

# Advanced Rider Assistance Systems for Powered Two-Wheelers (ARAS-PTW)

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## ABSTRACT

The results of a survey by the Institut für Zweiradsicherheit e.V. (ifz) on the topic “Advanced Rider Assistance Systems for Powered Two-Wheelers (ARAS-PTW)” carried out by ifz in the year 2009 triggered the study at hand. In fact the survey showed that both male and female motorcycle riders have knowledge deficiencies as regards rider assistance systems.

Against this background we explored the matter and found out that the respective literature offers a wide variety of definitions of assistance systems. This variety was the reason for a first attempt to clearly define the term “Rider Assistance Systems for Powered Two-Wheelers” – taking into account all the relevant specific requirements.

Furthermore, the study offers a general synoptic view (updated September 2010) of current rider assistance systems for powered two-wheelers.

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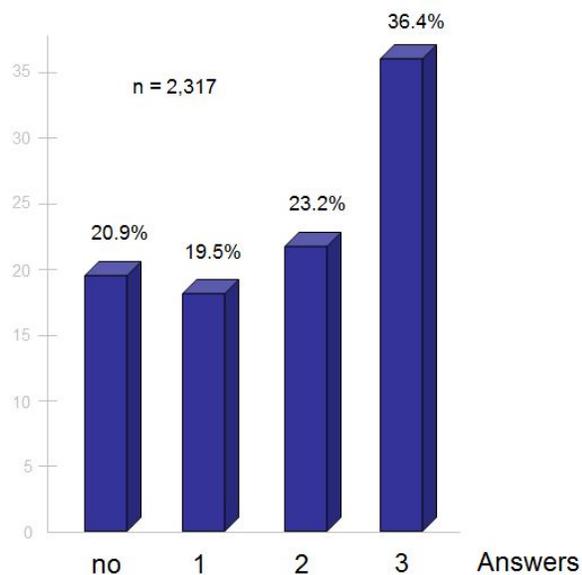
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## Results of an ifz-survey

The results of an ifz poll among 2,317 motorcycle riders (male and female) in the year 2009 revealed that only few riders have knowledge about what “Driver Assistance Systems” are.

20.9 percent of those questioned were not able to answer the question “Please tell us three different advanced rider assistance systems for powered two-wheelers.” They did not know even one of these systems or could not see the connection between the device and the question asked. Furthermore, 19.5 percent could give one example, 23.3 percent could name two, but only 36.4 percent were able to name three different driver assistance systems at all (see figure 1).



**Figure 1: “Please tell us three different rider ADAS for powered two-wheelers.” – Frequency of naming**

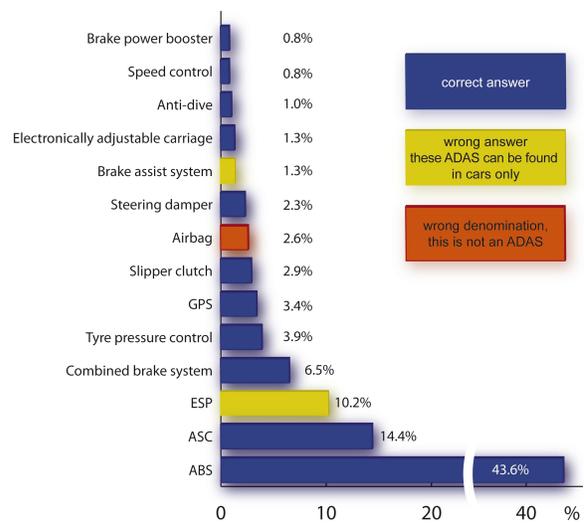
Anti-lock braking systems (ABS) have been sufficiently known in wide sections of the population for quite some time, and since 1988 many motorcycles have been equipped with it. This might be the reason for the fact that “ABS” was the most

frequent answer (96 percent) in this context (driver assistance systems for powered two-wheelers).

93 percent of those who only knew one assistance system mentioned ABS. If the interviewees knew two or three systems, they also designated ABS in most cases (94.1 and 98.8 percent respectively).

The familiarity with ABS can also be deduced from the fact that the first of three answers given in 75.6 percent of all cases was “ABS”.

Figure 2 shows other systems mentioned and their frequency of naming.



**Figure 2: Frequency of driver assistance systems for powered two-wheelers mentioned by the interviewees**

Another interesting result was the fact that airbags as a means of passive driver protection were mentioned in 2.6 percent of cases although they are definitely not part of a driver assistance system. Also, the interviewees brought up systems that up to now only have been fit to cars, trucks or coaches.

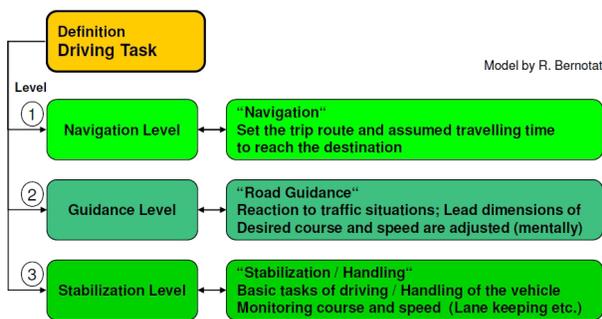
Thus it is important to keep in mind that only about one third of the interviewed persons were able to name three driver assistance systems. One fifth of the interviewees could not mention even one system although the example of ABS and its widespread familiarity with it would have suggested this. Maybe

the difficulty lies in the term “driver assistance”. Due to the results of the survey we took a closer look at the subject and found the different definitions of driver assistance systems. This is why we try to shape a first definition of “Rider Assistance Systems for Powered Two-Wheelers” in the paper at hand – in due consideration of the requirements characteristic of two-wheelers.

### The Driving Task

In this context it is necessary to give a brief explanation of the term “driving task”, as this term will be referred to at a later stage in this study in order to give a further differentiation of driver assistance systems. Furthermore this is important for a classification of these systems.

For more than 40 years scientists have dealt with driving tasks, a term that designates the requirements and operations that are necessary to drive a motorized vehicle. Again, there are a lot of definitions of the term in use, some of which are rather complex ones. In the study at hand we have chosen the model according to R. Bernotat, a basic and clear approach that is quite easy to understand. It can be outlined in the following way:



**Figure 3: Classification of driving tasks into three levels (according to [1])**

Roughly speaking, the driving task consists of three levels: The navigation level, the guidance level and the stabilization / handling level. While the navigation level means the determination of the trip route and maybe also the length of the trip, level

number 2, the guidance level, already includes tasks such as reactions to diverse road traffic situations. These induce a mental determination of the set course and the desired speed in due consideration of existing traffic regulations. Level 3, the so-called stabilization or handling level, covers basic driving tasks and the monitoring of course and speed. The Levels 2 and 3 require constant interaction, whereas the interaction between Level 1 and 2 is less frequent.

The hierarchy in the classification of driving tasks is obvious: Level 1 is superior to Level 2 which is superior to Level 3. The navigation level, which roughly determines the trip route, always plays a superior role among the driving tasks as a whole. In the same way the guidance level is superior to the stabilization level, since without a set course and without a desired speed there is no need for action on this level.

### Advanced Driver Assistance Systems – what is the idea behind it?

Since 1966 there has been an official classification into *active* and *passive safety systems* [2]. According to this classification all systems and technologies that help prevent accidents are classified as *active* safety devices. Systems and technologies that help reduce accident results are classified as *passive* safety systems. Meanwhile the boundaries between active and passive safety have become fluent and were softened by driver assistance systems in many different fields.

The term “driver assistance system” derives from the field of automobiles and originally was defined as “Advanced Driver Assistance Systems” (ADAS) in English-speaking countries. Where and when this term was mentioned for the first time in the corresponding professional literature could not be exactly sorted out, probably this was the case shortly before the turn of the millennium.

In the respective publications one finds countless reports and studies on driver assistance systems (ADAS). As well, there are several different definitions since different criteria were taken as a

basis for classification.

At the beginning a lot of systems that relieved or supported the driver were assigned to be an ADAS, such as the electric starter because this made starting the engine a lot easier. At the time this device was invented, however, nobody talked about driver assistance systems at all.

As more electronic equipment was fitted to vehicles, it was possible for the first time to realize complex systems. At times of purely mechanical equipment such systems were unimaginable. Thus traffic news has been broadcasted since 1969; and since 1978 many cars have been equipped with anti-lock braking systems (ABS) as standard. Other systems followed.

Due to the fact that the great number of ADAS according to these criteria would be hardly comprehensible or understandable, some sources refer to driver assistance systems only at the guidance level, whereas others see them at the stabilization level. At the navigation level, one frequently uses the term information systems.

To give just one example: “They act as a sort of electronic pillion passenger discreetly from the background”, as one could read in a brochure about driver assistance systems of Continental Teves AG & Co oHG published in the year 2008.

The general meaning of the word “assistance” is *to render help*. In our context the aim of this help is to relieve and support the driver from his operation tasks in some way or other by different systems. This first and foremost refers to *active safety*, which means the reduction of the probability of the occurrence of dangerous road traffic situations. If a critical situation occurs, the driver gets support for the driving task by one or more assistance systems; pre-crash systems can even reduce potential accident results. Very occasionally post-crash systems in order to improve the rescue management (e-Call) are also included into ADAS.

At present driver assistance systems are developed mainly with respect to self protection and to a lesser extent in order to protect other road users. Thus ADAS only support the driving tasks of the driver whose vehicle is equipped with it. As a consequence

they do not have supporting effects on other road users, although a certain correlation (i.e. accident results) cannot be denied.

From the field of civilian air traffic, for example, the so-called TCAS (Traffic Alert and Collision Avoidance) is well known. This system prevents a collision of two aircrafts by calculating an evasive manoeuvre for both planes in mutual adjustment. A transfer of this system to the road traffic system seems aptly conceivable.

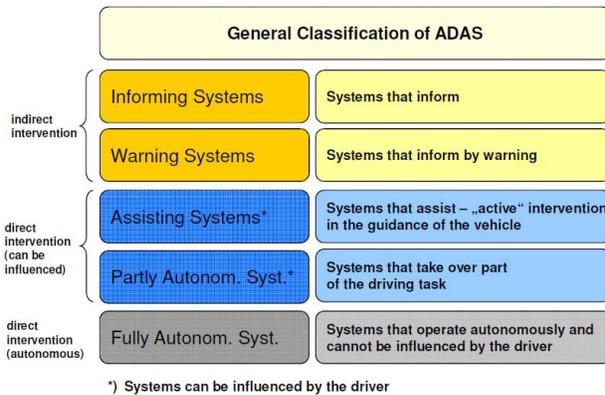
Within the framework of the European research project SAFERIDER (January 1, 2008 – December 31, 2010) the term ADAS (“Advanced Driver Assistance System”) which originates from the field of automobile driving, was renamed into ARAS “Advanced Rider Assistance Systems” for the very first time. At that time the focus was on using the correct English term and not yet on an adjusted definition.

But no matter which view or classification is under consideration: for a motorized two-wheeler both are inadequate as the very specific features of operating a powered two-wheeler are not taken into consideration at all. This is especially true when taking into account that motorcycle riders belong to the group of vulnerable road users.

Even motorcycle manufacturers normally do not label their equipment “Rider Assistance Systems”. Thus one finds terms such as “active safety equipment” or “an important step towards more riding safety” ([source](#): BMW Motorrad). The reason for this is probably the fact that the numerous definitions of assistance systems derive from the field of automobiles.

This is why we hope that this study will provide new definitions of rider assistance systems for motorized two-wheelers and will thus enable a better designation of the corresponding equipment. In the end the amount of safety features influences the purchase decisions of motorcycle riders [3].

Advanced Driver Assistance Systems in the field of automobiles can be classified into five categories:



**Figure 4: General Classification of ADAS**

According to Figure 4 the systems are classified with respect to informing, warning, assisting, and partly and fully autonomous. The informing and warning systems only have an indirect influence on the driving task. They can but they do not necessarily have to be observed by the driver and/or induce him/her to a corresponding activity. In contrast to them, the assisting and partly autonomous systems do mean a direct intervention into the driving task. However, they can be adjusted by the driver at any time.

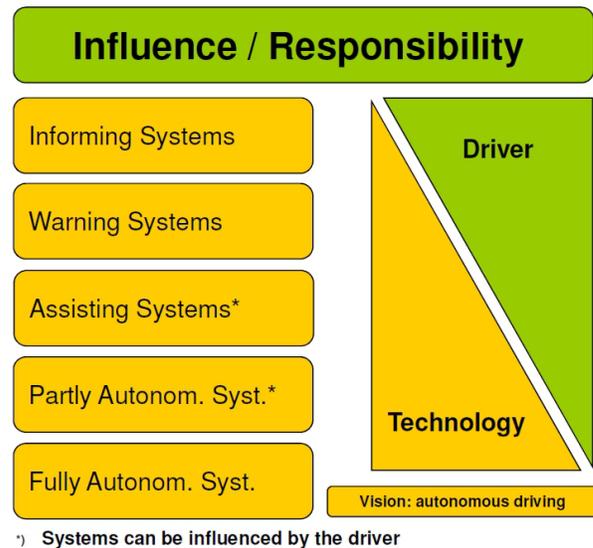
The assisting systems are systems that indicate driving errors while operating the vehicle. The indication happens directly and in a haptically perceptible way to those steering elements of the vehicle which should be operated in order to prevent an accident. Optical and audible warning signals are also possible. Take for example the active lane keeping assistance for automobiles and trucks. If a driver is inobservant and leaves the lane – for whatever the reason is – there is an automatic counter steering which alerts the driver and is supposed to make him leave the false lane. If the driver, however, decides against the counter steering, it is possible to adjust the automatic steering by a slightly raised exertion of force.

An example of a partly autonomous system is ACC (Adaptive Cruise Control), an automatic vehicle distance and speed regulator. After having set one’s desired speed and vehicle distance the ACC takes

over this part of the driving task. The driver still has to monitor this function but can switch it off or readjust at any time.

The fifth and last category of ADAS consists of fully autonomous systems. The oldest and best known systems in this category are anti-lock braking systems (ABS). These systems operate fully autonomously and cannot be influenced by the driver.

The increasing automation of operating tasks and the increasing autonomy of driver assistance systems means a growing influence and taking over by technology; the driver’s share in the driving task decreases which results in a decrease of alertness on the part of the driver. In this context some researchers even have a vision of fully autonomous driving in the near future (cf. figure 5).



**Figure 5: Influence and Responsibility of Driver Assistance Systems**

The reason for the fact that this vision will remain a vision for the years to come is due to legal circumstances, although this matter is being worked on currently.

According to the Vienna Convention on Road Traffic (1968) the following requirements must be met:

Article 8: Driver

(1) Every moving vehicle or combination of vehicles shall have a driver.

(4) Every driver of a power-driven vehicle shall possess the knowledge and skill necessary for driving the vehicle. ...

(5) Every driver of a power-driven vehicle shall at all times be able to control ... his vehicle.

(6) Every driver of a vehicle must avoid all other activities and concentrate on the operation of his/her vehicle. National law must have prescriptions for the use of mobile phones while steering a motor vehicle. In any case these regulations have to prohibit the use of mobile phones or hands-free speaking systems for motorists of motorized vehicles in motion.

Article 13: Speed and distance between vehicles

(1) Every driver of a vehicle shall in all circumstances have his vehicle under control so as to be able to exercise due and proper care and to be at all times in a position to perform all manoeuvres required of him. He shall, when adjusting the speed of his vehicle, pay constant regard to the circumstances, in particular the lie of the land, the state of the road, the condition and load of his vehicle, the weather conditions and the density of traffic, so as to be able to stop his vehicle within his range of forward vision and short of any foreseeable obstruction. He shall slow down and if necessary stop whenever circumstances so require, and particularly when visibility is not good.

The contents of the Vienna Conventions make clear that Driver Assistance Systems can only work in a limited sense as fully autonomously. Still, the motorist himself has to be in control of his vehicle and thus of his driving.

Figure 6 shows the classification of Advanced Driver Assistance Systems in the field of automobiles taking into consideration the three levels of driving tasks. Some ADAS are exemplarily catalogued.

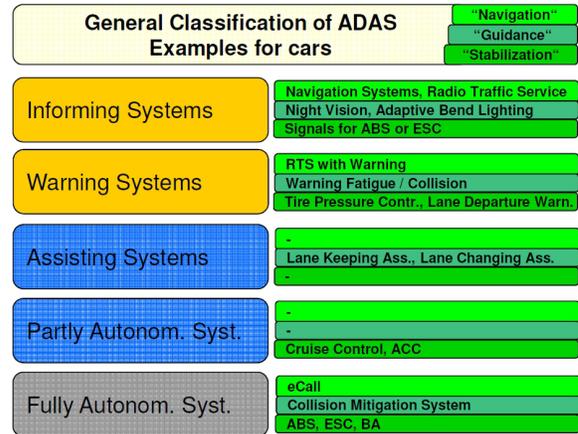
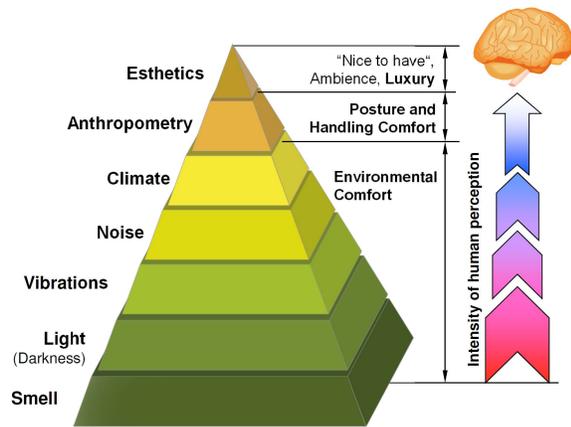


Figure 6: Classification of driver assistance systems for automobiles considering the three-level model for driving tasks

Specifics of powered two-wheelers and implications

As chapter “Advanced Driver Assistance Systems – What is the idea behind it?” showed, there are many different driver assistance systems for car drivers. Equipment that seems to be normal for car drivers, however, is not necessarily commonplace for motorcycle riders. One simple example in this context is traffic news. Information about the current road traffic situation (i.e. about wrong-way drivers) are withheld from motorcycle riders, since there is no space for radios or because communication turned out to be rather difficult at least until some years ago.

In contrast to car drivers, motorcycle riders are much more exposed to the environment. There is no bodywork that protects them from outside influences (such as weather conditions) which is also the reason why there is much more sensory strain on motorcycle riders than on car drivers. This important matter, however, has not been given a lot of attention up to now; in our view, though, this aspect plays an important role in the evaluation of assistance systems for motorcycles and should be taken into consideration when a classification is to be set. The reasons for this will be shown in the following “Pyramid of Convenience”.



**Figure 7: Pyramid of Convenience (according to /4/)**

As figure 7 shows, sensory impressions such as odour, light, vibration, noise, climate and anthropometry (determination and application of physical dimensions of the human body) and aesthetics are hierarchically structured.

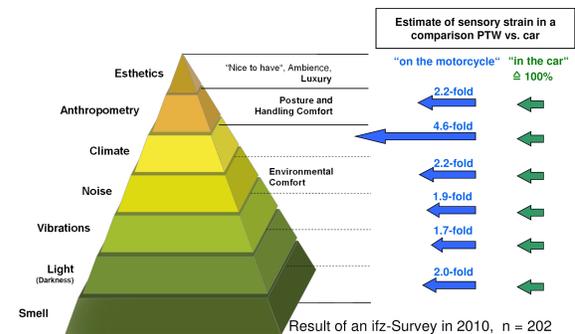
One interesting aspect of the pyramid is that higher-level sensory impressions are felt as a lack of comfort only when the needs from lower-level impressions have been satisfied. In concrete terms, this means for example that noise is being perceived as disturbing only when the rider does not feel affected negatively by odour, light or vibrations.

This hierarchical structure of human sensations reveals the big difference in the strain of car drivers and motorcycle riders. Today, impairments such as smell, light, vibrations, noise and climate are for car drivers more or less eliminated, which leads to the fact that requirements in the field of anthropometry and aesthetics (“nice to have”) have gained more and more importance.

And the motorcycle riders?

In order to answer this question, we carried out a survey on the occasion of the Dortmund trade fair “Motorräder Dortmund 2010”, which revealed the following results. The interviewees were asked to make a direct comparison between their “own motorcycle” and their “own car” and evaluate the different sensory strains. In doing so the aim was not

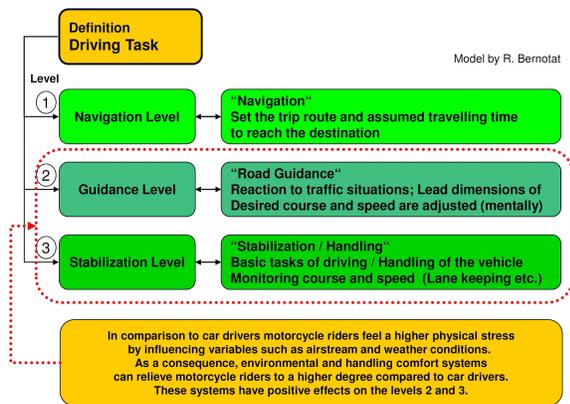
to control the ranking as revealed in the pyramid of convenience but to evaluate the different sensory impressions for both vehicles. Figure 8 shows the results of this survey.



**Figure 8: Sensory strain: A direct comparison car – motorcycle within a pyramid of convenience**

The figure clearly shows that the sensory strain among motorcycle riders is considerably higher than among car drivers. In all categories the car was taken as being the standard (100%). The obtained data are mean scores obtained from the answers of 202 persons interviewed. The smallest difference with only 70% additional strain was reached for the aspect strain by light, the biggest difference was obtained for the aspect “climate” with 360% additional strain felt among motorcycle riders. All the other feelings of straining sensory impressions when riding a motorcycle ranked about twice as high compared to driving a car.

As the amount of the sensory strain in the pyramid shows, it is especially the environmental-comfort systems and the posture and handling comfort systems that play a significant role for motorcycle riders, a role that should not be underrated. These systems exert a significant influence on Level 2 (guidance level) and on Level 3 (stabilization / handling) of the driving task (cf. Figure 9).



**Figure 9: Positive effects of environmental and handling comfort systems**

The directly influencing variables on the physical strain for motorcycle riders are:

- Vibration (“sitting directly on the motor / engine”)
- Noise (no encapsulation of the engine, airstream)
- Direct exposure to airstream and precipitation
- Direct exposure to sun and heat (no roof, no air conditioning)
- Additional physical strain by heat of engine
- Additional physical strain by motorcycle gear

Being exposed to these factors may lead to the following negative impacts after a certain amount of time:

- decline in physical condition (bodily fatigue)
- decline in coordination (steering, banking)
- decline in concentration (mental fatigue)
- decline in alertness (environment, road traffic, street /road)
- decline in reaction
- increased accident risk

These are reasons enough to include environmental-comfort systems into assistance systems for motorized two-wheelers. Just as well as the fact that the sensory strain when riding a motorcycle is at least

twice as high as when driving an automobile, which supports the importance of furnishing motorized two-wheelers with environmental-comfort systems. But what exactly are these?

*“Environmental-comfort systems” means assistive equipment that eases the operation of motorized two-wheelers for the rider with regard to odour, light, vibration, noise and climate / weather conditions.*

In addition, the “posture and handling comfort systems”, which can be classified among the “ergonomic systems”, play an important role. In general, “ergonomics” is considered to be the science of the regularity of human work with the aim to improve the interaction of user and machine in order to reduce the strain for the user which results in a more efficient and safer operation.

The influence on the driving task is well recognized so that explanations that go more into detail are not necessary at this point.

Both systems, the “environmental-comfort systems” as well as the “posture and handling comfort systems” can be seen as included in the term “comfort assisting systems”. Comfort in this context means rather a relief of strain and support of the rider and to a lesser extent the idea of pleasure or luxury. Following this allocation it becomes clear that with this in mind comfort systems should definitely be classified into the devices of assistance systems for powered two-wheelers. If there is a lack of comfort, this inevitably will lead to discomfort which leads to increased strain, going along with growing fatigue but also a decline in alertness. This is a circle with subsequent effects which is the reason why comfort systems indeed can be considered as supportive safety devices for motorized two-wheelers. In a direct comparison with cars, the above mentioned systems are usually taken for granted in the equipment for automobiles.

## Definition of “Advanced Rider Assistance Systems for Powered-Two-Wheelers (ARAS-PTW)”

As could be seen in the previous chapters there is no standardized definition for rider assistance systems. In order to meet the requirements of motorized two-wheelers and their specific features the study at hand shaped a new definition of assistance systems for powered two-wheelers.



The following definition refers solely to the vehicle level, thus to systems that can be allocated to the vehicle.

The differentiation was made deliberately, although a lot of equipment that improves the active safety for the riders do exist. The background for this decision is the reference to automobiles, for their drivers no special equipment is necessary.



Definition:

*The term “Advanced Rider Assistance Systems for Powered Two-Wheelers (abbr. ARAS-PTW)” denotes equipment which supports and assists the operator of a powered two-wheeler and / or reduces the stress and strain for the rider.*

*It is a means of active safety (accident avoidance) but also influences accident results during a pre-crash-phase in a positive way.*

*An ARAS-PTW should be assigned to at least one of the three levels of rider tasks.*

According to the above mentioned definition, rider assistance systems for motorized two-wheelers predominantly serve the purpose of *active safety*. This is the reason why systems such as e-call or those that reduce fuel consumption and thus emission or an electrical motor starter do not fit among ARAS-PTW.

One important feature according to the definition of ARAS-PTW above is that the physical strain for the rider can be reduced by the comfort assisting systems. This is why systems which have been taken for granted in automobile equipment [windshield, windshield wiper (if they existed for motorized two-wheelers), heating, etc.] for a long time already now do class among “rider assistance systems for powered two-wheelers”.

Systems that call attention to the motorized two-wheeler and its unprotected and exposed rider (self-protection) by audible or optical means, do also fit among ARAS-PTW. Among them are vehicle-to-vehicle systems which at present, however, are still in the process of development.

Based on the already known classification of driver assistance systems, these will be enhanced by comfort assisting systems which can be subdivided into systems supporting the handling and posture comfort and the environmental comfort (see Figure 10).

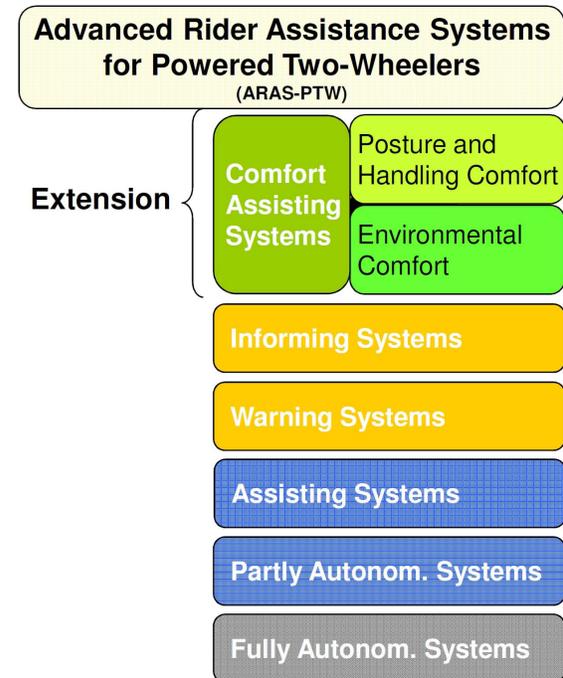


Figure 10: Classification of ARAS-PTW

## Synopsis of present on-bike assistance systems for powered two-wheelers (as of 9/2010)

According to the definition and classification of rider assistance systems, the following elements can be listed as ARAS-PTW. Categories are classified according to their support of driving tasks. In order to avoid multiple entries, the boundaries between some systems are fluid.

### Comfort assisting systems:

- **Posture and handling comfort**
  - Handling/Stabilization level
    - Gear Shift Assistance
      - Full automatic transmission (stepless too)
      - Half automatic transmission
      - Dual-Clutch
      - Quickshifter (1)
    - Reverse Gear (2)
    - Electro-hydraulic main stand (2)
    - Automatic turn signal off-switch (3)
    - Radial brake master cylinder (4)
    - Adjustable seat
    - Adjustable handlebars
    - Adjustable footrests
    - Adjustable levers
- **Environmental comfort**
  - Guidance level
    - Xenon headlight
    - Adaptive cornering light
  - Handling/Stabilization level
    - Adjustable chassis
      - Spring pre-load adjustable
      - Adjustable damping
      - Leveling systems
    - Electronically adjustable chassis
      - “ESA”, “DES; Spring pre-load and damping adjustable
    - Wind/Airflow/Weather protection
      - Fairing
      - Mechanically/electronically adjustable windshield
    - Heated grips

- Heated seat
- Any other heating or cooling system

### Informing systems:

- Navigation level
  - Radio with traffic service
  - GPS
- Guidance level
  - Fuel gauge
- Handling/Stabilization level
  - Neutral indicator light (gear) (5)
  - Gear display (6)
  - Shift timing indicator light (7)

### Warning systems:

- Guidance level
  - Fuel reserve (8)
  - Ambient air temperature (ice warning)
  - Brake pad wear indicator
  - Tyre pressure control
  - Daytime running light (9)
  - Hazard warning light (10)

### Assisting systems:

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### Partly autonomous systems:

- Handling/Stabilization level
  - Cruise control
  - Hill start assist (11)

### Fully autonomous systems:

- Handling/Stabilization level
  - Integral (combined) braking systems
    - Single- / Dual-
    - Mechanic/electronic brake balance
    - Adaptive brake balance
  - ABS
    - Integral ABS (Single- / Dual-)
    - “Brake-by-wire” C-ABS
  - Real-Wheel Lift-Off Protection
  - Brake booster
  - Traction control
  - Wheelie protection
  - Mapping

- Drive mode switch
- Slipper clutch (Anti-hopping)
- Electronic steering damper
- Side stand switch (12)

*(This list is not intended to be exhaustive.)*

Annotations:

(1) Quickshifters prevent fatigue of the hand that holds the clutch and induce reduced carriage strokes while shifting the gears.

(2) In contrast to two-track vehicles, heavy one-track vehicles are difficult to park and manoeuvre and need a high amount of physical exertion. This is why a reverse gear as well as an electro-hydraulic main stand provide safety and prevent the vehicle from toppling over.

(3) The automatic turn signal off-switch ensures a turning-off of the indicator and thus prevents unintentional indicating after having turned (which in fact happens quite often). Not to switch off the signals can lead to dangerous situations with other road traffic users, as they get wrong information.

(4) The radial brake master cylinder fit to motorcycles that are not equipped with ABS offers a much better pressure point compared to common systems which reduces the probability of overbraking the front wheel.

(5) The neutral indicator light (gear) is very helpful when operating a motorized two-wheeler because of the sequential gearbox.

(6) Due to the sequential gearbox the rider never knows exactly whether he/she is riding in top gear already. This is why there is often “void” shifting of gears which would be obsolete in case of gear displays.

(7) Although the shift timing indicator light originally comes from racing, it can be useful for riders in road traffic as well. The reason for this is that the necessary look at the revcounter is no longer

necessary and thus the concentration is focused at 100% on the road and the road traffic.

(8) Since the introduction of displays for fuel reserves, the manual opening of the fuel tap has become unnecessary. In the past this sometimes led to dangerous situations, for example when opening the tap during an overtaking manoeuvre.

(9) Daytime running lights are a form of self-protection by warning others or catching other road users’ attention that a motorcycle is approaching.

(10) Hazard warning lights are important for the self-protection of motorcycle riders, for example in order to warn other road users at the tail end of traffic jams; thus they won’t be unnoticed and hit by the next vehicle.

(11) Up to now motorcycles have not been equipped with hill start assist systems. In order to use this device, integral braking systems will be necessary.

(12) A side stand switch indeed is a true rider assistance system as it indicates the position of the side stand and allows a start-up only when the stand has been retracted. In addition, a spring fracture would be recognized immediately during the trip which would lead to an immediate cut off of the ignition. Without this safety device a lot of accidents happened in former times.

## **Summary & conclusion**

A survey carried out by ifz on the topic of advanced driver assistance systems revealed that male and female motorcycle riders lack the knowledge of driver assistance systems.

The subsequent research in literature definitions of driver assistance systems clearly showed that on one hand there are a lot of very different definitions, and on the other there is none which meets the requirements of motorized two-wheelers. The reason for this fact is relatively simple: The term “driver

assistance systems” originates from the field of automobiles.

This is why – taking into consideration the specific requirements of motorized two-wheelers – the well-known classification of advanced driver assistance systems was enhanced and a new definition of advanced rider assistance systems for motorcycle riders was developed (ARAS-PTW). This definition is intended to provide a more direct classification of systems as well as a generally accepted labeling.

The definition derives with reference to the three levels of driving tasks as well as requirements specific to two-wheelers which have become particularly clear in the so-called “pyramid of convenience”.

The study ends with a list of ARAS-PTW which have already been in existence for some time.

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