Institut für Zweiradsicherheit e.V.

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Benefit estimation of the Power Two Wheelers Advanced Rider Assistance System on accidentology

Université Gustave Eiffel

Presentation Plan

- Context
- Technologies (ARAS)
- Objective

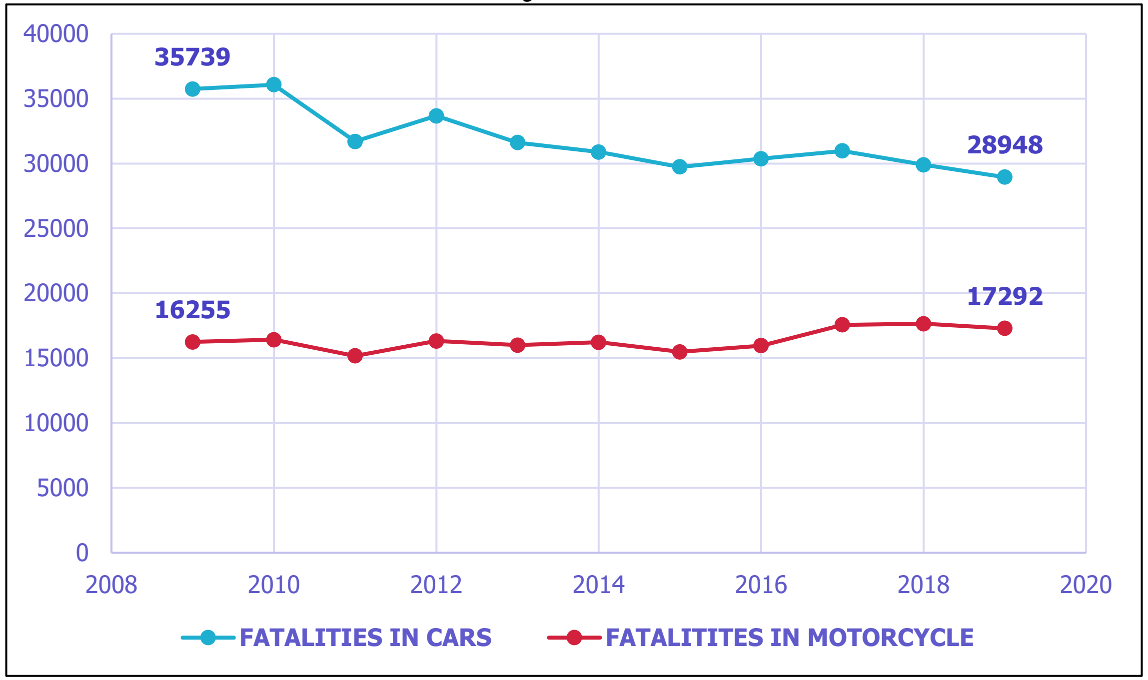
} Introduction

- Methods
- Results
- Conclusion

Introduction

Accidents rate

comparison between cars and motorcycles fatalities in the world from 2009-2019.



FATALITIES IN MOTORCYCLE

19 %

6 %

FATALITIES IN CARS

the number of car deaths has decreased, while that of motorcycles has increased, and it represent a high level.

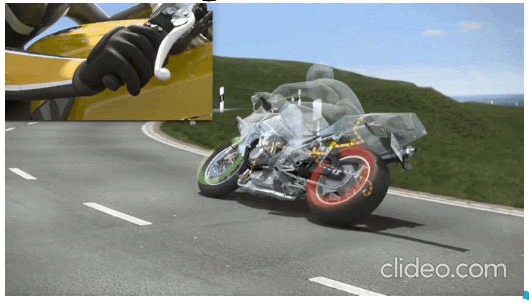
Cars

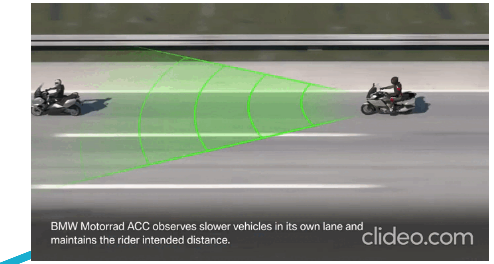
Motorcycle

Source : International Road Traffic and Accident Database (IRTAD).

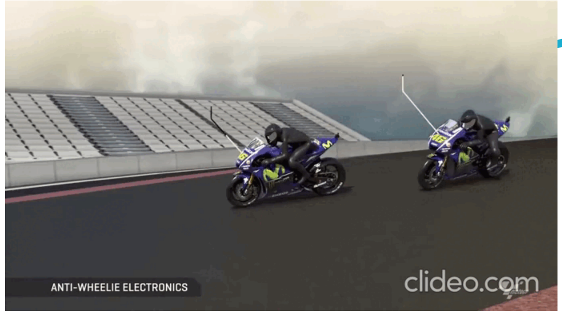
Technologies

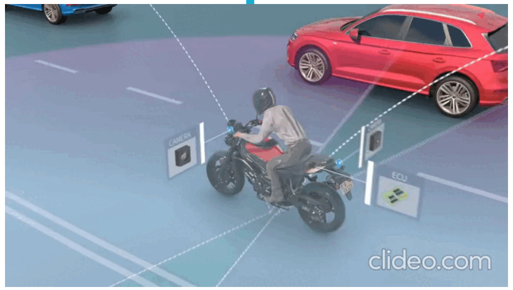
Among the solutions used to reduce the number of accidents and improve user safety

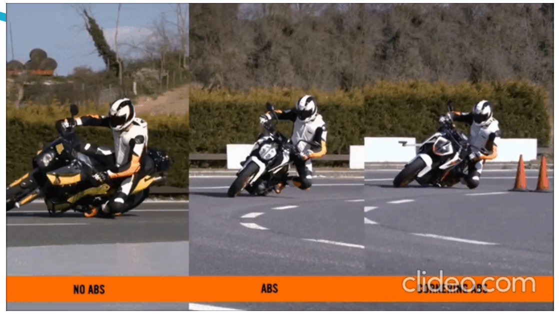




The Advanced Rider Assistance System (ARAS)







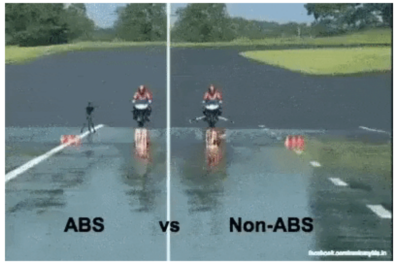
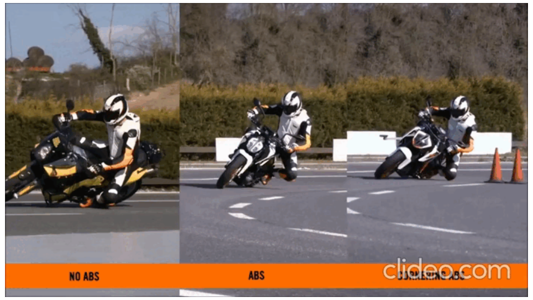
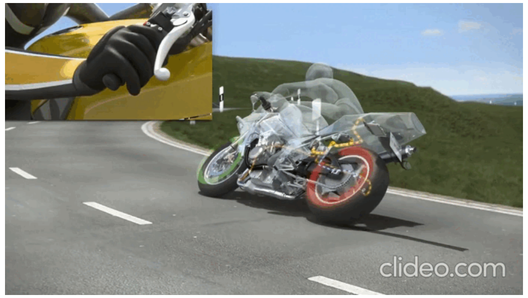
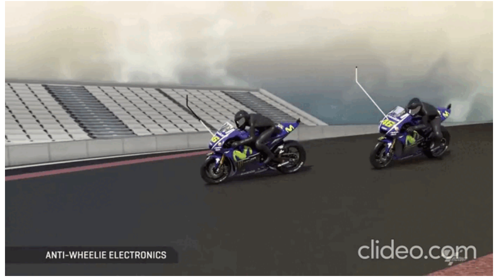
Their interventions can be passive (information) or active (control), they work inside the vehicle but they can be connected to external sources.

Source : Rivers RW. Traffic accident investigators' handbook. Thomas ; 1980.

ARAS

There are 2 types of technologies

Active ARAS

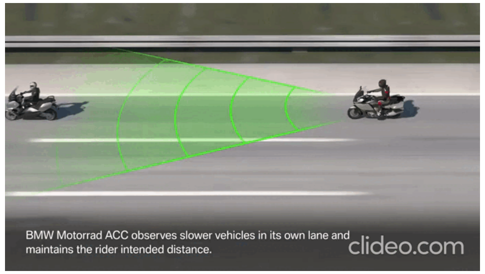
Technology		Functioning
Anti-lock Braking System (ABS)		To avoid wheel locking
Motorcycle Stability Control (MSC)		To avoid wheel locking in a curve
Traction Control (TCS)		To balance the grip of the tire with the road surface
Anti-Wheelie (A-W)		A system that prevents the front wheel from coming off

Active ARAS

Stoppie Control (S-C)

Contrary to the A-W, the Stoppie is when the rear wheel has a tendency to take off and lose contact with the road

Active Cruise Control (ACC)

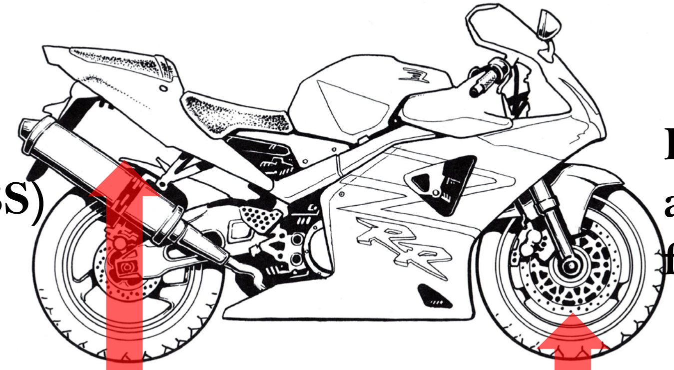


It adapts the speed of the vehicle according to the chosen distance

Launch Control (L-C)

Preventing the loss of grip of the rear wheel when starting.

Combined Braking System (CBS)



It helps the rider to achieve an almost ideal distribution of braking force in different conditions

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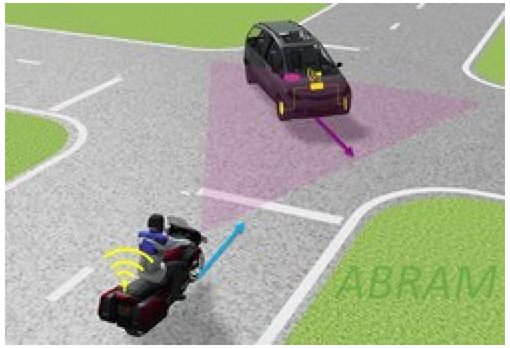
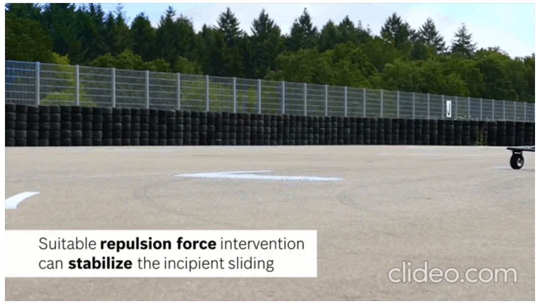
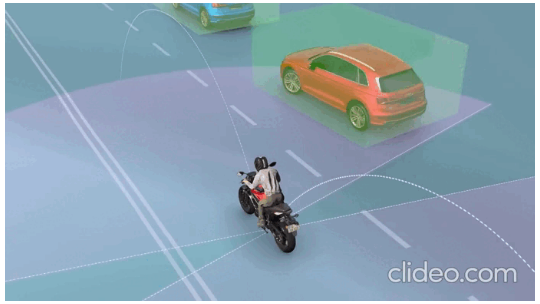
Active ARAS

Technology		Functioning
Autonomous Emergency Braking (AEB) *PCB (Pre-Crash Braking)*		Anticipate a head-on collision and initiate vehicle braking
Anti-Skid (A-S)		Force in the form of gas that escapes under pressure to create a force in the direction opposite to the skid, and help the rider regain control.

ARAS

There are 2 types of technologies

Passive ARAS

Technology		Functioning
Dangerous Turn Warning		To warn drivers about dangerous turns according to their instantaneous speeds
Smart Helmets (S-H)		It monitors the driver's alcohol and drug levels and checks if they exceed a certain threshold.
Collision Aversion Technology (CAT)		Developed by RIDE VISION, this passive system monitors the surroundings of the vehicle at 360°.

Objective

Given that several interesting studies have been conducted on the subject in order to analyze different ARAS (like ABS, CBS, PCB),

And

Based on the study that has already been carried out on the qualitative influence of the ARAS in the accidentality of PTW,

Where it has been found that the ARAS such as (A-W, L-C, S-C) don't have any influence in accidentality of PTW, because they are intended for racing motorcycles.

Objective

We conducted this study to analyze and evaluate the effectiveness of *3* other technologies

- Active Cruise Control ACC
- Motorcycle Stability Control MSC
- Collision Aversion technology CAT

In order to enlarge the number of analyzed ARAS and to make a better selection of technologies to integrate on PTW to improve their safety.

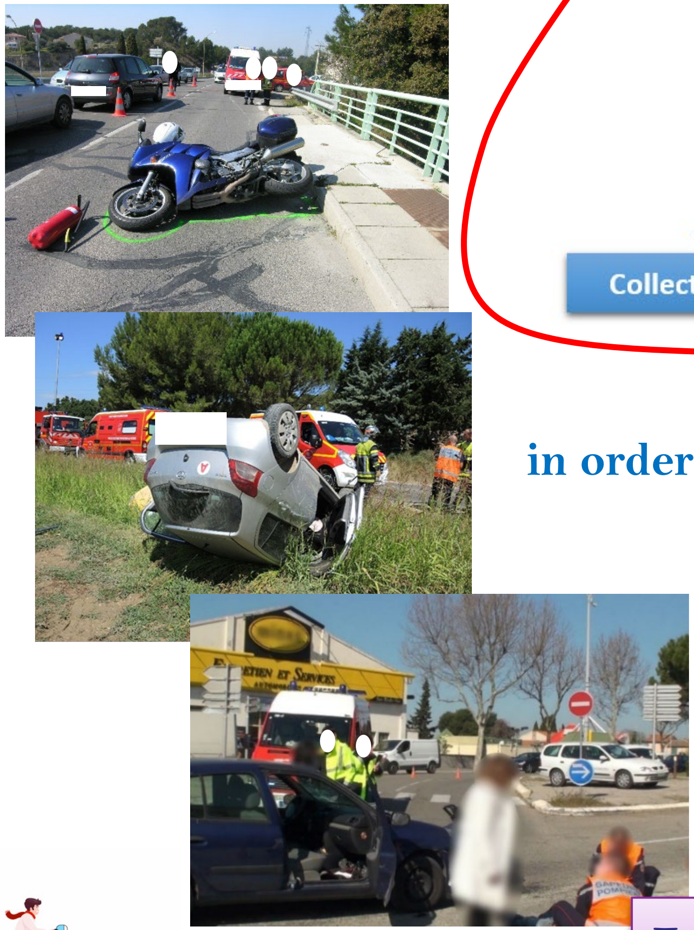
Methods

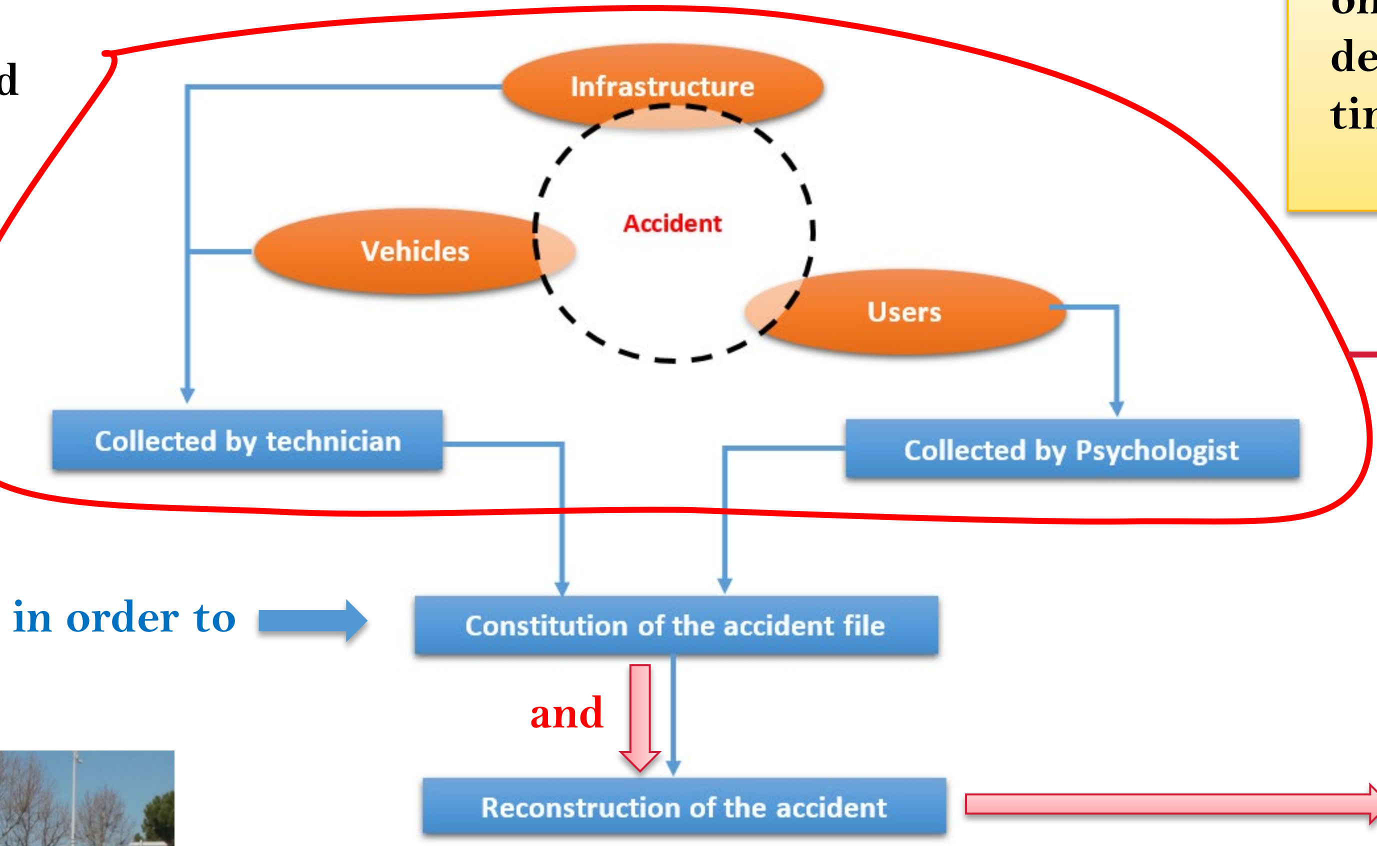
DATABASE

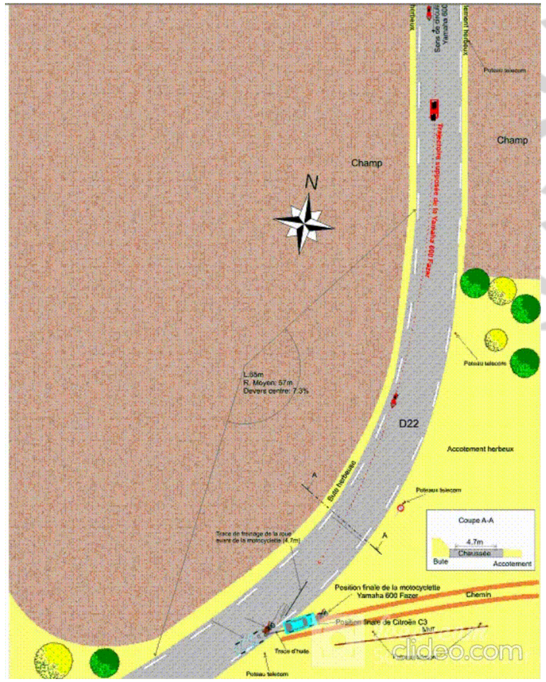
DATABASE **“EDA => In-depth accident studies”** : This databse is performed at LMA since 1985.

The methodology based

on the collection of detailed data in real time at the scene of the accident





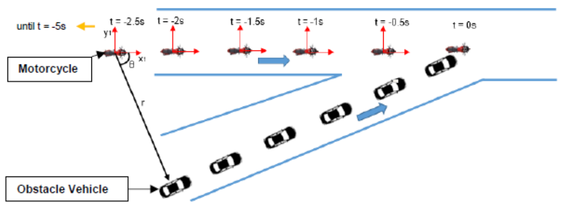


It consists of 210 PTW cases

Method for CAT

In order to analyze the effect of each technology on real accident situations, we have developed three different methods

Collision Aversion technology CAT



Motorcycle Stability Control MSC

1. Calculation of the angle of inclination (α) using the initial speed (V_i) and the radius of curvature (r):

$$\alpha = \arctan\left(\frac{V_i^2}{g*r}\right) \quad (1)$$

2. Calculation of the maximum deceleration (a_{max}) using the force circle:

$$a_{max} = \sqrt{(g.\mu)^2 - [g.\tan(\alpha)]^2} \quad (2)$$

3. Calculation of the new collision speed V_f' taking into account the maximum deceleration calculated in step 2 and the braking distance measured at the accident site (d):

$$V_f' = \sqrt{V_i^2 - (2.d.a_{max})} \quad (3)$$

4. Estimated results:

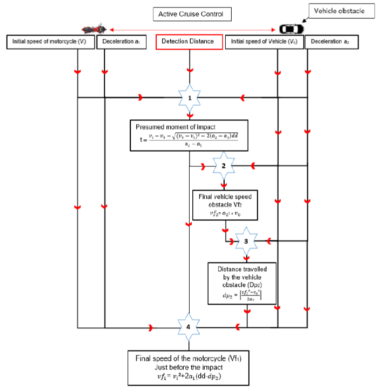
$V_f' = 0 \Rightarrow$ *Accident avoided*

$V_f' \neq 0$:
$\alpha < 20° \Rightarrow$ *Accident avoided by standard ABS*

$V_f' < V_f \Rightarrow$ *Accident Mitigated*

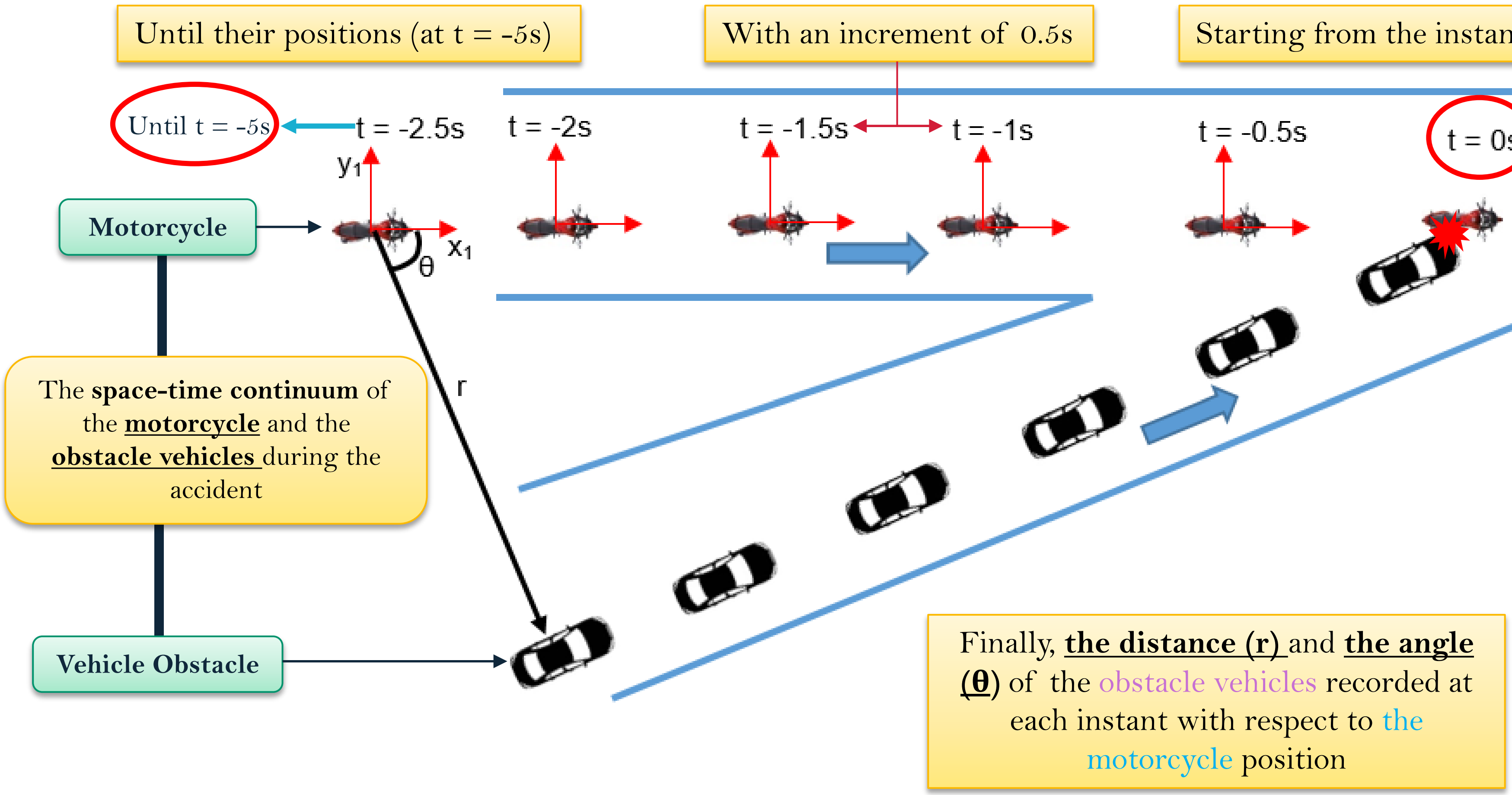
V_f': *New calculated impact speed of the motorcycle*
V_f: *The original impact speed*

Active Cruise Control ACC



Method for CAT

On the first technology, we have analyzed the detectability of the vehicles involved in relation to the motorcycle, in order to determine an optimal detection distance interval.



Cases	r	θ
Case 1	r1	θ1
Case 2	r2	θ2

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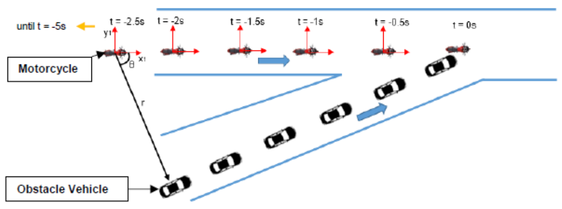
Method for CAT

In order to analyze the effect of each technology on real accident situations, we have developed three different methods

Collision Aversion technology CAT



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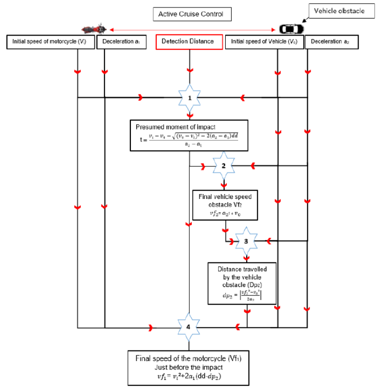
Active Cruise Control ACC



Method for MSC

The method used to determine the effect of MSC on the EDA accident database is the same one developed in the previous studies *Sevarin & al* [2018], *Lich & al* [2016]

1- Calculation of the angle of inclination (α) using the initial speed (Vi) and the radius of curvature (r):

$$\alpha = \arctan(\frac{V_i^2}{g*r})$$

2- Calculation of the maximum deceleration ($amax$) using the force circle :

$$a_{max} = \sqrt{(g.\mu)^2 - [g.\tan(\alpha)]^2}$$

3- Calculation of the new collision speed Vf' taking into account the maximum deceleration calculated in step 2 and the braking distance measured at the accident site (d):

$$V_f' = \sqrt{V_i^2 - (2.d.a_{max})}$$

4- Estimated results:

$$V_f' = 0 \Rightarrow Accident\ avoided$$

$$V_f' \neq 0 :$$

$$\alpha < 20° \ Accident\ avoided\ by\ standard\ ABS$$

$$V_f' < V_f \Rightarrow Accident\ mitigated$$

Method for CAT

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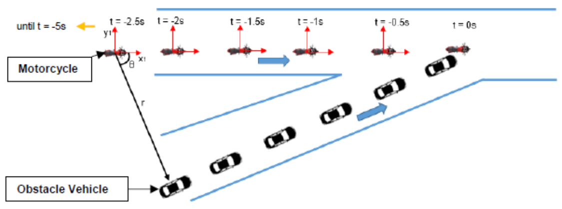
Collision Aversion technology CAT



Motorcycle Stability Control MSC

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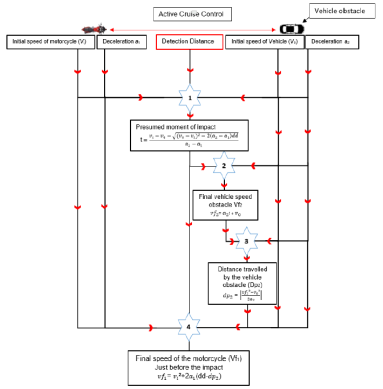
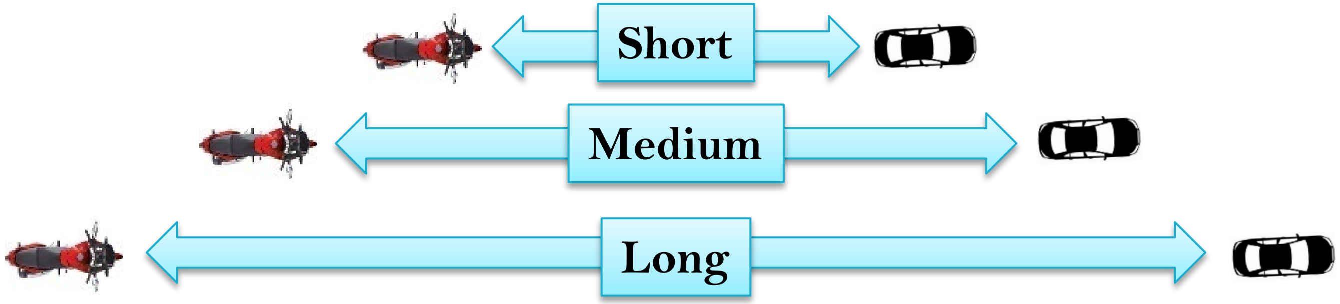
Active Cruise Control ACC



Method for ACC

In order to analyze the influence of the latest technology (Active Cruise Control) on the dynamics and the accident rate of PTW, we based on the only existing version developed by BMW.

This device is composed of 3 variable detection distances **and** **2 deceleration modes**



Comfortable

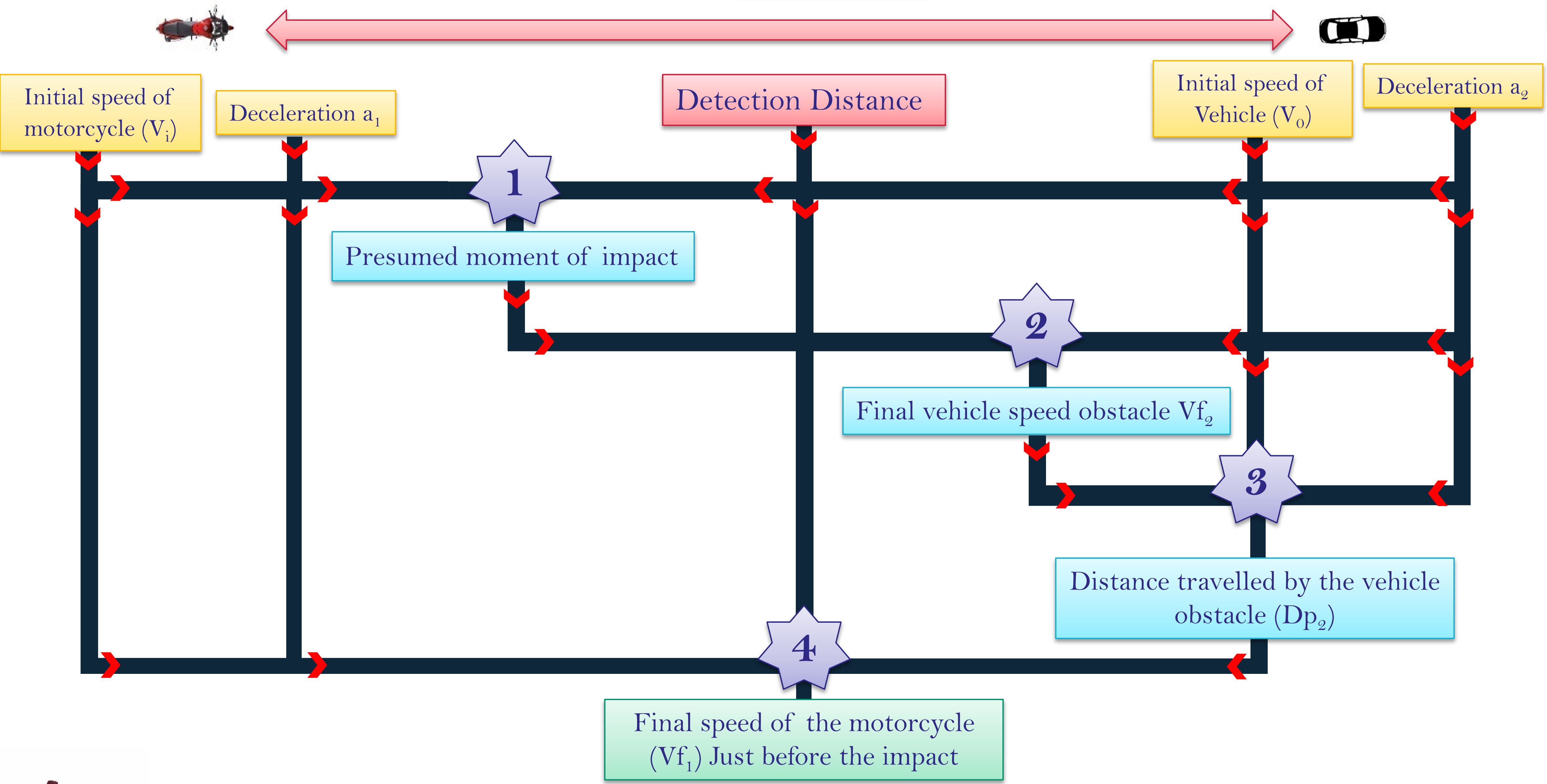
Dynamic

for a more detailed analysis of this technology

We have oriented this study to the analysis of fixed distance levels (10 - 20 - 30 - 40 - 50 meters)

In order to evaluate the effectiveness of this technology according to several levels, and to define an optimal Detection Distance (DD).

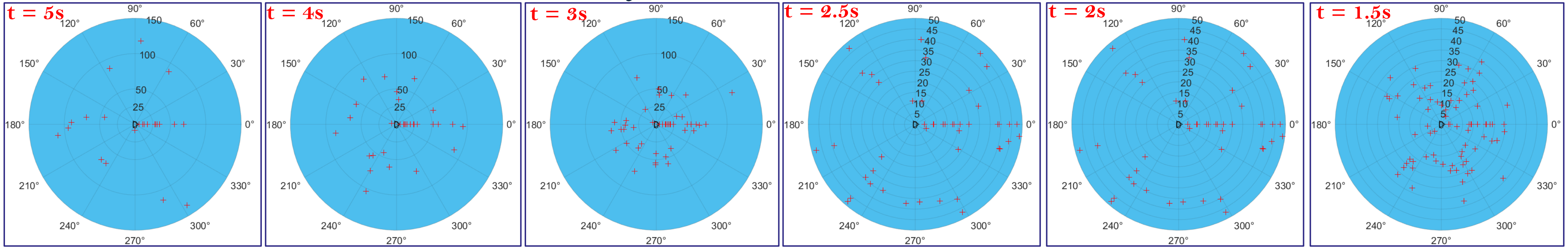
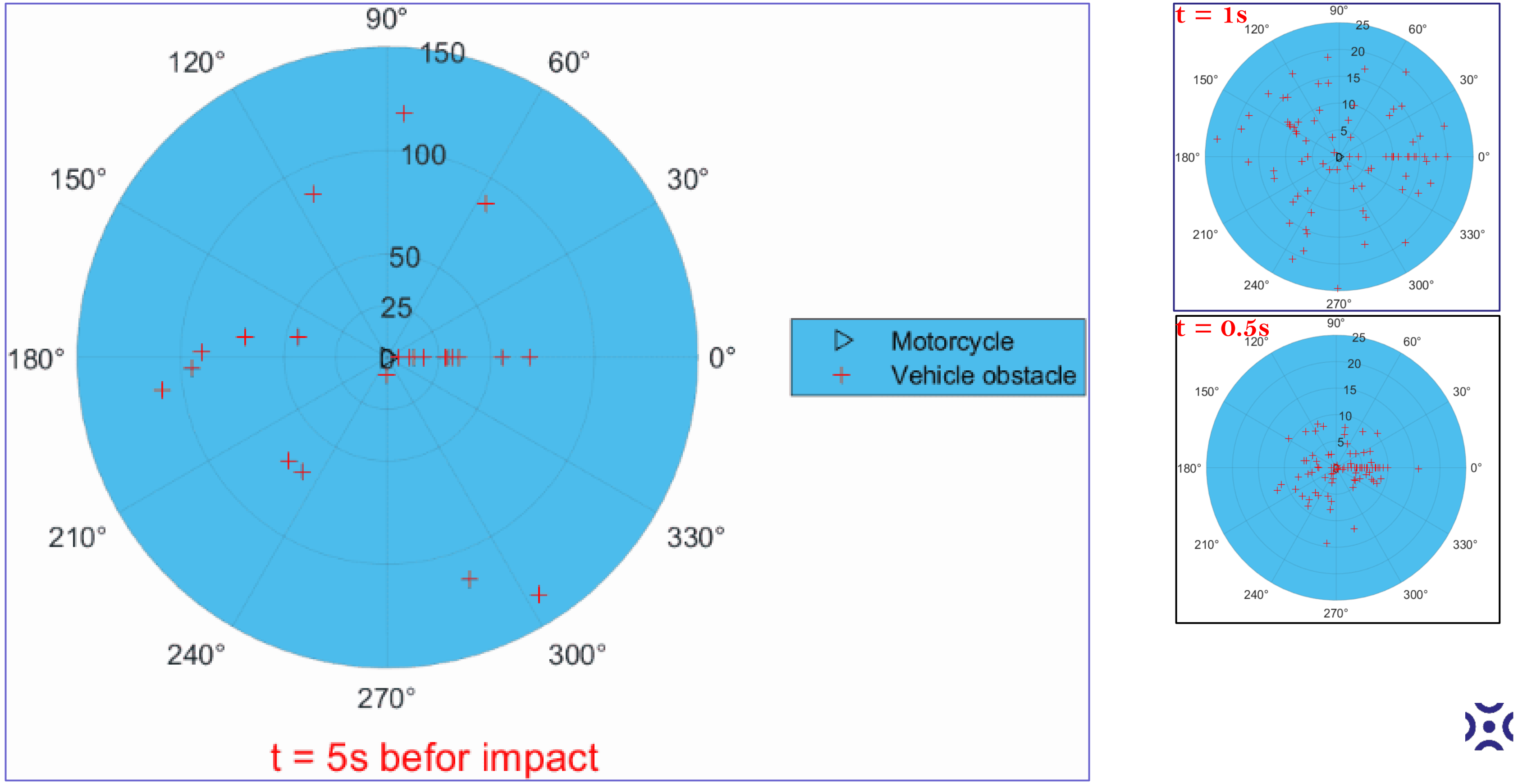
Method for ACC



Results

CAT Results

The graph above shows us the variation of the number of cases as function of time and with respect the distance between the motorcycle and the vehicles involved on the 85 cases treated

CAT Results

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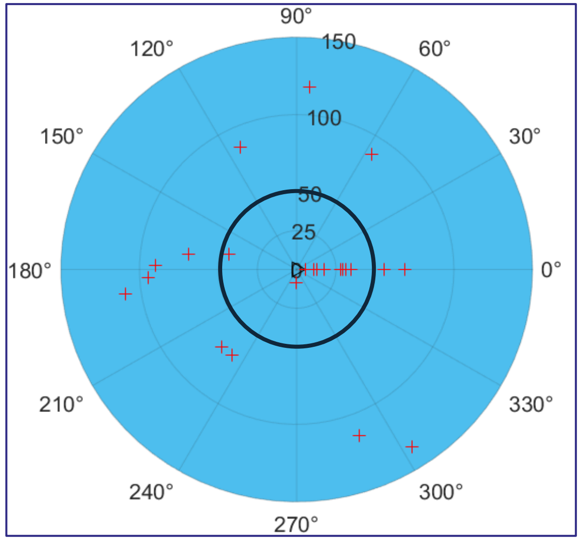
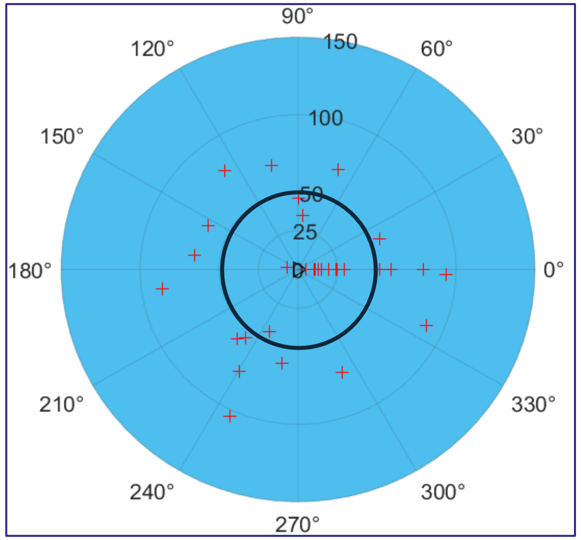
t=5s



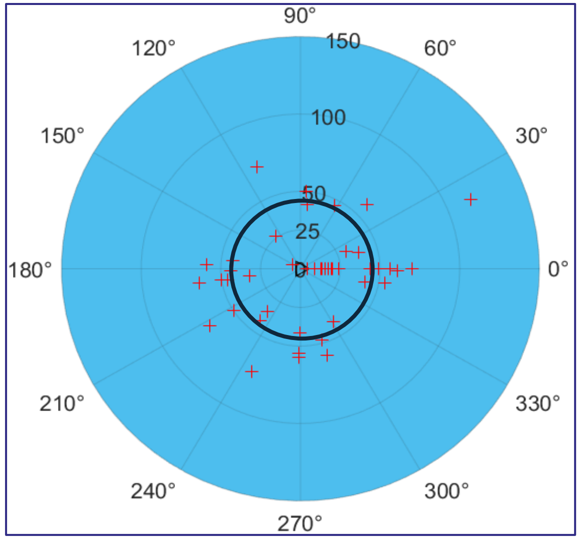
54% of cases > 50m

t=4s



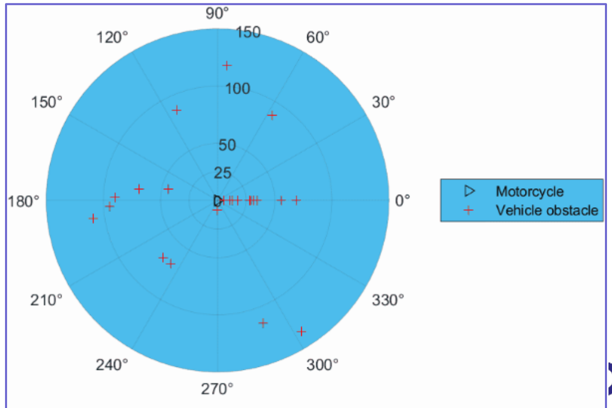
58% of cases > 50m

t=3s



61% of cases > 40m

By analyzing this graph, we notice that starting from **5s** before the collision until **3s**, the distance between the motorcycle and the other vehicles was higher than **50m (40m in 3s)** for the majority of the cases.



t = 5s befor impact

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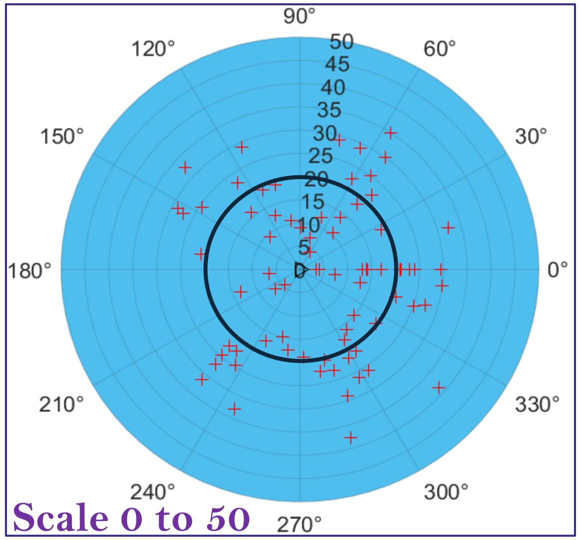
CAT Results

The graph above shows us the variation of the number of cases as function of time and with respect the distance between the motorcycle and the vehicles involved on the 85 cases treated

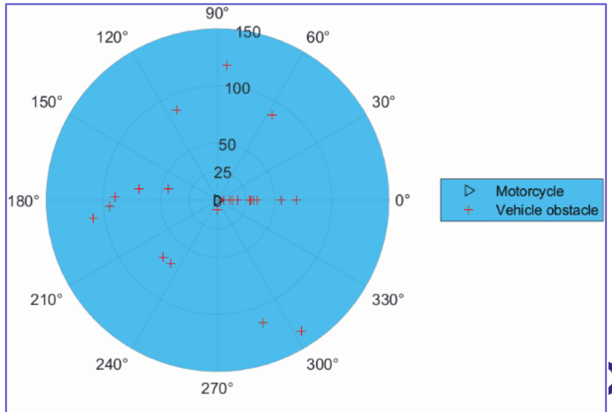
t=1.5s



56% of cases > 20m

Moreover, the graph we also find that until **1.5s** before impact, the distance was greater than **20m** on most cases.

These large values of distances on **very short durations** before the impact show us **the high degree of the speed** at which the vehicles are driving on the analyzed accidents.

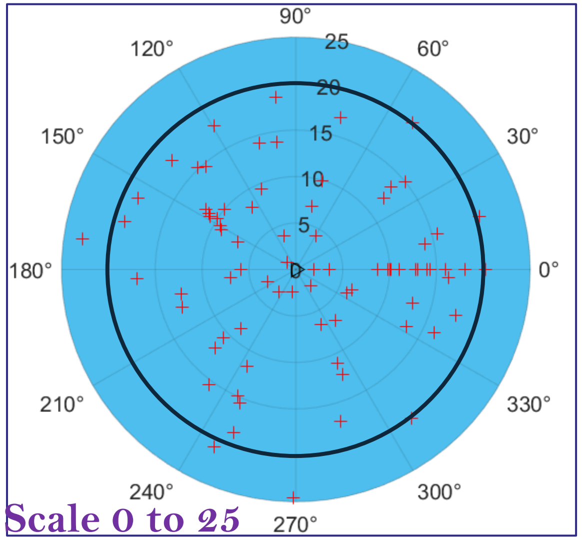


t = 5s befor impact

CAT Results

The graph above shows us the variation of the number of cases as function of time and with respect the distance between the motorcycle and the vehicles involved on the 85 cases treated

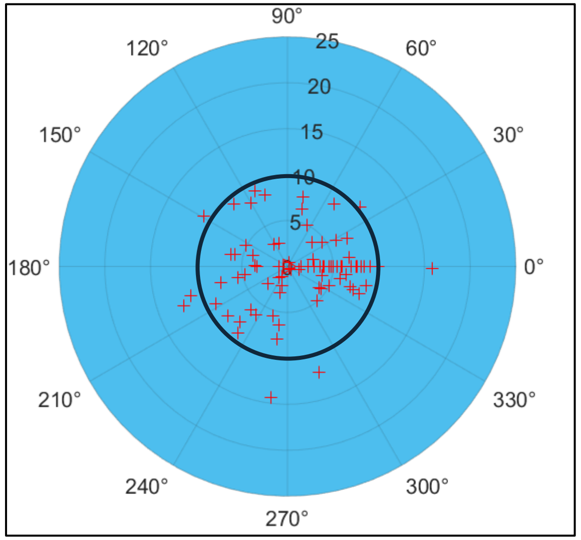
t=1s



Scale 0 to 25

87% of cases < 20m

t=0.5s

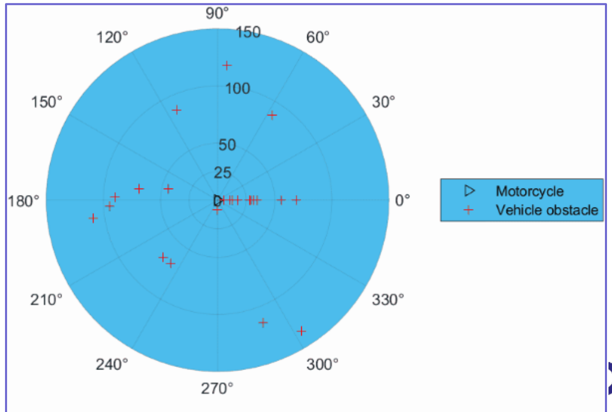


89% of cases < 10m

Following the results presented, a detection distance of **15m to 20m** seems to us more adequate for a collision detection system. This related to the reaction time of the PTW riders estimated between [0.8-1] s, and to allow them to perform an avoidance maneuver.

This graph also indicates that it was necessary to wait until **1s** before the collision to see small distances (**lower than 20m**).

And at the **0.5s** all the vehicles involved are at a **distance lower than 10m**.



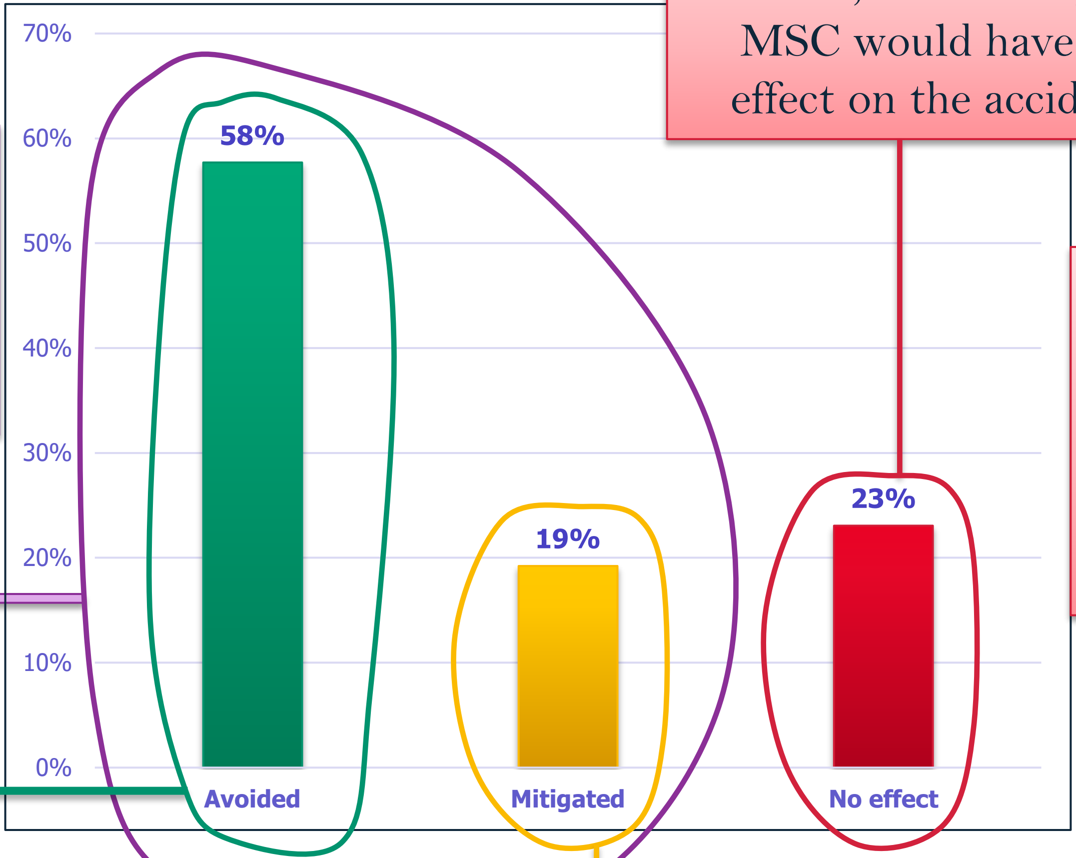
t = 5s befor impact

MSC Results

The obtained results show that

The MSC has an influence of **77%** on the 26 selected cases, i.e. 20 cases, this influence varies between **avoidance** and **mitigation**

In 23% of the accidents treated, i.e. 6 cases, the MSC would have no effect on the accident



This can be explained:

- On the one hand by the risk-taking and exorbitant speeding of some PTW drivers.
- On the other hand by the vulnerability of motorcycle.

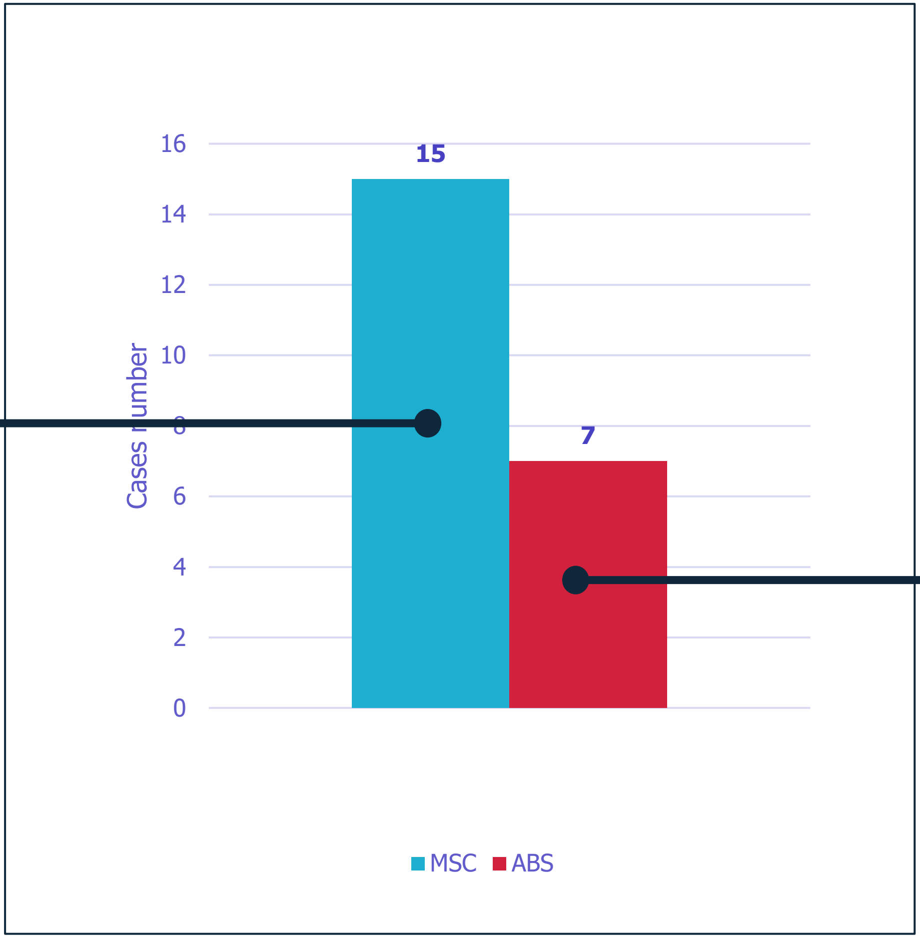
On 58% of the treated accident cases, i.e. 15 cases, the MSC could have avoided the incident

On 19% , i.e. 5 cases, the MSC could have mitigated the impact

MSC Results

Another interesting result is the comparison between ABS and MSC

The MSC can intervene on the 15 avoided cases



While the ABS can intervene only on 7 cases

This describes the efficiency of the MSC which represents 2 times more avoided cases than an ABS on situations in curve

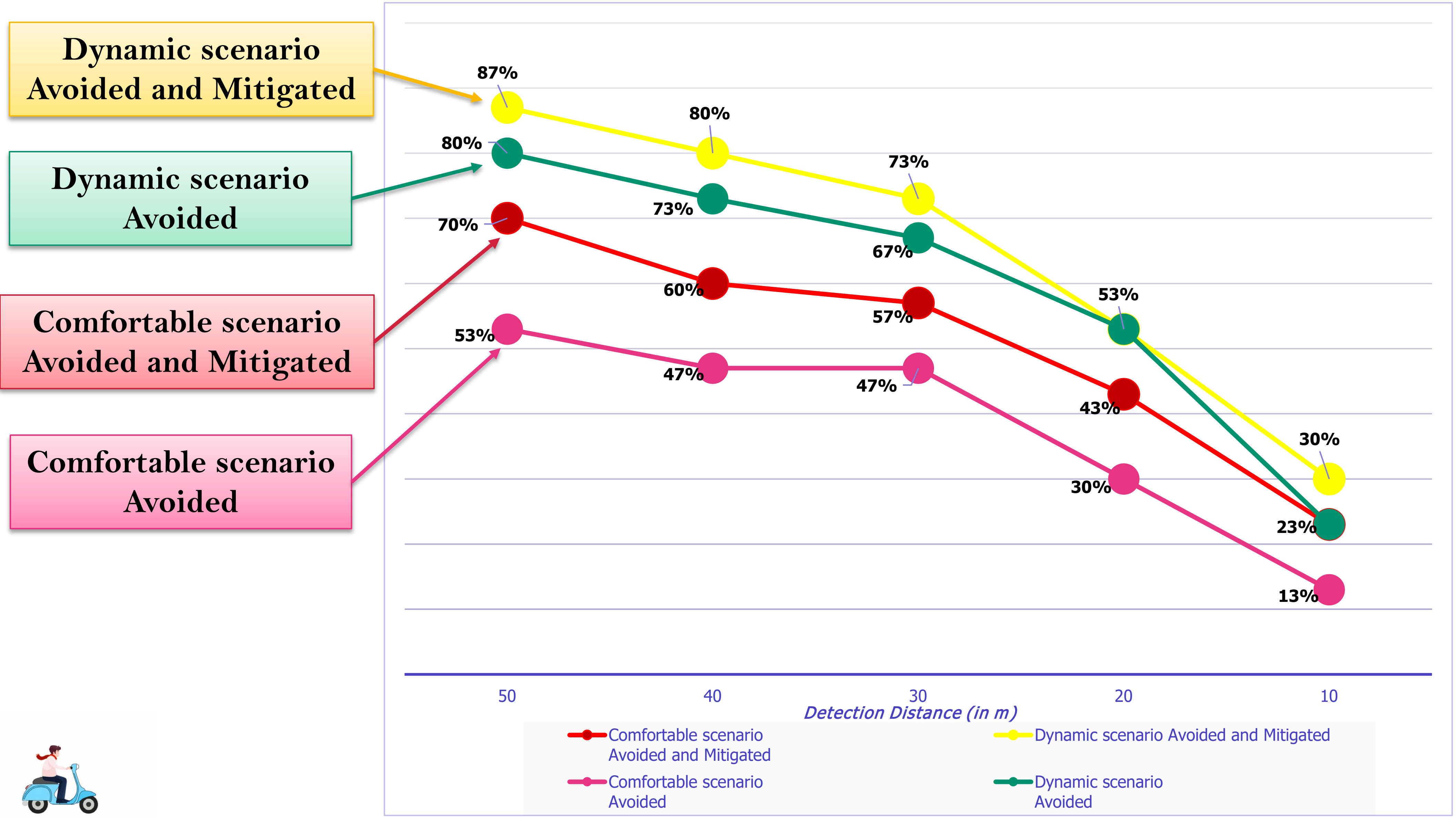
ACC Results

In order to evaluate the ACC and estimate these effects on the sample of 30 treated accident cases, three classes of benefits then formed:

- **Avoided: Accident avoided.**
- **Mitigated : Collision unavoidable but ARAS could have mitigated the impact.**
- **No effect.**

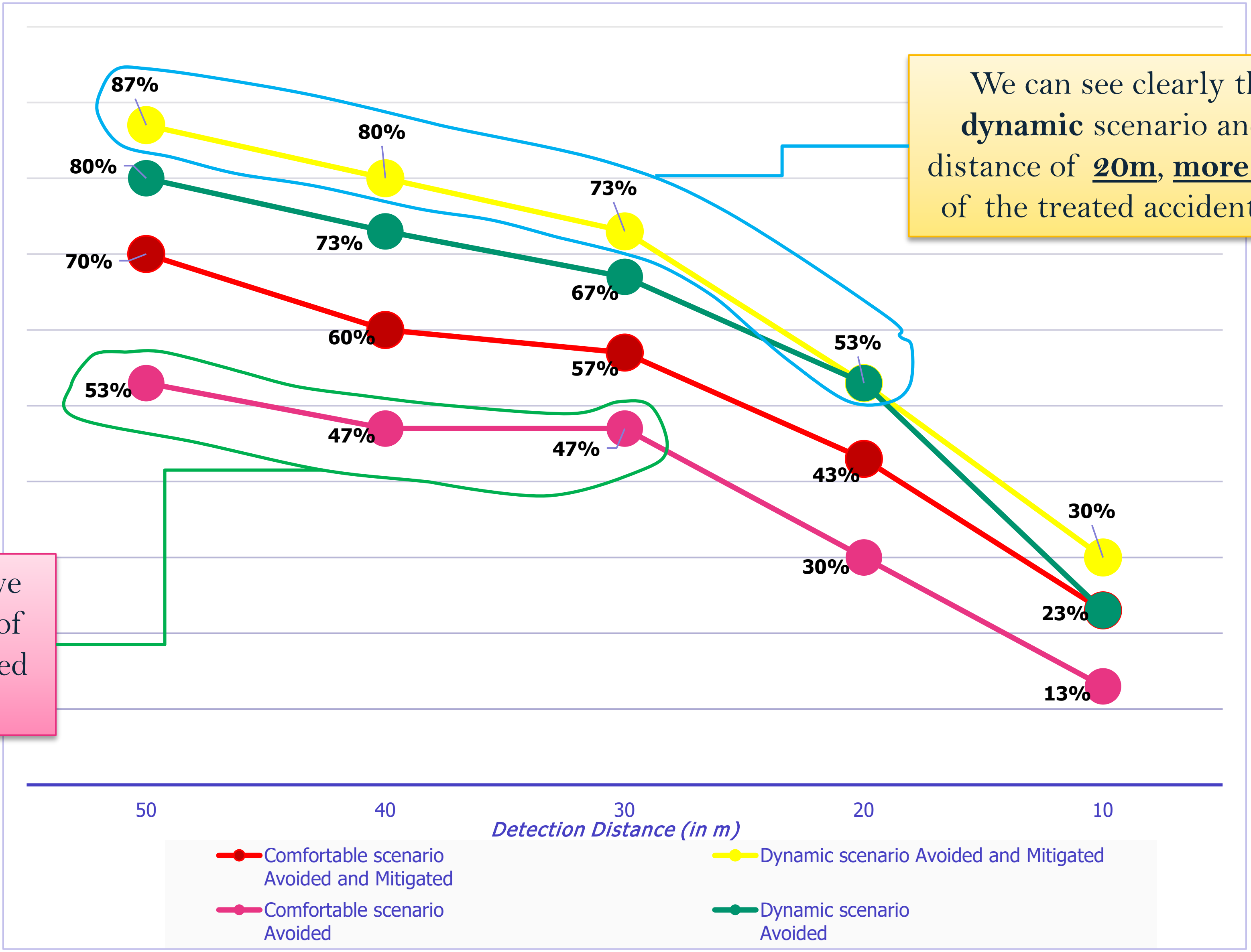
ACC Results

This graph shows the percentage of **"crashes avoided only"** and **"crashes avoided and mitigated"** on the 30 cases according to the triggering distance in the two mode of deceleration.



ACC Results

This graph shows the percentage of crashes **avoided** with avoided **and mitigated** on the **30 cases** according to the detection distance in the two mode of deceleration.



We can see clearly that on a **dynamic** scenario and from a distance of **20m**, **more than 50%** of the treated accidents avoided

In a **comfortable** scenario we can see that from a distance of **30m**, the frequency of avoided cases is about **50%.**

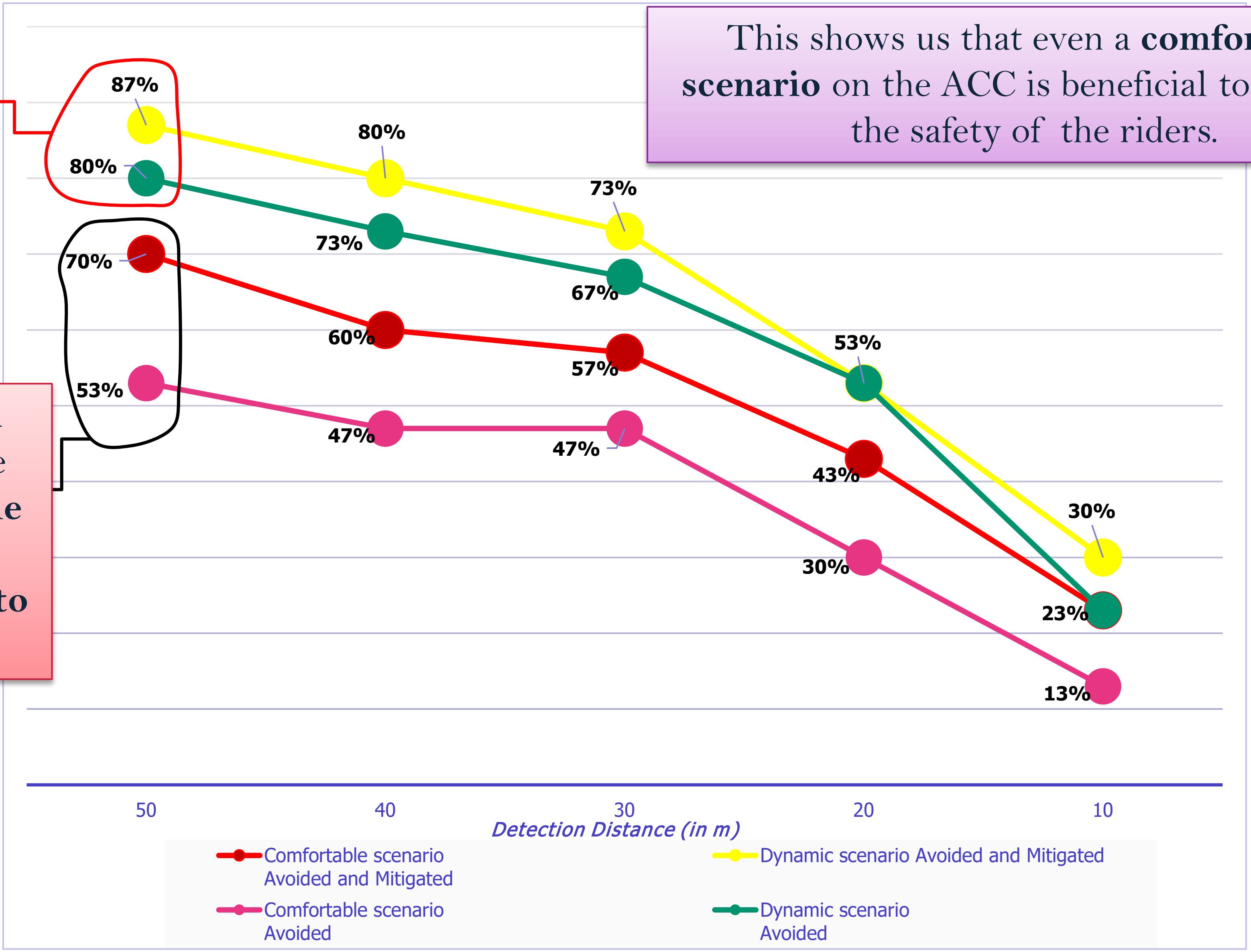
ACC Results

This graph shows the percentage of crashes **avoided** with **avoided and mitigated** on the **30 cases** according to the detection distance in the two mode of deceleration.

While in the **dynamic scenario** we go from **80%** to **87%.**

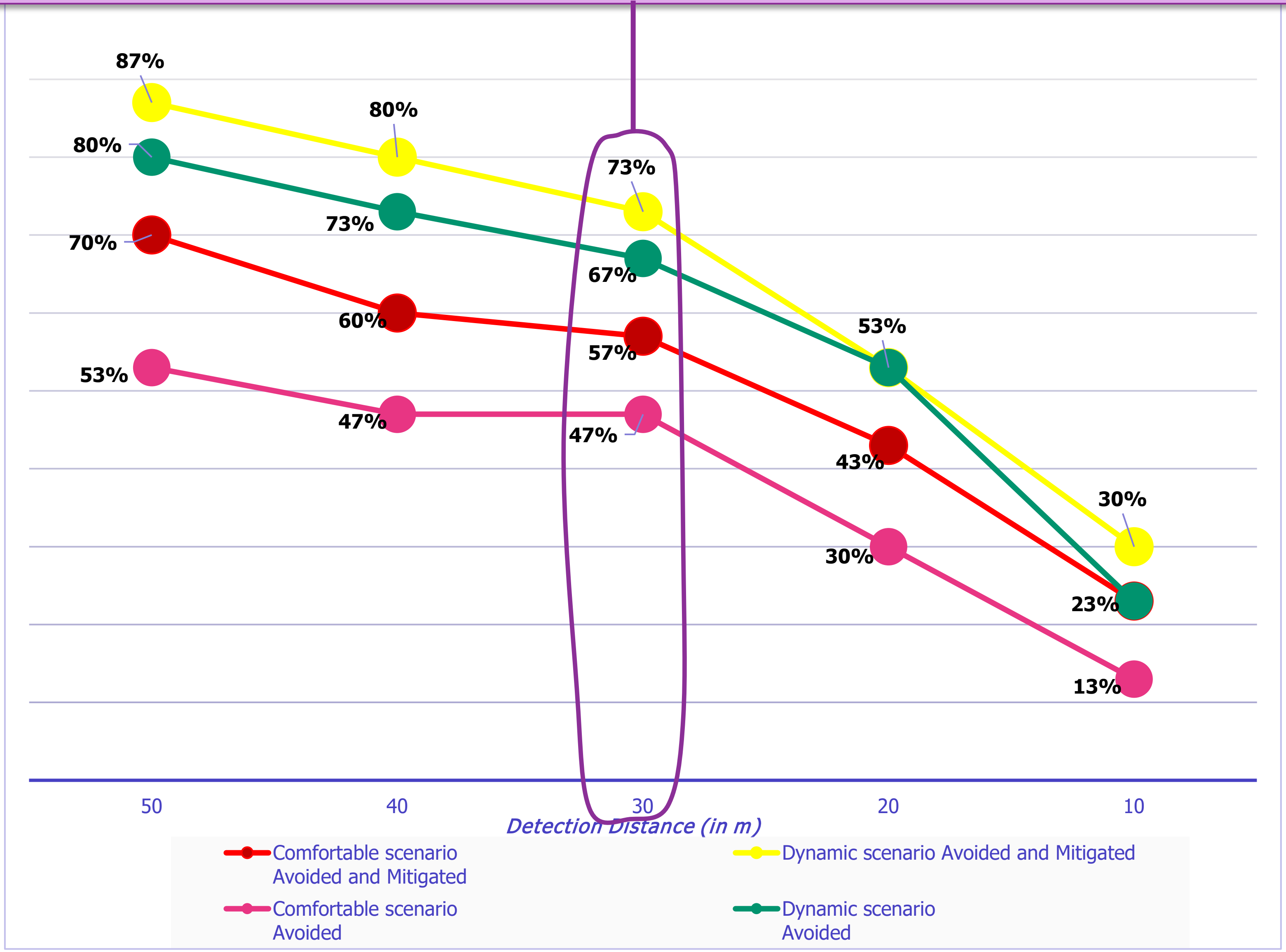
This shows us that even a **comfortable scenario** on the ACC is beneficial to improve the safety of the riders.

In the results of **avoided and mitigated** impact we can see that in **comfortable scenario** and at **50m** for example we go from **53% to 70%**



ACC Results

Finally, we find that in **all accidents** a distance around **30m** seems to be optimal, because it represents a tipping point of the slope of the different curves, and it means that from 30 m we have less gain.



Conclusion

Conclusion

This study quantitatively evaluated the effectiveness of three driver assistance systems developed for **PTW:** "**Collision Aversion technology**", "**Motorcycle Stability Control**", and "**Active Cruise Control**"

Finally, we note that

For the CAT technology

offers a remarkable efficiency in terms of detection of other vehicles. We note that a detection distance of **15 to 20m** seems to us **more optimal** to offer a sufficient reaction time to the riders.

For the MSC technology

has an influence of **77%** on the accidents treated. We find that **58%** of the treated accidents could **avoided**, and that on **19%** of the treated cases the impact could **mitigated**

For the ACC technology

offers a remarkable efficiency in terms of avoided accidents, where we can clearly see that in **a dynamic scenario**, we manage **to avoid more than 50%** of the treated accidents. It can be seen that from **30 m**, we have less gain of avoided or strongly reduced impact.

thank you for your attention

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