PUBLIC CRASH VIDEO EVIDENCE FOR ADAPTING EURO NCAP INTERSECTION SCENARIOS TO NORTH AMERICA

Krzysztof Czarnecki
University of Waterloo, Canada

Paper Number 26-279

ABSTRACT

Intersection crashes remain a major source of fatalities and serious injuries in North America, yet current vehicle safety evaluations place limited emphasis on intersection collision avoidance. The European New Car Assessment Programme (Euro NCAP) has recently introduced structured intersection collision test scenarios based on European crash evidence, but their assumptions may not fully represent driving conditions in the United States and Canada. This study assesses whether additional scenario coverage may be warranted for North America by analyzing real-world intersection crashes captured in publicly posted videos.

A set of one hundred crashes from the United States and Canada was reviewed to extract road layout, turning and crossing movements, traffic-signal compliance, and visibility. Each crash was characterized at the same level of abstraction used in the Euro NCAP catalog and classified either into an existing Euro scenario or into a new candidate when no suitable configuration existed. The analysis focused on straight-crossing and left-turning conflicts, which were the most common configurations in the sample.

More than half of straight-crossing crashes involved visual obstruction from parked vehicles, roadside objects, queued traffic, or moving vehicles, and roughly half of these cases exhibited tight sight openings inconsistent with current Euro test geometry. Left-turning crashes also commonly involved obstruction, and several cases indicated a need to evaluate turning and oncoming roles symmetrically. Additional low-frequency configurations were identified, including several existing Euro NCAP configurations and new variants. Some of the newly observed configurations appear to be sufficiently similar to established scenarios that they may already receive partial test coverage. These findings point to (i) tightly obstructed straight-crossing-path scenarios, (ii) obstructed left-turn-across-oncoming scenarios, and (ii) their symmetric variants as priority candidates for future scenario coverage.

The findings demonstrate that public crash video offers unique value for reconstructing pre-crash dynamics and, critically, for identifying static and dynamic obstructions, enabling scenario identification aligned with Euro procedures and supporting concrete recommendations for North American candidate extensions to future intersection collision testing.

Keywords: Intersection crashes; automated emergency braking; collision-avoidance testing; NCAP; vehicle safety assessment; visibility obstruction; dashcam video analysis; turning and crossing conflicts; scenario development; North America.

INTRODUCTION

Advanced driver assistance systems (ADAS) and automated emergency braking (AEB) have become central to efforts to reduce roadway fatalities and serious injuries, and the effectiveness of such systems depends on the realism and relevance of standardized test scenarios. Intersection safety represents a major motivation for advancing these evaluations. Analyses of the National Motor Vehicle Crash Causation Survey (NMVCCS) and the Fatality Analysis Reporting System (FARS) indicate that roughly 36–40% of serious or fatal crashes in the United States are intersection-related [1], [2], and NHTSA has estimated that intersection crashes account for nearly half of total societal and economic crash costs in the United States [3]. A comparable burden is seen in Canada: according to Transport Canada's National Collision Database [4], 27% of traffic fatalities and 41% of serious injuries in 2022 occurred at intersections.

In Europe, similar safety concerns have motivated the gradual expansion of the European New Car Assessment Programme (Euro NCAP) [5] beyond lead-vehicle and existing vulnerable-road-user evaluations toward more complex crash-avoidance tests, including a set of intersection-collision configurations. These represent the most advanced AEB intersection tests currently available and reflect European roadway design, traffic mixes, and crash evidence—most notably from the German In-Depth Accident Study (GIDAS) [6]. As AEB systems and consumer-rating protocols are applied globally, an important question is whether test configurations derived from European crash data provide adequate coverage for North American driving environments, roadway geometrics, traffic controls, and behavioral risk factors.

Addressing this question requires attention to pre-crash characteristics—road layout, intersection control, trajectories, speeds, and especially visibility. North American crash databases such as CISS [7] encode intersection type and pre-crash movements but often omit visibility factors, including static or dynamic obstructions created by scenery and other traffic. Driver behaviors associated with violations (e.g., red-light running) may be redacted for privacy, and detailed speed profiles are frequently unavailable. In contrast, publicly shared crash videos allow direct inspection of line-of-sight restrictions, acceleration behavior, and whether obstructions arise from parked vehicles, queued traffic, or infrastructure.

To address these limitations, the present study analyzes 100 publicly available intersection-collision recordings from the ViralHog platform [8], which includes U.S. and Canadian dashcam and other types of traffic-related footage. Pre-crash trajectories, traffic-signal compliance, and visibility obstructions are extracted from each video, and collisions are mapped either to existing Euro NCAP scenarios or to proposed variants when no suitable configuration exists. Particular attention is given to straight-crossing-path and left-turn-across-path crashes, which dominate the sample, and to the frequency and geometry of obstructed views, including tightly constrained sight openings created by queued vehicles.

This work contributes the following:

- a first systematic comparison of Euro NCAP intersection-collision scenarios against real-world U.S. and Canadian crashes using public video evidence;
- empirical evidence that more than half of straight-crossing-path crashes involve static or dynamic obstructions, and that approximately half of these exhibit tightly obstructed openings differing substantially from current Euro NCAP test geometry;
- identification of obstructed left-turn-across-path cases, which are absent from current test catalogs, and motivation for symmetric role variants in which either the turning or the oncoming vehicle may be treated as the vehicle under test;
- preliminary proposals for candidate extensions and variants that may improve the realism of future test protocols and provide hypotheses for subsequent benefit analysis using crash statistics.

Overall, the findings motivate consideration of North American evidence when assessing AEB intersection-performance and illustrate how publicly available crash video can complement structured crash databases by revealing visibility constraints and dynamic obstructions that are otherwise difficult to document.

BACKGROUND AND RELATED WORK

The New Car Assessment Program (NCAP)

The New Car Assessment Program (NCAP) was launched in 1979 by the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) to provide consumers with comparative information on vehicle crash safety [9]. The program initially focused exclusively on crashworthiness evaluations. In 1996, a similar initiative was introduced in Europe—the European New Car Assessment Programme (Euro NCAP) [10]. Euro NCAP subsequently broadened its assessments beyond crashworthiness to include emerging crash-avoidance technologies, beginning with electronic stability control and speed-assistance systems, and later progressing to advanced interventions such as autonomous emergency braking (AEB) and autonomous emergency steering [11].

Euro NCAP employs a formal, data-driven process for extending test protocols and consumer-rating criteria to incorporate advances in ADAS and other safety-relevant technologies [12]. The process follows two phases: an initial submission must provide a technical description of the system and clearly identify the targeted safety problem, while a subsequent, detailed assessment specifies test procedures, performance targets, anticipated casualty reduction, and supporting real-world evidence. To quantify benefit, manufacturers are required to analyze representative crash data, define operational design limits, and provide independent validation of performance. The primary empirical resource used for benefit assessments is GIDAS [6], a systematic crash-investigation program that documents collisions in Germany and includes video records when available. Euro NCAP also provides standardized procedures to calibrate GIDAS statistics for application to other EU member states.

Several additional NCAP programs have since been established worldwide, including Japan NCAP, ASEAN NCAP, C-NCAP, and Latin NCAP. Among these, Euro NCAP is generally viewed as the most advanced, particularly through recent crash-avoidance test protocols such as the 2026 Crash Avoidance Protocol [13], [14], which advances several intersection-related test configurations. Other regional NCAPs have begun adopting or adapting elements of these protocols; for example, C-NCAP incorporates additional motorcycle-related scenarios to reflect the prevalence of powered two-wheelers in China.

By contrast, the current U.S. NCAP [15] includes AEB performance evaluation under Federal Motor Vehicle Safety Standard (FMVSS) No. 127 [16], [17], with lead-vehicle (car-to-car rear) and pedestrian scenarios (crossing, longitudinal, standing), but it does not yet incorporate dedicated intersection crash-avoidance configurations.

Intersection-Related Crashes and Test-Scenario Development

NHTSA has analyzed causal factors in intersection crashes in the U.S. using the National Motor Vehicle Crash Causation Survey (NMVCCS), which includes 787,236 intersection-related cases [1]. This study focused on critical driver errors, identifying a dramatically elevated odds ratio for "turned with obstructed view" in intersection versus non-intersection crashes (relative ratio 335). "Inadequate surveillance exhibited the next-highest ratio (6.1), followed by "illegal maneuver" (4.1). Turning left accounted for 22.2% of critical events, compared with 12.6% for crossing over and only 1.2% for turning right. Although this analysis underscores the significance of obstruction and surveillance failures in intersection safety, it does not derive crash-avoidance test scenarios.

A complementary NHTSA effort [18] is the development of a pre-crash scenario typology for crash-avoidance research based on the 2004 General Estimates System (GES) [19], which encodes vehicle movements, dynamic states, and the critical event immediately preceding a crash. The resulting taxonomy defines 37 pre-crash scenarios covering approximately 5.94 million police-reported light-vehicle crashes (LVS), representing an estimated $120 billion in economic losses and 2.77 million functional years lost. The typology is comprehensive across roadway environments, including intersection-related configurations such as straight-crossing-paths at unsignalized junctions (4.44% of all LVCs in GES 2004) and left-turn-across-path from the opposite direction (LTAP/OD) at both signalized (3.71% of LVCs) and unsignalized (3.19%of LVCs) junctions. However, several categories are not decomposed purely by pre-impact movement—for example, red-light (4.27% of LVCs) or stop-sign violations (0.81% of LVCs) may involve multiple crossing or turning behaviors. A separate NHTSA analysis [20] provides a cleaner breakdown of fatal intersection crashes according to pre-crash movements.

One of the most relevant prior efforts is the work by Bangert et al. [21], which developed functional intersection crash scenarios for ADAS and ADS safety evaluation. The authors used NHTSA's Crash Investigation Sampling System (CISS), a large, nationally representative database of U.S. vehicle crashes. Crashes were clustered based on detailed intersection geometry, traffic control devices, and pre-crash movements, yielding 44 scenario clusters. The largest clusters corresponded to straight-crossing-path (SCP) and left-turn-across-path, initial opposite-directions (LTAP/OD) configurations. The analysis relied on both structured classification fields and scene diagrams capturing intersection layouts and vehicle paths.

Several important differences distinguish the current study from Bangert et al. First, CISS does not include video recordings; additional contextual information is removed for privacy, including critical driver-behavior indicators such as stop-sign or red-light violations. Velocity information is also frequently missing. Although CISS includes fields for visual obstructions, these data are rarely populated. As a result, Bangert et al. could not characterize dynamic obstructions. Moreover, their study does not relate findings to Euro NCAP test definitions. In contrast, the present work leverages video recordings to examine visibility, static and dynamic occlusions, and causal factors more directly. The two approaches are therefore complementary: CISS provides representative frequency estimates for the U.S., while video analysis enables richer behavioral interpretation.

A second relevant line of work examines intersection crashes in the context of C-NCAP. Pan et al. [22] combined CIDAS (the Chinese analogue of GIDAS) with crash videos harvested from the Internet to propose new AEB scenarios targeting collisions between cars and electric two-wheelers. Using clustering methods, the study analyzed road design, lighting, pre-crash movements (including estimated speeds), and visual obstructions—enabled in part by video access. The most frequent clusters were compared against existing C-NCAP scenarios, and new configurations were proposed accordingly.

A related study by Zhao et al. [23] used CIDAS to examine parameter distributions for an existing C-NCAP intersection test. The analysis reported that visual obstructions were present in roughly 10% of cases; about three-quarters of these were due to environmental features (e.g., buildings or pollution) and more than 20% were caused by vehicles. These findings reinforce the importance of visibility constraints in real-world intersection dynamics.

The present paper differs from both Pan et al. and Zhao et al. by focusing on U.S. and Canadian intersection crashes and by grounding its assessment in publicly available video data rather than CIDAS or other formal in-depth crash-investigation sources.

Using Public Camera Recordings for Crash Analysis

Publicly shared accident videos have become an increasingly useful resource for analyzing real-world traffic crashes, including at intersections. Dashcam adoption is widespread—estimated at roughly 30% of vehicles in the United States [24] and 11% in Canada [25]—and drivers routinely upload recordings of crashes and near-crashes to online platforms. Motivations for sharing include warning other drivers, documenting incidents for insurance or legal purposes, and generating online engagement or revenue [26].

Dashcam recordings are increasingly used in crash reconstruction and forensic investigations [27], [28], and online platforms also host footage from mobile phones and fixed infrastructure cameras. These videos enable frame-by-frame assessment of pre-crash maneuvers, signal compliance, lane positioning, and especially visibility and obstruction effects—factors central to intersection crash mechanisms but often unavailable or sparsely coded in structured crash databases. Similar methods have already been used to support test-scenario development in C-NCAP, where Pan et al. [22] combined CIDAS and publicly sourced crash videos to propose AEB scenarios for collisions between cars and powered two-wheelers.

The present study leverages these advantages by using publicly available crash footage from the United States and Canada to examine intersection configurations and visibility obstructions relevant to future NCAP test development.

METHOD

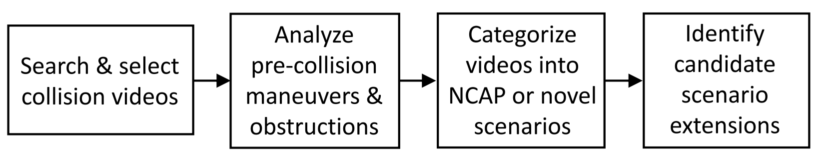


Figure 1: Overview of the collision scenario analysis.

The scenario analysis method used in this paper consists of four steps (see Figure 1):

1. *Search and selection of collision videos*: The first step is to identify videos depicting collisions involving at least one passenger car, relevant to intersection navigation, and occurring in the United States or Canada. The search primarily focused on ViralHog, a platform that hosts user-submitted original videos. Unlike other platforms such as YouTube or Reddit, which often contain compilations, edited content, or re-posted material, ViralHog predominantly features original submissions, making it well suited for systematic analysis. Although not limited to traffic-related content, ViralHog contains a substantial collection of traffic collision videos (more than 3,000 at the time of writing, with 878 recorded in the US and 87 in Canada).

   Exclusion criteria included videos with an insufficient field of view to reliably identify pre-collision maneuvers, videos showing only post-collision scenes, and videos unrelated to intersection handling. Examples of excluded cases include crashes caused by loss of vehicle control due to medical emergencies, stunt driving, road rage incidents, or protests.

2. *Analysis of pre-collision maneuvers and obstructions*: Each selected video is analyzed to identify the pre-collision maneuvers of the involved road users, as well as any obstructions (i.e., occlusions) that may have limited their mutual visibility prior to the collision. Obstructions are categorized as either static or dynamic. Static obstructions include buildings, dense vegetation, fences, and parked vehicles, while dynamic obstructions include other vehicles participating in traffic.

3. *Categorization into NCAP or novel scenarios*: The videos are classified based on the road users involved, the road and intersection configuration, the pre-collision movements, and the presence and type of obstructions. Each collision is mapped to an existing Euro NCAP intersection collision scenario [14] when applicable. If no existing

Euro NCAP scenario adequately captures the observed combination of these factors, the video is assigned to a new collision scenario category.

4. *Identification of candidate scenario extensions*: The newly identified scenario categories are analyzed with respect to the number of real-world instances observed in the video set and the extent to which they may be partially covered by existing Euro NCAP scenarios. This analysis is used to identify and prioritize candidate collision scenarios for potential inclusion as extensions to the current Euro NCAP test catalog.

The identified scenario extensions are intended as inputs to future analyses, including detailed reconstruction of vehicle trajectories and velocity profiles, refinement of road geometry, cross-referencing with crash reporting databases, and crash severity analysis. These follow-on studies are necessary to further assess the potential safety benefits of the proposed scenarios and to inform the detailed definition of test geometries and dynamic parameters for their possible inclusion in future NCAP protocols.

RESULTS

The first step of the analysis yielded 100 intersection-related collision videos, recorded between 2015 and 2025. The majority of the videos were recorded by dashcams, with a small number captured by doorbell cameras or infrastructure-mounted cameras. Only four of the collisions occurred in Canada, with the remaining cases recorded in the United States. Adverse weather conditions were rare: only two collisions occurred in rain and three in wintry conditions, while all others took place under fair-weather conditions. Most crashes occurred during daylight—only eight occurred at night—and at standard four-leg (cross) intersections; however, the dataset also includes at least five skewed intersections, one offset intersection, and six T-intersections. All crashes involve at least one passenger car, and ten of the car-to-car collisions involve three or more vehicles.

The results of the pre-collision maneuver and obstruction analysis, as well as the categorization into existing Euro NCAP scenarios or newly identified scenario categories, are summarized in Tables 1–4. Each row in the tables represents a collision scenario and includes a pictogram illustrating the pre-collision maneuvers and any associated obstructions. Solid arrowheads denote the vehicle under test (VUT), and open arrowheads denote target vehicles or vulnerable road users; car targets correspond to the Global Vehicle Target (GVT) used in testing. Vehicles are represented by solid arrows, and vulnerable road user targets are represented by dashed arrows. The gray rectangles represent static or dynamic obstructions. Some scenarios correspond to existing Euro NCAP definitions [14], while others are newly identified in this study; naming conventions and abbreviations follow Euro NCAP terminology for existing scenarios and analogous conventions for new ones. The descriptions and abbreviations of the novel scenarios are highlighted in boldface.

The scenarios are sorted by their observed frequency in the video collection; for ranking purposes, unobstructed and obstructed variants of the same scenario are counted together. The final column lists the identifiers of the videos instantiating each scenario. A video with a given identifier can be accessed online by prepending the identifier with `https://viralhog.com/watch/file/`.

The results are discussed in the following subsections.

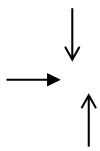
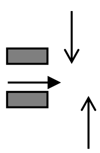
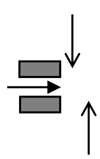
Car-to-Car Crossing, Straight Crossing Paths (CCCscp) Scenarios

Table 1 summarizes the Car-to-Car Crossing, Straight Crossing Paths (CCCscp) scenarios. These scenarios represent situations at cross intersections in which the vehicle under test (VUT) travels straight through the intersection while a target vehicle crosses the junction on a perpendicular path, approaching either from the near side or the far side (see Figure 2). A total of 41 videos fall into this scenario category, corresponding to 41% of the video dataset.

Euro NCAP defines two variants of the CCCscp scenario: unobstructed and obstructed. In the unobstructed variant, the conflicting vehicles have full mutual visibility (cf. Figure 2, without the black vehicles representing obstructions). The obstructed variant accounts for visibility limitations along the VUT approach, caused by obstructions on either the near side or the far side of the intersection (i.e., to the left or right of the VUT, respectively). In the analyzed dataset, obstructed cases dominate the CCCscp category, with 24 instances compared to 17 unobstructed ones.

In general, obstructions may be static (e.g., buildings, dense vegetation, or parked vehicles) or dynamic (e.g., vehicles participating in traffic). In the Euro NCAP test configuration (Figure 2), obstructions are implemented using parked vehicles, with relatively large opening distances between the obstruction edge and the crossing path of the target vehicle—21 m for near-side approaches and 24 m for far-side approaches. In contrast, in half of the obstructed CCCscp

Table 1: Car-to-car crossing scenarios with straight crossing paths (CCCscp); solid arrowhead denotes VUT, open arrowhead denotes GVT; novel scenarios in boldface

Pictogram	Description	Abbreviation	Count	Video IDs
	Car-to-car crossing, straight crossing paths, unobstructed	CCCscp (unobstructed)	17	Red-light violation: 249451901, 395995182, 395873175, 395840257, 323825354, 322800636, 171583974, 143182278, 112110791, 80804848, 61444220, 1640694 STOP sign violation: 385076350, 222743627, 395903461 Failure to yield at unsignalized intersection: 396281014, 396039612
	Car-to-car crossing, straight crossing paths, obstructed	CCCscp (obstructed)	12	Red-light violation, static obstruction: 396337273, 121621349, 340670420, 307169552, 246756841 STOP sign violation, static obstruction: 342371666, 129158952, 110421649, 396383695 Failure to yield at unsignalized intersection, static obstruction: 274128997 Failure to yield at unsignalized intersection, right-turning vehicle as obstruction: 109681965, 396271286
	**Car-to-car crossing, straight crossing paths, tightly obstructed, from stop or continuing**	**CCCscp (tightly obstructed)**	12	Red-light violation, near side, vehicles as obstruction: 396273543, 395900418, 396006166, 395852766, 304462542, 301154929, 352481631 Red-light violation, far side, vehicles as obstruction: 229297750, 184991579 Red-light violation, right-turning front obstruction vehicle: 269396870 Unsignalized intersection, static obstruction: 313677005 Unsignalized intersection, failure to yield, vehicles as obstruction: 1613194

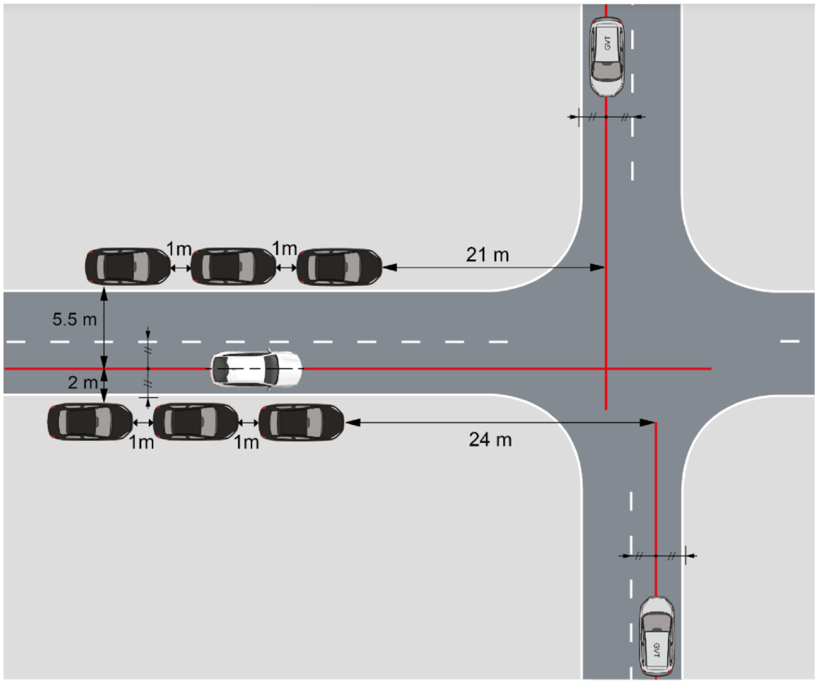


Figure 2: Car-to-car crossing, straight crossing paths (CCCscp) scenarios; reproduced from [14].

collisions observed in the video set, the opening distances are substantially shorter. This is primarily due to dynamic obstructions formed by vehicles queued in left- or right-turn lanes that extend up to the intersection stop line. Moreover, near-side obstructions are frequently located in the left-adjacent travel lane rather than in a curbside parking lane, as assumed in the Euro NCAP scenario.

Figure 3 illustrates a representative example of such tighter obstructions caused by adjacent-lane traffic. Based on these observations, a new CCCscp variant, termed *CCCscp, tightly obstructed*, is proposed and defined in Figure 4. In this variant, the tighter obstructions are created by the red vehicles, and the additional parked vehicles used in the original Euro NCAP configuration for near-side obstruction are not required. Twelve CCCscp collisions (i.e., half of the obstructed cases) fall into this newly proposed variant.

Among CCCscp collisions involving dynamic obstructions, approximately half involve the VUT continuing its approach alongside the obstruction before being struck by the target vehicle, while the remaining cases involve the VUT accelerating from the stop line, as illustrated in Figure 3. All CCCscp collisions at signalized intersections involve a signal violation by one of the vehicles, with 27 instances of red-light running. This represents the most prevalent fault mode across the entire video dataset. At unsignalized intersections, the remaining CCCscp collisions were attributed to failure to stop at a STOP sign (7 instances) or failure to yield (6 instances).

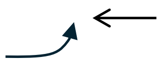
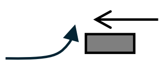
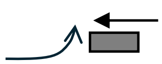
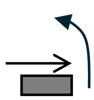
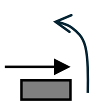
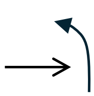
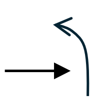
Car-to-Car, Left Turn Across Path Scenarios

Table 2 summarizes the most frequent scenarios involving a left turn across path. The first configuration, Car-to-Car Front, (left) Turn Across Path (CCFtap, aka LTAP/OD), is defined by Euro NCAP and represents a collision in which the vehicle under test (VUT) turns left across the path of an oncoming target vehicle (see Figure 5; ignore the black and yellow vehicles for now). Euro NCAP specifies this scenario without obstructions, and with 19 instances in the dataset, it is the most common left-turning configuration observed.

In the Euro NCAP catalog, the VUT is always assigned the left-turning role, consistent with the normative expectation that the turning driver should yield to oncoming traffic. However, it may also be argued that the oncoming vehicle has a duty to brake once it becomes evident that the turning vehicle will not yield or is braking insufficiently. To account for this, a symmetric variant is proposed in which the VUT plays the oncoming-vehicle role. All videos listed under CCFtap can instantiate either interpretation, since the same collision can be reenacted with the VUT in the turning or the oncoming role.

Analogous to the CCCscp scenarios, CCFtap also occurs with visibility obstructions, although the current Euro NCAP

Table 2: Most frequent car-to-car scenarios with left turn (LT) across path (CCFtap, CCCltal); solid arrowhead denotes VUT, open arrowhead denotes GVT; novel scenarios in boldface

Pictogram	Description	Abbreviation	Count	Video IDs
	Car-to-car front, (left) turn across path	CCFtap	19	Signalized intersection, LT vehicle fails to yield: 396193436, 396035594, 396342461, 396010965, 395802391, 395783668, 382181347, 370601584, 310594839, 298978013, 286733356, 66269587, 285555578, 296151 Signalized intersection, oncoming vehicle violates red light: 341701614, 333782027, 97916444 Unsignalized intersection, LT vehicle fails to yield: 358705892, 395906423
	**As above (symmetric)**	**CCFtap (symmetric)**		
	**Car-to-car front, (left) turn across path, obstructed**	**CCFtap (obstructed)**	9	Signalized intersection, LT vehicle fails to yield, obstruction at stop line: 396041909, 356005965, 293041814, 396230678 Signalized intersection, LT vehicle fails to yield, obstruction within intersection: 395971190, 395981095, 140276860 Signalized intersection, oncoming vehicle violates red light, obstruction at stop line: 396111185, 297925528
	**As above (symmetric)**	**CCFtap (obstructed, symmetric)**		
	**Car-to-car crossing, left turn across straight from left, obstructed**	**CCCltal (obstructed)**	5	Signalized intersection, LT vehicle violates red light, static obstruction: 332038196, 395851476 Signalized intersection, oncoming vehicle violates red light, static obstruction: 12356789, 270838274 Unsignalized T-intersection, LT vehicle fails to yield, static obstruction: 396005602
	**As above, symmetric**	**CCCltal (obstructed, symmetric)**		
	**Car-to-car crossing, left turn across straight from left**	**CCCltal**	3	Unsignalized T-intersection, LT vehicle fails to yield: 182447347, 172611881, 299697104
	**As above (symmetric)**	**CCCltal (symmetric)**		

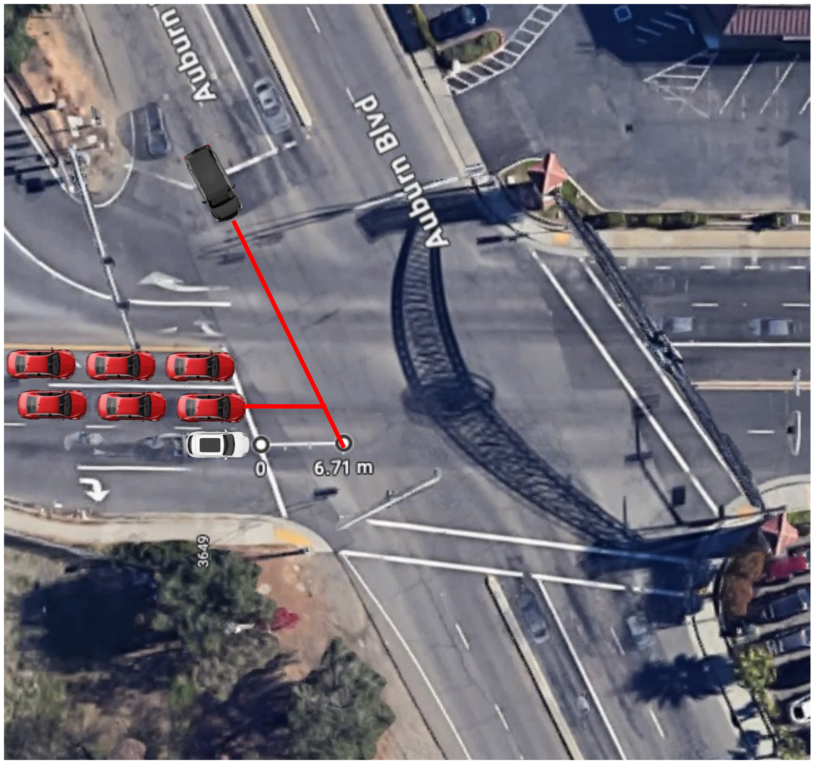


Figure 3: Three-vehicle collision ID 396273543, at the signalized intersection of Fulton Ave and Auburn Blvd in Sacramento, California, is an instance of car-to-car crossing, straight crossing paths (CCCscp), near side, tightly obstructed. The black vehicle runs a red light, while the white vehicle and one of the red ones start driving from the stop line.

catalog does not include such variants. Figure 6 shows an example involving a dynamic obstruction created by a school bus waiting in the intersection to turn left. The oncoming vehicle does not perceive the left-turning vehicle until it emerges from behind the obstruction, leaving insufficient reaction distance; see Figure 7 for the video keyframes of the collision recording. A corresponding *CCFtap, obstructed* scenario is defined in Figure 5, and a symmetric counterpart is also defined by switching the VUT and GVT roles.

Figure 6 additionally overlays the standard Euro NCAP intersection geometry onto the physical intersection. The example corresponds to a multi-lane, signalized urban junction with dedicated left- and right-turn lanes, a layout common in the United States and Canada. The Euro NCAP approach geometry and the standard lane width of 3.5–3.75 m largely align with the physical lanes. However, the physical distance from stop line to stop line (approximately 40 m) is considerably larger than in the Euro NCAP template. In the illustrated collision configuration (Figure 6), the left-turning vehicle and the nearest school bus are positioned as in the video (Figure 7), producing an approximate 10 m gap between them. This configuration is designated *CCFtap, obstructed, within intersection*. Had the obstructing bus been stopped at the opposite-direction stop line, adjacent to the oncoming lane, it would be approximately 40 m from the turning vehicle—corresponding to *CCFtap, obstructed, at stop line*, also illustrated with the second school bus positioned further to the right in Figure 5.

The dataset contains nine instances of obstructed CCFtap: three *within-intersection* and six *at-stop-line*, all at signalized intersections. Seven of these involve failure to yield by the turning vehicle, and two involve a red-signal violation by the oncoming vehicle.

The final configuration in Table 2 is Car-to-Car Crossing, Left Turn Across Straight-From-Left (CCCltal; aka turn into opposite directions—turning left [29] or left turn across lateral traffic [20]), in obstructed and unobstructed forms. The obstructed variant appears five times in the dataset, four of these at signalized intersections and necessarily involving a red-signal violation by either the turning vehicle or the straight-travelling vehicle. The unobstructed variant appears three times, all at unsignalized T-intersections, where a vehicle turns left from a minor leg across near-side main-road traffic traveling at higher speed. CCCltal is closely related to CCCscp, because the turning vehicle initially proceeds

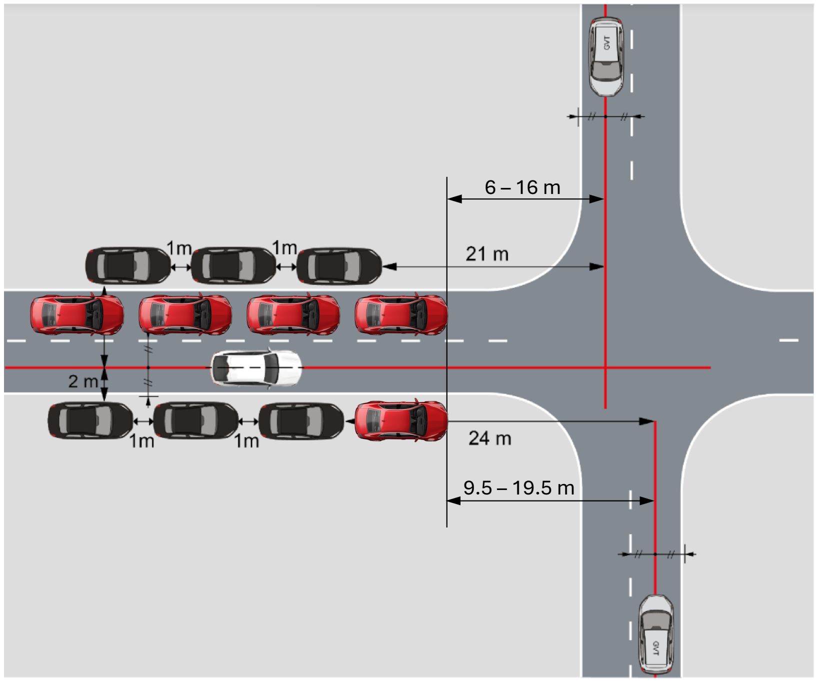


Figure 4: Car-to-car crossing, straight crossing paths, near side, tightly obstructed (new scenario).

straight toward the conflict point. For wide multi-lane approaches, the two configurations may be indistinguishable in practice (e.g., see video ID 12356789). Consequently, execution of CCCscp scenarios may provide partial test coverage for CCCltal.

The Remaining Car-to-Car Scenarios

Table 3 summarizes the remaining car-to-car collision scenarios identified in the video dataset. These configurations occur infrequently and collectively represent a small portion of the sample. The table contains one existing Euro NCAP scenario—Car-to-Car Rear, stationary (CCRs)—which appears when an approaching vehicle rear-ends a vehicle waiting in a queue at an intersection (three occurrences). The table also lists four newly observed scenarios (or eight when considering their symmetric variants):

1. *Car-to-Car Crossing, Left Turn Across Same Direction (CCCltas; aka turn across path: initial same directions—turning left [29])*: This scenario occurs when a vehicle performs an illegal left or U-turn across an adjacent, same-direction through lane (three occurrences), or when a straight-moving vehicle illegally overtakes a left-turning

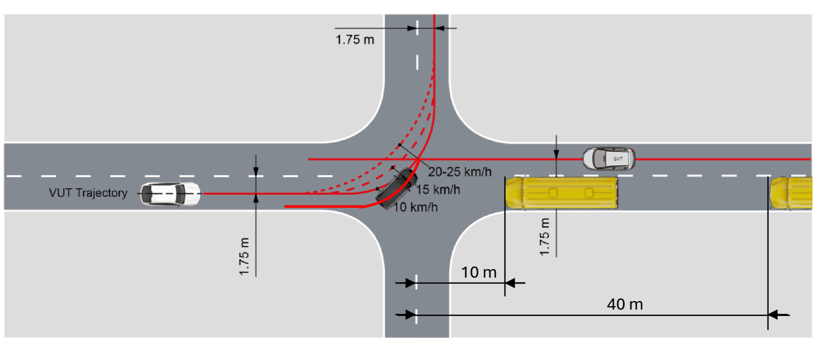
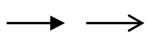
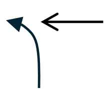
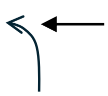
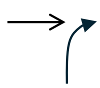
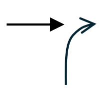


Figure 5: Car-to-car front, (left) turn across path (CCFtap) [14]; obstructed variant (with school bus) is new. The black car illustrates the position and trajectory of the VUT that is consistent with the left-turning vehicle in Figure 6.

Table 3: Additional car-to-car crossing, rear, and merge scenarios;
solid arrowhead denotes VUT, open arrowhead denotes GVT; new scenarios in boldface

Pictogram	Description	Abbreviation	Count	Video IDs
	**Car-to-car crossing, left turn across same direction**	**CCCltas**	4	Signalized intersection, illegal U-turn from right lane: 344199121 Signalized intersection, red light violation and failure to yield to bus in bus lane: 396035410 Unsignalized intersection, illegal LT from right lane: 396322650 Unsignalized intersection, illegal overtaking at intersection: 395902975
	**As above, symmetric**	**CCCltas (symmetric)**		
	Car-to-car rear, stationary	CCRs	3	Unsignalized intersection: 180435707, 24058909, 289248676
	**Car-to-car merge, left turn into straight path**	**CCMltip**	3	Signalized intersection, LT vehicle violates red light: 396043342 Signalized intersection, oncoming vehicle violates red light: 396432874 Unsignalized intersection, LT vehicle fails to yield: 228640107
	**As above, symmetric**	**CCMltip (symmetric)**		
	**Car-to-car merge, right turn into straight path**	**CCMrtip**	2	Signalized intersection, RT vehicle fails to yield to oncoming truck: 934414 Unsignalized intersection, RT vehicle fails to yield: 396018123
	**As above, symmetric**	**CCMrtip (symmetric)**		
	**Car-to-car crossing, right turn across same direction**	**CCCrtas**	2	Unsignalized intersection, illegal RT: 396337456, 1497122
	**As above, symmetric**	**CCCrtas (symmetric)**		

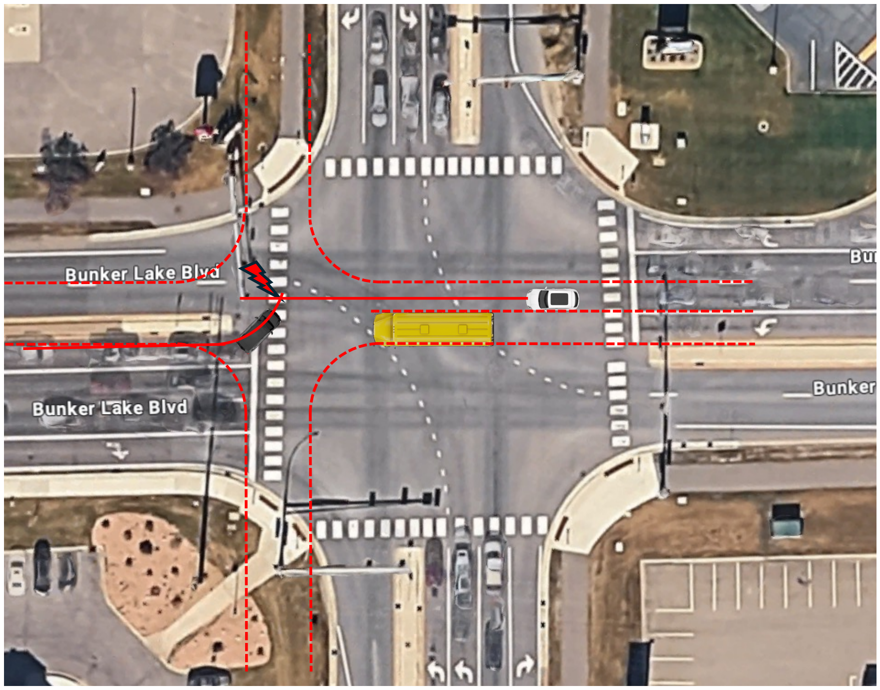


Figure 6: Two-vehicle collision ID 395971190, at the signalized intersection of Bunker Lake Blvd and St Francis Blvd in Ramsey, Minneapolis, is an instance of car-to-car front, (left) turn across path (CCFtap), near side, tightly obstructed. The oncoming white vehicle has green light, the black vehicle turns left and fails to yield, while the school bus waits within the intersection to turn left and obstructs the view mutually between the conflicting vehicles. The outline of the standard Euro NCAP intersection from Figure 5 is overlayed in red.

vehicle at the intersection (one occurrence). A left-turning vehicle would benefit from blind-spot-monitoring capability to detect the presence of the adjacent through-moving vehicle. This configuration is atypical for AEB evaluation because intervention could involve braking or steering. The symmetric scenario, however, is suitable for AEB testing. CCCltas shares some conceptual similarity with the Euro NCAP "cut-in" scenario [30], although the cut-in is intended for adaptive-cruise-control evaluation rather than collision-avoidance assessment.

2. *Car-to-Car Crossing, Right Turn Across Same Direction (CCCrtas)*: This is the right-turn counterpart to CCCltas and was observed twice in the dataset.

3. *Car-to-Car Merge, Left Turn Into Path (CCMltip; aka turn into same direction—turning left [29])*: This configuration occurs when a vehicle turns left and merges into the path of a through-travelling vehicle approaching from the right, leaving an insufficient temporal or spatial gap (two occurrences). The scenario has partial conceptual overlap with CCR-moving [14], although dedicated evaluation of this merge-type interaction may be warranted.

4. *Car-to-Car Merge, Right Turn Into Path (CCMrtip)*: This is the right-turn analogue of CCMltip (two occurrences), with similar implications for AEB relevance and potential testing considerations.

Car-to-VRU Scenarios

Table 4 summarizes the nine collision scenarios involving vulnerable road users (VRUs) represented in the dataset. All but one correspond to existing Euro NCAP scenario definitions [14]. Notably, the single occurrence of the CPNCO scenario involves a pedestrian in a wheelchair rather than a child; however, in both cases the low profile of the VRU and full occlusion by the obstructing vehicle play a critical role. This observation suggests that dedicated pedestrian-in-wheelchair targets may warrant explicit testing.

The only newly identified scenario is CMMrtip, which mirrors the earlier CCMrtip configuration but involves a motorcycle as the target VRU instead of a passenger vehicle.

Table 4: Car-to-VRU scenarios;
solid arrowhead denotes VUT, open arrowhead and dashed arrow denote VRU target;
new scenarios in boldface

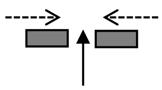
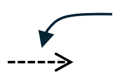
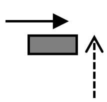
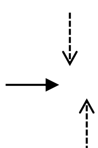
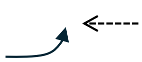
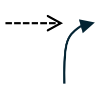
Pictogram	Description	Abbreviation	Count	Video IDs
	Car-to-bicyclist crossing	CBC	4	Signalized intersection, bicycle violates red light: 396001460, 396024604 Signalized intersection, e-scooter violates red light: 396260243, 396012482
	Car-to-pedestrian turning, adult, far-side turn	CPTAfo	1	Signalized intersection, vehicle turning left on green light fails to yield to pedestrian in crosswalk: 258774688
	Car-to-pedestrian nearside child obstructed	CPNCO	1	Unsignalized intersection, car violates red light and collides with pedestrian in wheelchair: 396021185
	Car-to-motorcyclist crossing, straight crossing paths, unobstructed	CMCscp (unobstructed)	1	Unsignalized intersection, car fails to yield: 161389807
	Car-to-motorcyclist front, (left) turn across path	CMFtap	1	Signalized intersection, LT car fails to yield: 395801572
	**Car-to-motorcyclist merge, right turn into straight path**	**CMMrtip**	1	Signalized intersection, RT car fails to yield: 292975431

Figure 7: Key frames from the video of the two-vehicle collision ID 395971190 from Figure 7.

DISCUSSION

The most frequent severe intersection-related collisions in North America involve straight crossing paths (CCCscp) and left turns across oncoming traffic (CCFtap), with left turns across traffic from the left (CCCltal) representing the third most frequent—though far less common—configuration. Between 1997 and 2004, among the 11,571 fatal two-vehicle collisions at signalized intersections each year, on average, the proportions of CCCscp, CCFtap, and CCCltal were 43%, 31%, and 11%, respectively [20]. Over the same period, in the 20,732 fatal two-vehicle collisions at stop-sign-controlled intersections each year, the corresponding proportions were 70%, 1%, and 17% [20]. Left turns into a straight path (CCMltip) and right turns into a straight path (CCMrtip) each accounted for 1% or less at either intersection type, and rear-end collisions (CCR) accounted for 7% at signalized and 1% at stop-sign-controlled intersections.

Canadian data reflect the same dominant patterns [4]. Between 1999 and 2023, the proportions of CCCscp, CCFtap, and CCR among all fatal collisions involving two or more vehicles at signalized intersections were 40%, 20%, and 8%, respectively; at stop-sign-controlled intersections, the corresponding proportions were 74%, 6%, and 1.5%. These data underscore the importance of addressing CCCscp, CCFtap, and CCCltal configurations in intersection-related collision-avoidance testing.

For comparison, in the present video dataset, the proportions of CCCscp, CCFtap, and CCCltal crashes at signalized intersections with two or more vehicles were 44%, 42%, and 6%, and at unsignalized intersections were 48%, 7%, and 14%. These proportions are broadly consistent with the frequency rankings in national crash data. The videos, however, do not represent the highest-severity collisions. Uploaders occasionally commented on injuries, but such information is incomplete and potentially unreliable. No fatalities were reported; five collisions led to hospitalizations, with additional three with minor injuries noted.

The video dataset analysis highlights the importance of visibility obstruction as a defining factor in real-world intersection crashes—information that is absent or largely incomplete in public crash databases like CISS in the U.S. or the National Collision Database in Canada. More than half of the straight crossing-path (CCCscp) collisions in the video dataset involved static or dynamic obstructions, and half of those obstructed cases exhibited *tightly obstructed* conditions with substantially shorter opening distances than assumed in current Euro NCAP configurations. This suggests that refining CCCscp to reflect more constrained line-of-sight conditions may improve the realism of test coverage. A similar observation applies to the left-turn-across-path configurations (CCFtap), for which the current catalog specifies only unobstructed variants. The video evidence indicates that obstructed left-turn crashes are common, and that incorporating obstructed variants would better reflect real-world crash mechanisms.

Interestingly, the NHTSA pre-crash typology report [18] provides statistics on visual obstruction for several intersection scenarios, estimating unobstructed versus obstructed status at 72% vs. 4% for stop-sign running, 71% vs. 3% for red-light running, 87% vs. 1% for LTAP/OD (CCFtap) at signalized intersections, and 58% vs. 16% for LTAP/OD at unsignalized intersections (with the remainder in each case coded as unknown). However, these percentages almost certainly underreport dynamic obstructions created by other road users in traffic.

A second proposed extension concerns scenario symmetry. The present Euro NCAP definition of CCFtap assigns the left-turning role exclusively to the VUT, implicitly assuming that the critical responsibility lies with the turning driver. In practice, however, an oncoming driver may be required to brake once it becomes apparent that the turning vehicle will not yield. Supporting a symmetric version of CCFtap would therefore allow evaluation of collision-avoidance behavior from both perspectives.

Some additional configurations observed in the dataset may already receive partial test coverage. For example, the CCCltal configuration (left turn across straight from the left) is often indistinguishable, or nearly indistinguishable, from CCCscp when the conflict occurs at wide, multi-lane intersections. In such cases, dedicated test development may not be necessary. In the video dataset, two instances of CCCltal are effectively indistinguishable from CCCscp because the turning vehicle enters a wide, divided roadway (ID 12356789) or a wide, multi-lane roadway (ID 270838274). Four further cases become slightly oblique but remain very close to CCCscp due to wide roadways and the approach trajectories (332038196, 395851476, 182447347, 172611881). Only two instances are meaningfully different—nearly head-on—because they occur on narrow roads where the turning vehicle cuts the corner or overtakes a parked vehicle near the intersection (299697104 and 396005602). Notably, the majority of the CCCltal scenarios involved a visual obstruction.

Other newly observed scenarios—such as CCCltas/rtas or CCMltip/rtip and their motorcycle analogues—occurred infrequently and may require additional data to assess their relevance, benefit, and prioritization for future NCAP development.

Future work should extend this analysis to larger video samples, incorporate detailed reconstruction of geometry and dynamics, quantify collision severity, and link the observed configurations to more granular crash statistics in the United States and Canada. Such integration would enable more comprehensive test-scenario design and a more systematic assessment of potential safety benefit, allowing new test cases to be prioritized based on their real-world harm-reduction potential rather than occurrence frequency alone.

LIMITATIONS

This study has several limitations. First, the sample consists of only 100 intersection-related collisions and therefore may not capture the full diversity of roadway, traffic, behavioral, and environmental conditions. As a result, the findings may not generalize beyond the observed sample. Second, the use of an online video repository introduces potential selection biases. It is unclear what systematic factors influence which crashes are uploaded; for example, severe collisions involving fatalities are likely underrepresented.

Third, the recordings lack a full 360-degree field of view and their camera perspectives differ from those of the involved drivers. The restricted camera perspective may omit critical information about conflicting vehicles, signal states, additional obstructions, or evasive maneuvers, and can introduce uncertainty in reconstructing dynamics and interpreting causal factors. Some collisions are captured from a third-person viewpoint (e.g., doorbell or infrastructure cameras, or a dashcam mounted on a vehicle not directly involved in the collision), making it more difficult to assess potential visual obstructions compared with first-person recordings. Even in the latter case, a dashcam viewpoint does not coincide with the eye position of the driver involved in a collision, further limiting the fidelity of visibility assessment.

Fourth, although some videos include anecdotal statements about injury outcomes, these reports are unverified and cannot be used to reliably infer severity.

Finally, the present analysis is primarily visual and qualitative. While precise geolocation was possible for most videos, only occasional map analysis was conducted. Future work could exploit geolocation more systematically to extract road geometry, reconstruct trajectories and speed profiles, and estimate actual and potential delta V for risk assessment.

CONCLUSIONS

This work examined 100 real-world intersection collision videos from the United States and Canada to assess the coverage of current Euro NCAP intersection scenarios and to identify potential extensions. The analysis shows that a large share of crashes correspond to straight crossing-path (CCCscp) and left-turn-across-path (CCFtap) configurations, but that real-world instances frequently involve visibility obstructions not represented in current test definitions. More than half of the CCCscp crashes involved static or dynamic obstructions, and half of these were tightly obstructed, with substantially shorter opening distances than assumed in the Euro NCAP setup. Left-turn-across-path crashes also commonly exhibited obstruction, suggesting the need to add obstructed CCFtap variants to the current testing protocols. The findings further motivate supporting symmetric CCFtap roles so that intervention performance may be evaluated from both the turning and the oncoming-vehicle perspective.

Several additional configurations were identified, including CCCltal cases that may be adequately covered by CCCscp, and low-frequency scenarios such as CCCltas/rtas or CCMltip/rtip (and corresponding motorcycle variants), which merit further investigation before prioritization as standalone tests.

Overall, the results indicate that

1. tightening obstruction geometry for CCCscp,
2. adding obstruction to CCFtap, and
3. considering symmetric role assignment to CCFtap

may strengthen the realism and safety relevance of future NCAP intersection protocols.

Future work should expand the dataset, quantify severity, and integrate crash-reporting statistics to assess potential safety benefit. Detailed reconstruction of road geometry, trajectories, and delta V would enable a more rigorous evaluation of collision dynamics and support prioritization of new scenarios based on real-world harm reduction.

ACKNOWLEDGMENTS

The author would like to thank Dr. Michal Antkiewicz for his comments on an earlier draft of the paper. This research was supported through Transport Canada's Enhanced Road Safety Transfer Payment Program.

REFERENCES

[1] Eun-Ha Choi. *Crash Factors in Intersection-Related Crashes: An On-Scene Perspective*. DOT HS 811 366. Technical report analyzing intersection-related crashes using the National Motor Vehicle Crash Causation Survey. Washington, DC: National Highway Traffic Safety Administration, U.S. Department of Transportation, 2010. URL: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811366.

[2] National Highway Traffic Safety Administration. *Fatality Analysis Reporting System Analytical User's Manual, 1975–2021*. DOT HS 813 417. Government Database. Washington, DC: National Highway Traffic Safety Administration, U.S. Department of Transportation, Apr. 2023. URL: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813417.

[3] L. Blincoe. *The Economic and Societal Impact of Motor Vehicle Crashes, 2019*. DOT HS 813 403. Technical Report. Washington, DC: National Highway Traffic Safety Administration, U.S. Department of Transportation, Feb. 2023. URL: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813403.

[4] Transport Canada. *National Collision Database (NCDB)*. https://wwwapps2.tc.gc.ca/saf-sec-sur/7/ncdb-bndc/p.aspx?l=en. Accessed: 2025-12-20. 2025.

[5] Euro NCAP. *Euro New Car Assessment Programme*. https://www.euroncap.com. Accessed: 2025-12-19. 2025.

[6] *GIDAS – German In-Depth Accident Study*. Bundesanstalt für Straßenwesen and Forschungsvereinigung Automobiltechnik e.V. In-depth traffic accident investigation program in Germany. URL: https://www.gidas.org.

[7] National Highway Traffic Safety Administration. *CISS 2020 Coding Manual*. DOT HS 813 221. Government Database. Washington, DC: National Highway Traffic Safety Administration, U.S. Department of Transportation, Jan. 2022. URL: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813221.

[8] ViralHog. *ViralHog – Viral Footage from Users Around the World*. https://viralhog.com. Accessed: 2025-12-19. 2025.

[9] L. L. Hershman. "The US New Car Assessment Program (NCAP): Past, Present and Future". In: *Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles (ESV)*. Amsterdam, The Netherlands, 2001.

[10] Michiel van Ratingen, Aled Williams, Anders Lie, Andre Seeck, Pierre Castaing, Reinhard Kolke, Guido Adriaenssens, and Andrew Miller. "The European New Car Assessment Programme: A historical review". In: *Chinese Journal of Traumatology* 19.2 (2016), pp. 63–69. DOI: 10.1016/j.cjtee.2015.11.016. URL: https://www.sciencedirect.com/science/article/pii/S1008127516000110.

[11] Richard Schram. “Euro NCAP’s First Step Towards Scenario-Based Assessment by Combining Autonomous Emergency Braking and Autonomous Emergency Steering”. In: *Proceedings of the 26th International Technical Conference on the Enhanced Safety of Vehicles (ESV)*. Paper No. 19-0128. Eindhoven, The Netherlands: NHTSA, 2019. URL: https://www-nrd.nhtsa.dot.gov/pdf/ESV/Proceedings/26/26ESV-000182.pdf.

[12] Euro NCAP. *Euro NCAP Advanced Assessment Protocol V2.0*. https://cdn.euroncap.com/media/39217/euro-ncap-advanced-assessment-protocol-v20.pdf. Accessed: 2025-12-19. 2012.

[13] Euro NCAP. *Euro NCAP Protocol — Crash Avoidance — Low Speed Collisions Version 1.1*. https://www.euroncap.com/media/91777/euro-ncap-protocol-crash-avoidance-low-speed-collisions-v11.pdf. Protocol document; implementation January 2026. Oct. 2025.

[14] Euro NCAP. *Euro NCAP Protocol – Crash Avoidance – Frontal Collisions Version 1.1*. https://www.euroncap.com/media/91710/euro-ncap-protocol-crash-avoidance-frontal-collisions-v11.pdf. Protocol document, implementation January 2026. Oct. 2025.

[15] National Highway Traffic Safety Administration. *NCAP Final Decision Notice – Advanced Driver Assistance Systems Roadmap*. Technical Report. Accessed: 2025-12-19. National Highway Traffic Safety Administration, U.S. Department of Transportation, Nov. 2024. URL: https://www.nhtsa.gov/sites/nhtsa.gov/files/2024-11/NCAP-Final-Decision-Notice-Advanced-Driver-Assistance-Systems-Roadmap-11182024-web.pdf.

[16] Code of Federal Regulations. *49 CFR § 571.127 – Standard No. 127; Automatic Emergency Braking Systems for Light Vehicles*. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-571/subpart-B/section-571.127. Accessed: 2025-12-19. 2025.

[17] National Highway Traffic Safety Administration. *Final Rule — Automatic Emergency Braking Systems for Light Vehicles*. Technical Report. Accessed: 2025-12-19. National Highway Traffic Safety Administration, U.S. Department of Transportation, Apr. 2024. URL: https://www.nhtsa.gov/sites/nhtsa.gov/files/2024-04/final-rule-automatic-emergency-braking-systems-light-vehicles_web-version.pdf.

[18] W. Najm, J. Smith, and M. Yanagisawa. *Pre-Crash Scenario Typology for Crash Avoidance Research*. Tech. rep. DOT-VNTSC-NHTSA-06-02. Washington, DC: National Highway Traffic Safety Administration, Apr. 2007.

[19] National Center for Statistics and Analysis. *National Automotive Sampling System (NASS) General Estimates System (GES) Analytical User’s Manual 1988–2004*. Tech. rep. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2005.

[20] Rajesh Subramanian and Louis Lombardo. *Analysis of Fatal Motor Vehicle Traffic Crashes and Fatalities at Intersections, 1997 to 2004*. DOT HS 810 682. Traffic Safety Facts Research Note. Washington, DC: National Highway Traffic Safety Administration, 2007. URL: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/810682.

[21] L. Garrett Bangert, Theodore Lubash, John M. Scanlon, Kristofer D. Kusano, and Luke E. Riexinger. “Determination of functional scenarios for intersection collisions”. In: *Accident Analysis Prevention* 193 (2023), p. 107326. ISSN: 0001-4575. DOI: https://doi.org/10.1016/j.aap.2023.107326. URL: https://www.sciencedirect.com/science/article/pii/S0001457523003731.

[22] Di Pan, Yong Han, Qianqian Jin, He Wu, and Hongwu Huang. “Study of typical electric two-wheelers pre-crash scenarios using K-medoids clustering methodology based on video recordings in China”. In: *Accident Analysis Prevention* 160 (2021), p. 106320. ISSN: 0001-4575. DOI: https://doi.org/10.1016/j.aap.2021.106320. URL: https://www.sciencedirect.com/science/article/pii/S0001457521003511.

[23] Shishu Zhao, Yang Liu, Shuai Zhang, Zhiyu Wang, Qing Li, Hongtao Zhai, and Yanchen Li. “Research on AEB Car-to-Car Test Scenario in Intersection”. In: *Proceedings of SPIE, Volume 13018 – International Conference on Smart Transportation and City Engineering (STCE 2023)*. 2024, 130185P. DOI: 10.1117/12.3023994. URL: https://doi.org/10.1117/12.3023994.

[24] Maya Afilalo and AutoInsurance.com Staff. *Dash Cam Usage Report: 30% of U.S. Drivers Use Dash Cams, Millions More Plan to Purchase*. Oct. 2025. URL: https://www.autoinsurance.com/research/dash-cam-usage-report/ (visited on 12/07/2025).

[25] Olivia Bush. *Dashcam Statistics in Canada*. Oct. 2024. URL: https://madeinca.ca/dashcam-statistics-canada/ (visited on 12/07/2025).

[26] Sangkeun Park, Joohyun Kim, Rabeb Mizouni, and Uichin Lee. “Motives and Concerns of Dashcam Video Sharing”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. 2016, pp. 4759–4769. DOI: 10.1145/2858036.2858581. URL: https://dl.acm.org/doi/10.1145/2858036.2858581.

[27] E. Giovannini, A. Giorgetti, G. Pelletti, A. Giusti, M. Garagnani, J. P. Pascali, S. Pelotti, and P. Fais. “Importance of dashboard camera (Dash Cam) analysis in fatal vehicle–pedestrian crash reconstruction”. In: *Forensic Science, Medicine and Pathology* 17.3 (2021), pp. 379–387. DOI: 10.1007/s12024-021-00382-0. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8413177/.

[28] Micha l Mariusz Abramowski and Andrzej Reński. “Analysis of video recordings in accident reconstruction”. In: *Archives of Transport* 69.1 (2024), pp. 127–143. doi: 10.61089/xvvscd77. url: https://www.archivesoftransport.com/index.php/aot/article/view/19.

[29] National Highway Traffic Safety Administration. *2021 FARS/CRSS Coding and Validation Manual*. https://downloads.regulations.gov/FMCSA-2022-0003-0185/attachment_1.pdf. Report No. DOT HS 813 426. 2023.

[30] Euro NCAP. *Euro NCAP Protocol — Safe Driving and Vehicle Assistance Version 1.1*. https://www.euroncap.com/media/91705/euro-ncap-protocol-safe-driving-vehicle-assistance-v11.pdf. Accessed: 2025-12-19. Oct. 2025.