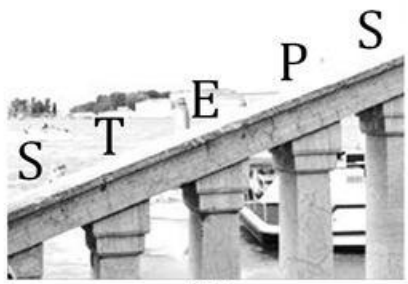

IN
VENICE

Study **T**o **E**valuate **P**edestrian **S**ystems

An Interactive Qualifying Project report submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the Degree of Bachelor of Science

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This Interactive Quantifying Project consisted of many different parts and each team member contributed their own ideas to each of them. Tim Forrest's main contribution was technical work such as understanding QGIS and contributing to the creation of infographics. Erin Heckley's main contribution was making the presentations and creating infographis. Alex Kim's main contribution was to understand and update Venipedia. Melanie Wiater's main contribution was to writing and editing of the final report.

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Abstract

Each year Venice is impacted by the large number of tourists that travel to the city for its famous celebrations and landmarks. Consequently, the number of pedestrians has been rapidly increasing and the mobility of the streets has been compromised. Beginning in 2007, data of the number of pedestrians on bridges and street segments has been collected by Worcester Polytechnic Institute students. Our project sought not only to continue this data collection, but also analyze how the numbers of pedestrians impact the streets. The pedestrian data we collected will serve several purposes. First, this data provides general information and the understanding of traffic flow on the streets. Second, the data collected will serve as a baseline to later determine the effect the installation of a new public tramline will have on the city. Our team also worked to model the infrastructure of the streets through the creation of GIS map layers as well contributed data to a Pedestrian Model. The information about the infrastructure of the streets was entered into a database accessible to the public through Venipedia pages, which can be referenced in the future to understand how the pedestrian system changes over time.

Executive Summary

Venice faces unique challenges when supporting pedestrian travel. Attracting thousands of tourists each day during summer months, pedestrians depend entirely on two modes of transportation. The primary means of navigating the vast network of streets is walking the 157 kilometers of streets by foot. Alternatively pedestrians can utilize public boat transportation but canals become equally crowded by other vessels. This infrastructure is not able to effectively support the number of tourists who come to visit every year. In the high tourist season it is not unheard of for the population of 60,000 Venetians to double in a single day. The influx of tourists can overwhelm for the city's delicate infrastructure. The limited amount of space in the city is further hindered by dead ends, narrow streets, and bridges. All of these greatly exacerbate the congestion levels. In addition, many streets are crowded by vendors, restaurant seating, and in certain seasons *passarelle* (elevated walkways to overcome high water). Congestion has increased so severely that Venetians have started to relocate, causing a consistent population decrease since the 1950's.

Figure 1: Pedestrian Congestion in Saint Mark's

Congestion has become such a problem for the city that numerous mobility studies have been previously completed in Venice. Measurements of pedestrian traffic have been completed through studies by the Venice Mobility Department as well as previous Worcester Polytechnic Institute students.

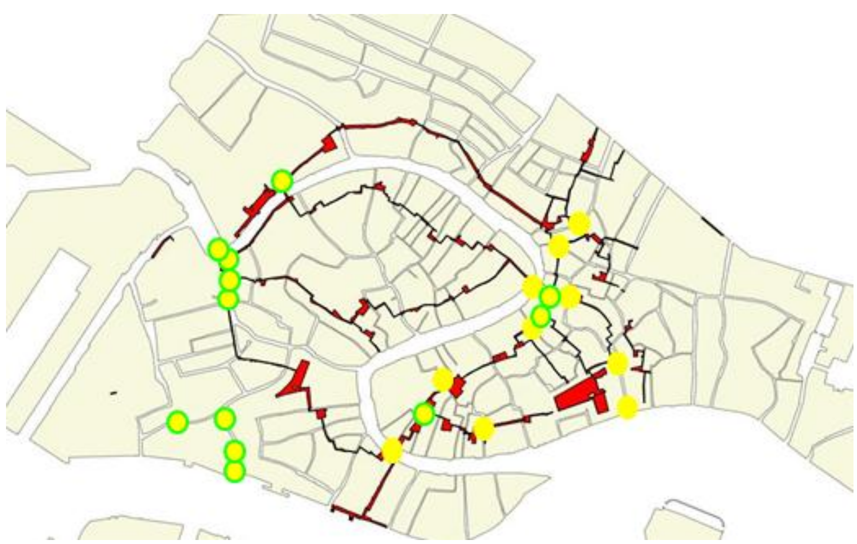

Figure 2: Map of Previous Years (yellow) and This Years (green) Project Counts

The Venice Mobility Department focused on the entrance points to the city as well as the main arteries of the city. They determined the number of pedestrians that entered the city through San Lucia and Piazzale Roma; then calculated the density of the main arteries to determine the disbursement of tourists across the city. Previous WPI groups completed pedestrian counts in the San Marco district to determine the effects of tourism on bridge traffic, as well as incorporate this mobility data into a pedestrian model. We expanded upon these studies to include additional information regarding the future tramline, collected additional data for the pedestrian model, and calculated the capacity of the main artery streets.

This project contributed to the understanding and modeling of pedestrian pathways in Venice. The first necessary component was to model the physical infrastructure of the streets of Venice by gathering the physical information and historical background about each street. The next component was quantifying pedestrian traffic to understand the space each pedestrian occupies and the speed at which they can travel. Finally we developed a method to determine the maximum capacity of each street. This identified the maximum number of people that can flow through specific streets in the city. Compiling this street data, the information was published online using Venipedia and incorporated into a pedestrian model.

To gather the physical and historical information of the streets in Venice we used a computer program, QGIS, that provided a geospatial map of all the streets in Venice. This map provided information such as the length, minimum width, and surface area of each street as well as showed buildings on each street and the shapes of all the canals, bridges, underpasses and islands. With this information we created two completely new layers, one consisting of the entire street as one line, and another layer of each segment of every street. With this physical data we were able to calculate the amount of space available for pedestrians to travel throughout the city to predict possible sources of congestion.

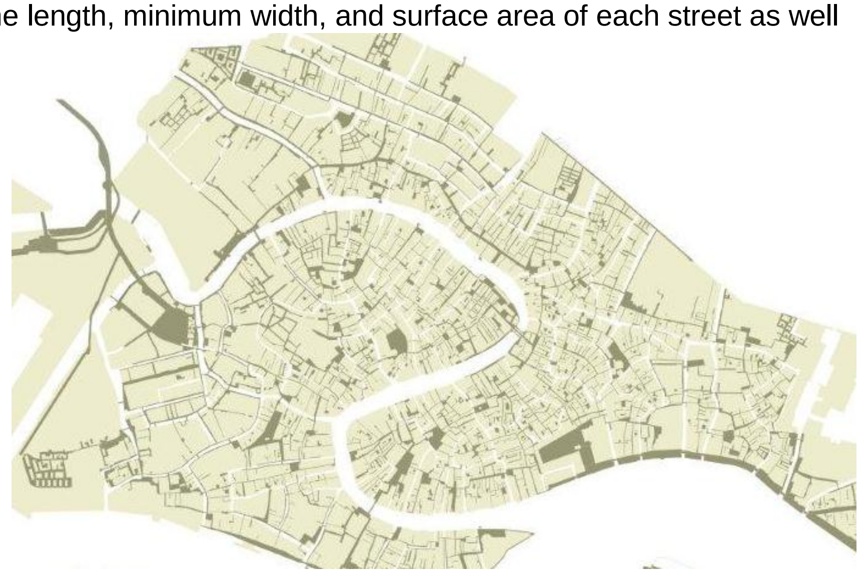
Figure 3: GIS Layer

Our data collection was aimed at achieving two main objectives. The first was to quantify a baseline measure of pedestrian traffic at future tram stop locations, Piazzale Roma and San Basilio. A new tramline will be built to come in from the mainland through Piazzale Roma, stop in Santa Marta, and end in San Basilio. The Venice Mobility Department is interested in understanding how the installation affects traffic in this area. Our data along with future studies will be able to show the tram's effect on pedestrian traffic flow. The second object was contributing to a pre-existing pedestrian model. San Marco is a high tourist location on the island so we collected data at three intersections of main arteries roads in this district. This data will be added to the pedestrian model that tracks the movement of pedestrians throughout the city and then uses this information to establish trends that the pedestrian agents follow.

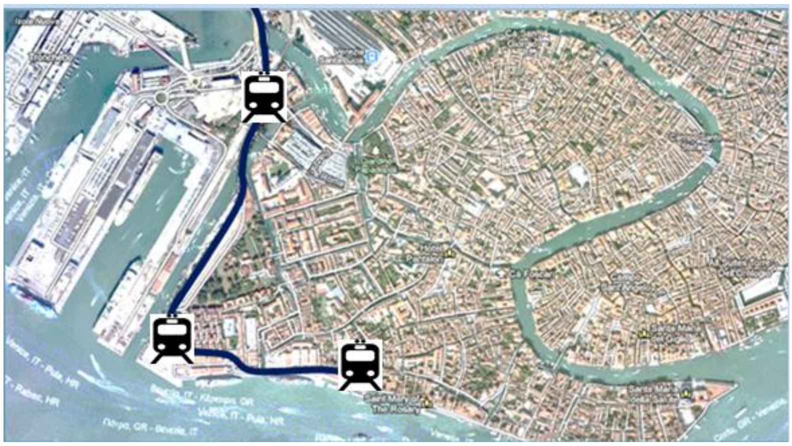

Figure 4: Map of the Tramline Locations

The city's infrastructure is limited while tourism is steadily increasing. The maximum capacity of every street was calculated using a simple formula where the surface area of the street is divided by an estimated necessary walking space for each pedestrian. The physical information as well as average walking pace were used to determine the pedestrian flow through bottleneck areas and estimate the time delay for particular paths through the island during high congestion. By determining the surface areas of all the main arteries and using the figure for the space each pedestrian takes up, the team determined that if tourism keeps increasing at its current rate, many of the arterial streets of the city will be at near standstill in eight years. This estimation is based off of several assumptions including: the rate of increase in tourism each year maintains or increases, that this event will happen in the main tourist months such as

Figure 5: Pedestrian Walking Capacity

July or August on a weekend, that minimal day trippers were in the city when the counts that this number was based on occurred, and that the same percentage of tourist are on the high capacity streets as when our counts were taken.

All of our pedestrian data gathered and calculated will be published online for the public to see using Venipedia. There will be pages that consist of the physical, historical, and capacity information for every street. All of the pre-existing data that has been collected about the streets and bridges will be uploaded to their respective pages. All of the areas we counted were uploaded onto their corresponding pages. As well as producing these pages our counts were used to update a pre-existing pedestrian model which is also available for everyone to see. Although our project is completed there is still a vast amount of work to be done toward understanding the state of Venetian pedestrian mobility.

To allow for user friendly and accurate information, the existing GIS layers should all be thoroughly reviewed to ensure the removal of any duplicate streets, misnamed streets, and provisions for unnamed segments. The segment layer created by the 2012 streets team this year should be supplemented with bridge information. For the layer to be useful in the modeling of pedestrian traffic the bridges should be added as a continuation of existing street segments. The team would have to decide a method for consistent incorporation of bridges into the segment layers. New layers should be created as well, including major bottleneck areas on streets defined by a specific ratio of street and bottleneck width, to assist in estimating pedestrian flow. The continuation of the GIS layer maintenance, as well as the creation of new layers is integral to improving the model of the city's infrastructure.

Many of streets of Venice are crowded with street vendors, restaurant sitting areas, *passarelle* and other permanent obstructions. To understand how severely these obstacles affect the pedestrian flow, objects should be measured and their total percentage of the street occupied should be incorporated to capacity and flow rate measurements. Cataloging the locations where *passarelle* are available or absent would give light to the structure of the pedestrian model during flooding.

Figure 6: Calculated Time Delay from Santa Lucia to Rialto Bridge

It is always necessary to continue to count to understand the pedestrian system of the city. In the near future the Santa Marta island should be counted and included in our pre-tramline baseline. Following the completion of the tramline, all three stops should be recounted to reveal any differences in traffic flow. In addition the intersections and bridges in San Marco prove to be great sources of information for the pedestrian model. It is also important to understand the flow of pedestrians on a greater scale and can be achieved by counting the flow of pedestrians on and off each specific island.

Understanding the precise causes of congestion is integral to maintaining the city as a whole. Considering the impact that traffic has on the individual is equally important and much relatable to the public. Ideally future studies should be performed that timed a pedestrian's walking time on a specific route based on various factors, such as high tourist times, cruise ship dockings or others. Effectively, this would show how tourism can affect the single persons commute.

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Chapter 1 Introduction

Worldwide urbanization, in response to a growing population, transforms many city centers into densely traveled areas. Pedestrians navigating these urban centers quickly can discover a multitude of hindrances when walking from place to place. A number of cities have dedicated extensive studies and city departments to search for solutions to alleviate pedestrian and general traffic congestion. The city of Tokyo, which is notorious for narrow streets and high foot traffic, performed a study on the effect of obstacles on the natural flow of traffic. The study observed people's reactions to many different "obstacles" including sidewalk edges, fire hydrants, and construction sites. In general, the study showed that pedestrians on the street avoided the obstructions and would keep as great a distance as permitted. This tendency of pedestrians causes additional crowding and speed reduction in traffic flow[1]. Pedestrian congestion is especially prevalent in Historic Centers because they are rich in historic culture and art which draw large crowds of tourists. Limited space for pedestrians is a general theme throughout the world with many city governments taking "restrictive measures" directed at traffic management in the historic centers.[2] In Boston, Massachusetts, for example, the Boulevard Project sought to improve the urban environment for residents and commuters alike.[3] In these and other related studies, the word traffic is most often associated with cars, but pedestrian mobility is equally important when considering how to make city systems easier to navigate for travelers. These traffic problems are paramount in Venice, Italy, where the only other form of transportation beyond walking involves boats on the narrow canals.

Figure 7: Shibuya Intersection in Tokyo, Japan.
It is one of the most crowded intersections in the city.

[1] Kwon, Young-In, Shigeru Morichi, and Tetsuo Yai

[2] van der Borg Jan, Paolo Costa, and Giuseppe Gotti, "Tourism in European Heritage Cities," *Annals of Tourism Research*, 23, no. 2 (1996): 306-321,

[3] Beauvis

A unique scenario challenges the city of Venice since it is a pedestrian city. As the second most popular Italian attraction, the city of Venice consists of multiple islands.[4] Since the city is so small, it experiences overcrowding that affects the mobility of tourists and residents alike. Sixty thousand Venetians reside on the islands, while the population doubles daily as many as 20 million tourists visit the island every year.[5] Venetians encounter throngs of tourists crowding streets and bridges on their daily travels. Frustrated with pedestrian congestion, some locals relocated to other parts of Italy.[6] The cruise line industry contributes to congestion. As many as seven ships can dock at Piazzale Roma each day carrying about 3,500 people.[7] Piazzale Roma is the central entrance hub of the city and almost all people who enter the city do so through this point. The existing bus depot is located in Piazzale Roma where the bridge from the main land connects to the island. The bridge offers the only form of transportation into the city other than private boats. To address congestion problems, the Venice Mobility Department is studying the influx of tourists and transportation issues on the islands. Additional forms of transportation are being planned to ease traffic congestion such as a tramline.

The increased number of tourists greatly impacts the small city of Venice. Streets and bridges become impassible due to the large number of people trying to traverse them. Numerous studies have evaluated pedestrian congestion in busy cities. For example, a German Research Foundation study conducted on bottleneck areas concluded that the wider the exit, the less time it takes for the density to decrease. The length only affects results when the bottleneck is a short length with a greater flow of traffic. Pedestrians in this study created a zipper type formation, with a pattern of either side of traffic taking turns moving forward through the narrow bottleneck area. However generally two or three rows of people would tend to move more quickly.[8] To inform pedestrians of possible routes throughout Venice there are multiple applications available online. For example, ACTV, a Venetian department in charge of public boat traffic, has a website similar to Mapquest that provides routes based on a starting location, intermediary stops, and an ending point selected by the user. This mapping program illustrates a variety of different paths to get around Venice by foot, boat, or both.[9]

Previous mobility studies that assessed purely pedestrian traffic, (readily applicable to Venice) focused on controlled structures such as stadiums and airport terminals. Knowledge of

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[4] Bakerjian
[5] Livesay, Christopher
[6] MoVe 10
[7] Brown
[8] Liddle
[9] ACTV

mobility issues in urban centers that are predominately traveled by pedestrians is limited. Previous attempts to gather data and construct mobility models of Venetian pedestrian traffic are considered imprecise. A comprehensive analysis of pedestrian movement in additional areas of Venice would reveal a clear picture of the major causes of congestion. Analyzing mobility impairments will expose common patterns that can be found in other cities throughout the world.

This project is intended to gather data for the Venice Mobility Department. It will expand upon previously incomplete physical and historical information and include new pedestrian data. This information will provide a baseline for the number of pedestrians in certain areas of the city before a tramline is constructed, which will redirect tourists to less crowded areas. The maximum capacity of each street also will be determined for consideration in the event of heavy traffic or need for evacuation. All applicable data will be published by means of the Venipedia website and will be available to anyone on the internet.

Chapter 2 Background

Composed of narrow streets and canals, the city of Venice is naturally inclined to have problems with traffic flow. This historic city is much smaller than an average city with only 177 square miles and is not organized to accommodate large crowds[10]. The small number of natives can thrive in this condensed space, but the daily influx of tourists creates congestion throughout Venice. Many historic sites such as Saint Mark's Basilica and the Rialto Bridge contribute to the large number of tourists. To enter the city, tourists must take a boat or travel across the *Ponte della Libertia,* all converging in Piazzale Roma. The cluster from the drop-off areas as well as historical sites cause traffic jams during the tourist season. The purpose of this project is to quantify the number of pedestrians in three districts, allowing the Venice Mobility department to see the major areas of congestion.

2.1 Traveling to Venice

There are limited ways to enter Venice. Trains, cars, and buses can access the island across the *Ponte della Libertia,* dropping people off at the *Piazzale Roma*. To enter by water, tourists either arrive on a cruise ship, water taxis or Alilaguna (a public boat line).[11]

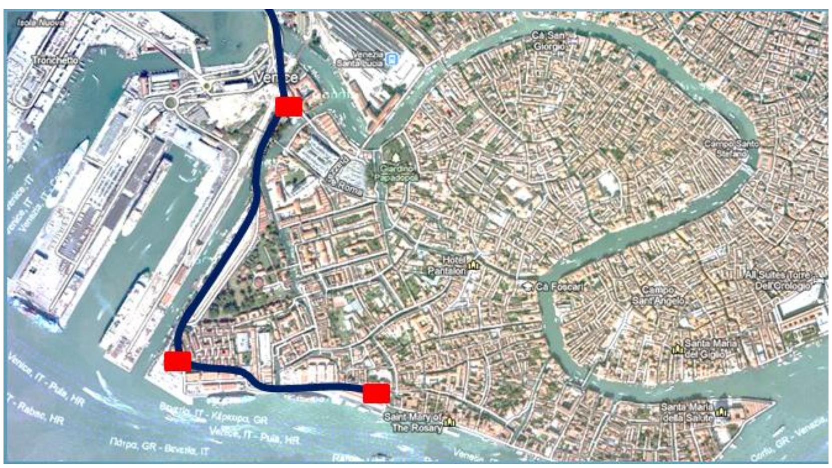


Figure 8: Future Tramline Stops

In an effort to allow for easier movement throughout the city and to disperse pedestrians the city of Venice is working on the installation of a tramline into the city. This line will have three stops in the districts of Santa Croce and Dorsoduro.[12] These districts have major sources of pedestrians, tourists and locals alike. Santa Croce is home to the Piazzale Roma as well as the parking decks located on the island. Piazzale Roma is where the new stop will be located. Dorsoduro is home to the University of Venice and many workers and students commute to this district daily during the week. The new tramlines will be located in San Basilio and Santa Marta.

[10] Travora Media
[11] Fogarty, Chelsea, Geordie Folinas, Steven Greco, and Cassandra Stacy
[12] Venice Mobility Department

This tram has the potential to majorly impact the traffic in the districts it will be located in. Santa Croce should see a major drop in traffic while Dorsoduro may experience a major increase. It is important to document the levels of traffic near these tram stops now so that in the future the Venice Mobility department will be able to understand the effect that the installation will have on the city.

2.2 Public Boat System in Venice

One aspect of Venice greatly separates it from many other cities. There are no cars in this city. Residents and visitors have just two options to traverse Venice, walking or traveling through the canals by boat. In this section, we will discuss the public boat system used by locals and tourists alike and in the next section discuss the components of the pedestrian system.

Figure 9: Gondolas

It is believed that Venice was founded in 421AD by fishermen from the Italian mainland who sought refuge from invaders.[13] While most of the city's islands today are artificial, Venice's core is based on a series of naturally formed islands that guided the original construction. The early canals were dug into these islands to allow fast and easy transportation between them. However, just as Venice's first islands were based on previous landmasses, the Grand Canal follows the path of a river now hidden by the city's growth. These canals are pivotal for the public ACTV boat line throughout the city.

The image of a canal occupied with a few colorful gondolas is an outdated idea depicting travel in these waterways and ignores the canals' impact on the city's infrastructure. Today, these iconic gondolas are used by tourists for a high fee, while other more efficient modes of transportation operate throughout the canals[14].

[13] Howard, Quill. The Architectural History of Venice

[14] Davis Robert C, and Marvin Gary R, *Venice, the tourist maze: A cultural critique of the world's most touristed city*, (University of California Press, 2004).

Motorboats were introduced to the canals in the 1950s and since then, have made up the majority of boats on the canals. These boats have three main purposes: transportation of people, shipment of goods, and recreation. Public transportation is the primary function, and boats called *Vaporetti* primarily perform this task. *Vaporetti* are larger vessels that perform the same function of a public bus in an average city. In addition to these bus-like boats, water taxis can be hired at docks to take a person to a chosen destination for a fee. *Gran Tourismos* are similar to chartered buses and are available for large groups of people who want to travel through Venice together.

Figure 10: Vaporetti

Additionally, cargo boats make up a large portion of the canal traffic. In general, cargo boats differ in size, but have similar functions. These boats are responsible for transporting goods throughout Venice since the streets cannot accommodate trucks or trailers. Other large boats such as garbage boats and construction barges are necessary for the general function and upkeep of the city. These large vessels can disrupt traffic due to their size and lack of maneuverability.

Figure 11: Cargo Boat

With all the traffic throughout the canals, it is clear that regulations must be set to ensure the safety of travelers and boat operators. The primary law is imposing speed limits. The Provincial di Venezia Settore Mobilita e Transporti is the portion of the government responsible for enforcing these rules. This regulatory body divides boats into two general divisions, boats that have scheduled stops, such as bus boats, and boats without scheduled stops, such as taxis and chartered boats. Boats with scheduled stops have higher speed limits than those without, because they are generally smaller in size, are more maneuverable, and produce smaller wakes. One-way canals, closed canals, and canals undergoing construction further reduce where boats may travel. The Coast Guard and Venice police are responsible for monitoring these regulations[15].

2.2.1 Boat Schedules

Water transportation places a large number of people at drop-off points. The water buses in Venice, organized by the ACTV, operate similar to a bus or subway line in other cities. Tickets must be purchased to board, and they can be for as little as one passage (as low as 2€) or a ticket that can be used for an entire month (30€). There are 22 lines that operate during the day throughout the city. Depending on the size of the line, water buses will arrive at pickup points roughly every ten minutes. The exodus of departing passengers creates intermittent periods of pedestrian congestion on the streets leading away from the various docks. Somewhat recently, the ACTV also decided to offer a night service to the public that runs from midnight until five o'clock in the morning. This service consists of three additional lines with consistent pick-up and drop-off times throughout the city.[16]

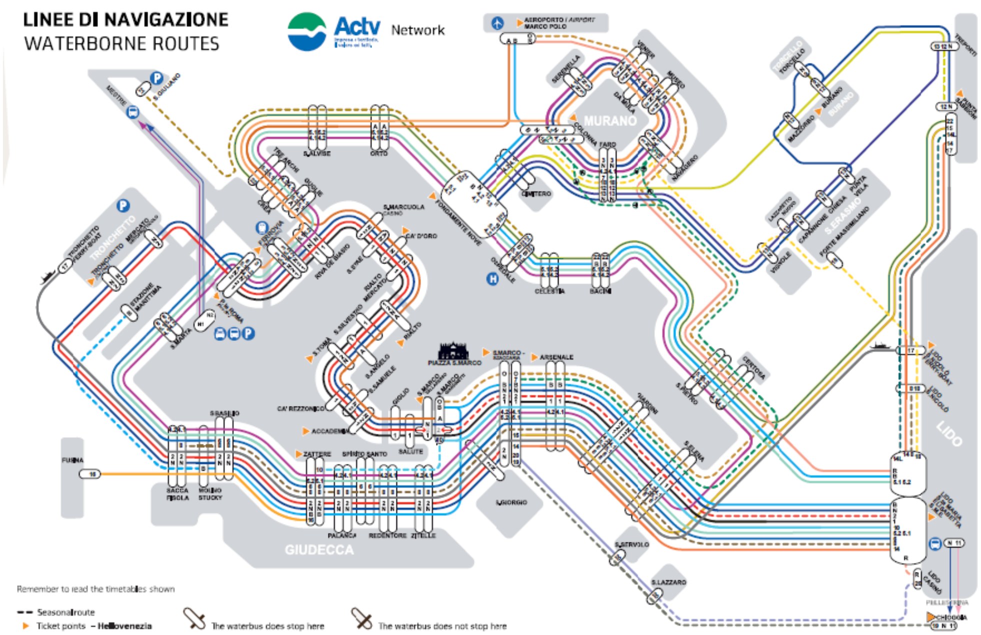


Figure 12: ACTV Boat Route

[15] ACTV
[16] "Actv" 2011

2.3 Pedestrian Systems in Venice

Though built upon a series of islands, Venice is a pedestrian city where streets and bridges are the primary means of getting around. Although some people travel on the canals, the majority traverse the city on foot.

2.3.1 Streets

Figure 13: Street View

Venice is made up of an enormous network of 2,194 streets, and walkways which can be quite small.[17] In the city's original construction, many buildings were built along the edges of the islands, allowing little space for roads. The first roads in Venice were unpaved and turned to mud during rain storms or floods.[18] It wasn't until the 13th century that Venice began to pave its streets with more permanent materials such as brick and stone.[19]

The most well-known streets in Venice are the *fondamenta*, streets that run along the canals and the outer edges of the city. Initially the *fondamenta* were unpaved. However since they bordered the water, these streets would crumble and gradually fill the nearby canals, resulting in the need to dredge. Some of these *fondamenta* were bordered with trees to help prevent erosion. Eventually all of the *fondamenta* were reinforced, giving them their current appearance.[20]

As pedestrian traffic increased in Venice, some of its canals were filled in to form new streets. Since the canals were not planned the same way as streets, some of these newly formed walkways terminated in dead ends, making the city even more confusing to navigate.[21]

In present day, locals and tourists meander through narrow streets that seem unorganized and random in their positioning. Many small streets and bridges connect the islands and cause congestion in highly populated areas. The streets in Venice form an “arterial” network where major streets are interconnected and continuous. Most of the popular tourist

[17] Mobility B11
[18] MoVe B10
[19] Encyclopedia Britannica, 1911
[20] Encyclopedia Britannica
[21] Venice, The Tourist Maze

attractions can be found along this main network of streets. Branching off of these "arteries" are smaller dead-end "capillaries" used mostly by locals within their neighborhoods.[22]

2.3.2 Bridges

Surprisingly, bridges were the last means of pedestrian mobility added in Venice. At first, people simply laid planks over canals to cross them, but these makeshift bridges were never permanent solutions. Similar to paved streets, permanent bridges were not constructed until the 13th century, and by then many roads and islands were completed.[23] Due to this later construction, many bridges connected to the existing streets in odd locations, therefore making intersections even more complicated.

Figure 14: Pontoon Bridge

Spanning the Grand Canal was a particularly infamous endeavor. The Grand Canal varies between 30 and 70 meters across, up to ten times the width of the smaller canals that branch off of it. Since pedestrians needed a way to cross the water, a bridge became necessary. First a makeshift pontoon bridge was constructed across the canal, and was later replaced by a more permanent wooden bridge. However, the wooden bridge eventually collapsed and was replaced by the Ponte di Rialto, the bridge that still stands today. For many years, only one bridge enabled pedestrians to cross the Grand Canal. Today, a total of four bridges span that major waterway.[24]

[22] Marcello Mamoli, Paolo Michieletto, Armando Bazzani, and Bruno Giorgini, "Venice as a Pedestrian City and Tourist Magnet Mass Events and Ordinary Life," *International Forum on Urbanization* (2012): 25-27

[23] MoVe B10

[24] MoVe B10

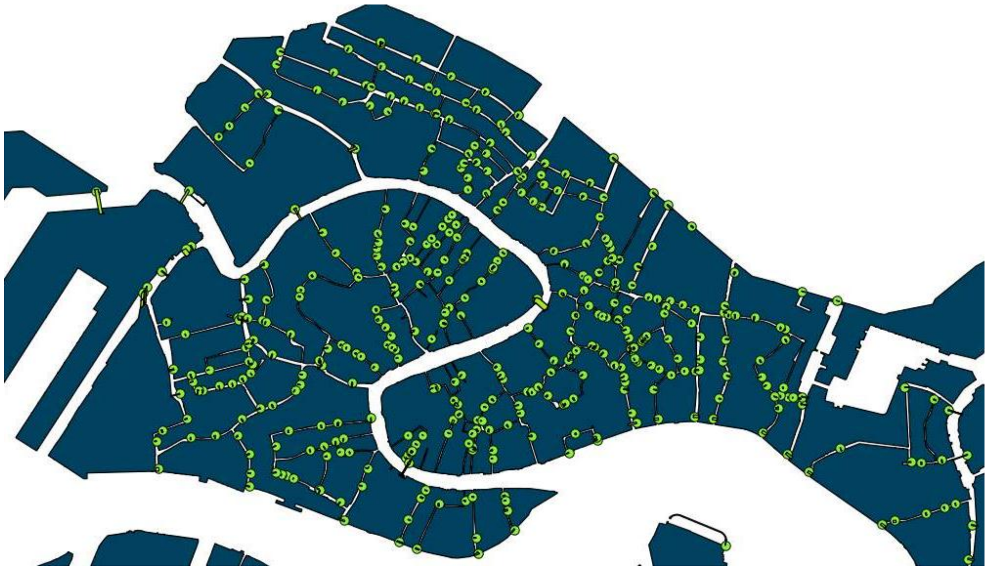


Figure 15: All of the Bridges in Venice

Bridges in Venice were originally built to ease commuting and trading, but now they serve additional purposes in the modern world. As a city built on the water, Venice lacks a solid foundation for pipes and wires. Today, many of the city's bridges contain or support utility pipes and wires, modernizing the ancient city.[25]

2.3.3 Modeling Pedestrian Traffic

A good way to understand the pedestrian movement in the city Venice can be done using autonomous agent based modeling. This system was developed by a 2011 project team and allows for the individual interaction of each agent with their environment. These interactions are based off of programming that determines the agent's tendencies. The agents have starting and ending points on their paths, these points are called nodes. These areas are sources and terminations points of pedestrians. They can be homes, hotels, and places of work, schools, boat stops and other locations. These same locations can also serve as a termination point where an agent's path will end. In addition to nodes there are edges. The edges act as boundaries that the agents stay in during their random travels from node to node. This type of model is helpful in allowing for a bigger picture of mobility in the streets of Venice to be seen. The models are programmed in such a way to allow for their random movement similar to that of pedestrians. Also the programming can be applied to more pedestrians than data has been collected for. This allows for gaps to be filled in based off the patterns used.

[25] Venipedia, Bridges

The model also has some limitations that have not yet been overcome. One is that the model does not currently work interactively with the boat system. When a pedestrian enters or exits the boat system they seem to appear or disappear out of the model. For this model to be comprehensive the paths of the models must include the boat system[26].

2.3.4 Pedestrian Behavior

Many studies have been done on human tendencies when walking. The relationship between stride length and frequency is a very specific and varies from person to person. This relationship can also vary slightly within the individual; however this variation is usually small and any major changes in stride length and frequency are consciously executed.[27] This comfortable stride length and rate ratio requires minimal energy output can be referred to as unrestrained walking. However when a pedestrian does not have enough room to execute continuous unrestrained walking they must consciously alter their stride length, rate, or both. This restrained walking is not as efficient as the preferred walking relationship and causes the body to use more energy.

When waking in an unrestrained environment the relationship between stride length and stride frequency are directly related to one another. This has to do with the swing period in a step. This swing period when the leg is swinging forward before it once again comes back into contract with the ground ahead of the opposite food. The longer a stride that is taken the more momentum the leg will have. This results in the pedestrian naturally increasing his stride rate as well. If they were to reduce the stride rate it would require more energy as the pedestrian would have to fight the momentum of his swing leg. The opposite reasoning explains why a pedestrian would also reduce his stride rate when he reduces his stride length. When the swing period is decreased then the leg gains less momentum and this results in decreased forward propulsion. So naturally when a person decreases their stride length their rate will decrease as well because of the decreased forward momentum. This balance is interrupted in restrain walking situations as the pedestrian must walk within a certain area, limiting the stride length, and at the same rate as the crowd around them not allowing for the proper correlating stride frequency. This makes walking less efficient and puts more stress on a pedestrian's body. It is possible that a pedestrian becomes so constrained that they will no longer continue the forward motion because the stride length possible is so decreased that the increase in energy needed to take does not manifest in enough forward motion. In this case a pedestrian would wait until the

[26] Traversing the Labyrinth B11
[27] Stride variability in human gait

restraint was decreased enough so that the energy was not squandered on such little forward motion[28].

2.4 Pedestrian Congestion in Venice

Various factors multiply the pedestrian density on certain streets contributing to the pedestrian congestion problem. High tides, organized tour groups, and construction can obstruct or divert pedestrian traffic onto already crowded streets.

2.4.1 Tourist Attractions

Venice is a historic city full of beautiful buildings and traditions. As a popular tourist destination, Venice has seen an increase in visitors, and a decrease in residents. The main cause of traffic in Venice is the many tourist attractions it is home to. Many streets are extremely narrow making it difficult for large groups of people to travel to all of the city's incredible structures. "Last year we had 30 million tourists… that's 89,000 per day in a city of 60,000."[29] These numbers show a surge of people in Venice on a daily basis, resulting in increased pedestrian traffic.

Figure 16: Saint Mark's Basilica

Venice is a popular tourist destination, known throughout the world for its incredible architecture and spectacular events. "With a city such as Venice, the buildings take precedence over the people who live in them or work in them."[30] Venice's main attraction is the *Piazza San Marco* (St. Mark's Square). Within St. Mark's Square there are two top tourist

Figure 17: Carnevale

[28] Bonnard, Mireille

[29] Livesay, Christopher

[30] Steves, Rick

attractions: St Mark's Basilica and Doge's Palace. St Mark's Basilica has 8,500 square meters of mosaics covering every surface of the basilica. Its huge-domed ceilings are covered in gold. The main part of the cathedral, for which it is known, is the " 'Pala d'oro,' one of the richest and most precious altars covered with more than 3,000 precious stones and enamel icons inlaid in gold."[31] Doge's Palace is a "masterpiece of Gothic architecture" consisting of three large blocks. Once housing state offices, it is now a public museum.[32] In addition to Piazza San Marco, another notable attraction in Venice is the Rialto Bridge. One of the most famous bridges in Venice, it was the first bridge to span the Grand Canal. These prominent attractions are focal points for most tourists, and therefore create a vast amount of traffic in these parts of the city.

In addition, the popular tourist event of *Carnevale* brings people from around the world to Venice. This Italian version of Mardi Gras has been a tradition since the 14th Century. A hundred years later, it attracted foreigners who brought in a lot of money. Since everyone was required to wear a mask for this celebration, it was difficult to distinguish nobility from the common people, providing entertainment for all. *Carnevale* begins on December 26th, and costumes are allowed until the start of Lent.[33]

Tour Groups not only cause a mobility problem throughout the city, but they also cause an economic problem. Tour groups visit the main attractions of St Mark's Basilica, Doge's Palace, and Rialto Bridge, as well as the "hidden Venice" which helps disperse the tourists and share the history of the city with them. Other highlights include visits to the San Polo districts, the old commerce center, and Casteltto to see *Ponte delle Tette*. In addition to walking tours, boat tours show the palaces and churches along the Grand Canal. The boat tours help eliminate some of the pedestrian traffic, but cause additional boat traffic instead. Visitors cause an economic problem since "many tourists come to Venice on tour buses and spend little to no money on hotels or restaurants."[34] The lack of sufficient tourist income makes it difficult for residents to afford to live in Venice, resulting in the decrease of Venice's native population. The tourists are making it difficult to reach different locations on the island, but are not making use of the sites. In addition, the real estate sector is increasing in cost, contributing to the relocation of Venetians.

[31] "St Marks Basilica."
[32] "Palazzo Ducale."
[33] Giorgi, Sebastiano
[34] Steves, Rick

2.4.2 Impact of High Tide on Pedestrians

Pedestrian congestion severely hampers the mobility of Venetians and tourists walking through the city. At a normal state with an average number of tourists traveling the streets, bottlenecks and pedestrian-traffic jams form on various streets. The environmental effect of flooding increases the congestion of pedestrian mobility.

Tidal flooding is not unfamiliar to Venetian residents who experience it every year during certain seasons. To unknowing tourists, entire streets seem to be transformed into single-file aisles. The Adriatic Sea's tidal cycle will flood many walkways and streets with water at high tide. Tidal extremes are the most significant during the fall and winter months when *acqua alta* (high water) can occur. *Acqua alta* is defined as abnormally high tide where the water rises 140 centimeters above sea level. When the sea level rises greater than 140 cm , more than 54% of the city is flooded.[35]

Figure 18: Pedestrians walking on passarelle

To assist pedestrian mobility even in times of tidal flooding, *passerelle* (temporary wooden walkways) are constructed as raised walkways to allow pedestrians to continue to travel the streets above the high water. Rarely the water rises higher than 120 centimeters, but when it does the *passerelle* may start to float and will no longer be a viable solution to the high

[35] Citta di Venezia. The flooding percentage. 2009

water.[36] In this case, low-lying areas must be avoided or crossed with extra-high waterproof boots.

2.4.3 Impact of Construction on Pedestrians

Since the streets of Venice are considered historic artifacts, each stone is preserved when the street is redone. Each stone is given a number so Insula employees will know exactly where the stones were for correct realignment. Also the distance between the stones is recorded to be able to create an exact replica of each street. In addition, Insula has been raising the height of the streets to decrease flooding. All of this construction can divert pedestrians to other streets causing further congestion.

Venice is a pedestrian city made up of a maze of narrow canals and streets which cause traffic throughout the island. With its richness in historical attributes and Italian culture, Venice attracts a lot of tourists. The tourists double the population causing congestion. The streets and canals were not built to sustain massive amounts of people but rather as a means to quickly travel throughout the island. Since mobility is a serious problem, this project will quantify the number of pedestrians, allowing the Venice Mobility Department to locate the major areas of congestion.

2.5 Previous Mobility Studies on Venice

The team has received information from the Venice Mobility Department as well as past WPI projects. It is important to organize this information in such a way that it is useful and understandable information.

A study was performed by the Venice Mobility Department in 2008. It includes information of counts done on streets and bridges in the city. Also it includes information on flow as well as information from a sound study, correlating traffic and sound volume. The information on pedestrian density and flow was all that the team organized and published on Venipedia.

Several projects have been performed on the mobility of Venice. Starting in 2009 students from WPI have been recording data in Venice on pedestrians mobility. Most of this information has been collected about bridges. The data is generally sporadic so we will have to organize it and determine the best way to publish the data and determine its significance.

[36] ItalyHeaven. Acqua alta: High water and floods. Available

Chapter 3 Methodology

Determining accurate methods in which to quantify pedestrian mobility is integral to the success of this project. The team collected data regarding the movement of tourists and locals through Venetian streets. The databases of pedestrian movement have facilitated the analysis of density studies, as well as representative heat maps. Eventually these deliverables will serve as suggestions to the Venice Mobility Department to improve the current mobility state. Our collected data also will be a platform for future reference when an additional tramline is added to the city.

This project is intended to contribute to the maintenance and modeling of the pedestrian pathways of the city of Venice.

Project Objectives:

1. To gather physical information and historical background about the streets of Venice to support maintenance and modeling.
2. To quantify baseline pedestrian traffic in selected locations to support pedestrian models and allow future comparisons.
3. To determine the maximum capacity of each street to support the pedestrian model in the event of heavy traffic or evacuation.
4. To publish all street data by making it freely available to anyone online.

We hope our project will help to improve the mobility of the city and preserve Venice. A future pedestrian tramline will bring tourists into Piazzale Roma, San Marta and San Basilio altering current traffic patterns. Our project will serve as a valuable baseline to measure the impact of the completed tramline.

3.1 Representing Venetian Street Infrastructure

We created two additional GIS layers that automated the information for us as well as future pedestrian projects. The two layers created contained elements for each segment of the streets in Venice and as well as elements for full entirety of the streets. Specifically, there was a “Segment” layer listed by Street name and segment code as well as a “Street” layer listed by the name of each street.

3.1.1 Representing Street Network

We created the entire street network of Venice by taking preexisting GIS layers and deleting segments. Every street has one line from the beginning to the end of the street. This street layer has data such as length, minimum width, and the surface area of each street in the layer by combing other layers into the newly created layer.

3.1.2 Segmenting Street Network

The segment layer contains line segments for every road. Each segment represents an uninterrupted portion of a street, meaning the portion of the street is not intersected by any other streets or squares. An entire street is made up of one or more street segments depending on how many times it is intersected. When creating this segment layer the team did not include bridges in the segments, rather just the length of the segment of the streets. Creating a layer consisting of each individual street segment was valuable, as pedestrian counts can vary at different points along a street, since pedestrians enter and exit the street at different segments. Studying these counts and segments can allow the determination of the flow of each respective area.

3.2 Quantifying Pedestrian Mobility

Evaluating the Venetian traffic flow through quantitative observation was the first step in analyzing pedestrian congestion. The team has researched the movement of tourists and locals through Venetian streets in various focus areas and at specific peak traffic times during the day. In order to analyze the effects of tourism traffic, a proper method for discerning Venetians and tourists has been formulated.

3.2.1 Focus Areas

The main entrance to the city of Venice is in the district of Santa Croce. Trains and buses from the mainland terminate their routes at Piazzale Roma. Cruise ships dock in the region of Santa Croce as well, adding to the large influx of visitors. This region is highly populated by tourists and has a noticeable traffic congestion problem.

Figure 19: Districts of Venice

After considering the main objectives of this project, the team decided to center the efforts of their counting to the districts of Dorsoduro, Santa Croce, and San Marco. See figure 16. The first two districts, Dorsoduro and Santa Croce, were selected to evaluate traffic in the area prior to the construction of new tramlines that will affect the movement of pedestrians. The third district, San Marco, is a major tourist stop and historic section of the city.

When counting in Santa Croce the team focused on the island Piazzale Roma. We counted pedestrians as they crossed the five bridges that connect the island to the rest of the city. This served as a way for the team to count the amount of tourists that entered the city on foot from the station each day.

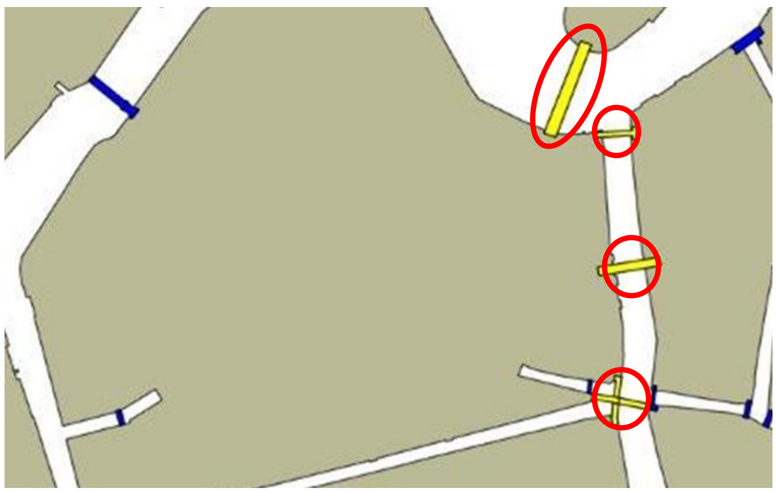


Figure 20: Bridge counted in Piazzale Roma

Currently, Dorsoduro is less frequented by tourists, and mainly accommodates locals on the streets. In this district the team again focused on counting a particular island that the tram station will be located on. Here six different bridges were counted to calculate the number of pedestrians coming into and leaving the island daily. These numbers may be referenced in the future to see the change in the district.

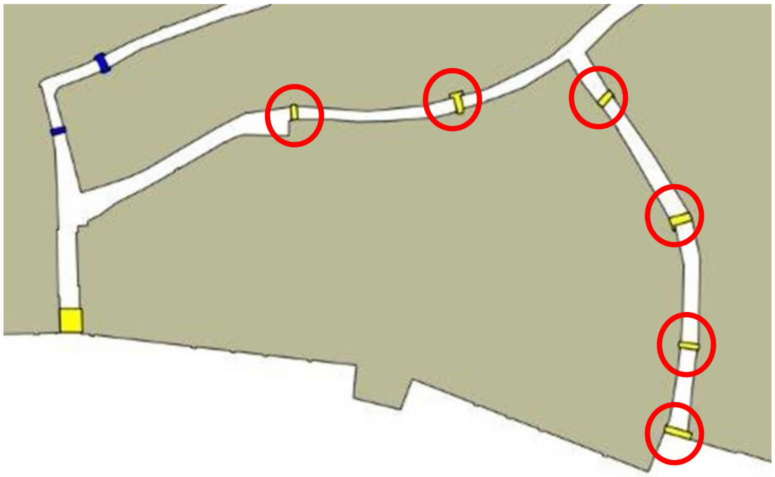


Figure 21: Bridges Counted in Dorsoduro

In San Marco the team counted street intersections. This allowed us to count multiple street segments simultaneously. The team counted pedestrians entering and exiting the intersection from each street. The data collected was useful toward creating a pedestrian model of the city by providing the program with general patterns of pedestrians. The counting in this district was done in conjunction with the Transpostation IQP team in Venice. This team studied the effects of tourist on the local transportation system. We base our time intervals of the ones used by this team determined by a schedule of cruise ships entering and exiting the islands.

Figure 22: Intersections counted in San Marco

We will be counting in San Marco at the high tourist hours which the transportation team has determined to be 9 am to 11 am and 3 to 5pm.

3.2.2 Counting Tools and Methods

Organizing a repeatable and accurate method for quantifying pedestrian traffic is integral to drawing conclusions about the city's mobility issue. The team dedicate much of our time in the beginning of the term to determine the best times and tools for acquiring accurate data.

3.2.2.1 Counting Methodology

To gather the most accurate depiction of Venetian street traffic, the team focused their counting efforts in specific locations.

In order to develop an analysis of pedestrian mobility, the team made several observations about the current traffic flow. The counting components included the number of pedestrians, the direction, and the type of pedestrian traveling on each street. . Each team member was responsible for one direction of traffic flow. They then counted the pedestrians traveling in their directions and used one counter in each had, one counter was used for locals and the other for tourist. For consistency sake young children being carried by adults or pushed in strollers were counted as pedestrians.

Using simple hand counters limits the amount of possible data recorded, but is a reliable counting tool. The results and observations had to be recorded in a field form at the end of a counting interval when using hand counters. The placement of the two field researchers depended on what they were counting, bridge, street segment or intersection. Ideally areas where street members could see the width of the street or bridge were chosen so that they could easily count pedestrians traveling in each direction.

3.2.2.2 Testing the Accuracy of Our Counts

The test to confirm that each team member we counting the pedestrians accurately was done on November 2 in the afternoon. This test was performed on a street in the district of San Marco. The result of each team member can be seen in Figure 23.

Team Member	Difference from 712	Average Percent Error
Alex	14	+2
Erin	7	+.6
Tim	19	-2.8
Melanie	18	+2.55

Figure 23: Counting Accuracy Test Results

3.2.3 Distinguishing Between Locals and Tourists

Another important aspect of that data that we collect was whether or not a person was a local our tourist. It is important to understand how much of the traffic the Venetians are responsible for and likewise the tourists.

3.2.3.1 Method of determining the difference between locals and tourists

In order to analyze pedestrian traffic information, the team had to differentiate between locals and tourists. To accomplish this task, a few different techniques were used. Keen observation is the key to separating the two groups. When watching locals and spending time in areas tourists seldom visit, we were able to observe their typical paths and normal appearance. To analyze characteristics of tourists, we watched passengers departing from cruise ships. Noticing mannerisms is an additional way to determine the differences between locals and tourists. Tourists often look less confident, carry maps, suitcases, and cameras, walk in large groups, and stop at every historical site. Locals most likely walk more briskly and do not stop to look at all of the historical architecture and into all of the stores. In addition, differences can be detected when listening carefully to the languages spoken.

However, some margin of error still existed, as this aspect of our counting is based on our perception. To minimize this source of error, we had conducted various test counts. Each group member tested his or her assumptions by asking every tenth person if they are Venetian for a certain amount of time. We each counted the same area individually, and then compare our numbers and any particular distinctions between tourist and locals we noticed. Unfortunately, it is impossible to completely remove this source of error. The information we collect during this time was not included in our final database, but we did use it to make more accurate judgments and assumptions.

3.2.3.2 Testing the Team's Accuracy

The team also performed a test to make sure that our ability to determine a local from a tourist on a street was fairly accurate. The team performed this test on Friday November 9. The team combined the accuracy of both methods of the test, the video surveillance and asking individuals on the streets to get the accuracy of each member. The accuracy for the street test is in Figure 24.

Team Member	# Correct/40	Percent Error
Alex	32	20
Erin	35	12.5
Tim	37	7.5
Melanie	38	5

Figure 24: Distinguishing between Tourist vs Locals

3.2.5 Determine Count Schedule

To achieve the objectives stated it is important to count during times of maximum foot traffic throughout the day. To determine the counting intervals the team counted for the duration of an entire day, starting at 7am and ending at 7pm. These counts were performed on two weekdays and weekend day in the districts of Santa Croce and Dorsoduro. The purpose of this was to find the time frames of maximum foot traffic on both weekdays and weekends. This also served as a way to prove to us that weekdays are all generally the same while weekend days differ. This kept the team from performing unnecessary counts during our time in Venice. The data collection in San Marco will be determined by the schedule of the cruise ships entering and exiting the city.

3.2.6 Preliminary Counting in Piazzale Roma

Preliminary counting in Piazzale Roma occurred on Campazzo Tre Ponte and Ponte Papadopoli the data gather is displayed in figure 23.

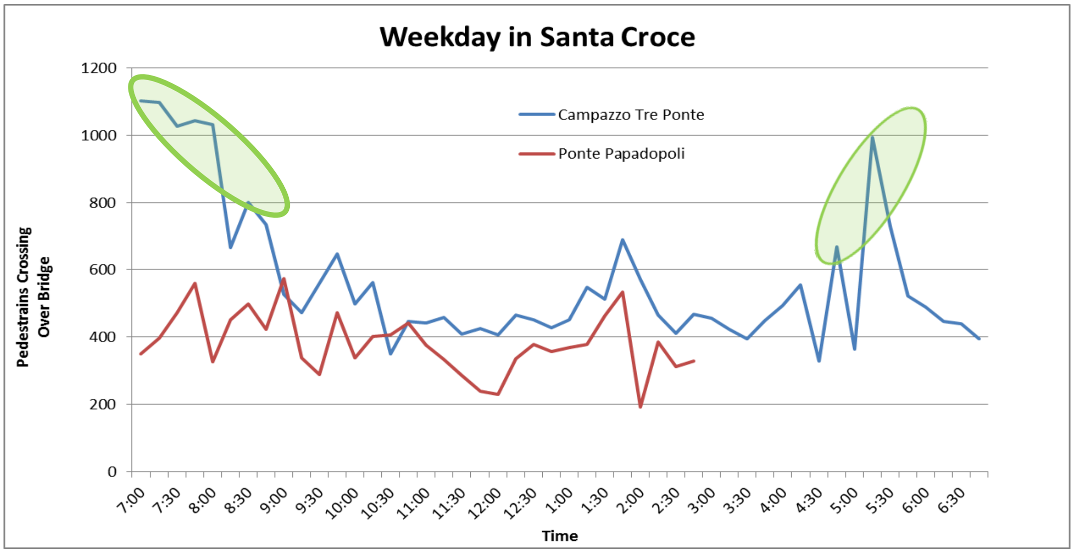


Figure 25: Graph for Counting Weekdays in Santa Croce

This graph is based off the counts that were taken on a Tuesday. There are two clear peaks in this table and they are circled. It is at these times that the highest levels of foot traffic occurred, 7-9am and 5-8 pm. These times reflect the major commuting hours of students and those who are employed in Venice. The influx of pedestrians comes from the bus station on the island as well as San Lucia, the train station located on an adjacent island. We also took time to count on the weekend. The figure 24 below shows the comparison of a weekend morning to a weekday morning. This data shows that the traffic flow is significantly reduced and counting during this time would not be useful for determining maximum traffic entering and exiting the island.

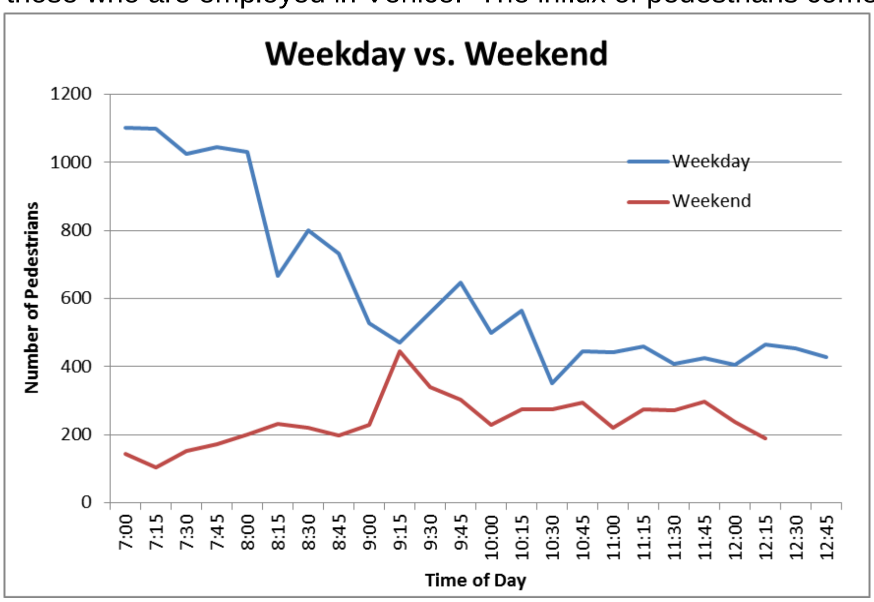


Figure 26: Weekday vs Weekend Comparison at Tre Ponti

3.2.7 Preliminary Counting in San Basilio

Test counts in San Basilio were done on Ponte della Piova on a Thursday. This showed us that the peak times that should be used for counting were 8:00-10:00am and 1:00-2:30pm. The weekend test counts done in San Basilio were very low. The numbers were much too low to produce any data that would be important to our results.

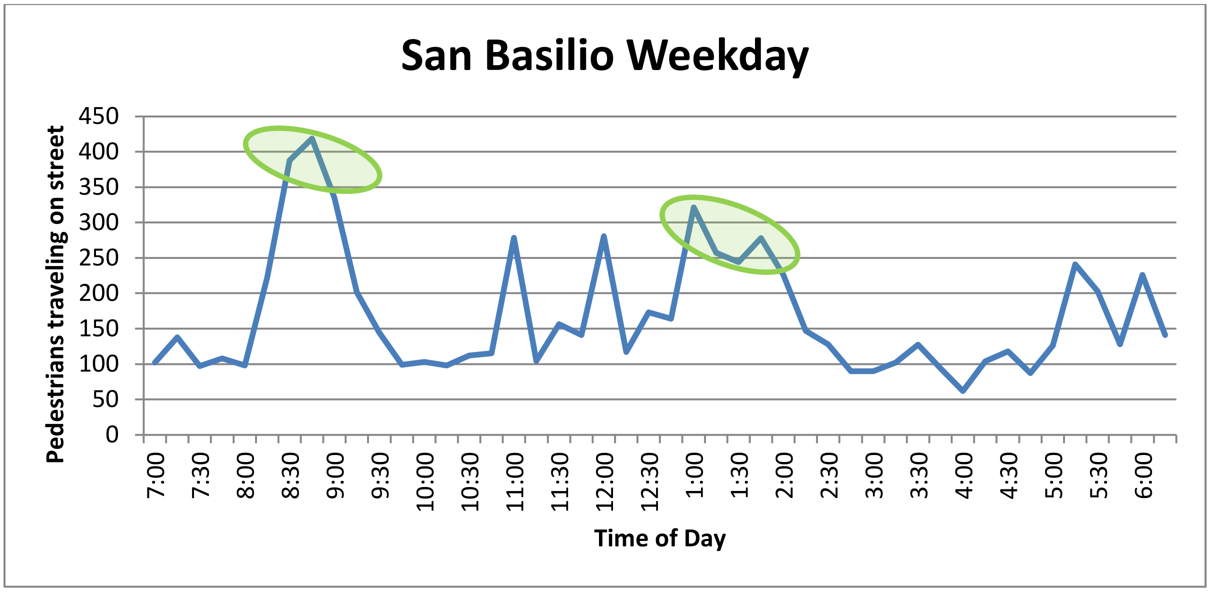


Figure 27: San Basilio Weekday Count

The peak times in this district are reflective of the major commuting times. It is near the University of Venice. The peak in the morning is a result of the students commuting to their classes. The second peak that we see is as a result of students returning to the University after their lunch period or perhaps arriving for afternoon classes. There was no major peak in the second half of the day as student days end at all different times and they leave when their individual classes conclude

3.3 Determining Maximum Capacity

In addition to the physical dimensions of the streets, our team has calculated various aspects for a street's ability to accommodate pedestrians. Analyzing a street as a medium of transportation for pedestrians requires the consideration of the traveling speed of pedestrians rather than only the physical features of a street. Specifically, we divided this analysis into two parts to calculate the maximum capacity of a street.

3.3.1 Physical Capacity

The theoretical capacity of each street we count on can be calculated with a simplified area calculation. Although traffic flow is usually compared to a fluid flowing through pipes, the capacity of a street is directly influenced by the surface area available for pedestrians to walk on top of. Following this area comparison, each pedestrian can be represented by a square portion of the street that they would occupy while walking on the street. One dimension of this square was defined by the shoulder width of the person plus a distance that represents the individual's comfortable personal space. The other dimension was determined by the stride length of the pedestrian. The comfortable personal space for most Venetians is twenty-five centimeters.

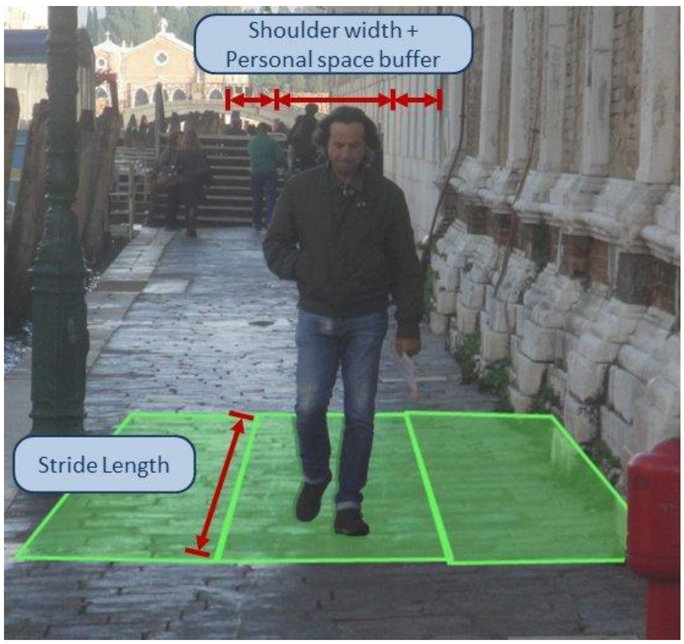


Figure 28: An individual's personal space

In order to calculate the theoretical capacity of the street, the average area a pedestrian occupies was determined by male average shoulder widths and average stride lengths. The average shoulder width for men is 48 centimeters. The average stride length for men is 79 centimeters.[37] The theoretical capacity of the street was calculated by dividing the area of the street by the average area a single pedestrian occupies.

Expanding on the formula to calculate a streets capacity, the flow rate of pedestrians walking down a street can be determined. Two different flows have been calculated; one being the average walking pace down a uncongested street and another being the flow of a high

[37] Murray, M.P.

volume area where pedestrians' strides are much smaller and the speed is slower. This number was calculated based on the average walking speed of a pedestrian of 4 ft/sec.[38] The flow of a highly congested area can be used in the event of an emergency to determine evacuation routes. These streets must be able to handle the volume of pedestrians exiting the city as well as allowing pedestrians to vacate at an efficient speed.

3.3.2 Determining Critical Pedestrian Density

Maximum walking capacity is the most simplistic way of quantifying the limit of pedestrians the streets of Venice can contain. Unfortunately pedestrians do not move in continuous flows and are affected by the street geometry.

After performing many counts at bridges and intersections the team noticed that abrupt reductions in the street width also known as bottlenecks caused the most amount of congestion for pedestrians commuting along the streets. Major bottlenecks were usually caused by the following examples: A wide street ending at a narrow bridge, a square funneling to a small exit street, as well as wide streets simply reducing their width because of a building or canal.

At bottleneck areas the flow of pedestrians is constricted and therefore, pedestrians pack closer together trying to get past the bottleneck area. When the pedestrians pack closer together, the density of pedestrians increases. What is the upper limit to this density increase? Will it get to the point where the density increases so greatly that the street becomes a gridlock?

Conclusively the team discovered a more accurate measure of a streets maximum capacity. To determine this critical density, we return to the space a single human occupies. When pedestrians are packed closer together, there personal space decreases as well as the space allowance for each pedestrian's stride.

[38] "A Hisotory of Pedestrian Signal Walking Speed Assumption

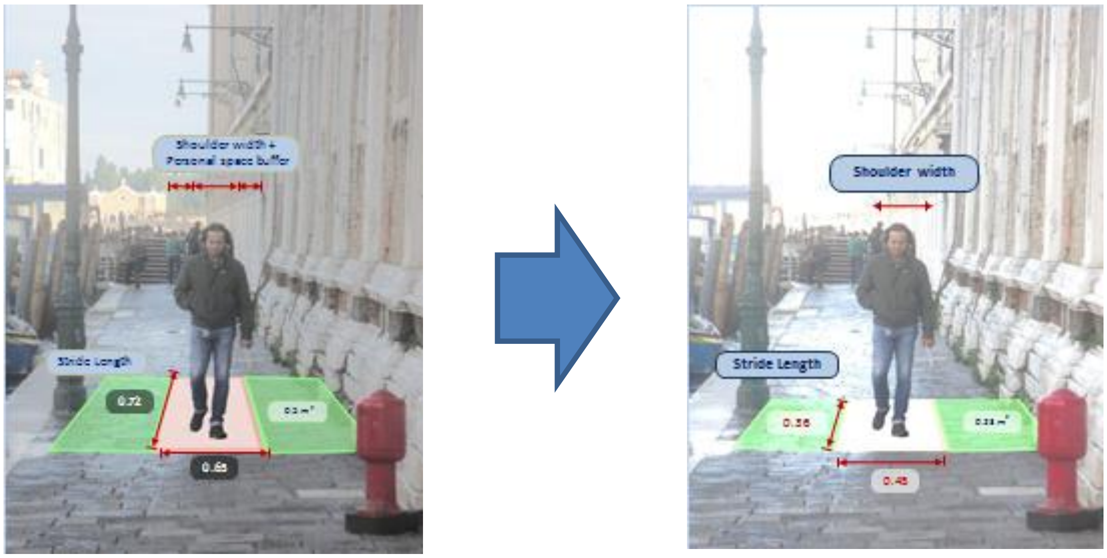


Figure 29: Difference between Walking Capacity and Critical Density

In the second graphic is this area a single pedestrian occupies at the critical density. In other words, if the area for a single pedestrian was any smaller, the street would reach a state of gridlock. The dimensions of the pedestrian's personal area at critical density are determined by his shoulder width and half of his stride length.

Humans exhibit a range of stride lengths while walking with other individuals on a street. At the bottom end of this range is one's minimal stride length. Humans have a natural tendency not to make any movement forward unless they visually perceive there to be enough room for a full step. We estimated the average minimum step distance to be half of the stride length. Therefore the critical density occurs when each pedestrian has only enough space for their shoulder width and half of their stride. When one individual occupies .162 square meters, the density at this critical spacing is 6.1 people per square meter.

Figure 30: Pedestrian's Shoulder Width and Shorten Stride

3.3.2 Bottleneck Behavior Equation

Now that we have a number for the critical density of pedestrians trying to transverse the bottleneck of a street, bridge, or square a relation between the density of pedestrians and the bottleneck width. To more accurately quantify congestion and determine this relationship, the team created a simplified bottleneck equation.

$$\rho := \frac{(\beta_b + \beta_q)\cdot\eta - \left(\frac{\beta_b}{S_w}\right)}{\frac{(\beta_b + \beta_q)}{\beta_b}\cdot t\cdot S_L\cdot(\beta_b + \beta_q)} \qquad \rho := \frac{[(\text{street Width}) * \text{Rows}] - (\text{Bottleneck flow})}{(\text{Bottleneck ratio}) * \text{Time} * \text{Stride} * (\text{street width})}$$

Figure 31: Bottleneck Equation

To explain how this equation works, it is best to imagine each pedestrian as a block of area (similar to the area determined as the critical density area).

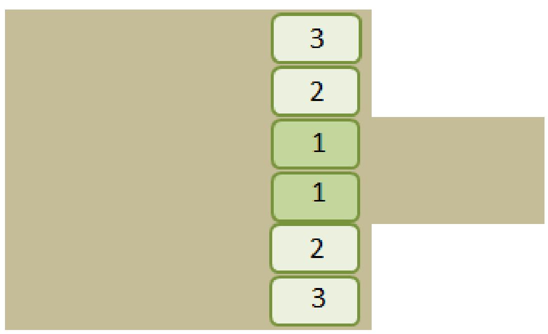


Figure 32: Bottleneck Equation Explanation

In this example, a street ends in a narrow bridge and therefore creates a bottleneck. The street is wide enough to contain 6 people across in one row. When this single row approaches the bottleneck, the width of the bridge can only allow 2 pedestrians to cross at a time. Therefore, the rest of the pedestrians in that row have to wait until other pedestrians have crossed the bridge before they themselves can cross.

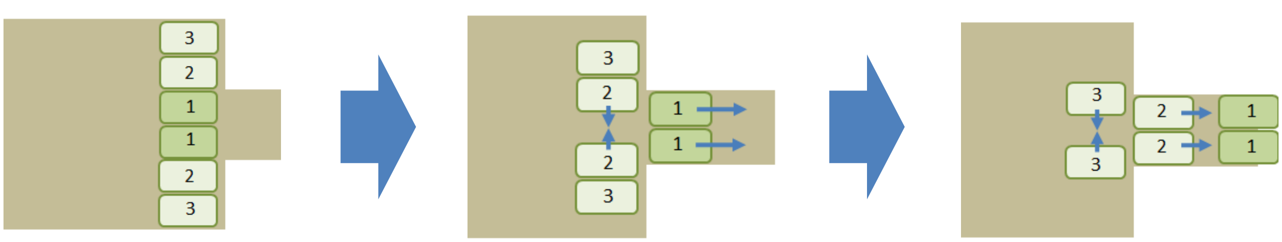
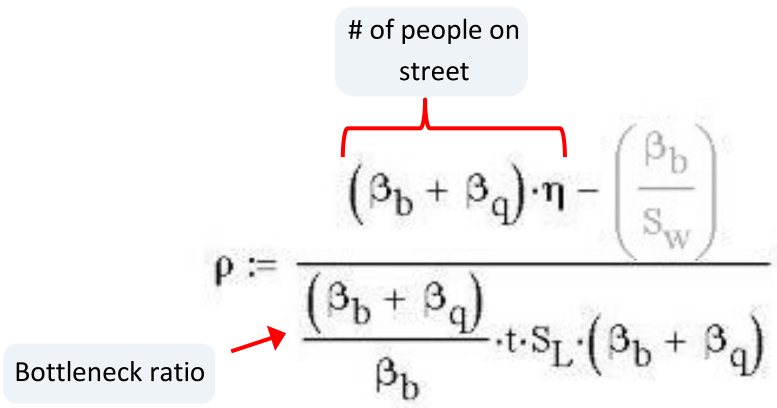


Figure 33: Explanation of a Bottleneck

This creates a time delay where the pedestrians on the outer most portion of the street must wait before crossing the bridge. Clearly this time delay is directly proportional to the ratio of the street width to bottleneck width. This time delay increases as the number of rows of pedestrians increases.

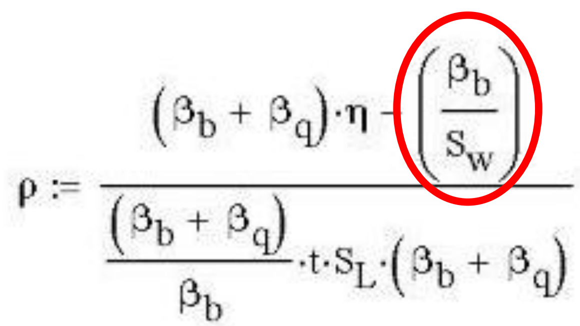
The equation now has the number of people on the street (number of people wide by the number of rows) divided by the ratio of street width and bottleneck width (the factor that determines the time delay.



$$\rho := \frac{(\beta_b + \beta_q)\cdot\eta - \left(\frac{\beta_b}{S_w}\right)}{\frac{(\beta_b + \beta_q)}{\beta_b}\cdot t\cdot S_L\cdot(\beta_b + \beta_q)}$$

Figure 34: Bottleneck Equation Description

Finally, for each time delay the original pedestrians that fit on the bottleneck cross the bridge and leave the area. Therefore the equation needs a term to account for pedestrians leaving at a slower rate than entering.



$$\rho := \frac{(\beta_b + \beta_q)\cdot\eta - \left(\frac{\beta_b}{S_w}\right)}{\frac{(\beta_b + \beta_q)}{\beta_b}\cdot t\cdot S_L\cdot(\beta_b + \beta_q)}$$

Figure 35: Bottleneck Equation Flow Rate Variable

This term subtracts the number of pedestrians leaving the bottleneck area for each row entering the bottleneck area.

There are many factors that affect traffic flow that are significantly more complicated than we could account for in our equation. The following is a list of assumptions that the team established in order to simplify the calculations. The team assumed that the traffic flowing from the wide street to the bridge was all flowing in the same direction. Each pedestrian was confined to the established area rectangle defined by shoulder width and stride length and pedestrians would not overlap between rows. Each pedestrian was moving at roughly 4 feet per second.[39] It was assumed that twenty-five percent of the daily tourists to enter the city were residential tourists.[40]

3.4. Publishing Pedestrian Information

In order to create the complete and comprehensive database we seek, all of our collected data had to be properly organized, as all our Venipedia pages were generated from this source.

Given the nature of our numerical data, the majority of our information was organized into spreadsheets. This format was used to fill existing Venipedia templates, and enabled us to organize our information into set categories. Spreadsheets were then uploaded to the internet and inserted into our Venipedia pages to create comprehensive data fields.

To upload our spreadsheets to Venipedia, we used an online tool called CityKnowledge. This functions as a database manager that automatically creates web pages when supplied with a spreadsheet containing the necessary information. Each row of the spreadsheet is separated into its own page, and then various fields within each page are filled in using the data in each column. Then, the user is given a template which can be rearranged to best display the given information, and once this is complete, the CityKnowledge console will then create the pages automatically. This allowed us to create a page for each street and segment in Venice without having to hand-craft thousands of pages that all contain the same data fields.

[39] Manual of Uniform Traffic Control Devices
[40] Bahlatzis

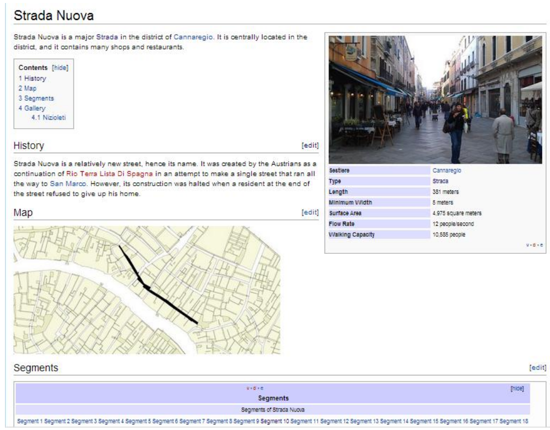
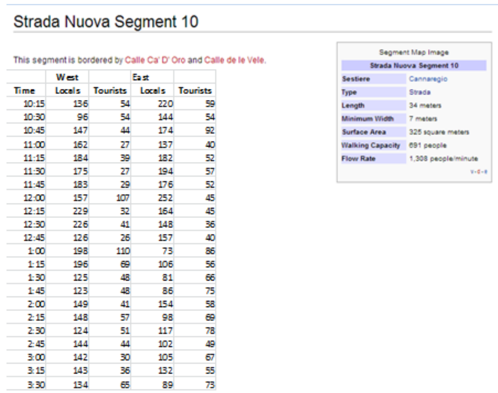


Figure 36: Venipedia Page

In addition to the information gathered by the team in the field and through GIS, we also gathered and organized information from the projects conducted in 2009, 2010, and 2011 by WPI students. We took the field counts produced by these teams and added them to the information in the Venipedia pages. We also included information provided by the Venice Mobility Department which includes a data base of roughly 250 streets that they performed a study on in 2008.

Each street page contains a section for historical and physical information gathered from GIS layers and a book by Tassini. This information includes the meaning of the street's name, its dimensions such as the length, minimum width, average width, and surface area. The technical data is displayed in the page's information box along with a street view image.

Each street that is counted is given segment pages in addition to its main page. A new street segment begins every time the street is intersected by another street. Additional sub-segment pages may also exist if a segment contains a boat stop. Segment pages contain information similar to the overall street page, but it is specific to the segment rather than to the street as a whole. These pages have sections to include pedestrian traffic data for the segment.



Strada Nuova Segment 10

This segment is bordered by Calle Ca' D' Oro and Calle de le Vele.

	West		East	
Time	Locals	Tourists	Locals	Tourists
10:15	136	54	220	59
10:30	96	54	144	54
10:45	147	44	174	92
11:00	162	27	137	40
11:15	184	39	182	52
11:30	175	27	194	57
11:45	183	29	176	52
12:00	157	107	252	45
12:15	229	32	164	45
12:30	226	41	148	36
12:45	126	26	157	40
1:00	198	110	73	86
1:15	196	69	106	56
1:30	125	48	81	66
1:45	123	48	86	75
2:00	149	41	154	58
2:15	148	57	98	69
2:30	124	51	117	78
2:45	144	44	102	49
3:00	142	30	105	67
3:15	143	36	132	55
3:30	134	65	89	73

Segment Map Image

Strada Nuova Segment 10	
Sestiere	Cannaregio
Type	Strada
Length	34 meters
Minimum Width	7 meters
Surface Area	325 square meters
Walking Capacity	691 people
Flow Rate	1,308 people/minute

v·d·e

Figure 37: Venipedia Segment Page

Several bridge pages already exist on Venipedia, but they do not contain the mobility data. As we collected data for several bridges throughout the city, specifically those at Piazzale Roma and San Basilio, we added our new information. Similar to street pages, bridge pages contain historical and physical information such as length, width and history, as well as some information specific to bridges such as height and the duration of its construction. The primary information we added consisted of pedestrian counts for both directions as well as the counts the Venice Mobility Department have collected.

Chapter 4: Venetian Pedestrian Infrastructure

The team created two additional GIS layers that automated physical street information for our analyses and for future pedestrian projects. The two layers created contained elements for the full entirety of each street as well as street segments of each particular street in Venice. Specifically, these layers were titled a “Street” layer listed by the name of each street, and a “Segment” layer listed by Street name followed by a segment code.

4.1 Complete Street Network

The full streets layer contains every street in Venice except for the streets on Guidecca. These line segments contain the length of each street as well as information on the minimum width and surface area of the street. This layer will directly supply Venipedia with the physical information of each street.

Figure 38: The Entire Street in GIS

4.2 Segmented Street Network

The segment layer contains line segments for each uninterrupted section of road within specific streets. A segment is a portion of a street broken up by intersections side streets and squares. Looking at Figure 30 are various examples of street segments. A full street is made up one or more street segments depending on how many other divide the pathway. Creating a layer consisting of each individual street segment is valuable, as pedestrian counts can vary at different points along a street when pedestrians enter and exit the street through side streets.

Studying each individual segment will allow us to determine the flow for street segments and allow us to determine the most congested intersections.

Figure 39: Street Segments in GIS

4.3 Pedestrian Network Recommendations

The 2012 Streets team created two new GIS layers that now contain the length of every street and street segment in Venice. These two layers as well as many others are available to future teams as invaluable resources the city's infrastructure. However there are some errors contained in the team's created layers. Several of the layers have duplicate streets or miss-spellings that detract from the information available. In addition there are several streets whose names are represented only by asterisks. A future team should verify the asterisks and attempt to determine their names for proper labeling.

4.3.1 Bottleneck Location Layer

In addition to updating and editing the database another interesting and useful layer that could be created by a future team to identify bottleneck locations on certain streets. This layer could be defined based on a certain ratio of street with to bottleneck width and then located on a map. Ideally this information would aid in trying to locate congested areas in the city. The bottlenecks could be located by a specific latitude and longitude position on the street.

4.3.2 Street Classification Layer

Additional layers that could be created that could be of interest and helpful to group in the future would be to create separate layers that contained on certain street types such as a calle layer, fondamenta layer, salizada layer etc. As well as containing an interesting comparison of the types of streets, this layer would also reveal which streets are the most common in the city. Each of these streets are categorized for different reasons, some however have tendencies to be longer or wider than others, such as fondamentas running along long canals. For this reason, these layers could prove helpful to future teams.

Additionally, the street layer will contain line segments for the entire length of the street. Essentially, the street layer will possess one element that is the sum of a street's segments. This layer will contain general information about the street as a whole such as overall length, but will not include pedestrian mobility measurements.

Creating a database within GIS allows this information to interact with other geo-located data and allows future project teams with a more comprehensive assessment of the streets in Venice.

Chapter 5 Collected Data

5.1. Previous Data

Many groups in the past have done studies on the pedestrian mobility in Venice. Groups from WPI and the Venice Mobility Department have spent time collecting data on the streets of Venice. It is important that this data is organize to that it may be easily understood and used in the future.

5.1.1 Venice Mobility Department Bridge Counts

The Venice Mobility Department collected data at the main entrances of the city: San Lucia and Piazzale Roma. They also calculated the density of the city's main arteries which reveals locations of the highest congestion. The department's data was published on Venipedia as well as was used to analyze our data counts to show the increase of tourism over the years. The pedestrian density on the main streets was incorporated to the model to have the dots cluster in those particular areas.

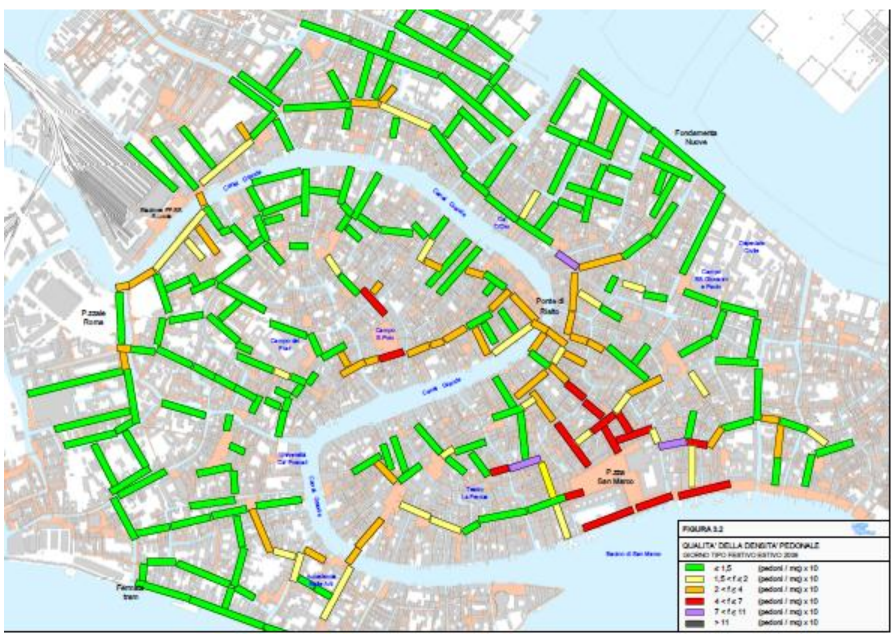


Figure 40: Venice Mobility Department's Pedestrian Density of Main Arteries

5.1.2 Previous Project Bridge Counts

We gathered all of the data from previous Worcester Polytechnic Institute (WPI) groups. We combined the WPI data to simplify analysis for future groups to use their data and update the model as well as compare their data to our data. We complied bridge counts from the students from 2009 to 2011. These counts will show how tourism has increased over the years as well as show the increase in congestion on the streets and bridges. The streets and bridges have not increased in size so this data is comparable to ours.

Figure 41: WPI Past Projects

5.2 Piazzale Roma

After determining the time intervals to count on the island the team returned to count at the four main bridges to determine how many people entered and exited the city during a weekday and distinguished how many of them were tourists or locals. The counts are displayed as people leaving the island departing into the rest of the city and those coming into the island. We did not include the data for the fifth bridge as the traffic on this bridge was negligible compared to the remaining bridges.

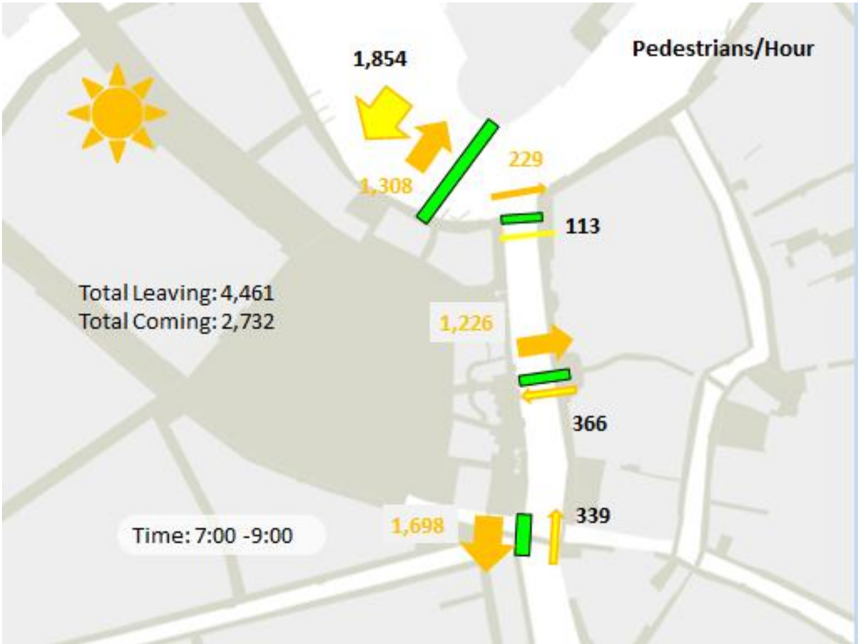


Figure 42: Morning Results in Piazzale Roma

As expected significantly more people left the island in the morning rather as opposed to entering it. The only bridge that didn't follow this pattern was Ponte della Calatrava. The reasoned that this is a result of the bridges proximity to the train station on the adjacent island. Many students and commuters use the train to enter the city each day and then cross over the Ponte della Calatrava and travel through the island and exit over one of the other bridges. In a student's case, they would exit the island on the opposite side to get to the University of Venice. With the exception of Ponte della Calatrava the data collected by the team was predictable at this time.

The counts performed at night for Piazzale Roma re displayed in figure 26 in the same manner as the morning counts. The data collected at this time was the opposite of the morning, with far more pedestrians entering the island to go to the bus station, parking deck, or other ways out of the city.

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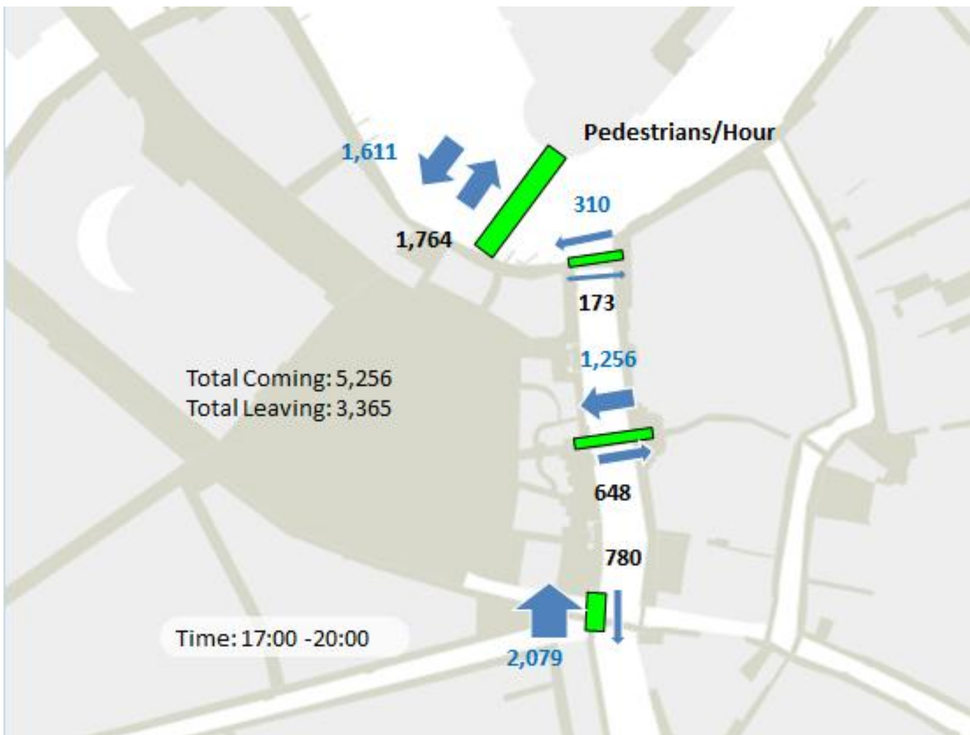


Figure 43: Piazzale Roma Counts at night

Far more pedestrians entered the island than exited during this counting period. Once again the exception to the rule was Ponte della Costituzione, once again this was contributed to its proximity to the train station.

Another important aspect of the teams counting was the number of locals and tourists entering and exiting the areas. Displayed in Figure 27, as the total number for both counting periods, it is apparent that a majority of pedestrians were locals in this area. This is not surprising due to the time that we were counting in addition to the location. Few tourists are awake at this time in the morning, never the less traveling on this particular island. In addition this area is mainly used as a transportation hub for locals to going to their jobs and classes. It is far removed from the historic center of the city and is far out of the way of most tourist attractions.

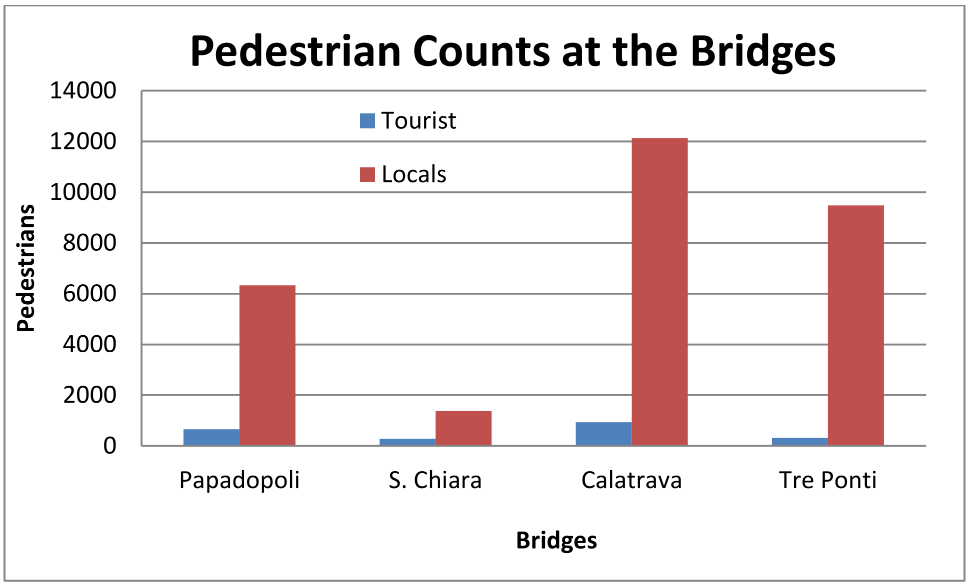


Figure 44: Tourist vs Local counts at each bridge in Santa Croce

5.3 San Basilio

The counts performed on this island were mainly to provide a baseline to compare traffic after the new tramline is installed. This island is not a major source of pedestrian traffic, however in the future the new tram stop could become a major source of pedestrians. Due to the limitation of team members we were only able to count four of the six bridges at any one time. The team wanted to make sure that we counted the bridges that would have the most pedestrians. We determined which bridge to use off of their location as well as proximity to one another. In the case that two or three bridges were very close to one another we would put only one team member near on one bridge in the cluster. The bridges that the team counted on were Ponte Lungo, Ponte San Basegio, Ponte della Piova, and Ponte della Maddalena. (see Figure 36)

The counts in the morning were not extraordinary for any single bridge however in comparison to the other times throughout the day the numbers were larger. In the morning most of the pedestrians were entering the island over bridges. Each bridge, with only one time interval exception, had more pedestrians entering the island rather than exiting. This is easily explained by the trend of the pedestrians, the great majority of them being students, walking to class.

Figure 45: San Basilio Morning Counts

The counts taken again at 13:00 were again similar to those in the morning session. The majority of pedestrians were students who once again entered the island after going to lunch. Every time interval on each bridge showed more pedestrians entering the island than exiting. Two of the bridges both had one time interval outlier in which the number of pedestrians was just slight higher than those exiting (less than ten).

Figure 46: San Basilio Mid-Day Counts

The majority of the pedestrians on this island were all students. There were minimal to no tourist when we were taking our counts. This is mainly explained by the location of the bridges. This island is further southwest of all the major historic attractions of the city as well as all major transportation hubs of the city.

The team believes that in the future the number of pedestrians on these bridges will increase. It is likely that the traffic will increase in the opposite direction that the majority it now flows. This is because people who work in the city and other commuters will be able to use this tramline to travel further south into the city than the current stop in Piazzale Roma. This stop will allow students to ride right to the university decreasing the traffic entering the island. More people who work in the city can use the stop to get closer to their work place and then will exit the island.

5.4 San Marco Intersections

Intersections in the district San Marco were chosen because they provided additional data for a preexisting model that demonstrates pedestrian traffic throughout the Saint Mark area. The three intersections chosen were Santo Stefano, San Salvador, and San Bortolomio. The methodology behind the selection of these three intersections was that their connection of main artery roads and proximity to the tourist areas of the island. Due to the fact that there were only four team members and eight directions at an intersection, each team member counted one street and only recorded directional flow of the pedestrians. We picked the highly populated entrance points of the square and placed a team member at each one. The time intervals that were chosen for these intersections were 11:00 to 13:00 and 15:00 to 17:00. These are peak times for when tourists are out and walking around the city.

5.4.1 Santo Stefano

Santo Stefano is an intersection close to Academia major streets connecting Rialto and Saint Mark's. Comparing the number of pedestrians entering the square shows that most of the pedestrians entered from Rialto and the exit toward Academia. The three main entrance points are Calle San Stefano, Calle Spenzier, and Campo San Vidal. The higher number of pedestrians on certain streets denoted them as arteries or primary streets. However, the side entrance, Calle Botteghe, is a secondary street which is an alternative route that locals would know to take if the main arteries were more congested.

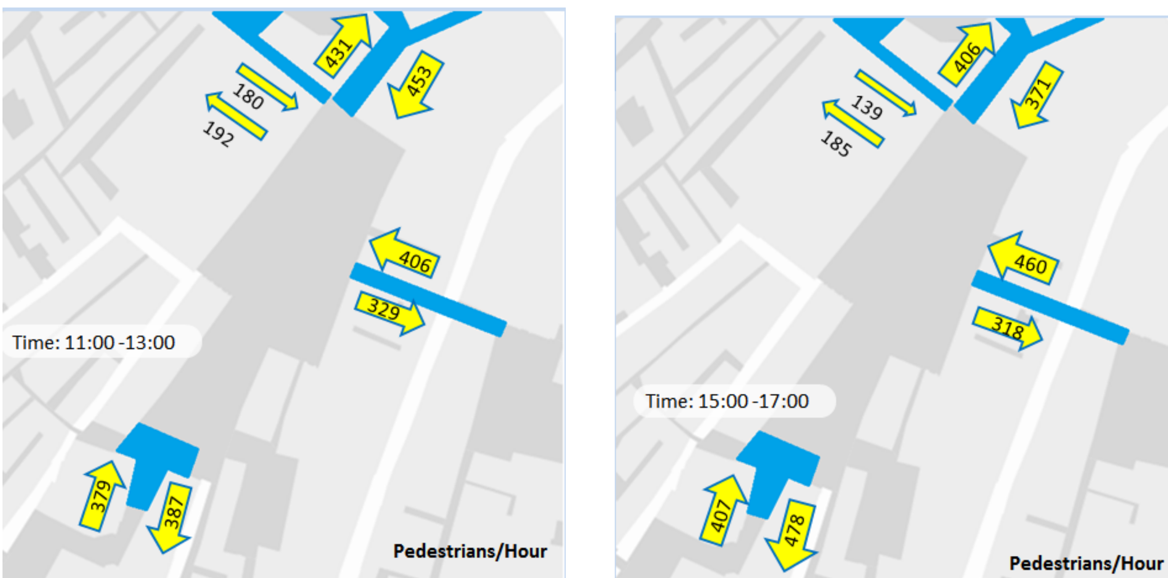


Figure 47: Santo Stefano Pedestrian Counts in the Morning and Afternoon

5.4.2 San Salvador

San Salvador is a large intersection due to its connection of two major arteries. This square connects the main route from Rialto to Saint Mark's Square as well the route leading to Academia. The three main entrance points are Marzaria Due Aprile, Marzaria S. Salvador, and Calle de Lovo. These streets have a significantly higher number of pedestrians than Calle Larga Mazzini. Primarily this is due to the fact that Calle Larga Mazzini is a secondary street and is an alternative route to the Rialto Bridge. These streets create more of a bottleneck than Santo Stefano because their widths are smaller as well as the flow of pedestrians has increased. This will appear on the model by drawing more pedestrians to this area.

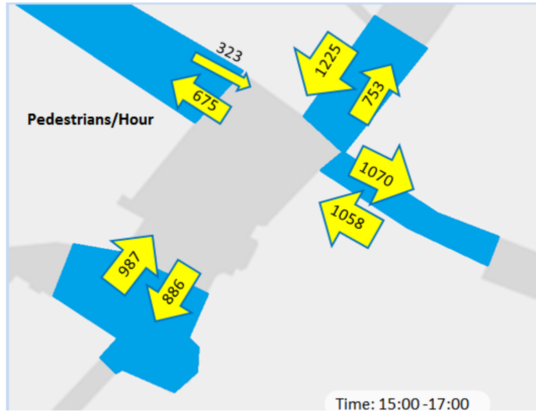


Figure 48: San Salvador Morning and Afternoon Pedestrian Counts

5.4.3 San Bortolomio

San Bortolomio is the intersection connected directly to the Rialto Bridge in the district of San Marco. It has multiple entrance points. There are three main entrance points as well as multiple secondary exit points. The main arteries to this intersection are Salizada da Pio X, Salizada del Fontego dei Tedes, and Marzaria Due Aprile. This intersection has multiple exits and is fairly wide to help mitigate congestion. The numbers of people entering and exiting at each point of this intersection are relatively similar. The maximum number of pedestrians entering and exiting the square are entering from Salizada del Fontego dei Tedes, which is interesting considering that direction is leads toward Strada Nuova, not Rialto or Saint Mark's which are the major tourist attractions. This is probably because it is not the main tourist season when we counted meaning it is mostly locals here.

Figure 49: San Bortolomio Morning and Afternoon Counts

All of the data from these three intersections was put into the pedestrian model that was created last year. This data will help improve its accuracy as well as tell the dots where to go more specifically besides just going back and forth. The dots are attracted to different spots depending on how many people we have counted go there and determine a ratio for all of our counts.

5.5 Recommendations: Continuing Quantifying Pedestrians

The pedestrian counts for this project aimed toward achieving two main goals: creating a baseline of pedestrians traffic in future tram locations, and collected addition data in the district of San Marco.

5.5.1 Counting in San Basilio

During out time in Venice we were able to complete counts at the future tram stop locations of Piazzale Roma and San Basilio. It is imperative for a team to take counts at the third remaining stop Santa Marta. Although the traffic on this island is currently low and therefore not a source of pedestrians, without data to prove its current state it will be impossible to determine the tramline's impact on the island and surrounding area. The counting intervals used should be similar to those that the 2012 team used. The island has only five bridges leading to it, so counting to complete this task would not occupy much of a future team's time.

5.5.2 Gather Data post-Tram Installation

After the tramline is completed, roughly around the year 2015, it will be important that a future team returns to the newly instated tram stops and count the flow of pedestrians on and off the islands by counting the same bridges. It will be necessary that the counts last an entire work day (roughly 7am-8pm), in order to observe the flow of pedestrians in and out of the islands as well as any unexpected fluctuations throughout the day.

Ideally, if the tram began functioning during the months that WPI students are in the city, the team would be able to see how quickly commuters adapted to using the tram. It would be interesting to know if a large percentage of pedestrians used the tram, or if many pedestrians preferred to continue their previous walking commute. Teams should continue to count at the same locations to see if the use of the tramline increases or decreases over the time. This would allow the Venice Mobility to see if the use of the tramline increases or decreases pedestrian congestion.

***5.5.3* Ridership on the Tramline**

It would also be important for a transportation focused team to perform a study on the tramlines movement of pedestrians. Existing as a single line and three stops the ridership tramline study would be rather simple. Team members could either post themselves at the tram stops to count pedestrians entering or exiting the line, or ride the train and count the riders per trip. The time of day when these counts occurred should be similar to the 2012 Streets team's commuting hours. However, these times would also be dependent on the tram schedule and frequency of trains.

5.5.4 Future Model Support

Continued counting at intersections and bridges of the island are imperative for the continuing progress and accuracy of the pedestrian model. In the future counts should be once again performed in the intersections of arterial streets in the district. It would also be ideal to continue to count bridges in specific districts as a means of understanding pedestrian flow.

To increase the accuracy of the model a counting team should track pedestrian paths across intersections. Labeling routes and recording the number of pedestrians that follow each route would eliminate some of the random assignments agents take on paths in the pedestrian model.

5.5.5 Pedestrian Flow Throughout the Island

The pedestrian flow of Venice is best understood by counting people as they move from island to island. This allows for a bigger picture of pedestrian movement rather than the specifics of certain streets alone. There are also far less islands in the city than streets. Using an island method would allow for quicker data collections. When completed, the data would still be an accurate in display pedestrian movement throughout the city. The amount of time it would take to complete pedestrian counts on every street versus movement between every island is significantly more. With only slightly more than 200 islands this study could be completed in only a few years.

Chapter 6 Pedestrian Network Carry Capacity

6.1 Physical Capacity

After successfully creating two new geospatial GIS map layers, and organizing our pedestrian counts, we can use both of these as tools to better understand current pedestrian congestion. Tourism is increasing each year in particular during the peak tourism months of the summer. The number of tourists navigating the city increases well above average. Is there a way to estimate how many pedestrians these pathways will be able to support in the future?

Paolo Costa estimated the carrying capacity of the city of Venice would reach its maximum at 22,500 people.[41] Referencing our earlier figures, Venice has already exceeded this capacity. Costa did compute this number based on several factors including accommodations and public services.

6.1.1 Physical Walking Capacity

To simplify this complex problem significantly, we can focus purely on a physical capacity. Looking at the size of a street we can determine a limit or maximum capacity where there would be so many pedestrians that any increase in density would result in immediate gridlock.

Figure 50: Walking Capacity Man

Using our figure for the physical space that a single pedestrian occupies, previously determined in our methodology, the maximum number of people who can instantaneously fit on a street while walking will be referred to as the maximum walking capacity. For example, selecting a fairly large street such as Strada Nuova, we extract the physical dimensions of the street from the GIS map layers that we have created. For Strada Nuova the surface area is 4,975 square meters. Dividing the surface area by an individual's personal walking space, 10,585

[41] Canestrelli

pedestrians can fit on the entirety of Strada Nuova.

6.1.2 Critical Pedestrian Density

Maximum walking capacity is the most simplistic way of quantifying the limit of pedestrians the streets of Venice can contain. Unfortunately pedestrians do not move in continuous flows and are affected by the street geometry.

After performing many counts at bridges and intersections the team noticed that abrupt reductions in the street width also known as bottlenecks caused the most amount of congestion for pedestrians commuting along the streets. Major bottlenecks were usually caused by the following examples: A wide street ending at a narrow bridge, a square funneling to a small exit street, as well as wide streets simply reducing their width because of a building or canal.

At bottleneck areas the flow of pedestrians is constricted and therefore, pedestrians pack closer together trying to get past the bottleneck area. When the pedestrians pack closer together, the density of pedestrians increases. What is the upper limit to this density increase? Will it get to the point where the density increases so greatly that the street becomes a gridlock?

Conclusively the team discovered a more accurate measure of a streets maximum capacity. To determine this critical density, we return to the space a single human occupies. When pedestrians are packed closer together, there personal space decreases as well as the space allowance for each pedestrian’s stride.

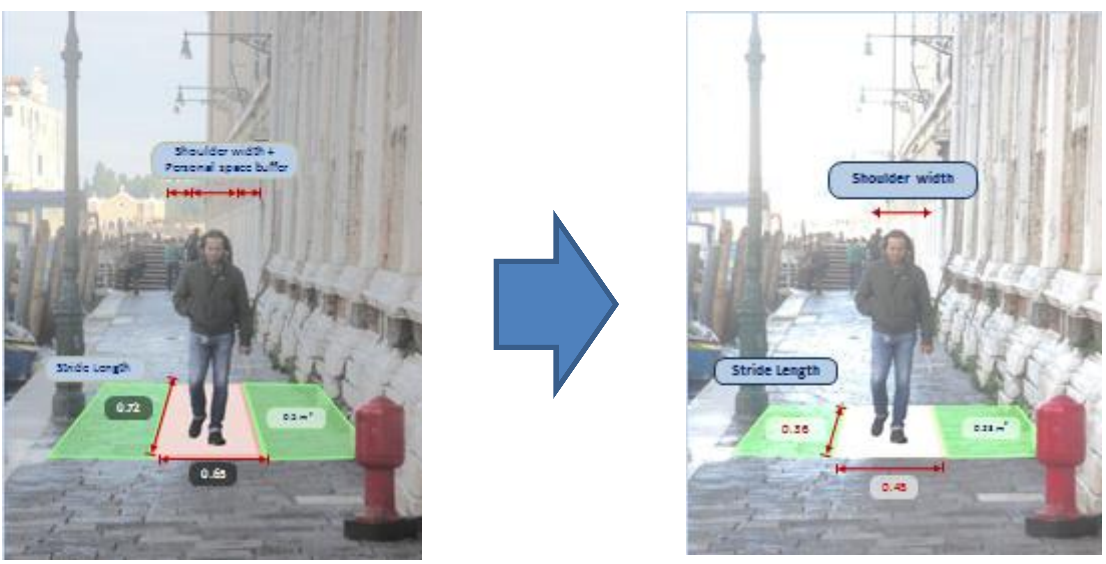


Figure 51: Difference between Walking Capacity and Critical Density

In the second graphic is this area a single pedestrian occupies at the critical density. In other words, if the area for a single pedestrian was any smaller, the street would reach a state of gridlock. The dimensions of the pedestrian's personal area at critical density are determined by his shoulder width and half of his stride length.

Humans exhibit a range of stride lengths while walking with other individuals on a street. At the bottom end of this range is one's minimal stride length. Humans have a natural tendency not to make any movement forward unless they visually perceive there to be enough room for a full step. We estimated the average minimum step distance to be half of the stride length. Therefore the critical density occurs when each pedestrian has only enough space for their shoulder width and half of their stride. When one individual occupies .162 square meters, the density at this critical spacing is 6.1 people per square meter.

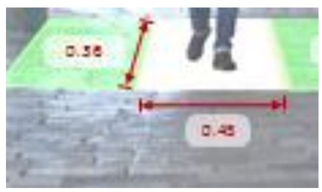


Figure 52: Pedstrian's Shoulder Width and Shorten Stride

6.2 Bottleneck Delays

Now that we have a number for the critical density of pedestrians trying to transverse the bottleneck of a street, bridge, or square a relation between the density of pedestrians and the bottleneck width.

6.2.1 Equation Modeling

To more accurately quantify congestion and determine this relationship, we return to the team's derived equation.

$$\rho := \frac{\left(\beta_b + \beta_q\right)\cdot\eta - \left(\frac{\beta_b}{S_w}\right)}{\frac{\left(\beta_b + \beta_q\right)}{\beta_b}\cdot t\cdot S_L\cdot\left(\beta_b + \beta_q\right)} \qquad \rho := \frac{[(\text{street Width}) * \text{Rows}] - (\text{Bottleneck flow})}{(\text{Bottleneck ratio}) * \text{Time} * \text{Stride} * (\text{street width})}$$

Figure 53: Bottleneck Equation

This creates a time delay where the pedestrians on the outer most portion of the street must wait before crossing the bridge. Clearly this time delay is directly proportional to the ratio of the street width to bottleneck width. This time delay increases as the number of rows of pedestrians increases.

Returning to the example, a street ends in a narrow bridge and therefore creates a bottleneck. The street is wide enough to contain 6 people across in one row. When this single row approaches the bottleneck, the width of the bridge can only allow 2 pedestrians to cross at a time.

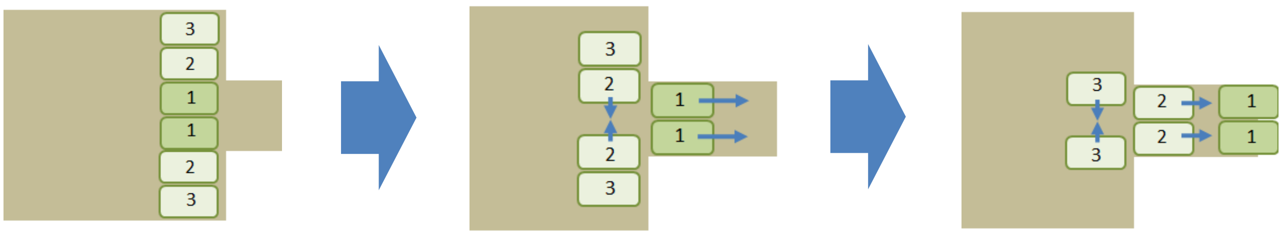
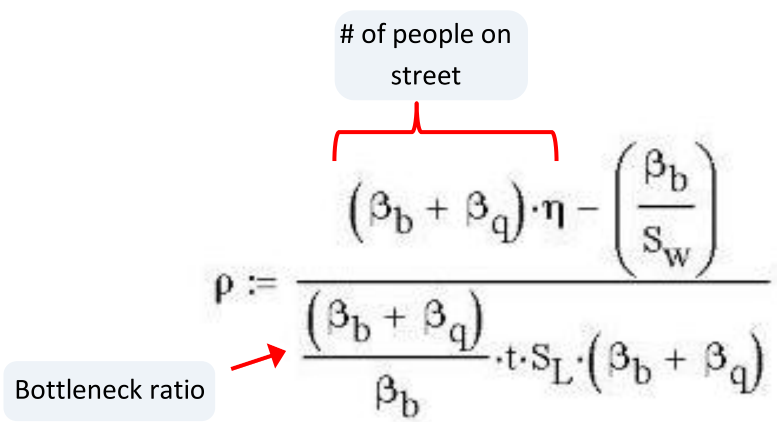


Figure 54: Explanation of a Bottleneck

This creates a time delay where the pedestrians on the outer most portion of the street must wait before crossing the bridge. Clearly this time delay is directly proportional to the ratio of the street width to bottleneck width. This time delay increases as the number of rows of pedestrians increases.



$$\rho := \frac{(\beta_b + \beta_q)\cdot\eta - \left(\frac{\beta_b}{S_w}\right)}{\frac{(\beta_b + \beta_q)}{\beta_b}\cdot t\cdot S_L\cdot(\beta_b + \beta_q)}$$

Figure 55: Bottleneck Equation Description

In recap, the equation now has the number of people on the street (number of people wide by the number of rows) divided by the ratio of street width and bottleneck width (the factor that determines the time delay. The equation also accounts for pedestrians leaving the bottleneck while the density is increasing before the bottleneck.

6.2.2 Delay in Pedestrian Commutes

The team used this bottleneck equation to relate the significance of our pedestrian counts with the physical capacity of the streets themselves. As stated in our methodology, a network of the main streets in Venice is referred to as the major arteries. Pedestrians trying to travel throughout the city mainly use these streets.

To clearly represent the effect of congestion on these main arteries, our team calculated the effect certain bottlenecks had on travel time between certain landmarks. Using the team's derived bottleneck equation, we established that if density of pedestrians at particular bottleneck areas reached a critical density then the bottleneck area would delay a pedestrian a specific amount of time. For example, if an individual attempted to walk from the Venezia Saint Lucia train station to the Rialto Bridge, there are 5 major bottleneck areas that cause congestion.

Figure 56: Pedestrian Pathway from Saint Lucia to Rialto pointing out the 5 major congestion points

If we look at the reduction in width at each intersection, we can calculate what the time delay would be for pedestrians based on different densities. Using the critical density formulated earlier where an individual has just enough room for their shoulders and minimum stride length we can prove how problematic pedestrian congestion is becoming. Putting pedestrian congestion in terms that many venetians can relate to, we can compare how long a morning commute will take now, about 22 minutes, versus the same commute with pedestrian congestion.

For the Saint Lucia to Rialto trip, the first of five bottleneck areas, approaching Salizada San Geremia, pedestrians move from a square onto a narrow street. The effective width of the pedestrian route therefore shrinks from 14 meters to 1.3 meters. Converting these widths, the width of the bottleneck is 6 people wide, and the width of the street is 21 (6 + 15) people wide. Following the equation, the ratio of street width to bottleneck width is 3.5 ((6+15) / 6). Consequently, for each row of pedestrians trying to enter the narrow street, the time delay it takes for a single pedestrian to enter the street is multiplied by 3.5 times. Compounding this delay are rows of pedestrians in the square waiting to enter the narrow road.

$$\text{Density} := \frac{(6+15)\cdot r - \left(\frac{6}{.65}\right)}{\left(\frac{6+15}{6}\right)\cdot(.8)\cdot(.72)\cdot(6+15)}$$

r = # of rows

Figure 57: Bottleneck Equation for Salizada San Germia

Therefore if the square reached a critical density of 6 pedestrians per square meter, 17 rows of pedestrians would be walking in the square. Plugging this into the equation along with the average stride rate, the time delay at this bottleneck is 47.6 seconds.

Continuing this calculation with the next four intersections, the respective time delays are 50.4s at Rio Terra Maddalena, 30.4s at the beginning of Strada Nova, 134.4s at Calle Dolfin, and 14s at Salizada San Giovanni Grisostomo for a total of 276.8 seconds or approximately 5 additional minutes. Looking at the percent increase from the original 22 minute walk, pedestrian congestion caused a 23 percent increase.

Figure 58: Complete Time Delay for Santa Lucia to Rialto

Looking at shorter walk with narrow bridges and many tourist crowds, we can apply the same equation to the route from the Rialto Bridge to Piazza San Marco. On this journey we identified 4 major bottleneck locations.

Figure 59: Rialto to Saint Mark's Square

Computing the bottleneck equation with the same assumptions, the 4 bottleneck delay pedestrian traffic by 60 seconds at Marzaria Due Aprille, 141 seconds at Marzaria San Salvador, 57 seconds at Marsaria San Zulian, and 15 seconds at Calle del Pellegrin totaling 272 seconds. This delay of 4.5 minutes creates a staggering increase in travel time by 56 percent. Such a large increase in travel time for a relatively short walk reveals how understanding and resolving pedestrian congestion in Venice is becoming exceedingly important.

6.3 Network Capacity

In review, the team found a specific measure of pedestrian density at which people have a physiological tendency to stop. Second the team created an equation that relates that density to the ratio of bottleneck width to street width. Finally, this equation was applied to actual bottleneck areas where the team performed pedestrian counts in order to analyze the current state of congestion.

But how far can it go? These major arteries are relied upon by countless venetians and tourists as direct connections between different areas of Venice. As tourism increases will these essential highways slow to a cease at the hands of tourist groups?

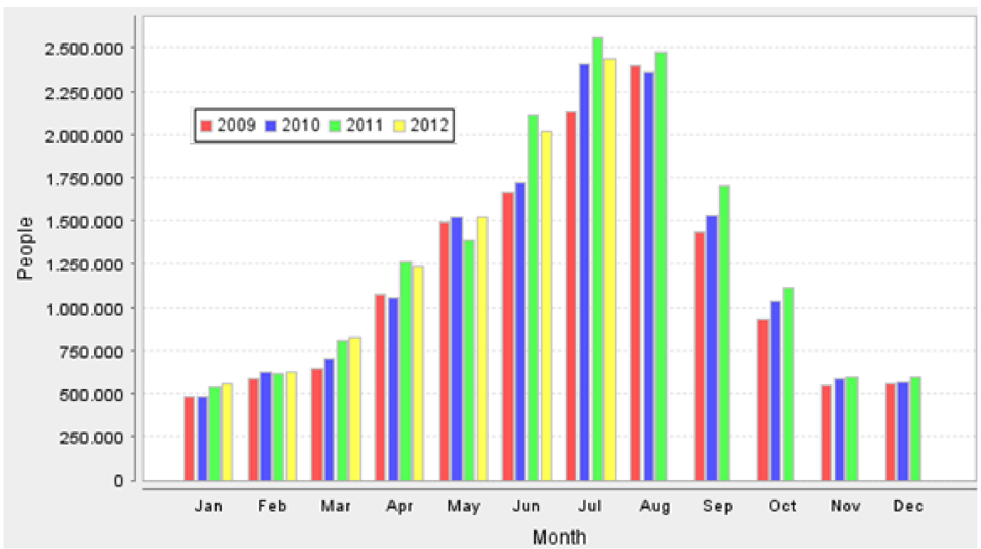


Figure 60: Venetian Tourists Per Month

To make a grand prediction about the major arteries of Venice, we can extrapolate our pedestrian counts from intersections of these major arteries.   Scaling up the current average density of the intersections we counted at in the district of San Marco to peak summer months such as July and August, traffic congestion increases dramatically. We calculated a flow rate of 1.65 people/sec. We then calculated the maximum flow rate for the narrowest part of the street and found it to be 2.12 people/sec.   If we increase this measure of flow rate at the same rate that tourism is increasing each year (3.7%), the major arterial roads will approach their maximum capacity. The major arteries themselves will reach critical capacity in approximately 8 years

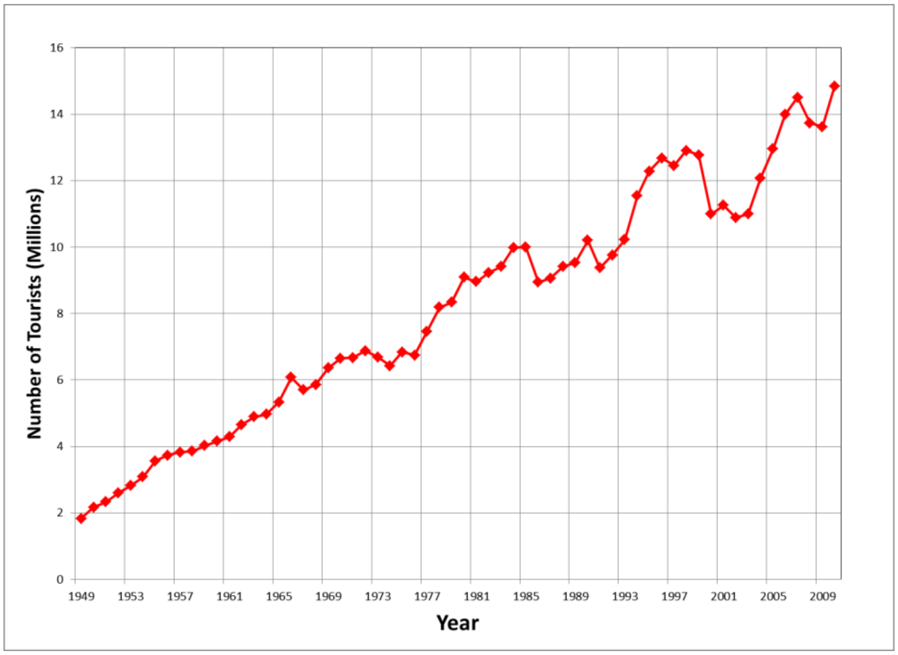


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Figure 61: Annul Increase of Tourism in Venice

Although rightfully scary this prediction is not precise. When major arterial roads begin to have congestion problems at certain bottleneck areas, pedestrians will spill over onto secondary and tertiary roads. Similarly, these assumptions were based on the peak pedestrian levels at the height of the tourism season and the density of the tourist frequented intersections in San Marco were applied to the entirety of the major artery pathways. Also the following assumptions were made: that the arterial streets were a closed system, the flow rate is directly proportional to the increase in tourism, and that the flow rate was unidirectional. This is where the Pedestrian model can fill the gaps left uncovered by our field counts. Traffic levels changing throughout the day and varying by location can be estimated based on attractions of certain pedestrian sources and sinks.   Therefore improving the accuracy of the pedestrian model will contribute the most to understanding and resolving congestion on Venetian pedestrian pathways.

6.4 Recommendations: Cataloging Traffic Obstructions

Although it is possible to obtain the surface area of streets and squares in GIS these numbers rarely reflect the actual area of the street that is clear for pedestrians to travel over. On the majority of the arterial streets and the smaller streets by large tourist attractions, there are multiple street vendors with large carts. These will often line either side of a street or be located in the center of squares. During flooding season the *passarelle* remain stacked in roads, taking up possible walking space. Many restaurants also have large sitting areas outside of their buildings taking up substantial amounts of space from certain streets. In additional to these movable obstructions there are also countless permanent fixtures, such as statues, monuments and wells.

Figure 62: Street Vendors

It would be valuable information to know how much space in a road is taken up by obstructions that reduce the area for traffic to flow through. By simply going around and measuring the area that these various obstructions occupy it could be possible to determine this percentage. It would also be valuable to note what each percent a particular obstruction occupies, such a permanent and movable objects. If an argument could be made that reducing or putting a limit on how much of a street can be occupied by certain obstructions, would increase the flow throughout the street. Although the area taken up by these obstacles may seem small in comparison to the entire street, the impact that is had on pedestrian traffic may be significant.

6.3.1 Cataloging Passarelle

The solution that the city uses to allow pedestrians to is the setup of passarelle, dock like structures that allow pedestrians to walk over the water. The structures are very important for movement in the city when the flooding occurs. It would helpful to know where in the city these are located, and more importantly, where they are missing. As the city leaves the passarelle stacked in the street, it would be possible to travel throughout the city and take note where the stacks are not present. Then when flooding occurs, the locations without passarelle could be returned to, to see the state that the street is in and if it was necessary in the location or not.

Any streets that were found to need passarelle that did not have them could be noted by the team. After all the data had been gathered, all the streets in Venice that did not have the necessary passarelle docks could be mapped so that tourists would know to avoid those areas in a flood situation.

The locations of the passarelle also seem rather random at times. It would be interesting to study where the best place to store passarelle so as to reduce its impact on traffic as much as possible when not in use. It is possible that there is also a better way to set up the passarelle so that the traffic flows well over them, and if a pedestrian choses to, that is room on the street to walk in the water.

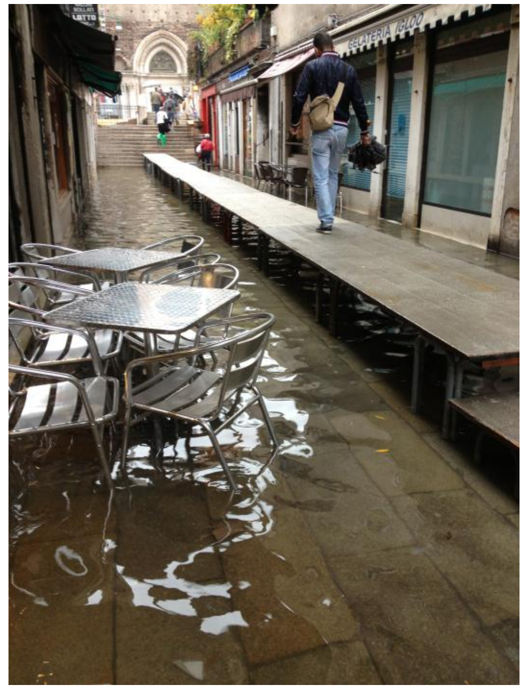

Figure 63: Passarelle Obstruction

6.3.2 Impact on Individual Pedestrian

Trying to understand and locate where and how congestion occurs in the city is very important when considering the state of the city as a whole. Considering the impact that traffic has on the individual is also very important. How this traffic affects the quality of life for people in the city is a very important topic that shouldn't be neglected. Our study on this was brief, using mainly our equation to calculate choke points on certain routes in the city. It would be ideal for a team to instead go out and walk the city themselves, timing and video recording the path that they take. High traveled routes along arterial roads from major land marks to another should be selected for study.

Once a route has been selected for study it should be studied multiple days. To be able to try to understand the impact of tourist on daily routes would be to conduct counts when cruise ships port in the city for a day. The team could perform counts when there are no cruise ships as well as when they are in the city. In addition weekend and weekdays counts should also be performed to compare the impact on commute time. These time comparisons would provide strong arguments supporting the impact on the quality of life for the people who live in the city.

In addition to supporting this argument, if conducted on days when cruise ships were in port, it could begin to show the impact of cruise ships on the mobility on the streets of the city. Another interesting day to include in these studies would be when the weather is poor in the city. The traffic flow is often severely impacted by rain with most pedestrians utilizing umbrellas which occupy much more space than a person. If possible, this should also be repeated when there the city is experience flooding. The amount of time that it would take to commute the same route over passarelle would be an interesting to see how greatly this impact the commute time.

Chapter 7 Conclusion

Focusing on traffic trends and patterns requires accurate and inclusive pedestrian data. Multiple tools and techniques will help make sense of the maze of Venice Streets. A smartphone counting application can organize traffic flow data, while GIS mapping software verifies the geographic component. But how far can it go? The city's major arteries are relied upon by countless venetians and tourists as direct connections between different areas of Venice. As tourism increases will these essential highways slow to a cease at the hands of tourist groups?

The city is moving in the direction of reaching its actual capacity. Should there be a limit to the number of people allowed into the city? It may be possible to limit excursionist access through regulation or incentives for longer stays. Lengthier visits would entice tourists to expand their normal thoroughfares and disburse throughout the city. In order to alleviate the pedestrian stress from the major arteries of Venice, the sources and attractions of pedestrians must be fully understood. This is where the Pedestrian model can fill the gaps left uncovered by our field counts. Traffic levels changing throughout the day and varying by location can be estimated based on attractions of certain pedestrian sources and sinks. Therefore improving the accuracy of the pedestrian model will contribute the most to understanding and resolving congestion on Venetian pedestrian pathways.

Figure 64: Pedestrian Model

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Appendices

Appendix 1: Field Form

This is the field form every member of the team filled out each time they were counting. This field form allowed the data to be easily determined when logging the counts as well as being neat and organized. This form made each team member reliable for the counts they came up with.

Field Form Streets B12

Name:______________________________
Type:______________________
District:____________________
Date:______________________
Counting Interval:_____________

TIME	IN	OUT	LOCALS	TOURISTS	TOTAL
TOTAL					

Team Members Counting:____

Additional Notes:

Appendix 2: Database

The database is a spreadsheet of street information containing the following: name, district, street type, length, minimum width, surface area, and the historical information if applicable. The walking capacity was calculated for the main arteries of the street.

<u>Our Databse:</u> go to our website to see the full version

Type	Name	District	x	y	Length	Minimum Width	Average Width	Surface Area	Background
	GALION	SANTA CROCE	2310828.373	5035402.5	1	0	0		
	RIO TERA'	SANTA CROCE	2310929.933	5035449.1	1	0	0		Rio Terra - "River Earth/Land"
	RUGA BELLA	SANTA CROCE	2310915.28	5035325.7	1	0	0		According to the Dezan S. James of Orio, the names emanated from amenities of the site
	RUGA VECIA	SANTA CROCE	2310917.168	5035354.4	1	0	0		Veochi - "Old Wrinkle" - Named after a group of old sailors who turned the church of Saint Nicholas Bari into a place for wounded sailors and those unable to s
	SENZA NOME "Z"	SANTA CROCE	2310830.954	5035173.4	1	0	0		"nameless"
	VOLTO SANTO	SANTA CROCE	2311211.963	5035748.4	1	0	0		"the Holy Face" - Lucchesi silk merchants in Venice formed a society called "Volto Santo" in 1360 because it was called a miraculous crucifix. In October 2, 1
CALLE	A FIANCO LA CHIESA	SANTA CROCE	2310578.891	5035358	59.0787975	1.29	0		It means "Facing the Church."
CALLE	BERGAMI	SANTA CROCE	2310700.334	5035379.5	27.41319079	1.94	10.5058912	288	This street name comes from a town inn called "the Bergama" because it is intended to receive the strangers came from the city of Bergam
CALLE	CA' TRON	SANTA CROCE	2311169.074	5035466.1	49.81982662	1.04	3.050994158	152	Luigi Poli Ferrazzo a carver, who was orphaned by parents who died in the plague of 1630, he lived a spiritual life under the direction of th
CALLE	CAPPELLO	SANTA CROCE	2310912.757	5035232.8	27.96976582	1.3	0.965328068	27	"Hat" - From the city of Capua, many families went to Rome, and among them the Capuelli, afterwards called Cappello, who were admitted to Roman citizenshi
CALLE	CARRERA	SANTA CROCE	2310804.657	5035498.3	37.2067534	1.71	0		
CALLE	CON MARIGNI	SANTA CROCE	2310719.795	5035442.1	1	0	0		
CALLE	CONTARINA	SANTA CROCE	2310789.715	5035231.9	86.61032024	15.05	0.316359528	27.4	This name came from the family name Contarini. Vuobi produced no less than eight Doges. Domenico, did a lot for his country and fabricated the church and r
CALLE	CORNER	SANTA CROCE	2311027.462	5035525	1	0	142.62	142.62	This calle was named after the Corner or Cornaro family. The Corner family were ambassadors for Emperor Maximillian. Giorgio Cornaro r
CALLE	CREMONESE	SANTA CROCE	2310377.337	5034909.4	49.11231604	3.1	3.135669674	154	It was named after a man named Alessandro Cremonesi who founded the parish of the Cross.
CALLE	DANDOLO	SANTA CROCE	2311178.656	5035474.4	18.85002587	2.02	3.294425186	62.1	This street was named after the noble family of Fantino Dandolo who had his house on this street and bought the church of Saint Thomas.
CALLE	DE BERNARDO	SANTA CROCE	2310370.847	5034984.7	55.10324763	5.4	7.894271549	435	It was named after the noble family, Bernardo. The Towers at the Bridge belonged to this family. Francesco Bernardo in 1303 was captain of a large armed ship
CALLE	DE CA' AMAI	SANTA CROCE	2310678.009	5035115.9	1	0	0		The family Amadi, also known as Amai are know for their great wealth and many buildings, one of which is on the "Rio del Fontego," in S. John Chrysostom. Sev
CALLE	DE CA' BEMBO	SANTA CROCE	2310942.987	5035496.1	49.0252861	2.6	4.079527442	200	Dedicated to S. Salvatore and is the location of The Palazzo Bembo. Home of the Bembo a very conspic conspicuous family among nobl
CALLE	DE CA' BRAGADIN AL CRISTO	SANTA CROCE	2311251.322	5035230.4	35.58645218	2.08	0		This street is next to a building that was owned by the noble family Bragadin. Bragadin family, in 800, was one of those who composed the first aristocratic nobi
CALLE	DE CA' CORNER	SANTA CROCE	2311344.57	5035389.6	88.14620529	2.5	3.573608177	315	see corner
CALLE	DE CA' FALIER	SANTA CROCE	2310640.012	5034984.1	76.37804543	1.2	1.662781488	127	It is named after the parish of St. Falier Vitale. From San Vitale James Falier was elected in 1268 Prosecutor S. Marco. In 1082 Doge Vitale Falier erected the ch
CALLE	DE CA' MUTI O CA' BAGLIONI	SANTA CROCE	2311310.654	5035217.1	1	0	125	125	Muti (Branch, Bridge, Court) to Our Lady of the Garden. The family Muti lived in the district of Our Lady of the Garden.
CALLE	DE L 'ERBAROL	SANTA CROCE	2311380.046	5035255.5	1	0	54	54	A "erbarol" or erbajuolo means hard working/the working class.
CALLE	DE LA CHIESA	SANTA CROCE	2311221.347	5035309.1	40.27951609	1.35	0		"Church"
CALLE	DE LA COMEDIA	SANTA CROCE	2311223.829	5035188.6	1	0	23.5	23.5	"comedy"
CALLE	DE LA CROSE	SANTA CROCE	2310785.542	5035336.2	56.7461346	1.6	0		Crosera literally means "cruise." This is used often as a street name because it means where people are headed.
CALLE	DE LA MADONNA	SANTA CROCE	2310625.235	5034939.6	1	0	0		S. Angelo M. lived on this street in Venice. He was a genius poet and political advocate and was imprisoned in Vitale. He was going to be
CALLE	DE LA REGINA	SANTA CROCE	2311258.636	5035261.7	116.1665423	1.47	1.652799474	192	San Cassiano. It was here that in 1454 the famous Catterina Cornaro, became Queen of Cyprus. She dies in 1510 and was buried in the chu
CALLE	DE LA VIDA	SANTA CROCE	2311012.767	5035384.9	20.3828723	1.19	1.766188763	36	
CALLE	DE LA VISSIGA	SANTA CROCE	2310736.831	5035217.3	100.5706118	1.52	2.137631413	215	This street is named after a family who had a member who had an affair with another man's wife. They got into an argument and the wom
CALLE	DE L'AGNELLA	SANTA CROCE	2311238.153	5035200.4	1	0	83	83	A family of the name Agnella lived on this street. During the Way Chiogga the head of the family offered 150 men from the house to the ca
CALLE	DE LE BURCHIELLE	SANTA CROCE	2310122.916	5034910.1	1	0	0		Dedicated to S. Andrea. This streets is named aftert the "Burchiele"(small barges) that were Stationed here. These were used for many d
CALLE	DE LE CASE NOVE	SANTA CROCE	2310527.823	5035202.1	112.9917509	6.5	2.807742001	317.25	Case Nuove means "New Homes." It is named after the new houses Charles VI and Charles VII built when they were emperors.
CALLE	DE LE CHIOVERETTE	SANTA CROCE	2310625.606	5035290.3	65.61756777	8.1	9.128652895	599	The "chioverete" are small "Chiovere." Many were located on this street and are stores where fine custom clothes were made.
CALLE	DE LE OCHE	SANTA CROCE	2310947.308	5035235.3	141.363859	1.88	1.598711308	226	Dedicated to S. James dall'Orio. A place where baptisms occurred, many of the building have fine "paterae" on the façade. This streets is
CALLE	DE LE POSTE VECCHIE	SANTA CROCE	2311430.546	5035261.3	1	0	19	19	This street was the location of a major, if not only at the time, post office in Venice. It was later converted as a place to store and age wine.
CALLE	DEI ALBANESI	SANTA CROCE	2311171.012	5035440.7	52.4950357	1.71	0		This streets was home to a high number of Albanian people. The erected a School of Albanians and dedicated it to the church of St. Serv
CALLE	DEI BERGAMASCHI	SANTA CROCE	2310572.319	5035293.1	75.6598293	1.4	0		This street is named after the people from Bergamo. These people worked with crops and made wool in the sixteenth and seventeenth cen
CALLE	DEI BOTERI	SANTA CROCE	2311361.154	5035208	1	0	0		This street seems to have been the location of some sort of religious school were sacramental wine and other religious symbols such as oil
CALLE	DEI LAVORATORI DE LANA	SANTA CROCE	2310423.59	5035061.7	36.09980985	1.08	3.490323094	126	A shop that washed and spun wool was located here.

Appendix 3 Venipedia Pages

3.1 Street Page

Strada Nuova

Strada Nuova is a major Strada in the district of Cannaregio. It is centrally located in the district, and it contains many shops and restaurants.

Sestiere	Cannaregio
Type	Strada
Length	381 meters
Minimum Width	5 meters
Surface Area	4,975 square meters
Flow Rate	12 people/second
Walking Capacity	10,585 people

v • d • e

Contents [hide]

History [edit]

Strada Nuova is a relatively new street, hence its name. It was created by the Austrians as a continuation of Rio Terra Lista Di Spagna in an attempt to make a single street that ran all the way to San Marco. However, its construction was halted when a resident at the end of the street refused to give up his home.

Map [edit]

Segments [edit]

v • d • e [hide]

Segments

Segments of Strada Nuova

Segment 1 Segment 2 Segment 3 Segment 4 Segment 5 Segment 6 Segment 7 Segment 8 Segment 9 Segment 10 Segment 11 Segment 12 Segment 13 Segment 14 Segment 15 Segment 16 Segment 17 Segment 18

3.2 Segment Page

Strada Nuova Segment 10

This segment is bordered by Calle Ca' D' Oro and Calle de le Vele.

	West		East	
Time	Locals	Tourists	Locals	Tourists
10:15	136	54	220	59
10:30	96	54	144	54
10:45	147	44	174	92
11:00	162	27	137	40
11:15	184	39	182	52
11:30	175	27	194	57
11:45	183	29	176	52
12:00	157	107	252	45
12:15	229	32	164	45
12:30	226	41	148	36
12:45	126	26	157	40
1:00	198	110	73	86
1:15	196	69	106	56
1:30	125	48	81	66
1:45	123	48	86	75
2:00	149	41	154	58
2:15	148	57	98	69
2:30	124	51	117	78
2:45	144	44	102	49
3:00	142	30	105	67
3:15	143	36	132	55
3:30	134	65	89	73

Segment Map Image

Strada Nuova Segment 10	
Sestiere	Cannaregio
Type	Strada
Length	34 meters
Minimum Width	7 meters
Surface Area	325 square meters
Walking Capacity	691 people
Flow Rate	1,308 people/minute

v • d • e

Appendix 4: Pedestrian Counts

4.1 Previous Projects:

2009:

Acadamia Bridge					Rialto			
						# tourists	# locals	total
	North	South	Total		7:00	30	33	63
7:00	14	35	49		7:30	32	11	43
7:30	92	65	157		8:00	39	37	76
8:00	33	74	107		8:30	53	42	95
8:30	44	39	83		9:00	104	41	145
9:00					9:30	51	12	63
9:30	27	138	165		10:00	34	9	43
10:00					10:30	40	4	44
10:30								
11:00	278	266	544		16:00	388	27	415
11:30	360	224	584		16:30	187	29	216
12:00	363	378	741		17:00	83	29	112
12:30	323	431	754					
13:00	486	326	812					
13:30	354	69	423					
14:00	423	381	804					
14:30	438	386	824					
15:00	369	254	623					
15:30	384	483	867					

16:00	237	213	450					
16:30								
17:00	362	195	557					
17:30								
18:00	389	413	802					
18:30	728	420	1148					
19:00	365	279	644					
19:30	504	285	789					
20:00	123	62	185					
20:30	141	93	234					
21:00	75	62	137					
21:30	30	87	117					
22:00	48	57	105					

2010:

Ponte Del' Ovo					Ponte Dei Bareteri			
	Coming towardRialto		Going		Coming		Going	
	V	T	V	T	V	T	V	T
7:15	41	5	79	6				
7:45					46	8	97	37
9:15	121	20	182	26				
9:45					61	22	103	37
11:15	190	74	173	26				

11:45					56	59	95	65
13:15	150	65	129	51				
13:45					54	65	58	94
17:15	140	76	102	63				
17:45					30	58	74	108

	Ponte Della Canonica				Ponte Della Paglia			
	Coming		Going		Coming		Going	
	V	T	V	T	V	T	V	T
8:15	47	6	39	15				
8:45					35	51	24	26
10:15	65	31	49	11				
10:45					33	133	79	75
12:15	72	31	45	37				
12:45					31	117	43	77
16:15	54	26	63	55				
16:45					25	194	44	68
18:15	46	31	69	16				
18:45					36	92	16	23

	Ponte Dei Fuseri				Ponte De Le Ostreghe			
	Coming		Going		Coming		Going	
	V	T	V	T	V	T	V	T
7:15	5	0	3	3				
7:45					25	2	39	2

9:15	24	15	56	15				
9:45					44	31	49	24
11:15	29	29	48	36				
11:45					45	61	35	43
13:15	32	31	46	24				
13:45					41	59	40	34
17:15	26	49	28	30				
17:45					30	37	32	27

	Ponte Dell'Accademia				Ponte Sant'Angelo			
	Coming		Going		Coming		Going	
	V	T	V	T	V	T	V	T
8:15	65	24	150	7				
8:45					64	25	88	6
10:15	50	38	101	16				
10:45					54	55	94	28
12:15	45	30	89	47				
12:45					61	41	72	32
16:15	50	35	98	34				
16:45					92	65	72	26
18:15	73	51	43	16				
18:45					52	31	61	17

	Ponte				Ponte Di Rialto		

	Sant'Antonio								
	Coming		Going			Coming		Going	
	V	T	V	T		V	T	V	T
8:45	105	19	124	30	8:30	145	54	181	28
10:45	172	36	161	41	9:30	139	81	199	57
12:45	125	82	136	119	11:30	130	173	220	133
16:45	107	162	155	134	15:00	98	176	165	130
18:45	124	114	117	55	18:00	97	221	144	133

2011:

Ponte Del Treatro			Ponte de San Paternian			Ponte de la Cortesia			Ponte San Mose		
	Weekday (avg)		Weekday (avg)			Weekday (avg)			Weekday (avg)		
	Dir. 1	Dir. 2		Dir.1	Dir. 2		Dir.1	Dir. 2		Dir. 1	Dir.2
7:00	3	9	7:00	1	2	7:00	13	17	7:15	18	19
7:15	9	15	7:15	1	4	7:15	22	26	7:30	14	31
7:30	9	8	7:30	0	0	7:30	52	41	7:45	45	54
7:45	18	15	7:45	4	4	7:45	49	91	8:00	46	41
8:00	14	18	8:00	2	6	8:00	65	65	8:15	64	70
8:30	14	18	8:30	2	2	8:30	96	71	9:15	232	99
8:45	27	21	8:45	4	6	8:45	70	112	11:30	324	350
9:00	22	25	9:00	5	11	9:00	91	86	11:45	285	381
9:30	19	31	9:30	14	7	9:30	98	87	12:00	300	344

11:45	16	13	11:15	6	0	11:15	110	132	13:00	301	315
12:00	21	20	11:45	8	3	11:45	178	149	13:15	344	353
12:45	13	13	12:00	3	3	12:00	177	198	13:30	293	375
13:00	22	27	12:45	5	2	12:45	118	151	13:45	298	395
13:30	17	22	13:00	7	7	13:00	204	172	14:00	287	457
13:45	24	20	13:30	3	15	13:30	264	179	14:15	342	344
14:00	13	30	13:45	7	3	13:45	178	165	14:30	358	547
14:15	12	12	14:00	20	3	14:00	484	112	14:45	354	539
14:30	51	6	14:15	7	3	14:15	235	103	15:00	356	478
14:45	23	21	14:30	1	13	14:30	298	170	15:15	242	244
15:00	18	27	14:45	0	7	14:45	216	109	15:30	184	256
15:15	21	27	15:00	9	8	15:00	166	112	15:45	211	275
15:30	11	23	15:15	4	5	15:15	112	158	16:00	223	326
15:45	11	28	15:30	6	15	15:30	149	117	16:15	287	304
16:15	21	16	15:45	10	24	15:45	186	131	16:30	254	355
16:30	21	25	16:15	13	9	16:00	181	144	16:45	242	289
16:45	17	20	16:30	2	9	16:15	211	128	17:00	310	310
17:00	15	22	16:45	3	20	16:30	212	137	17:15	211	276
17:30	11	11	17:00	5	2	16:45	193	153	17:30	358	600
			17:30	14	4	17:00	190	116	17:45	322	536
						17:15	252	167	18:15	261	456
						17:30	225	130	19:00	210	424
						18:00	195	124	20:00	215	410
						18:15	170	109			

4.2 Our Project:

Piazzale Roma:

Bridge :	Tre Ponti				Ponte Papadopoli				
	Leaving		Coming			Leaving		Coming	
Time	Tourist	Locals	Tourist	Locals	Time	Tourist	Locals	Tourist	Locals
7:00	3	126	6	28	7:00	25	221	13	14
7:15	0	297	4	75	7:15	15	314	17	52
7:30	5	407	5	70	7:30	20	315	18	54
7:45	0	640	2	120	7:45	18	382	26	52
8:00	0	525	2	65	8:00	13	239	41	65
8:15	0	574	2	122	8:15	20	252	39	91
8:30	0	644	0	93	8:30	21	314	42	85
8:45	1	174	4	79	8:45	14	269	47	75
		3396		677			2452		731
5:00	4	155	36	526	5:00	14	101	18	279
5:15	2	169	33	544	5:15	9	95	16	268
5:30	2	105	37	536	5:30	12	99	10	242
5:45	6	105	13	314	5:45	10	86	20	213
6:00	9	125	30	250	6:00	7	114	36	163
6:15	6	132	47	355	6:15	2	121	23	188
6:30	6	140	20	332	6:30	5	110	28	171
6:45	4	166	14	189	6:45	6	118	14	193
7:00	4	90	0	367	7:00	8	102	6	214

7:15	2	99	0	265	7:15	5	92	4	155
7:30	0	101	2	126	7:30	8	71	0	125
7:45	2	125	4	118	7:45	6	94	3	123

Ponte S. Chiara					Ponte della Costituzione (Calatrava)				
	Leavin g		Comin g			Leaving		Comin g	
Tim e	Tourist	Local s	Tourist	Local s	Time	Tourist	Local s	Tourist	Local s
7:00	0	51	0	17	7:00	0	284	3	178
7:15	1	45	0	20	7:15	13	299	6	193
7:30	0	54	4	11	7:30	3	353	5	203
7:45	0	18	3	25	7:45	5	343	9	331
8:00	63	37	2	20	8:00	1	385	59	508
8:15	2	32	3	27	8:15	0	326	2	893
8:30	70	39	10	31	8:30	2	355	47	660
8:45	5	40	23	30	8:45	0	246	14	596
		457		226			2615		3707
5:00	0	15	9	68	5:00	41	415	63	256
5:15	3	31	9	53	5:15	15	504	71	280
5:30	4	22	0	39	5:30	20	353	32	464
5:45	2	28	4	24	5:45	39	211	22	442
6:00	0	17	0	36	6:00	37	181	8	318
6:15	6	31	2	58	6:15	32	189	26	116
6:30	4	42	11	72	6:30	39	224	21	146

6:45	3	36	7	64	6:45	42	220	25	185
7:00	0	28	4	47	7:00	39	200	19	203
7:15	2	31	2	34	7:15	41	184	23	122
7:30	0	24	9	39	7:30	32	216	27	139
7:45	4	13	0	28	7:45	32	221	21	192

San Basilio:

	Erin		Tim		Mel		Alex	
	entering	exiting						
8:00	34	19	12	26	33	9	24	36
8:15	46	7	40	21	29	13	41	38
8:30	119	16	50	31	47	4	52	26
8:45	74	15	66	38	16	3	43	24
9:00	44	27	50	22	36	13	26	19
9:15	78	14	50	22	12	10	19	16
9:30	78	20	26	19	22	12	23	20
9:45	72	17	60	37	13	10	27	22
1:00	94	76	38	26	27	14	38	29
1:15	96	81	41	22	30	10	39	31
1:30	91	123	67	34	32	39	37	41
1:45	118	108	46	23	72	89	43	51
2:00	68	50	55	22	20	13	38	47
2:15	68	50	32	20	14	12	28	26

San Marco Intersections:

	Near Academia		San Stefano					
	Erin	Calle dei Frati	Mel	Calle de le Botteghe	Tim	Calle del Spezier	Alex	Cpl. S. Vidal
	Entering	Exiting Square						
11:30	103	136	58	50	88	69	124	96
11:45	103	114	36	58	107	75	95	94

12:00	139	114	47	56	107	76	101	116
12:15	136	96	33	48	86	81	84	97
12:30	107	117	55	26	103	78	86	94
12:45	91	69	42	51	118	114	78	84
3:00	76	75	21	42	84	71	95	89
3:15	92	107	18	31	92	73	104	96
3:30	87	109	49	38	116	82	94	92
3:45	97	87	26	35	120	78	117	160
4:00	93	122	32	58	116	70	121	163
4:15	81	99	47	66	115	84	94	134
4:30	98	152	47	51	146	76	102	127
4:45	118	60	38	49	131	102	87	95

	Rialto - 1st	San Bortolomio				
	Erin/Mel		Alex		Tim	
	Entering	Exiting				
11:00	335	364	341	391	352	305
11:15	427	376	293	372	371	335
11:30	433	420	313	402	369	327
11:45	512	437	304	394	460	344
12:00	540	474			371	413
12:15	285	280			227	270
12:30	333	325			222	240
12:45	377	345			203	237

3:00	386	319	234	181	221	267
3:15	327	334	227	190	241	283
3:30	421	400	217	201	476	256
3:45	346	346	189	190	316	299
4:00	484	476	178	186	320	345
4:15	395	396	162	173	327	333
4:30	504	439	175	188	326	317
4:45	520	514	218	236	331	332

	Rialto to San Marco		San Salvador					
	Erin		Mel		Alex		Tim	
	Entering	Exiting Square						
11:30	212	193	324	305	142	131	384	600
11:45	214	222	332	292	124	127	259	170
12:00	220	135	254	270	125	130	286	229
12:15	267	189	279	328	153	122	288	282
12:30	254	211	306	289	108	112	210	274
12:45	158	163	206	198	97	86	215	142
3:00	356	223	303	364	149	163	293	236
3:15	268	214	264	246	76	174	249	250
3:30	292	204	283	239	67	170	228	244
3:45	334	162	212	287	71	164	274	188
4:00	362	201	275	303	73	175	209	217

4:15	252	158	294	256	67	173	239	205
4:30	272	189	251	227	69	169	261	224
4:45	315	156	234	218	74	161	221	207

Appendix 5: Calendars

October:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21 Arrive in Venice	22 Frist Meeting at VPC	23 -Frist Team Meeting -Team counting on Fondemanta Nove (no data just for methods)	24 -Team walk around Santa Croce -Meeting with Advisors	25 -Team Counting Day Dorsoduro (no meaningful data help to determine methods)	26 -Team Meeting: Methodology -Meeting with Advisors	27
28	29 Team Meeting: Methodology	30 Test Count in Santa Croce	31 Meeting With Advisors			

November:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1 Test Count in Santa Croce	2 Counting test for Accuracy	3 -Test Count in Santa Croce -Test Count in Dorsoduro
4	5 Revise Background and Methodology	6 -Meeting with Advisors -Revised draft of Background and Methodology due	7 Counting Test for Tourist vs. Locals	8 Test Count San Marco	9 -Meeting with Advisors -Counting test tourists vs. locals	10
11	12 Ignite Presentation with Transportation team	13 Work on Presentation for Mobility Department	14 Presentation Rehearsal with Advisors	15 Meeting with Venice Mobility Department	16 Meeting with Advisors	17
18	19 -Final Background	20 -Meeting with Advisors	21 Thanksgiving	22 Thanksgiving	23 Thanksgiving	24 Thanksgiving

	and Methodology, results outline and progress statement due	-Counting in San Marco				
25 Thanksgiving	26 -GIS Work -Report Editing	27 Counting in Dorsoduro	28 -GIS Work -Report Editing	29 Counting in San Marco	30 -GIS Work -Report Editing	

December:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1 Counting near Ferrovia with Transportation Team
2	3 -Time Lapse of Piazzale Roma -GIS Work	4 Counting in San Marco	5 -GIS Work -Writing Results	6 -GIS Work -Writing Result	7 -GIS Work -Final Presenation	8
9	10 -Final Presentation -Results and Analysis	11 -Final Presentation -Result and Analysis	12 Final Presentation and Submissions	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					