**Pedestrian and Bicyclist Safety and Comfort on Water Street**
(Technical Paper)

**Sustainable Urban Mobility in the Context of Smart Cities: How Utilization of Non-motorized Transit Improves Lives in Urban Areas**
(STS Paper)

**A Thesis Prospectus Submitted to the**

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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

## Introduction

As humanity is nearing the end of the second decade in the twenty first century, a vast majority of the world's population live in urban areas and especially low- and middle-income countries are undergoing a rapid urbanization trend (UN Environment, 2016). This trend creates a huge burden on the local authorities in those countries, who are responsible for building and maintaining the transport infrastructure, as they struggle to cope up with this pace of expansion and building stress on the transportation infrastructure in those cities in terms of social, environmental, and economic challenges (Biyik, 2019). The capstone project is on improving pedestrian and bicyclist safety and comfort along Water Street Corridor in downtown Charlottesville. Water Street is a primary east-west thoroughfare in Charlottesville, identified as one of the bicycle arterial routes in the city's bicycle and pedestrian masterplan. Yet, the Water Street corridor presents a high level of traffic stress for bicyclists. For the capstone project, alternative pedestrian and bicyclist infrastructure in this corridor, including safety countermeasures to bolster pedestrian visibility and facilities to improve safety, comfort, and connectivity for bicyclists will be evaluated.

In line with the objective of the technical part of the project related with the City of Charlottesville, there is ever more increasing interest in improving the lives of people in the urban areas around the world through introducing non-motorized transportation alternatives that are safe and comfortable. Those methods, if planned carefully, will contribute dramatically to the quality of life in the cities by improving the urban mobility along with social and economic conditions in a sustainable manner. The intended objective of my STS paper is to lay the foundation towards reaching sustainable urban mobility in the context of future smart cities to improve overall quality of lives.

## IMPROVING PEDESTRIAN AND BICYCLIST SAFETY AND COMFORT ALONG WATER ST. CORRIDOR

Virginia Department of Transportation (VDOT) has identified the West Water Street corridor in downtown Charlottesville (between 2nd Street SW and 4th Street SE) as a priority corridor for pedestrian safety countermeasure planning in the Pedestrian Safety Action Plan (Beardsley et al., 2018). Along this corridor (see Figure 1), which hosts one of the busiest bicycle routes in the city, 10 pedestrian crashes were reported between 2012 to 2016, with ranging outcomes.


Figure 1. Map for the related part of Charlottesville for the technical project: This map is prepared by the Capsone team (Kutay, 2019)

Ideally, Water Street would be able to accommodate vehicles, pedestrians, and bicyclists in a safe and efficient manner through the evaluation and design of alternative pedestrian and bicyclist infrastructure in this corridor, including safety countermeasures to bolster pedestrian

visibility and facilities to improve safety, comfort, and connectivity for bicyclists. In this this capstone project, the focus of the team will be around researching, creating, and testing alternative designs to improve bicyclist and pedestrian safety in the Water Street corridor. In achieving this goal, the team will analyze best practices from other bike- and pedestrian-friendly cities to inspire design ideas focusing on the descriptive and normative scenarios.

Figure 2. Virtual Reality simulation testing view. This picture is prepared by the Capsone team (Kutay, 2019)

Testing of the proposed design alternatives (see Figure 2) using virtual reality (VR) and biometric data will include both traditional surveys and novel methods such as simulation models. The project team will have the opportunity to implement alternative designs in the bicycle and pedestrian VR simulators in the Omni-Reality and Cognition Lab (ORCL). ORCL researchers have developed a VR environment that replicates the Water St. corridor, and the project team can alter this base environment to include the design alternatives and evaluate user comfort as the subject pedestrian and bicyclist virtually walks and cycles through the new designs. Planning level design documents are to be created in order to communicate the team's design solution alternatives. These solutions will stem in part from research on the reactions of bicyclist and pedestrian test subjects who are introduced to a VR simulation of the Water Street corridor, so VR environments of the alternatives will also be created as part of the project's

scope. The team will be responsible for the preliminary design of the alternatives, evaluating each of the alternatives in VR through user testing, and determining the preferred alternative through the feedback by the users. However, the project scope does not include actual installation of the alternatives, such as detailed design documents for construction, detailed cost breakdowns, removal of buildings, signal timing changes, or changes that require additional right-of-way.

The Project plan along with designing alternative solutions, includes implementing design alternatives and completing testing of subjects using the Unity software. The end-user experimental studies will be used to evaluate how different alternative design may impact pedestrian and bicyclist behavior, perception of safety, and comfort. These experimental studies will be conducted within a fully immersive VR environment, where participants' behavioral and preferential information will be collected via physiological indicators such as heart-rate, skin temperature, and arm movements to be collected through wearables, as well as survey-based methods. The evaluation methodology should document which criteria were included (cost, safety outcomes, operations across all modes, constructability, aesthetics and environmental impacts, equity, context sensitive design, user perceived safety and comfort, etc.) and document all justifications for that criteria including design standards, experimental design, data collection, etc.) Finally, a set of design plans for the preferred alternative should be included with the final design report. The steps of the Project delivery are seen in Figure 3.

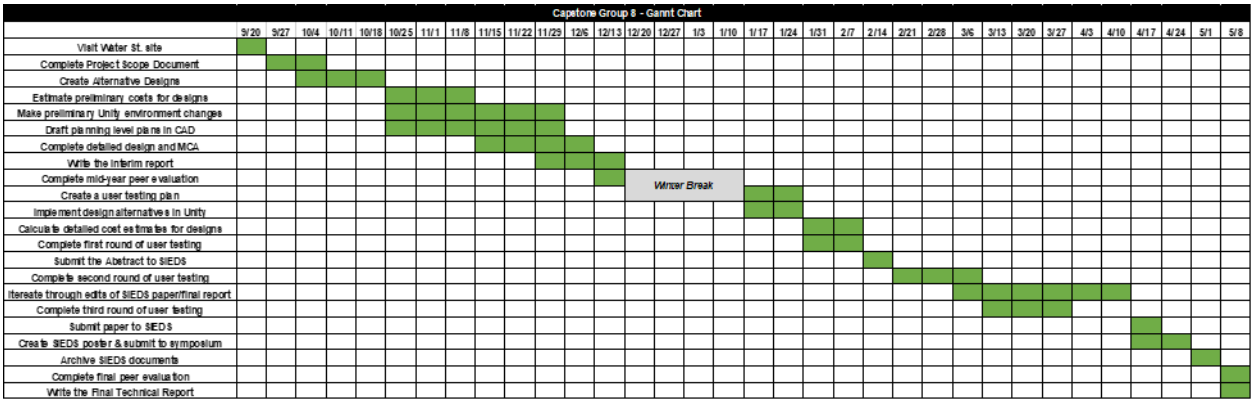


Figure 2. Timetable for the technical project: This Gannt Chart shows the deliverables and action plan of the Capsone team (Kutay, 2019)

**SUSTAINABLE URBAN MOBILITY IN THE CONTEXT OF SMART CITIES: HOW UTILIZATION OF NON-MOTORIZED TRANSIT IMPROVES THE LIVES IN URBAN AREAS**

Technological developments, rapid urbanization, and economic rationale makes urban mobility an inevitable concept for city planners and administrators. In his research exploring the impact of sustainable transport and mobility on social development, Chakwizira (2019) discusses the strong links between transport infrastructure mobility and socio-economic development in South Africa. Properly designed, accessible, and inclusive transport infrastructure alternatives support the disadvantaged and marginalized neighborhoods to be able to access to the urban economic development in a stronger way. It is critically important for the city residents to be able access to key socio-economic services at a reasonable cost, in reasonable time and at reasonable ease as discussed in the article "Do Artifacts Have Politics?" (Winner, 1980) with the example of purposefully lowly built overpasses in Long Island, New York.

A smart city is defined as an efficient city, a livable city, as well as an economically, socially, and environmentally sustainable city (Buscher). The increased use of motor vehicles globally on the back of rapid urbanization, increasing income levels, and formation of a new working class significantly improved the car ownership and caused higher hydrocarbon usage. Increased car ownership certainly has a negative impact on environmental sustainability due to the increasing carbon emissions from those vehicles. Efficient ways of urban mobility also contribute to more pedestrian based alternatives, increased bicycle usage and wider public transportation access among commuters, which promotes the social and economic wellbeing of the users of those non-motorized alternatives. The improved mobility of people also helps improved health conditions and reduces cost of living, as well as improving overall comfort of people.

## Various Challenges Encountered in Reducing Motorized Transportation

While the non-motorized transport alternatives may be seen as the most viable options in terms of sustainable urban mobility within the context of smart cities, there are a number of challenges faced to reach the desired level of pedestrian, bicycle and public transit methods of transportation. Those challenges are grouped as social and structural challenges.

### Social Challenges

Social challenges are represented by issues related with self-esteem, personal security, and affordability (Chikawizara, 2019). Wealthier countries usually have higher private motorized transport compared to others. In most parts of the developing world, such as Middle Eastern countries, the bicycle usage and transportation by walking is mainly by two different groups. For those who cannot afford a private motorized vehicle, the bicycle or walking are methods for transportation, while those with time and money for leisure activities, cycling is primarily a recreational activity (El-Geneidy, A., Diab, E., Jacques, C., and Mathez, A., 2013). One of the limiting factors in a social context is that in some of the developing countries, such as countries in Africa, based on habits dating to its colonial past, use of motorized transportation is often associated with education, affluence and an elevated status in the society. Therefore, the general attitude towards non-motorized transportation (NMT), such as walking or use of bicycles, are often associated with the poor (UN Environment, 2016). Likewise, as per findings of the 2010 research by Roşca E., Ruscă A., Ilie A., and Ruscă F., the use of personal car is equivalent to a social status symbol and are seen as issues related with free movement and free choice in the Central and Eastern European countries. Another important factor is related with safety. Owning a private car is a major aspiration for people in Manila, Philippines as the non-motorized

transport is often seen as inadequate and unsafe (Neyestani, p5). As a result, considering road safety is an important factor to achieve sustainable mobility.

**Structural Challenges**

Structural challenges are issues faced around infrastructure, information, and planning. Enabling proper infrastructure is often seen as one of the most important factors to improve affordability and accessibility for urban communities. Non-motorized transport alternatives should be encouraged not only by providing the right infrastructure, but also by ensuring that pedestrians and other users, such as cyclists, feel safe and secure in their environment. As per the 2019 research by Biyik, the key message is that "switching much of the population to more active forms of transport for many journeys is entirely feasible, if such forms of transport are made accessible, comfortable, and can easily be integrated into the user's daily routine". Consequently, the solutions towards reaching sustainable level of urban mobility not only require a radical change in the traveler's habits but also improvements in the structure and organization of the transportation systems.

**Socio-Economic Implications with respect to Actor Network Theory**

Achieving sustainable urban mobility inevitably requires a high degree of dedication and coordination by the city planners and administrators. Despite the demanding technical requirements for the proper design and implementation, there are many other implications in the social, economic, political, environmental, safety and health related space, which significantly outweigh the importance of technology related considerations, requiring a multi-dimensional approach (Speirs).

In order to identify all the implications of non-motorized transportation alternatives within the context of sustainable urban mobility, this paper intends to use an Actor-Network Theory (ANT) approach. ANT is described as the interaction among people, institutions, and organizations. ANT considers both human and non-human elements equally as actors within a network (Cressman, 2019). In other words, the same analytical and descriptive framework is to be employed when faced with either a human, a text or a machine. The main goal of this thesis prospectus is to lay the framework between various actors in the context of urban mobility while elaborating various relationships between the technological change and the behavioral and social practices of the stakeholders that are closely impacted by those changes (see Figure 4).

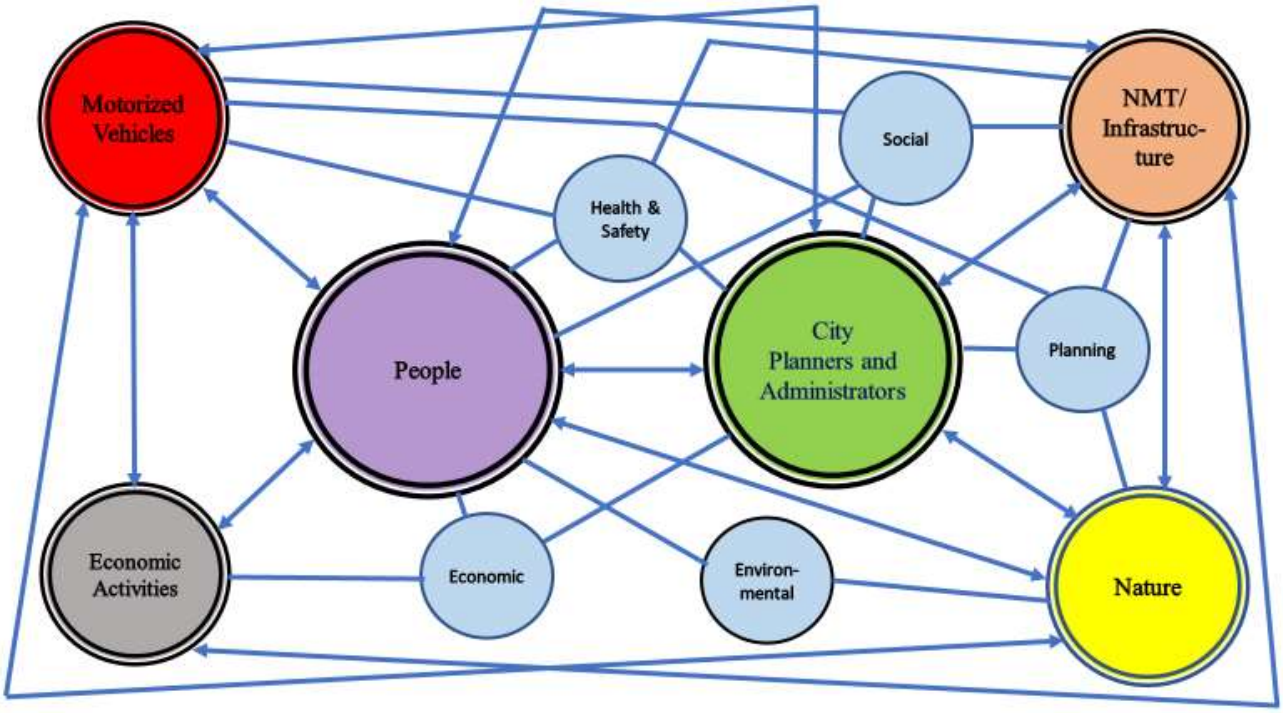


Figure 4: ANT Network for interaction of stakeholders: This network depicts the interactions between different actors and the influential factors as interconnected color-coded circles, where blue refers to the factors and other colors refer to different stakeholders. Two-headed arrows mean that both parties affect each other (Kutay, 2019)

The ultimate goal should be how to improve the quality of life by emphasizing the relationships between the actors such as city planners and administrators, the public through interactions around social, economic, political, environmental, safety and health factors (Del Pozo, P.B., Benito, P., Serrano, N., Marquess-Sanchez, P., 2016).

The ANT is often criticized for having an exclusive emphasis on empirical observation tools and therefore has methodological limitations in understanding the social experience outside the pre-established models and tools of social research. To remedy this, a more interpretive approach as emphasized by the concept of translation can be utilized (Cressman, 2019).

## RESEARCH QUESTION AND METHODS

What are the complex relationships between different stakeholders while promoting the non-motorized transport alternatives to achieve sustainable urban mobility, and how the non-technological factors influence the ultimate goal of improving the quality of lives in the context of a smart city? In exploring this question, a documentary research method organized by the topic will be employed principally utilizing the set of references provided in this paper. There is a wide variety of research completed in the area of sustainable urban mobility and its implications in the social, economic, political, environmental and health context. A strong connectivity with actor network theory (ANT) will be established as the main underlying socio-technical framework. According to ANT, different stakeholders; people, city organizations, technologies and infrastructure, nature, and economic activities are the result, or effect of heterogeneous networks (Cressman, 2019).

## CONCLUSION

The technical project proposal focuses on the research, creation, and testing of design alternatives to improve bicyclist and pedestrian safety in the Water Street corridor. These proposed design alternatives will be based on user feedback utilizing both conventional surveys and other technology-based methods. In parallel, the STS part of the paper explores how socio-economic, political, environmental, health and safety related factors interact towards building non-motorized transport alternatives to reach sustainable urban mobility in smart cities (Wallim, 2017). While the provision of physical infrastructure is fundamental to enable mobility at a safe and convenient manner, there are numerous social, economic, environmental and policy-related factors that would influence sustainable urban mobility. Technology can provide some solutions to some of the challenges in achieving the results. The intended study will address how a serious consideration of those other factors that work in tandem with the technological solutions will add value in terms of improving the quality of people's lives through confronting those challenges.

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