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MINISTÈRE DE L'INTÉRIEUR

NATIONAL ROAD SAFETY COUNCIL

COMMITTEE OF EXPERTS

SAFETY OF POWERED TWO-WHEELERS : TOWARDS A USE ADAPTED TO THEIR VULNERABILITY

SUBMITTED TO THE PLENARY MEETING OF THE CNSR ON February 3, 2021

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Executive summary

In 2019, 820 of the 3,498 fatalities in France were powered two-wheelers (PTW) users (23.4%), 160 were moped riders (4.6%) and 660 were motorcyclists (18.9%). Nearly one in four fatalities was a PTW user, although their estimated share of road traffic is less than 2%. The risk of losing one's life on French roads for the same number of kilometers traveled is about 22 times higher for these users than for users of light vehicles (24 times for drivers of heavy motorcycles > 125 cm3).

The CNSR's committee of experts devoted a large part of its work to the safety of PTWs by interviewing 14 scientists and experts, then comparing the information gathered with the scientific literature. Finally, the committee drew up an inventory of the measures proposed by road safety stakeholders over the last two decades, identifying those that have been implemented, those that have remained unimplemented, and those that are still relevant, and the degree of priority that should be given to them.

This exercise enabled the committee of experts to produce 28 recommendations based on six themes: power and speed, personal protective equipment, visibility and detectability of motorcycles, technologies, initial and post-license training, and infrastructure. For each of these themes, the measures are presented in order of importance, starting with those with the greatest expected benefit in terms of reduced mortality and morbidity.

This document is therefore a summary of the committee's recommendations. The criteria that prevailed in making these choices are: scientific relevance, efficiency, equity, and acceptability.

Finally, it should be noted that, because of the speeds practiced by motorcyclists and the major role played by speed in the risk incurred, recommendation R1.1, which calls for the development of effective speed enforcement, represents the greatest road safety opportunity.

Recommendations

Axis 1: Power and speed

R1.1 - Make speed enforcement effective for PTWs as for other motorized vehicles:

- Use automated enforcement equipment to achieve the same level of performance for all categories of motorized vehicles.
- Check license plate position and orientation for all motorized vehicles in a compliance monitoring system.
- Include in the annual report on offences drawn up by the ONISR, data enabling a distinction to be made between the various categories of motor vehicles.
- Change the size of the characters on motorcycle license plates to the general size defined for passenger cars. The height of the characters would increase from 45 mm to 75 mm and the width from 23 mm to 39 mm.
- Design automated speed control devices capable of taking into account the specific trajectories of motorized vehicles.

R1.2 - Define identical taxation for the different categories of motorized vehicles for personal use (motorcycle and passenger vehicle). Currently, the General Tax Code (Article 1599 sexdecies) reduces the unit rate of the tax for issuing a registration certificate for motorcycles by half compared to that for passenger cars. Similarly, motorcycles are not subject to the ecological malus, unlike passenger vehicles.

R1.3 - Give insurers the regulatory and technical possibility of establishing a safety contract based on the monitoring of driving and speeds
The aim here is to initiate discussions on how to set up a system of continuous recording of speeding and acceleration/braking in exchange for a significant reduction in the insurance premium. This system must be compatible with the RGPD[1] and must be subject to an evaluation phase with a comparative measurement of its impact on accident rates.

R1.4 - Develop and use communication techniques that engage motorcyclists in prevention (e.g. insurers), particularly focusing on the dangers of speeding. Insurers should be mobilized to adopt and relay these methods in order to raise awareness and bring about lasting changes in behavior. Prior work on consolidating, promoting and disseminating research work on the subject should be supported.

Axis 2: Personal protective equipment (PPE)

R2.1 - Make it compulsory to wear a full face helmet
This measure has been proposed for more than 10 years and the latest injury studies confirm that, in the event of an accident, protection of the face is always superior with such a helmet.

R2.2 - Continue and strengthen incentives for widespread use of airbag vests
All stakeholders must continue to organize themselves to implement incentives to promote the widespread use of airbag vests. Such measures are preferable to mandatory wearing. However, if it turns out that, despite its interest, this PPE is still not widely used, its mandatory use should be considered in order to reap its full benefits.

[1] RGPD : Règlement général sur la protection des données (General Data Protection Regulation) https://eur-lex.europa.eu/legal-content/FR/TXT/HTML/?uri=CELEX:32016R0679

R2.3 - Continue research and development work on the autonomous airbag vest
Since the first models were developed, airbags have evolved to provide better protection for motorcyclists with improved comfort and to increase their reliability. Progress remains to be made to move from the wired airbag to the radio or connected airbag, which are popular with motorcyclists but which still need to become more reliable while maintaining costs that are appropriate for their wide distribution. Actions to support research and development must be encouraged.

R2.4 - Ensure the continuity of French scientific expertise within international PPE standardization committees
PPE is generally covered by European or even international standards. French representation in these institutions must remain effective and be coordinated. It is important to ensure that French experts in the various participating organizations have the means to contribute to reducing the morbidity of motorcycle users by supporting French know-how when it is beneficial in terms of road safety.

R2.5 - Improving the treatment of motorcycle injuries
It is proposed to finance 1) work aimed at optimizing triage and care for road accident victims, 2) improvements to health and medico-social structures. In the end, this measure will benefit all road accident victims, in particular motorcycle victims.

R2.6 - Establish a provisional timetable for the widespread use of PPE
In conjunction with the establishment of an observatory on the wearing of PPE, set up a committee bringing together user representatives and road safety stakeholders to establish a provisional timetable setting out milestones with equipment rates to be achieved. If the planned equipment rates are not achieved, this consultation and monitoring will be a prerequisite for the implementation of coercive regulations concerning the wearing of PPE.

Axis 3: Visibility and detectability of PTWs

R3.1 - Define a visual signature specific to PTWs
Recent research on the detectability of PTWs suggests that a visual signature specific to PTWs should be defined so that they are more clearly detected by car users and other road users on the one hand, and in the future by vehicles with driver delegation on the other. Based on these results, the committee recommends the adoption of a particular color, yellow, which would allow them to be distinguished from other vehicles, and an appropriate arrangement of lights in order to increase the vehicle's perception surface. To do this, France must define and support a proposal to international bodies.

R3.2 : Develop best practice information for users and the PTW profession for the installation of additional retrofit lamps
Pending changes in European regulations and in order to avoid a proliferation of additional lighting configurations, inform users and the PTW profession on the best configuration for installing these lights and on those to avoid. The objective is to eventually achieve a single visual signature for motorized vehicles.

R3.3 - Amend the highway code to prohibit overtaking at urban intersections and crosswalks
This measure, which corresponds to the practice of PTW queue-jumping in urban areas, has already been proposed during the 2006 PTW safety studies [Guyot et al., 2008] and by the previous CNSR's committee of experts. Although it concerns a significant proportion of accidents in urban areas, it has not been followed up. It is complementary to the previous one because, in addition to masks, the trajectories adopted by motorcyclists may surprise other road users. This measure could be monitored by semi-automated video-verification.

Axis 4: Technologies

R4.1 - Develop European regulations for motorcycle assistance systems

It is regrettable that PTW users do not currently have the same driving assistance systems as those available for other motorized vehicles, particularly those that can help them choose an appropriate, controlled and calm speed. These systems should be the subject of research and development work involving motorcycle manufacturers, research institutes, public authorities and PTW user associations. Devices or functions to be transposed for PTWs include speed limiters, road sign recognition (including maximum authorised speed), and intelligent speed adaptation systems. It is necessary to work towards extending to PTWs the obligations planned by Europe for cars and commercial vehicles from 2022.

R4.2 - Deploy fully coupled braking on all motorcycle ranges

The aim here is to propose that France adopt a position on the subject with a view to changing international regulations. This measure has already been proposed during the 2006 PTW safety surveys [Guyot et al., 2008] and by the previous CNSR expert committee. Studies show that braking attempts made by motorcyclists in emergency situations rarely avoid an accident [Dubos & Varin, 2015]. Coupled braking makes it possible to effectively dose front and rear braking, allowing optimal braking by limiting the risk of falling. This is a system that is much in demand by motorcyclists.

R4.3 - Make the motorcycle eCall mandatory

Mandatory for cars since March 31, 2018, it is also useful for motorcycles. A French position must be asserted on this subject in order to change international regulations. Failing that, the ecosystem of existing private initiatives should be encouraged, especially those that are French.

Axis 5: Initial and post-license training

R5.1 - Develop training in perceptive and cognitive skills in consultation with the profession and integrate it into the curriculum

The over-involvement of novice motorcyclists in accidents and the evaluations carried out both during initial training and after licensing show that the skills necessary to avoid motorcyclists being confronted with dangerous situations are not acquired simply by obtaining a license. An in-depth work is necessary so that these skills can be acquired in the same way as motor skills. In this perspective, digital training techniques could be advantageously mobilized.

R5.2 - Increase the compulsory duration of driver training in order to deepen and individualize it

The duration of practical driving training is considered very insufficient by instructors who often have to offer (or impose) additional hours to their students. This practice undermines the economic model of motorcycle schools. A concerted effort should be made to define new obligations for driver training, in particular the duration of practical training, the distribution of the stage/road driving, and the individualization of training with reference to the GDE matrix[2].

R5.3 - Propose a reform of the license in the continuity of the previous ones to define a new practical test so that it can be prepared and passed by the candidates on compliant motorcycles

The last reform of the license removed the notion of timing for this test. However, it is common practice to modify the characteristics of motorcycles in order to prepare and pass this test: fork stops filed down to increase handling at reduced speed, "optimized" idle speed to facilitate kinematics. It is therefore advisable to develop the courses in line with the handling of an unmodified motorcycle.

[2] GDE matrix, for Goals for Drivers Education.

R5.4 - Conduct a cost-benefit evaluation of raising the age of access to mopeds to 16
In most European countries, access to mopeds is only possible from the age of 16. This measure has been proposed for more than 10 years, but has never been adopted, mainly because of fears of a negative impact on mobility in areas not served by public transport. A multidisciplinary cost-benefit assessment is now required to inform the public authorities before any decision is made.

R5.5 - Encourage upgrading after a significant period of inactivity
Refresher training is one of the reasons for post-license training. This training should be encouraged so that those returning to the sport have the necessary skills to practice safely.

R5.6 - Professionalize trainers and post-license training
The evaluations of these training courses show a great heterogeneity of structures (material and human means) and contents. As a first step, the creation of teaching kits for the continuous training of trainers would allow for an improvement and homogenization of practices (both technical and pedagogical).

Axis 6: Infrastructure

R6.1 - Apply the new European directive 2019/1936 on road infrastructure safety management to the main network of the State and local authorities
The new European directive on road infrastructure safety management explicitly mentions taking into account vulnerable users, including motorcyclists. To this end, the corresponding technical corpus is based on the existing technical guides produced by Cerema, which take into account the specific nature of motorized vehicles.

R6.2 - Carry out a road safety analysis of the site following a fatal PTW accident
Within two months of a fatal or seriously injured PTW accident, the road manager must carry out a road safety analysis of the accident site.

R6.3 - Limit sources of masking in the vicinity of the road infrastructure
Accident studies show that in certain driving situations, particularly in urban areas and at interurban intersections, interacting vehicles can be masked by elements present in the road environment and its surroundings. These masks can come from improperly parked vehicles, street furniture or any other source of sufficient size to fleetingly or permanently obscure the presence of a PTW or other user. Good practices should be identified and capitalized on so that they can be shared by managers.

R6.4 - Encourage interurban road managers to remove obstacles on bends
Motorcycles are particularly involved in accidents on bends, with a high risk of collision with obstacles. In a logic of prioritization of interventions, this point constitutes a priority that will benefit other users, especially car users.

R6.5 - Take PTW users into account in the development of infrastructure
Encourage all road managers to take better account of PTWs by implementing the recommendations of Cerema in this regard.

R6.6 - Professionalize infrastructure stakeholders (managers, design offices, companies) to the specificity of PTWs
Ensure the dissemination of good practices, train and qualify the participants. Encourage the emergence of an ecosystem to ensure this professionalization.

Contents

Introduction

The road accident report for 2019 shows that 820 of the 3498 fatalities in France were powered two-wheelers (PTW) users (23.4%), 160 were moped riders[3] (4.6%) and 660 were motorcyclists[4] (18.9%) [ONISR, 2020]. A quarter of the fatalities are therefore PTW users, whereas their estimated share of road traffic is barely 2% [KANTAR TNS, 2019]. The risk of losing one's life on French roads for the same number of kilometers traveled is about 22 times higher for PTWs than for light vehicles. These figures show that the use of PTW in France is a real public health problem and that there is a real opportunity for progress in road safety.

The CNSR's committee of experts has devoted a large part of its work to the safety of motorcycles and bicycles, adopting a twofold strategy. Firstly, it heard 14 scientists and experts[5] working on the subject. These hearings testify to the intensity of the research effort in this field and the diversity of the disciplines involved: biomechanics, psychology, cognitive sciences, epidemiology, sociology, engineering sciences, anthropology, and education sciences. The information gathered during this phase was then compared with the knowledge in the scientific literature. Finally, the committee drew up an inventory of the measures proposed by road safety stakeholders over the last two decades: safety factors for motorcycles and motorcycles in transport, the work of the previous CNSR and the measures proposed by the CISR. The status of each of these measures was reviewed, identifying those that have been implemented, those that have not been followed up, those that are still relevant and the degree of priority that should be given to them.

Secondly, based on the knowledge thus compiled, the committee focused on six themes centered on vehicles, their users and infrastructures: power and speed, personal protective equipment, visibility and detectability of motorcycles, technologies, initial and post-license training, and infrastructures. Each of these topics is discussed in this document, with a review of the latest knowledge and outstanding issues, followed by a short list of recommendations. Most of the research results mentioned are from work conducted in France, as the specificities are so great in this field. Nevertheless, when the subject was relevant, the committee explored the knowledge acquired abroad.

The present document is a synthesis of this dual approach with choices of proposed recommendations based on scientific relevance, efficiency, equity and acceptability.

[3] 134 in metropolitan France and 326 overseas
[4] 615 in metropolitan France and 45 overseas
[5] The list of persons audited by the committee is available in the appendix.

General data on PTWs: fleet, use and accidents

The PTWs fleet and sales grew substantially in the decade 2000-2010. However, since 2007, the market for new vehicles has been declining, stabilizing at around 250,000 annual sales (Figure 1). It can be seen that sales of mopeds and light motorcycles are decreasing while sales of heavy motorcycles remain almost constant.

The latest KANTAR-TNS survey, conducted in 2018[6], estimated the PTW fleet in France at nearly **2.9 million vehicles**. This fleet is characterized by a large predominance of motorcycles (80%). More than half of the fleet is made up of heavy motorcycles (55%) with a clear trend towards an aging fleet and greater power and capacity.

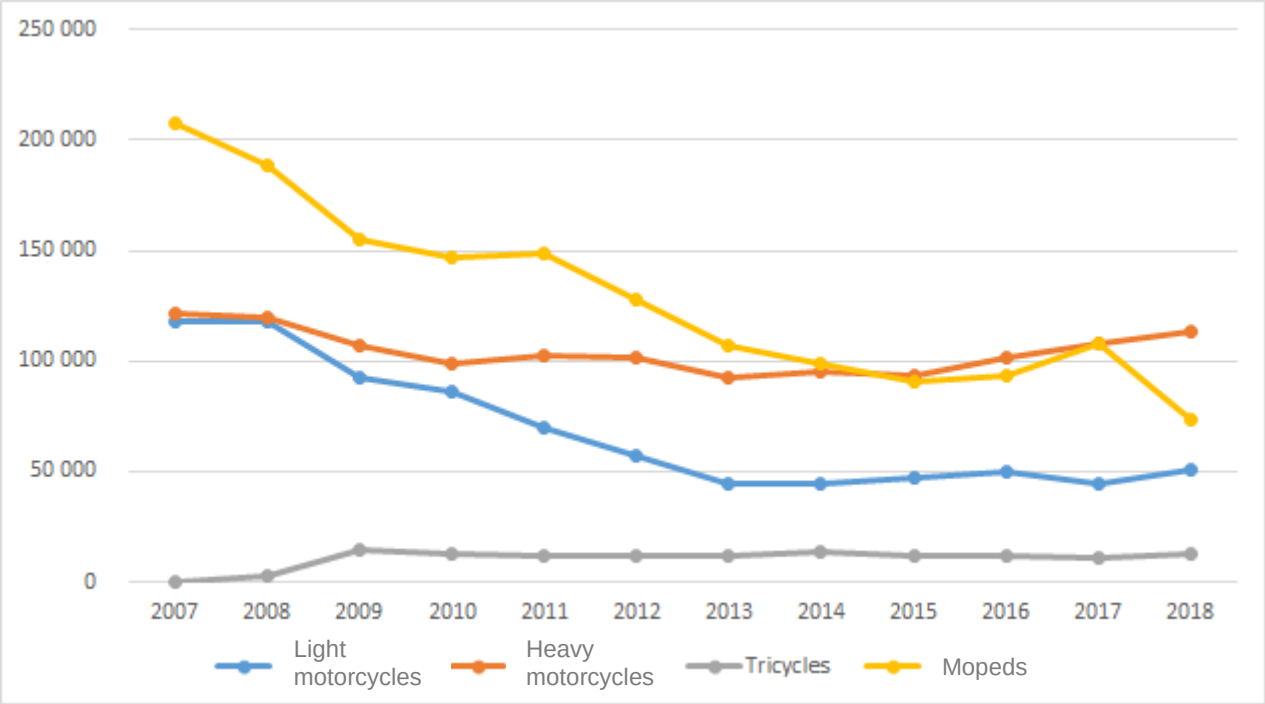

Figure 1 : Sales of new vehicles (PTWs and Tricycles) in France, period 2007/2018
(Source : ONISR et CSIAM, 2018)

Regarding uses, this same survey [KANTAR-TNS, 2018] shows that PTWs and tricycles are primarily used for "strolling/leisure" (73% of reasons for use); home/work trips represent 45% of reasons for use. Mileage outside built-up areas represents the largest share, especially for heavy motorcycles (70%), while it represents 49% for light motorcycles and 54% for scooters. Finally, there has been an erosion of the average annual mileage. This point is confirmed in Ile de France by the recent figures of the current global transport survey (EGT[7]) which mentions a 25% decrease between 2010 and 2018 of trips by PTW.

The vast majority of **PTW users** are men, regardless of the category of PTW. The largest proportion is found among motorcycle users (89% for heavy motorcycles and 85% for light motorcycles) while it is 79% for mopeds. In 2017, women accounted for 16% of successful A2 license applicants. A general aging of PTW users is also observed, characterized by an increase in the number of over-55s.

[6] https://www.onisr.securite-routiere.interieur.gouv.fr/contenus/etudes-et-recherches/vehicules/parc-des-vehicules/le-parc-deux-roues-motorises-des-menages
[7] https://www.iledefrance-mobilites.fr/communiques-dossiers-de-presse-2019/

The accident rate for PTWs is described globally by the statistics published each year by the ONISR [ONISR, 2020]. In metropolitan France, it shows that this mode of travel is quantitatively the second road safety issue in terms of number of fatalities (749 fatalities in 2019), after car users (1622 fatalities). Of these 749 fatalities, 615 are motorcycles and 134 are mopeds. The number of injuries is also high, with a respective total of 5,927 moped riders and 12,952 motorcyclists (32,075 car users) in 2019.

Although there has been an improvement in the accident rate for PTWs since the 2000s, it is still much lower than that for car users, especially motorcyclists (Table 1).

Annual change in fatlities	Period 2000/2010	Period 2010/2019
Car users	-8,9 %	-2,9%
Motorcyclists	-2,9 %	-1,5%
Moped riders	-6,0 %	-6,6%

Table 1 : Annual change in the number of fatalities (Table reading: for the period 2010/2019 the number of car users killed has fallen by an average of -2.9% per year) (Source: ONISR, 2020)

Among moped riders, young people (ages 14-17 and 18-24) are the most involved in a fatal crash (52% of fatalities for 13% of the population). The youngest users under the age of 17 went from 82 fatalities in 2010 to 33 in 2019. Accidents outside built-up areas are more serious than in built-up areas (factor 6) and account for nearly half of the moped riders killed. In built-up areas, half of the accidents occur at intersections (1/3 outside built-up areas). The alcohol factor is particularly present among moped riders: 35% of those involved in a fatal accident had a level of alcohol above 0.5 g/l (19% for other drivers).

The sharp decline in moped rider unsafety since 2010 is largely attributable to the sharp decline in this mode of transportation as evidenced by the reduction in moped sales during the same period (Figure 1). Despite this, moped deaths now represent a little more than one fatality per year and per department, with a higher representation in the overseas territories.

Among motorcyclists, the 18-34 age group is the most concerned. They represent 41% of those killed and 45% of those injured, even though they represent only 20% of the population. Since 2010, there has been an increase in the average age of motorcyclists killed and injured in hospital. Two-thirds of motorcyclists killed were killed outside built-up areas and in half (49%) of these cases, the accident occurred on a bend. Nearly 40% of motorcyclists were killed in accidents with no identified third party. Fatal motorcycle accidents show a marked seasonality with 2/3 of fatalities between April and September, and mainly during leisure trips. Finally, motorcycles with an engine capacity of more than 125 cm3 account for 86% of motorcyclist deaths. Excessive or inappropriate speed is the most frequently reported cause of fatal accidents for all age categories of motorcyclists. It is cited in more than half of the fatal accidents.

Ifsttar's work based on data from the Rhône[8] register during the Secu2RM project[9] [Ifsttar, 2018] (questionnaire survey of 970 PTW drivers involved in an injury accident between 2010 and 2014) provides details on the circumstances of non-fatal PTW accidents: 35% took place without any other road user involved, 32% in an intersection and involving another vehicle, 28% outside an intersection and involving another vehicle, 2% of accidents involved a pedestrian. The responses of these 970 PTW drivers reveal that 11% of them stated that they were travelling above the speed limit at the time of the accident. The PTW first struck a vehicle in more than 50% of the cases. In a crash or collision, the driver

[8] http://www.revarrhone.org/
[9] Sécu2RM: Powered two and three-wheelers: causes and consequences of accidents (Fondation Sécurité Routière project)

hit his or her own vehicle in more than 30% of the cases. In third-party crashes, the injured PTW driver had struck the third-party vehicle in over 50% of the crashes, a fixed obstacle in 10% of the crashes, and a guardrail in 2.4% of the crashes. For accidents without a third party, the driving errors reported by the driver were inappropriate speed in 28% of cases, braking too hard in 26% of cases and lack of attention in 25% of cases. For accidents with third parties, risky overtaking was reported in 20% of cases and insufficient safety distance in 15% of cases. The error is more often attributed to the third party: refusal to give right of way (39% of cases), unnoticed change of direction (31% of cases) and lack of attention (34% of cases).

In addition, the VOIESUR[10] project [Dubos & Varin, 2015], which analyzed all fatal accidents in 2011 and 1/20 of those involving injuries (9,000 accident reports), highlighted the following main points concerning motorcycles: roadsters (without fairings) represent 28% of the fleet and are involved in half of the fatal accidents (47%). Sport bikes make up 9% of the fleet and are involved in 23% of fatal accidents. These two types of motorcycles are therefore the main source of safety. The first four years of licensing and the first four months of owning a new motorcycle are the riskiest periods. While two-thirds of accidents occur with a third party, the most serious are non-third party motorcycle accidents. For fatal crashes involving a heavy motorcycle, the initial speed of the motorcycle is 20 km/h higher than that of cars and speeding is particularly common (over 60%).

More recently, the FLAM2RM study [Cerema, 2020] analyzed the fatal accidents of 2015 involving a PTW. This study is based on the FLAM[11] database, which is the result of a coding of 2878 traffic tickets (85% of the total) of fatal accidents that occurred in 2015 and were issued by law enforcement agencies. The qualitative information contained in this database provides a better understanding of accident mechanisms and their factors. FLAM2RM has confirmed the importance of roadsters and sportbikes (respectively involved in 47% and 23% of the fatal accidents in 2015). For these two types of motorcycles, ¾ of the accidents occur outside built-up areas. 1/3 of the accidents occurred in built-up areas, mainly loss of control of the vehicle alone and accidents with a third party in an intersection, whereas 2/3 occurred outside built-up areas, mainly loss of control of the vehicle alone and accidents with a third party in a road section. The study reveals two types of accidents of concern: group accidents and overtaking. Group accidents represent 13% of fatal accidents, they mainly involve roadsters and sport bikes, they occur on weekends, outside built-up areas, on two-way roads and on bends. Overtaking accidents account for 1/4 of motorcycle accidents (18.6% overtaking and 7.0% just overtaking). Heavy motorcycles are the most concerned and the associated factors are inappropriate speed, dangerous overtaking maneuvers and queueing. Finally, FLAM2RM allowed us to identify the accident factors by distinguishing those related to the human, the vehicle, the road infrastructure, and the traffic conditions (HVIC). The graphs in Figure 2 summarize these factors by distinguishing accidents with and without PTWs. These graphs show that the human factor is largely preponderant in both cases and that for accidents with a motorcycle, the vehicle and infrastructure factors are more present (respectively 2.3 and 1.3 times more). Among the human factors identified, the three main ones are excessive or inappropriate speed (50%), alcohol or drug consumption (48%) and failure to observe the rules of priority (22%). The vehicle factor corresponds to the specificity of the PTW to be both less detectable and powerful. Concerning the infrastructure factors, it is the design or the facilities that can lead to unexpected behaviour or a poor understanding of the situation that are predominant.

[10] VOIESUR : Véhicule Occupant Infrastructure Etudes de la Sécurité des Usagers de la Route (projet Agence Nationale de la Recherche)
[11] FLAM : Facteurs Liés Aux Accidents Mortels (Factors Related to Fatal Accidents)

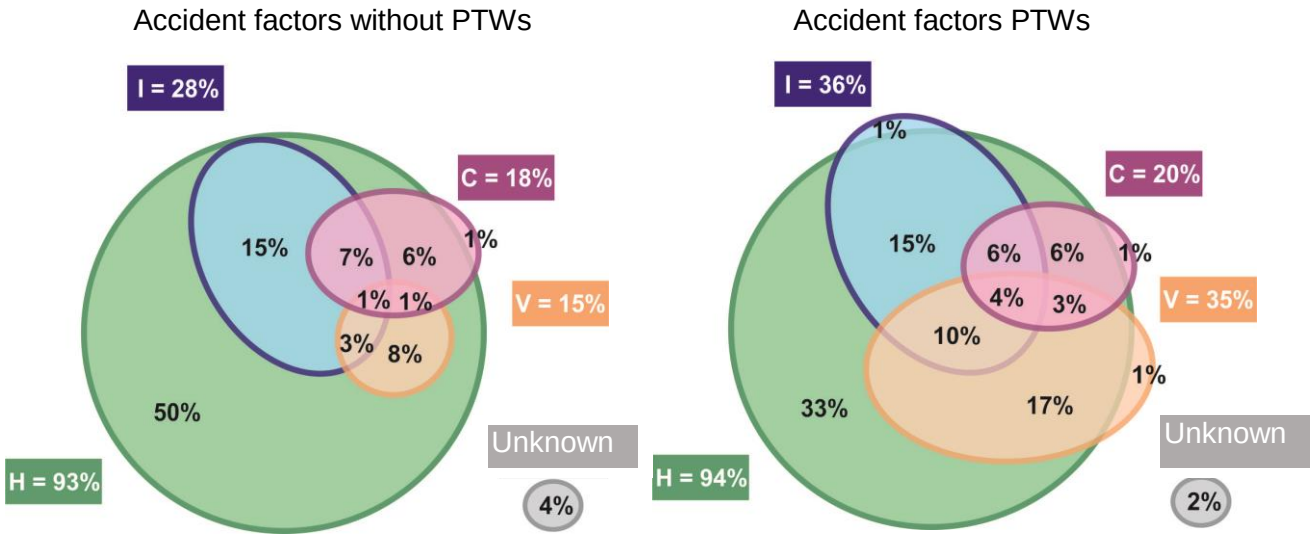

Figure 2 : Combined analysis of accident factors: H = human factor, V = vehicle factor, I = infrastructure factor, C = traffic conditions factor, Unknown = unidentifiable cause (Source: Cerema)

Other work conducted by Ifsttar [Van Elslande, 2011] has also shown, based on a detailed analysis of a sample of 1,000 traffic tickets, that accidents involving PTWs and car users are mainly the result of an interaction between perceptual failures on the part of car users and prognostic and execution failures on the part of PTWs. For car users, the main perceptual failures are attributed to the low visual salience of PTWs (30%), the specific behavior of PTWs (29%), and the motorist's low level of attention (23%). For motorcyclists, their main failings concern a rigid attachment to priority status (27%), inappropriate speed (20%) and an illusion of visibility (18%).

In summary, the accidentology of PTWs is characterized by an extremely high accident risk, which is not comparable to the risks of other road users. Due to the combination of a much larger number of users and higher speeds, motorcycles are the main cause of fatalities and morbidity among PTW users, and this risk increases with the size of the motorcycle (heavy motorcycles are more affected than light motorcycles). There has been a significant reduction in the number of mopeds and light motorcycles, while the number of heavy motorcycles has remained relatively constant.

Priority themes for reducing PTW mortality and morbidity

The work and hearings carried out by the committee of experts, as well as the assessment of the various measures proposed over the past several years, have made it possible to identify six priority themes:

1. The power and the speeds practiced
2. Personal protective equipment
3. Visibility and detectability of PTWs
4. Technologies
5. Pre and post license training
6. Infrastructure

With the exception of technologies, these themes are not new. They may have already been expressed in a similar or significantly different context [Guyot et al, 2008] [CNSR, 2014], and may have been the subject of proposed measures or recommendations. In the appendix, a summary of the proposals and recommendations already formulated for motorcyclists is developed, indicating whether or not they have been the subject of operational measures [Violette & Hiron, 2019].

1. The power and the speeds practiced

1.1. Power

As mentioned above, heavy motorcycles are the most involved in accidents (86% of fatalities), and among them roadsters and sportbikes are over-represented categories in accidents and fatalities. They are respectively involved in 49% and 23% of fatal accidents [Dubos & Varin, 2015] while they represent 28% and 9% of the heavy motorcycle fleet[12]. Thus, these two categories of motorcycles alone constitute the main issue in motorcyclist fatalities with 72% of fatal accidents.
In France, since the arrival on the market in 1978 of the first motorcycle exceeding 100 hp, the maximum power has only increased in 40 years to reach 231 hp in 2019 (Figure 3). Decree no. 84-1065, which came into force on January 1, 1985, specifies that motorcycles with more than 100 hp must be restricted in order to be authorized to circulate on the territory. Decree No. 2016-448 of April 13, 2016 abolishes this obligation, in application of European Regulation No. 168/2013. Since the reform introduced by the CISR of 2015, access to the most powerful motorcycles is only possible after 2 years of holding the A2 motorcycle license limited to 35 kW.

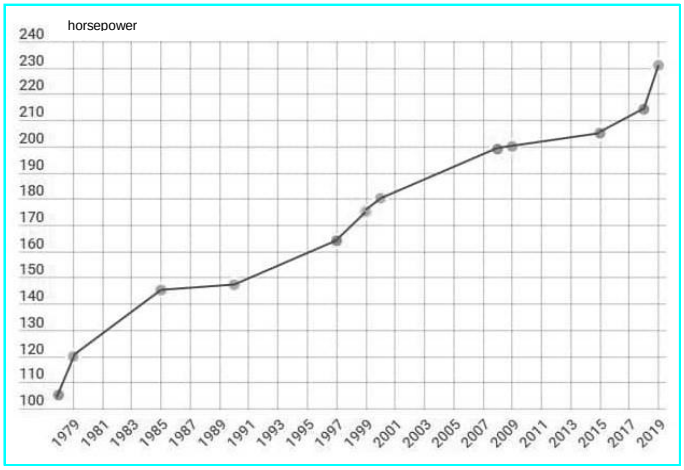

Figure 3 : Evolution of the maximum power of production motorcycles above 100 hp, period 1979/2019
(Source : Moto-Station[13])

The scientific literature [FIT, 2017] on the issue of the link between power (or power-to-weight ratio) and crash risk shows that usage, speeds practiced, and rider experience are also important risk factors. The very high contribution to road safety of the most powerful motorcycles is therefore probably the result of a combination of factors, of which power is one.

In Belgium, in order to limit the circulation of powerful vehicles, a tax according to the power of the vehicles was set up, for both cars and motorcycles. In 2019[14], this tax on the use of motorcycles, calculated according to power (expressed in kW), amounts to €61.50 for a power of less than 70 kW (about 95 hp) and reaches €4,957 for a power of over 155 kW (about 210 hp). This tax is degressive with the age of the vehicle.

In France, PTWs benefit from a favorable tax system, which is expressed as follows:

- Mopeds are exempt from the tax for the issuance of a traffic certificate,
- Motorcycles benefit from a reduced rate (divided by two) for the tax on the issuance of a traffic certificate,
- Motorcycles are not subject to the ecological malus unlike passenger cars while the Euro4 standard is now in application for motorcycles and allows the control of emissions,
- Motorcycles can benefit from the ecological bonus.

[12] The PTW fleet is that of January 1, 2012 and published in March 2013 by the Ministry of Ecology, Sustainable Development and Energy.
[13] https://moto-station.com/moto-revue/actu/la-puissance-des-motos-de-1978-a-2018-126-ch-gagnes-graphique/410278
[14] https://www.mon-assurance-auto.be/taxes/taxe-mise-en-circulation-moto-belgique.html

1.2. Speed and accidents

The international literature extensively documents the link between speed and accidents [Elvik, 2009], [Elvik et al,2019], [ITF, 2018], [Nillson, 2004]. The laws of physics remind us that speed is involved in proportion to its square in the event of an impact. The Safe System principles [OECD, 2016] suggest that public road safety policies should be oriented by taking into account the vulnerability of the human body to impacts occurring at high speeds.

ONISR statistics from the 2019 assessment [ONISR, 2020] show that accidents outside built-up areas are the most serious (2/3 of fatalities) and that 39% of motorcyclists were killed alone. The cause "excessive or inappropriate speed" for the presumed perpetrators of fatal accidents is the first one retained by the police for all age groups of motorcyclists, with a particularly high occurrence for the under 35 years old (in more than 60% of these accidents). Figure 4 illustrates this point by comparing it with the figures for car users, which are lower for all age groups.

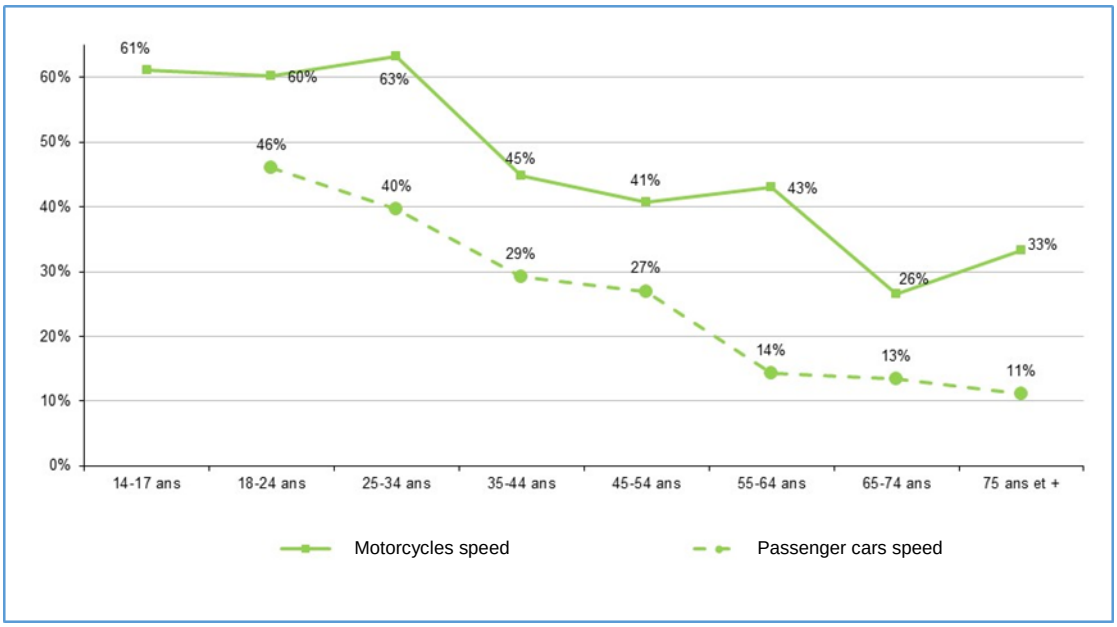

Figure 4 : Accident factor "Excessive or inappropriate speed" for alleged perpetrators of fatal accidents - APAM (Source: ONISR, 2019)

In the Secu2RM project, when asked about the cause of their accident, motorcyclists mentioned inappropriate speed in 28% of cases (non-fatal accidents).

The Detailed Accident Studies conducted by Ifsttar [Wu et al, 2018] also show that excessive and/or inappropriate speed is a factor in 44% of PTW accidents. This result confirms previous work by Van Elslande [Van Elslande, 2011].

The VOIESUR project [Dubos & Varin, 2015] highlighted higher initial speeds for motorcycles than for cars in case of accident occurrence. While this difference is 4 km/h in the case of injury accidents, it reaches 20 km/h for fatal accidents. A complementary analysis [Varin & Ledoux, 2018] of fatal accidents in the VOIESUR database that occurred on two-way roads outside built-up areas showed that for 47% of fatal accidents involving a motorcycle, the driver of this motorcycle was not respecting the maximum authorized speed (VMA). This proportion increases with the size of the motorcycle, especially for motorcycles with an engine size of 500 cm3 or more. In comparison, cars exceeded the speed limit in 26% of the fatal accidents in which they were involved.

The FLAM2RM study [Cerema, 2020] revealed that among the factors contributing to fatal accidents, excessive or inappropriate speed was present in 50% of cases for PTWs (58% for motorcycles and 33% for mopeds respectively). In fatal accidents without PTWs, the speed factor was 35%.

The speed of PTWs also has an impact on their detectability by other road users [Clabaux et al, 2009]. This work shows scenarios where the over-speed contributes to the erroneous diagnosis of the motorist: when the motorist takes information, the over-speed PTW was positioned beyond the place where the car driver was seeking information.

The speed of the vehicle also influences the ability to perform emergency manoeuvres. Thus, the VOIESUR project [Dubos & Varin, 2015] showed in particular that emergency maneuvers such as braking and avoidance do not reduce the severity of accidents.

1.3. Speed practiced

The speeds practiced by PTW users are on average higher than those of other road users.

Since the 2000s, the ONISR speed observatory[15] has published general statistics on speeds practiced by user categories and according to the types of road networks used. Until 2015, the figures always showed that motorcycles traveled at a higher average speed than other categories of vehicles and that they complied less with the maximum authorized speeds (VMA). In 2016, a study by the automated control department of the delegation for road safety [DISR, 2016], analyzed speeding tickets issued by law enforcement with fixed and mobile controls: drivers of heavy motorcycles have the highest rates of speeding, especially when the VMAs are 50, 70 and 90 km/h. Drivers in their fifties and young drivers of 34 hp motorcycles had the highest violation rates. As of 2016, general motorcycle speed statistics are no longer available, but several studies provide relevant evidence.

The DYMOA project[16] [Serre et al, 2018] measured the speeds of an instrumented fleet of motorcycles in real-world driving situations. The analysis of the data collection carried out in the Normandy region (412 routes and 513,000 measurements) revealed speeds practiced by these motorcyclists that exceeded the VMA for one third of the driving time and for half of the distance traveled (Figure 5).

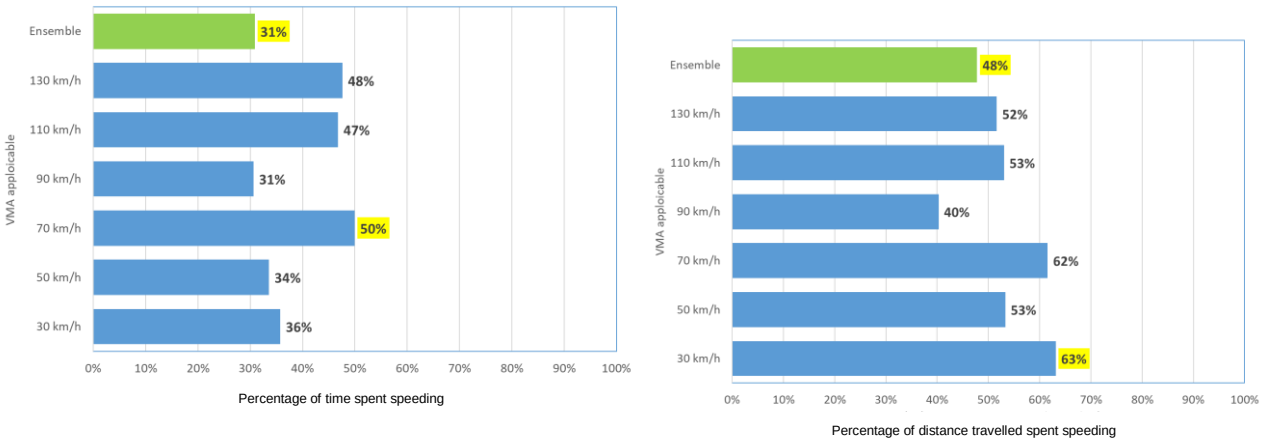

Figure 5 : Times spent and distances traveled above the VMA from speeds collected in DYMOA (Source: Cerema, 2018)

This same collection of data made it possible to analyze incident situations characterized by exceeding dynamic thresholds (acceleration, deceleration, jerks) of instrumented motorcycles in comparison with a panel of automobiles. The analyses showed that motorcyclists use their motorcycles with high levels of stress, both in acceleration and deceleration, and always higher than those observed for cars (Figure 6).

[15] https://www.onisr.securite-routiere.interieur.gouv.fr/contenus/etudes-et-recherches/comportements-en-circulation/observations/observatoire-des-vitesses

[16] DYMOA : Diagnostic d'Infrastructures et Dynamique du Véhicule pour les Motos et les Autos (Infrastructure Diagnostics and Vehicle Dynamics for Motorcycles and Cars)

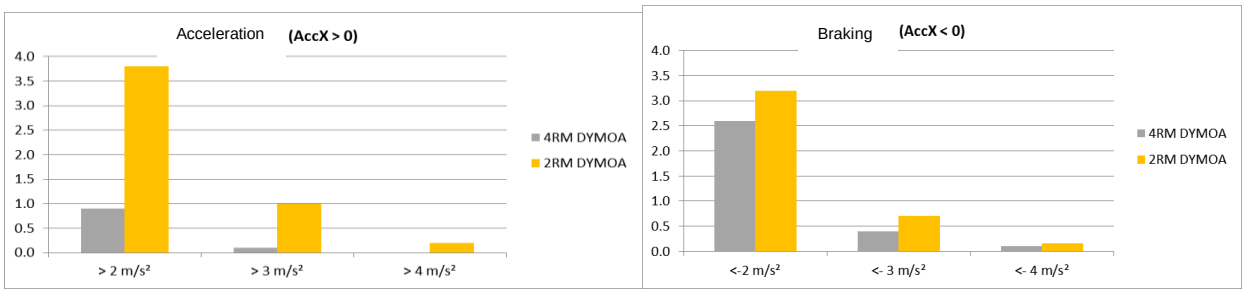

Figure 6 : Acceleration and deceleration levels measured for PTWs (heavy motorcycles) and PFWs (cars) in the DYMOA project (Source: Ifsttar, 2019)

In urban areas, a study on the speeds of PTWs at Paris traffic lights [Cerema, 2014] showed that motorcycles have faster speeds than scooters and tend to respect the VMA less, especially when the light is yellow or green.

The practice of queue-jumping, whether practiced as part of ongoing experiments or illicitly, encourages PTW users to adopt speeds higher than the flow of other vehicles. This practice, in built-up areas off the dual carriageway, has been observed and evaluated by a team from Ifsttar in Marseille [Clabaux et al, 2017]. This work will show that PTWs in a queue-jumping situation are on average 4 times more likely to be involved in an accident, and 6 times more likely in the case of collisions with pedestrians.

1.4. Representations and relationship to the rule

Several researchers have asked why, given their high vulnerability, PTW users drive faster than other road users. Some answers are given by surveys of large panels of motorcyclists. The Gema prevention survey carried out in 2009[17] (639 interviews with PTW drivers) [TNS-SOFRES, 2009] highlighted five profiles of PTW users (passionate, moderate, transgressive, serene, stressed). Overall, for 20% of motorcyclists, speed is one of the factors that contribute to the pleasure of motorcycling and for 15% riding above the speed limit is not perceived as a source of danger. Thus, 53% say that they sometimes drive between 110 and 120 km/h on a country road (two-way) and 36% say that they drive between 150 and 160 km/h on a freeway. In this respect, motorcyclists belonging to the profile of "enthusiasts" are those who minimize the danger of the behaviors they tend to adopt, especially those related to the speeds they practice:

- Driving at 110/120 km/h on a country road is systematically dangerous for 19% of them, whereas 83% declare driving at such speeds.
- Driving at 150/160 km/h on a freeway is systematically dangerous for 19% of them, whereas 72% declare driving at such speeds.

More recently, the barometers published each year by AXA Prévention provide elements of comparison between motorcyclists and car drivers. The one conducted in 2018[18] shows how much more heavy motorcycle users report practicing high speeds (Table 2).

Driver Declaration	Passenger car	Heavy motorcycle (>125cc)	Light motorcycle (50<cc<125)
Speeding	78%	86%	65%
Travels in the built-up areas (VMA50) at over 65km/h	30%	56%	15%
Travels on a two-lane road (VMA90) between 120 and 130 km/h	15%	48%	18%

Table 2: Speeding reported by car drivers or motorcyclists (Source: AXA Prevention Barometer 2018)

[17] In 2009, the VMA is 130 km/h on freeways and 90 km/h on two-way roads.
[18] https://www.axaprevention.fr/chiffressecuriteroutiere-barometre-axaprevention-2018

Researchers describe systems of representation that allow these behaviors to be legitimized by car users and motorcyclists. For example, for motorcyclists, driving faster than others, or above the VMA, is a practice often justified by a safety imperative [Bellet et al, 2011]. More recently, in the department of Hérault, which is confronted with a high number of accidents involving PTWs, a study by the University of Angers [Gaymard et al, 2018] conducted on a panel of motorcyclists interviewed in the form of focus groups suggests that high speed is a norm for this community. A complementary survey conducted by Cerema [Eyssartier, 2018] showed that the thresholds beyond which speed is considered too important correspond to levels well above the VMA and that they increase with the mileage traveled and the engine capacity of the motorcycle.

A recent thesis carried out at Ifsttar [Tamisier, 2017] studied the contribution of "engaging communication" (which is based on the concepts of persuasion and commitment) with motorcyclists in the perspective of reducing their speed. This method of communication has proved to be effective, on the one hand, in the intention and actual reduction of speeds, and on the other hand, for a modification of the driving style in the direction of a smoother and calmer driving.

The work of Ifsttar [Coquelet, 2018], which focuses on gender differences among PTW drivers, also sheds original light on accident rates, risk behaviors and gender stereotypes. Although women represent 27% of PTW drivers, they account for only 4% of fatalities (nearly 25% for car drivers). These studies, which used a modified version of the Motorcycle Rider Behavior Questionnaire (MRBQ) [Elliot et al. 2007] with 2,500 drivers (mainly heavy motorcycles, 10.5% of whom were women), identify five typologies of unsafe behavior: two related to errors (driving errors and negligence in wearing safety equipment) and three related to rule violation (ordinary, aggressive, deliberate risk-taking). The main observations related to gender are:

- A male/female difference for extreme violations and deliberate risk-taking, which is greater for men.
- Little difference for ordinary violations, which seemed to be part of what was perceived as "normal" driving of a PTW.
- Crash risk behaviors depend on the type of motorcycle: roadsters and sport bikes are associated with more violations and deliberate risk taking.

In addition, self-reported risk behaviors are predicted by gender stereotype conformity. As with car drivers:

- High conformity to female stereotypes is predictive of driving errors.
- High conformity to male stereotypes is predictive of violations, in particular because of the search for confrontation and competition that it engenders, which corresponds to socially expected behavior among motorcyclists and reinforces risky behavior.

Finally, the issue of gender stereotypes associated with PTW riding [Coquelet, 2018] was addressed among adolescents through a self-administered questionnaire survey, in order to analyze the anchoring of these stereotypes. These are already present from adolescence and are characterized by:

- The association of the female motorcyclist with accidents and danger, with an ambiguous image (careful and dangerous), with a lack of skills.
- The association of the male motorcyclist with high speed, accident and danger.
- The association of motorcycling with a male activity.

1.5. Fairness and effectiveness of automated speed enforcement

Since the implementation of automated speed enforcement, the question of the fairness and effectiveness of the enforcement system for different categories of vehicles has been raised. Concerning PTWs, two factors are linked to a decreased probability of enforcement:

- The lack of a front license plate, while a significant portion of fixed speed cameras[19] only control vehicles from the front. Several recommendations[20] have called for the installation of a number plate on the front of motorcycles. Current European regulations suggest that such a request will take time.

- The small size of PTW license plates limits the performance of automatic reading systems due to smaller characters in height and width ([Cerema, 2011] [Cerema, 2012]). Regarding the plates at the rear, the regulation (order of December 15, 2016[21]) imposes since 01/01/2017 a standardization of their size and installation (inclination between 0 and 35° towards the front).

Finally, the measures that aim to reduce the speeds practiced are perceived in a very negative way by many motorcyclists. If the impact of the recent measure to lower the VMA to 80 km/h on roads outside built-up areas without a central separator cannot be evaluated specifically for PTWs, the reduction in speeds practiced by car users and heavy goods vehicles since 01/07/2018 could contribute to indirectly improving the safety of PTWs.

1.6. Fate of past recommendations

Several recommendations aimed at limiting access to power and encouraging the reduction of speeds practiced by PTW users have been made in the past, notably through reforms to the motorcycle license. These have included gradual access to the most powerful motorcycles and harmonization of rear license plates. Measures aimed at ensuring fair speed control for different categories of users have not been implemented, in particular the measure relating to the installation of a speed camera for PTWs. Similarly, the development of tools for observing and measuring the use of motorcycles (traffic for risk exposure) and the practices of PTWs (speeds) has not yet been effectively implemented.

1.7. Proposed recommendations

R1.1 - Make speed enforcement effective for PTWs as for other motorized vehicles:

- Use automated enforcement equipment to achieve the same level of performance for all categories of motorized vehicles.
- Check license plate position and orientation for all motorized vehicles in a compliance monitoring system.
- Include in the annual report on offences drawn up by the ONISR, data enabling a distinction to be made between the various categories of motor vehicles.
- Change the size of the characters on motorcycle license plates to the general size defined for passenger cars. The height of the characters would increase from 45 mm to 75 mm and the width from 23 mm to 39 mm.
- Design automated speed control devices capable of taking into account the specific trajectories of motorized vehicles.

[19] There are also mobile on-board radars that control oncoming vehicles from the front.
[20] The road safety deposits as well as the CNSR committee of experts.
[21] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000033607457&categorieLien=id

R1.2 - Define identical taxation for the different categories of motorized vehicles for personal use (motorcycle and passenger vehicle). Currently, the General Tax Code (Article 1599 sexdecies) reduces the unit rate of the tax for issuing a registration certificate for motorcycles by half compared to that for passenger cars. Similarly, motorcycles are not subject to the ecological malus, unlike passenger vehicles.

R1.3 - Give insurers the regulatory and technical possibility of establishing a safety contract based on the monitoring of driving and speeds
The aim here is to initiate discussions on how to set up a system of continuous recording of speeding and acceleration/braking in exchange for a significant reduction in the insurance premium. This system must be compatible with the RGPD[22] and must be subject to an evaluation phase with a comparative measurement of its impact on accident rates.

R1.4 - Develop and use communication techniques that engage motorcyclists in prevention (e.g. insurers), particularly focusing on the dangers of speeding. Insurers should be mobilized to adopt and relay these methods in order to raise awareness and bring about lasting changes in behavior. Prior work on consolidating, promoting and disseminating research work on the subject should be supported.

[22] RGPD : Règlement général sur la protection des données (General Data Protection Regulation) https://eur-lex.europa.eu/legal-content/FR/TXT/HTML/?uri=CELEX:32016R0679

2. Personal protective equipment (PPE)

Personal protective equipment (PPE) is the only protection for PTW users[23], because of the absence of bodywork and equipment that could protect them in the event of an accident. Numerous research studies [ACEM, 2004] have demonstrated their effectiveness and have led to the development of this equipment (technology, materials, effectiveness, etc.). However, there is still room for improvement in their widespread use and more proactive measures should be proposed. Although the wearing of a helmet and approved gloves is compulsory in all conditions, the other obligations only concern the practical tests of the driving license defined by the decree of 10/01/2013 which stipulates that the candidates to the driving license must wear adapted PPE: approved helmet, certified gloves, long-sleeved jacket, pants and boots or high shoes.

2.1. Description of the injuries and protections provided

In-depth studies of PTW accidents provide detailed information on the main injuries suffered by motorcyclists and on the impact of protective equipment on the different parts of the body.

The work carried out in the framework of two doctoral theses at Ifsttar has very well documented the injury assessment of PTW victims [Wu, 2018], [Moskal, 2009]. The upper and lower limbs are the most frequently affected body regions but are not the most severely affected (Figure 7). They can nevertheless cause permanent disability. The most severe injuries (AIS4+[24]) are to **the thorax (50%) and the head (44%). These two regions constitute the bulk of the severe morbidity and mortality of PTW users.** Moreover, head injuries are also the main cause of major sequelae (IIS $\geqslant$ 3). As for thorax injuries, the most frequent being rib fractures, they are strongly associated with a risk of contusions and tears of vital organs (lung, heart, aorta, liver or spleen). Finally, injuries to the spine are not the most frequent but are often serious and have important long-term consequences: permanent or temporary neurological incapacity such as paraplegia, quadriplegia and temporary or permanent disability. PTW accidents also cause rare injuries in other contexts: open fractures of the pelvis (tank impact), vertebrae fractures due to hyper-extension of the neck and rib fractures due to thoracic compression.

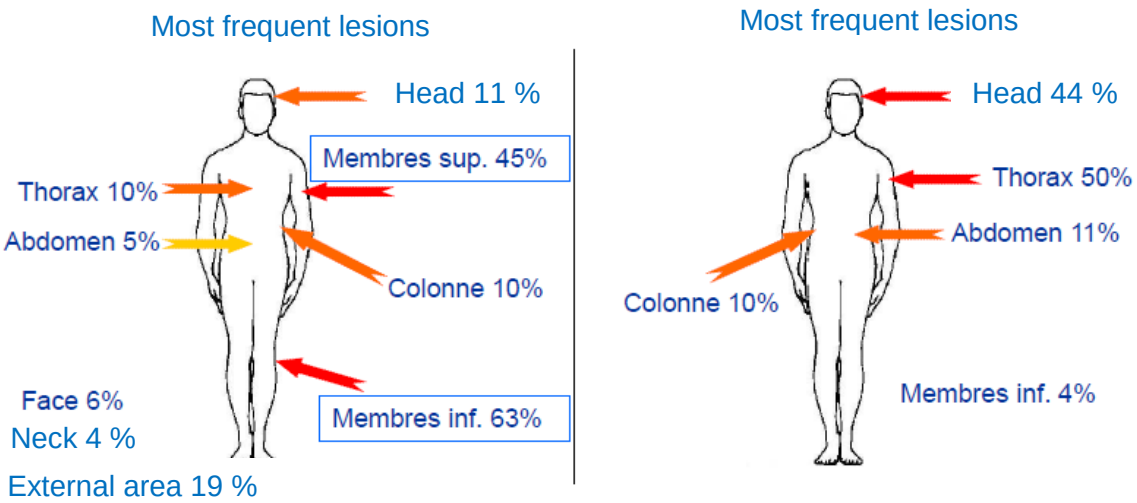

Figure 7: Injuries suffered by motorcyclists according to their severity (Source: Ifsttar)

[23] The term user here refers to both driver and passenger.
[24] AIS4+ : Abbreviated Injury Scale 4+ : in the AIS scale, corresponds to severe, critical and maximal injuries

The nature and performance of the helmet has an impact on the severity and nature of head injuries by absorbing impacts in a useful way up to impact speeds that remain low (with possible improvements for tangential effects). Thus, in order to be approved, helmets must meet the tests of the European standard ECE 22-05, which are carried out for an impact speed of less than 30 km/h. Finally, statistics from the Rhone registry show that full-face helmets provide better protection of the face [Wu et al, 2019]. The FLAM2RM study [Cerema, 2020] highlights the problem of helmets in fatal accidents, particularly for mopeds and light motorcycles. It appears that only 57% of moped riders and 60% of light motorcycle riders involved in fatal accidents wear a helmet properly. This rate rises to 81% for heavy motorcycle users. The cases of helmets ejected during the accident are worrying because they represent 27% of moped accidents and 30% of light motorcycle accidents. This observation raises the problem of the appropriate use of helmets: inappropriate size, type of helmet (favourable to dislodging), tightening of the chin strap.

For trunk and spine protection, the airbag vest appears to be the most appropriate equipment (the effectiveness of the back protector appears to be low for spine protection) [Wu et al, 2019]. Like the helmet, the airbag vest is effective for relatively low impact speeds of less than 40 km/h[25]. Ifsttar's work conducted within the Effigam project[26] [Serre et al, 2017] has shown through field experiments a positive effect of airbags, both for accidents involving falls and slips and for those involving impact against obstacles. A study of the performance of marketed products showed that all airbags provide a good level of protection, both those with a wired trigger and those using a radio-controlled system, with, however, better performance for the latter.

For other parts of the body, the Secu2RM project confirms a reduction in the risk of dermabrasions when the driver wears a jacket and gloves (-68%) and, to a lesser extent, pants and boots (-40%), the latter also being associated with a reduction in foot and ankle fractures. An experimental study conducted by Ifsttar during the COMPAR project[27] provides results along the same lines. Using slip scenarios of 30 to 50 km/h, it shows that wearing a jacket, even a light one, limits dermabrasions and that a heavier jacket is more effective. The NF13592-2 abrasion standard, which concerns equipment for professional motorcyclists, has requirements that are too high for leisure wear, and virtually none of these products meet them.

2.2. Equipment rates and user expectations

Successive surveys on the rate of wearing this equipment show that the possession and wearing of protective equipment is increasing.

The survey conducted between 2010 and 2014 of 970 PTW accident drivers identified by the Rhône registry (Secu2RM project) reported the following reported wearing rates: helmet (97%), gloves (85%), jacket (69%), high shoes (50%), back protector (28%), motorcycle pants (20%) and airbag (0.3%).

The VOIESUR project, based on accident reports from 2011, has nevertheless identified very different wearing rates from one category of PTWs to another. For helmet use, it is 95% for heavy motorcycles, 76% for light motorcycles and 77% for mopeds. For the other equipment, it appeared that after the helmet, it is respectively the jacket, the gloves, the boots and the pants which are the most worn. Finally, when distinguishing between categories of PTW, heavy motorcycle users are the best equipped.

In 2017, AMDM's survey[28] auprès des motards du panel 2-roues Lab a montré que seuls 4 % des 2 000 répondants utilisaient un gilet airbag mais que 46 % se disaient prêts à un achat. of motorcyclists in the 2-Wheel Lab panel showed that only 4% of the 2,000 respondents used an airbag vest but 46% said

[25] The VOIESUR project has shown that for more than 80% of fatal accidents involving PTWs, the speed of the first impact is greater than 40km/h.
[26] EFFIGAM, Airbags for motorcyclists: how effective are they for how fast? (DSR Project).
[27] COMPAR, Behavior and its determinants in powered two-wheeler accidents (DSCR project).
[28] AMDM : Assurance Mutuelle Des Motards : https://www.mutuelledesmotards.fr/actualites/infographie-lusage-de-lairbag-moto

they were ready for a purchase. A similar new survey[29] of the same panel in 2019 reports that 8% own an airbag and 8% are ready for a purchase within a year. In addition, 100% of motorcycle respondents report having helmets and gloves, 99% have jackets, 96% have shoes or boots, 81% have back protection, and 71% have suitable pants.

In terms of expectations, the PIONEERS project[30] has collected, through focus groups, the expression of the needs of motorcyclists in terms of PPE. Expectations mainly concern the evolution of existing PPE: connected jacket, jacket adapted to climatic conditions (heating, cooling), using lighter, more robust materials and with better visibility (retro-reflective). In the main selection criteria, price and comfort take precedence over certification. Opinions regarding the obligation to wear PPE are rather negative (motorcyclists most often consider themselves well equipped) but they vary according to use; scooterists, for example, are more in favor of tightening constraints in this area.

2.3. Fate of past recommendations

Since the 2008 PTW consultation, several recommendations have been made on PPE, only two of which have been acted upon: measures to promote the use of airbags and the obligation to wear certified gloves. All the other recommendations made have not been followed up: definition of a standard for this equipment, obligation to wear a full-face helmet properly strapped on (or offering equivalent face protection), reinforcement of the requirements of the ECE-22-05 standard[31] (which has not changed since 2000 and whose tests are not fully representative of the impacts observed in the main accident situations).

Other measures have also remained unimplemented for the time being, in particular those proposing to improve knowledge of injury mechanisms in motorcycle accidents and, in particular, to evaluate the link between impact speed and physical damage (underway in the European research project PIONEERS), to create two medical indicators, one summarizing the immediate severity of injuries, the other the potential sequelae of these injuries, and finally to extend the Rhône Registry to the entire Rhône-Alpes region. In addition, there is a need to continue standardization work to improve both PPE and motorcycle design to limit the severity of injuries.

Not specifically related to PPE but linked to the issue of injuries, let us finally mention that one of the 18 measures of the CISR of January 9, 2018 had the objective of improving the care of victims of road accidents (measure #4). For this, the government committed to creating an investment fund for the modernization of health and medico-social structures intended for the care of road accident victims. It was planned that this fund would be endowed with all the surplus revenue received by the State as a result of the lowering of maximum speeds.

[29] http://2roueslab.mutuelledesmotards.fr/

[30] PIONEERS : Protective Innovations of New Equipment for Enhanced Rider Safety http://pioneers-project.eu/

[31] The ECE-22-05 standard is the current approval standard that helmets must meet in order to be placed on the market. As an example, the shock absorption test is carried out at an impact speed of 27km/h.

2.4. Proposed recommendations

R2.1 - Make it compulsory to wear a full face helmet
This measure has been proposed for more than 10 years and the latest injury studies confirm that, in the event of an accident, protection of the face is always superior with such a helmet.

R2.2 - Continue and strengthen incentives for widespread use of airbag vests
All stakeholders must continue to organize themselves to implement incentives to promote the widespread use of airbag vests. Such measures are preferable to mandatory wearing. However, if it turns out that, despite its interest, this PPE is still not widely used, its mandatory use should be considered in order to reap its full benefits.

R2.3 - Continue research and development work on the autonomous airbag vest
Since the first models were developed, airbags have evolved to provide better protection for motorcyclists with improved comfort and to increase their reliability. Progress remains to be made to move from the wired airbag to the radio or connected airbag, which are popular with motorcyclists but which still need to become more reliable while maintaining costs that are appropriate for their wide distribution. Actions to support research and development must be encouraged.

R2.4 - Ensure the continuity of French scientific expertise within international PPE standardization committees
PPE is generally covered by European or even international standards. French representation in these institutions must remain effective and be coordinated. It is important to ensure that French experts in the various participating organizations have the means to contribute to reducing the morbidity of motorcycle users by supporting French know-how when it is beneficial in terms of road safety.

R2.5 - Improving the treatment of motorcycle injuries
It is proposed to finance 1) work aimed at optimizing triage and care for road accident victims, 2) improvements to health and medico-social structures. In the end, this measure will benefit all road accident victims, in particular motorcycle victims.

R2.6 - Establish a provisional timetable for the widespread use of PPE
In conjunction with the establishment of an observatory on the wearing of PPE, set up a committee bringing together user representatives and road safety stakeholders to establish a provisional timetable setting out milestones with equipment rates to be achieved. If the planned equipment rates are not achieved, this consultation and monitoring will be a prerequisite for the implementation of coercive regulations concerning the wearing of PPE.

3. Visibility and detectability of PTWs

The difficulties and shortcomings of PTWs detectability have been widely documented in the literature since the 1980s, referring to the concepts of conspicuity or visual salience [Hurt et al, 1981] [Olson et al, 1981].

The salience of PTWs is inherently lower than that of cars because of their small size, more irregular contours, and the generally dark color of the clothing worn. The main safety measure to increase the salience of PTWs was the mandatory daytime running lights, taken in France in 1975, whose positive impact has since been shown [Cavallo & Pinto, 2012].

In-depth accident studies have highlighted accident scenarios that have as their main factor a lack of detectability of the PTW by car users[32] : non-detection, late detection, or erroneous perception of the movement or trajectory of the PTW.

It is also noted that specific driving situations or behaviours (especially trajectories) can cause masking situations (e.g. a PTW in a lane departure situation is masked for vehicles coming from the right).

Finally, the speed at which PTW users drive can further reduce their chances of being detected in time, especially in urban areas, creating a risk of "looked at but not seen" accidents [Clabaux et al, 2009].

In 2019, motorcycle accidents with another motorized user were responsible for more than half of the motorcyclists killed (51%) [ONISR, 2020]. In the majority of cases (69%), the opposing user was a car user. The VOIESUR study provides details on the typology of these accidents. For both fatal and injury crashes, the most frequent configuration is intersection crashes, followed by vehicle-to-vehicle (non-intersection) collisions, overtaking and parking maneuvers. Motorcycle detection failures are primarily involved in accidents with a change in direction by the motorist and in intersections. The FLAM2RM study [Cerema, 2020] specifies that the factor "low perceptibility of the PTW" is present in 1/3 of the accidents with an antagonistic user. Similarly, factors with a mask preventing detection of the PTW are present in 17% of fatal accidents. The "Moped in blind spot" factor accounts for 7% of fatal accidents.

In an environment increasingly subject to the multiplication of light sources (public lighting, illuminated advertising, etc.), the detectability of PTWs seems to be decreasing. This trend has been reinforced since 2011 by the presence on cars of daytime running lights which are automatically switched on when the engine is started. These lights have specific geometries and rely heavily on LED technology.

All the work carried out since the 1980s shows the importance of improving the visibility and detectability of powered two-wheelers. Recent research has concluded that it is important to define a visual signature for PTWs and to improve the perception of their movements.

In order to study ways to improve the detectability of PTWs, the AVIMOTO project[33] ([Cavallo et al, 2013] [Ranchet et al, 2016]) led by Ifsttar compared several light configurations. The results suggest on the one hand to define a visual signature for PTWs and on the other hand to improve the perception of their movements. A first experiment, carried out on a driving simulator, showed that a vertical arrangement of lights (configurations C and D in Figure 8) allows motorists, by significantly increasing the visual size of the PTW, to better detect the approaching movement during a left turn maneuver at an intersection (Figure 9).

[32] The lack of detection can also be linked to the driver: inattention, double task, ...
[33] AVIMOTO Project Improving the Visibility of Motocycles (Fondation MAIF Project)

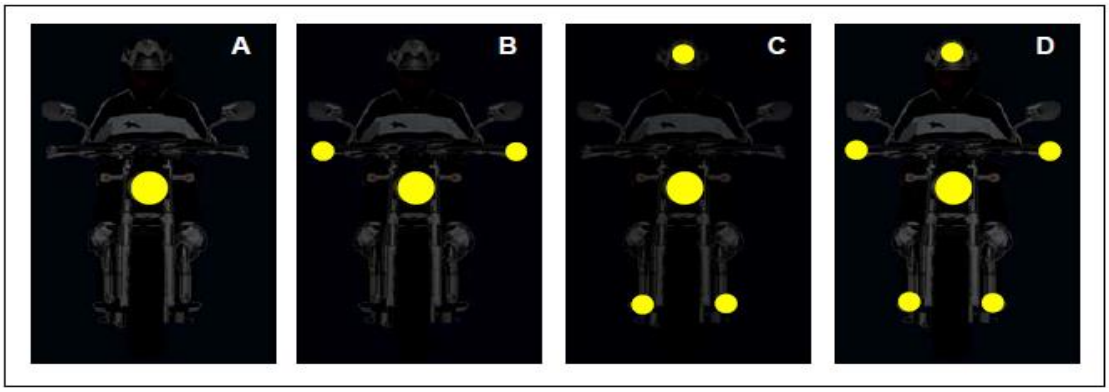

Figure 8: Front lighting configurations of PTWs evaluated in AVIMOTO (Source: Ifsttar, 2013)

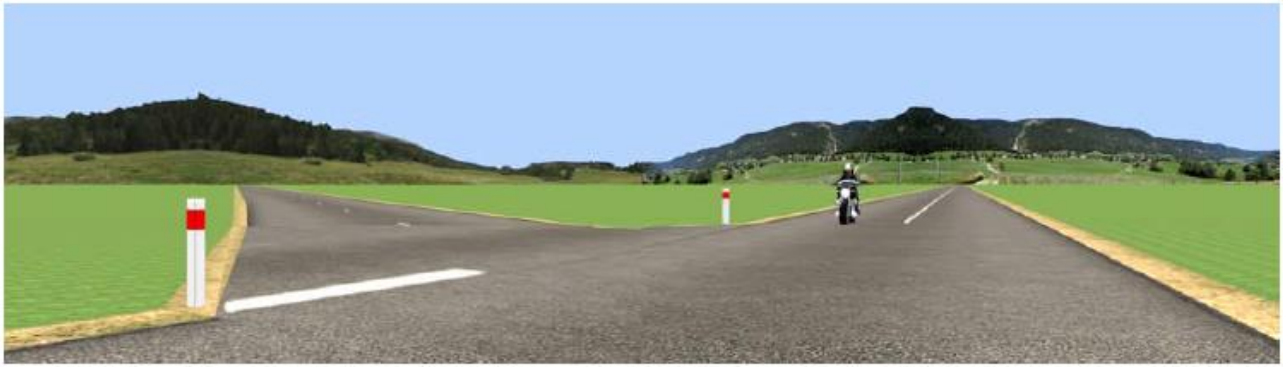

Figure 9: Context evaluated in AVIMOTO (Source: Ifsttar, 2013)

A second experiment [Ranchet et al, 2016] tested four light configurations in an environment with multiple car lights (Figures 10 and 11).

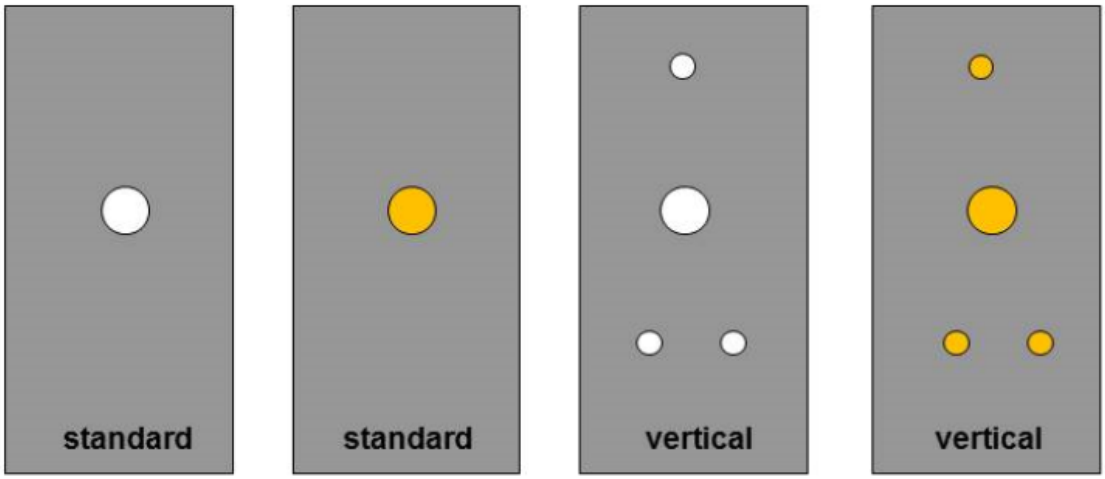

Figure 10: PTW front lighting configurations and colors evaluated in AVIMOTO (Source: Ifsttar, 2016).

Figure 11: Example PTW / car context evaluated in AVIMOTO (Source: Ifsttar, 2016)

The best detectability result corresponded to configuration D in Figure 8, with yellow lights in a vertical configuration. These results were confirmed by track tests with LED lights [Espié et al, 2019]. These tests also identified the technological challenges related to these additional lights, which must remain cheap, energy efficient, and light for mounting on the fork in the case of an aftermarket installation.

3.1. Fate of past recommendations

Les résultats du projet AVIMOTO apportent des éléments de réponse aux recommandations proposées lors la concertation 2RM qui proposaient d'utiliser des phares de couleur spécifique et d'élargir le gabarit visuel. Ces mesures ne peuvent cependant s'envisager qu'à l'échelle européenne puisque les spécifications techniques des véhicules neufs ne relèvent pas des pays membres. D'autres recommandations ont été formulées, qui renvoient aux bonnes pratiques en termes de gestion des abords de l'infrastructure routière afin d'éviter les masques à la visibilité : contrôler de manière systématique le bien fondé des panneaux de signalisation et d'information (Cf. démarche ISRI[34]), limiter le nombre de panneaux publicitaires implantés aux abords de voirie (Cf. articles L581-1 et suivants du code de l'environnement). De même, l'idée, plusieurs fois évoquée, de promouvoir le port d'équipements détectables n'a pas été retenue, sauf pour le casque et pour le gilet haute visibilité dans les situations d'urgence. La recommandation relative aux angles morts pour les automobiles et les poids lourds interroge sur les spécifications des détecteurs qui répondent aujourd'hui à des exigences formulées essentiellement pour les piétons et les cyclistes qui se déplacent à des vitesses bien plus faibles que les 2RM. Enfin, les évolutions récentes des référentiels des permis de conduire ne prennent pas en compte les recommandations qui favorisent la détection en sensibilisant les autres usagers aux situations dans lesquelles ils risquent de se faire surprendre par l'arrivée inattendue d'un 2RM.

[34] ISRI : Inspection de Sécurité Routière des Itinéraires (Road Safety Inspection of Routes)

3.2. Proposed recommendations

R3.1 - Define a visual signature specific to PTWs
Recent research on the detectability of PTWs suggests that a visual signature specific to PTWs should be defined so that they are more clearly detected by car users and other road users on the one hand, and in the future by vehicles with driver delegation on the other. Based on these results, the committee recommends the adoption of a particular color, yellow, which would allow them to be distinguished from other vehicles, and an appropriate arrangement of lights in order to increase the vehicle's perception surface. To do this, France must define and support a proposal to international bodies.

R3.2 : Develop best practice information for users and the PTW profession for the installation of additional retrofit lamps
Pending changes in European regulations and in order to avoid a proliferation of additional lighting configurations, inform users and the PTW profession on the best configuration for installing these lights and on those to avoid. The objective is to eventually achieve a single visual signature for motorized vehicles.

R3.3 - Amend the highway code to prohibit overtaking at urban intersections and crosswalks
This measure, which corresponds to the practice of PTW queue-jumping in urban areas, has already been proposed during the 2006 PTW safety studies [Guyot et al., 2008] and by the previous CNSR's committee of experts. Although it concerns a significant proportion of accidents in urban areas, it has not been followed up. It is complementary to the previous one because, in addition to masks, the trajectories adopted by motorcyclists may surprise other road users. This measure could be monitored by semi-automated video-verification.

4. Technologies

Apart from ABS braking[35] which is now compulsory, PTWs benefit very little from the development of driver assistance systems (ARAS), which are mainly used on cars and trucks: braking, speed maintenance (speed limiter/regulator), trajectory maintenance, maneuvers (blind spot monitoring, parking assistance), perceptive improvements (automatic lighting, automatic reading of road signs, detection of pedestrians, etc.), and alerts (*eCall*[36]). Some of these devices are required by law for new vehicles that are gradually being put on the road, often after having already been offered in high-end vehicles.

The expression of motorcyclists' needs, known in particular thanks to the PIONEERS project, highlights the desire to have many aids similar to those of cars, and in particular cruise control/ speed limiter, braking and trajectory assistance, lateral detection of the arrival of a vehicle and *eCall*.

The Federation of European Motorcyclists Associations (FEMA) conducted two surveys of European motorcyclists in 2014 and 2019, which respectively collected the opinions of 17,000 and 2,300 European motorcyclists on the usefulness of various driving aids (ARAS)[37]. Putting these two surveys into perspective provides relevant information on the perceived benefit or danger of these devices. Between 2014 and 2019, the position of motorcyclists for these systems is more reserved, especially for their interest in safety. Overall, there was a significant drop in the opinions "really useful" and "essential" for safety. Similarly, the "dangerous" opinion has increased significantly (Table 5). In 2019, 70% of respondents consider that safety-critical devices should simply be available as an option, as opposed to 30% for standard devices on new motorcycles.simplement.

Opinions of European motorcyclists	**Change in response in 2019 (base 100 in 2014)**
Dangerous	136,9%
Useless	108,1%
Maybe useful	117,0%
Useful	93,3%
Really useful	76,4%
Essential for safety	52,6%

Table 5 : Summary of the 2014 FEMA ARAS survey (source: FEMA, 2019 survey).

The responses were compiled to rank these aids among the 44 proposed. Table 6 shows the ranking of "really useful" and "essential for safety" devices according to the score of responses obtained. Among the best ranked ARAS, braking aids are highlighted by motorcyclists as well as those aimed at protecting the motorcyclist after the accident.

[35] ABS : Antiblockiersystem
[36] https://fr.wikipedia.org/wiki/ECall
[37] https://www.femamotorcycling.eu/new-technologies/

Classement	Dispositif	Score (% de réponses)
1	Coupled braking ABS	48,3%
2	Shock sensitive circuit breaker system	41,7%
3	eCall	40,4%
4	Improved visibility in the helmet	40,0%
5	Adaptive cornering light	38,6%
6	ABS for light motorcycles <125 cm3	38,5%
7	Emergency Brake Assist	36,8%
8	*Airbag vest*	33,1%
9	Tire pressure monitoring	32,5%
10	Emergency lighting in case of accident	32,3%

Table 6: Ranking of ARAS according to their perceived usefulness for safety (Source: Cerema from FEMA survey 2019)

As a counterpoint, Table 7 presents the RASCs that are considered "unnecessary" and dangerous. It is clear that the RASCs that aim to control and moderate speed are rejected by the respondents. More generally, the RASCs judged to be useless and dangerous are those that tend to reduce or limit the motorcyclist's control of the motorcycle.

Classement	Dispositif	Score (% de réponses)
1	Speed Limiter	76,1%
2	*ISA (Intelligent Speed Adaptation)*	73,0%
3	Strobe light	59,9%
4	Lane Departure Warning (LDW/LKA)	56,0%
5	Automatic emergency braking	55,6%
6	Anti-start if no helmet is detected	53,0%
7	Helmet visor display	51,5%
8	*ISA (Intelligent Speed Adaptation)*	50,4%
9	Automatic sign recognition	46,0%
10	Speed threshold warning	42,2%

Table 7: Ranking of ARAS according to their perceived safety hazard.(Source: Cerema from FEMA survey 2019)

4.1. Status of regulations

Since the implementation of the EU regulation 168/2013 of 15/01/2013, ABS is mandatory for new motorcycles with a capacity greater than 125 cm3. For light motorcycles with a cubic capacity of less than 125 cm3, this regulation requires either ABS or coupled brakes. This requirement has been in effect since January 1, 2017. On the other hand, there is no particular obligation for mopeds. The integral coupled braking would however allow to better manage the emergency braking situations and would thus deserve to be compulsory in the same way as the ABS. If traction control is available for sport bikes, its purpose is not to improve safety but to facilitate the transmission of engine torque to the tires. The regulation on the mandatory installation of an eCall device for new passenger cars has not been considered for PTWs. To meet this need, applications such as the one proposed by *Liberty Rider*[38] in France have appeared on the market. Other devices are being developed by manufacturers and are inspired by those developed for cars, notably stability control, adaptive speed control and blind spot monitoring.

European regulations are constantly evolving for cars and trucks, gradually imposing the deployment of new technologies to improve road safety. Recent decisions taken with an implementation date of 2022[39] include Intelligent Speed Adaptation (ISA), facilitating the installation of an alcohol ignition interlock device, driver drowsiness and attention monitoring, advanced driver distraction warning, emergency brake signal, reverse detection and an accident data recorder. These systems are not expected to be

[38] https://liberty-rider.com/, https://www.bikeguard.eu/fr/

[39] http://www.europarl.europa.eu/news/fr/press-room/20190220IPR27656/des-technologies-sauvant-des-vies-seront-obligatoires-dans-les-vehicules

developed and available for PTWs.

The EuroNCAP roadmap for 2025 [EuroNCAP, 2017] mentions the need to consider PTWs in the same way as other vulnerable road users for the development of vehicle ARAS. The European MUSE project [40] has thus contributed, with regard to the main PTW/car accident scenarios, to proposing new procedures for evaluating the PTW detection devices by the ARAS. Finally, it should be noted that the final classification of vehicles by EuroNCAP will take into account the performance of the ARAS evaluated for all vulnerable users (pedestrians, cyclists, motorcyclists).

4.2. Fate of past recommendations

With the exception of a call for the development of braking devices (ABS, coupled brakes), there have been no recommendations in the past to encourage the deployment of driver assistance technologies for motorized vehicles. This point should be discussed so that the French authorities can define a clear and substantiated position vis-à-vis European and international bodies, in line with the accident rate observed. However, we note the extreme reluctance of motorcyclists' representative bodies to introduce, or even require, assistance devices for motorcycles, even though some are expected by users.

4.3. Proposed recommendations

R4.1 - Develop European regulations for motorcycle assistance systems
It is regrettable that PTW users do not currently have the same driving assistance systems as those available for other motorized vehicles, particularly those that can help them choose an appropriate, controlled and calm speed. These systems should be the subject of research and development work involving motorcycle manufacturers, research institutes, public authorities and PTW user associations. Devices or functions to be transposed for PTWs include speed limiters, road sign recognition (including maximum authorised speed), and intelligent speed adaptation systems. It is necessary to work towards extending to PTWs the obligations planned by Europe for cars and commercial vehicles from 2022.

R4.2 - Deploy fully coupled braking on all motorcycle ranges
The aim here is to propose that France adopt a position on the subject with a view to changing international regulations. This measure has already been proposed during the 2006 PTW safety surveys [Guyot et al., 2008] and by the previous CNSR expert committee. Studies show that braking attempts made by motorcyclists in emergency situations rarely avoid an accident [Dubos & Varin, 2015]. Coupled braking makes it possible to effectively dose front and rear braking, allowing optimal braking by limiting the risk of falling. This is a system that is much in demand by motorcyclists.

R4.3 - Make the motorcycle eCall mandatory
Mandatory for cars since March 31, 2018, it is also useful for motorcycles. A French position must be asserted on this subject in order to change international regulations. Failing that, the ecosystem of existing private initiatives should be encouraged, especially those that are French.

[40] MUSE : Motorbike Users Safety Enhancement (European project).

5. Initial and post-license training

If there is one lever that has often been mobilized in recent years to improve the safety of PTWs, it is training, and in particular initial training. The last reform of motorcycle licenses dates from 2013 and a new reform should be effective from 2019 (2020 in fact). Thus, several significant improvements have recently been made, based on recommendations made by various bodies working on the subject (Gisements de sécurité des 2RM, CNSR, CISR). The main changes brought about by the latest reform of the motorcycle license are the following:

- A theoretical test (code) specific to PTWs.
- A reduction of the "plateau" test.
- A teaching of the "safety trajectory"[41].
- An increase in the length of the road test.

This reform also tends to harmonize the conditions of access to French motorcycle licenses with those of the main other European countries.

The accident analysis conducted within the VOIESUR project [Dubos & Varin, 2015] shows an over-involvement of novice drivers[42] (license less than 2 years old) as illustrated in Table 8. This study also points out that this over-involvement persists during the first five years of license ownership.

The ONISR report [ONISR, 2020] recalls that for the year 2019, the share of novices among motorcyclists killed is 18% (14% for car users). However, the progressive access to power (A2 license mandatory for under 24 years since 2013) greatly reduces the mortality of 18-24 years novices.

Vehicle	**Passenger cars**		**Heavy motorcycles**		**Light motorcycles**	
Involvement	Physical	Fatal	Physical	Fatal	Physical	Fatal
< 2 years	18 %	18 %	30 %	27 %	17 %	17 %
< 5 years	34 %	33 %	50 %	48 %	31 %	30 %
>= 5 years	66 %	67 %	50 %	52 %	69 %	70 %

Table 8: License duration of drivers involved in injury and fatal accidents: VOIESUR study (Source: Cerema, 2015)

L'étude FLAM2RM [Cerema, 2020] confirme la sur-implication des cyclomotoristes et des motards peu expérimentés. Ce facteur de risque est surreprésenté pour les tranches d'âge 14-17 ans et 18-25 ans.

This over-involvement of novices raises questions about the adequacy of initial training for future PTW practice. The "Apprentissage Moto" (Motorcycle learning) project conducted by Ifsttar [Aupetit, 2011] [Aupetit et al, 2013] studied the educational content proposed by instructors and described the difficulties encountered by students during the learning of the A license. To do this, four studies were carried out in immersion by an ergonomist during training sessions (on track and on the road), first by recording driving situations and then by conducting self-confrontation interviews with students. The results of this work show:

- A significant gap between the prescribed training and the real training with an over-valuation of the motorcycle control and the plateau test (on average, 19 hours spent on the track instead of the prescribed 8 hours and 6 hours spent on the road instead of the prescribed 12 hours).
- The poverty of the on-track training situations, which amount to cramming the exam situations (98%), to excessive repetition of the exercises (on average 425 repetitions) and finally to learning specific tasks for the exam, which are out of step with real driving.
- Insufficient road training to acquire perceptual skills because the routes chosen are those of the exams for which the instructors communicate the prevention of possible dangers (cramming). In

[41] The safety trajectory concerns the crossing of curves, based on the experience of law enforcement training centers and the work of the VIROLO++ project (in progress) coordinated by Ifsttar and which aims at developing adapted training modules.

[42] The notion of novice motorcyclist is independent of the age of the motorcyclist. One can be a novice at 50 years old after 20 years of not riding a motorcycle.

fact, the learning routes avoid critical areas that would allow students to be confronted with risky situations.
- It is at the end of such a training that the motorcyclist will learn the "real" driving and the discovery of risky situations, without the support of a trainer to assist him ("on the job training").

Additional work carried out at the Gustave Eiffel University [Legrand et al, to be published] was interested in the content of training and educational practices of motorcycle school instructors by seeking to highlight "good" and "bad" practices. Based on semi-directive interviews with 14 instructors, this work identified five "good" practices: adapting the difficulty of the task, individualizing learning, making learning lively, learning more than necessary to obtain the license, and working on the cognitive and psychological aspects. Four "bad" practices were revealed: not using the "good" practices, not teaching driving techniques or teaching them poorly, focusing on the test, and not setting an example. This work confirms previous studies that point to the need for additional training for instructors, particularly the GDE matrix[43].

In order to improve perceptual skills during driving tests, the SIM2CO+ project[44] coordinated by Ifsttar was interested in the knowledge and recognition of risky situations experienced by novice drivers during the first three months after obtaining their license. The results of the follow-up show that these novice motorcyclists are confronted with numerous risky situations, especially during the first four weeks after obtaining their license (10 situations judged as risky for the first week on average). Most of the risky situations concern the usual trips made in built-up areas and in interaction with a car user. The classification of risky situations shows that in 57% of cases there was a problem anticipating the behavior of the other driver, in 22% a difficulty in combining dynamic management of the motorcycle and reading the environment, and in 21% a failure to read the infrastructure.

In practice, the system is organized around passing the driving test. Motorcycle schools thus "optimize" training in a constrained ecosystem and candidates develop stereotyped strategies for success at the lowest cost. Worryingly, it is reported that motorcycle schools generally "optimize" motorcycles for passing the test (e.g., fork stops filed down to increase low-speed handling and idle speed adjusted to avoid having to throttle back). Although the ecosystem of motorcycle license training is sensitive and the changes are complex to implement in a constrained European framework, it appears that an in-depth change is desirable to rebalance the skills to be acquired in order to significantly increase perceptual and cognitive skills. The online training modules and those using "low cost" motorcycle simulators developed within the framework of the SIM2CO+ project by the industrial partners, which aim to train cognitive motorcycle driving skills, have not found a market (skills not tested on the exam and therefore not developed in driving schools).

Thus, despite the successive reforms of the driving test during the last ten years, the necessary rebalancing between motor skills (widely taught) and perceptive-cognitive skills (little or not taught) during the learning of motorcycle driving still remains to be done.

In addition to the initial training for a driver's license, there is a range of post-license training courses that meet the needs of motorcyclists. The S-PER project[45] (in progress) [Loubiere et al, 2019], led by Ergo-Centre and Ifsttar, is carrying out: a) an inventory of existing courses, b) a measurement of the effectiveness on safety based on an accident study, c) a study of the lessons delivered in the field and an identification of good educational practices. The methodology of the field study is based on the tools developed in the "Motorcycle learning" and SIM2CO+ projects. The inventory revealed a large offer (numerous actors including two major associations, AFMD[46] and CASIM[47]), too little known,

[43] GDE Marix, for Goals for Drivers Education.
[44] SIM2CO+ : Design of training modules for cognitive motorcycle driving skills on a simulator (Projet Agence Nationale de le Recherche) https://anr.fr/Projet-ANR-10-VPTT-0005
[45] S-PER : Measuring the Effectiveness of Motorcycle Safety Training Courses and Identifying "Good" Educational Practices (DSR Project)
[46] AFMD : Association pour la Formation Des Motards (Association for the Training of Motorcyclists)

heterogeneous (titles and training objectives), with various formats (individual, collective), and various trainers (professionals, volunteers or others). The evaluation of the "1 and 2 days" training courses is carried out by a field study with two associations and two private companies in order to collect objective data (direct observations, photos, video, verbalization, ...) and subjective data by interviews. This field observation shows a heterogeneity of the prescribed educational contents (there is not always a document describing the training programs) and a temporal organization which favors the training on track to the detriment of the one on road (repetition of maneuverability exercises). In fact, this type of training, despite the existence of original exercises, remains focused on the acquisition of skills related to machine control.

Finally, post-licensing training, which could be complementary to initial training by filling in the gaps, leads to the same problems by focusing on motor skills. Although there is a consensus in the scientific literature (in psychology, sociology, accidentology) on the fact that these cognitive skills (knowledge and recognition of risky situations, anticipation, etc.) are decisive for driving safety, they are not addressed in the end, probably due to the lack of a viable ecosystem and despite a significant evolution in the methods that can be used. This observation deserves a mobilization of the various stakeholders to build a training offer adapted to an efficient improvement of motorcyclists safety.

5.1. Fate of past recommendations

The subject of training has been the subject of recommendations in the past which have led to changes in access to driving the various categories of PTWs, the practical content of initial training and the examination conditions. This is partly the sense of the recent reforms of the different motorcycle licences.

However, many of the recommendations have not been followed up favourably, mainly because of difficulties in practical implementation or a lack of sufficiently strong will. Among these recommendations, some are based on preliminary studies that have not been carried out, such as: the evaluation of the interest of joining the European standard on the age of access to driving a moped (16 years old), studies and research on the return to driving of adult novice drivers whose licence has been cancelled or invalidated for a zero points balance, or studies on the actual risk exposure of novice PTW users. Similarly, the study of the modalities and consequences of abolishing the A1 subcategory remains to be conducted. Other recommendations have not been acted upon. They concern the conditions of access to licences: raising the age of access to the different categories of powered two-wheelers by two years; authorizing the passage of the A licence only after five years of A2 licence and the provision of proof of motorcycle use during this period (for example: insurance certificate); making training compulsory after five years of interruption of the actual driving of a motorized two-wheeler Finally, some of them were aimed at the pedagogical content of the training, with in particular a call to give a greater place in the preparation of licences to learning about the coexistence of users and to the specific knowledge of each one.

5.2. Proposed recommendations

R5.1 - Develop training in perceptive and cognitive skills in consultation with the profession and integrate it into the curriculum

The over-involvement of novice motorcyclists in accidents and the evaluations carried out both during initial training and after licensing show that the skills necessary to avoid motorcyclists being confronted with dangerous situations are not acquired simply by obtaining a license. An in-depth work is necessary so that these skills can be acquired in the same way as motor skills. In this perspective, digital training techniques could be advantageously mobilized.

[47] CASIM : Chaine d'Amitié pour la Sécurité et l'Information des Motards (Friendship Chain for the Safety and Information of Motorcyclists)

R5.2 - Increase the compulsory duration of driver training in order to deepen and individualize it
The duration of practical driving training is considered very insufficient by instructors who often have to offer (or impose) additional hours to their students. This practice undermines the economic model of motorcycle schools. A concerted effort should be made to define new obligations for driver training, in particular the duration of practical training, the distribution of the stage/road driving, and the individualization of training with reference to the GDE matrix.

R5.3 - Propose a reform of the license in the continuity of the previous ones to define a new practical test so that it can be prepared and passed by the candidates on compliant motorcycles
The last reform of the license removed the notion of timing for this test. However, it is common practice to modify the characteristics of motorcycles in order to prepare and pass this test: fork stops filed down to increase handling at reduced speed, "optimized" idle speed to facilitate kinematics. It is therefore advisable to develop the courses in line with the handling of an unmodified motorcycle.

R5.4 - Conduct a cost-benefit evaluation of raising the age of access to mopeds to 16
In most European countries, access to mopeds is only possible from the age of 16. This measure has been proposed for more than 10 years, but has never been adopted, mainly because of fears of a negative impact on mobility in areas not served by public transport. A multidisciplinary cost-benefit assessment is now required to inform the public authorities before any decision is made.

R5.5 - Encourage upgrading after a significant period of inactivity
Refresher training is one of the reasons for post-license training. This training should be encouraged so that those returning to the sport have the necessary skills to practice safely.

R5.6 - Professionalize trainers and post-license training
The evaluations of these training courses show a great heterogeneity of structures (material and human means) and contents. As a first step, the creation of teaching kits for the continuous training of trainers would allow for an improvement and homogenization of practices (both technical and pedagogical).

6. The infrastructure

The national statistics [ONISR, 2020] mention that the majority of motorcyclists killed are on roads outside built-up areas (64%), whereas the majority of injured motorcyclists are killed in built-up areas (65%). 12% of those killed on freeways are motorcyclists, whereas they represent 19% of those killed on departmental roads, 75% of which are outside built-up areas. Among the 309 motorcyclists killed on departmental roads outside built-up areas, 114 were killed in accidents without third parties and 91 in head-on collisions. 37% of motorcyclists killed were killed in accidents in which a fixed obstacle was hit and the severity of this type of accident is much higher than that observed for car users: 34 killed for every 100 injured against a tree, 21 killed for every 100 injured against a pole, 17 killed for every 100 injured against a guardrail. The same figures for car drivers are 22, 10 and 4 respectively. Overall, motorcyclists represent 18% of the people killed in vehicles that hit a fixed obstacle. For moped riders, fatalities are equally distributed outside and inside built-up areas (49% and 51% respectively) but it is in built-up areas that the vast majority of injuries occur (85%). In built-up areas, intersections account for half of all accidents (1/3 outside built-up areas).

The VOIESUR study [Dubos & Varin, 2015] emphasizes the importance of the plan factor, particularly the large proportion of accidents occurring on bends, as well as the problem of obstacles. It also mentions the issue related to the recovery possibilities of PTWs compared to cars (in case of a roadway exit, PTW+s return to the roadway 6 times less often than car drivers).

It is therefore mainly outside built-up areas that measures must be proposed to improve motorcyclist safety. It should be noted that the new European directive 2019/1936[48] on road infrastructure safety management, which comes into force on December 17, 2019, is intended to cover most of the main road network[49], not just the roads of the trans-European transport network (TEN-T) as provided for in the previous directive 2008/96. This directive explicitly mentions functions and characteristics that must promote the safety of all users, especially vulnerable users, including PTWs. The directive insists in particular on functional requirements for safety such as "the forgiving road", quality equipment, in particular signs and signals, as well as monitoring and management through periodic road safety audits.

For several years, a technical corpus aimed at taking into account the safety of PTWs for the development of road infrastructures has been established by mobilizing scientific and technical organizations, road managers and representatives of the PTW community. A Cerema publication for planners [Cerema, 2018] provides a useful summary of this approach, emphasizing good practices. Unfortunately, this tool has been very poorly developed, its dissemination and implementation coming up against the complexity of the decentralized road and street management system in France.

6.1. Fate of past recommendations

Several recommendations have been proposed to design and equip infrastructure to improve the safety of motorcyclists. The one that has been followed up and is now widely deployed concerns passive safety signal support devices [Cerema, 2016], which greatly limits the use of restraint devices such as guardrails. The recommendations concerning the limitation of signage in the vicinity of lanes have not been followed by explicit measures, even if regulatory texts exist. This is particularly the case for the control of the installation of advertising panels, which could benefit from a stricter application of the environmental code. Similarly, control of the appropriateness of vertical signs is not systematic; it depends on the willingness of managers to implement road safety inspections of routes (ISRI). The

[48] https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=uriserv%3AOJ.L_.2019.305.01.0001.01.FRA&toc=OJ%3AL%3A2019%3A305%3ATOC

[49] The network concerned can be the one managed by the State and the communities.

recommendation to promote lower speed limits on priority roads near rural intersections has not been implemented. The appropriateness of this recommendation should be reconsidered since the VMA has been lowered to 80 km/h on two-way roads without a center divider and outside built-up areas. Finally, in a more prospective way, the recommendation which concerned the research and development of absorbent materials for road signs and equipment has not been followed up.

6.2. Proposed recommendations

R6.1 - Apply the new European directive 2019/1936 on road infrastructure safety management to the main network of the State and local authorities
The new European directive on road infrastructure safety management explicitly mentions taking into account vulnerable users, including motorcyclists. To this end, the corresponding technical corpus is based on the existing technical guides produced by Cerema, which take into account the specific nature of motorized vehicles.

R6.2 - Carry out a road safety analysis of the site following a fatal PTW accident
Within two months of a fatal or seriously injured PTW accident, the road manager must carry out a road safety analysis of the accident site.

R6.3 - Limit sources of masking in the vicinity of the road infrastructure
Accident studies show that in certain driving situations, particularly in urban areas and at interurban intersections, interacting vehicles can be masked by elements present in the road environment and its surroundings. These masks can come from improperly parked vehicles, street furniture or any other source of sufficient size to fleetingly or permanently obscure the presence of a PTW or other user. Good practices should be identified and capitalized on so that they can be shared by managers.

R6.4 - Encourage interurban road managers to remove obstacles on bends
Motorcycles are particularly involved in accidents on bends, with a high risk of collision with obstacles. In a logic of prioritization of interventions, this point constitutes a priority that will benefit other users, especially car users.

R6.5 - Take PTW users into account in the development of infrastructure
Encourage all road managers to take better account of PTWs by implementing the recommendations of Cerema in this regard.

R6.6 - Professionalize infrastructure stakeholders (managers, design offices, companies) to the specificity of PTWs
Ensure the dissemination of good practices, train and qualify the participants. Encourage the emergence of an ecosystem to ensure this professionalization.

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Abbreviations

ARAS : *Advanced Rider-Assistance Systems*

BAAC : Bulletin d'Analyse des Accidents de la Circulation

CISR : Comité Interministériel de la Sécurité Routière

CNSR : Conseil National de la Sécurité Routière

EDA : Enquête Détaillée d'Accident

EPI : Equipement de Protection Individuel

PV : Procès-Verbal d'accident

VMA : Vitesse Maximale Autorisée

ONISR : Observatoire National Interministériel de la Sécurité Routière

Glossarry

hp : Horsepower (hp) is a unit of power that is not part of the international system of units. Horsepower is commonly used to define the power of an engine instead of watts (W). 1 hp = 736 W.

CV : The tax horse, noted cv or CV in tax law is used for the establishment of French registration certificates. It is an administrative unit calculated, in part, from the power of an engine.

PTW : Powered two-wheeler means either a motorcycle or a moped.

Moped : a machine with a cylinder capacity of less than 50 cm3 and a speed limit of 45 km/h.

Motorcycle : means indifferently a motorcycle or a scooter independently of its cubic capacity.

Heavy motorcycle: motorcycle with a capacity of more than 125 cm3

Light motorcycle : motorcycle with a cubic capacity between 50 cm3 (excluded) and 125 cm3 (included).

Killed : a person who dies as a result of a traffic accident, either on the spot or within thirty days of the accident.

Hospitalized : victim hospitalized for more than 24 hours

Slightly injured: victim who has received medical attention but has not been admitted as a patient to the hospital for more than 24 hours.

AIS : Abbreviated Injury Scale. This is an anatomical coding system for classifying and describing injury severity.

IIS : Injury Impairment Scale. This is a scale to assess the impact of injuries on the long-term health of the victim.

Appendixes

List of people audited by the committee of experts on the theme: Safety of PTWs

Pascal Dunikowski, **DSR**

Jean-Louis Martin, **Ifsttar**

Wu, D., Hours, M., Martin, J.-L., 2018. Risk factors for motorcycle loss-of-control crashes. Traffic Inj. Prev. 19 4, 433–439. doi:10.1080/15389588.2017.1410145

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Nicolas Clabaux, **Ifsttar**
Jean-Emmanuel Michel, **Ifsttar**

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Nicolas Dubos, **Cerema**

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Thierry Serre, **Ifsttar**
Vincent Ledoux, **Cerema**
Eric Violette, **Cerema**

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Stéphane Espié, **Ifsttar**
Samuel Aupetit, **Ergocentre**
Aupetit, S., Gallier, V., Riff, J., Espié, S., & Delgehier, F. (2016). Naturalistic study of the risky situations of novice riders. *Ergonomic, 59(8)*, 1109-1120.

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Pascal Defrance, **ONISR**
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Isabelle Ragot-Court, **Ifsttar**
Chloé Eyssartier, **Cerema**
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Cécile Coquelet, **Ifsttar**
Coquelet, C (2018), Les différences de sexe chez les conducteurs de deux-roues motorisés : approches sociologique et psycho-sociale, thèse de doctorat, Université d'Aix-Marseille / Ifsttar, 283pp.

Marc Lanfranchi, **Cerema**

Analysis of PTW recommendations made between 2008 and 2018

The consultation on PTWs safety [Guyot, 2008], which began in 2006, provided an opportunity to identify the main areas of safety for these users. It mobilized most of the actors involved in motorcycle safety and resulted in a substantial list of recommendations, identifying ten main levers. Since this important work, the CNSR and the various CISRs have formulated proposals which are the subject of an "expert opinion" analysis, the aim of which is to determine which have been taken into account and implemented [Violette & Hiron, 2020].

The proposed recommendations were classified into the following seven families: the motorcyclist (protection, equipment), the motorcycle (technical requirements), education/training/licensing, infrastructure (management, maintenance, equipment, facilities), enforcement (motorcycle, rules, traffic regulations), improving knowledge of PTWs (studies, research, etc.) and others (driving, interactions, strategies for taking PTWs into account, etc.) Table A1 below summarizes the distribution obtained.

Families	PTW deposits	CNSR	CISR	Total
Motorcyclist	3	7	4	14
Motorycle	3	1		4
Formation	13	3	5	21
Infrastructure	14	2	2	18
Control	7	5	7	19
Knowledge	30			30
Other	4	3	1	8
Total	**74**	**21**	**19**	**114**

Table A1: Classification of recommendations for PTWs safety since 2008 (Source: Cerema, 2019)

In a second step, all recommendations were analyzed to estimate the follow-up given to the proposed recommendations: favorable and effective (a measure has been taken and implemented), favorable and partial (a measure has been taken but its application modality limits its scope), without follow-up (no measure has been implemented), and "don't know. It appears that only half of the recommendations and measures proposed to improve PTW safety have been fully (22%) or partially (27%) implemented (Table A2).

Suite	PTW deposits	CNSR	CISR	Total	%
Favourable effective measure	9	7	9	25	**22 %**
Favorable partial measure	25	5	1	31	**27 %**
No action	32	7	9	48	**42 %**
Don't Know	8	2	0	10	**9 %**
% Favourable	**46 %**	**57 %**	**53 %**		

Table A2: Action taken on recommendations and proposed measures for motorcycle safety since 2008 (Source: Cerema, 2019)

Le tableau A3 ci-dessous précise les suites données aux recommandations selon la classification proposée.

Families	Effective measure	Partial measure	No action	DK
Motorcyclist	4	4	6	
Motorcycle	1		3	
Training	7	5	8	1
Infrastructure	2	8	8	
Control	5	1	10	3
Knowledge	3	10	12	5
Other	3	3	1	1

Table A3: Action taken on recommendations and proposed measures for motorcycle safety since 2008 (Source: Cerema, 2019)

Finally, during this same period, several international bodies[i],[ii],[iii] have carried out work specific to PTWs that has led to the proposal of recommendations and measures on a large scale [ESTC, 2008], [ESTC, 2011], [OECD/ITF, 2015]. This work has been the basis for the establishment of European directives for the safety of PTWs.

[i] ETSC (2008), VULNERABLE RIDERS: Safety implications of motorcycling in the European Union, 2008.

[ii] ETSC (2011), Road Safety PIN Flash 19, Unprotected road users – a key concern of road safety, 2011.

[iii] OECD/ITF (2015), Improving Safety for Motorcycle, Scooter and Moped Riders, OECD Publishing, Paris, 2015.