FRAMEWORK FOR A CONFLICT TYPOLOGY INCLUDING CONTRIBUTING FACTORS FOR USE IN ADS SAFETY EVALUATION

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ABSTRACT

The aim of a successful conflict typology (also sometimes called crash or maneuver typology) is to group conflicts, some of which may result in a collision, into groups that have common characteristics influencing avoidability and potential severity. A conflict typology can be used in safety impact methodologies that analyze and predict the potential performance of a safety countermeasure or system within a set of defined crash modes. More generally, conflict typologies are used across many traffic safety analyses, including those related to evaluating the safety of an Automated Driving System (ADS). The objective of this paper was to describe a conflict typology including contributing factors that can be used in both Automated Driving System (ADS) and human driven vehicle safety evaluations. The proposed typology is comprised of 5 layers: (1) conflict partners - the types of the actors or objects involved in a conflict, (2) conflict group - the high-level description of a conflict, (3) conflict perspective - assigned to each actor based on their relative maneuvering, (4) the actor role - either the initiator of some surprising action that leads to a conflict or the responder, and (5) contributing factors - factors that in combination contributed to the conflict initiating or non-nominal response that caused the conflict. The main contribution of the proposed conflict typology and contributing factors are applicable conflicts from both retrospective crash data and near-crashes from a naturalistic driving study (NDS), and in the future ADS conflicts. The results also highlight potential difficulties reconciling differences in contributing factors observed in high-severity crash data having limited contributing factor information and those contributing factors observed in lower severity NDS data.

Keywords: Conflict Typology, Contributing Factors, Automated Driving Systems

INTRODUCTION

Conflict typologies, which have also been called crash groups or scenario typology [1], are an essential tool used by traffic safety practitioners to analyze collision data and study the potential effectiveness of proposed countermeasures and systems, such as Advanced Driver Assistance Systems, or other safety systems like Automated Driving Systems (ADS). Traditionally, this has been accomplished by describing the collision geometry, pre-collision maneuvers, and collision actors. Once these crash types are established, different characteristics of the collisions can be compared, such as environmental factors or driver characteristics [2].
Analyzing crash data by first grouping by collision type is necessary, as different collision types often have heterogeneity in their causes, referred to as horizontal heterogeneity (as opposed to vertical heterogeneity in different severity of collisions) [3]. By identifying the characteristics and causes of collisions, traffic safety professionals can investigate countermeasures (directly linked to the causation of the event) that strive to reduce and mitigate collisions. One example of this type of study in vehicle technology is the prospective safety assessment, where the potential benefit of a proposed vehicle safety system, like automated emergency braking, is projected into

the future [4 - 14]. Historical crash databases, such as NHTSA's CRSS, FARS, and CISS databases, have relied on a more general description of the collision geometry and involved partners to describe various conflict types. Relying on these general categorical elements is convenient and practical, as they do provide meaningful context about the nature of the collision event and the information can be generally identifiable using retrospective crash investigation (such as through analyzing on-scene evidence and taking witness statements). However, within each one of these permutations, there is considerable uncertainty as to the nature of the event that affects avoidability and potential severity. For example, in straight crossing path vehicle-to-vehicle collisions, the opportunity for avoidance and injury potential is much different at four-way stop controlled intersections (generally lower travel speeds) when compared to cases involving a red light runner [15].

As different types of naturalistic driving data become more prevalent, from the usage of instrumented vehicles recording driving data for extended periods of time, the typology approach has been extended to use in near-crash, or conflict, events where there is no contact between actors [16]. In this paper and framework, we adopt the definition of a conflict from ISO/TR 21974-1 [17]:

> *Conflict*
> "Situation where the trajectory(ies) of one or more road users or objects (conflict partners) led to one of three results: 1) a crash or road departure, 2) a situation where an evasive maneuver(s) was required to avoid a crash or road departure, or 3) an unsafe proximity between the conflict partners" (ISO/TR 21974-1, [17]).
>
> NOTE 1: Three general classes of traffic conflict are of interest in naturalistic driving analyses: trajectory conflict, single-vehicle conflict, and proximity conflict.

Using the same conflict typology definition between conflicts and collisions allows for studies that attempt to correlate near-crashes to crashes, as crashes are rarely observed in naturalistic driving studies due to their smaller amount of driving compared to police accident report databases [18 - 19]. Additionally, these instrumented vehicles provide meaningful, objective information about the causation of the conflicts/collisions that are often impossible to discern from retrospective crash investigations. Because of this desire to use a common definition between collision and non-collision events, we refer to conflict typologies instead of collision typologies.

As noted above, one of the key areas that conflict typologies are used for is to attempt to understand the causes of collisions so that those causes can be prevented, thus improving traffic safety. Causal relationships between factors in a scenario and the adverse outcomes are becoming ever important in the understanding of how to perform safety assurance for automated vehicles [20]. To avoid confusion with other, more philosophical, definitions of causality, for the rest of this paper we will refer to contributing factors as the factors that in combination contributed to the conflict initiating or non-nominal response that caused the conflict. These contributing factors are a desired property of a conflict typology, but can be difficult to obtain. In retrospective collision databases, some causes are straightforward to extract from the data. For example, if one is studying intersection collisions, a collision database can be queried to determine when drivers perform a traffic control violation that leads to a collision. Due to the retrospective nature of most crash data sources, however, this type of information is considered incomplete and difficult to obtain. For example, distraction or inattention is theorized to be underreported in police accident report data [21]. The possibilities to directly observe driver behavior increase when using naturalistic driving data that often has video recordings of the interior of a vehicle. For example, using the observations of a driver on video, information on the driver's activity (e.g., gaze direction) can be used to infer contributing factors [21].

Selecting the correct level of aggregation or a conflict typology including contributing factors can be challenging as it requires consideration of what is actionable, what can be readily reduced from available data sources, and what will lead to meaningful conclusions in safety impact analysis. In historical, human-driven crash and conflict analysis, naturalistic data enables more detailed inference on driver state and is useful in determining plausible causes for adverse events. The data sources that allow for this level of detail by having video, however, often have far fewer serious collisions in comparison to near-crash events. Representative crash databases selectively target rare, high severity collisions, but lack the level of detail available from naturalistic driving data sources as the information is often collected retrospectively without video data. The introduction of ADS will add to this difficulty in grouping by contributing factors. These ADS are expected to be exposed to other road users exhibiting many of the same failure modes as human road users expose each other to. The ADS could possibly have many of the same failure modes as humans, but the causes for these failures may be vastly different. For example, an ADS may fail to recognize an object, that causes a late response, and a collision or near collision. This late reaction may be similar in nature to a distracted human driver, but an ADS would not react late for using a smartphone or driving under the influence.

The objective of this paper was to describe a conflict typology including contributing factors that can be used in both Automated Driving System (ADS) and human driven vehicle safety evaluation. Because ADS are augmenting or replacing human drivers, the methodology must also be able to equally describe human conflicts recorded in crash databases and naturalistic driving studies. This paper presents the underlying conflict typology structure and motivation, but is not intended to be a full recitation of the entire typology, which is quite extensive and naturally evolves as novel scenarios are encountered. To demonstrate the typology, the typology methodology is also applied to both a national crash database and a limited naturalistic driving study dataset.

METHODOLOGY

Conflict Typology Layers

The conflict typology uses a layered, hierarchical structure to capture unique sets of scenarios from which safety impact evaluation can be performed. The success of the conflict typology as a tool in safety impact evaluation hinges on its ability to adequately cover at least the reasonably foreseeable conflict and collision space. To accomplish this, our approach was to leverage causation, avoidability, and severity potential as foundational principles in designing our bucketing scheme.

Figure 1 shows an illustrative example of the 5 layers of the proposed conflict typology for an example pedestrian straight crossing path conflict. The layers are: (1) conflict partners - the types of actors involved in a conflict, (2) conflict group - the high-level description of a conflict, (3) conflict perspective - assigned to each actor based on their relative maneuvering, (4) the actor role - either the initiator of some surprising action that leads to a conflict or the responder that is exposed to the surprising event, and (5) contributing factors - factors that in combination directly contributed to the event outcome. Each of the first 4 layers will be discussed in detail in this section. The 5th layer, the contributing factors, will be discussed in the following section.

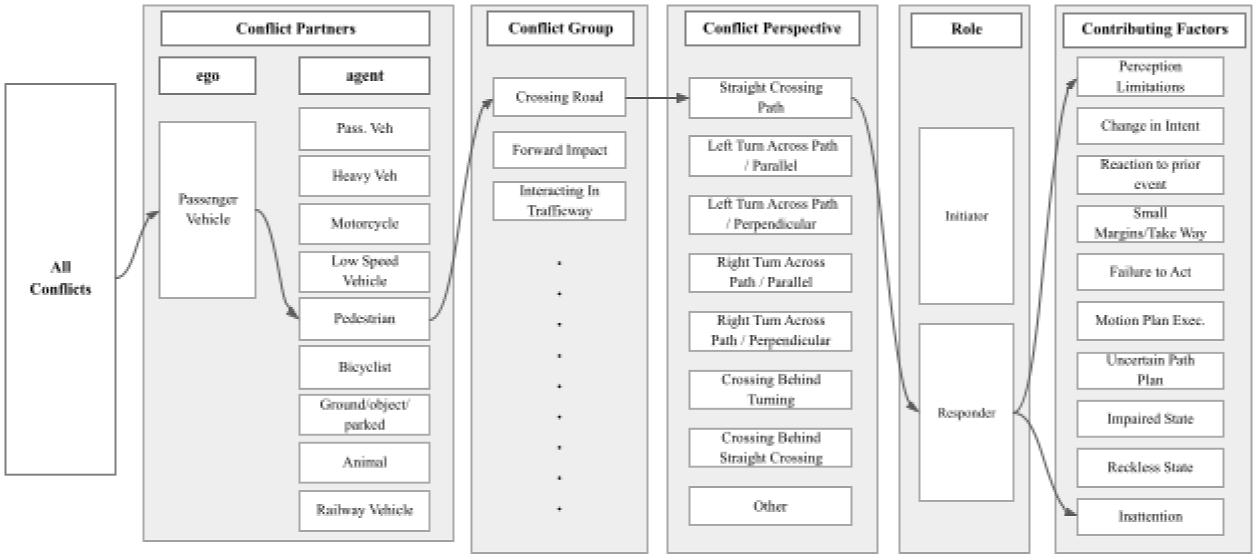


Figure 1. Illustrative example of 5 layers of the conflict typology for a pedestrian straight crossing path conflict.

One important characteristic of the current conflict typology is that a single conflict always involves two partners. One of those partners may be a non-vehicle, such as fixed objects, a road edge or the ground, resulting in what many other typologies refer to as a “single vehicle” conflict type. We find it useful and necessary, however, to retain that all conflicts have exactly two participants (i.e., conflict partners), even if one of those partners is not a road user. A chain of conflicts (each with their own unique conflict type) can occur in succession that can involve more than two parties. This partitioning by conflicts between pairs of actors fits well into the organization of most crash databases, which present collisions as a sequence of events.

Conflict Partners. The collision partners define the type of road users that enter into a conflict. Table 1 describes the collision partners in the conflict typology. The approach for grouping conflict partners was to aggregate road users that have similar maneuver capability and perception qualities. For example, traditional motorcycles and all terrain vehicles often have capabilities to travel at much higher speeds and generally have more maneuverability compared to low speed vehicles such as low powered golf carts. Ambulatory humans, those using wheelchairs, or those using personal means of conveyance have similar perception qualities as pedestrians, although those on personal means of conveyance, such as skateboards, may be able to travel at much higher speeds than ambulatory pedestrians. As this example shows, there can be some variability within conflict partner groups. The analyst may choose to further separate these conflict groups if a particular analysis warrants.

Table 1.
Conflict partners and brief description.

Conflict Partner	Definition
Light vehicle	Sedans, coupes, and station wagons intended to carry passengers and those vehicles pulling light trailers. Additionally includes two-axle, four-tire vehicles, such as pickups and vans.
Heavy vehicle	Buses and other two-plus axle, one-plus unit trucks
Motorcycle	Motorcycles, mopeds, three-wheel motorcycles, all-terrain vehicles, and other recreational vehicles not classified as a low speed vehicle.
Low Speed Vehicle	Powered three-plus wheeled vehicles capable of a maximum speed of less than or equal to 25 mph.
Pedestrian	All non-cyclist human actors, including: ambulatory, wheelchair using (powered and non-powered), and non-ambulatory (e.g., skateboarders)
Bicyclist	Bicyclists, motorized/electric bikes, motorized scooters, and other non-pedestrians on people moving devices that navigate within the flow of all other road user traffic.
Ground/Objects/Parked Vehicle	Contact with the road surface, stationary or moving inanimate objects or structures present, or parked vehicles on or off the trafficway.
Animal	Any living non-human animal variation that may potentially enter a trafficway and poses property damage and/or injury risk.
Railway vehicle	A vehicle that travels on rails.

Conflict Group. The conflict group provides a high-level description of the conflict configuration based on similar geometrical, environmental, and severity related considerations. It describes what the conflict partners were doing just prior to entering the conflict. To adequately describe conflict groups, we will introduce some additional definitions:

> *Trafficway*
> "Any right-of-way designated for moving persons or property from one place to another, including the surface on which vehicles normally travel, plus the shoulders, painted medians, and painted gore areas at grade with the roadway".
>
> NOTE 1: The trafficway also includes parking lanes and parking areas (e.g., parking lots, driveways).
>
> NOTE 2: The trafficway is bound by the outer edges of the shoulder or by raised roadside barriers (e.g., curb, guardrail, pylon) and thus does not include raised medians, grassy medians, sidewalks, etc." (ISO/TR 21974-1, [17])
>
> *Roadway*
> "The portion of a trafficway that is designed and ordinarily used for vehicular travel, including all designated or implied travel lanes (through lanes, turn lanes, acceleration and deceleration lanes), but not

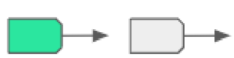
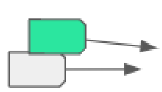
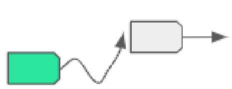
shoulders, painted (whether usable or not), medians of any type, roadsides, gore areas, etc., that are of a similar road surface to the parking lanes, parking areas, or driveways” (ISO/TR 21974-1, [17]).

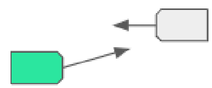
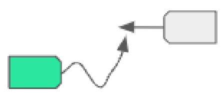
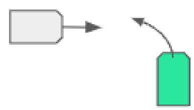
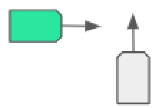
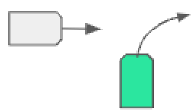
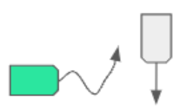
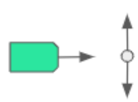
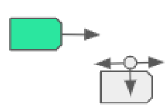
NOTE 1: Some lanes of travel can be partially or fully blocked by parallel parked vehicles during certain times of day. These lanes are part of the roadway when there are no parked vehicles (i.e., traffic is using the lanes) and not part of the roadway when being used as a parallel parking area.

Roadway Actors
A roadway actor is any non-parked stationary or mobile actor that actively navigates along roadways within the flow of vehicle road users. Roadway actors include passenger vehicles, heavy vehicles, motorcycles, low speed vehicles, and cyclists, as defined in the previous section.

An important distinction for the conflict groups is between roadway actors and non-roadway actors. As defined above, roadway actors are using the space dedicated for vehicle traffic. Non-roadway users are traveling in space not dedicated for vehicle traffic, such as sidewalks or unpaved areas adjacent to the road. Conflicts between non-roadway actors with roadway actors can occur when the latter enters the roadway. Pedestrians are most often non-roadway actors, but many actor types can be either roadway actors or non-roadway actors. For example, cyclists, motorcyclists, low speed vehicles, and even motor vehicles can be driving off the roadway (e.g., on a sidewalk) and enter the roadway to be involved in a conflict. For example, a light vehicle driving on a sidewalk into a crosswalk can have many of the same contributing factors as a pedestrian crossing from a sidewalk, and thus it is appropriate to aggregate these types of conflicts together. We use roadway actor to make this distinction to avoid confusion with the term roadway user, which in many other contexts includes all individuals that use the road system, including pedestrians entering the roadway.

Table 2.
Conflict Groups and Short Descriptions. A 🚙 symbol means the conflict group is relevant for conflicts between roadway actors. A 🚶 symbol means the conflict group is relevant for conflicts between a roadway actor and a non-roadway actor.

Conflict Group	**Picture**	**Description**
Single Vehicle (SV) 🚙🚶		Includes all actions (or lack thereof) where the ego vehicle is traveling in a trafficway but then experiences an in-trafficway interaction without a conflict partner (e.g., a rollover event) or an off-trafficway interaction (e.g., a road departure).
Front-to-Rear (F2R) 🚙		Involves one road user interacting with another road user in the same direction and same travel lane.
Same-Direction Lateral Incursion (SDLI) 🚙		Occurs when two roadway actors are traveling in the same trafficway but in initially different travel lanes at the time of the initial interaction due to lateral incursion by some actor.
Same-Direction Prior Circumstances (SDPC) 🚙		Involves two roadway actors operating on the same trafficway in the same direction when one road user performs a lateral evasive action, experiences loss of control, or is involved in a prior collision that results in an interaction with the other road user.

Conflict Group	Picture	Description
Opposite Direction Lateral Incursion (ODLI) 🚙		Occurs when a non-turning actor operating in the trafficway's intended travel direction interacts with another actor that is operating opposite of the travel direction in the same trafficway.
Opposite Direction Prior Circumstances (ODPC) 🚙		Involves two roadway actors traveling in opposite direction trafficways in their respective trafficway's direction of travel when one road user performs a lateral evasive action, experiences loss of control, or is involved in a prior collision that results in an interaction with the other road user.
Turn into Path Opposite Direction (TIPOD) 🚙		Occurs as a result of one actor changing vehicle-operated trafficways via a turning maneuver and interacting with another actor, where one of these actors is operating in the opposite direction of the trafficway's direction of travel.
Intersection Cross Traffic (ICT) 🚙		Involves interactions that occur as a result of both actors changing or crossing over trafficways, and where the two actors cross paths with one another.
Intersection Turn Into Path (ITIP) 🚙		Involves interactions that occur as a result of one of the actors moving on to a trafficway via a turning maneuver into the path of another actor that is operating in the trafficway being turned on to.
Perpendicular Direction Prior Circumstances (PDPC) 🚙		Involves two roadway actors operating on crossing roadways that interact with one another following some lateral evasive action, prior loss of control, or prior collision.
Crossing Road 🚶		Involves interactions between an actor moving along a trafficway and another actor crossing that trafficway (while not traveling along or onto another trafficway).
Forward 🚶		Involves vehicle actors moving in the forward direction and interacting with a non-road user conflict partner in the trafficway that is not attempting to cross the road.
Interacting in Trafficway 🚶		Occurs when a forward moving ego is on a trafficway and interacts with an agent that is in the trafficway and moving around, entering, exiting, or interacting with an immediately adjacent vehicle or object.
Backing 🚙 🚶		Includes all interactions where at least one road user is moving in reverse.
Miscellaneous Circumstances		Events that do not fit into the aforementioned conflict groups, and are intended to cover all abnormal circumstance interactions that pose some collision risk.
Other/Unknown		All remaining events that do not fit into a conflict group, but that may need future considerations and those cases that have insufficient information to adequately determine the conflict group.

Conflict Perspectives. The conflict perspectives are subcategories that belong to the conflict groups described in the previous section. Unlike the conflict group that describes an interaction between one or two actors, conflict perspectives apply to one of the actors in a conflict, and describe the specifics of the maneuvers more granularly. For example, an Intersection Cross Traffic conflict perspective is left turn across path, opposite direction, where one agent is the straight traveling vehicle and the other agent is the left turning vehicle. This current paper will not cover a full suite of conflict perspectives as they are too numerous and evolve as new data is compiled and new analysis is performed.

Conflict Role. A conflict, as defined in this framework, involves either one or two actors. In conflicts between two actors, there is an initiator and a responder role, which are defined in more detail below.

Initiator
The road user in a potential conflict that first initiates a surprising behavior [23] that another road user (the responder) would need to act upon to avoid entering into a conflict. Here we are using surprise to mean a violation of an initial expectation of how a road user should behave given the circumstances.

NOTE 1: The surprising behavior of the initiator may involve both actions (e.g., a lead vehicle braking suddenly) and non-actions (e.g., continuing straight in a turn lane)

NOTE 2: The initiation of a conflict is orthogonal to legal considerations of fault (e.g., in a front-to-rear collision where a lead vehicle brakes suddenly for a child entering the street and is being hit by a tailgating following vehicle, the lead vehicle is the initiator while the legal fault would typically be entirely assigned to the follower).

NOTE 3: Surprise is defined from a third-party perspective, relative to prior expectations produced by a generative model that accurately represents the statistical properties of the traffic environment where the conflict occurs. Thus, surprising behaviors are those that violate the expectations generated by the generative model, irrespective of the surprise actually experienced by the responder or the initiator.

NOTE 4: A road user can play the role of both initiator and responder in a chain of conflicts. For example, consider a scenario where a vehicle A enters the road at an intersection causing a vehicle B to brake which, in turn, causes a vehicle C, which follows B, to brake. Following ISO TR 21974-1 [17], this situation can be divided into two separate conflicts, Conflict 1 (the intersection conflict) and Conflict 2 (the front-to-rear conflict). In Conflict 1, A is the initiator and B the responder. In Conflict 2, B is the initiator and C is the responder. One can also imagine a different scenario where both B and C have to respond to the surprising behavior of A to avoid the conflict. In this case, A is the initiator in both conflicts, B the responder in Conflict 1 and C the responder in Conflict 2.

Responder
The road user in a potential conflict that would be required to act upon a surprising behavior initiated by another road user (the initiator) in order to avoid entering into a conflict.

NOTE: The responder does not necessarily have to exhibit a response for the definition to apply. It suffices that the surprising action of the initiator puts the responder in a situation where they need to respond to avoid entering into a conflict (assuming that the initiator does not take any further evasive action).

Contributing Factors Model of Conflicts

Based on the conflict model presented in the previous section, we aim to develop contributing factors for traffic conflicts based on previous work, in particular Piccinini et al. [22] (but see [24 - 26] for related work). The basic conflict model is presented in Figure 2. In this model, a conflict is the result of a conflict initiating behavior from the initiator, a non-nominal response from the responder, or a combination of both. Examples of conflict initiating behaviors include a vehicle running a red light at an intersection or a pedestrian jaywalking. Examples of non-nominal response behaviors include delayed responses (relative to a reference human reaction model; e.g., [27]) or a complete lack of response.

The goal of the conflict causation analysis is then to identify factors *contributing* to the conflict initiating behavior and/or the non-nominal response. Contributing factors are defined in terms of insufficient and necessary conditions for the observed conflict initiating behavior or non-nominal response to occur. That is, the factor may not by itself have been sufficient to cause the conflict but the conflict would not have occurred if the factor was not present. Factors contributing to conflict initiating behaviors may include surprising or unexpected behaviors from other road users, occlusions or reduced visibility conditions. Non-nominal response is the behavior of the responder that contributes to the responder entering a conflict state, such as a delayed response to initiate avoidance maneuvers or an inappropriate avoidance maneuver. Examples of factors contributing to non-nominal responses include inattention, drowsiness or reduced visibility.

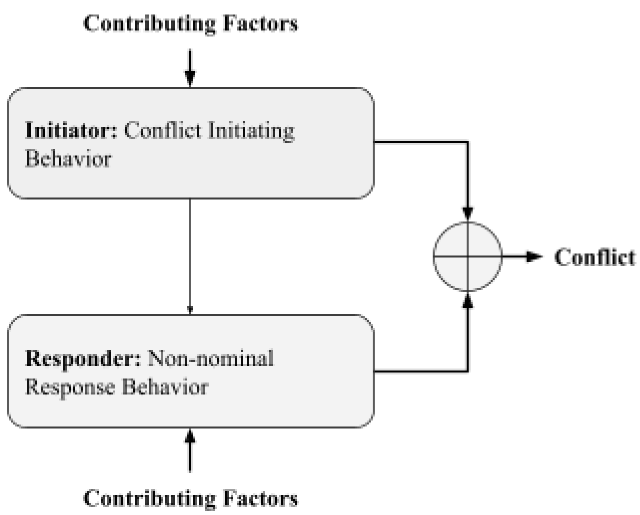


Figure 2. Conflict Model for Contributing Factors.

Assigning contributing factors in crashes is challenging as the number of factors that could be assigned as contributing to an event is potentially infinite. Thus, the assignment of contributing factors always depends on the purpose of the analysis. One could theoretically consider every minutiae of an event, such as prior experiences by actors, demographics-related features, or familiarity with an area. However, such seemingly minor features would end up generating an infinite array of clusters that say little individually about the performance of an ADS. Another difficulty is determining the presence of “internal” cognitive contributing factors. In most crashes, there is no possibility to interview or observe participants to try to determine their thinking or focus prior to a crash. Often, video and recorded vehicle data are the only data sources available. Therefore, to practically assign contributing factors, guidelines must be developed. Two criteria are proposed for identifying case-specific contributing factors to help limit the granularity of the noted factors.

The first criteria is to restrict the contributing factors to physically and easily observable behaviors and environmental features at the time of the event from either ego or agent perspective. This criteria helps classify the events by features that can be readily detected and objectively measured from existing non-ADS data (e.g., conflict and collision data sets) and ADS data.

The second criteria is to only select factors deemed to meet the INUS conditions proposed in the philosophy literature by authors such as J. L. Mackie [28]**.** INUS stands for conditions that are "**i**nsufficient but **n**on-redundant parts of a condition which is itself **u**nnecessary but **s**ufficient for the occurrence of the effect". An example of applying the INUS conditions would be to consider the causes for a house burning to the ground. INUS conditions for this outcome could be a short circuit in wiring in the house, the proximity to flammable materials, and a lack of available firefighters. Many other causes could result in the same outcome (e.g., a meteorite falling on the house), but the lack of any of the aforementioned factors could prevent the outcome from occurring. In the traffic conflict application we are considering here, the contributing factors are things that are necessary to produce an observed conflict-initiating action or response failure that also can meet the first laid out criteria of being externally observable.

Like the conflict groups that can be further decomposed into conflict perspectives, we believe it is useful to have a hierarchical structure for contributing factors. Unlike the conflict groups and perspectives which are mutually exclusive for a given conflict, there can be multiple contributing factors that are present for both the initiator's conflicting initiating behavior and the responder's non-nominal response. One of the difficulties with generalizing previous causal models to use in many conflict types is that they develop sophisticated dependencies between different contributing factors. In this study, we strive to introduce a level of aggregation for contributing factors that can be applied across data sources with different types of data available (e.g., retrospective crash databases and naturalistic driving data with video) and meet the overall goal of the conflict typology of grouping conflicts that have common characteristics in studying safety impact.

To accomplish this high-level grouping of contributing factors, the conflict model, principles of observability and INUS introduced previously were applied to contributing factors that are commonly available in crash databases and observable from video and/or sensor data from NDSs. A key distinction from previous studies, such as the many factors reported in crash studies like the the National Motor Vehicle Crash Causation Survey, NMVCCS [29], was that the contributing factors should be directly observable from the conflict initiating behavior of the initiator or non-nominal response of the responder. Factors such as hours of rest or medications taken are not observable directly, but could indirectly be observed as an impaired state by swerving of the vehicle or eye closure captured on video. Clearly, some contributing factors are difficult to reliably determine from retrospective crash data without video recordings (e.g., inattention, occlusions). Even if underreported, most collision databases do include fields for noted inattention (either through violations of state cell phone laws or otherwise). Many of the contributing factor groups at least can be partially inferred from descriptions of scenarios in crash data. For example, some crash scenarios will mention occlusions (e.g., "dashed out"). Grouping into high level contributing factors groups has a benefit of facilitating comparison between crash data with low precision/availability of contributing factors and NDS with higher (but not always complete) availability of contributing factors .

Table 3 lists high-level contributing factor groups with descriptions and example observable indicators. Like the conflict groups and perspectives, these causal factor groups could be further decomposed for specific analyses purposes. The results presented later in this paper, however, demonstrate the utility of grouping contributing factors into the proposed groups. It should be noted that the conflict model and contributing factor group definitions do not require the initiator and responder to have a single or mutually exclusive contributing factors. In practice, there are often multiple contributing factors that in combination contribute to the occurrence of a conflict. For example, inattention and/or an impaired state may contribute to a failure to react. The presence of these different contributing factors, however, may dictate different analyses. For example, when determining the prevalence of a certain type of collision to use for a benchmark to define reasonable human performance, one may want to exclude events that involve impaired state and reckless state.

Table 3.
Description of Contributing Factor Groups.

Contributing Factor Groups	Contributing Factors Description	Example Observable Indicators
Limited Visibility	Limited visibility between conflict partners caused by occlusions and/or environmental factors	Observable regions based on lines of sight. Environmental conditions such as weather, darkness.
Change in Intent	Surprising action, intentional / unintentional change of mind, or unpredictable / non-legible behavior.	Actors that act in ways that violate the predictions of generative models of nominal driving behavior.
Reaction to Prior Event	Reactions to prior conflicts & surprising events	Actors from previous conflicts that create surprising conflicts or events that then cause the initiator to respond, creating a new conflict.
Small Margins	Adopting too small safety margins (following too closely), taking way or allowing for small margins that force others to make space, or unintentionally misjudging gap sizes	Road users are forcing their way to make space, or operate with small margins (either intentionally or unintentionally)
Failure to Act	Failure to act on changes in motion of other road users or change in traffic signals	Road users not responding to the change in motion by others / traffic signals
Motion Plan Failure	Failure in execution of motion / plan (fall, slip, loss of control)	Road users executing plans that might result in loss of control (slippery, difficult to control). Traveling too fast for conditions that results in loss of control or unintended path.
Uncertain Path Plan	Uncertain or unpredictable path planning due to external factors (unstructured environments / difficult to make the right decision)	Uncertainties in the road scene, leading to uncertain path planning for all (e.g., construction, emergency response scene)
Impaired State	Impaired state (DUI/drowsy/repeated inattention/overly cautious behavior)	Road users that are unable to keep a steady course, speed profile, walk straight
Reckless State	Reckless driving state	Road users that are speeding, driving on the shoulder of a road, far from nominal behavior. Includes emergency vehicles operating in emergency situations.
Inattention	Failure in attention to the appropriate area	Not looking in the direction of the conflict (based on head pose, head or eye direction)

RESULTS

To demonstrate the utility of applying the conflict typology proposed in this paper to multiple types of safety data, this results section presents an example analysis of retrospective crash data and human naturalistic crash and near-crashes. First, all layers of the conflict typology are applied to retrospective, police-reported crash databases. The first 3 layers of the conflict typology (actor types, conflict groups, conflict perspectives) are most similar to past conflict typologies that have been primarily used for analyzing retrospective crash databases. These results examine whether, like past typologies, the conflict typology provides insights into the characteristics of crashes in subsets of the crash populations (e.g., in a dense urban ride-hailing environment). Second, we apply the conflict role and causal factors layers to the retrospective crash data. Traditionally, this has been difficult due to the limited information available from retrospective crash data. We then examine whether analyses of the conflict role and causal factors can be done. Finally, we analyze the video data from an NDS dataset to assign conflict role and contributing factors, to enable a comparison of the NDS and retrospective crash data.

Conflict Partners, Collision Groups, and Collision Perspectives

This study analyzed two nationally representative crash databases maintained by the National Highway Traffic Safety Administration: the Crash Report Sampling System (CRSS) and the Fatality Analysis Reporting System (FARS). The CRSS crashes are a nationally representative sample of police-reported collisions that occurred on public roadways in the U.S. Weights are applied to the sampled collisions so that the summed counts correspond to the number of collisions annually in the U.S. FARS is a census of fatal collisions that occur on public roadways. This study examined CRSS and FARS years 2016 to 2020. The 2016 case year was the first year of enhanced pedestrian and bike data reporting and the 2020 case year is the latest year where data was available at the time of writing.

To examine the police-reported crashes in this type of operating environment, we selected collisions from FARS and CRSS with the following properties:

- Involving at least one passenger vehicle (i.e., car, light truck, or van).
- Those that did not have inclement weather or surface conditions (e.g. snow, ice, blowing sand, heavy fog). Rain and wet surface condition was included because the amount of rain is not known.
- Those crashes where at least one vehicle was driving on a road with a speed limit up to 45 mph. Collisions between vehicles traveling on a road with speed limit greater than 45 mph were included if another vehicle was traveling on a road with speed limit 45 mph and below. Speed limits are often missing from these crash databases. If the speed limit was missing, the road type (undivided vs divided) and number of lanes was used to infer which road types would likely be included in the ride-hailing ODD.
- The case was classified as occurring in an urban location (RUR_URB = 2 in FARS and URBANICITY = 1 in CRSS)

To demonstrate the potential effects of collision severity on crash trends, the CRSS data was split into two groups based on the reported KABCO (that is, police reported) collision severity score. “CRSS - A+K” severity were those collisions with either a maximum reported severity of “killed” (K) or “incapacitating” (A). “CRSS - Minor” were those collisions where the maximum reported severity was between “minor” (B), “possible” (C), or “no apparent” (O) injury.

Table 4 summarizes the total number of collisions extracted from CRSS and FARS that met the urban ride-hailing environment conditions. This ride-hailing environment accounted for 41% of minor severity collisions (CRSS - Minor), but fewer severe (32% of CRSS - A+K) and fatal (22% of FARS) collisions.

Table 4.

Considered Cases from CRSS and FARS 2016 - 2020 for a Urban Ride-hailing Environment (passenger vehicle, non-inclement weather, up to 45 mph speed limit)

	Total			**Urban Ride-hailing Environment**		
Count Description	**CRSS - Minor**	**CRSS - A+K**	**FARS**	**CRSS - Minor**	**CRSS - A+K**	**FARS**
Number of Cases	221,325	31,891	171,972	91,570 (41%)	11,215 (35%)	38,435 (22%)
Weighted Cases	30,044,252	885,436	171,972	12,369,395 (41%)	282,247 (32%)	38,435 (22%)
Average Annualized Weighted Cases	6,008,850	177,087	34,394	2,473,879 (41%)	56,449 (32%)	7,687 (22%)

To demonstrate how the *conflict partner* layer is used, Figure 3 shows the proportion of each conflict partner group in urban ride-hailing environment collisions. In minor collisions, vehicle-to-vehicle partners make up almost three quarters (74%), whereas in serious collisions vehicle collisions with pedestrians, fixed objects, and motorcyclists are more common (between 50% and 65%). This results shows that differences in crash severity can be observed by grouping by actor types. Vulnerable road users (especially pedestrians and motorcyclists) are overrepresented in serious and fatal collisions compared to minor collisions.

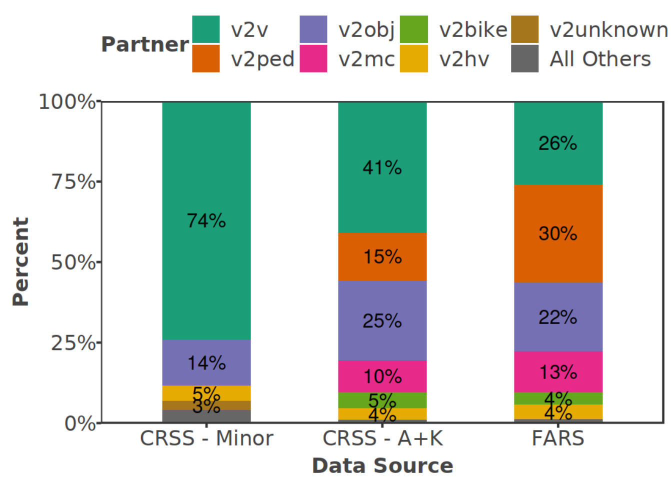


Figure 3. Conflict Partners for Urban Ride-hailing Environment Collisions from CRSS and FARS 2016 - 2020.

To demonstrate the use of the *conflict groups* layer, Figure 4 shows the distribution of conflict groups by data source for an urban ride-hailing environment. Minor collisions have much higher occurrence of front-to-rear (F2R) collisions compared to serious collisions. Serious and fatal collisions have a higher occurrence of single vehicle (SV) and crossing road (CR) collisions compared to minor collisions. This result shows that grouping by collision groups can also provide useful insights into traffic safety trends.

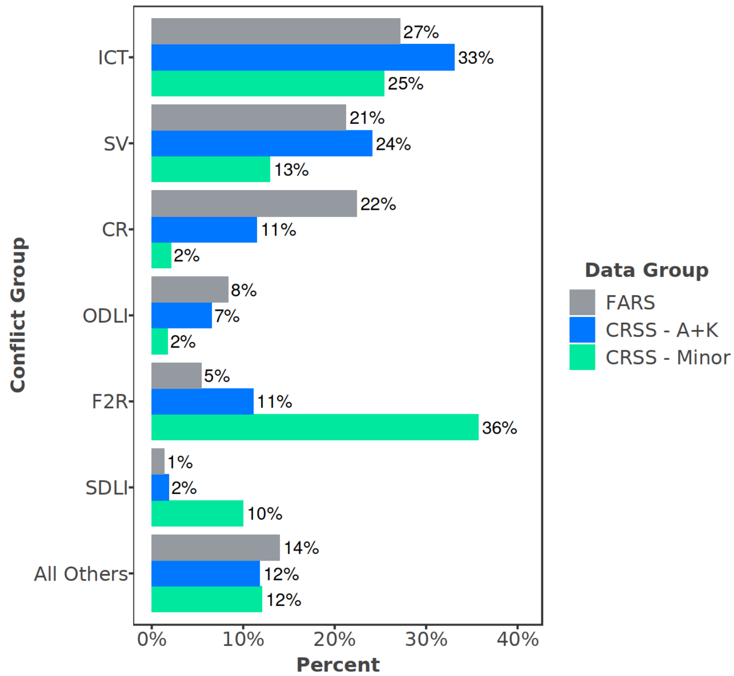
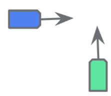
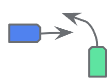
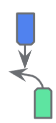
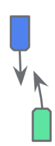


Figure 4. Distribution of Conflict Groups by Data Source in an Urban Ride-Hailing Environment from CRSS and FARS 2016 - 2020.

To demonstrate the use of the *conflict perspectives* layers, Table 5 shows the most frequent conflict perspectives in multi-agent (i.e., excluding the vehicle-to-object collision partner group) from fatal collisions in FARS for the urban ride-hailing environment. The percentages in the table are the proportion of each conflict perspective within the collision partner group (i.e., columns sum to 100%). For the conflict perspectives, the passenger vehicle involved in the collision is presented as the ego role. For example, in vehicle-to-motorcycle collision partners, 42% of collisions were with a motorcyclist going straight and the passenger vehicle turning left across path.

Table 5.
Primary Collision Perspectives in Multi-agent Fatal Collisions from FARS 2016 - 2020 in the Urban Ride-hailing Environment.

			Vehicle-to-X Conflict Partner				
Conflict Mode	**Picture**	**Perspective**	**Ped.**	**Veh.**	**MC**	**HV**	**Bike**
ICT: Straight Crossing Path (for all but ped.) or CR: Straight Crossing Path (for ped)		SCP from Right (blue)	68%	12%	7%	9%	40%
		SCP from Left (green)		12%	6%	14%	
ICT: Left Turn Across Path, Lateral Direction (for all by ped.) or CR: Left Turn Across Path, Perpendicular Direction (for ped.)		ALTAP/LD (blue)	0%	5%	0%	0%	0%
		ELTAP/LD (green)	0%	5%	13%	11%	0%
ICT: Left Turn Across Path, Opposite Direction (for all but ped.) or CR: Left Turn Across Path, Parallel Direction (for Ped.)		ALTAP/OD (blue)	0%	9%	2%	4%	1%
		ELTAP/OD (green)	4%	9%	42%	7%	3%
ODLI: Lateral Incursion (for all but ped.) or FWD: Opposite Direction (for ped.)		ALO (blue)	0%	10%	3%	2%	0%
		ELO (green)	1%	10%	2%	19%	0%
F2R: Lead Going Straight (for all but ped.) or FWD: Same Direction (for ped.)		ALGS (blue)	5%	4%	4%	11%	24%
		ELGS (green)	0%	4%	5%	4%	0%
All Others			22%	20%	16%	19%	32%
Total			100%	100%	100%	100%	100%

The results in this subsection demonstrate that the first 3 layers of the conflict typology (actor types, conflict groups, conflict perspectives) can provide insights into the characteristics of crashes in subsets of the crash populations. As an example, serious injury and fatal collisions involve a different proportion of actor types (more vulnerable road users) compared to minor collisions in a typical urban ride-hailing environment. We also show that for for fatal collisions in urban ride-hailing environment, 5 collision perspectives account for a majority of collisions (between 68% and 84%).

Conflict Role and Contributing Factors

As shown in Table 5, vehicle-to-pedestrian crossing road collisions where the vehicle is going straight account for a large proportion of serious injury and fatal collisions in the urban ride-hailing environment. As mentioned in the Methodology section, it can be difficult to determine some contributing factors from retrospective collision databases due to a lack of video or other sensor data that can be used to determine the behavior of actors. These crash databases, however, are important data sources to consider, as most NDS data sources lack a large number of collisions, and have few or no serious injury or fatality collisions. How to reconcile these high-severity, yet low fidelity, data with the higher fidelity, yet low severity, data from NDS is an unanswered research question. To demonstrate this difficulty, we first applied the conflict role and contributing factor groups proposed in this paper to pedestrian crossing road conflicts from CRSS and FARS and then compared these results to contributing factors observed in an NDS.

The PEDCTYPE variable is a new addition to CRSS and FARS since case year 2016. The categories of PEDCTYPE are a combination of conflict perspectives and contributing factor groups that attempt to describe which actor (the pedestrian or vehicle) initiated the conflict and the maneuvers taken by both actors. The PEDCTYPE values that are applicable to the pedestrian crossing road, straight crossing path conflict perspective are: "Motorist Failed to Yield”, “Pedestrian Failed to Yield”, “Dash Out”, “Dart Out”, “Multiple Threat”, “Trapped” and “Crossing Expressway”. Table A1 in the appendix lists the full PEDCTYPE variable descriptions for categories used in Table 6 taken from the FARS and CRSS coding manual [30]. All of the PEDCTYPE groups except “Motorist Failed to Yield” were assigned the vehicle as the responder role. Contributing factors were assigned using the primary contributing factors that are associated with the behavior described in the PEDCTYPE variable. For example, the Dart Out scenario is when the pedestrian enters the travel lane of a vehicle from behind some occlusion, which is directly related to the change in intent (surprising) and limited visibility (occlusion) contributing factor groups. The potential contributing factor groups listed are those that are most likely and/or prominent to be present based on the physical scenario described in the PEDCTYPE variable. Other contributing factors can also be present independent of the scenario, such as impaired state.

To show the application of the *conflict role* and *contributing factors* to retrospective crash data, Table 6 shows the proportion of pedestrian crash types (variable PEDCTYPE) in vehicle-to-pedestrian crossing road collisions from CRSS and FARS where the vehicle was in the responder role. Of all pedestrian crossing road collisions, 26% of CRSS - Minor, 14% of CRSS - A+K, and 10% of FARS collisions had the “Motorist Failed to Yield” PEDCTYPE, and thus the vehicle assigned the initiator role. The most common pedestrian crash type in all data groups was pedestrian failed to yield, followed by motorist failed to yield. The CRSS groups, both minor and A+K, had a higher proportion of dash out and dart out crash types compared with the FARS data. Finally, the multiple threat and trapped crash types were the least frequent.

Table 6.
Pedestrian Crash Type Variable from CRSS and FARS 2015 - 2022 for Pedestrian Crossing Road Collisions with the Vehicle in the Responder Role.

Pedestrian Crash Type (PEDCTYPE)	**Vehicle Role**	**Primary Contributing Factor Group**	**CRSS - Minor**	**CRSS - A+K**	**FARS**
Pedestrian Failed to Yield	Responder	Change in Intent	56%	66%	82%
Dash Out	Responder	Change in Intent	30%	25%	14%
Dart Out	Responder	Limited Visibility, Change in Intent	12%	7%	3%
Multiple Threat	Responder	Limited Visibility, Change in Intent	1%	1%	1%
Trapped	Responder	Change in Intent	< 1%	1%	< 1%
Crossing Expressway	Responder	Change in Intent	< 1%	1%	1%
Total			100%	100%	100%

As noted above, naturalistic driving data provides a unique opportunity to record video of potential conflicts, which makes determining contributing factors easier compared to retrospective crash databases such as CRSS and FARS. This study examined near-crash events from the Strategic Highway Safety Research 2 (SHRP-2) Naturalistic Driving Study (NDS) [16]. The SHRP-2 NDS included over 3,000 personally owned vehicles that drove over a 3-year period in 6 study locations in the U.S. that resulted in a dataset with almost 50 million miles of data collected. A set of 57 near-crash events from the SHPR-2 NDS were examined. These events were all near-crash events that featured a pedestrian in the crossing road conflict group where the pedestrian was in the initiator role. The video from all pedestrian near-crash events from SHPR-2 were reviewed to determine the pedestrian's role. The contributing factors related to the pedestrian's initiating behavior were also determined by video review. The contributing factors related to the non-nominal response behavior of the responder (vehicle driver) could have also been determined as the SHRP-2 study had in-vehicle video recording. This was not done for this study, however, due to the additional burden necessary to view the potentially identifying information.

To show the application of the *contributing factors* groups to NDS data, Figure 4 shows the contributing factor groups present in pedestrian initiated crossing road conflicts from the SHRP-2 NDS. The figure is an "upset" plot, which shows a histogram (top) for each combination of contributing factors (bottom center). Multiple contributing factors can be present in any given conflict. The histogram at the bottom left shows the frequency of each individual contributing factor in all events. The most frequent contributing factor was perception limitations, which was present in 72% of conflicts and as the sole contributing factor in 33% of conflicts.

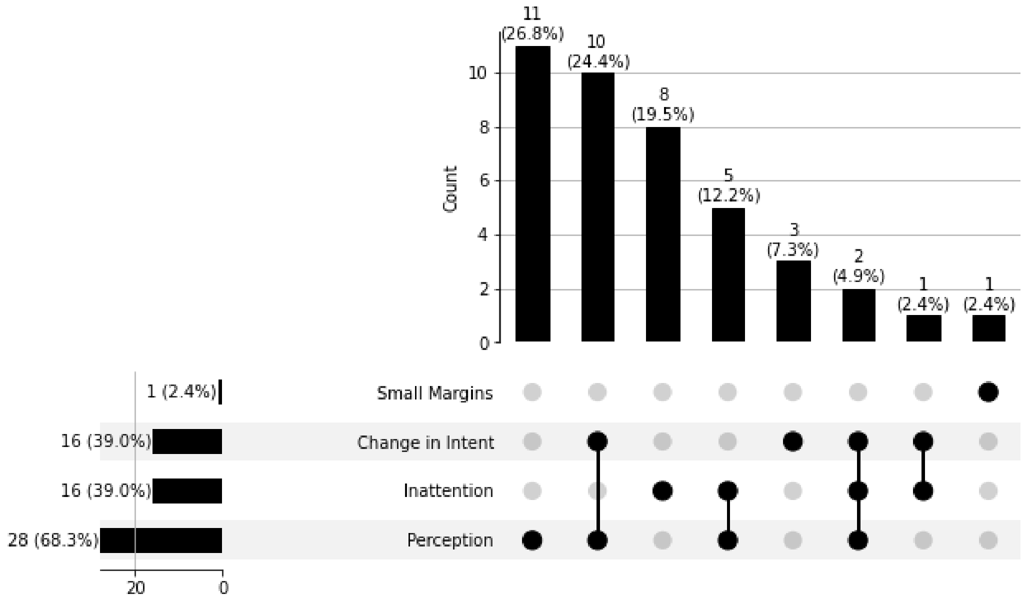


Figure 4. Combinations of Contributing Factor Groups Present for the Pedestrian in the Initiator Role in Crossing Road Near-crashes from the SHRP-2 Naturalistic Driving Study.

Table 7 breaks down the SHRP-2 near-crash events by contributing factor groups into subgroups and attempts to relate the contributing factor to the pedestrian crash type variable from CRSS and FARS presented in Table 6. In general, the contributing factors in the NDS near-crashes match the crash data. Pedestrian failed to yield (due to limited visibility or inattention) made up 37% of NDS cases compared to between 56% and 82% of the crash data. The next most frequent contributing factors in the NDS data were suddenly entering traffic (dart-out and dash-out, 22%) compared to between 17% and 42% of the crash data. One difference, however, was that the NDS data had a large number of events that were related to the multiple threat scenario, where yielding behavior of one vehicle prompts the pedestrian to cross creating a conflict with a vehicle traveling in the same direction (24% of NDS events). This multiple threat scenario made up only 1% of the crash data, across all severities.

Table 7.
Contributing Factor Groups and Subgroups and their Relationship to the CRSS/FARS Pedestrian Crash Type.

Contributing Factor Groups	**Subgroup**	**Approximate Pedestrian Crash Type**	**Description**	**N (%)**
Limited Visibility	Environmental Visibility	Pedestrian Failed to Yield	The pedestrian enters a multi-lane road when the conflict partner is far away and traveling at a high speed. The pedestrian continues to cross even as the ego vehicle continues to travel. Other environmental factors such as darkness or rain may be present.	7 (17%)
	Occlusions (static and dynamic)	Dart-out	An in-transport vehicle (dynamic occlusion) or static objects (e.g., not in-transport vehicles, bushes/trees, structures) make an occlusion between the pedestrian and conflict partner.	4 (10%)

Limited Visibility & Change in Intent	Occlusions (dynamic and static), Other Agent Prompts Crossing	Multiple threat	A pedestrian signals their intent to cross, and some approaching actor in the scene slows to yield to the pedestrian or in a way that mimics yielding (e.g., making a right turn). This slowing behavior prompts the pedestrian to start to cross. The yielding vehicle causes a dynamic occlusion between the pedestrian and conflict partner vehicle traveling in the same direction as the yielding vehicle.	10 (24%)
Inattention	Looking at Other Actors	Pedestrian Failed to Yield	The pedestrian is focusing on other actors in the scene (vehicles, other pedestrians) or at another location (e.g., their destination), causing the pedestrian to not look in the direction of the conflict partner.	4 (10%)
	Looking at object on their person		The pedestrian is interacting with an object (e.g., looking at a cell phone in hand, reaching for objects inside of a bag), causing the pedestrian to not look in the direction of the conflict partner.	2 (5%)
	Not looking, other		The pedestrian does not check for traffic in the direction of the conflict partner.	2 (5%)
Limited Visibility & Inattention	Occlusion (static and dynamic) & Looking elsewhere	Dart-out	Static objects (e.g., not in-transport vehicles, bushes/trees, structures) create an occlusion between the pedestrian and conflict partner. Further, the pedestrian is looking at a pedestrian on the other side of the street, making them unaware of the potential conflict with a conflict partner.	5 (12%)
Change in Intent	Sudden change in velocity	Dash-out	A pedestrian enters the path of a conflict partner, then suddenly changes their velocity (slow down, speed up, change direction) violating the expectation of the conflict partner and entering into a conflict.	3 (7%)

The results of this subsection demonstrated how the conflict role and contributing factors can be applied to both crash data and NDS data. There are challenges with determining conflict role and contributing factors from retrospective crash data because some information is either missing or may suffer from underreporting. These results demonstrated, however, that in certain collision modes and data sources, at least a partial assignment of conflict role and contributing factors can be done for retrospective collision databases. The conflict role and contributing factors can also be applied to NDS data, where the conflict role and contributing factor information can be observed from the video recordings of conflicts. This ability to apply the conflict role and contributing factors to both data sources allows for comparison between data sources of different quality, like retrospective crash and NDS data.

DISCUSSION

This paper presented a novel conflict typology that describes the conflict partners, groups, perspectives, role, and contributing factors. The paper describes the definitions and framework used to derive these layers of the conflict typology. The conflict perspectives, which are the further decomposition of the conflict groups into more specific maneuver types, were not presented in great detail in this paper. As they currently stand, there are over 100 conflict perspectives. Although all of the current perspectives could have been listed with short narrative descriptions, this provides limited use to researchers. A full publication and/or application of the conflict perspectives is the topic for future work.

Although the results presented in this paper were exclusively human crash and near-crash data, the conflict typology has been developed to also be applicable to describe ADS conflicts, even if there is no human driver in the ADS vehicle. The study of human conflict types and contributing factors is useful for ADS safety evaluations because ADS will continue to operate in environments with human participants, who will likely continue to initiate conflicts with ADS in similar ways that the humans initiate conflicts with each other today. There are also likely conflict types and/or contributing factor groups that will become more frequent for ADS when compared to human drivers. Many of the conflict actors, groups, perspectives, and roles apply, however, equally to human driven vehicles and ADS operated vehicles. Although many of the contributing factor groups are applicable to both human and ADS operated vehicles (e.g., perception limitations, change in intent), some contributing factor groups may manifest themselves in different ways or be entirely not applicable to ADS equipped vehicles. Most notably, whereas humans must choose where to apply their attention, ADS can monitor their surroundings in multiple directions simultaneously. For example, the contributing factor of inattention may not be applicable to an ADS. Because the contributing factors focus on describing the observable behaviors of actors and not internal reasoning or states of actors, we demonstrated in this study that the contributing factors can be successfully applied to conflicts involving an ADS operated vehicle.

Notably, the results of this study showed that there were different contributing factors in pedestrian crossing road collisions from CRSS and FARS than observed in the SHRP-2 near-crash events. Specifically, the multiple threat scenario made up under 1% of the CRSS - A+K and FARS data and 24% of the SHRP-2 events. Further research is needed to determine if this difference is in fact a difference between conflicts (near-crashes) and serious outcome collisions, or if there is underreporting of this type of scenario in the crash report data. Regardless of the potential differences in observed proportions of contributing factors in these data sets, the results of this study showed that the entire conflict typology, including conflict role and contributing factors, can be applied to both retrospective crash and NDS data. This enables comparisons between different data sources. The PEDCTYPE variable in CRSS and FARS compactly provide pertinent information regarding the conflict role and contributing factors. In other conflict types, like those between vehicles, other types of variables like traffic control presence and moving violations may need to be used to determine role and contributing factors.

Ideally, there would be a data source that had both a representative sample of high severity collisions from crash databases and the video and sensor data that exist in NDS data. Most public NDS datasets require retrofitting equipment onto vehicles that results in recorded mileage on the order of millions of miles. With the advent of cloud connected cell-phone- and consumer electronics-based dash cameras, there is an opportunity to extract collision events from billions of driven miles, increasing the likelihood that some of the collisions will have a serious outcome.

As discussed in the introduction, conflict typologies have been a tool used by traffic safety researchers, especially in the areas of crash data analysis, naturalistic driving, and prospective safety benefits research. Scenario description languages, which describe the trajectories of actors and how the actors interact with the environment often in machine readable format (e.g., [31]), are a related but separate topic. These scenario description languages are useful for defining abstract, logical, and concrete scenarios, especially for scenario-based testing. They focus on describing scenarios in a way that can be translated into simulations or evaluations of an ADS. The conflict typology could be used in conjunction with a set of scenarios to organize them by actor types, groups, perspectives, and contributing factors. For example, this conflict typology is the basis for the aggregation used in the Collision Avoidance Testing scenario-based testing program at Waymo, where collision avoidance competency is evaluated relative to a reference behavior model in conflicts where the ADS is the responder role vehicle [32 - 33].

The appropriate level of aggregation in the conflict typology is one that allows for a safety impact assessment of a potential system, in our application an ADS. As larger-scale naturalistic driving data becomes available (e.g., from commercial dash cam companies) and as ADS are more widely deployed, it is possible that relevant distinctions between conflict perspectives are not fully captured by the conflict typology presented here. The way the conflict typology presented in this study has been constructed is a layered approach, which can easily accommodate additions of newly discovered actor types and conflicts.

CONCLUSION

This paper introduced a conflict typology for traffic conflicts that includes a definition of conflict partners, groups, perspectives, role, and contributing factors. The results showed that these layers of the conflict typology are useful for organizing conflicts into groups of similar causes, which can aid in retrospective or prospective analysis of traffic safety. To demonstrate the utility of this conflict typology, we presented results of an analysis of nationally representative crash data from the US (CRSS and FARS) and naturalistic driving data (SHRP-2). The main contribution of the proposed conflict typology and contributing factors are applicable to a wide range of conflicts (i.e., collisions from retrospective crash data and near-crashes from an NDS). The results also highlight potential difficulties reconciling differences in contributing factors observed in high-severity crash data having limited contributing factor information and those contributing factors observed in lower severity NDS data.

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APPENDIX

Table A1.
PEDCTYPE Variable Descriptions (Quoted from FARS/CRSS Pedestrian/Cyclist Coding Manual [30]).

PEDCTYPE Category	**Description**
Pedestrian Failed to Yield	'**760 (Pedestrian Failed to Yield)** is used when the pedestrian was involved in a collision with a vehicle while crossing the roadway (not an expressway). The involved motorist had the right-ofway and was traveling or intending to travel straight through. This code should not be used if any of the following apply: 710 (Multiple Threat), 730 (Trapped), 741 (Dash), and 742 (DartOut). If it is NOT apparent that either party had the right-of-way, select "Other/Unknown."'
Motorist Failed to Yield	'**770 (Motorist Failed to Yield)** is used when the pedestrian had the right-of-way and was involved in a collision with a vehicle while crossing the roadway (not an expressway) by a vehicle that was traveling or intending to travel straight through. This code should not be used if any of Crash Type - Pedestrian PB30 2019 FARS/CRSS Pedestrian/Bicyclist Manual 15 the following apply: 710 (Multiple Threat), 730 (Trapped), 741 (Dash), and 742 (Dart-Out). If it is NOT apparent that either party had the right-of-way, select "Other/Unknown."'
Dash Out	'**741 (Dash)** is used when the pedestrian ran into the roadway and was involved in a collision with a vehicle and there is no mention in the case materials that the driver's view of the pedestrian was obstructed. The case materials should state that the pedestrian ran.'
Dart Out	'**742 (Dart-Out)** is used when the pedestrian walked or ran into the roadway and was involved in a collision with a vehicle where the driver's view of the pedestrian was blocked until an instant before impact. A dart-out can only occur if there is some documented visual obstruction (e.g., parked vehicle, building or vegetation).'
Multiple Threat	'**710 (Multiple Threat)** is used when the pedestrian entered the traffic lane in front of stopped or slowing traffic and was involved in a collision with a vehicle traveling in the same direction as the stopped or slowing traffic. If there is a traffic signal present and the light changes while the person is crossing, see 730 (Trapped).'
Trapped	'**730 (Trapped)** is used when the pedestrian was involved in a collision with a vehicle while crossing at a signalized intersection or signalized midblock crossing when the light changed, and traffic started moving.'
Crossing Expressway	'**910 (Crossing Expressway)** is used when the pedestrian was attempting to cross an expressway or expressway ramp when involved with collision with a motor vehicle. An expressway is a major thoroughfare without intersecting cross streets, having specific entrance and exit ramps. It includes superhighways, interstates, freeways, turnpikes, and parkways. Entrance and exit ramps are considered part of an expressway. The pedestrian does not have to be in a travel lane of the expressway or expressway ramp. The case materials need to indicate that the pedestrian was attempting to cross not just walking along or in the expressway.'