COMMON HIGH COLLISION LOCATION PATTERNS ON CITY STREETS

What They Look Like

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THE PURPOSE OF THIS SITE

In a nutshell, **this site presents a dozen collision patterns I've seen in my work as a traffic engineer that tend to occur at high collision locations on city streets.**[1] It includes two more urban street patterns that don't tend to occur at high collision locations, but of which drivers should also be aware. These are real world conditions that drivers will likely encounter on city streets. These situations present levels of complexity by which drivers are challenged and often make mistakes. The result is that, too often, collisions occur and, too often, people get hurt.

In my experience as a traffic engineer, I hadn't seen this kind of information collected and presented in one place. My aim in creating this site is to share this information to improve safety for street users, including drivers, pedestrians, and cyclists. **This can be used to help:**

Engineers, planners, and street designers design safer streets.

Drivers—particularly new and learning drivers—be aware of and recognize these patterns. To do this, this site describes what they "look like"—including the kind of streets they generally occur on, the traffic conditions when they take place, and the movements street users are trying to make.

Safety research. One way this information could be of use is in helping to recognize different fundamental factors that contribute to the different types of collisions—that this might affect the aggregation/disaggregation of collision data used in traffic safety studies. This could affect, as well, how street safety studies that use fully aggregated collision data are interpreted.

A point of emphasis in the presentation of this information is that walking and bicycling are intrinsic parts of healthy urban street systems. As the smallest users (in terms of physical size) of the street, pedestrians, bike riders, and motorcyclists require special consideration in terms of safety. Their small size and mass translates to being vulnerable to the force of collisions. A large proportion of collisions on city streets that end in severe injury and as fatalities involve pedestrians, bicyclists, and motorcyclists. This site presents information about urban collision patterns involving pedestrians and bicyclists so everyone can be on the lookout for these patterns.

The high-collision location types presented, while common to many cities and urban settings, are limited by my own experience. No doubt, others (including traffic engineers, street users, and driving instructors) in other cities have observed other high-collision patterns and patterns that too often result in serious outcomes. My hope is this work suggests a platform to which these patterns (presented in similar detail) can be added—so that street users may benefit from awareness and understanding of these patterns, as well.

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[1] My experience is in working with traffic in the city of Seattle. My sense is many of these collision patterns take place on urban streets throughout the U.S. and Canada.

WHY THIS MATTERS

When I had completed my first draft of this work, a part of the feedback I received back is that information about high collision locations is "niche information"—implying that these patterns tend to be special conditions that are unique and make up only a small proportion of all the collisions that occur on city streets. …and, as such, this isn't information that should necessarily be on the center of one's radar when thinking about street safety or learning to drive.

In fact, many of the patterns described here are common and occur at many more locations than just high collision locations.[2] And collisions similar to the patterns described occur at many more locations than that. Together, these make up a large chunk of the collisions[3] that occur on city streets.

The kinds of collisions described on this site include:

- right-angle collisions
- rear-end collisions
- collisions that involve left turns
- Pedestrian collisions and
- Bike collisions

In general-

Right-angle (t-bone) collisions account for about 18 percent of all fatal collisions, 30 percent of injury collisions, and 23 percent of all reported collisions in the United States.[4]

Rear-end collisions account for about 7.5 of all fatal collisions, 27.5 percent of injury collisions, and 30 percent of all reported collisions in the United States.[5]

Left turns are associated with much greater numbers of collisions, injuries, and fatalities than right turns.[6] [7]

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[2] The numbers of collisions at other individual locations are just not as high as the numbers of collisions that occur at high collision locations.

[3] Particularly injury-related collisions.

[4] Traffic Safety Facts Annual Report Tables, National Highway Traffic Safety Administration, 2021, Table 29 - Crashes, by First Harmful Event, Manner of Collision, and Crash Severity https://cdan.dot.gov/tsftables/tsfar.htm#

[5] Traffic Safety Facts Annual Report Tables, National Highway Traffic Safety Administration, 2021, Table 29 - Crashes, by First Harmful Event, Manner of Collision, and Crash Severity https://cdan.dot.gov/tsftables/tsfar.htm#

[6] See for example, The New York City DOT's report *Don't Cut Corners – LEFT TURN Bicyclist and Pedestrian Crash Study,* August 2016. In New York City, based on data collected for the period of 2010 to 2014, "...left turns account for more than twice as many pedestrian and bicyclist fatalities as right turns and over three times as many serious injuries and fatalities." Page 3. https://nyc.gov/html/dot///downloads/pdf/left-turn-pedestrian-and-bicycle-crash-study.pdf

[7] *The Case for Almost Never Turning Left While Driving*, Matt McFarland, The Washington Post. To the extent it reasonably can, UPS, in its operations, seeks to minimize the left turns made by its fleet.

In cities, the proportions of fatal collisions involving pedestrians and bicyclists are greatly overrepresented. In large U.S. cities, the proportions of fatal collisions involving pedestrians and bicycle riders tend to range from 25 percent to upwards of 45 percent of their traffic fatalities.[8] [9] In Seattle, for example, collisions involving pedestrians and bicyclists account for nearly half of the city's fatal and severe-injury collisions.[10]

This site collects and lays out basic dynamics of many of these kinds of patterns—in a way in which many who use streets can relate. In doing this, it offers fundamental insights and understanding into not only collisions that occur at high collision locations, but the same kinds of collisions, and similar collisions, that occur at many more locations and by which large numbers of people who use city streets are hurt. As such, this information is a kind that can be meaningfully applied to support safe street design, drivers' education, and traffic safety research. And, as such, the information shared on this site belongs on the radar and toward the center of understanding traffic safety.

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https://www.washingtonpost.com/news/innovations/wp/2014/04/09/the-case-for-almost-never-turning-left-while-driving/

[8] *Traffic Safety Facts 2020, Pedestrians*, National Highway Traffic Safety Administration, 2022, DOT HS 813 318. See Table 8 - Total and Pedestrian Fatalities in Cities With Populations of 500,000 or Greater, and Fatality Rates, 2020.
https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813310

[9] *Traffic Safety Facts 2016, Bicyclists and Other Cyclists*, National Highway Traffic Safety Administration, 2018, DOT HS 812 507. See Table 7 - Population, Total Traffic Fatalities, Pedalcyclist Traffic Fatalities, and Fatality Rates in Cities With Populations of 500,000 Or Greater, 2016 (sorted by highest to lowest resident population).
https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812507

[10] Seattle Department of Transportation 2022 TRAFFIC REPORT. Tables 18: Fatal/Serious Collisions, Table 19: Bicycle Collisions, and Table 20: Pedestrian Collisions. See data for 2016 through 2021.
https://www.seattle.gov/documents/Departments/SDOT/About/DocumentLibrary/Reports/2022_Traffic_Report.pdf

DISCLAIMER

As a beginning engineer, I heard a story about a senior engineer who was asked by a lawyer, "What does it take to make streets perfectly safe?" The older engineer answered, "Don't have streets."

His meaning is that there is risk in driving, and collisions will happen. In the same vein, it can't be guaranteed that use of this site will prevent you from being in a collision. The factors that go into collisions can be very complex—more than this or any text can fully cover.[11] And even if one is a very careful driver, this can't always counter what other street users do.

This site is NOT intended as a drivers' education class. A hope is that information it provides may be used to *supplement* drivers' education courses—the integration of this material in these courses based on the judgment of experienced professional driving instructors. An intrinsic part of professional driver training, particularly for new drivers, includes not only classroom presentation of material but the hands-on, in-the-car, on-the-street instruction to support classroom presentation.

This site has been published with the intent to provide accurate and authoritative information in regard to the subject matter within. While many precautions have been taken in preparation of this book, the author and publisher expressly disclaim any responsibility for errors, omissions, or adverse effects arising from the use or application of the information contained herein.

The author assumes no responsibility for the actions of drivers, vehicle condition, driver selection, route planning/journey management, establishing and enforcing distraction policies, fatigue management, effective knowledge transfer and other aspects of the safe operation of vehicles.

[11] To name a few, these factors include: the specific *street design* (including the lanes, how they are designated and marked with paint and signs, the presence of a signal and how it's designed, the presence of curb, sidewalk, driveways, and traffic islands and how they are designed); the specific *traffic conditions* (including their volumes, traffic speeds, the types and mix of vehicles that make up the traffic); *Lighting conditions* (including street lighting, its design, and its condition); *weather conditions*; street *surface conditions* (including the type of pavement. Is it wet/dry/icy/slick? Is the surface in good condition or poor? Does it have joints? Does it have rail tracks?); the *conditions of those involved in the collision* (including their physical and mental states); the *levels of driving experience* of those involved in the collision (including the depth of their experience in driving on city streets and in driving in conditions like those presented in the collision); the *types of vehicles* involved in the collision (which can vary in their sizes, the visual fields they offer, their acceleration, how they steer and turn, and their braking); and the drivers' level of experience in use of their vehicles.

WHERE DID THIS INFORMATION COME FROM?

States and most cities and counties have Departments of Transportation (DOTs) or the equivalent.[12] In addition to their everyday work with paving, signs, and signals, many of these departments have programs that look for locations with high numbers of collisions. These locations are often referred to as *high-collision locations (HCLs)* or *high-accident locations (HALs).*[13] These DOT programs aim to make improvements to these locations to reduce their numbers of collisions and improve their safety. This process generally goes as follows:

1. Identify High Collision Locations
2. Collect Information about the Locations Identified
3. Prioritize Locations for Review
4. Perform Detailed Reviews
5. Select Method to Improve the Location's Safety
6. Design Street Changes
7. Implement Them
8. Track How the Changes Work
9. Repeat

1. Identify High Collision Locations. The DOT identifies locations in its jurisdiction that have very high numbers of traffic collisions. This is done by looking at collision data for a set period of time which is often for the last year or the previous three years. The number of collisions used to identify high-collision locations varies from location type to location type. The city of Seattle's safety program, for example, identifies five types of HCLs:

- High-collision intersections with traffic signals
- High-collision intersections without traffic signals
- Lengths of street between intersections (mid-block) that have high numbers of collisions
- Locations having high numbers of pedestrian collisions
- Locations having high numbers of bike collisions

2. Collect Information about the High Locations Identified. After identifying these locations, the investigating staff collects information to understand the nature of their collisions. The information collected generally includes:

- *The patterns of collisions at the location.* In most cases, high-collision locations have a predominant pattern of collisions characterized by factors like the directions of traffic involved in the collision; movements the drivers, pedestrians, and cyclists involved were attempting; and times of day and days of week they tend to occur.
- *Collision severity.* In addition to looking at the numbers of collisions at locations, the DOT weighs their severity, giving greater consideration to locations with fatalities and severe injuries versus those with fender-benders.
- *Street design*. This includes numbers of lanes, types of lanes, signing, pedestrian facilities, parking design, etc.

[12] Like an Engineering Department or a Public Works Department.
[13] In the site, I use "high collision locations."

- *Signal design* (if the location is signalized.)
- *Weather conditions* at the times of collisions
- *Street-surface conditions* at the times of collisions
- *Traffic volumes*
- Types and numbers of *turning movements* at intersections
- *Traffic speeds*
- *Traffic composition* (cars, buses, pedestrians, bikes, trucks, etc.)
- And additional information, as pertinent, including pavement condition and lighting design.

3. Prioritize Locations for Review. Like all programs, traffic-safety programs have limited resources (the main constraints are staff time and funding). With the information above, the programs and their agencies decide which locations will be addressed each year, within the staffing and budget available.

4. Perform Detailed Reviews. Identify factors that contribute to collision patterns. The DOT performs further review of the selected locations. This process often includes collecting additional data. A key part of this is performing *in-person field checks*, where reviewers go to the locations and make first-hand observations of the streets and their operation. There are many factors that can affect safety. Some of these are subtle and difficult to understand by simply reviewing data or looking at a street diagram. An aim in performing this review is to understand what factors in the location's design, use, and operation may be contributing to its collision pattern, so one or more of these can be targeted to address the pattern.

5. Select Method to Improve the Location's Safety. There are a number of general ways to address traffic safety needs. They include:

- Engineering, by change to the design and operation of the street
- Education and sharing information with street users, of which this site is an example
- Enforcement
- A combination of these[14]

DOTs generally select engineering solutions that make a change to the street design and/or its operation. In this case, decide to make changes to one or more elements of the street design that (based on the location's review) look like they will improve safety at the location.

6. Design Street Changes.

7. Implement Them.

[14] The strategies of Engineering, Education, and Enforcement are often referred to in traffic safety work as the "3-E's." Other broad strategies that aim toward enhancing traffic safety include: improvements to vehicle design; research to better understand human response to vehicle design and driving conditions; mitigating injury with strong emergency-response services; and affecting safety in roadway design and operations through work in policy-making and legislation.

8. Track How the Changes Work. Do they, over time, reduce locations' numbers of collisions and their severity?

9. Repeat the steps above. If a change isn't successful in reducing the numbers and severity of collisions at a previously-reviewed high collision location, review it again, and try another action to improve its safety.

This is a very brief description of this kind of work. In fact, work affecting street design can be very complex. In urban areas, streets are relied on to serve many purposes. There are many considerations, along with safety, that can come into play when weighing changes to the design and operation of a street.

The information in this site is largely drawn from my experience in working with high collision locations in the city of Seattle. I was responsible for overseeing Seattle's High-Collision Location program for more than five years and have worked to support its safety program work for a number of years beyond that. In the course of my work, I found:

1. There are a limited number of types or patterns of collisions one usually encounters at high-collision locations. In my work in Seattle, I saw about twelve of these patterns. This site presents fourteen patterns; I included two more patterns that drivers, cyclists, and pedestrians should be aware of.

2. Each of these patterns tends to occur under a certain set of conditions. These conditions relate to:

- The street design.
- The level and character of traffic at the location when these collisions occur. This includes traffic volumes, their speeds and directions, turning movements, and so on.
- The relative positions and movements attempted by those involved in the collision.

When the street design, operating conditions, and user movements associated with a collision type are all present at the same time and place, that specific type of collision is prone to occur. And when these sets of conditions are presented over and over again at the same location, this type of collision can happen again and again—making it a high-collision location.

There are good resources that present information relating to specific types of collisions.[15] With that being said, I have not run across a single source that has collected and described the range of high collision location patterns, in detail like this site, that often take place in city and urban high collision locations.

A point of emphasis on this site is collision patterns involving pedestrians and bicyclists. Walking and cycling are a part of a healthy urban transportation system. As the smallest users (physically speaking) of the street, pedestrians, bike riders, and motorcyclists are much more vulnerable to impact than other street users. They require special consideration in safety.

I'd note that the high-collision location types presented, while common to many cities and urban settings, are limited by my own experience. No doubt, others in other cities have observed additional high-collision patterns and patterns that too often result in severe outcomes. I hope this work suggests a platform to which these patterns (presented in similar detail) can be added—so that street users may benefit from awareness and understanding of these patterns, as well.

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[15] Some that I'd highlight are works by Michael Bluejay and Robert Hurst related to bike safety on urban streets. In his article "How Not to Get Hit by Cars," Bluejay describes a range of cycling collision types one will encounter on city streets and offers suggestions to cyclists on how to avoid them.
https://bicyclesafe.com/index.html
In his book, *The Art of Cycling*, Hurst presents, with nuance, safety issues bicyclists can expect to encounter in an urban setting.
Likewise, in *Proficient Motorcycling*, David Hough presents safety issues and some collision types motorcyclists can expect to encounter on city streets.
In its report, *Don't Cut Corners – LEFT TURN Bicyclist and Pedestrian Crash Study,* the New York City DOT presents a pattern involving pedestrians that occurs when drivers make left turns from one-way streets onto wider, two-way streets.
https://nyc.gov/html/dot///downloads/pdf/left-turn-pedestrian-and-bicycle-crash-study.pdf

CHAPTER 1: COMMON URBAN HIGH COLLISION LOCATION PATTERNS
High collision locations present conditions:

- that drivers will encounter,
- that challenge them,
- at which they often fail, and
- collisions occur and people get hurt.

This chapter presents and describes common patterns of collisions that occur at urban high-collision locations.

The patterns presented include:

1. Opposing Left-Turns on a 4-Lane Street Collision Pattern
2. Bus Lane Collision Pattern
3. On-Ramp/Merge Collision Pattern
4. Left Turn from Right-Hand Lane on One-Way Streets Collision Pattern
5. Left Turn Collisions In and Out of Driveways on Major Streets
6. Looking X, Turning Y Pedestrian Collision Pattern
7. Left Turn from One-Way Streets Pedestrian Collision Patterns
8. The Good Samaritan Pedestrian Collision Pattern
9. Downhill Bike, Right-Hook Collision Pattern
10. Downhill Bike, Left-Hook Collision Pattern
11. Bikes and Tracks Crash Pattern
12. Dooring
13. Right-Angle, Red Light Running Collisions
14. Crossing an Arterial Lane from a Stop-Controlled Approach

Each of these patterns tends to occur under a specific set of conditions. The presentation of each starts with a description that includes:

- The general street design on which the pattern often occurs.
- The character of traffic on the street when the pattern usually occurs.
- The relative positions of those involved in the pattern and the movements they are trying to make.

The description includes a diagram of the pattern.

The general problem or safety challenge presented by the pattern is then identified.

The patterns have variations—differences in how they appear from one location to the next. These can include differences in the street's design, different traffic conditions, differences in the types of vehicles involved in the collisions, etc.[16] These are presented.

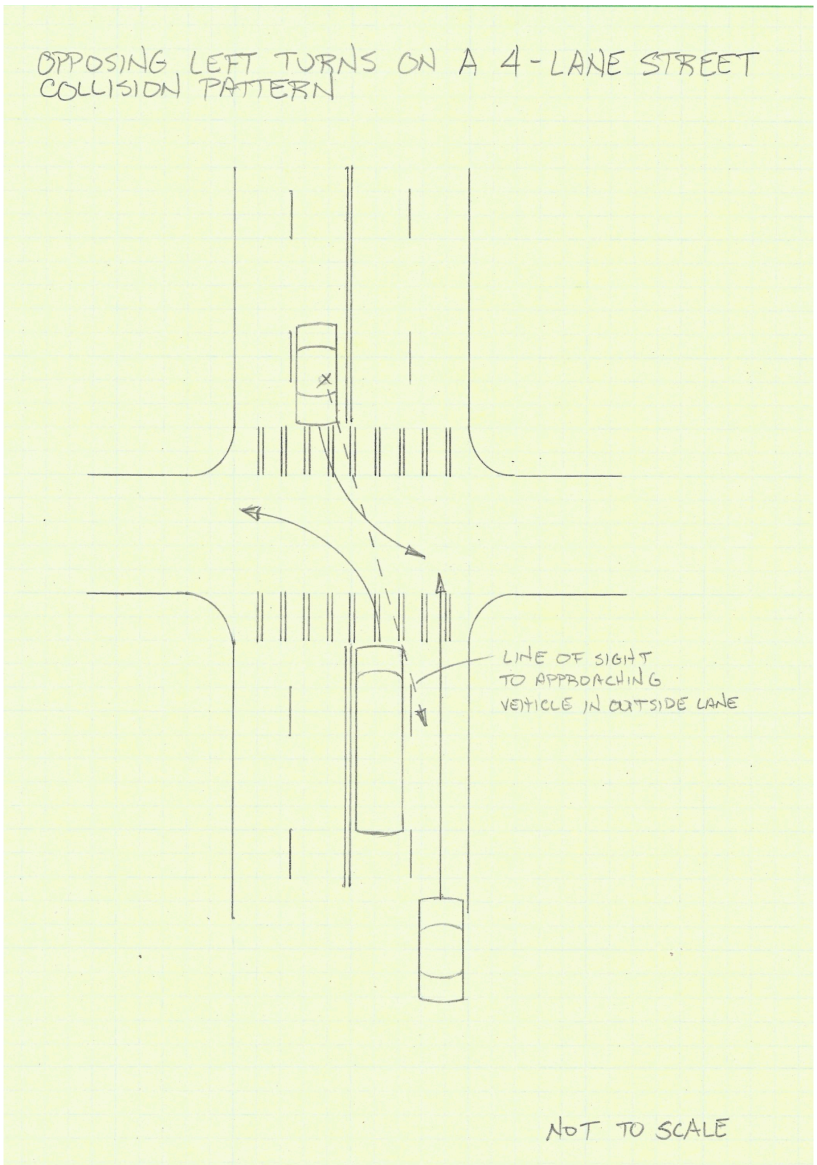
[16] For example, some types of collisions typically occur at signalized intersections, but they can also take place at unsignalized intersections or driveways. Or, some bike-related patterns tend to occur more on downhill grades, but have been observed to take place in streets that are flat.

The patterns involve multiple street users; street users can encounter them from different perspectives. The different ways the pattern can be encountered are presented.

OPPOSING LEFT-TURNS ON A 4-LANE STREET COLLISION PATTERN

This Pattern Looks Like This

The street has 4 traffic lanes, with 2 lanes operating in each direction.
These lanes are through lanes.
The street doesn't have a left-turn lane or left-turn pockets.
Two vehicles, in opposing directions, stop at an intersection to make a left turn.
Traffic in the outside lanes, in one or both directions, is free-flowing (traveling at arterial speed).
Traffic in the free-flowing, outside lanes may be sporadic, so its arrival to the intersection is not predictable.



The Problem

The issue with this pattern is the two left-turning vehicles (and the traffic backed up behind them) can screen each other from being able to see traffic in the approaching, outside lanes. This affects the drivers' abilities to judge when they can make their turns safely.

What Happens

One of the drivers attempts their left turn. They don't see an approaching vehicle in the outside lane. Likewise, the approaching driver in the outside lane doesn't see and is unaware of the left-turning vehicle. The left-turning vehicle turns into or is struck by the oncoming vehicle in the outside lane.

These kinds of conditions can happen any time of day. It's not unusual that they occur near and during peak commute times, when traffic volumes—including left-turning volumes—are higher.

Variations in the Pattern

This pattern can occur at signalized intersections and at unsignalized intersections.

One of the left-turning vehicles may be a larger vehicle, like a van or a truck. Given its larger size, a truck can obscure the other turning driver's line of sight toward approaching traffic in the outside lane even more.

This kind of collision can occur where there's a curve in the roadway—in which case, the curve and positions of the opposing left-turning vehicles can further affect drivers' lines of sight to approaching vehicles in the outside lanes.

For this pattern, it's not unusual for the vehicles in the outside lane to be smaller vehicles, including motorcycles, which are harder to see. This can be particularly true when these vehicles are traveling toward the inside of their lane and don't have lights on.

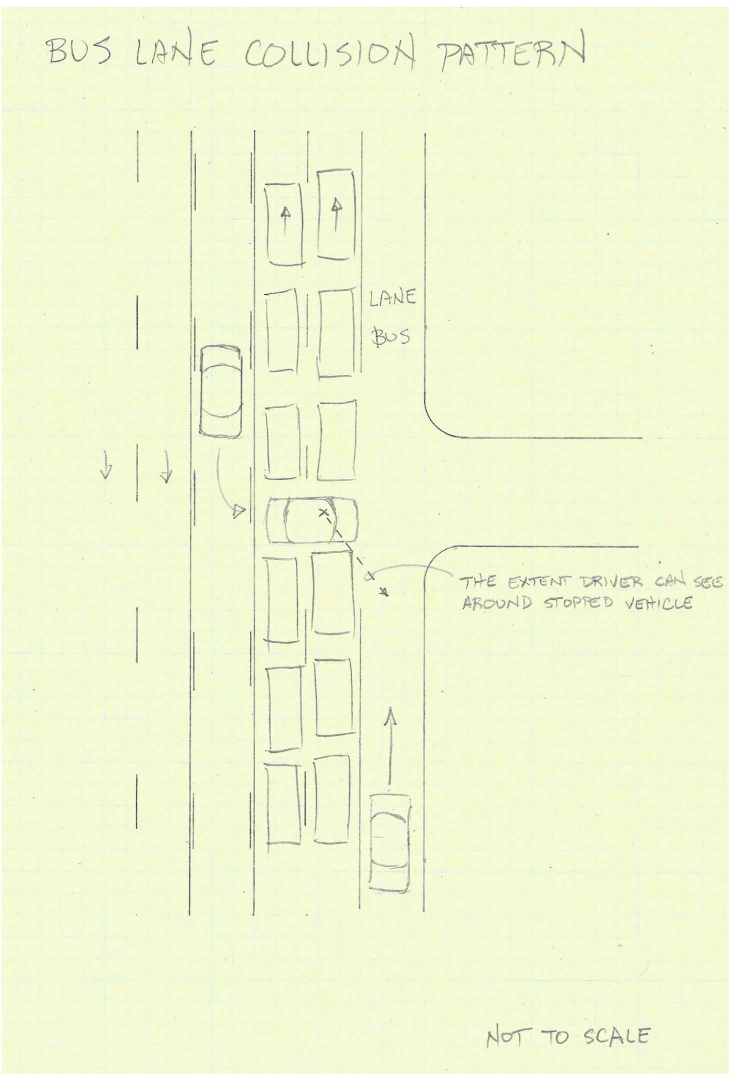
Sometimes the vehicles in the outside lane are initially approaching the intersection in the inside lane. On seeing a vehicle stopped in front of them, drivers change their lane—from the inside lane to the outside lane—to pass the stopped vehicle.

Different ways this pattern can be encountered include as a driver attempting the opposing left turn and as a driver approaching the intersection from the outside lanes.

BUS LANE COLLISION PATTERN

This Pattern Looks Like This

The street is five or more lanes wide.
It has a center, two-way left-turn lane.
An outside lane in one direction is a bus lane, or a bus-and-carpool lane.
Generally, this pattern occurs during peak commute times. Traffic is heavy. In the direction of the bus lane, the inside lanes for general traffic are very slow or stopped. In most cases, this traffic is backed up from a signal.
Traffic in the bus lane is free flowing and traveling at or near arterial speed.
The mix of traffic in the bus lane includes smaller vehicles—passenger cars (that may or may not be carpools) and/or motorcycles.
A driver attempts to turn left through the lanes of backed-up traffic and the bus lane from the left-turn lane.
Typically this turn is attempted at an unsignalized intersection or at a driveway.



The Problem

To make their turn, the driver proceeds from the turn lane into the backed-up lanes of traffic. On entering these lanes to cross the street, the turning driver's line of sight into the bus lane is blocked by vehicles stopped in the outside, general traffic lane. Likewise, in this position, smaller vehicles in the free-flowing, outside lane cannot see the turning vehicle.

What Happens

In this position, turning drivers often try to improve their line of sight to traffic in the bus lane by inching their cars forward. This yields only a very limited line of sight to approaching traffic in the lane. And, once in this position, there is no simple, safe and reliable way to get out of it. The turning driver attempts to enter and cross the bus lane with limited ability to see the traffic in it. Drivers in the bus lane do not have time to see and react to the crossing vehicle entering their lane. The crossing vehicle turns into or is struck by a vehicle in the outside lane. The vehicle in the bus lane is typically a smaller vehicle—a passenger car or a motorcycle—traveling in the lane at arterial speed.

Variations in the Pattern

Typically these left turns are from center, left-turn lanes, but in some cases, they are from through lanes.

Typically the outside lane is a bus lane, but in some cases the outside lane is a lower-volume, free-flowing, general-traffic lane. In some cases, this may be in a location just a block or two before a bus lane starts or a block or two after a bus lane ends.

Typically the turner is attempting to turn through two lanes of backed-up traffic. In some cases, this pattern occurs when they are turning through only one lane of traffic.

Sometimes the backed-up lanes of traffic are moving slowly and present some gaps. In this case, the challenges in turning through this traffic are:

- identifying a reasonable gap in the backed-up traffic to turn into,
- recognizing there is a free-flowing lane outside of the backed-up lanes, and
- seeing approaching traffic in the outside lane while dealing with traffic in the backed-up lanes.

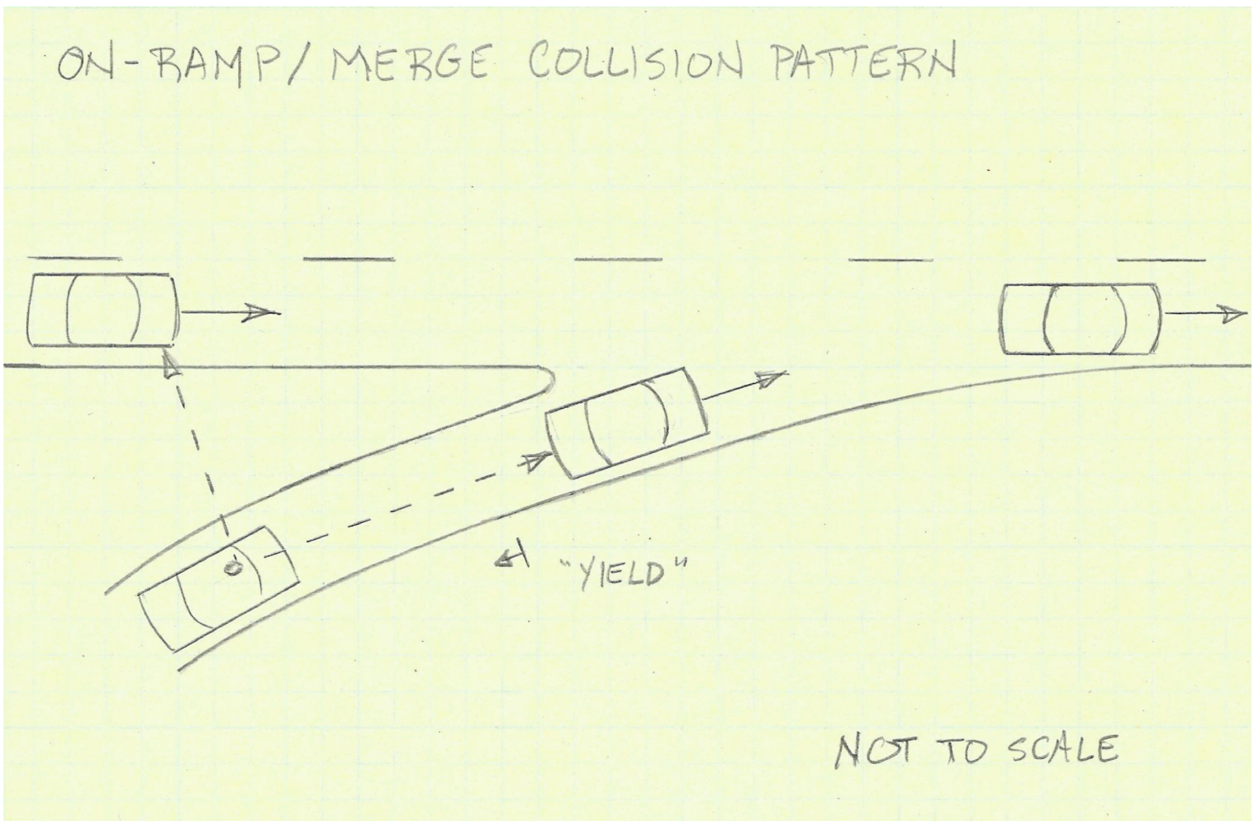
In some cases, a driver in the outside, stopped lane of traffic may indicate to the turning driver that the lane beyond them is clear, when in fact it's not safe to turn.

Different ways this pattern can be encountered include as the driver attempting the left turn, as a driver in the bus lane, and as a driver in the backed-up lanes of traffic (in front of whom the left turn is being made).

ON-RAMP/MERGE COLLISION PATTERN

This Pattern Looks Like This

Traffic is merging from a short ramp (often an on-ramp) onto a major roadway which may be a highway or freeway.
The merge is controlled by a yield sign.
The volume of traffic in the lane being merged into is moderate-to-high, so that merging drivers have to watch this lane closely to identify gaps in which to merge.
The line of traffic in the merging lane may be heavy and backed up.



The Problem

The challenge with this merge, especially onto a high-speed roadway, is that merging drivers must keep track of conditions in two directions at once—conditions *in front* of their vehicles (so they don't rear-end the merging vehicle ahead), while having to judge for gaps in the merge lane traffic *approaching from behind* them.

What Happens

One driver enters the ramp to merge. A second driver follows shortly behind them.
The second perceives a reasonable gap to merge into. The first driver does not.

As the second driver is looking *back* to judge their gap, the first driver *in front* suddenly slows or stops. The second driver runs into the first.

Variations in the Pattern

This kind of pattern can take place at non-ramp locations when drivers are trying to change from one lane to another in heavy traffic. Usually one lane is stop-and-go and the other is more free-flowing. In their attempt to merge from their lane, the driver looks back into the free-flowing lane for a gap, and when they do this, the traffic in their own lane suddenly slows or stops.

The key driver in this pattern is the trailing driver, who is following too closely given the conditions. *Different ways this pattern can be encountered include* as the "lead driver" in the merging lane, the trailing driver, and as a driver in the lane being merged into.

Takeaway—Rear-End Collisions and Injury

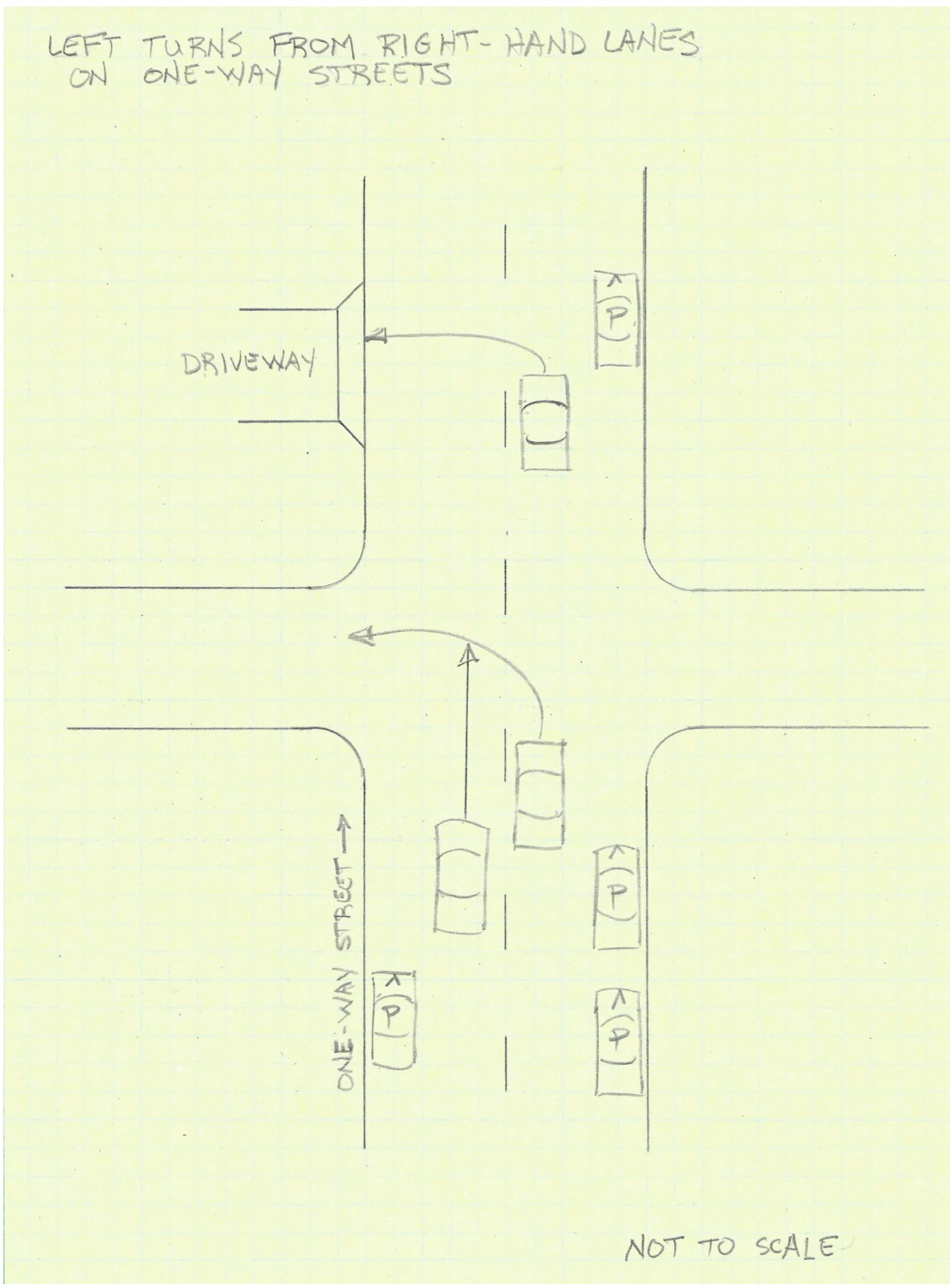
Rear-end collisions occur in many different ways. This pattern is one example. In general, these collisions are the product of not maintaining a sufficient buffer and inattention to the conditions in one's driving path.

Rear-end collisions account for many collisions and *they are a source of many, many significant injuries*.

LEFT TURN FROM RIGHT-HAND LANE ON ONE-WAY STREETS COLLISION PATTERN

This Pattern Looks Like This

A driver is in the right-hand lane of a one-way street they are not familiar with, often in a neighborhood they are unfamiliar with.
Generally the street has two lanes, though it may have more.
The driver is seeking a route through the neighborhood, parking, or access to the freeway.
Traffic on the street is light-to-moderate.



What Happens

Thinking they are on a two-way street, the driver in the right-hand lane attempts a left turn into a cross-street or a driveway. This turn cuts off a vehicle that's traveling in the left lane, slightly behind the turning vehicle, causing a collision.

This kind of collision typically takes place during the middle of the day at non-signalized intersections and driveways.

The Problem

My experience has been that high-collision locations of this pattern occur almost exclusively in parts of the city visited by out-of-towners. The streets in these parts of the city tend to be active. They serve a diversity of street users. There's a lot of street-related information to take in and process—all while trying to get to a specific destination by a specific time. In these conditions, drivers unfamiliar with the streets can become too overwhelmed to register that they are on a one-way street.

Variation

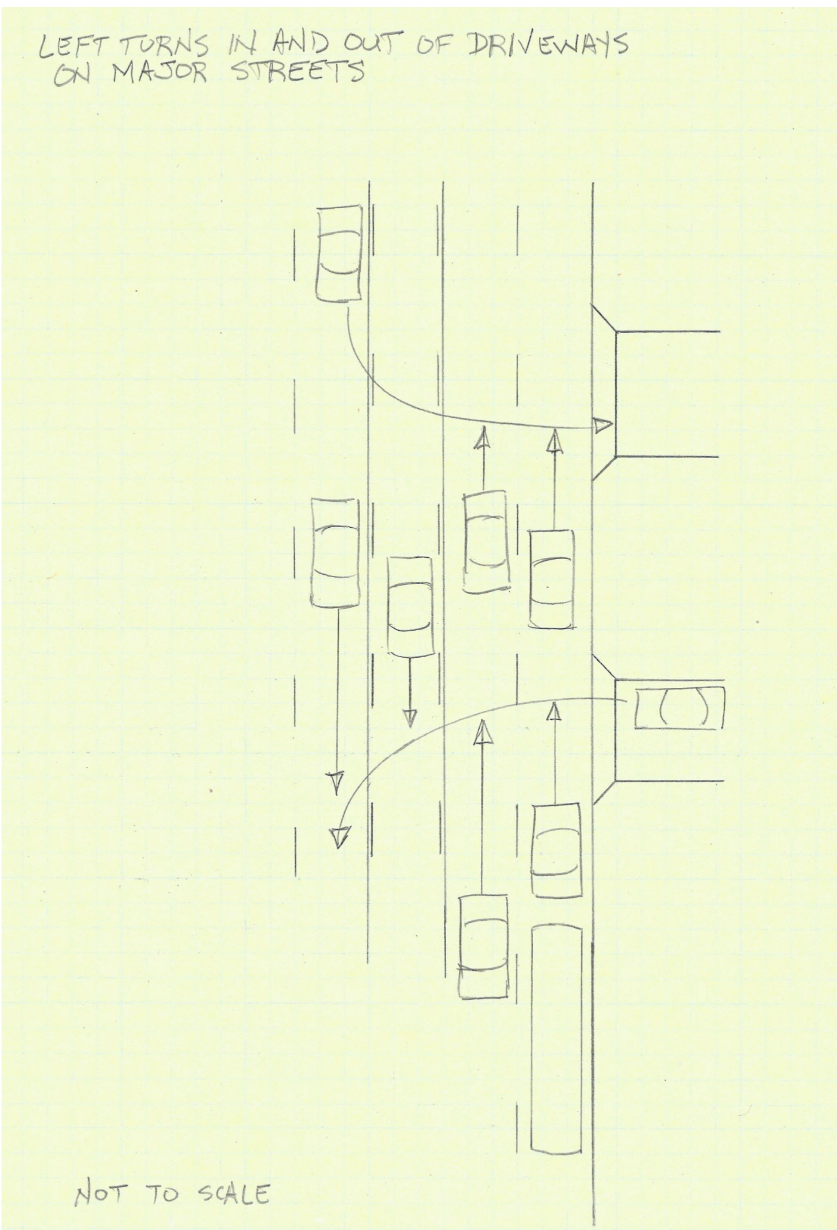
It's not unusual for this pattern to occur on one-way streets either approaching or just coming off of freeway ramps.

Different ways this pattern can be encountered include as the driver in the right-hand lane (who is unfamiliar with the street) attempting a left turn and as a driver one lane over who is cut off by the turning driver.

LEFT TURN COLLISIONS IN AND OUT OF DRIVEWAYS ON MAJOR STREETS

This Pattern Looks Like This

The street is five or more lanes wide.
It generally has a left-turn lane in the center.
There are a number of driveways along the street. These often include driveways for large parking lots.
The street is active. Traffic is moderate-to-high.
Transit may be operating along the street.
The driveways along the street are active. Traffic is making left turns in and out of them.



The Problem and What Happens

Turns in and out of driveways in these conditions are across multiple lanes. In general, the more lanes one has to cross when making a turn, the more difficult the turn. The turning driver has to take into account and judge the speed and flow and gap opportunities presented by each lane they are crossing.

Judging traffic can be more challenging when there's a mix of traffic on the street—for example, when there's a bus or a truck operating in one lane. These vehicles operate differently than passenger cars. They accelerate differently. They slow differently. Buses will stop at bus stops. They also alter passenger-car behavior. Drivers are often forced to slow to accommodate larger vehicles or to change lanes to get around them. Mixed traffic requires turning drivers to take more into account and do more mental processing (it increases their cognitive load) when deciding how to make their turns.

One problem with crossing many lanes is that turning drivers misjudge their turns and collide with traffic in the through lanes. Often these collisions are t-bones.

Variations

In some cases, drivers make their left turns more complex by not using the center turn lanes, which increases the number of lanes in which they have to judge other traffic.

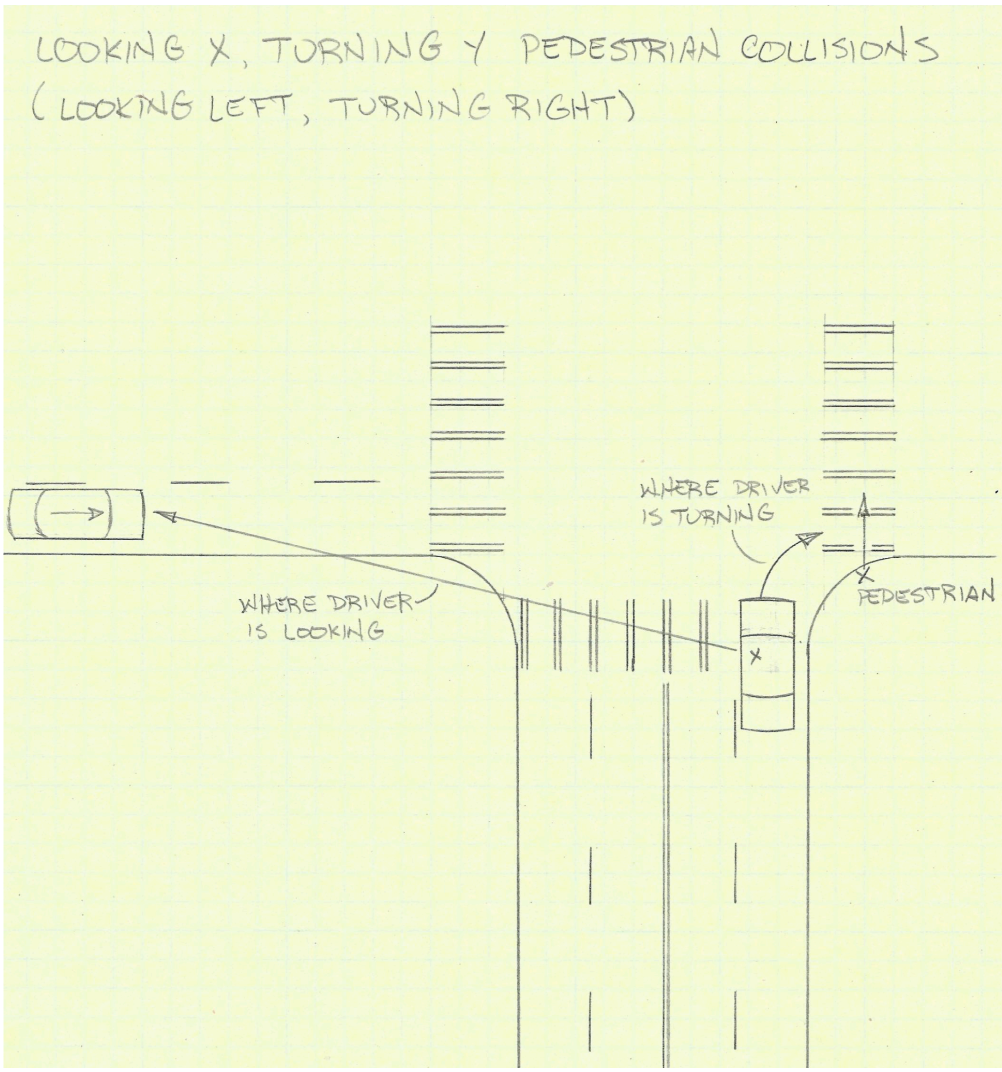
Another problem is turning drivers may precipitate other collisions. For example:
a left-turning driver darts in or out of a driveway.
A driver in a through lane slams on their brakes to avoid hitting the turning vehicle.
The driver behind them, following too closely, rear-ends them.

Different ways this pattern can be encountered include as a driver making a left turn into a driveway, a driver making a left turn out of a driveway, and as one driving along one of these heavily-traveled streets.

LOOKING X, TURNING Y PEDESTRIAN COLLISION PATTERN

This Pattern Looks Like This

A driver wants to make a turn at an intersection.
Usually this is a right turn from a two-way street to another two-way street.
This turn is into the nearest lane of the cross-street.
Traffic in the lane they want to turn into is moderate-to-high.
Looking for a gap to enter the lane, the driver is focused on the oncoming traffic in that lane.



What Happens

The driver sees a gap in traffic and turns without adequately checking in the direction they are turning. At the same time, a pedestrian enters the crosswalk or legal crossing area in front of the turning vehicle and is struck.

The Problem

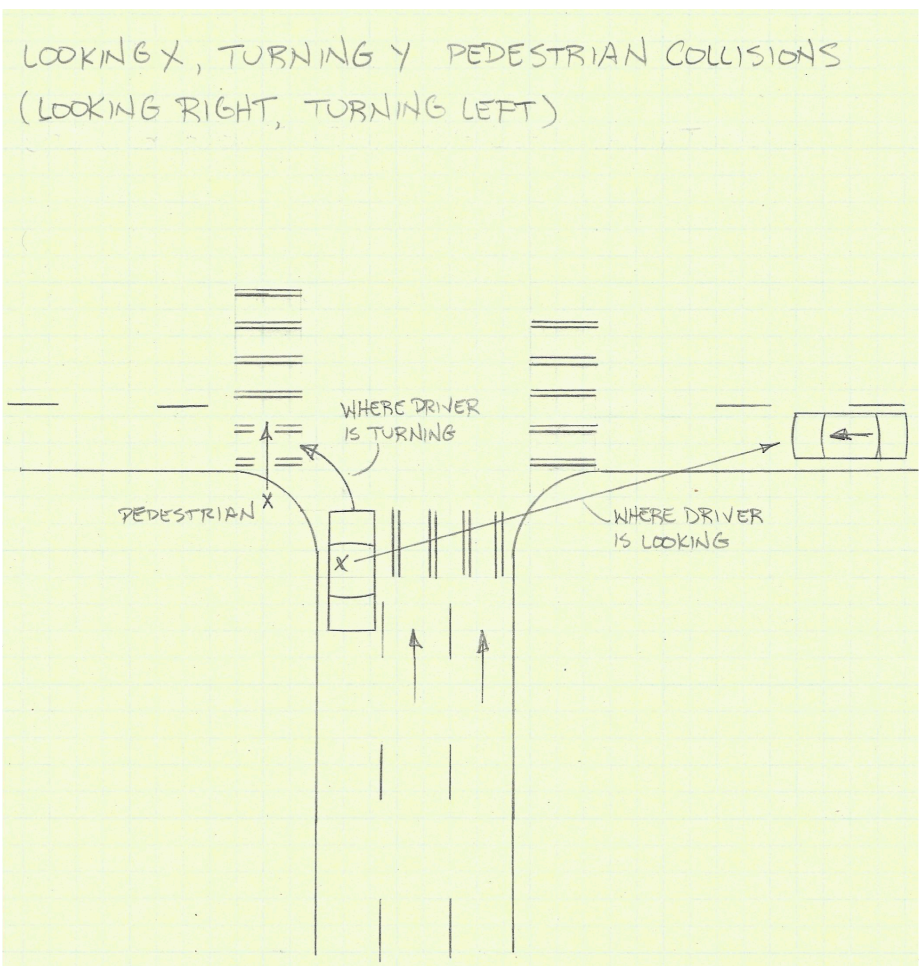
This pattern is similar to the on-ramp collision pattern. In both cases, the driver's attention is so focused on trying to identify a gap in the lane they want to enter, they don't maintain enough awareness of the condition in front of their vehicle.

Variations

This pattern can take place anywhere there are pedestrians—at signalized and unsignalized intersections and on one-way and two-way streets.

More typically it takes place where drivers are attempting right turns from one two-way street onto another. In this case, drivers are looking left while turning right.

I have seen this as a high collision location pattern at an intersection between one-way streets where drivers were attempting left turns. In this case, drivers were looking to the right while turning left.



Typically this pattern takes place where one or both of the streets are arterials and in areas with higher numbers of pedestrians.

Though you might think this pattern shouldn't occur at signals, beware that it does! This variation can look like this:
A driver is stopped and wants to make a turn on a red signal (typically this is for a right turn on red).
As they are watching the near lane on the cross-street for a gap, traffic in the lane slows and a gap becomes apparent.
Focused on that gap, the driver makes their turn.
What the driver is not aware of—because they are focused on the traffic in the lane they are turning into—is the signal in that lane's direction has turned yellow (causing traffic in that direction to slow and create the apparent gap). The driver perceives this "gap" and turns about the moment their own signal turns from red to green and its corresponding pedestrian signal turns from "Don't Walk" to "Walk."
Unaware of the turning vehicle, a pedestrian steps into the crosswalk with the Walk signal.
The turning driver strikes the pedestrian.

Another variation at signalized intersections can involve drivers turning into pedestrians who disregard their pedestrian signal and cross the street against a "Don't Walk." Pedestrians can do surprising things, particularly in areas with a lot of pedestrian activity.

Different ways this pattern can be encountered include as the turning driver and as a pedestrian whose path is crossed by the turning driver.

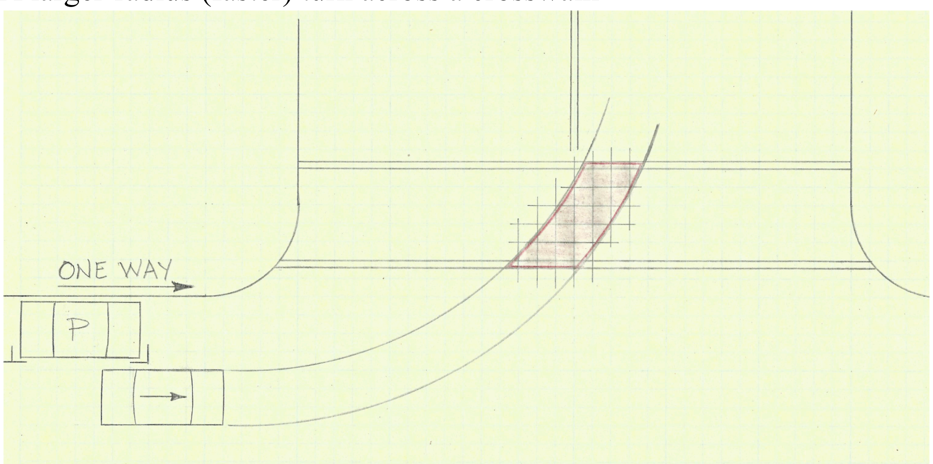
LEFT TURN FROM ONE-WAY STREETS PEDESTRIAN COLLISION PATTERNS

Left-Turn Pedestrian Collision Pattern in New York City

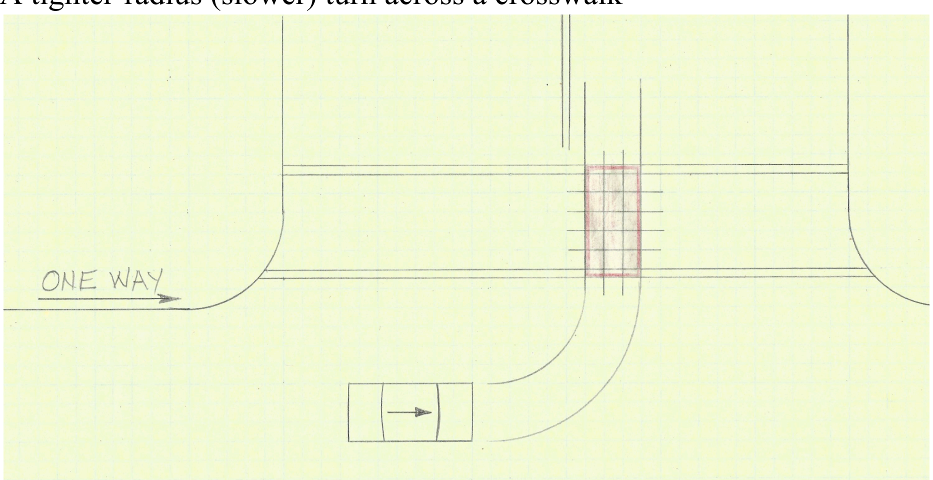
In its safety work, the New York City Department of Transportation identified a pattern[17] that generally occurs when drivers make left turns from one-way streets onto wide, two-way streets at signalized intersections, and they strike pedestrians who are legally crossing the street.

One element in these collisions is that drivers (in not having to contend with a lane of on-coming traffic) will tend to travel more diagonally over the crosswalk as they make their turns. When they do this, their vehicles travel through a greater area of the crosswalk than when crossing it at a right angle. When drivers cut diagonally across the crosswalk like this, they also tend to carry more speed than when turning across a crosswalk at a tighter-radiused angle.

A larger-radius (faster) turn across a crosswalk



A tighter-radius (slower) turn across a crosswalk



[17] Source: the New York City DOT's report *Don't Cut Corners – LEFT TURN Bicyclist and Pedestrian Crash Study,* August 2016. Pages 9-10.
https://nyc.gov/html/dot///downloads/pdf/left-turn-pedestrian-and-bicycle-crash-study.pdf

Another factor noted in this kind of collision is that the left side of the one-way streets may be heavily parked, which can affect a driver's line of sight to some crossing pedestrians.

One more factor in these collisions is related to vehicle design. In the U.S. and Canada, we drive on the right-hand side of the road, and the driver is on the left side of the car. The vertical post that runs along the left side of the windshield and the driver's door is about one to two feet from the driver. The posts on both sides of the windshield, which connect the car's roof to its body, are called "A Pillars." Because the A Pillar on the driver's side is close to the driver's eye, it can affect their visual field and create a blind spot large enough to hide a pedestrian in the direction of left-hand turns.

New York City's experience with this pattern of collisions is that, too often, they are severe. Left-turn collisions involving pedestrians have made up a large proportion of severe-injury and fatal collisions on their streets.

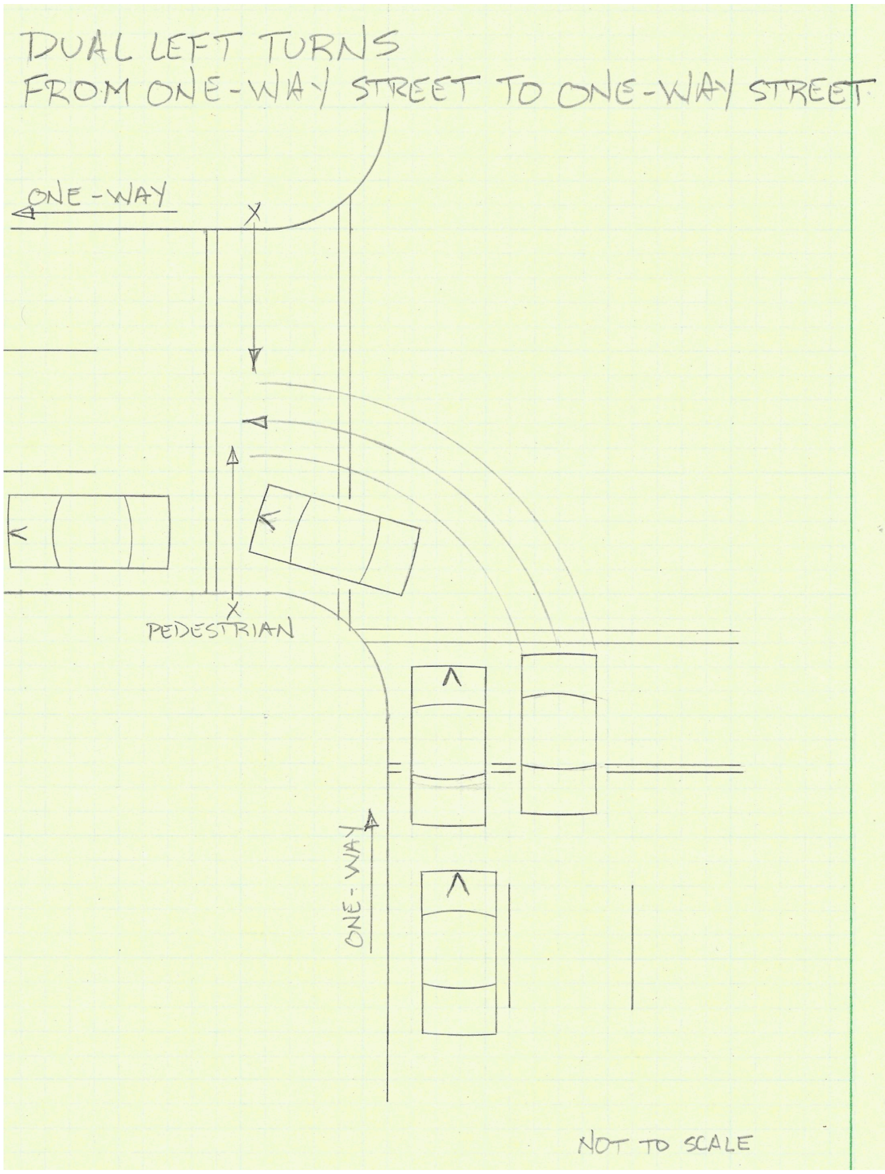
Left-Turn Pedestrian Collision Pattern in Seattle

Likewise, a left-turn collision pattern involving one-way streets and pedestrians has been found at signalized intersections in downtown Seattle.

This Pattern Looks Like This

Drivers are making left turns downtown from a one-way street to another one-way street.[18]
These streets provide access to the freeway or are next to streets that do.
These turns are through signalized intersections.
Pedestrian and vehicle traffic is heavy. This is often during afternoon commute times.
The left-turning vehicle traffic is backed up in the curb lane. It may be backed-up in the next lane, too.
These left turns may or may not be signed as dual left turns (which allow left turns from the next lane over from the left curb).
Drivers make dual, left turns (i.e., make their left turns from the second lane out) to get around the left-turning traffic backed up in the curb lane.

[18] This differs from the New York City pattern, which generally involves left turns from a one-way street to a two-way street.



The Problem

The causes of these collisions aren't fully clear. Problems raised by dual left turns across crosswalks can include:

- Pedestrians can get trapped in between two lanes of turning vehicles.
- One turning vehicle can obscure the other's line of sight to crossing pedestrians. This may be particularly true when turning traffic in the curb lane is stopped or near-stopped; pedestrians begin to cross the street from behind this traffic; and they are met by turning traffic in the next lane.
- Drivers have to watch for pedestrians entering the crosswalk from both sides of the street.

- Higher speed turns made in the next lane out from the curb reduce the time for drivers and pedestrians to see and react to each other. They increase the potential for injury if a pedestrian is hit.

The downtown streets this pattern has been observed on are near freeway on-ramps. So a part of the challenge in these locations is likely that drivers are aggressive in seeking to gain access to the freeway. In general, once a platoon of turning vehicles starts through an intersection toward a freeway ramp, it's common for the platoon to keep going whether there are pedestrians present or not.

The A Pillar, partially blocking drivers' vision of pedestrians, is a potential factor in these collisions, as well.

Another factor may be related to vehicles' sizes. In recent work, it has been found that larger vehicles—including pick-up trucks, SUVs, vans, and minivans—are more likely than passenger cars to hit pedestrians when making turns.[19] A big concern with this is larger vehicles are also known to cause more severe injuries than smaller passenger cars when they strike pedestrians.[20] A factor in the higher rates of collisions associated with these larger vehicles may be their A Pillars. Their A Pillars tend to be wider than those of passenger cars. Their width and their placement in larger vehicles may have a pronounced effect on drivers' line-of-sight to pedestrians when making left turns.[21] The larger hoods of these vehicles can also be a factor in their drivers being able to see pedestrians.

Different ways this pattern can be encountered include as a driver making a left turn from the curb lane, as a driver making a turn from the next lane out, and as a pedestrian who may be crossing the crosswalk from either direction.

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19 *SUVs, other large vehicles often hit pedestrians while turning.* Source: Insurance Institute for Highway Safety- Highway Loss Data Institute (IIHS-HLDI). According to this work: At intersections, the odds that a crash that killed a crossing pedestrian involved a left turn by the vehicle versus no turn were about twice as high for SUVs, nearly three times as high for vans and minivans and nearly four times as high for pickups as they were for cars.
https://www.iihs.org/news/detail/suvs-other-large-vehicles-often-hit-pedestrians-while-turning

20 *SUVs, other large vehicles often hit pedestrians while turning.* Source: Insurance Institute for Highway Safety- Highway Loss Data Institute (IIHS-HLDI). "We already know that larger vehicles cause more severe injuries when they strike pedestrians."
https://www.iihs.org/news/detail/suvs-other-large-vehicles-often-hit-pedestrians-while-turning

21 *SUVs, other large vehicles often hit pedestrians while turning.* Source: Insurance Institute for Highway Safety- Highway Loss Data Institute (IIHS-HLDI). "It's possible that the size, shape or location of the A-pillars that support the roof on either side of the windshield could make it harder for drivers of these larger vehicles to see crossing pedestrians when they are turning."
https://www.iihs.org/news/detail/suvs-other-large-vehicles-often-hit-pedestrians-while-turning

THE GOOD SAMARITAN COLLISION PATTERN

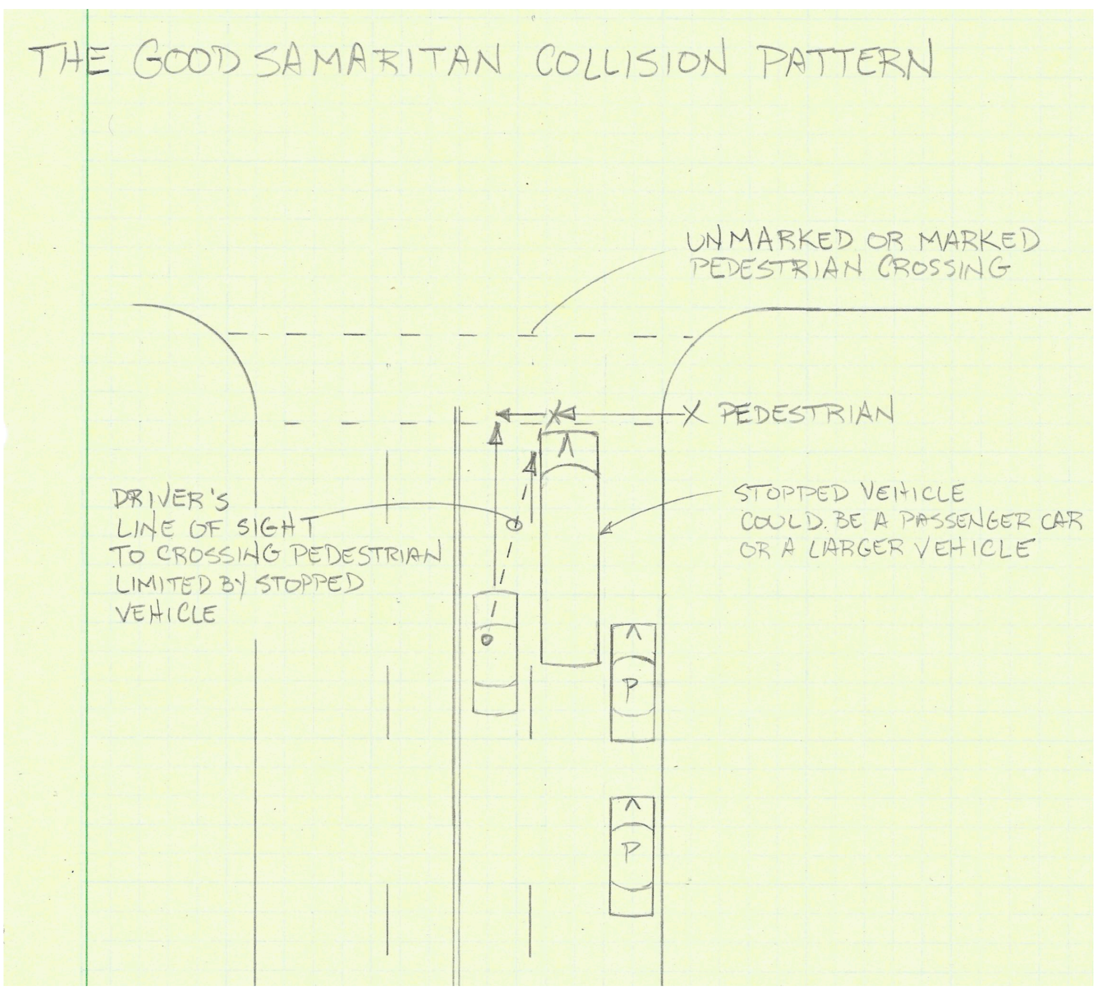
I've not seen this pattern in large numbers. However, the injuries that result are, too often, very severe. Drivers and pedestrians need to be aware of it.

This Pattern Looks Like This

The street has two or more lanes of traffic operating in the same direction.
A pedestrian wants to cross the street at a legal crossing.
A driver in the lane nearest the pedestrian stops their vehicle to allow the pedestrian to cross.
Traffic continues to flow at arterial speed in the next lane.

What Happens

The pedestrian crosses the lane in which the vehicle is stopped. They continue crossing into the next lane of free-flowing traffic and are struck.



The Problem

When pedestrians see that a driver has stopped for them, they may overlook the next lane of traffic or assume the drivers in the next lane will also stop for them, too. They may assume, too, because they are in a legal crossing that traffic will stop for them. The stopped vehicles limit the line of sight between the crossing pedestrian and moving traffic in the next lane. This is particularly true when the vehicle is stopped very near where the pedestrian is crossing. Drivers in the lane of moving traffic don't realize the vehicle in the lane next to them has stopped for a pedestrian.

Most of these collisions that I know of involved children or elderly pedestrians—who may not be able to reliably make safe judgments in these conditions.

Because the drivers cannot see the pedestrians, they have little time to react and slow for the crossing pedestrian. The outcomes of these collisions are too often severe.

Variations

Usually, this pattern occurs when the pedestrian steps off from the curb, a driver in the adjacent lane (usually the right-hand travel lane) stops for the pedestrian, and a moving vehicle in the next lane strikes the pedestrian at speed.

This can also happen when a pedestrian crosses from the other side of the street, they reach the centerline, a vehicle in the left lane stops for them, but the vehicle in the right lane does not. In this case, the stopped vehicle (stopped next to the centerline) may be incorrectly assumed to be making a left turn instead of stopping for a pedestrian.

In some cases, these collisions occur:

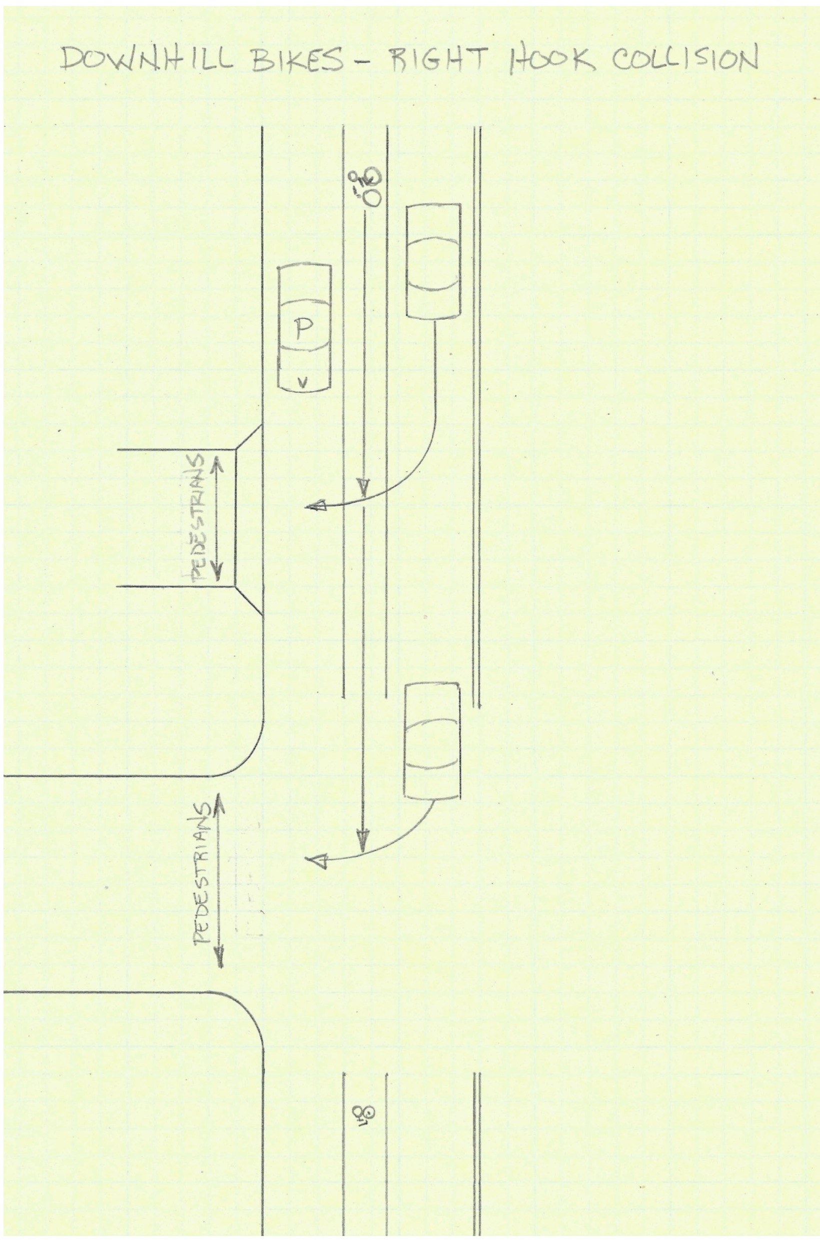
- Where the stopped vehicle is a large vehicle, like a truck or a bus—further limiting line of sight between the pedestrian and approaching traffic in the live lane.
- When a driver approaching the stopped vehicle from behind changes lanes to go around the stopped vehicle.
- When a driver stops for the pedestrian and invites the pedestrian to cross.
- When a pedestrian is not crossing at a legal crossing.
- When, at a signal, a pedestrian is crossing against a Don't Walk signal.

Different ways this pattern can be encountered include as the crossing pedestrian, the driver stopped in the lane nearest the crossing pedestrian, and the driver in the adjacent free flowing traffic lane.

DOWNHILL BIKE, RIGHT-HOOK COLLISION PATTERN

This Pattern Looks Like This

A driver and a cyclist are traveling downhill.
The driver is in the right hand, general traffic lane.
The cyclist is in a marked bike lane to the driver's right, between the general traffic lane and the curb.
The driver is in front of the cyclist.
The cyclist is traveling at or near arterial speed.
The driver slows to make a right turn.
The cyclist continues at speed, catches up to the car, and enters its blind spot.



The Problem and What Happens

Not aware of the cyclist, the driver makes a right turn across the bike lane, in front of the cyclist. The cyclist isn't able to react fast enough to avoid crashing. They crash either into the car's side or, if they avoid the car, onto the street.

Variations

On city streets, where there are bike lanes, there's generally pedestrian traffic. Pedestrians in the driver's turning path (in the crosswalk or crossing a driveway) can draw the driver's attention away from approaching cyclists. Where there's pedestrian activity, part of the driver's challenge with this pattern is having to balance their attention between cyclists (approaching from *behind* them) and pedestrians *in front* of them, in the path of their right turn.

This kind of collision can occur at signalized intersections, unsignalized intersections, and driveways.

It can occur on flat roadways as well as on downhill grades.

There's often a parking lane between the bike lane and the curb, but sometimes not.

It can occur where a bike trail runs parallel to a street (where the driver, unaware of the trail and cycling traffic on it, turns across the trail).

It can occur when a cyclist is riding along the sidewalk (and crosses the street in the crosswalk).

It can occur when a cyclist is riding in an open parking lane.

A variation can occur when a vehicle, making a left turn from a one-way street, turns across a bike lane on the left side of the street.

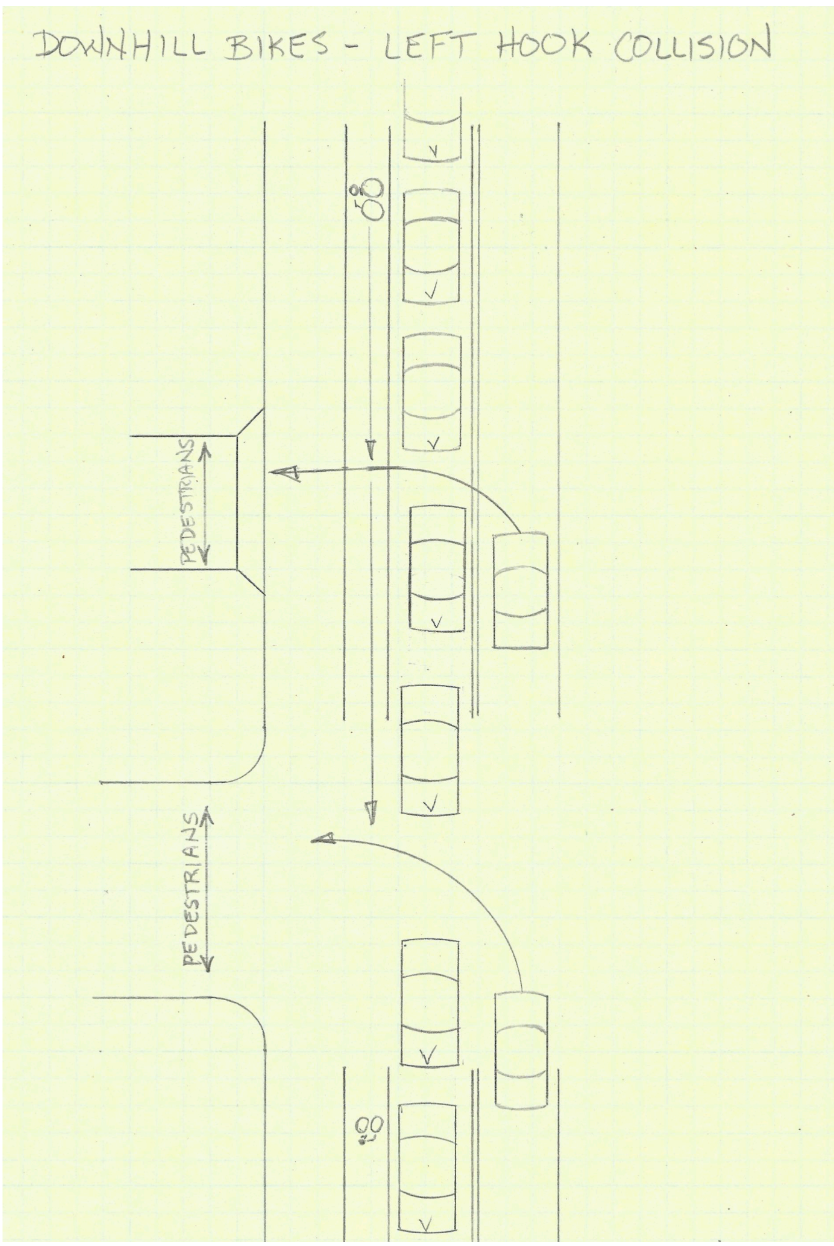
A variation that requires extreme attention is when the vehicle making the turn is a large truck or a large truck pulling a trailer. When large vehicles make turns, they can swing wide and create an apparent space for smaller vehicles to run up alongside them in the curb or bike lane. As they make their turns, cyclists are cut off and can end up beneath the truck or trailer. These collisions are often fatal.

Different ways this pattern can be encountered include as a cyclist and as a driver making a right turn across a bike lane.

DOWNHILL-BIKE, LEFT-HOOK COLLISION PATTERN

This Pattern Looks Like This

A cyclist is riding downhill in a marked bike lane.
A driver is headed uphill in the opposing direction, seeking to turn left.
There is a general traffic lane in the downhill direction, between the bike lane and the lane the left-turning driver is turning from.
Traffic backs up in the downhill, general traffic lane. This traffic is generally backed up from a nearby signal.
The bike lane is free-flowing; the cyclist is traveling at or near arterial speed.
The uphill driver attempts a left turn through a gap in the lane of backed-up traffic.



The Problem

The heavy lane of traffic in the downhill, general traffic lane limits the driver's ability to see and be aware of the bike lane. It limits the turning driver's ability to see cyclists in the bike lane and cyclists' ability to see the turning vehicle.

Drivers, in focusing on heavy traffic in the opposing direction and/or different kinds of traffic (including pedestrians and buses) that are common on city streets, may not be looking for and anticipating cyclists in the oncoming direction.

After the vehicle enters the bike lane, it either strikes or is struck by the cyclist.

Because these collisions are often t-bone collisions, the cyclists in them tend to be riding with speed, and (in some cases) the left turns made in them can be made with speed, they tend to be very severe.

Variations

This kind of collision can occur at driveways and at intersections.[22]

It can occur where the driver makes their turn from a center turn lane or a general traffic lane.

Though more common on streets with downhill grades, on which cyclists can easily pick up speed, this kind of collision can happen on flat grades as well.

There's often a parking lane between the bike lane and the curb, but sometimes not.

It can happen in locations where there's not a bike lane—for example, where there's a lane of parking that's open or cleared away and a cyclist is using it like a bike lane.

Sometimes the driver in the stopped vehicle nearest the turning driver, unaware of the approaching cyclist, will wave the turning driver through.

Left-turn collisions into cyclists can occur in conditions when there isn't a lane of backed-up traffic. In this case, the lane(s) of traffic between the turning driver and the cyclist may be moving and active. In focusing on and trying to judge a gap in the general-traffic lanes, the turning driver doesn't see or is unaware of the cyclist. In this case, when accelerating through the gap in oncoming motor traffic, the left turn is made at a higher speed, adding to the severity of the collision.

Different ways this pattern can be encountered include as the left-turning driver, the cyclist, and drivers in the lane of backed-up traffic through which the driver is turning.

[22] Many of the collisions I've seen of this type have been at driveways.

BIKES AND TRACKS CRASH PATTERN

This Pattern Looks Like This

There's a rail track in a street used by cyclists.
The track is not physically separated from the bike route.
The track runs near parallel to the path cyclists ride and crosses their path.

The Problem

In Seattle, this pattern has been observed in high numbers at track crossings on an industrial street, where there's a low volume of motor vehicle traffic. Feeling safe on the low-volume street, cyclists apparently overlooked the tracks or underestimated the hazard they present.

Bike crashes on tracks have also been seen on active city streets that have both streetcar tracks and bike lanes. While in the presence of tracks and having to maneuver in complex traffic conditions cyclists can:

- Lose awareness of the tracks and their location.
- Be suddenly forced to react to other traffic and inadvertently cross the tracks.

In either case, the cyclist crosses the tracks at a shallow angle. Their narrow tire catches in the track flangeway. While they don't necessarily involve another vehicle, these are violent crashes. The cyclist goes down hard and is generally injured—often severely. In areas of active traffic, the down cyclist is then at risk of being struck by another vehicle.

In a study performed in Toronto and Vancouver, the presence of streetcar and train tracks was identified as a major cause of bike-related injuries. This work focused on visits by cyclists to emergency departments in and near these cities' central business districts. For the period studied, track-related crashes accounted for about 14 percent of cyclists' visits to these emergency departments for injuries and treatment.[23]

Variations

This kind of crash has been seen in locations where:

- A bike lane turns onto a street on which there's a track that runs straight, the lane crosses the tracks, and the turn presents a situation in which cyclists cross the tracks at a shallow angle.

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[23] *Bicycling Crash Circumstances Vary by Route Type: A Cross-Sectional Analysis*, Kay Teschke, Theresa Frendo, Hui Shen, M Anne Harris, Conor CO Reynolds, Peter A Cripton, Jeff Brubacher, Michael D Cusimano, Steven M Friedman, Garth Hunte, Melody Monro, Lee Vernich, Shelina Babul, Mary Chipman and Meghan Winters. See Figure 1 on page 3.
https://bmcpublichealth.biomedcentral.com/counter/pdf/10.1186/1471-2458-14-1205.pdf

- A track turns onto a street and crosses a bike lane that runs straight—presenting a situation in which cyclists might cross the tracks at a shallow angle.
- The track doesn't cross the marked bike lane, but it runs parallel and near the lane and isn't physically separated from it. In this case, conditions in traffic may cause the cyclist to veer from the bike lane onto the track. Or the cyclist may be distracted and veer from the path and inadvertently meet the track.

Wide joints in concrete panels or raised edges along panels can create conditions that catch bike tires in a manner similar to tracks, causing bike crashes.

Cyclists can catch their tires in old-style, slotted drain inlets.

Rather than catch their tires in the flangeway, cyclists can slip on the rail and go down, particularly in wet or icy weather.

Falls can occur on tracks that cross streets diagonally.

Other smaller vehicles, including motorcycles and motor scooters, are also susceptible to slipping on tracks.

Different ways this pattern can be encountered include as a cyclist or as a driver near a cyclist who may influence the cyclist's travel toward a track or strike them should they fall.

DOORING

Dooring is a kind of bike collision that's hard to keep track of in terms of numbers. We know these collisions happen; many cyclists have a dooring story they can tell, but they aren't generally reported and included in traffic collision reports and records.[24] [25] While they don't involve another moving vehicle, they involve a smaller, vulnerable road user versus one that's larger and immovable. They are often violent. When they occur, the cyclist is often injured.

This Pattern Looks Like This

A cyclist is riding in a bike lane next to a vehicle parked in a parking lane.
The bike lane has no separation from the parking lane.
The cyclist is riding with some speed—downhill or along a flat grade.
The driver or passenger opens the door of their vehicle directly in front of the cyclist.
Riding at speed, the cyclist doesn't have time to stop and hits the opened door.

Variations

Often doorings happen next to short-term parking with high turnover, like loading zones, but they can happen anywhere there's parking.

Rather than hitting the door head-on, the cyclist might swerve to avoid the door and go down hard—or be exposed to traffic in the adjacent lane.

The cyclist is not riding in a bike lane but between parking and general traffic.

The cyclist is riding on the right-hand side of a vehicle and the passenger door is opened.

Different ways this pattern can be encountered include as a cyclist, as a driver having parked and opening their vehicle door next to a bike lane or bike route, and as a driver following/near a cyclist riding next to parked cars.

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[24] This kind of information is not typically collected and provided in traffic collision reports to the Seattle Department of Transportation.
[25] A study involving cyclists' injuries requiring emergency department treatment in Toronto and Vancouver found that doorings made up a significant proportion, and number, of bike collisions that result in injuries in these cities' central business districts—on the order of 9 percent. See *Bicycling Crash Circumstances Vary by Route Type: A Cross-Sectional Analysis*, Kay Teschke, Theresa Frendo, Hui Shen, M Anne Harris, Conor CO Reynolds, Peter A Cripton, Jeff Brubacher, Michael D Cusimano, Steven M Friedman, Garth Hunte, Melody Monro, Lee Vernich, Shelina Babul, Mary Chipman and Meghan Winters. See Figure 1 on page 3.
https://bmcpublichealth.biomedcentral.com/counter/pdf/10.1186/1471-2458-14-1205.pdf

RIGHT-ANGLE, RED-LIGHT-RUNNING COLLISIONS

Collisions where a vehicle runs a red light are often extremely violent because they tend to involve impacts at a right angle at high speeds. The running vehicle often t-bones (or is t-boned by) a vehicle legally crossing the intersection. The running vehicle may strike a pedestrian or a cyclist at high speed. These collisions are generally the result of high-risk behavior by drivers, including aggressive or inattentive driving.

Red light running often occurs just after the signal has changed, and drivers entering the intersection on a new green (or pedestrians stepping into their crosswalk on a "Walk" signal) are struck by drivers from the cross-street who have entered the intersection either on a very stale yellow light or against a new red one.

Variations

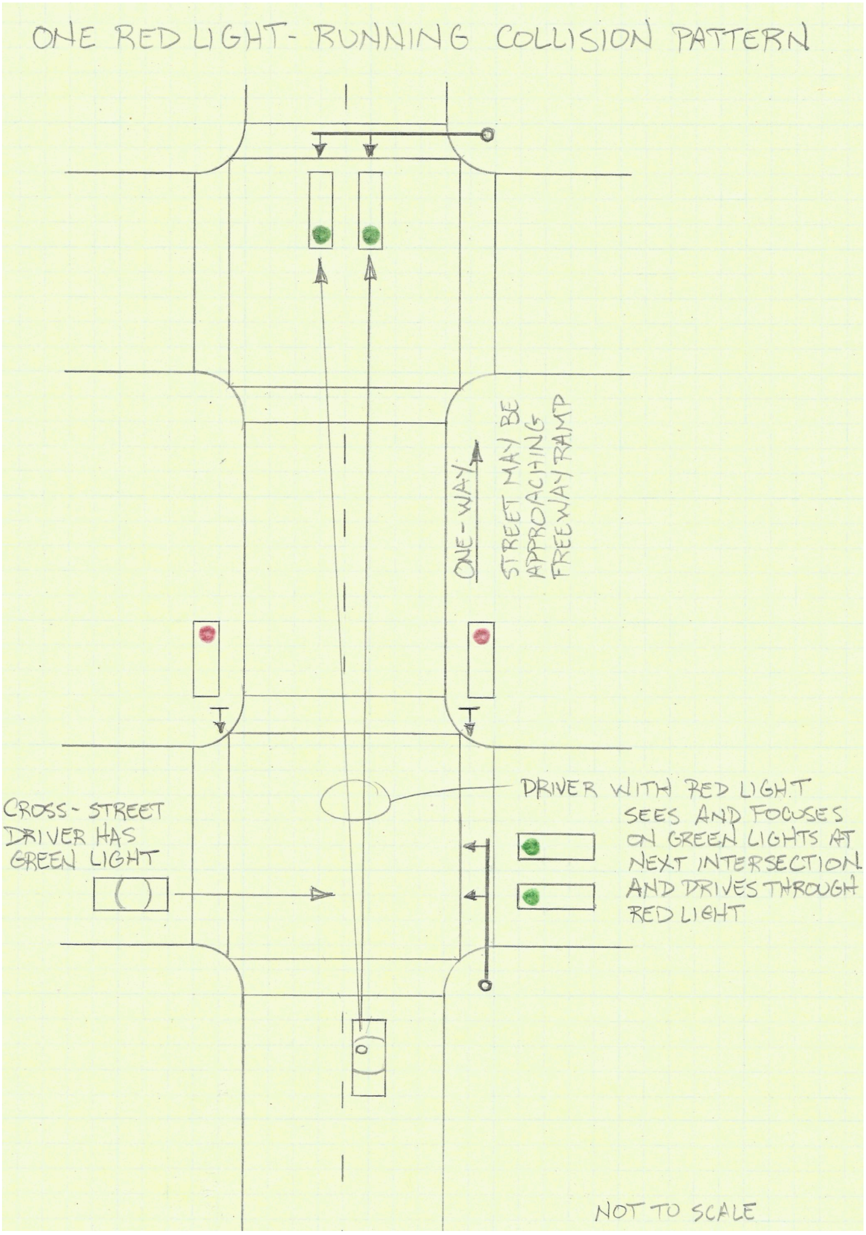
There are intersections between very large streets (usually of five lanes or more each). Given their sizes, these intersections tend to have many signalized movements. The result is their cycle lengths are often very long, and drivers may have to wait a long time before it's their turn to go. In these conditions, it's not unusual for drivers (trying to avoid waiting a whole another cycle) to push beyond the length of their yellow signal and enter the intersection after their light has turned red.

In Seattle, a red-light running pattern has been observed that doesn't apparently involve intentional, high-risk behavior. This pattern looks like this:

A driver is on a one-way street downtown, approaching a freeway ramp.
This is typically at night time.
They are about two blocks from the ramp.
Traffic in their direction may be light. There are no cars in their direction immediately in front of them.
The signal heads for the intersection the driver is approaching are located over the sidewalk, on the left and right sides of the street.
The signal heads for the intersection one block further down the street, at the ramp entry point, are located overhead, directly over the lanes. These signals are visible for a distance greater than a block.

A challenge of this situation is that, if a driver is tired or unfamiliar with this design, they may overlook the signals at their intersection (on the sides of the street) and mistakenly focus on the signal straight in front of them (overhead) at the next intersection—if the signal from the next intersection is visible beyond one block. In this case, when the nearest intersection signal is red and the signal at the next intersection is green, the driver may overlook and run the red light at their intersection.

This pattern can occur at locations other than approaches to freeways.

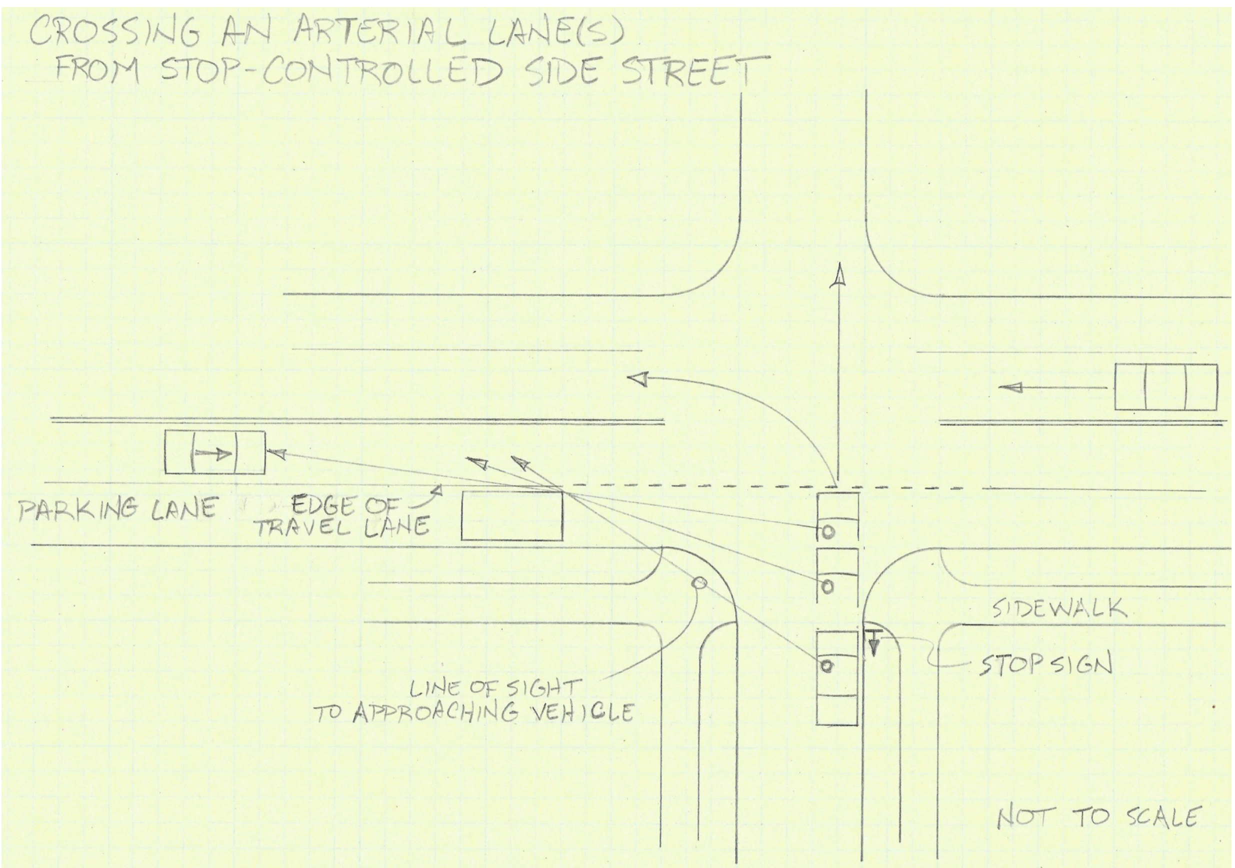


Different ways this pattern can be encountered include as a driver running their red light and drivers/pedestrians/cyclists having entered the cross street.

CROSSING AN ARTERIAL LANE FROM A STOP-CONTROLLED APPROACH COLLISION PATTERN

This Pattern Looks Like This

A driver is on a side street approaching an arterial.
The arterial is a two-way street.
The side street approach has a stop sign. The arterial does not.
The driver wants to go straight or turn left, crossing at least one lane of live traffic.
Traffic on the arterial is free-flowing.
A car is parked on the arterial, typically close to the intersection, on the driver's left-hand side.



The Problem

The parked car blocks/limits the driver's view of oncoming traffic (approaching from the left) in the arterial's near lane. This affects the driver's ability to determine when it's safe to enter and cross this lane.

At the same time, the entering driver has to judge the flow of traffic on the far side of the street, approaching from the right.

What Happens

The driver attempts to go straight or turn left. They don't see the approaching vehicle in the near lane of the arterial (coming from the left), and are struck.

Variations

The parked vehicle near the intersection is large—a van or a truck—further obscuring lines of sight.

Something other than a parked vehicle blocks the driver's sight: for example, a tree or a line of trees in the planting strip; a fence built near the street; or construction barriers or construction material placed near the intersection.

There can be a curve in the arterial that increases the challenge of seeing around the parked vehicle.

The sight obstruction might be a hill/grade in the street, so that the driver cannot see traffic coming up the incline.

A vehicle is parked near the intersection on the driver's right-hand side—affecting their ability to see vehicles approaching from the right. Another outcome of this pattern can be the entering vehicle being struck by a vehicle approaching from the right.

The arterial can be a one-way street, rather than a two-way street.

There can be an impatient driver on the side-street behind you, nagging you to move, while you're trying to judge how to enter the intersection.

Different ways this pattern can be encountered include as a driver on the side street trying to enter the arterial, drivers traveling along the arterial, and the driver who parked their car near the intersection.

CHAPTER 2: ADDITIONAL LESSONS FROM HIGH-COLLISION LOCATIONS AND THEIR COLLISION PATTERNS

Locations Where High-Collision Locations Tend to Occur

Here are some characteristics I've seen common to where high collision locations occur. High collision locations I've worked with have tended to occur:

- In parts of town that receive **high numbers of visitors,** who often aren't familiar with the street system. This includes neighborhoods that have regional draws, including universities, regional shopping, and regional cultural centers. In this case, drivers are challenged by street designs and types of traffic they are not used to. They are challenged by having to find their way while driving in unfamiliar conditions.
- Along **streets with a diversity of traffic**—cars, bikes, pedestrians, trucks, buses, streetcars, and so on. Paying attention to and the processing needed for these different kinds of traffic adds to the complexity of drivers' decision-making.
- Along **major streets that have large numbers of commercial driveways.** These are streets of five or more traffic lanes; where there are driveways that serve parking lots for large and small malls or box stores; and where drivers are allowed to turn in and out of these driveways across the centerline.
- Near **freeway on and off-ramps**. Traffic around ramps is often heavy. When approaching ramps, many drivers become single-minded and/or aggressive or overwhelmed in their efforts to get to their ramp. When exiting a ramp onto busy city streets, drivers can carry some of their freeway driving mode onto city streets. Out-of-town drivers not familiar with city streets can also become disoriented when they touch down on unfamiliar, busy city streets.
- At **transition locations** where there's a change in a street's design and character. Transition locations can occur at and near **political boundaries**. One example of this is freeway ramps—where freeway facilities and city streets meet. City-city and city-county lines are others. Other kinds of transitions can occur where there's a significant change in a street design—for example, locations along a street where a bus lane or bike lane or facility begins or ends.
- At **intersections between two (or more) major streets**. Typically these streets are five lanes or more; they have many different green signal phases (separate movements protected by the traffic signal); and, as a result, their cycle times and driver wait times are long. These intersections' large sizes, high volumes, and many movements may cause confusion and errors that lead to collisions. Because traffic often backs up at these intersections and their wait times are often long, it's not unusual that they are sites of aggressive driving and red light running.

In Seattle, bicycle high collision locations are known to occur in **bike lanes on downhill grades**, on bike lanes and trails **approaching bridges** and on streets with **railroad or streetcar tracks**.

Characteristics Shared by High-Collision Patterns

These are characteristics I've seen common among high collision patterns.

A large number of patterns involve the **vulnerable street users—pedestrians and cyclists**. Pedestrians and cyclists are particularly vulnerable to the impact force of collisions. The great concern is that collisions involving pedestrians and cyclists result in high and disproportionate numbers of injuries, severe (life-changing) injuries, and fatalities on city streets.

A large number of patterns involve **inadequate line of sight around other vehicles**/drivers not obtaining needed line of sight around other vehicles.

Several patterns involve **driving or riding with speed when traveling alongside a line of slow or stopped traffic.** Stopped traffic in a lane next to yours tends to imply that your lane won't be entered from that direction, and in these conditions, it's tempting to cruise along in your lane. But we know from several patterns that traffic can jump from a stopped lane into your lane. For these conditions it's important to moderate your speed—to better see and react to others who suddenly enter your lane.

Speed. In many of the patterns presented, a driver (or cyclist) is *traveling at a speed that's fast for the complex conditions presented.*

When bicyclists' speeds approach arterial speeds, which can happen when riding downhill, they can become more prone to being in collisions and being seriously injured.

Left Turns. Many of the high-collision patterns involve left turns.

In general, left turns are more complex, have more conflict points, and are more cognitively demanding to safely judge than right turns. When made from two-way streets and not protected by a signal, left turns on city streets can require drivers to judge a safe gap across an opposing general traffic lane(s); across a special use lane—a bike lane or a bus lane; and around pedestrians in a crosswalk (or on the sidewalk when turning into a driveway). The greater the number of lanes, the heavier the volumes, the faster the speeds, and the more kinds of traffic one has to process for in their turn, the more complex the turn and the less room there is for error in making it.

A number of high-collision patterns involve drivers **having to be aware of and judge traffic in multiple directions at the same time.**

CHAPTER 3: WHERE FATAL COLLISIONS TEND TO OCCUR

Fatalities occur at high collision locations, though, from my experience, this isn't common. By far and away, fatal collisions happen at other locations.[26]

What's common to almost all of Seattle's fatal collisions is they occur on arterial streets. In Seattle, a large proportion of fatal collisions on city streets (not including freeways) occur on major arterials[27] that are regional in nature and are typically five lanes or more.[28] These streets carry high volumes of traffic. Speed is a significant factor; these streets often have speed limits of 35 miles per hour or more.[29] By virtue of their volumes and their adjacent land use, they may include numbers of drivers and pedestrians who are impaired.

The remainder of the city's fatal collisions are largely spread out over other city arterial streets.

In having reviewed too many fatal collision locations, my sense is that many of these locations seem unremarkable. They're not near landmarks. They don't present the level of complexity—in terms of traffic volumes and the kinds of movements—that high collision locations tend to. The worst collisions, including fatalities and severe life-changing injuries, are often those:

- In which neither street user has *anticipated* the other[30]—so that neither is on their guard nor has acted to avoid or lessen the collision and its impact force and
- That involve a pedestrian or cyclist.

Takeaways

Any street one is traveling at arterial speed presents the potential for severe injury and fatal collisions. This is simply a reminder that driving is probably the riskiest, most dangerous thing most of us do on a regular basis.

Streets with higher speed limits, on which drivers are traveling 35 miles per hour or more, present even more potential for severe injury and fatal collisions.

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[26] From my experience in Seattle, fatal collisions tend in large part to take place in locations that are not high collision locations. From 2009 through 2015, the Seattle Department of Transportation (SDOT) performed 183 high collision location reviews. Over this same period, 118 fatal collisions took place on city of Seattle streets. Through this six-year period, there were 8 fatal collisions that took place at locations that at some time during this period were also determined to be high collision locations. For locations at which high collision location reviews were performed and fatal collisions took place, generally the fatal collision preceded the location's determination as a high collision location and its review—the fatal collision was a large part of the rationale for identifying the location as a high collision location.

[27] From reviewing fatal collision locations in Seattle, my experience is about half.

[28] By Seattle's system of street classification, these streets are "principal arterials."

[29] I'd note that speed limits on many of these streets have been reduced in recent years.

[30] Perhaps because the street conditions seem unremarkable/uncomplex, users allow their attention to shift away from anticipating and monitoring for other traffic.

Fatal and very severe collisions can occur anywhere—not just at locations with complex conditions where one has to mentally "gear up" in the way one has to for high collision locations.

In very general terms, it can be said that collisions tend to occur in:

Conditions that are complex, and drivers often realize they are complex. In this case, drivers are overwhelmed or just don't do an adequate job of processing and executing for the conditions. Many collisions at high collision locations can probably be put in this category.

Conditions that seem, or drivers perceive as, fairly simple. When drivers (and pedestrians and cyclists) encounter street conditions they perceive as so familiar as to seem unchallenging or trivial, they may allow themselves to wander from the task of driving, instead of being on guard and anticipating the actions of others. When drivers (and pedestrians and cyclists) do this, they make themselves extremely vulnerable. They give up the benefits of being able to see, to react, and mitigate when something unexpected happens. When doing this in and around vehicles traveling at arterial speeds, this invites collisions of high impact force that have severe outcomes.

When neither street user in a collision is focused on driving/being on guard, this invites outcomes that are particularly bad—including severe injuries and fatalities. This is particularly true when a person involved in the collision is a pedestrian or cyclist.

It's important to remember that in most cases, fatal collisions on city streets involve two street users. Most collisions can be avoided if one is driving (or riding or walking) defensively. This, in short, is the case for defensive driving—being on the lookout when others, too often, are not.

On city streets, pedestrians can—and do—get just about anywhere. When they appear in an unexpected place, their risk is very high. Likewise, cycling is common on city streets. It's important to keep in mind that pedestrians and cyclists (vulnerable street users) can be severely injured in collisions at speeds much less than than arterial speeds. Keys to driving safely on city streets include anticipating pedestrians and cyclists on streets and, when encountering them, giving them a lot of room.

CHAPTER 4: HIGH-RISK BEHAVIORS

A discussion relating to driving safety wouldn't be complete without talking about high-risk behaviors. These behaviors fuel and radically increase the potential for collisions; for injuries, including severe injuries; and for fatalities:

- Speeding.
- Driving under the influence of alcohol and drugs.
- Driving while distracted, while using phones and other devices.
- Driving while tired.
- Driving without a seatbelt.
- Tailgating.

What all of these risky behaviors have in common is that they are by choice. Drivers choose whether or not to do them. They present great risks to other road users as well as to the drivers themselves. They are all forms of aggressive driving.

Speeding and Driving Under the Influence of Alcohol and Drugs

When leading causes of fatalities, and severe injury collisions are named, speeding and driving under the influence are at the top of the list. The effects of speeding and DUI are far-reaching, well-known, and well documented. In the United States alone, they account for more than 10,000 fatalities a year each.[31] They cause many times more injuries.

The problems speeding and driving under the influence present are straightforward. They affect drivers' processing, decision-making abilities, and reaction times. They greatly increase stopping distance. The result is that large numbers of these collisions are of high impact force.

States and local governments have laws that are aimed to prevent the high numbers of crashes, injury, severe injury, and death that result from them. The consequences of being convicted of DUI and reckless driving can really sting—including huge fines, loss of one's license and driving privileges for long periods of time, and significant challenges to obtaining driver's insurance once one is eligible to resume driving.

One more thing (this is an aspect of being under the influence that doesn't receive much attention): *being under the influence as a pedestrian or bicyclist—particularly along an arterial street—puts you at serious risk, too.*

[31] National Highway Traffic Safety Administration (NHTSA) Overview of Motor Vehicle Crashes in 2020. Table 4.
https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813266

Driving While Distracted—Using Phones and Other Devices

The emergence of cell phone use, along with texting and browsing on-line "is probably the single factor that has created the greatest increase in U.S. crashes in recent years." [32]

This should be fairly obvious, but when I watch people driving, it's not. When you're driving, the tasks of looking for your phone, reaching for it, dialing it, and accepting a call take your eyes off the road. They require you to take at least one hand off the steering wheel. They draw your attention away from the task of driving.

Turning your attention from the road to your phone (or other devices) takes time. This adds to (and it delays) the time you need to see and make good judgements about hazards on the road, to decide how to respond to them, and to make your response. Just the action of taking your eyes off the street to look at your cell phone (or other device), requires:

- Time for your eyes to move and *refocus* onto your phone.
- Time for your brain to *process and understand* what it's seeing on your phone.
- Time for you to *decide* what to do with the information presented by your phone.
- Time to *take the action* you decide to take with your phone.
- Time to *return your eyes back to the street*.
- Time for them to *refocus*.
- Time for your brain to *process and understand* the street conditions you are seeing.
- Time to return to the task of driving.

This is a lot.[33] The more involved your interaction is with your phone, the more time these steps take. On an active street, all of this time adds up, diverts your attention from your driving, and creates risks. For this reason, almost all states have laws in place against texting, and many have laws against use of hand-held phones while driving.

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[32] Driver Crash Risk Factors and Prevalence Evaluation Using Naturalistic Driving Data
PNAS (Proceedings of the National Academy of Sciences of the United States)
March 8, 2016, vol. 113. See the Discussion section of the report.
www.pnas.org/cgi/doi/10.1073/pnas.1513271113

[33] And when you engage in a phone conversation its effect on your driving doesn't end here. When using your phone or texting, the effect of the distraction can linger well beyond your actual phone use—as much as half a minute. See The Persistence of Distraction: The Hidden Costs of Intermittent Multitasking
Turril J., Castro S., Cooper J., Strayer D.
https://www.spencercastro.com › assets › publications › Strayer_Castro_Turrill_Cooper_2021.pdf
and
Research has also found that tunnel vision caused by cell phone use continues well after the conversation ends. Cell Phone Use in Cars Causes Tunnel Vision; "Cell-Free Zones"
https://www.sciencedaily.com/releases/2002/06/020611071201.htm

Hand-held phone use increases your chance of a collision, a lot. The likelihood of getting into a collision when driving and using a hand-held cell phone is roughly four times that of normal, attentive driving.[34]

Hand-held phone use is known to cause:

- Drivers to focus their vision more straight ahead—in a way that their visual field narrows into a "tunnel vision."[35] This means that drivers using hand-held phones are less aware of other vehicles and road users ahead that may be entering their driving paths. They are less aware of the conditions around their vehicles.
- Drivers' reaction times to slow.[36]

When distracted enough, another experience that can occur with phone use is ***"Inattention Blindness"***—in which a driver's eyes are aimed right at a hazard, but they don't see (process and recognize) it! On a city street, this can mean looking at, but not seeing/recognizing a stop sign or traffic signal, a pedestrian or a cyclist.[37] [38]

These are *serious* driving issues. They affect your ability to anticipate, maintain space between yourself and other street users, and respond to what they might do.

The distraction phone use causes is not only from the holding and handling of the phone, *the greater issue is the work your brain has to do to support the phone conversation*.[39] If it's not enough to be concerned about the use of handheld phones, there's substantial work that indicates

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[34] Driver Crash Risk Factors and Prevalence Evaluation Using Naturalistic Driving Data
PNAS (Proceedings of the National Academy of Sciences of the United States)
March 8, 2016, vol. 113. This finding is based on analysis of data from on-board video cameras performed as part of The Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS). See Observable Distraction section of report.
www.pnas.org/cgi/doi/10.1073/pnas.1513271113

[35] Cell Phone Use in Cars Causes Tunnel Vision; "Cell-Free Zones"
This research also found that the tunnel vision caused by cell phone use continued well after the conversation ended, perhaps because drivers were still thinking about their conversations.
https://www.sciencedaily.com/releases/2002/06/020611071201.htm

[36] Drivers on Cell Phones Are as Bad as Drunks. University of Utah News Center, posted June 29, 2006.
See Key Findings
https://archive.unews.utah.edu/news_releases/drivers-on-cell-phones-are-as-bad-as-drunks/

[37] University Of Utah. "Cell Phone Users Drive 'Blind:' Study Explains Why Hands-Free Phones Just as Bad as Hand-held." ScienceDaily. ScienceDaily, 29 January 2003.
www.sciencedaily.com/releases/2003/01/030129080944.htm

[38] See also practical discussion of inattentional blindness from the perspective of motorcyclists (and from perspectives of cyclists and pedestrians, as well) in *Proficient Motorcycling* by David Hough, pp 41-43.

[39] Cell Phone Use in Cars Causes Tunnel Vision; "Cell-Free Zones" Recommended
"The debate surrounding cell phone use in cars has been directed toward concerns over holding the phone. Holding the phone isn't the main issue. Thinking is."
https://www.sciencedaily.com/releases/2002/06/020611071201.htm

that ***use of hands-free phones present the same kinds of cognitive demands on and risks to drivers as handheld phones***."[40]

The bottom line is that our brains have a limited capacity for what we can focus on at one time.[41]

And despite what many may think-
"Multitasking, when it comes to paying attention, is a myth." [42] When you have a phone conversation while you are driving, you are "task switching" (switching between these two tasks). When switching tasks, there are steps the Executive Network in your brain has to execute to enable this switch. These take time. And, as people are interrupted and switch their tasks, they get inefficient; their tasks take longer to do, and they can make many more errors—and driving while using a cell-phone is no exception. [43]

I'd add-

The power of phones and headphones to distract applies to pedestrians and cyclists, too. Their use can make these vulnerable users even more vulnerable.

Texting is even worse than phone use. Drivers are about six to eight times more likely to be in a collision when texting than when driving undistracted.[44]

And ***when using your phone or texting, the effect of the distraction can linger well beyond your actual phone use***—as much as half a minute.[45] It takes time for your brain to fully return to

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[40] Hands-Free Talking, Texting Are Unsafe.
The University of Utah UNews Archive
https://archive.unews.utah.edu/news_releases/hands-free-talking-texting-are-unsafe/
[41] Motor Vehicle Safety at Work. Distracted Driving at Work
CDC Centers for Disease Control and Prevention
The National Institute for Occupational Safety and Health (NIOSH)
https://www.cdc.gov/niosh/motorvehicle/topics/distracteddriving/default.html
[42] *Brain Rules* by John Medina. When referring to one's brain's ability to pay attention, "The brain naturally focuses on concepts sequentially, one at a time." page 84.
[43] *Brain Rules* by John Medina. See discussion of steps the executive network of the brain must take—every time—as it switches attention from one task to another, pages 86-87.
[44] Car Talk. The Science of Distracted Driving
Driver Distraction Center (produced in partnership with the University of Utah and the University of Kansas)
https://www.cartalk.com/content/science-distracted-driving
and
Driver Crash Risk Factors and Prevalence Evaluation Using Naturalistic Driving Data
PNAS (Proceedings of the National Academy of Sciences of the United States)
March 8, 2016, vol. 113. See Observable Distraction discussion. Figure 2 shows an Odds Ratio related to texting of about 6.1
www.pnas.org/cgi/doi/10.1073/pnas.1513271113
[45] The Persistence of Distraction: The Hidden Costs of Intermittent Multitasking
Turril J., Castro S., Cooper J., Strayer D.
https://www.spencercastro.com › assets › publications › Strayer_Castro_Turrill_Cooper_2021.pdf

the task of driving after using your phone or texting. This affects split-second decision-making that's often called for in city driving.

Phones aren't the only source of distraction presented to drivers. There are other forms of distraction that present similar risks.

Young drivers are known to be particularly distractible by young passengers.

Another distraction concern is the provision of complex media devices in cars. This includes voice-activated devices in the consoles of new cars that allow drivers to send and receive texts, access social media, and surf the net.[46] Again, use of these devices while driving is task switching. Problems with these devices include:

- Some of these devices cause drivers to take their eyes off the road.
- Drivers may not realize that the complex, speech-based tasks by which many of these systems work–the brain power required to work them—may unintentionally overload drivers' abilities to process and respond safely to roadway conditions.[47]
- Drivers automatically assuming these systems are safe to use—not realizing they present the potential to compromise their driving and safety—simply because they are provided in cars.[48]

So, what do you do if you're following a driver who:

- Is using a phone or texting
- Can't hold a straight line in the middle of their lane
- Is varying their speed for no apparent reason
- Is overcorrecting on their turns—versus controlling their vehicle with small corrections
- Shows a pattern of braking suddenly

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and
Research has also found that tunnel vision caused by cell phone use continues well after the conversation ends. Cell Phone Use in Cars Causes Tunnel Vision; "Cell-Free Zones"
https://www.sciencedaily.com/releases/2002/06/020611071201.htm

[46] Visual and Mental Distractions Behind the Wheel Are Real and Potentially Dangerous
AAA Exchange
https://exchange.aaa.com/safety/distracted-driving/

[47] Hands-Free Talking, Texting Are Unsafe
Science Daily, Science News section. See paragraphs 3 and 4.
https://www.sciencedaily.com/releases/2013/06/130612092949.htm

[48] Visual and Mental Distractions Behind the Wheel Are Real and Potentially Dangerous
AAA Exchange
https://exchange.aaa.com/safety/distracted-driving/

These are clues they are distracted and/or impaired, and they are putting themselves and everyone else on the road at risk. When you see drivers do these things, increase your buffer—give them a lot of space.

Likewise, if you notice any of these in your own driving, this should raise a red flag that your driving is affected. In this case, find a safe place to pull off of the road to assess what's going on with your driving, and to correct it before you get back on the road.

Driving While Tired

While we may tend to associate tired driving with driving along long, solitary stretches of country highways, drowsy driving is a real thing on city streets. Understanding this is a Big Deal. Here's why.

We're all susceptible to the effects of tired driving.

Driving while tired is like driving drunk, and we know how serious drunk driving is. For instance, when you drive after you've been up for 18 hours straight, research has found your driving will likely show signs of impairment—like that of a driver who has been drinking. If you try to drive after being up for 24 hours straight, your decision making and reaction abilities may match or be more impaired than a driver who is legally drunk.[49]

Tired driving factors into crashes more often than you think. It's hard to measure how many tired drivers are on the road. Until a few years ago, it was thought that drowsiness factored into about two percent of all crashes. However, new work that used dashcams placed in vehicles has found that drowsiness is much more common—***it's a factor in roughly one in ten crashes***.[50]

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[49] Research has found that Drivers who have been up for 16 straight hours have driving reactions like those with .05 blood alcohol level. And drivers who have been up for 24 hours straight have perceptions and reactions like that of a driver with a .10 BAC who is more than legally drunk.
Drowsy Driving vs. Drunk Driving: How Similar Are They". SleepFoundation.org
https://www.sleepfoundation.org/articles/drowsy-driving-vs-drunk-driving-how-similar-are-they
and
Williamson AM, Feyer A.M. Moderate Sleep Deprivation Produces Impairments in Cognitive and Motor Performance Equivalent to Legally Prescribed Levels of Alcohol Intoxication.
Occupational and Environmental Medicine 2000; **57:**649-655. https://oem.bmj.com/content/57/10/649
and
Dawson, D., Reid, K. Fatigue, Alcohol and Performance Impairment. *Nature* 388, 235 (1997). https://doi.org/10.1038/40775

[50] Drowsy Driving: Don't Be Asleep at the Wheel. AAA NewsRoom.
"Using a scientific measure linking the percentage of time a person's eyes are closed to their level of drowsiness, the researchers determined that 9.5 percent of all crashes and 10.8 percent of crashes resulting in significant property damage involved drowsiness." For more information, see *Prevalence of Drowsy Driving Crashes: Estimates from a Large-Scale Naturalistic Driving Study,* based on the analysis of in-vehicle video footage of crashes that occurred during the Second Strategic Highway Research Program's Naturalistic Driving Study (SHRP 2 NDS).
https://newsroom.aaa.com/2018/02/drowsy-driving-dont-asleep-wheel/

Drowsy driving can happen in the daytime, as well as at night. In addition to being awake for long periods (of 18 hours or more), it can be brought on by many causes, including sleep disorders, staying up long hours for work or school, non-traditional work schedules, medications, and driving after a heavy meal.

Driving tired crashes are often very severe. It affects your alertness and abilities to focus on the road. It slows your decision-making. It slows your reaction times.[51] In extreme cases, tired drivers nod off and don't react to or brake for a hazard at all. These kinds of crashes are known to include those in which single vehicles go off the highway/the road, often at high speeds.[52] When other vehicles are involved, tired driving contributes to more than its share of head-on and rear-end collisions.

These kinds of crashes involve more than their share of young drivers (under 25 years of age).[53]

The result is crashes at high speeds and of high-impact force—in which people are really hurt. ***It has been estimated that one in six fatal crashes involve drowsy driving.***[54]

There are many tips to help drivers to avoid driving tired.[55] Key among these are:

- Drive when you are rested.
- Drive during times of day you're generally awake.
- When you plan long trips, include rest stops. Bring along a passenger for company who is also able to help share in the driving.
- Caffeine can help, but it takes time for it to take effect.

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[51] Dawson, D., Reid, K. Fatigue, Alcohol and Performance Impairment. *Nature* 388, 235 (1997).
https://doi.org/10.1038/40775

[52] Pack AI, Pack AM, Rodgman E, Cucchiara A, Dinges DF, Schwab CW. Characteristics of Crashes Attributed to the Driver Having Fallen Asleep. Accid Anal Prev 1995;27:769–75.
https://pubmed.ncbi.nlm.nih.gov/8749280/

[53] Pack AI, Pack AM, Rodgman E, Cucchiara A, Dinges DF, Schwab CW. Characteristics of Crashes Attributed to the Driver Having Fallen Asleep. More than half of those identified by this study were 25 years old or younger. Accid Anal Prev 1995;27:769–75.
https://pubmed.ncbi.nlm.nih.gov/8749280/
and
Asleep at the Wheel: The Prevalence and Impact of Drowsy Driving
AAA Safety Culture
https://aaafoundation.org/wp-content/uploads/2018/02/2010DrowsyDrivingFS.pdf

[54] Asleep at the Wheel: The Prevalence and Impact of Drowsy Driving
AAA Safety Culture
https://aaafoundation.org/wp-content/uploads/2018/02/2010DrowsyDrivingFS.pdf

[55] For more tips, see—Asleep at the Wheel: The Prevalence and Impact of Drowsy Driving
AAA Safety Culture
https://aaafoundation.org/wp-content/uploads/2018/02/2010DrowsyDrivingFS.pdf

If you find yourself drifting from your lane, yawning, nodding, fighting to keep your eyes open, trying all kinds of things with your radio and climate controls to stay awake—these are red flags! Find a safe place to pull off the road and get some rest.

Driving Without a Seatbelt

In 2020, more traffic fatalities were associated with drivers and passengers not wearing seatbelts than either speeding or DUI driving. ***Among passenger vehicle occupants killed in 2020, more than half (51%) were unrestrained***—not wearing seatbelts.[56]
That's stunning.

In terms of physics, when a collision occurs with another mass (such as another car), there's a huge advantage to drivers and passengers who are secured to their vehicle by wearing seatbelts. In collisions, larger masses decelerate at a slower rate than smaller masses. In a collision, your car is suddenly slowed and stopped. Seatbelts and shoulder belts work by slowing you more gently (at the rate your car slows down—though this force may still be incredibly high) than if your body (your smaller mass) were left to stop on its own.

Likewise airbags work by slowing you down more gently than just hitting the steering wheel and the dashboard.

When you're not belted-in and a head-on collision occurs, the car stops, but your momentum carries—and slams—you into your dashboard and into (and, in extreme cases, through) the windshield, so you are "struck" at high speed by the inside of your car. Basically, you are making yourself an individual highly vulnerable to impact.

Wearing a seat and shoulder belt may save your life. Seat belts reduce drivers' risk of fatality by 45 percent in a car and even more in a larger vehicle like a pick-up or SUV. They greatly lessen your potential of being ejected from your car. They cut the risk of serious, life-changing injury by half.[57]

Wear your seatbelt.

Riding Without a Helmet

The bike and motorcycling analogy to driving without a seatbelt is riding your bike without a helmet. There are cyclists who believe that helmet safety studies performed to support helmet laws have been done incorrectly. They may be right, but this argument misses the point. When it's head versus pavement, the pavement wins. Head injuries are devastating. As a cyclist, not wearing a helmet makes one even more vulnerable to impact. Wearing a good helmet is a small price to pay for lessening the chance of head injury. When riding, wear a helmet.

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[56] National Highway Traffic Safety Administration (NHTSA) Overview of Motor Vehicle Crashes in 2020, Figure 7 - Passenger Vehicle Drivers Involved in Fatal Crashes, by Speeding Involvement, Alcohol Impaired Driving, and Restraint Use. See also discussion of Restraint Use and Time of Day, p. 13. https://www.nhtsa.gov/press-releases/2020-traffic-crash-data-fatalities
[57] Seat Belts. IIHS-HLDI. https://www.iihs.org/topics/seat-belts

Tailgating and Rear-End Collisions

Rear-end collisions, by far and away, are the most common type of collision drivers report. They ***trail only right-angle collisions in generating numbers of people who are injured by traffic collisions.***[58]

Their causes include:

- Following too closely—tailgating. Tailgating is like speeding. It's a choice to drive too fast for conditions. Like speeding, following too closely behind another vehicle limits the time you have to see and react when it suddenly slows or stops in front of you.
- Inattention—distraction—not paying enough attention to road conditions ahead and not maintaining a buffer to match those conditions.

Tailgating will burn you in two ways. In following other vehicles too closely, you're more likely to run into them when they suddenly slow or stop. Tailgating sets you up to be hit by others. It forces you to brake suddenly in response to changes in conditions ahead—so that drivers following (too closely) behind you are more likely to run into you. When you tailgate, you set yourself up to run into others and you set yourself up for others to run into you.

Rear-End Collisions and Injury

The set of factors that contribute to the outcome and severity of these collisions are complex. They include:

- The pattern of the collision. This includes the relative directions of the vehicles, their speeds and points of impact/where they strike each other.
- The designs of the vehicles and how they transmit the energy from the collision to their occupants.
- The physiology of the individuals involved in the collision.

A large amount of research has been done to understand the mechanics of rear-end collisions and their related injuries.[59] This work has found that ***the force of rear-end collisions can generate a large amount of acceleration in the head and neck of those who have been rear-ended. Too often, this results in neck injuries.***

[58] Source: National Highway Traffic Safety Administration (NHTSA) Traffic Safety Facts Annual Report Tables, Table 29 - Crashes, by First Harmful Event, Manner of Collision, and Crash Severity. This table presents broad categories of collision types and the severity of outcomes associated with them (property damage only/injury/fatality). In the US in 2020, rear-end collisions were reported to have been the cause of nearly 28 percent of all traffic collisions, more than 26 percent of all collision-related injuries, and nearly 7 percent of all traffic-related fatalities.
https://cdan.nhtsa.gov/tsftables/tsfar.htm

[59] See, for example, summaries of research compiled in Soft Tissue Index: Essential Medical and Crash Studies by Charles Davis, DC, QME and David N. Finley, Esq. 2008-2009 Edition.

This kind of force on the neck can be generated even at what might seem like low speeds.[60]

Given that neck injuries can be very serious, as a driver, you don't want to go there. *This is a pattern of collisions to be very wary of*. When following others, key parts of safe driving include: maintaining your buffer (keeping a generous following distance), controlling your speed, and maintaining a consistent level of attention to the street conditions ahead.

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[60] Ojalvo, I.U. and Yanowitz, H. Vehicle and Occupant Responses to Low-Speed Impact: Comparison of Analysis with Test and Parametric Study. Society of Automotive Engineers, 1998. In rear-end collisions of 15 kilometers per hour (about 9 miles per hour), this work noted head accelerations (i.e., forces which translate to forces in the neck) ranging from about 5 G's to upwards of 16 G's.

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This work is indebted to works of others aimed at raising attention to traffic safety and collision patterns involving pedestrians, bicyclists, and motorcycle riders. Authors whose works that I found in my searching, and relied on this piece include:

- Michael Bluejay, *How to Not Get Hit by Cars.* This site shows different patterns of bike collisions and provides tips to cyclists on how to avoid them. https://bicyclesafe.com/
- Robert Hurst, *The Art of Cycling,* provides a great deal of guidance on what kinds of challenges to look for in urban cycling and advice on how to encounter these challenges safely.
- David Hough, *Proficient Motorcycling,* presents safety challenges motorcyclists are confronted by and advice on how to encounter them safely.
- the New York City Department of Transportation, *Don't Cut Corners – LEFT TURN Bicyclist and Pedestrian Crash Study.* https://nyc.gov/html/dot///downloads/pdf/left-turn-pedestrian-and-bicycle-crash-study.pdf On this site, see Left Turn From One-Way Streets Collision Patterns in Chapter 1.
- The research team that produced the work *Bicycling Crash Circumstances Vary by Route Type: A Cross-Sectional Analysis*, Kay Teschke, Theresa Frendo, Hui Shen, M Anne Harris, Conor CO Reynolds, Peter A Cripton, Jeff Brubacher, Michael D Cusimano, Steven M Friedman, Garth Hunte, Melody Monro, Lee Vernich, Shelina Babul, Mary Chipman and Meghan Winters. This work collected data about the types and numbers of bike collisions by which cyclists were injured and required treatment in local hospital emergency departments in Toronto and Vancouver from May 2008 to November 2009. https://bmcpublichealth.biomedcentral.com/counter/pdf/10.1186/1471-2458-14-1205.pdf

While working for the Seattle DOT, I felt that I was placed in a unique position to see, work with, consider, and (to try and) understand traffic safety. Transportation systems have many objectives—including economic, environmental, public health, and social justice. The provision of safety is a key and underlying element of the transportation system and a major consideration on how it's both designed and used. How safety works (or doesn't) has significant bearing on the system's promotion of, and delivery on, all of its objectives. I'm grateful to the people of Seattle for the opportunity to perform this work. I hope that this piece is, in part, a “giving back” to the people of Seattle for having been presented this opportunity.

AND, By Far and Away my greatest Thanks is to my wife, Val, for her patience and support through this work and for believing in its value.

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ABOUT MORRIS-LENT ENGINEERING LLC

I'm a civil engineer and have spent most of my career in transportation and traffic engineering with the Seattle Department of Transportation (SDOT).

I spent twelve years focused on traffic safety and led the department's High Collision Location program from 2009 to 2015. With this, I reviewed fatal collision locations; supported Seattle's legal team in work to improve the city's street network; and wrote grants to fund safety improvements.
A substantial part of my time with SDOT was in support of community outreach efforts, including working several years for the Seattle Department of Neighborhoods' Matching Fund Program.

Some tangible projects I led included the street design for:

- installation of the South Lake Union streetcar.
- installation of the bus lanes on Elliott Avenue W and 15th Avenue W—that now make up part of the RapidRide D Line route.

Information included on this site was used to create the basis for Seattle's Bike and Pedestrian Safety Analysis (BPSA)—a safety tool intended to:

- identify and address, in a proactive way, locations in Seattle that may be prone to patterns of bike collisions and pedestrian collisions.
- evaluate the safety performance of various kinds of bike facilities.

If you'd like, you can learn more about this work here -
https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/step_case_studies_seattle.pdf

My friend and fellow engineer, Chris Eaves, and I created the traffic safety product reflective post sleeves. In Seattle, you'll commonly see them placed on posts with stop signs and with school crossing signs—to increase the visibility of their signs and posts. If these are of interest, you can learn more about them:

- here - U.S. patent # 9574312 https://patentimages.storage.googleapis.com/a0/12/ad/b56846f9d98677/US9574312.pdf
- here - https://www.saflector.com/
- And here - https://www.tssco.com/product/saflector-reflective-post-sleeves/

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Thoughts and ideas with regard to this site are welcome.
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