Motor vehicles making turns at intersections can be a hazard for pedestrians and bicyclists. Data from the National Highway Traffic Safety Administration indicate that 20 percent of fatal pedestrian crashes and 34 percent of fatal bicyclist crashes occur at intersections, predominantly in urban areas (Traffic Safety Facts: Pedestrians, 2015, p. 2; Traffic Safety Facts: Bicyclists and Other Cyclists, 2015, p. 2). In a 2015 study, the City of Seattle found that the most significant crash type at both signalized and unsignalized intersections was a turning motorist crossing the path of a through bicyclist or pedestrian. Left-turning motorists accounted for 19 percent of bicyclist crashes and 31 percent of pedestrian crashes at all intersection types. Right-turning motorists accounted for 15 percent of bicyclist crashes and 17 percent of pedestrian crashes at all intersection types.

Research has found that left-turning motorists on two-way streets are focused primarily on finding gaps in oncoming traffic, and a high percentage of motorists are not looking for crossing pedestrians or bicyclists. Scanning and awareness becomes more difficult for motorists on roadways with higher speeds and multiple travel lanes.

Generally, right-turning motorists have an easier time scanning for bicyclists or pedestrians since they are less focused on finding gaps in traffic. Conflicts often result from failure to yield or bicyclists approaching from the rear in a driver’s blindspot.

Turning movement conflicts may be addressed through designs that reduce motor vehicle speeds, minimize speed differentials at conflict points, maximize visibility and predictability, raise awareness, and separate movements through time and space.

**COMMON USERS IN CONFLICT AND TYPICAL CRASH TYPES**

- Right-turning vehicles crossing through bicyclists or pedestrians is known as a “right hook” crash type.
- “Left hooks” are similar, where left-turning vehicles come into conflict with opposing traffic traveling straight.

**GUIDING PRINCIPLES TO REDUCE CONFLICTS**

**SAFETY**
The design should proactively address known safety issues caused by turning vehicles.

**ACCOMMODATION AND COMFORT**
Intersections should be designed to be accessible for all users and maximize comfort to the greatest extent practicable.

**COHERENCE**
Intersections should provide adequate sight distance between turning vehicles and vulnerable road users.

**PREDICTABILITY**
The design should provide clear right-of-way to increase predictable behavior.

**CONTEXT SENSITIVITY**
The design should incorporate and support community resources, the natural environment, and adjacent land uses.

**EXPERIMENTATION**
Intersections should use innovative solutions to increase sight distance and decrease conflicts between turning vehicles and vulnerable road users.
DESIGN STRATEGIES

SIGNALIZED INTERSECTIONS

Traffic signals may be installed at locations where the continual flow of vehicles on one roadway results in excessive delay or hazard to crossing vehicles, bicyclists, or pedestrians. The decision to install a signal should be based on an engineering study which considers the warrants outlined in the MUTCD. Accessible pedestrian signals with countdown timers should be provided at signalized intersections to inform pedestrians when they may enter the roadway and how much time remains for their crossing (MUTCD 2009, Sec. 4E.07). A minimum pedestrian walk interval of 10 seconds should be provided except in rare circumstances where pedestrian volume is negligible (ITE Traffic Control Devices Handbook 2009, p. 381). For more information on accessible pedestrian signals, see the design topic on Accessibility.

Reducing left and right hooks can be achieved through partially or fully separating vehicle turning movements from conflicting pedestrian or bicycle movements. Partially separated movements are called leading intervals. A leading interval increases visibility and allows pedestrians or bicyclists to assert their right-of-way by providing a head start into the intersection before turning vehicles. Leading intervals are typically a minimum of 3–8 seconds in advance of the green phase for turning motor vehicles. Accessible pedestrian signals should be considered when adding leading intervals. Fully separated movements may require longer signal cycle lengths, which may result in reduced user compliance with signal indications and therefore increased potential for conflict. Cycle lengths should be minimized to reduce delay and maximize compliance. Designers should consider partially or fully separating bicycle movements from motor vehicles. At locations where conflicts are high and the provision of separate phases is not feasible or desirable, restricting vehicular turns should be considered when alternative motor vehicle routes are available. For more information, refer to the design topic on Signalized Intersections.

CROSSINGS

Bicycle and pedestrian crossings should be separate unless designated as a shared use path crossing. A 6-foot minimum crossing island can be added to provide a refuge for pedestrians and to slow left-turning vehicle speeds. Consider wider crossing islands to accommodate bicycles with trailers, which cumulatively measure at least 9.75 feet long (AASHTO Bike Guide 2012, p. 3-4).

PAVEMENT MARKINGS

Pavement markings improve the predictability of movements and raise awareness of potential conflicts. For bicyclists, this may be accomplished with dotted bicycle lane lines on an intersection approach to indicate a motorist merge area, or dotted extension lines through the intersection. The dotted lines are typically 6 inches or wider and could be supplemented with green colored pavement to improve visibility. Two-stage turn boxes are used to simplify turning for bicyclists. They may require FHWA approval. For pedestrians, high-visibility ladder-style crosswalks maximize visibility of the crossing (MUTCD 2009, Sec. 3B.18).

SEPARATED BIKE LANES

Providing additional separation between bicyclists and motorists can improve the visibility of bicyclists to turning motorists. For more information, refer to the design topic on Separated Bike Lanes at Intersections.

SIGNS

The TURNING VEHICLES YIELD TO (or STOP FOR) PEDESTRIAN (R10-15) sign can be installed at intersections to alert motorists of their requirement to yield or stop for pedestrians or bicyclists within the crossing. In cases where motorists need to be alert to a potential conflict with pedestrians and bicyclists, the sign can be modified to include both a pedestrian and bicycle symbol. The sign can be located at the near- or far-side of the intersection. Engineering judgment should be used to determine a location that is conspicuous to the turning driver. (MUTCD 2009, Sec. 2B.53.)

INTERSECTION GEOMETRY

Intersection geometry has a significant impact on the safety of pedestrians and bicyclists. Ideal intersection geometry should induce yielding by slowing turning vehicles to minimize speed differentials at conflict points. Techniques include installing speed bumpers, installing raised crossings, or reducing the curb radii. Consider roundabouts as an alternative to traffic signals and at intersections with complicated geometry. For more information, refer to the design topic on Intersection Geometry and NCHRP Report 672.

EDUCATION

Education campaigns can help to inform users about where to travel to be most visible to other users, where to expect other users to be traveling, and the blind spots of different users. Best practices include educational programs through Safe Routes to School, bicycle and pedestrian curriculum in driver’s education and licensing tests, and educational materials such as signs and fliers sent to residents or available at public events.
Access management techniques can be applied to reduce the frequency of turning movement conflicts caused by driveways or streets. Typical strategies include driveway consolidation, continuous medians, directional islands to restrict left turns, and driveway or street closures. Access management techniques may be particularly beneficial to reduce crashes caused by left turning motorists. Street sections with limited driveway openings maximize comfort and safety for bicyclists and pedestrians.

Freight vehicles range in size and require large turning radii. Freight vehicles also have blind spots creating challenges for vulnerable road users. For more information, refer to the design topic on Freight Interaction.
CASE STUDIES

MASSACHUSETTS AVENUE AT BEACON STREET
BOSTON, MA

In 2015, at the intersection of Massachusetts Avenue and Beacon Street in Boston, a through bicyclist was struck and killed by a right turning truck. As part of their Vision Zero Initiative to reduce traffic injuries and fatalities, the City of Boston quickly implemented short-term intersection improvements. By obtaining the latest three years of crash data, the City was able to respond with countermeasures to reduce crash patterns at the intersection. Improvements included removing a right turn lane to provide a separated bike lane, optimizing signal timings, providing leading pedestrian intervals, extending bicycle lanes through the intersection with high visibility green-colored pavement markings, adding a bicycle box, and adding signs for motorists to yield to pedestrians. The City will continue to monitor the intersection and plans to develop long-term recommendations to improve safety along the entire corridor.

BICYCLE AND PEDESTRIAN SAFETY ANALYSIS
SEATTLE, WA

Seattle is undertaking a robust collision and roadway data analysis to identify the factors that contribute most significantly to pedestrian and bicycle collisions. The findings of this analysis are anticipated to help Seattle proactively address safety issues through systemic improvements and uniform street design approaches. Preliminary results indicate that relatively few combinations of driver and bicyclist or pedestrian actions account for most crashes. The most prevalent—and most likely to be severe—crash type for bicyclists occurred between a bicyclist riding with traffic and a left-turning driver. The most prevalent and severe pedestrian crash type was when a pedestrian crossing a signalized intersection was hit by a driver turning left. The City is developing countermeasures for improvements, along with a tool to analyze future collision data for key factors of interest.

FOR MORE INFORMATION


Federal Highway Administration. Separated Bike Lane Planning and Design Guide. 2015.

