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Impacts on a Test Setup for the Evaluation of Advanced Emergency Braking for Cyclists in Japan Using Event-Driver Recorder Data

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ABSTRACT: The technical progess in the areas of driver assistance and active safety leads to valuable information to be used prior to, during and even after a crash event. Car makers and suppliers can make use of this situation and currently develop Advanced Emergency Braking (AEB) Systems for Vulnerable Road Users (VRUs) such as cyclists to either avoid a collision or in a crash event to reduce injury risks of the participants. Within Europe test scenarios were already defined aiming to cover the most common crash scenarios. Considering the advances of such AEB systems their impact towards Japan accident situation is of highly interest. This paper describes the impact to a possible test setup derived out from analysis of Event Driver Recorder data from Japan. Finally a comparison against Euro NCAP test protocol for car AEB-Cyclist is done.

KEY WORDS: **Safety,** Traffic, Cyclist Safety, Cyclist Accidents Japan, Autonomous Emergency Braking, AEB-VRU, AEB-Cyclist, Event Drive Recorder, Euro NCAP, Japan NCAP [C1]

1. Introduction

The number of traffic deaths in Japan decreased over the past 20 years from 12 670 in 1995 to 4 113 in 2014 per year but first of its time increased to 4 117 fatalities (+0,1%) in 2015 [(1,2)]. Thus the question arises if the Japanese government will reach its goal to reduce the number of road fatalities to less than 2 500 per year by 2020 [(3)]. Nevertheless traffic safety in Japan is worldwide on top level. This high safety level was achieved by means of education, enforcement, infrastructure and rescue measures. Furthermore as through the introduction of additional and more effective vehicle safety systems and the respective and continuous monitoring of the technical condition of vehicles. However, a stagnation in the annual number of road fatalities shows that traffic safety cannot be measured by the number of fatalities only. A more comprehensive way to measure traffic safety has been developed in-house. This approach can be illustrated on the data for the year 2015 (Table 1):

Table 1 Injury severities in traffic crashes, Japan (2015).

Injury severity	Slightly injured	Severely injured	Fatally injured	Total
No. persons	627 064	38 956	4 117	670 137
Share	93,57%	5,81%	0,61%	100%

A retrospective collection and representation of the shares between severely and fatally injured since 1995 provides a more comprehensive development of traffic safety in Japan (Figure 1). Here, the influence of taken measures in the last years becomes visible. This representation clearly shows that the shares of severely and fatally injured continuously decreased until 2010. In 2011, the share of fatally injured still decreased, but the share of severely injured (~5,6%) remained unchanged.

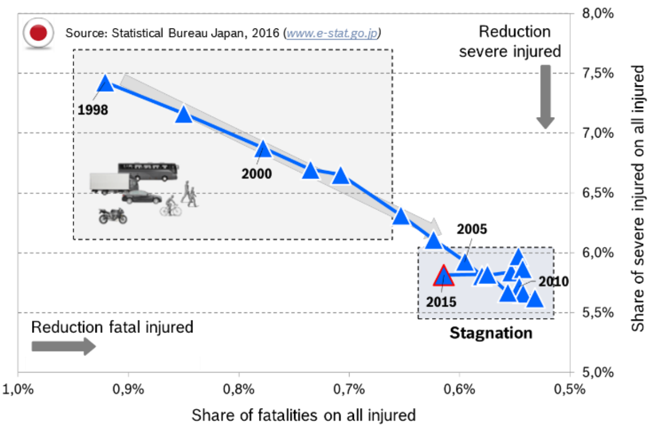


Fig. 1 Evolution of traffic safety in Japan (1998-2015).

In the last recent years since 2011, no significant improvements were made for both shares, severely and fatally injured. Applying this kind of representation to different traffic participants shows a reason for the stagnation (Figure 2): Particulary the injury development for Vulnerable Road Users (VRUs) show the need of additional action.

For example the introduction of motorcycle stability control (MSC) including Antilock Braking System (ABS) is worth mentioning. Impacts of Active and Passive Safety Systems on passenger car's safety is clearly positive. These safety devices reached a high market penetration within the last decade and therefore unfolded their potential for occupants safety. However,

current Driver Assistance Systems (DAS) such as Automatic Emergency Braking Systems for pedestrians (AEB-Pedestrian) cannot be fully effective due to less market penetration in the vehicle fleet.

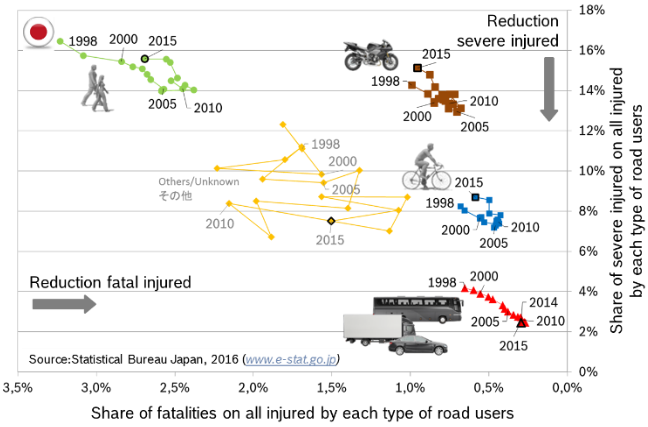


Fig. 2 Traffic safety by type of road users, Japan (1998-2015).

Focusing on cyclists as of now we still see some need for action. As seen in Figure 2 no improvements were made in the last two decades significantly. According to the nationals statistics more than 97 800 cyclists suffered from injuries caused by crashes in 2015 [1,2]. To achieve the national Japanese targets it is evident that further countermeasures have to be installed effectively.

First steps were made to bring awareness to the public, by collaboration with the police and local public organziations to familiarize cyclists with the rules of the road for bicycle users by setting up "Instruction in Methods of Traffic" and the "5 Rules for Bicycle Safety Usage" programs [4]. Moreover, the Road Traffic Act was revised and was put into operation in June 2015 to require bicycle users to take courses for repetitiously violating the Act in a way that poses a danger to the traffic. Besides education and enforcement also infrastructure related issues being discussed, i.e., coloured lane markings or separating cycle lanes from other motorized traffic. Additionally, vehicle safety systems could be extended from pedestrian protection towards cylists safety. As of now there has been no regulation for cyclists protection in Japan but active safety devices installed in a vehicle might be the next step to address these crashes.

Looking to Europe the car AEB-Cyclist technology has to be ready from 2018 on as they will be considered in the European New Car Assessment Program (Euro NCAP) as a rating test. Main input was given by the project CATS "Cyclist-AEB Testing System" [5,6]. Therefore the question arise what's the current situation in Japan? Are those scenarios applicable to the current crashes, and moreover what are the requirements for sensors and active safety technologies?

This paper intends to evaluate the current crash situation with cyclists in Japan and compare it against the protocol from Euro NCAP with respect to the test scenario setup [6,7].

2. Data Sources and Methods

For this study data from National Accident Statistics, National Police Agency and reports along with data from the Institute for Traffic Accident Research and Data Analysis (ITARDA) were assessed [1,2,8]. Based on this macro data the current crash situation including cyclists was evaluated.

For more detailed information Event-Drive Recorder (EDR) data was analyzed as micro level data to support underlying assumptions. This data was provided by the Japan Society of Automotive Engineers (JSAE) and the Tokyo University of Agriculture and Technology (TUAT) [17]. In cooperation with taxi companies, more than 125 cabs were equipped with drive event recorders. Vehicle position (GPS), velocity, longitudinal and lateral acceleration as well as brake and winker status were continuously measured next to a video stream. In case of an "event", 15 seconds of data-stream preceding the event and were stored. An "event" was defined by a braking deceleration above a defined threshold or abrupt steering (resulting in high lateral acceleration). Afterwards those events were separated into "accidents" and "incidents". If no collision occurred, the event is classified as an "incident".

For this study more than 3 400 events were reported retrospectively. Thereof are 39 collisions, 567 high level, 1 301 middle level and 1 526 low level incidents respectively. In a first assessment for this study in total 194 bicycle events were analyzed in more detail, including 39 crashes and 155 high level incidents.

Herefore EDR collected information was compared against national data to ensure representativeness of this data similar like in reference [9]. Afterwards an accident type was classified using the General Insurance Association (GDV) coding manual (see reference [18]) from Germany. This catalogue was adapted to left hand traffic so that it is applicable for Japan. Furthermore important crash parameters such as "collision angle", environmental conditions and vehicle or bicycle speed were determined out of the event data by using video post-processing methodologies.

Finally results out of the macro and micro data analysis were evaluated to achieve maximum real world benefit and used for a possible test scenario proposal. Afterwards the results were discussed and compared against the test protocol from Euro NCAP.

3. Euro NCAP – Advanced Emergeny Braking System Cyclist

Starting in 2018, Euro NCAP will consider in their safety assessment more AEB systems dedicated to avoid or mitigate passenger car-to-cyclist collision [7]. An appropriate setup and equipment was developed to test such systems and was part of the objectives in the CATS project [5]. The project aimed to setup a proposal for the most relevant test scenarios. Main objective was the proof of the relevance of the proposed test scenarios including their practical feasibility and implementation and test setup to Euro NCAP. Accidentology was used out of six countries within the EU (France, Germany, Great Britain, Italy, Netherlands, Sweden) to determine the most common car-to-cyclist crash scenarios. A focus was set on severe car-to-cyclists accidents resulting in severe and

fatal injuries. Three most relevant scenarios were identified as a result: two scenarios for a cyclist crossing the path of the car (from the far near side and the far side), and a longitudinal scenarios in which the car drives into the cyclist from the rear.

Data from observation along with accident data were use to determine relevant parameters and their ranges in the proposed test matrix for the selected scenarios. Hereof following criterias were identified as being relevant (Table 2).

Table 2 Derived relevant car-to-cyclist crash parameters.

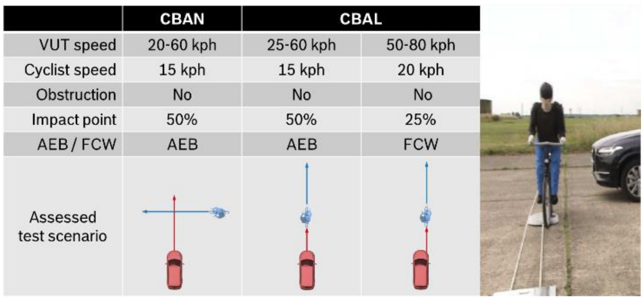
Crash scene	Collision partner
Location	Cyclist speed
Road layout / Obstruction	Cyclist age / size / gender
Season / Preciptiation	Vehicle speed
Lighting conditions	Vehicle braking
Speed limit	Collision/hit point

Together with 10 car manufacturers and 7 suppliers, a test matrix has been proposed and a testing setup including cyclist target has been built up, along with the German Federal Highway Safety Institute (BASt Germany) as review partner. Results enabled a harmonized and accepted protocol, target and test setup. Moreover it was used as main input to the draft test protocol, including scenarios and target for AEB-Cyclist systems by Euro NCAP. As a result the test protocol valid from 2018 on considers following three scenarios [7]:

(1) **Car-to-Bicyclist Nearside Adult 50% (CBAN-50)** – a collision in which a vehicle travels forwards towards a bicyclist crossing its path cycling from the nearside and the frontal structure of the vehicle strikes the bicyclist when no braking action is applied.

(2) **Car-to-Bicyclist Longitudinal Adult 25% (CBAL-25)** – a collision in which a vehicle travels forwards towards a bicyclist cycling in the same direction in front of the vehicle where the vehicle would strike the cyclist at 25% of the vehicle's width when no braking action is applied or an evasive steering action is initiated after a Forward Collision Warning (FCW).

(3) **Car-to-Bicyclist Longitudinal Adult 50% (CBAL-50)** – a collision in which a vehicle travels forwards towards a bicyclist cycling in the same direction in front of the vehicle where the vehicle would strike the cyclist at 50% of the vehicle's width when no braking action is applied.



	CBAN	CBAL	
VUT speed	20-60 kph	25-60 kph	50-80 kph
Cyclist speed	15 kph	15 kph	20 kph
Obstruction	No	No	No
Impact point	50%	50%	25%
AEB / FCW	AEB	AEB	FCW
Assessed test scenario			

Fig. 3 Euro NCAP test matrix to assess car AEB-Cyclist.

Selected scenarios will be assessed for AEB-Cyclist with an update in 2020 to cover more real life scenarios. A brief summary of the test matrix is shown in Figure 3.

4. Accident Research

4.1. National Accident Situation Japan

According to national statistics 98 936 crashes (18%) with casualties occurred involving bicyclists from overall 536 909 crashes with injuries in Japan in 2015. Thereof 97 802 cyclists suffer from injuries including 572 fatally and 8 595 severely injured [1,2]. To point out the need of a car AEB-Cyclist system as first their relevance as opponent was identified. Herefore it is assumed that such safety systems being installed for the vehicle types "car", "K-car" and "light truck". With this definition, the collision opponents were identified and displayed in Figure 4.

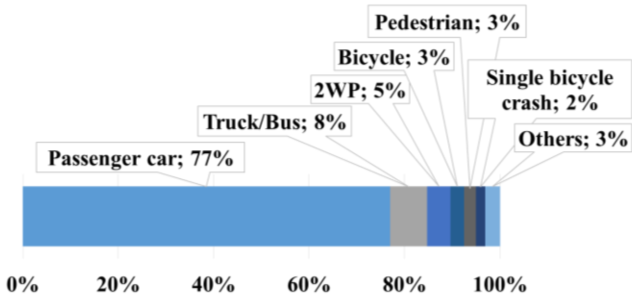


Fig. 4 Bicycle crashes with casualties by collision opponent (n=98 936, Japan 2015).

In 3 out of 4 crashes (75 871) involving cyclists a passenger car was reported as the collision opponent. Within this majority of car crashes 303 cyclists died and 6 014 were severely injured. In total car-bicycle collisions causing 77% of all injuries (75 871 out of 97 802) on bicycle riders whereof 9 out 10 crashes are caused by the passenger car and 1 out of 10 by the bicyle.

This indicates that an AEB-Cyclist system installed in passenger cars could contribute to reduce the number of accidents and severities. In the following analysis, crashes involving cars and cyclists will be considered only, negelecting which party caused the crash.

4.2. Characteristics of car-bicycle collisions in Japan

In a first step real-life accident parameters such as daytime or weather condition will be determined out of macro data. According to Table 3 those parameters are being seen as relevant to define realistic test scenarios.

Out of the remaining 75 871 car-bicycle crashes 77% occur during daytime and 23% at nighttime, respectively. Similar distribution is obtained if only severe and fatal crashes taken into account. Furthermore in 68% of the collisions the weather condition is fine (Figure 5). In additional 21% the weather was cloudy but supposed to be dry or at least good visibility given. Rainy conditions account to less than 11% and in ~0,27% the

collision occurred in foggy or snowy conditions. It is obvious that bicycle riding is mainly done under "normal" weather conditions. Doing the same analysis for fatal and severe crashes no different result is determined.

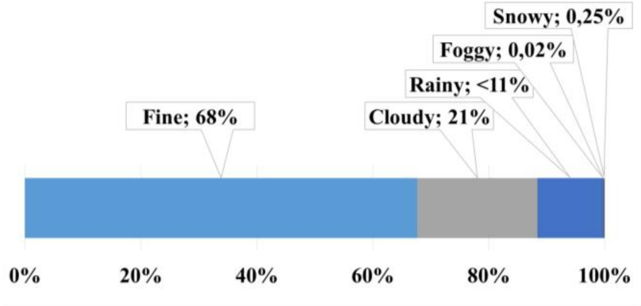


Fig. 5 Car-bicycle crashes by weather conditions (n=75 871, Japan 2015).

If a combination of daytime and weather is evaluated severe and fatal crashes are 2 times higher during nighttime and in rainy conditions (18%) compared to daytime and in rain (9%). Similar findings given for data prior to 2015 as seen in reference [8].

To determine the most relevant car-bicycle crashes scenarios the priority either can be set on their overall frequency or towards its crash severity (i.e. focusing on severe/fatal crashes only). Both approaches are shown in Figure 6.

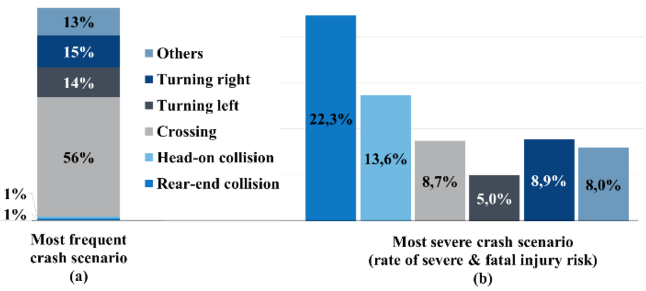


Fig. 6 Car-bicycle crashes by (a) frequency or (b) severity rate, (n=75 871, Japan 2015).

Crossing scenarios (either from near- or far-side) are determined as the most dominant car-bicycle crashes with respect to their occurancy – every 2nd car-bicycle crash (56%) occurs while the collision partners "crossing" each other (Figure 8a) whereas "rear-end" collisions occur only in a share of 1% of all car-bicycle crashes. Furthermore in every 3rd event (29%) a conflict while "turning" between the car and the cycle occur.

Focusing on severe and fatal collisions a severity/fatality rate was calculated by dividing the sum of all severe and fatal crashes by all crashes with casualties with respect to each scenario – see Figure 8b. For "rear-end" collisions the rate of 22,3% is remarkable high whereas for "crossing collision" its 2,5 times lower but presents the highest number of deaths and casualties overall. Moreover "head-on collisions" result in a rate of 13,6% hence collisions between cyclist and passenger cars moving in longitudinal direction are the most severe/fatal crash scenarios, but their overall relevance accounts to 2% only (Figure 8a). Similar results were obtained in [8] for fatal crashes involving all motorized 4-wheeled vehicles only.

To sum up, car-bicycle crashes occur mainly during daytime and in fine weather conditions. Main collision scenarios are "crossing" situations followed by "turn-right" and "turn-left" crashes whereas the most severe crashes are "rear-end" and "head-on" collisions followed by crashes while "crossing".

4.3. In-depth analysis of Event Drive Recorder data

From collected drive recorder data the accident to inicident ratio was determined first. This results in a risk ratio of 1:87 for a bicycle being involved in a collision against a car. In other words before a crash occurs 87 critical situtions involving a bicycle will happen. This gives some indication towards the complexity of the scenarios which should be detected by AEB-Cyclist Systems.

Anyhow in order to identify the representativness of the EDR data at first the 194 cases (39 crashes and 155 high level incidents) were classified with respect to their crash situation and compared against national data. Figure 7 shows the result: Even with the small sample size the overall shares for each accident situation is rather similar compared to national car-bicycle crash data.

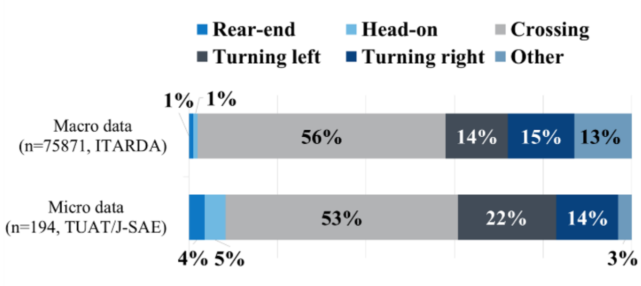


Fig. 7 Comparison of ITARDA car-bicycle crash scenarios against EDR data (TUAT/JSAE).

Being comparable against findings from Europe a towards left-hand traffic adapated 3 digit accident type classification sytems was applied [18]. The type of accident describes the conflict situation which resulted in the accident, i.e. a phase in the traffic situation where the further course of events could no longer be controlled because of improper action or some other cause. Unlike the kind of accident, the type of accident does not describe the actual collision but indicates how the conflict was touched off before this possible collision. Therefore it is important to assess active safety systems. Figure 8 shows the occurancy for the ten most frequent incident/crash scenarios within the overall sample (representing 66% of all events).

As expected mainly crossing along with turning scenarios are the most frequent collision types. Especially at intersection near-side crashes occure more often compared to far-side collisions but overall similar shares are given for near- or far side events (see also Figure 12). Overall in nearly every 3rd event some obstruction was observed. Obstructions were buildings but also cars in front of the ego-vehicle mainly on the near side of the vehicle. A more detailed analysis in terms of size of the obstruction was not investigated yet.

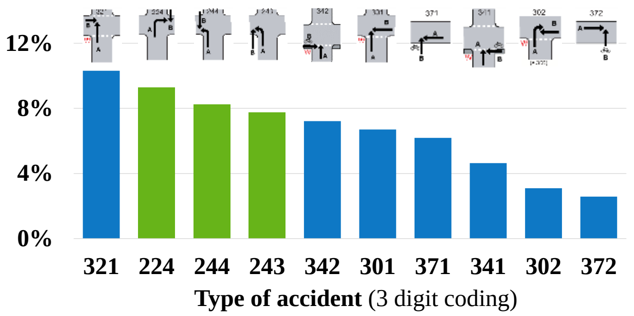


Fig. 8 Ten most frequent accident types of car-bicycle incidents with 3-digit classification.

In a share of 4% of all events the bicycle swung out and, hence, came in conflict with the ego vehicle this somehow will be influenced by the sample size.

To put national data side by side against EDR data, more events occurred during nighttime (41% in EDR, 23% in national data). Most of the events occurred at multi-lane (85%) compared to single roads (15%) in the EDR data. Similar results were found in reference [(10)]. In order to identify specific scenarios the position of the cyclists relative to the vehicle was determined at the time when the cyclist first appeared in the video ($t_{visible}$) and prior to the incident/crash (t_{event}) being seen as "collision" angle between the two participants. Investigations on behalf of the contact point in case of a crash event was not done yet.

The position of the cyclist relative to the vehicle along with the cyclists speed was determined by video processing methodologies. Herefore reference points were identified out of the video such as the vehicle front, pedestrian crossing lines or other objects on the road with known size and length and compared stepwise frame by frame. Figure 9 shows the comparison of the relative angle between the car and the bicycle for the two time steps ($t_{visibile}$ and t_{event}).

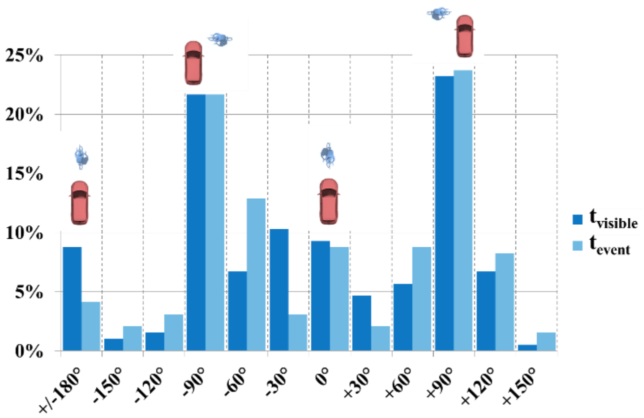


Fig. 9 Relative "collision" angle in car-bicycle events for two time steps out from EDR data (n=194, TUAT/J-SAE).

Especially for cases in which both vehicles travel along the carriageway changes in the travel directions were observed whereas events at intersections/crosswalk nearly have a perpendicular collision path. As seen from the distribution in Figure 9 nearly similar shares obtained for near-side (24%) and far-side (22%) events.

Along with the "collision" angle the speed of each participant is also important. Hence a special focus was set on the determination of the bicycle speed. To take into account deviations in the determination of the speed of the video stream three categories were defined (Table 3).

Table 3 Bicycle speed derived out from EDR data (n=194, TUAT/J-SAE).

Speed [kph]	≤5	>5 – ≤10	>10	n/a
Share	10%	74%	5%	11%

In a share of 11% no determination was possible. In more than 80% the bicycle speed was determined to 10 kph or less. Similar results were obtained in references [(10),(11),(12)]. A special investigation in reference (11) was made on the impact towards different vehicle front-end structure in car-bicycle crashes. Within a small sample size of real-world bicycle crashes the impact velocity at the time of impact was determined to 10 kph or less in 90% of the cases. As a main result it can be concluded that the velocity of bicyclists is relatively low in collisions with other vehicles in Japan.

The vehicle velocity at time of the event was obtained directly from the output of the drive recorder and compared against ITARDA data (Figure 10). In the ITARDA database, the vehicle velocity is related to the driving speed reported by the driver to the police, thus represents the speed at which the driver became aware of the risk of a collision with a cyclists. According to reference [(11)] the correlation between the vehicle velocity and the actual crash velocity has been shown in an analysis of ITARDA and tends to be ~10 kph lower on average.

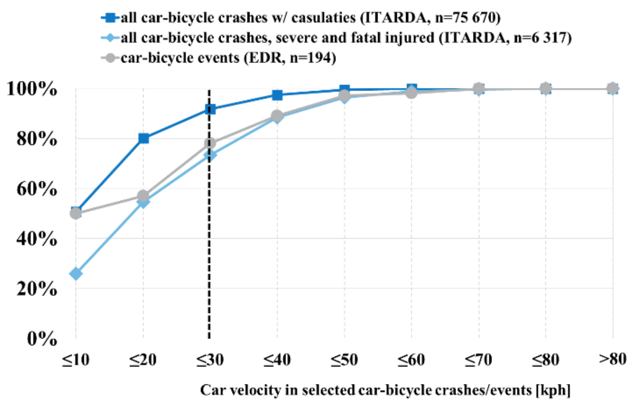


Fig. 10 Comparison of the vehicle speed in car-bicycle incidents/crashes with casualties from different data sources.

In the EDR data vehicle speed of 30 kph or less is observed in ~80% of the events. By taking a 10 kph overestimation for the ITARDA data into account the results are comparable. In case of severe or fatal collsions even less speed was evaluated. To have some more precise information with respect for each collision scenario the speed for car-bicylce events at the time t_{event} was evaluated in more detail out from the EDR data. Further

investigation on deceleration along with brake duration at t_{event} was not yet done. However some first investigations are presented in reference [13]. The result of the cumulative distribution is shown in Figure 11 and can be used as an indication of an initial speed definition in a test scenario setup.

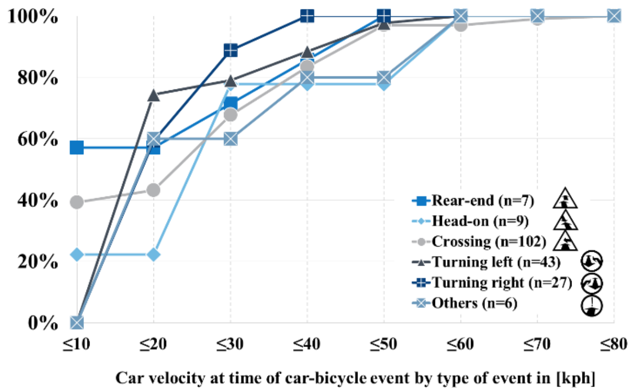


Fig. 11 Vehicle speed in car-bicycle incidents/crashes by type of crash/event from EDR data (TUAT/JSAE).

Focusing on the major crash situation "crossing" nearly 100% of all events occurred at 50 kph or lower whereas "head-on" or "rear-end" conflicts happens at higher vehicle speeds. Thus it is obvious that the latter cases result in more severe crashes. It is also seen that the overall speed in case of "turning" scenarios are lower which is also evident due to the fact that the car has to reduce its speed at intersections for maneuvering purposes.

5. Proposed car AEB-Cyclist test scenarios in Japan

For a definition of a car AEB-Cyclist system not all crashes can be taken into account in a first draft proposal. Anyhow to achieve a best benefit a simple maximum selection strategy was applied on each determinable crash parameter such as level of light or precipitation. Starting from the top including all 93 964 crashes with casualties against cyclists thereof are 75 871 collisions between a car and a bicycle. Herein the majority of 58 657 crashes occured during daytime and fine weather conditions were reported in 40 840 cases.

The dominant collision scenario for all 75 871 car-bicyle collisions are 42 259 crashes in "crossing" situations followed by "turning right" (11 411) and "turning left" (10 824) collisions. Less relevance is given for "rear-end" (938) and "head-on" (807) collisions. This priority is also valid if selected level along with precipitation is applied as filter criteria beforehand (Figure 12). With this selection 3 359 severe- and fatal injured and 37 481 slightly injured cyclist crashes were addressed.

To further derive possible test scenarios distuinguished configurations were setup (Figure 13) which are nearly similar to reference [5]. The most likely crash setup is a collision in which a vehicle travels forwards towards a bicyclist crossing its path. The frontal structure of the vehicle then strikes the bicyclists. Both near-side (Fig. 13, C1) and far-side (Fig. 13, C2) configurations are important. As a result out of the EDR analysis some perpendicular travel path for the cyclist seems to be effective. Obstruction was not considered yet therefore further investigation is needed. A first approach was done in (13) and (14) but more detailed analyses is required.

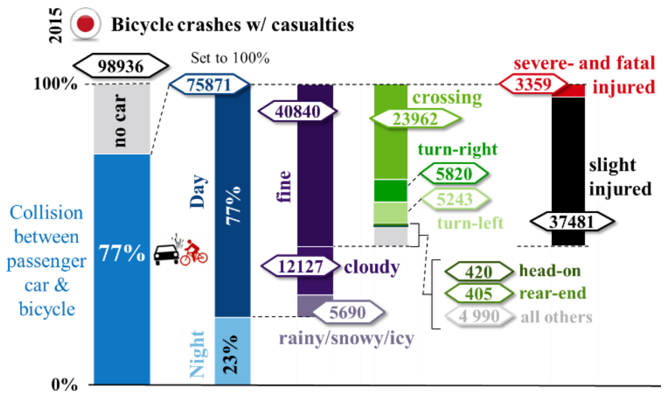


Fig. 12 Potential of a car AEB-Cyclist system on selected crash parameters in all scenarios in Japan.

From both, macro- and micro data, turning scenarios are rather more frequent compared to longitudinal scenarios. Turning left scenarios (Fig. 13, T1-T2) were observed more often in the EDR data (Fig. 9) compared to turning right events (Fig. 13, T3-T5). Nevertheless from a sensor point of view a rather large field of view is required to at least detect the cyclists while the car is maneuvering. To possibly come along with this problem additional sensors might be required, installed at the vehicle front- and rear-corners. Furthermore to realize a realiable and reproducible test configuration of such a complex scenario it is assumed that this will be rather intense not only costwise but also timewise. Therefore in a first evaluation of a car AEB-Cyclist system such scenarios might be not part of a test configuration.

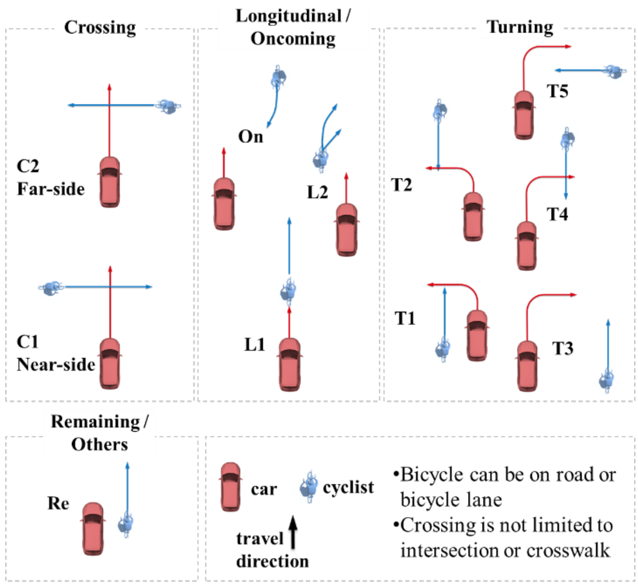


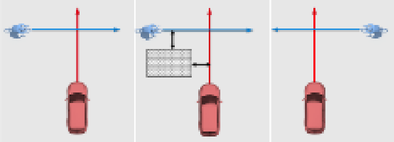
Fig. 13 Overview of distinguished car-to-cyclist crash scenarios.

Less frequent but more severe are collisions in which a vehicle travels forwards towards a bicyclist cycling in the same (Fig. 13, L1-L2) or opposite direction (Fig. 13, On) in front of the vehicle.

For the L1 and L2 scenarios state-of-the art sensor devices already used for AEB-Pedestrian might be extended to cover this situation. Nevertheless there overall relevance account to 2%. To achieve a maximum real-word benefit in a first step it is more likely to have crossing scenarios as a possible test setup. Table 4 shows the possible test scenario for car AEB-Cyclist in Japan.

Table 4 Possible test scenarios for car AEB-cyclist in Japan.

Light level	Daylight conditions		
Precipitation	Fine / Dry		
Vehicle speed in kph	≤50	≤35	≤50
Cyclist speed in kph	≤10	≤10	≤15
Relative angle	90°	90°	-90°
Obstruction	No	Yes	No
Assessed scenario	C1	C2	C2



The scenarios in Table 4 address a total number of 24 367 car-bicycle crashes with casualties including 2 125 severe- and fatal crashes. Overall this represents a share of 4% of all crashes with casualties and 5% of severe- and injured crashes in Japan, respectively. In other words every 5th collision with severe- and fatal injured cyclists could be positively influenced if each car is equipped with an ideal AEB-Cyclist system in Japan.

6. Comparison of car-bicycle crashes in Japan against Euro NCAP test scenario settings.

Reviewing Euro NCAP test protocol and comparing against findings from macro- and micro EDR data in Japan shows that similar scenarios are applicable. A baseline for a test proposal were findings from the CATS project which focused upon severe- and fatal injured car-bicycle crashes in Europe. The current study considered all injured cyclists crashes. No different results obtained if the same analysis is applied if the focus is set on severe and fatal crashes and slightly injured crashes filtered out. Table 5 compares and sums up major findings but also refers to other studies covering the topic of cyclist protection along with testing recently published.

Overall similar conditions given in Europe as well as in Japan. With respect to the prioritized collision scenarios in Japan “turning” scenarios are more important than “rear-end” crashes compared to Europe. Also vehicle speeds is slightly lower as far as the EDR data can be seen as representative. This is also obtained for the bicycle speed determined from the event data. Therefore adaptions should be made if a car AEB-Cylist system will be considered in a J-NCAP rating procedure. Of course collision point along with cyclist characteristics have to be investigated.

Table 5. Comparison of car-bicycle crashes in Japan against Euro NCAP test scenario settings.

Parameter	Japan	Euro NCAP
Lighting conditions	Daylight	Daylight
Precipitation	Fine/Dry	Fine/Dry
Collision scenarios	1. Crossing 2. Turning 3. Rear-end 4. Head-on 5. Others	1. Crossing 2. Rear-end 3. Head-on 4. Turning 5. Others
Cyclist age/size/gender	n/a – referred to (12),(16)	Adult
Bicycle speed in kph	~10-15 Crossing ~15 Rear-end	~10-20 Crossing ~15-20 Rear-end
Vehicle speed in kph (90th percentile)	~30-45 Crossing ~31 Turning right ~42 Turning left ~44 Rear-end ~55 Head-on	~50-55 Crossing n/a Turning right n/a Turning left ~70-80 Rear-end n/a Head-on
Collision point	n/a, referred to (11),(12)	50% Crossing 25%,50% Rear-end see also (5),(6),(15)

7. Summary

The analysis of the accident statistics and EDR data revealed the following results and characteristics among of collisions and incidents against bicycles in Japan:

(1) A stagnating trend in traffic safety for fatal and severely injured cyclists is observed and countermeasures are needed. Possible active vehicle safety systems are, e.g., Advanced Emergency Braking for cyclists.
(2) In 2 out of 3 crashes with casualties against cyclists the main collision opponent is a passenger car, K-car or light truck.
(3) Car-bicycle collisions occur mainly at daylight (77%) and in fine weather conditions (68%).
(4) Collisions at crossings are the major car-bicycle crash scenario (56%) in Japan, whereas the highest severity/fatality risk is given in rear-end collisions (22,3%).
(5) For crossing scenarios a perpendicular bicycle trajectory was obtained in 46% of the event data.
(6) In nearly every 3rd event an obstruction was identified within the EDR data. Type of obstruction was not evaluated in detail.
(7) In a share of 87% the vehicle velocity was 40 kph or less in all scenarios in the event data. Taking ITARDA data into account similar results obtained if a 10 kph averaged overestimation is considered.
(8) The cyclist’s velocity was evaluated to 10 kph or less in about 84% of all events. Compared to European countries this is lower as it was also found in reference (5).

(9) Most relevant car-bicycle test scenarios for AEB-Cyclist are crossing situations in daylight and fine weather conditions.

8. Conclusion and Discussion

As conclusion, the present study shows:

1. The relevance of safety against Vulnerable Road Users like cyclists in Japan.
2. Car AEB-Cylist could be an important countermeasure.
3. Importance of macro- and micro data to evaluate relevant crash parameters for the baseline assessment of test scenarios.
4. Similarities and differences of relevant crash parameters with respect to car-bicycle crashes in Japan and Europe.
5. Possible test setup for a car AEB-Cyclist in Japan and their overall relevance in terms of accident avoidance potential

The study aimed to give first impulses towards a possible test setup for a car AEB-Cyclist system in Japan. Derived from national and EDR data main findings with respect to relevant scenarios, speed, trajectories and boundary conditions were made. Nevertheless further investigations have to be done especially on specific crash parameters like impact points or obstruction dimensions. Furthermore cyclists characteristics such as height, age and gender along with use of safety devices such as a helmet were not discussed here. Those characteristics have been proven to be important in reference [11] especially if test definitions are discussed. Furthermore possible impacts on sensor charcteristics or effects of a car AEB-Cyclist system in terms of accident avoidance was not assessed here in detail.

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