Improving Pedestrian and Bicyclist Safety and Comfort Along Water Street
(Technical Paper)

Evaluating the Conflicts Between Drivers, Pedestrians, and Bicyclists in Sharing the Road
(STS Paper)

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Compromises to Pedestrian and Bicyclist Safety and Comfort

Post-World War II, the automobile became widely used across the United States, spurred by mass production with the invention of the assembly line and the affordability of cars for families (Zwillich et al., 2019, n.p.). Combined with the development of the interstate highway system and a movement of suburban sprawl away from dense urban cities, auto-oriented transportation infrastructure development became the norm (Zwillich et al., 2019, n.p.). More recently, pedestrians, bicyclists, and other non-motorized transportation users have become a distinct counterpart to drivers within the roadway hierarchy, yet these users are often still considered "second-class citizens" due to the continual "car-centric" development of many localities (Laker, 2016, n.p.). As is the case on Water Street in downtown Charlottesville, Virginia, economic activity has led to an increase in the number of people walking and cycling, yet the corridor has been designed primarily for vehicular through-traffic. Because of a lack of dedicated pedestrian and bicyclist infrastructure in many areas, including a lack of bicycle lanes on Water Street, the safety and comfort of non-motorized roadway users are compromised and their risk of crashes is increased. Furthermore, drivers themselves can find it difficult to share the road (that is often designed primarily for them) to better accommodate other modes (Laker, 2016, n.p.). Progress needs to be made by increasing safety and comfort for pedestrians and bicyclists, including through roadway infrastructure changes as well as reframing drivers' mentalities.

According to the National Highway Traffic Safety Administration (NHTSA), pedestrian and bicyclist deaths in the United States rose in 2018, despite overall traffic deaths falling 1% (Shepardson, 2019, n.p.). Specifically, for the City of Charlottesville, the Virginia Department of Transportation (VDOT) has identified the Water Street corridor as an area of focus due to a high

rate of pedestrian crashes between 2012 to 2016 (Cole & Read, 2018, p. 7). In order to address these recent crashes and roadway user comfort for pedestrians and bicyclists traveling along Water Street, my capstone team will develop roadway design alternatives, and a final preferred alternative, to accommodate drivers, pedestrians, and bicyclists on Water Street more effectively. For the STS topic, I will conduct a literature review to assess strategies to encourage drivers to share the road to improve the experiences of vulnerable roadway users, namely pedestrians and bicyclists.

Improving Pedestrian and Bicyclist Safety and Comfort Along Water Street

As part of its 2018 Pedestrian Safety Action Plan (PSAP), VDOT reported that, between 2012 and 2016, Water Street was the site of ten pedestrian crashes, the details of which are shown in Figure 1 (Cole & Read, 2018, p. 76). Because of this high concentration of crashes, VDOT has suggested the need for "visibility enhancements" to increase safety along the corridor (Cole & Read, 2018, p. 67). These enhancements would increase the visibility of pedestrians to drivers through changes to lane markings and signage, such as "high visibility crosswalks" that have flashing beacons and pedestrian crossing signs (Cole & Read, 2018, p. 67). Since many of these crashes took place at unsignalized intersections, there is a need for these additional warnings, as improvements to traffic signal operations are not possible at many points where conflicts have occurred.

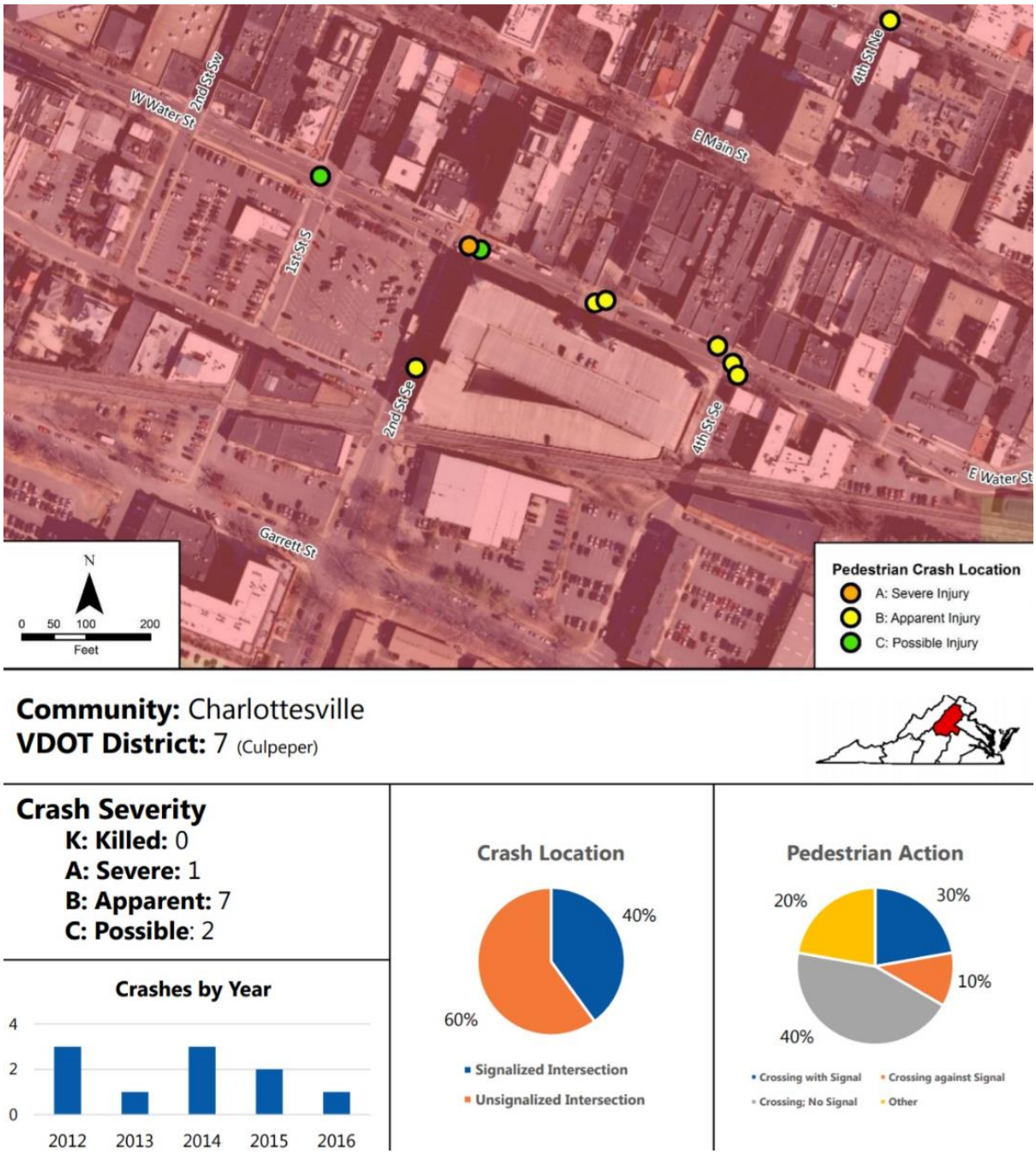

Figure 1: VDOT's PSAP crash cluster information for Water Street (Cole & Read, 2018, p. 76). A high concentration of pedestrian crashes (10) occurred along the corridor between 2012 and 2016, with more than half occurring at unsignalized intersections.

Water Street is currently characteristic of primarily car-oriented development. As seen in Figure 2, which depicts part of the study area, the corridor has shared lane markings, or sharrows, which designate its travel lanes as shared by both drivers and bicyclists, but lacks dedicated bicyclist infrastructure that would improve cyclists' visibility to drivers (Google, n.d.;

Cole & Read, 2018, p. 67). The corridor also hosts one of the main bicycle routes in the city; however, there is a high level of traffic stress for bicyclists. Furthermore, while the block lengths along the corridor are fairly short, the project team has observed pedestrians regularly crossing Water Street between intersections and at unsignalized intersections where dedicated pedestrian signals are not present. Therefore, it is critical to determine safety countermeasures; ideally, Water Street would be able to accommodate pedestrians and bicyclists in a safe, comfortable, and efficient manner in harmony with vehicles.

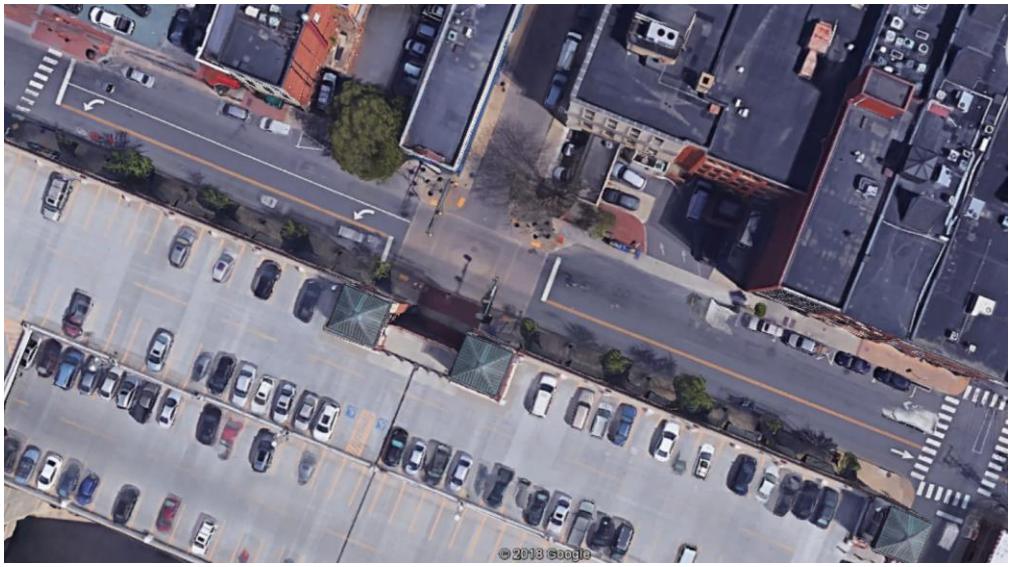

Figure 2: Plan view of Water Street between 2nd Street SE and 4th Street SE, part of the project's study extents (Google, n.d.). There is no dedicated bicyclist infrastructure along the corridor. The on-street parking and sharrows characterize the road as an auto-oriented environment.

While sharrows can remind drivers of the presence of bicyclists on the road, they do not provide dedicated facilities to separate bicyclists from faster-moving vehicular traffic. In a research study on cities with high cycling rates, Marshall & Ferenchak (2019) found that on-street bicycle infrastructure not only provides a barrier between drivers and vulnerable cyclists, but also serves as a traffic-calming effect to reduce vehicular speeds (p. 285). In turn, dedicated bicycle infrastructure leads to improved safety and perceived comfort for cyclists. Similarly, for pedestrians, a lack of high visibility crosswalks may be compromising safety. The NHTSA

reports that, since 2008, traffic deaths have risen by 17% in urban areas, indicating a need to improve safety in densely populated environments such as Water Street (Shepardson, 2019, n.p.).

Using previous research, roadway design guidelines, and best-practices in other cities, my capstone team will study, create, and test alternative designs to determine three feasible roadway configurations for Water Street to accommodate pedestrians and bicyclists more purposefully. Through their research on cyclist and pedestrian behavior in simulated environments, Xu et al. and Deb et al. found that VR studies are effective in replicating real-world roadway conditions and travel patterns (Xu et al., 2017, n.p.; Deb et al., 2017, p. 449). Because of the viability of VR in immersing subjects to test design changes to the corridor, we will implement our designs in an existing virtual reality (VR) environment model of Water Street and test subjects within each of the three alternatives using bicycle and pedestrian simulators. Using user feedback (surveys) and physiological indicators (biometric data), along with a multi-criteria analysis of each design, we will recommend a preferred alternative for the corridor that will improve safety and comfort for non-motorized roadway users.

This alternatives evaluation process will ensure that the final deliverable meets design standards and is feasible. The specific design changes will need to be implementable in VR and focus on the on-street characteristics, so the team has established guidelines for what can be changed on the roadway. These include:

- Pavement markings and additional roadway infrastructure (e.g., bicyclist and pedestrian safety barriers)
- Re-allocation of space within the existing right-of-way
- Signage

The team will be also be responsible for user feedback that will be collected before, during, and after subjects' immersion into VR using

- Physiological indicators (e.g., heart-rate, skin temperature, and arm movement, all collected through wearables)
- Survey-based methods

These factors will help to quantify the extent to which participants feel safe and comfortable in each of the alternative VR environments through both involuntary (physiological) and voluntary, perceived (survey) data. Both types of data are important to establish a holistic picture of the impacts of each alternative on participants walking and cycling. The roadway design alternatives and the final alternative will be compiled into a set of planning-level design documents in order to communicate the team's recommendations.

Evaluating the Conflicts Between Drivers, Pedestrians, and Bicyclists in Sharing the Road

As previously discussed, because roadways in the United States often prioritize drivers over other modes of transportation, society's prevailing attitude is that bicyclists and pedestrians are "second-class citizens" on the road (Laker, 2016, n.p.). This dedication of roadway infrastructure to driver accessibility has led to a common mindset that drivers have a right to the road, often without an obligation to share the space with other types of travelers. In turn, more vulnerable transportation system users may face difficult travel experiences (as on Water Street) that reduce their safety and comfort levels. Due to this vehicular bias, non-motorized travelers may be unconsciously blamed for problems on the road by drivers due the preeminence of vehicles in the roadway hierarchy (Laker, 2016, n.p.). As a result, auto-oriented environments are increasing segregation between drivers and other modes, which could lead to continued dominance by drivers if these biases are not addressed; a prioritization of vehicles on the road

will lead to perpetual auto-oriented developments as the status quo in the future. As "car-centric" roadways are seen the norm, this problem is something that is embedded in the present "cultural context," a term used by Neeley to describe the influence of technology (in this case, roads) when it is embedded into society (Laker, 2016, n.p.; Neeley, n.d., p. 38). To completely resolve the problem behind pedestrian and bicyclist safety, this perspective must be shifted from a cultural standpoint to redefine the country's transportation framework.

As Downey describes is necessary for technological innovation, engineers, but also policy-makers and citizens, must consider multiple stakeholders with possibly disagreeing viewpoints (including drivers, pedestrians, and bicyclists) when collaboratively problem-solving (in this case, planning, designing, and using a road) (Downey, 2005, p. 591). However, defining this problem of allocating the space on the road is not straightforward, since different roadway users inherently have different priorities. To adequately address this issue of varying priorities, it is not enough to simply redesign the roadway infrastructure to provided dedicated spaces for walking and cycling. Drivers see the need for a corridor to provide them with uninterrupted mobility and thoroughfare travel, typically viewing slower modes as impediments to their destinations, whereas bicyclists and pedestrians see the need for safety, comfort, and access.

To explore this conflict more in-depth, I will conduct research on the causes of and mindsets behind driver-dominated streets, including an examination of case studies in countries where their urban streets have prioritized non-motorized modes. Furthermore, I will perform a literature review to inform cultural strategies and social changes that can improve the experiences of pedestrians and bicyclists, especially from the standpoint of drivers. This review will focus on a perspective of problem definition, as developed by Downey, that frames engineers as needing to take on responsibility for the "technical mediation" of their work

(Downey, 2005, p. 591). To better mediate between often-conflicting roadway users, drivers must be encouraged to share the road and support pedestrians and bicyclists in utilizing a space where they feel they belong.

Intended Outcomes of the Project

My capstone team's determination of a preferred roadway design alternative would be a crucial step in providing a safer and more comfortable environment for pedestrian and bicyclist travel along Water Street, addressing the needs of these vulnerable roadway users in a way that is empirical and based on real-world user experiences. Ideally, the City of Charlottesville would implement the final design, with cyclists eventually using the dedicated bicycle infrastructure and pedestrians using the improved crosswalks. As a result, with this reallocation of roadway space, drivers along the corridor should be more likely to increase their tolerance and acceptance of pedestrians and bicyclists. Ultimately, the project would be a step toward a larger cultural shift toward roadway development that includes, and even prioritizes where feasible, non-auto forms of transportation.

The literature review I will conduct would provide a comprehensive framework of the need to improve the attitudes of drivers toward non-motorized roadway users and a set of strategies through which this shift in mindset could possibly take place. Ideally, the research would provide insight into ways through which sharing the road could more readily take place on the streets of Charlottesville as well as in other localities across the country.

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