regarding existing and near to market motorcycle technologies which may have a role to play within an ISS. In addition technologies from four-wheeled vehicles were considered which may be at least conceptually, if not technologically, transferable. Pertinent rider/driver issues were reviewed, such as age, gender, behaviour, vehicle usage, etc. Information on interface design was considered, in terms of cognitive psychology theories and Human-Machine Interface (HMI), including standards, best practice and guidance. Specific attention was given to gender issues associated with the project. Where available, information was identified regarding the involvement of females in PTW accidents and injury severity, but also their current PTW usage, trends and forecasts for the future. In the conclusion of the literature review the findings of the technologies and rider/driver issues were summarised in a table. This provided an overview of the information and illustrated how the information may be applied in the context of the PISa project.

The main findings of this review were that many technologies already exist on some high performance/cost PTWs and others exist in the wider road fleet. Thus, if these various technologies can be integrated and applied to the wider range of PTWs, many of the objectives of PISa can be achieved.

Task 2.2 Relevant Scenarios

Task 2.2.1 In-depth Accident Cases

The objective of the in-depth accident case review was to select appropriate in-depth PTW accident cases and to review them using a common methodology. The aim of the review process was to acquire an understanding of the issues of accident causation and to identify the functional requirements of intervention methods that would be effective for accident avoidance or mitigation.

Existing in-depth databases were used comprising a forensic accident database and the COST 327 database held by LMU, the UK On The Spot (OTS) database and the UK Fatals accident database held by TRL and the UK OTS database held by the VSRC.

The 7 accident scenarios previously defined by the APROSYS project formed the basis for the selection of relevant accidents. National data from Germany, Italy, Spain and The Netherlands were shown to fit well with the APROSYS scenarios. However, since the

majority of in-depth cases available to the PISa project were from the UK, it was necessary to consider whether the accident scenarios identified in APROSYS were also relevant in the accident statistics for Great Britain and to confirm if, and to what extent, they differ. A review of the national statistics for Great Britain (STATS19) was undertaken, and although this analysis showed that the priority of the scenarios is different, largely due to the different kinds of PTW in the UK fleet compared to that in Europe, it was concluded that a vast majority of the STATS19 accident cases could be described using the APROSYS scenarios. Analysis was also carried out to ensure that the two regional OTS databases held by TRL and the VSRC were representative of the national GB statistics. As a result of the general applicability of the APROSYS scenarios and the representativeness of the OTS data, it was considered that the in-depth cases from Great Britain could be used and that the findings from these cases would be applicable to European accidents in general.

Each team reviewed their existing in-depth accident cases according to an outline of accident characteristics and selected, according to a developed set of selection criteria, a number of cases (+/- 20) which fell within the scenarios of relevance as identified by 2.1.1 and which contained sufficient in-depth information. The selected cases were analysed in detail to determine their characteristics (reciprocal vehicle positions, vehicle speeds, etc), which in turn could allow the detection of a dangerous situation (e.g. stability hazard) or a pre-crash condition. A series of inter-team workshops was held to establish a common understanding to the analysis of the in-depth accident cases. This analysis addressed the pre-crash, crash and post crash accident phases. Case summaries were produced to aid the inter-team case review and validation process. These included descriptions of the crash circumstances, vehicles involved and damage sustained, individuals involved and injuries received and on some occasions witness statements of those involved. Also included were photographs of the scene, vehicles and approach and where available, scene plans with measurements and key scene information. Drive through video data for each accident case (where available) was also used to obtain aspects of pre-crash information. The detailed case reviews considered accident characteristics including accident causation, vehicle (PTW and opponent) characteristics, environmental factors, human factors, PTW rider and opponent vehicle occupant characteristics. All the selected cases were reviewed by LMU, TRL, VSRC and UNIFI, to clarify and confirm the issues and employ a common understanding and approach to the case analysis process. The result of this analysis was the finalisation of a list containing 43 intervention functions taken from the in-depth case analyses and ordered according to the pre-crash, crash and post-crash phases.

Each of the 60 in-depth cases was assessed against the list of 43 functions to determine whether each function might have made a contribution to crash avoidance, crash severity or injury severity reduction. This list was taken forward into Tasks 2.3.1 and 2.3.2 in order to assign safety systems to each of the functions and then prioritise them as described later.

Task 2.2.2 In-depth Video

Task 2.2.2 of the PISa project was originally intended to include an analysis of existing junction video and in-depth accident case ride/drive through footage. Due to a change in the partner contributions and project plan at the start of PISa the analysis of existing junction video was not possible. It was, however, possible to review video footage from in-depth accident cases where video footage either already existed or where it was recorded specifically for the PISa project. This video was recorded post-crash by the investigating teams following the route taken by the crash partners (PTW and other vehicles where relevant). Thus the video gives a drive-through perspective of the approach, site and background of the crash but it does not provide a visual reconstruction of the crash as the crash partners and circumstances are not present or recreated. In the PISa analysis the video was used to clarify the circumstances of the crash as interpreted by the review group from the case summary and supporting information. It was also possible to use the video to verify some of the variables recorded

in the case information and in some cases, make general estimates of distances and angles of approach. It was also possible to consider possible lines of sight of both the rider and driver. The video was also helpful in considering the alternative actions and outcomes that may have been possible in each crash situation. As a consequence the video analysis was used to enhance the understanding of each in-depth crash case. In total, 48 of the 60 in-depth cases had associated video footage which was included in the case review process. This video footage was either available with the original case material or collected retrospectively as part of the PISa project activity.

Task 2.2.3 User Information

A survey of PTW users was undertaken in Germany (D), Italy (I) and The Netherlands (NL). Additional information from an existing extensive UK survey was also analysed. The data collected included background information about the rider, their PTW and their views on various safety features, to obtain insight in the present usage of PTWs and the demand and acceptance for new safety systems.

The survey data allowed the information to be related to existing data sources and to investigate the trends in PTW accidents. This analysis was used to relate rider characteristics to accident risk and to the user acceptance of systems. In total 261 PTW riders were included in the survey (D=68, I=100, NL=93) of who 85% were male and 15% female. The total number of correspondents cannot be regarded as being representative for all PTW riders in the EU because of the limited amount of countries involved in this study. However, it provides user information for a large group of different types of riders from Germany, Italy and the Netherlands.

A total of 253 PTWs were owned by the survey population. These were classified according to 7 categories: sports, touring, roadster/conventional street style, cruiser, off-road/enduro, scooter >250cc and scooter <250cc. The distribution is given in Figure 1.

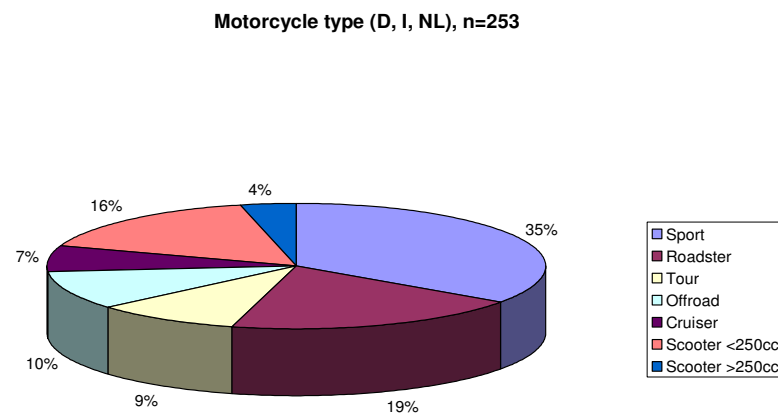


Figure 1: PTW classification, Motorcycle type (D, I, NL) n=253

The survey collected information including driving experience and licence held, types and circumstances of journey, reasons for riding a PTW, driving style and chosen protective equipment. Analyses of the data have been undertaken in order to establish the statistical relationships between variables of interest.

Of particular relevance to the PISa project were the views on safety systems. The outcome of the questionnaires referring to the desired systems showed that the PTW riders were in favour for direct driving support systems such as anti-lock brakes (ABS), electronic stability control (ESP/ESC), night vision displays, etc. Automatic support systems, taking away tasks from the PTW driver were disliked. It also seemed that the Italian drivers were more interested in the enhanced vision/night vision display than the other two countries. This could be related to the circumstances that the participants

drove in, as Italian riders rode more during night and twilight than German and Dutch participants.

A disparity may exist between user acceptance and the potential benefit of safety systems due to the perception of systems, the motivation of PTW riding and the accident liability for rider groups. However, advanced handling and protection systems (AHPS systems) may be the most viable for implementation and could provide the most immediate safety benefits. Collision warning systems (CWS systems) should be prioritised towards inexperienced riders who have reduced hazard perception and observational skills and a high accident liability. This group may also have the least opposition to new safety systems. Although generally considered undesirable, automatic driving task support systems (ADTS systems) should be focused towards particular user groups since the acceptance, functionality and therefore safety benefit is somewhat dependent on the purpose of riding.

Task 2.3 Derived Driver Assistance Functions

Tasks 2.3.1 and 2.3.2 Matrix of Scenario Interventions and Priorities

The process of system selection and prioritisation was based on the accident data which was analysed in the in-depth case review. Having determined the functions which could serve as countermeasure interventions for each in-depth accident, it was necessary to consider the possible technical system solutions that would contribute either to accident avoidance and injury avoidance or mitigation. The first step was therefore to define systems which fulfilled the functional requirements. This list of systems was constructed initially at a global level and then at a specific technological level as illustrated in Table 2.

Table 2 An example of one of the 43 function/global system/specific system combinations

Function	Global System	Specific System
Avoid locking of wheels	Braking	Anti-Lock Braking System (ABS)

It was then necessary to establish a priority list of these systems which would enable the PISa project to select those systems which would have most positive effect on accident prevention and/or mitigation.

Two different sets of analyses were completed to determine the priority list of functions. The first was carried out on the in-depth accident cases, where a system of scoring and weighting was developed. This scoring was allocated based on the expert team reviews, in which a common approach to the accident analysis and rating process was developed and validated in a series of inter-team workshops.

For the in-depth accident cases a matrix was constructed, consisting of the 43 functions/systems and the 60 accident cases in order to enable a score to be awarded to each system-case combination. A section of the matrix is shown in Table 3 Illustration of the system-accident case matrix. A score of 0 (white) means that the system in question would not have had an effect on accident prevention, mitigation or injury severity reduction in that accident. A score of 1 or 2 (blue) was awarded if it was believed that the system would have a low level of influence on the accident. A score of 3 (orange) refers to a system which was felt would have a medium level of effectiveness in that accident situation whilst a score of 4 or 5 (red) was given if it was considered that the system being analysed would have had a significant impact on preventing the accident or on reducing the injury outcome. The colour coding produced a pictorial representation of the results that enabled a quick initial analysis of the 2580 system-case combinations to see which systems were affecting more accident cases.

Table 3 Illustration of the system-accident case matrix

Function	System	Accident Case Number		
		TRL0001	VSRC0002	LMU0003
Prevent PTW from starting if BAL > 0.5mg	Alco-lock key	1	0	4
Improve PTW conspicuity	Active lighting	0	2	3
Prevent PTW wheels from locking	ABS	5	1	0

The second analysis was carried out on the UK Fatals Database. Due to nature of the coded data contained within this database, a rule-based system method of analysis was used to determine which systems would and would not have positively influenced the accident.

The ranking of functions based on the scores provided by the case by case analysis was used as the main input to prioritising the systems. The system list used as the basis of the proposed system selection was the "all scores" assessment of the in-depth cases for which any benefit was predicted. The most important priorities for PTW crash reduction were warning the other vehicle of the PTW presence and automatically stopping that vehicle. However, these and other functions that were deemed to be outside of the scope of the PISA project or not within the capability of the PISA consortium were then removed to give the priority list relevant to PISA. This proposed systems list was therefore the recommendation from WP2 to WP3 and an input for an initial benefit assessment which assessed the proposed list in terms of the monetary casualty benefit predicted for each system. The proposed system list was as follows:

1. Stop PTW (autonomous braking)
2. PTW to detect other vehicle and warn rider
3. Special Fairings on PTW (improve PTW conspicuity with special fairings)
4. ABS (anti-lock braking system)
5. Brake Assist - EBS (enhanced braking system)
6. Brake Assist - CBS (combined braking system/linked brakes)
7. ACC (adaptive cruise control)

In addition, a review of the data and a small sample of cases from India confirmed that there was broad agreement with the proposed systems chosen with relevance to the traffic conditions in India.

Task 2.3.3 Derived Driver Assistance Functions - Estimate of Impact

An initial benefit estimate was carried out on the proposed systems. This used the outputs from the prioritisation process to assess the 'target population' benefit attributable to each of the systems, where the target population is the number of annual casualties which may be influenced by the system.

The target population benefit assumed that the systems are 100% effective, and as such, this value provided the maximum potential benefit for each system. The potential benefit

was calculated for European PTW casualties based on those systems that were predicted to have any level of influence on the accident, and those in which the system was predicted to have a significant influence on the accident. This analysis was also repeated for Great Britain, since it was known that the distribution of PTW bike styles is different to the general European picture.

Using values for the estimated number of annual PTW fatal, serious and slight casualties for Europe and Great Britain a series of calculations were made to derive estimates regarding the distribution of the severity classes by APROSYS accident scenario and the percentage of accident cases in each APROSYS scenario where the system was predicted to provide a benefit. Combining these values and scaling them up to annual casualty numbers resulted in the target population. Monetary values were then assigned to these numbers of casualties to provide an annual casualty benefit for each system. This analysis revealed that for Europe, the priority order of systems in terms of benefit was nearly identical to the priority order proposed by Task 2.3.2 Scenario Interventions and Priorities.

The analysis of data from Great Britain exhibited expected differences when compared with European accidents. This is due to the different bike type distribution and hence the difference in use and accident circumstances. For Great Britain, the systems selected fit well to the proposed systems, with the top five priorities covered. For those accidents which the system was predicted to make a significant difference, the selection of systems fits less well, although the two main priorities are addressed.

It should be noted that significant assumptions were made in the methodology that have not been validated. The largest of these assumptions was that the in-depth accidents taken as a sample of each APROSYS accident scenario were representative of European or national accidents. However, this and other assumptions were necessary to produce the best possible benefit assessment to validate the selection of systems for development within the PISa project.

The results of the benefit assessment confirmed that the systems proposed to be taken forward by the PISa project were, in the light of the available information, appropriate in terms of the target population benefit.

The outputs of WP2 were twofold. The working results were passed on to WP3 (and other WPs when relevant) in electronic form. The formal outputs were in the form of deliverables, with the public deliverables available on the public PISa website and the restricted deliverables made available to the partners of PISa on the private PISa website.

1.3.2 Work package 3: System specifications [TRL]

The objective of WP3 was to define the specification of the components, which form part of the integrated safety system installed onto the Powered Two Wheeler which aim to detect dangerous situations and prevent potential accidents. The integrated safety system includes a module to determine the dynamic state of a motorcycle in real-time, during both normal driving conditions and emergency situations. The detection must occur early in the pre-crash phase so that action can be taken to avoid an accident. WP3 considered the most relevant accident mechanisms and rider assistance functions identified in WP2 and derived a specification for the system components with the assistance of computer modelling. Within this package an existing computer simulation was modified to incorporate rider and muscle behaviour to allow the evaluation of accident mechanisms.

A work plan was developed and agreed by the consortium to progress tasks that were critical to the project schedule. The work plan included a revised schedule to enable key information to be passed to subsequent work packages to minimise delays. In this reporting period, the work performed was the completion of the deliverables: D17, D19, D20 and D21. This involved considerable effort in analysing and reporting the results of WP3.

For task 3.1, TRL, along with UNIFI, developed a matrix of pre-crash rider behaviour and manoeuvres from the OTS cases analysed in WP2. This matrix enabled the derivation of some important information about accident avoidance and mitigation – which methods do and do not work and why that is the case.

For task 3.2 (Specification of rider assistance functions), the objective was to define the components of the safety systems chosen in WP2. This established the information needed and actions necessary to achieve the functional requirement of each safety system. TRL developed a matrix consisting of three parts:

Functions. This detailed the functional requirement and system specification for each of the six systems chosen. It specified the operating principle of the system, the information and action required to implement the system, any decision making processes that had to be considered and applicable situations for the system to be used.

Detect. This used the information required from the Functions matrix to develop a further matrix detailing what needs to be detected for the systems to work, how they would be detected, what kind of sensors would be needed and their availability, cost, power needs, space needs and robustness, plus an overall assessment of the feasibility of using each sensor.

Action. This also used the Functions matrix to layout what actions are needed, what actuators are required to implement those actions and the availability, cost, power needs, space needs and robustness of those actuators, plus an overall assessment of the feasibility of using each actuator.

TRL distributed this matrix to the PISa consortium and co-ordinated the input of the information which informed WP5 as well as providing information on systems not implemented by the PISa project which could be used by further research projects.

Tasks 3.1 (specification of human factors), 3.2 (Specification of driver assistance functions) have been completed and reported in D17 and D19. Task 3.3 reported on test results from track tests which had parameters important to braking and pre-crash manoeuvres. Some information on this task was completed from track tests and reported in D17. However, since the baseline performance of the PISa motorcycles is required, some testing activity was shifted to WP6, when it was possible to test the same PTW models with and without the system active.

UNIFI put considerable effort into the work creating the decision logic for the PTW integrated system as required by Task 3.2.1 and D20 was completed which reported on this aspect. This was an essential and technically very demanding aspect of the PISa system since it is effectively the “decision-making” code which determines from data sensed by the scanner and vehicle state sensors, when to activate the systems and when to inhibit the activations.

1.3.3 Work package 4: System development [IBEO]

The central work package objective was the development of a Motor driver assistance system (MDAS) for motorcycles. The outputs of WP2 and WP3 formed the framework parameters of the MDAS. The MDAS is comprised of the set of sensors and actuators which are mainly provided by the project partners. The system development includes the development of a warning strategy / collision mitigation strategy, which operates, based on the sensor system data and the development of an appropriate HMI.

Task 4.1 Selection of sensors

In this task a set of sensors and actuators was defined for the MDAS using the input from WP2 and WP3. In cooperation with all project partners, the following sensor systems were selected to be installed in the demonstrator motorcycles:

- Object detection sensor
- Motion platform sensor

- Haptic throttle sensor
- Semi-active front fork sensor

These sensors are described in detail in Section **Error! Reference source not found..**

Task 4.2 Design and adaptation of the sensor system and the actuators

In this task first sensor systems were mounted on a project motorcycle for data recording including a video camera for visual reference. With the help of these data and existing car-focused algorithms, the pre-processing of the sensor data could be adapted to the motorcycle domain. Moreover, the object tracking and classification were modified to the requirements of the MDAS.

Furthermore, the following actuators were designed in this task according to the specifications set in WP 3.3:

- Tactile saddle
- Haptic throttle
- Active Braking system
- Semi-active front fork

These actuators are described in detail in Section **Error! Reference source not found..**

Task 4.3 Sensor Fusion

In the sensor fusion task intelligent algorithms were developed in order to combine the output of all sensors and the state estimator selected in task 4.1 into one consistent set of sensorial data. This data formed the basis for the development of the situation interpretation and risk assessment module of task 4.4.

Task 4.4 Situation interpretation and risk assessment

Based on the finalized MDAS system layout, the module for situation interpretation and risk assessment was developed and implemented into the system. Therefore, the fused measurement data from the Laserscanner (as the forward looking sensing device) and from the XSens sensor (state estimating device) was used in order to get a good understanding of the current situation. The so gained object data (e.g. object number, position coordinates, and velocity data) together with the data of the demonstrator's dynamic state (e.g. velocity, roll angle ...) were passed on to the developed decision logic which interpreted the situation and prioritized road objects according to the potential risk they pose to the motorcycle. The outcome of this task was further reported in deliverable D26 "Module for risk assessment and warning algorithms".

Task 4.5 HMI and warning strategies

The HMI and warning strategies for the PISa demonstrator were developed in this task based on the results from WP 2, 3, tasks 4.1, 4.2 and 4.3. This HMI assisted the PTW rider to avoid the selected accident types. Special attention was given not to distract the rider or unexpectedly take over control, which may lead to unintended extra danger for the rider.

Three topics were considered and worked out in detail for this task:

1. Autonomous braking: autonomous braking was considered in this project, the question we asked ourselves was: when and how autonomous braking systems may be applied?
2. Automated PTW rider **D**istance **S**upport **S**ystem (DSS): a system was developed (hard and software) to aid the rider in maintaining proper time headway in an

intuitive manner. This resulted in an automated system, for which the rider is, however, still able to override the system and take over control when needed;

3. PTW rider warning devices and related warning signals (further details can be found in Section 1.3.4)

HMI and warning strategies were reported in the corresponding deliverable D29 "HMI for motorcycle driver assistance system".

Task 4.6 Autonomous collision mitigation and avoidance approaches

In this task the investigation and evaluation of the test scenarios with respect to collision mitigation and avoidance strategies was performed as well as the development of risk assessment algorithms based on a simulation of the PISa accident scenarios. As input to the development of the risk assessment as well as the warning strategies, real driver reaction times and braking behaviour was investigated. Therefore, a construction similar to a motorcycle was built and attached to a mechanical sled in order to simulate autonomous braking of a motorcycle. The results of this task were concluded in deliverable D27 "Evaluation of collision mitigation and avoidance strategies".

Task 4.7 System simulation

Simulations of the MDAS including HMI were performed at TNO Automotive/TNO Human Factors in order to determine the performance of the PISa system (benefit with respect to the bike without the system) during accidents, and the influence on the tuning parameters on the behaviour/ performance. The results were reported in the Deliverable D28 "Report on system simulation".

1.3.4 Work package 5: System integration [CARVER]

The objective of WP5 was to produce and implement the integrated safety systems, developed in WP4 (System development) into a range of full-scale PTWs (at least 1 scooter and 1 motorcycle) from the participating PTWs manufacturers, to be able to test the integrated systems in WP6 (Validation & Evaluation).

During the project, given the different safety systems considered within the project, it was decided to build two full-scale PTWs.

The first one is a scooter supplied by the Italian project partner Malaguti:

- Malaguti SpiderMax GT500
A 500cc scooter, commonly used in southern Europe



Figure 2: Malaguti SpiderMax GT500

The other one is a motorcycle supplied by the Indian project partner TVS:

- TVS Apache 180 RTR
A 180cc motorcycle, a bike type which is very commonly used in India



Figure 3: TVS Apache 180 RTR

Task 5.1 Preparation of the PTWs and realisation of the safety devices for implementation

WP5 was divided into 3 tasks. In Task 5.1 the preparation of the PTWs and realisation of the safety devices for implementation in the PTWs is addressed. In this task the design specifications for the physical interfaces of the integrated safety devices (sensors and actuators) and the PTWs were defined in cooperation with task 4.2 (Design and adaptation of the sensor system and actuators) and 4.5 (HMI & warning strategies). The specifications were used to prepare both PTWs for the installation of the safety devices later in WP5. An important specification composed within Task 5.1 is system architecture diagram of both PTWs.

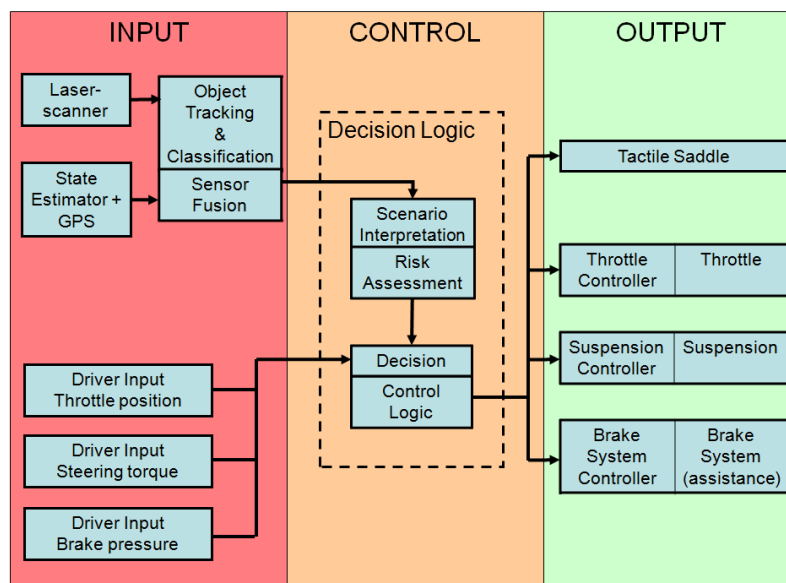


Figure 4: Malaguti system architecture

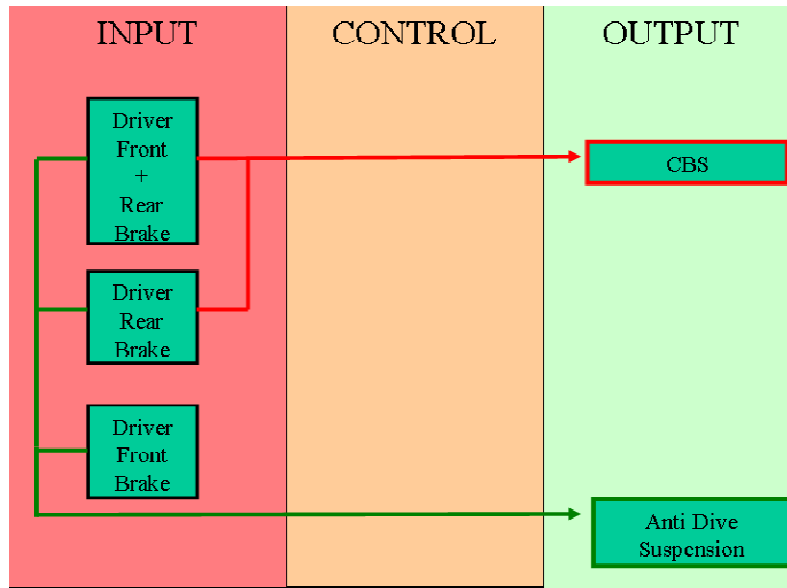


Figure 5: TVS system architecture

The diagrams give an overview of the PTW sensors (INPUT), their interface with the central computer (CONTROL) and the actuators (OUTPUT) installed on the PTWs.

Task 5.2 Validation of the sensors/actuators

To ensure a seamless integration of all sub-systems in Task 5.3, all sensors and actuators developed in WP4 were tested under laboratory condition, before being installed on the PTWs. The results of these tests are part of the combined deliverable D30 - D31. The following sensors and actuators were developed and installed on the PTWs:

Object detection sensor



Figure 6: object detection sensor system; Ibeo Lux Laserscanner

The main task of the object detection sensor system is to detect, classify and track the objects in the forward oriented surrounding of the PTW. This information is later used in the control level in order to interpret the situation and to issue warnings to the driver or set-off autonomous actions within the scenarios addressed by the PISa project.

The "heart" of the system is the Ibeo Lux Laserscanner. This device uses a time-of-flight measurement principle at near-infrared wavelength. The measurement range is up to 200m, however vehicles and other well reflecting objects are typically detected well beyond this distance. The device is eye-safe (class 1) and has the following features:

- Scan frequency: 12.5/25 Hz
- Field of view (horizontal): 100°

- Range: 0.3m to 200m
- Resolution angle: 0.1° to 1°
- Laser class 1
- Built-in processing
- 4 parallel and simultaneous scanning layers
- Ethernet- and CAN-interface

Motion platform

The intension of the motion platform is to measure the movements of the PTW. Main interest goes to the PTW speed and roll angle, the last one a difficult to measure quantity. For this reason a inertial measurement unit (IMU) with integrated GPS receiver is used. The sensor, an MTi-G manufactured by XSens, is an integrated GPS and inertial measurement unit with a navigation, attitude and heading reference system (AHRS) processor. The MTi-G is based on MEMS inertial sensors and a miniature GPS receiver and also includes additional aiding sensors; a 3D magnetometer and a static pressure sensor. The most important sensor features are:



Figure 7: inertial measurement unit; MTi-G manufactured by XSens

- 3D acceleration, 3D rate of turn
- Position and Velocity
- 3D Orientation (360°)
- built-in 16 channel Global Position System (GPS) receiver
- real-time computed GPS-enhanced attitude/heading and inertial enhanced position/velocity data
- high update rate (100 Hz)

Tactile saddle

One of the PTW actuators is a tactile interface, integrated in the PTW saddle. A tactile interface is an array of small vibrating elements, called tactors, which the user senses through touch when they are in contact with the skin. For example, when a mobile phone vibrates, it is a tactile interface that lets the user feel that an incoming call is waiting to be answered. As long as the tactors have a reasonable contact with the skin and are vibrating strongly enough, the tactors can be felt under high vibration or bumpy conditions.

These tactors were implemented in the saddle of one of the PISa test bike. The tactile saddle uses these vibrating elements in order to generate a tactile warning that can be felt by the PTW rider of the motorcycle. The tactile interface is used to presents warning signals to the PTW rider in order to draw his/her attention on a particular situation. The warnings are generated by the decision logic based on situation interpretation using the installed sensors.

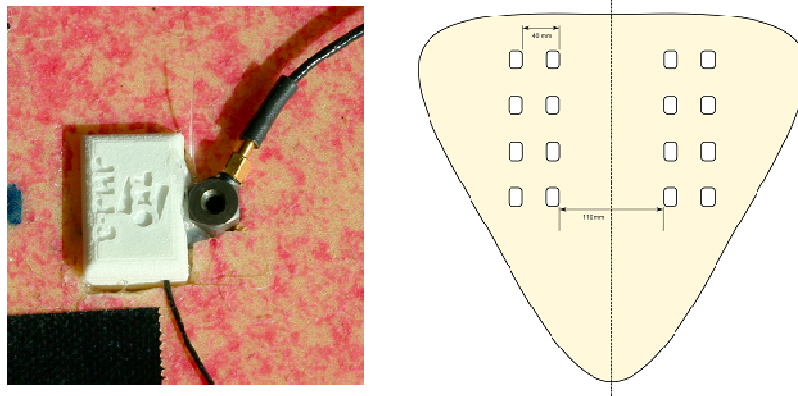


Figure 8: Tactos of the vibrating saddle

Haptic throttle

For the use in car-following situations, a haptic throttle was implemented on one of the PTWs. The actuator provides a controllable counter torque to the rider via the throttle. Again the magnitude of the counter torque is dictated by the decision logic.

The haptic throttle is used for the realization of the Distance Support System (DSS) on the scooter demonstrator. The concept of the DSS is that the rider is supported in maintaining a safe distance and speed by maintaining a constant torque on the throttle. For example, if the distance decreases, the torque increases, meaning that the rider has to release the throttle, which will increase the distance. This will keep the rider in the regulation phase and support him/her from getting into the critical reaction phase. If the rider enters the reaction phase, a maximum feedback torque is applied notifying the rider to release the throttle. The rider is able to overrule the torque feedback for example by doing a lane change.

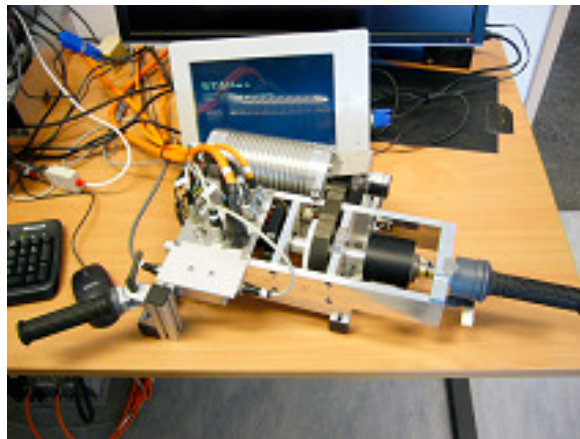


Figure 9: The haptic throttle on a test bench.

Before integration in the PTW, the haptic throttle was tested under laboratory conditions on a HIL bike simulator setup.

Combined braking system

Active Braking System

The most important actuator on the PTW is the Active Braking (AB) system, a system capable to slow down the PTW without any braking input from the rider. The AB device was designed and realised by Carver Engineering. It utilises an independent hydraulic system which operates through a dedicated calliper acting on the front wheel. The front

wheel mounts two parallel braking disks, one on each side. The left side disk is dedicated to the AB system. The front brake is also under control of the rider through the right braking disk. The AB device is constituted by the following main elements:

- dedicated braking disk
- hydraulic circuit and calliper
- electric motor and pump
- pressure sensor
- electronic control unit
- power supply

When the AB is idle, the pump is off and the pressure inside the circuit is close to the atmospheric value. Under these conditions, no braking torque is applied on the left braking disk and the rider has full control of the braking action on the front wheel.

When the electronic control unit receives the input to start the AB function, the electric motor connected with the pump is activated. Therefore the pump starts building up the pressure in the braking circuit and the calliper produces a braking torque on the front wheel.

The requirement of the AB is to achieve a predetermined deceleration. For this reason the pump must be controlled to obtain the needed pressure. A closed loop controller including the PTW dynamical state represents an appropriate solution for production vehicles. Differently, in the demonstrator the controller of the AB is in closed loop with the pressure sensor, so that a target pressure can be achieved. Tests with the prototype were performed to identify the brake pressure value needed for obtaining the target decelerations.



Figure 10: The installed Active Braking system

Semi-active front fork

Within the PISA project, both demonstrator bikes were fitted with a semi-active front fork. The forks, developed and manufactured by project partner Paioli, provide increased damping during emergency braking, in order to increase PTW stability and reduce stop distance during this critical phase.

Two different actuation principles were implemented:

- in one of the forks an on/off valve is integrated to switch between standard and increased damping,
- in the other front fork the damping ratio is continuously variable between standard and max damping. To this end a stepper motor was integrated, controlled by an

ECU and activated by the decision logic. When actuated the motor reduces the oil flow inside the fork, resulting in increased compression damping (20 times higher than standard) and increased rebound damping (3 times higher than standard). The response time of the system is about 0,2 s (from min to max).

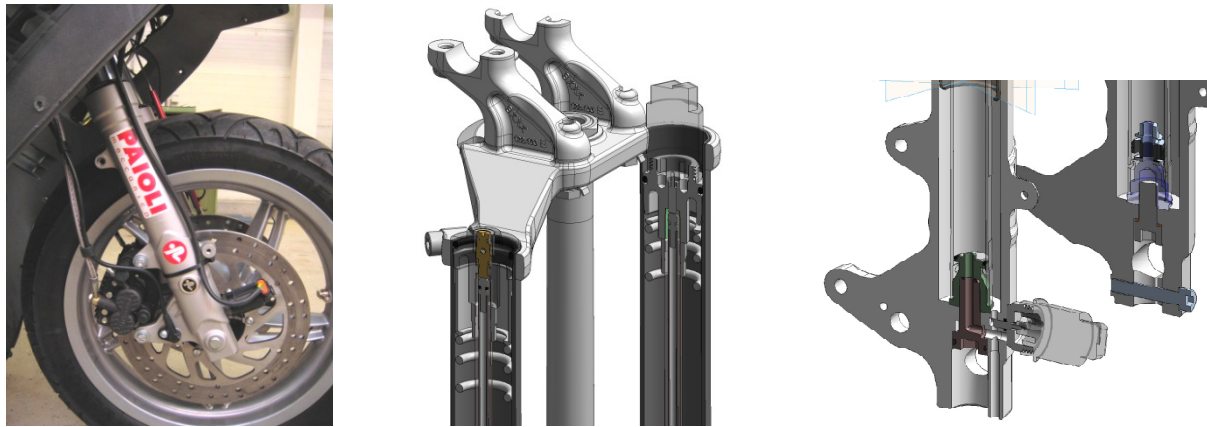


Figure 11: Semi-active front fork

Task 5.3 Implementation of the integrated safety systems developed in WP4 and made/tested in WP5.1 and WP5.2.

The last task of WP5 was the integration of all safety systems in the PTWs to be able to test the integrated systems in WP6.

After development and evaluation of the systems in WP5.1 and WP5.2, all systems were ready for integration. Integration of the systems in Malaguti was performed at Carver Engineering. The following sensors/actuators were integrated in the Malaguti:

- Object detection sensor
- Motion platform
- Tactile saddle
- Haptic throttle
- Active Braking system
- Semi-active front fork

All sensors and actuators are connected with the dSPACE MicroAutoBox. On this rapid control prototyping platform the decision logic is implemented. The decision logic is the set of rules and algorithms that implement the scenario recognition and the function deployment in order to synthesize the desired intervention strategies.

After integration of all systems, the Malaguti was shipped to TRL where the WP6 test activities would be performed. Within WP5, TRL test track facility was used for functional evaluation of the integrated sub-systems and tuning of the developed control. To get all system developers together, a one week technical workshop was organized at TRL in order to prepare the bike for WP6.



Figure 12: Malaguti test scooter with integrated sensors, actuators and control unit

The systems on the TVS motorcycle were integrated at Paioli. After Paioli had integrated the semi-active front fork, TVS came to Italy to install the combined braking system they have developed for this motorcycle. Functional test were performed at a small test track at Paioli. After successful evaluations, the TVS test bike, together with a standard TVS bike, were shipped to TRL for WP6 testing. The following systems were integrated in the TVS test bike:

- Semi-active front fork
- Combined braking system

WP5 Deliverables

In work package 5, the systems (sensors and actuators) designed and adapted in WP4, were implemented in two full-scale PTWs for testing in WP6 in a set of scenarios. The participating motorcycle manufacturers (MAL, TVSM) provided the PTWs. Before integration of the systems in the PTWs, prototypes of the selected safety devices were developed and tests were performed in laboratory conditions. After integration of the safety devices in the PTWs, functional tests were performed to prepare the PTWs for WP6. A description of the laboratory and functional tests performed, together with the test results are available in D30 and D31.

1.3.5 Work package 6: Evaluation and validation [TRL]

The objective of Work package 6 'Evaluation and Validation' was to test and evaluate the integrated safety system, according to the requirements developed in the previous work packages. This evaluation was to be carried out as set out in Annex 1 - Description of Work in Tasks 6.1 and 6.2 as described below:

Task 6.1 Test Plan

A comprehensive test plan was developed which successfully addressed the aims of the task to:

- Devise a test plan to evaluate the performance of the integrated systems and the modular elements plus the likely effect on the outcomes of accident scenarios identified in WP2.
- Existing driver performance evaluation methods will be considered to ensure that the test rider's safety is taken into account.

- Where suitable subjects are available the evaluation will assess the range of system performance using both male and female test riders.
- The test plan will ensure that a comparison of a baseline (normal) motorcycle can be made with one where the integrated system is fitted and active.
- The test plan will allow the performance of the prototype integrated system and consequential human factors to be investigated in terms of the safety, support (does the system actually make performance better), acceptance and comfort.

Task 6.2 Road/Track Tests

The aims of the road/track tests were to:

- Use skilled riders will be used to evaluate all integrated systems: warning, brake and suspension, on a test track, with some road tests depending on the results.
- Use video and instrumentation will be used to analyse the integrated system relative to the performance specification defined in WP4/5 and also to assess the human interaction.
- Complete trials will also be completed with typical motorcycle riders (where ethically feasible) to allow further assessment of the motorcycle with and without the integrated system.
- Develop a user questionnaire will be developed to investigate the rider's opinion of any warning actuators.

These systems were evaluated against a defined test plan (task 6.1; see D33a) to measure the performance of the systems. This was achieved by testing the system in representative test conditions and, where appropriate, comparing performance of "unequipped" and "equipped" PTWs. The full test results from the test programme are reported in D33b. The aim of this was two-fold; firstly to allow the performance of the systems to be used in the final benefit evaluation which aims to inform on the likely casualty reduction relating to system fitment and the costs of the systems, and secondly, to allow improvements to be recommended to the final prototypes.

A comprehensive system validation test programme comprising many thousands of test runs was carried out by TRL and the WP6 partners which validated the performance of the following PISA systems:

Active braking (AB) – Low level autonomous braking at 0.25g with pre-warning

Enhanced braking (EB) – Additional braking effort applied (brake assist) in an emergency

Combined braking (CB) – Distribution of brake forces between the front and rear wheels

Distance Support (DS) – Automatic throttle inhibition for critical time headways.

Additional suspension systems were developed which were not specifically recommended, but whose action complements the behaviour of the PTW under emergency braking

Active and anti-dive suspension – adjusting suspension characteristics to complement heavy braking performance

Results showed that for Active Braking (AB), the mean triggering reliability decreased with test speed, from 91% at 35km/h to 58% at 55km/h. Reliability increased with increasing AB trigger setting (range 58% to 89%). This showed that the system was more reliable when set to activate very close to impact (mitigation system). At settings consistent with accident avoidance, the reliability was low. For tests in which the system functioned correctly, the distance at which the AB system triggered was between 23.3m and 6.2m prior to impact, depending on the trigger setting, and between 11.2m (for tests at 35km/h) and 33.4m (for tests at 55km/h) for AB trigger setting 3.

For the tests involving crossing, the "crossing scenario", the reliability of the system was low for the lowest (avoidance) AB trigger settings, with the system triggering on the test

object in 9% of tests. At full mitigation (AB setting "9"), the reliability was 91%. For these tests the AB triggering distance was between 20.67m (1.16s TTC) and 5.48m (0.44s TTC) depending on the AB trigger setting. It is recommended that the decision logic is improved so that the performance in this important accident type is improved.

Test riders preferred AB trigger setting 5 (activation of AB when approximately 0.5g required to avoid impact). Test riders were content with the level (c0.25g) of the AB system

For the tests on the Enhanced Braking (EB) system, results showed that, on average, and with EB on, a rear brake application by the rider delivered a stopping distance between 2.1% and 6.8% better than a test rider applying both front and rear brakes. This shows that the PISa EB system is very effective at providing emergency braking. If such a system was introduced onto a production bike it would most likely be in conjunction with ABS and would mean that the even at high braking forces, the wheel would be prevented from locking.

The mean results also show a weak trend for better improvements with increased suspension settings, although statistical testing showed no significant differences by suspension setting for the "EB on" group. The results also show that for the EB off group, the test rider (an experienced rider performing a planned braking manoeuvre) was able to improve stopping distances on average by between 15.1% and 19.4%. For this group, the suspension at medium or maximum, had a significant ($P < 0.001$) effect on stopping distance. This shows that when the braking response of the rider is to use the front and rear brakes, the addition of active suspension makes a significant difference to the overall stopping distance; this is explained by the suspension reducing dive and giving the rider more confidence in applying the brakes, essentially realising more of the PTW's braking potential.

For the Combined Braking (CB) system, results showed that the addition on CB had a significant ($P < 0.001$) positive effect on stopping distances, with average distances decreasing by 18.5%. The addition of semi-active suspension did not have any significant effect on stopping distance, although a weak trend for a benefit was noted in the average stopping distances with the suspension.

For the Distance Support (DS) System), results showed that there was no clear improvement of the car-following task. There were two tests performed, one with a prescribed car-following distance and one with a car-following distance of which the rider felt comfortable with. There was no improvement of the car-following performance shown in the first test. The results of the second test showed that the rider was more capable of following the lead vehicle with the DS system compared to without the DS system with almost a 40% change. This supports the results of a motorcycle experiment conducted by TNO (Weijenberg, 2008). The track tests showed that the results were influenced by false alarms, with these being caused by falsely detected objects seen by the laser scanner. According to the subjective measures, the DS system appears promising for improving PTW car following performance. However, the system requires further improvements to reduce the false alarm rate and to assess what influence the system has on overall safety.

The systems fitted to the Malaguti exhibited initial technical problems and the overall system could be reasonably described as being still in the development phase. This also had significant impacts on the planned scope of the road test evaluation in Task 6.2 as it meant that the system was not developed sufficiently to obtain feedback from members of the public as initially planned. VSRC led the "user evaluation" of the PISa systems. The intention was that user evaluations by 'typical' riders would be conducted following the technical evaluation of the system by skilled test riders. Following a decision that it would not be possible to carry out tests using typical riders several alternative activities were undertaken. These are documented in D33c and include:

- Definition of the PISA systems (system diagrams) for both the Malaguti scooter and the TVS motorcycle,
- Development of an on-line survey (questionnaire) that might be used to collect views of the systems,
- Production of a PISA video which could be used in conjunction with the web-based questionnaire and also to assist in the technical dissemination of the PISA project,
- Collection of feedback about the PISA systems from an informed audience representing the motorcycle industry, riders' organisations and researchers

The results of the performance evaluations formed part of a final benefit and break-even analysis for the developed systems. The track results also formed the basis for recommendations for revised 2nd phase prototype. The revised PTWs was used to demonstrate the performance of the integrated safety system at the final PISA event held at TNO Helmond in February 2010.

This work package also estimated the casualty savings which could potentially be attributable to the PISA integrated system. To this end, an evaluation methodology was applied, and predictive estimates were made for the target populations applicable to each safety system. Further estimates using a speculative range of system effectiveness values were used to examine potential break even costs for the individual PISA systems.

The EU-27 target populations (numbers of PTW casualties who could be influenced assuming 100% system effectiveness) for the individual PISA systems were estimated as:

- Distance Support System: Fatal 108; Serious 970; Slight 2,366
- Active Braking (following): Fatal 269-869; Serious 1,639-5,900; Slight 3,364-12,609
- Active Braking/Warning (crossing): Fatal 1,012-1,646; Serious 8,389-13,279; Slight 17,065-28,049
- Enhanced and Combined Braking: Fatal 370-2,745; Serious 3,176-10,499; Slight 9,260-19,368

A sensitivity analysis on the system effectiveness was carried out to enable an indicative, analysis, covering subjective estimates of system effectiveness between 10% and 50% of the target population. For these casualties it was assumed that the casualty severity outcome was reduced by one level – i.e. from fatal to serious, serious to slight and from slight to no injury. This analysis yielded estimated EU-27 annual casualty benefits:

- Distance Support System: €34 million (low effectiveness); €170 million (high effectiveness);
- Active Braking (following): €18 million - €90 million (low effectiveness); €89 million - €451 million (high effectiveness)
- Active Braking/Warning (crossing): €47 million - €187 million (low effectiveness); €233 million - €934 million (high effectiveness)
- Enhanced and Combined Braking: €115 million - €552 million (low effectiveness); €577 million - €2,762 million (high effectiveness)

This speculative analysis indicated that the break-even costs for the system are relatively low and are likely to mean that scanning and autonomous decision making actions are not cost-beneficial without reductions in cost or specific studies or field-operational tests showing that the real world effectiveness is greater than has been assumed.

It should also be noted that the systems were necessarily validated in the test phase as independent systems and the analysis reported here reflects this. However, when implemented, the system is an integrated system and the benefits predicted are therefore not cumulative; the target populations for the individual system types will in

practice have some overlap, although without further data, the extent is difficult to predict.

The PISa integrated system has been developed successfully and has shown demonstrable performance level increases in specific test conditions. PISa has demonstrated that the application of safety technologies to assist the rider has been shown to be an effective strategy to mitigate the severity of critical situations and the PISa prototype shows potential for reducing European PTW casualties. Although good performance in test conditions is considered very likely to translate into real-world casualty savings, the estimates for the European population cover a wide range and are limited by the extent and quality of the effectiveness information available.

This work package delivered:

Reports describing the test plan (D33a), test and results (D33b) including the simulation outcomes which were included as an Annex to D33b, and a description of the alternative activities (D33c)

A report on the cost benefit analysis of the system (D32)

A PTW fitted with prototype system(s) which can be used to demonstrate the performance and benefits

Work package 7: Dissemination [UNIFI]

Task 7.1 Dissemination tools

Project image and project website

The public PISA project website www.pisa-project.eu was created at the beginning of the project and continuously maintained with the latest news from the project and relevant topics. The site as it is at the closure of the project contains two demonstrator movies; movie I; How it works, giving a detailed explanation of the two PTW demonstrators systems and principles and movie II; The demonstration, of the two demonstrator bikes. Furthermore, the public available results are available and the contact details of the partners involved in the project are there. The public website will be hosted at least 5 years after closure of the project.



Figure 13: PISa project logo

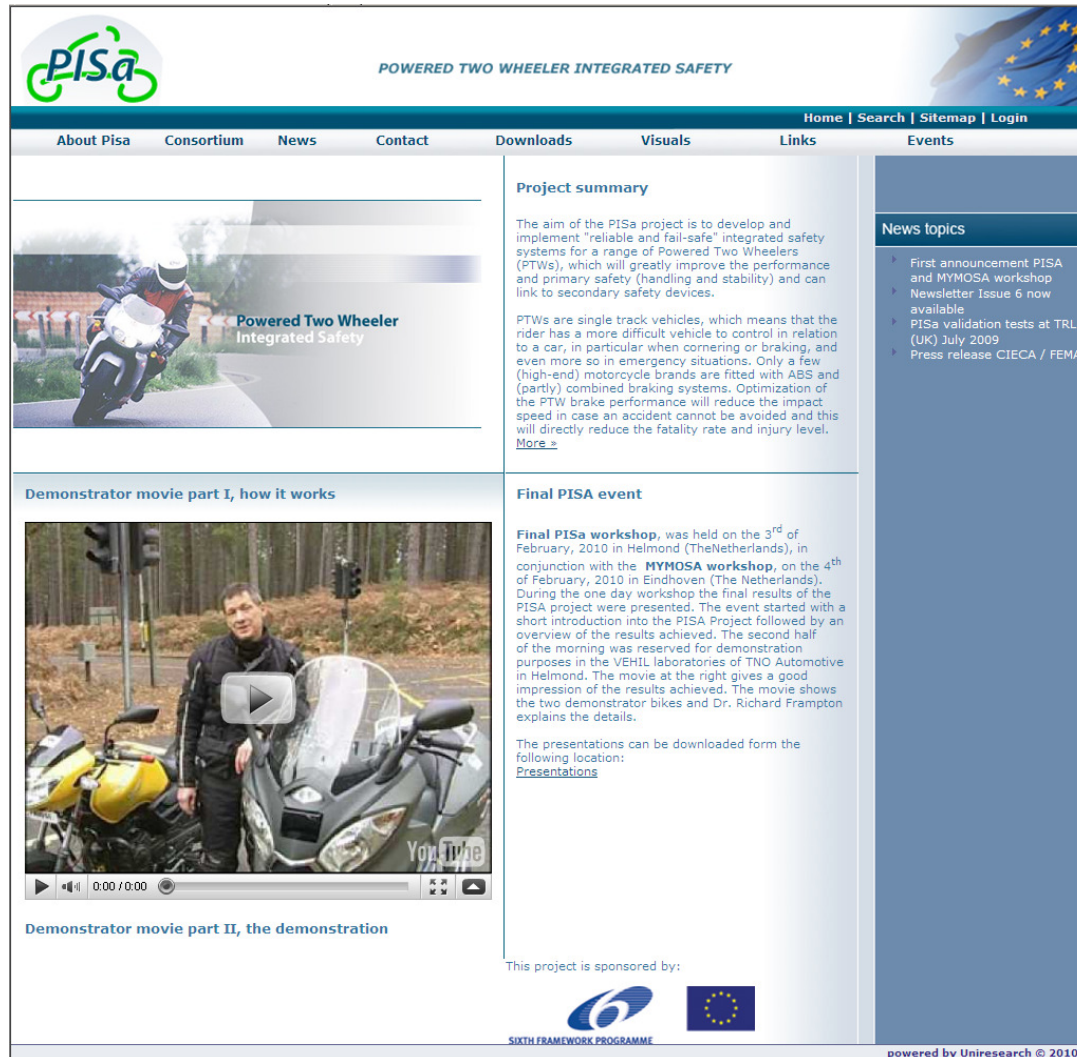


Figure 14: PISA project public website

Task 7.2 Dissemination actions

Dissemination database

A database containing more than hundred people (researchers and stakeholders, interested with PTW safety), has been created and maintained during these four years, to efficiently perform dissemination and invitation to workshops.

General Documentation and newsletters

At the very beginning of the project, a flyer was circulated to inform the general public about the start up of the Pisa project. Later on, each six months, a newsletter detailing the progresses of the various Work Packages has been sent to the people present in the database. Uniresearch placed the newsletters on the website.



Figure 15: PISA project Newsletters all as pdf downloadable on the public website.

Public Workshops I and II (Final)

Two public Workshops have been organized, the midterm PISA workshop held in Bologna (Italy) on the 29th of May, 2008, and the final Pisa workshop, held on the 3rd of February 2010 in Helmond (The Netherlands). All the partners attended the meeting and in each case, the audience was conspicuously enlarged, being attractive for researchers, stakeholders, and simply riders.



Figure 16: PISa FINAL event pictures, demonstration of PTW equipped with the developed Integrated Safety System.



Figure 17: PISa FINAL event pictures, demonstration of 3D PTW simulator equipped with warning devices (like, Tactile saddle and Haptic throttle) as part of the Integrated Safety System.

Technical publications

Several papers has been produced during the PISa project life span. See list of papers.

Project presentations

The Pisa partners attended *several* meetings and congresses all over Europe and US concerning motorcycles and safety, the most important of which are ESV, Intermot, AAAM. Pisa results has been disseminated to researchers and stakeholders.

Task 7.3 links to other initiatives

Public Workshops I together with SIM project.

The 1st PISa-SIM joint Workshop, held in Bologna (Italy) on the 29th of May, 2008, was the starting point for collaboration between PISa and SIM projects activity. The attendance to the meeting was higher than expected, and the audience of high level gave importance to the event.

Public Workshops II (Final) together with MYMOSA project.

The final Pisa Workshop, joint with the Mymosa midterm Workshop, was held on the 3rd-4th of February 2010 in Helmond/Eindhoven (The Netherlands).

The opportunity to participate at two events of such importance made it possible to collect a great number of participants, actively taking part to both workshops, and contributing to the success of this important event in the PTW safety research.

1.4 Degree to which the Objectives were reached

The Objectives of WP2 and WP3 were met.

The results of WP6 showed that the PISa system was predicted to deliver significant casualty reductions although the extent to which these address the accident and casualty reduction targets set by the PISa project was difficult to assess. The tests within the PISa project focussed on system validation with consideration of system evaluation. Although these tests showed that the system had the potential to function as intended and demonstrated good performance improvements in specific, "uncluttered" test conditions, the test results could not be related to real-world system effectiveness. This was because insufficient information exists with which to robustly define the system effectiveness at the level required to perform a full cost benefit analysis. This was for a variety of reasons:

- Information relating to the chronology of accident events are missing from the retrospective accident data, meaning that the magnitude of performance increase provided by the system cannot be objectively defined.
- Information on how the systems perform on other, more representative PTWs, is unknown.
- The real-world effectiveness is influenced by the rider. The PISa testing used test riders who were informed about the types of test being conducted. Therefore, no data is available regarding how riders of different ages, levels of experience, gender or attitude react to the PISa systems in "on-the road" conditions, or whether the systems have different levels of effectiveness for different users.
- For those systems where the performance can be directly compared to what the rider did in an accident situation (for example the braking performance for CB), while the results suggest that the impact speed can be reduced by approximately 18.5%, the effect on injury outcome cannot be objectively estimated. This is because the impact object and rider kinematics and trajectory are unpredictable and no injury risk functions exist with which to quantify the effect on injury level of reducing the impact speed, although the overall effect of reducing the impact energy is of course theoretically beneficial.

For these reasons it proved very difficult to extrapolate the track performance to a larger accident population. This, coupled with the fact that the system was focussed on accident mitigation (and not avoidance) made estimation of the injury benefits difficult. However, the EU-27 target populations (numbers of PTW casualties who could be influenced assuming 100% system effectiveness) for the individual PISa systems were estimated.

1.5 Methodologies and Approaches employed

In WP2, WP3 and WP6 the methodologies and approaches employed were all as planned with the exception of the analysis of junction video footage which was not undertaken.

1.6 Achievements of the Project in relation to the State of the Art

Technological developments have been made in parallel to PISa by vehicle manufacturers and other EC and national funded projects, such as ABS, combined and traction control. These systems are now available as an option on many, and as standard on some, premium motorcycle models. This means that as these systems are becoming more common in the fleet and market penetration improves, the braking technologies proposed and developed within PISa are becoming more widely feasible in terms of implementation and cost. This is a more positive situation than was the case when the PISa project was proposed. Furthermore, mandatory fitment of ABS or CBS is currently being considered by the EC for new PTWs.

1.7 Impact of the Project on its Industry or Research sector

The PISa project has made a good contribution to industry and policy makers as it has provided a demonstration that the Integrated Safety technologies can be combined and integrated successfully. Furthermore, the PISa project has defined a range of PTW accident countermeasures based on a sample of European accidents. This provides important accident causation information and could be used by the research community or by policy makers to target the most effective strategies to reduce European PTW accidents.

2 Dissemination and its use (Publishable results) – Annex I

See D35 – DRAFT - FINAL Publishable Activity report – Annex I PUDK - 17082010.doc for the details on the dissemination and publishable results.

From the plan for using and disseminating the knowledge the following results are published.

Project logo, website and dissemination material A PISA website is maintained during the project's lifetime. The webmaster answered questions and provided information on request. The public website is accessible via: www.PISA-project.eu. The PISA project will be hosted for at least several years, however no major updates will be done.

A PISA-Project General Flyer is available to be used for dissemination purposes at conferences, workshops and public events. Three newsletters in total are published and provided to relevant stakeholders, identified in the dissemination database.

All results presented at the combined workshop with the SIM project (29th of May 2008) are presented on the public part of the PISA website (www.pisa-project.eu).

All results presented at the Final workshop in conjunction with the MYMOSA project (4-5 February 2010) are presented on the public part of the PISA website (www.pisa-project.eu).