Floating Around Venice:

Developing Mobility Management Tools and Methodologies in Venice

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ABSTRACT

This Interactive Qualifying Project developed and refined tools to assist in managing Venice's boat and pedestrian traffic. We monitored boat traffic at 19 locations in Venice to improve the accuracy of a boat traffic model being developed by the Redfish Group. The completed model can be used to simulate the impact of changes in boat traffic regulations. Concurrently, we developed a pedestrian monitoring methodology to characterize behaviors of pedestrians in Venice. We used these behaviors to develop a model that can be used to manage *plateatici* (public spaces rented to private entities), which frequently encroach on pedestrian thoroughfares.

AUTHORSHIP

The preparatory work involving background research and designed approach was conducted by all of the members of the team. Field work involving boat and pedestrian monitoring was conducted by the entire group. Pedestrian data transcription was conducted by Danice Chou, and Bethany Lagrant, and Rudy Pinkham. Chris Catanese aided in data organization and was responsible for the majority of boat data transcription and was assisted by Danice. The bulk of the pedestrian results and analysis was completed by combined efforts of Rudy and Danice. Meanwhile, Danice completed boat data analysis. Chris Catanese was responsible for the development of our computer-based pedestrian model.

The final PowerPoint presentation of this project was the result of presentation reworking efforts conducted by Chris Catanese and Bethany Lagrant. Ideas presented in the presentation were the result of collaborative group efforts.

The bulk of the paper including the background, methodology, results and analysis, and conclusion and recommendations sections were written by Rudy Pinkham. Rudy also contributed to the revision and final editing of the majority of the report. Danice Chou wrote the initial draft of executive summary and assembled the project poster, while Rudy Pinkham reworked the summary to its finalized version. Bethany Lagrant was responsible for editing the executive summary, methodology, results and analysis, and conclusions and recommendations sections of the report. Danice Chou provided editing support on the introduction, background, methodology, boat results and analysis, and sections of the report. Chris Catanse compiled the appendices for the report with support from Bethany Lagrant. The final compiling of the paper was a collaborative group effort.

Executive Summary

The City of Venice has only two forms of traffic: boat and pedestrian. These traffic forms never intersect, as boats operate in canals**,** while pedestrians move on bridges and walkways. Although one would expect the City of Venice to face very few problems from her transportation system because of this separation, each form of traffic confronts the city with major challenges. Venice is a popular tourist destination, and is visited by an average of 38,000 tourists per day, which is more than half of the native population of 65,000[1]. Shop and café owners throughout the city rent public space from the government to place tables and kiosks in public squares and walkways, where they will attract tourists. These leased spaces, known as *plateatici*, often restrict pedestrian flow, resulting in pedestrian traffic congestion in many areas throughout the city. Additionally, Venice is the only city that can be dismantled, stone-by-stone, by its vehicular traffic. As each motor boat passes through a canal, it generates wake, which washes against canal walls and foundations, speeding erosion and leading to building collapse[2]. This phenomenon is known as *Moto Ondoso*.

Figure 1: Pedestrian Autonomous Agent Model

In response to the pedestrian traffic difficulties discussed above, we developed a pedestrian traffic autonomous agent model, which can be seen in Figure 1, 070intended to aid in managing the leasing of *plateatici*. This model can be programmed to simulate traffic in *Campo San Filippo e Giacomo* at different times of day, and flow around the *plateatici* in the square can be observed. Variables such as total number of people passing through the square, speed of pedestrians and ratio of tourists to Venetians can be changed to equal those of traffic at different times of day. Additionally, 3-D renderings**,** such as that shown in Figure 2, can be developed to aid in visualization.

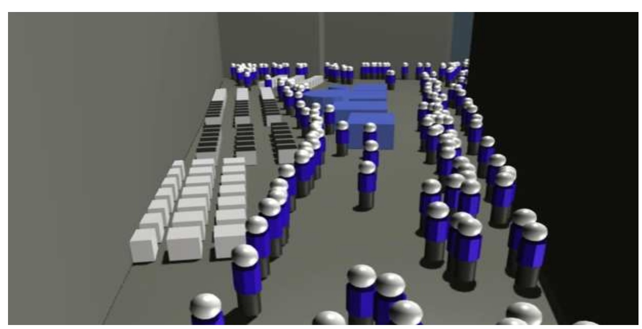
Figure 2: 3-D Rendering of Autonomous Agent Model

[1] Street Performances

[2] The Moto Ondoso Index

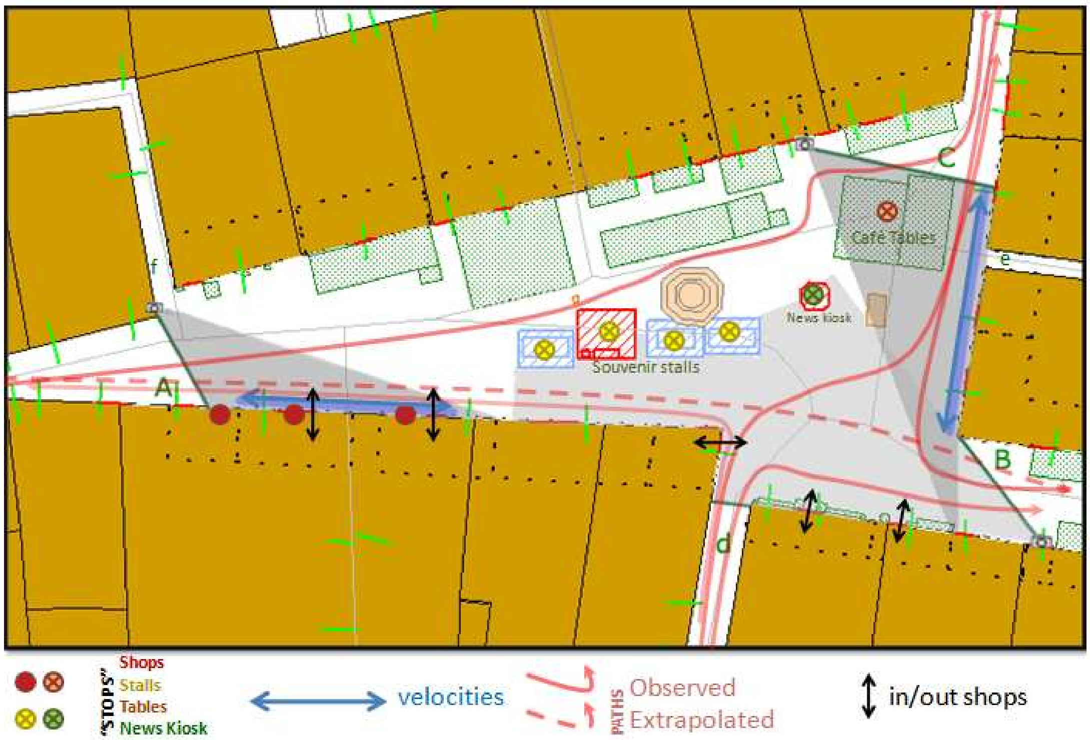

Figure 3: Visual Summary of Pedestrian Monitoring Method Including Camera Views (grey), Tables (green), and Kiosks and Stands (blue and red).

Before the model could be constructed, we needed to collect sufficient data on pedestrian traffic in Venice, a difficult task due to the random paths of tourists. We developed a pedestrian monitoring methodology intended to obtain data for modeling, as none had been adapted to Venice previously. This monitoring methodology is effective virtually everywhere in Venice, and as such is a major deliverable of our project. We monitored *Campo San Filippo e Giacomo*, because it contains many *plateatici* and is small enough to be monitored by four people. A visual summary of our methodology as used in *Campo San Filippo e Giacomo* is displayed in Figure 3. Fifteen-minute video clips were obtained at all three cameras shown on the map at the beginning of every hour, from 7 a.m. until 9 p.m. We used these videos to determine how different types of pedestrians behave, including speed, interactions with each other, with obstacles, and with attractions in the square. Additionally, we determined the traffic volume through the square, as well which paths pedestrians take. These can be used in pedestrian traffic models to create realistic simulations.

Moto Ondoso is a problem that the City of Venice has been fighting for years. Prior to this project, the city hired the Redfish Group to construct an autonomous agent model of boat traffic in Venice intended to simulate the effects of changes in traffic regulations. From these simulations the City of Venice could determine what traffic regulations would result in the smoothest flow, and therefore the least damage due to *Moto Ondoso*. However, the data used to construct this model were collected from only 29 monitoring locations located on major canal intersections[3], and were purely quantitative. This resulted in an inaccurate model in which boats frequently took incorrect paths through the city and did not interact correctly with other boats. We monitored 19 intermediate intersections during rush hour traffic to correct these flaws. We recorded data such as volume through the intersection, boat types (displayed in Figure 4), and turning maneuvers, which will correct paths in the model.

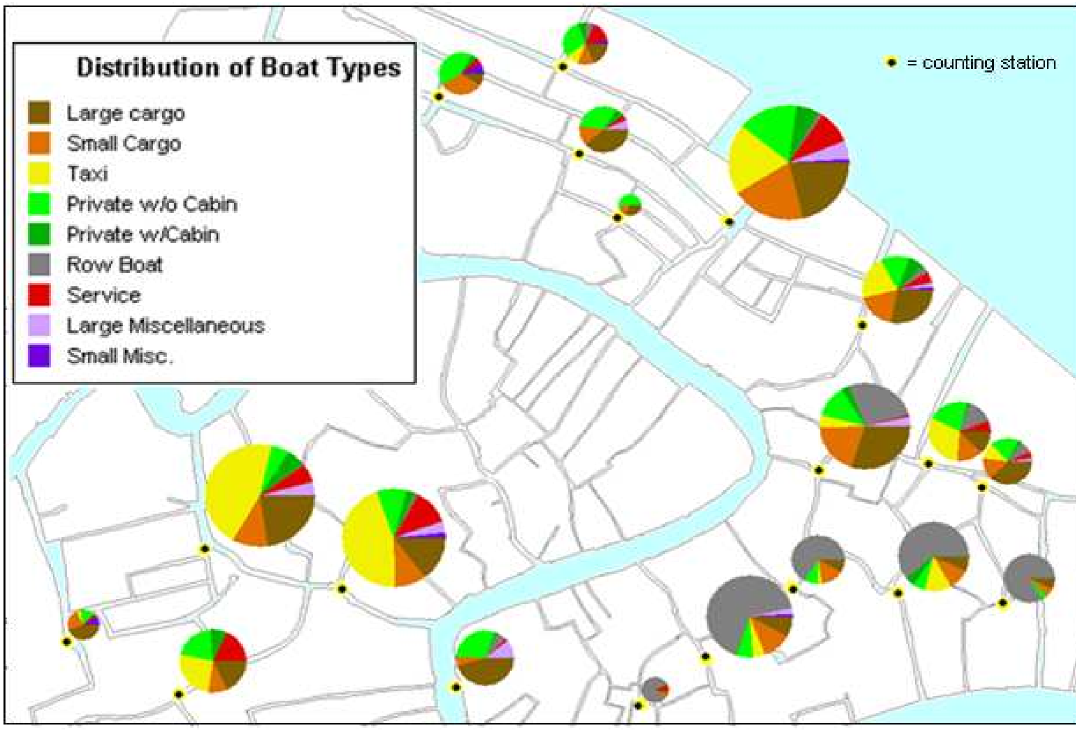

Figure 4: Boat Traffic Data: Volume and Boat Type at Intersections

Additionally, we obtained 15-minute videos from each of the monitoring locations, and delivered them to the Redfish Group, who used them to determine boat behaviors, such as which boats have right-of-way. When these data are incorporated into the model it will be significantly more accurate and useful for regulating boat traffic and reducing *Moto Ondoso*.

[3] Street Performances

This project aided in developing tools for Venetian decision-makers. Once the Redfish Group finishes incorporating our data in the boat traffic autonomous agent model, we envision government officials collaborating over the model shown in Figure 5[4] to develop boat traffic regulations resulting in smooth and efficient flow. This model will be used to dramatically decrease damage caused by *Moto Ondoso*. Additionally, we envision the City of Venice using the pedestrian monitoring methodology we developed to complete pedestrian traffic studies in crowded areas throughout the city. The data from these studies will be used to create pedestrian autonomous agent models based on our platform, which can be used to manage the leasing of *plateatici*. If government officials simulate traffic around a *plateatico* and find that it greatly restricts pedestrian flow, they can choose to remove it as a leasable location, but if pedestrian flow moves freely around the *plateatico*, they can approve it as a leasable space. Additionally, we believe these models will be used to develop a new pricing scheme, in which the price of a *plateatico* directly corresponds to how much it restricts traffic flow. An online system will be developed, in which a shop owner can select *plateatici*, and be informed how much they will cost based on how much traffic flow is restricted. This will help obtain a balance between smooth pedestrian flow and the number of *plateatici* present in Venice. Ultimately, both autonomous agent models that we helped advance will aid in creating a smoother and more efficient transportation system in Venice.

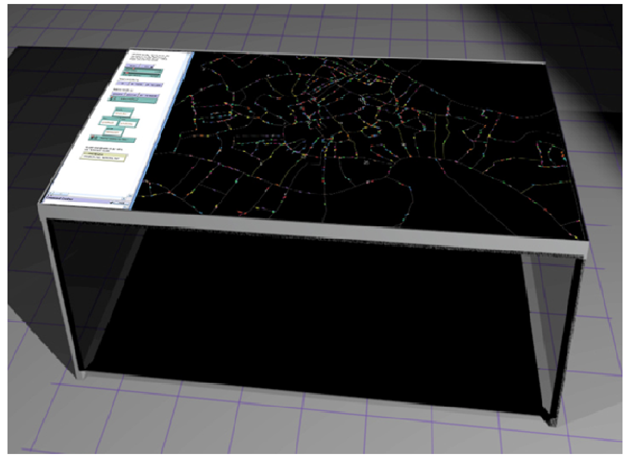

Figure 5: Computer Rendering of Completed Boat Traffic Autonomous Agent Model

[4] This computer rendering was given to us by Stephen Guerin of the Redfish Group

ACKNOWLEDGEMENTS

We would like to extend our appreciation and gratitude to the following for all of their assistance and guidance over the past fifteen weeks. We would like to thank our advisors Professor Fabio Carrera and Professor Paul Davis for making this project possible and for all of their guidance and continual support. We have much gratitude for the insight and assistance that Steve Guerin provided to us on modeling, and for his work to develop a rendered animation of our projected pedestrian model. Thank you, Alberto Gallo, for making our stay in Venice as comfortable as possible. And thank you, Andrea Novella for your technical support and comical relief.

We appreciate your contribution of guidance and support throughout the duration of this project.

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1.0 Introduction

Transportation creates economic and environmental dilemmas such as congestion, noise, environmental pollution and excessive fuel and vehicle costs. During the 7 years between 1999 and 2006, global automobile production increased from 39.8 to 44.9 million automobiles per year[5], resulting in increased traffic. In 2003, the United States wasted $63 billion in time and fuel due to rush hour traffic in congested cities[6]. Additionally, 14% of Americans have left jobs due to unreasonable traffic back-ups along their commute[7]. Worldwide, people are being urged to walk or use public transportation to ease traffic congestion, reduce costs, and optimize flow. Although vehicular traffic is the main source of these problems, it is directly affected by pedestrian movement within municipal areas. European governments, in particular, have been encouraging public transportation and walking, because old European cities were not designed for large numbers of automobiles.

Historic Venice already has the "ideal" transportation system for which most cities are striving. Due to its placement on nearly 120 islands[8] connected by canals and bridges, the only forms of transportation are boats and walking. These two modes of transportation never interact on the same level, allowing for a safe pedestrian environment and eliminating pedestrian interference with boat traffic. Due to the difficulties of maintaining and using a boat, very few Venetians own one, and instead rely heavily on public transportation. However, just as other old European cities were not designed for automobiles, Venice was not designed for motor boats. Many buildings in Venice are placed directly on canals. As boats pass, they generate wake, also known as *Moto Ondoso*. The wake washes against canal walls and foundations, which causes and leads to building collapse. In December, 2001, erosion in Venice was so advanced that the city was declared to be in a state of emergency[9]. Pedestrian traffic in Venice also faces several difficulties. Venice hosts an average of 38,000 tourists per day, increasing its population and pedestrian traffic volume by nearly fifty percent[10]. To cater to tourists, souvenir kiosks and café tables are set up in public areas, restricting walkways and worsening congestion.

Much has been done to understand and improve boat traffic in Venice. Students from Worcester Polytechnic Institute developed a boat counting method in 1998 that was passed to the City of Venice and used for biannual boat traffic counts.[11] A clumsy but functioning model, the Manta model, was developed using the data from these counts. The city then hired the Redfish Group to construct a more sophisticated, interactive model, which is currently being developed. When completed, this model will help decision-makers in Venice update traffic

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[5] Langer, G. *Poll: Traffic in the United States.*
[6] *Focus on Congestion Relief*
[7] Langer, G. *Poll: Traffic in the United States*.
[8] Bhan, R., et. al. *The Inventory and Analysis of the Bridges and Pedestrian Traffic in Dorsoduro, San Polo, and Santa Croce Sestieri of Venice*
[9] Chiu, D., et. al. *The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice*
[10] Carrera, F., et. al. *Street Performances: the Role of Visual Analysis in the Micro-zoning of Public Space in Venice, Italy.*
[11] The Lagoon project

regulations, because it can simulate the effects of blocking canals or adding one-way restrictions. With these capabilities, the model can be used to help decrease *Moto Ondoso* and preserve the city.

While much has been accomplished with Venetian boat traffic, there is much left to be done. The model currently under construction is very sophisticated, but is based on data from only 29 boat monitoring locations. The paths of boats between these intersections in the model are still random. While this model could be useful for making **traffic** regulation decisions in Venice, it would be much more useful and realistic if data were incorporated from intermediate intersections. Although pedestrian studies have been completed worldwide and much could be learned from Venice's ideal pedestrian environment, very little has been done to study Venetian pedestrian traffic. While methods have been developed to monitor pedestrians elsewhere, no method has been adapted to suit Venice. There currently is no technique for analyzing how varying traffic flows or public spaces rented to private entities, also known as *plateatici*, affect pedestrian movement. If a method were developed, tools could be created to aid the City of Venice in leasing out public space and ensuring smooth, efficient pedestrian flow.

Our project developed tools to help traffic management in the City of Venice. We used the previously-developed boat monitoring method to count boats at 19 intermediate intersections. We supplied our data to Redfish, who is incorporating it in the boat traffic model, making it much more accurate and useful for simulating changes in traffic regulations. We also developed a pedestrian monitoring methodology specific to Venice, and used this method to develop an autonomous agent model that simulates traffic through a public square in Venice. The City can use this model to achieve an optimum balance between the space occupied by *plateatici* and pedestrian mobility. Additionally, the methodology developed for monitoring and creating the model can be applied to any public space in Venice.

2.0 Venetian Boat Traffic

This chapter contains the background, methodology, results, and analysis of the boat traffic portion of our project.

2.1 Boat Traffic background

Venice uses a transportation system different from any other. The City of Venice consists of nearly 120 islands, connected by numerous canals and nearly 450 bridges.[12] There are no roads, and no cars, restricting travel to two forms: pedestrian and boat. Of these two forms of transportation, boats create the greatest economic and environmental impacts, therefore requiring careful consideration when regulating it.

2.1.1 Venetian Boat Traffic Background

While most cities are still in transition from private to public transportation, the Venetian government has no need to encourage this switch. Most Venetians either walk to their destinations, or take public boats. Very few Venetians own private boats, due to the immense amount of work required to maintain a boat and the lack of available parking spaces in Venice. These conditions lead to an overwhelming dependence on public transportation.

Boat traffic in Venice consists of three main types: taxi/public transportation, private transportation, and cargo transportation[13]. As depicted in Figure 6, taxi and public transportation constitutes the largest portion of Venetian boat traffic at 46 percent. Private transportation is the smallest, at 18 percent, leaving cargo transportation at 36 percent of Venetian boat traffic. Each of these types of traffic exhibits different behaviors and characteristics, as will be discussed in the following sections.

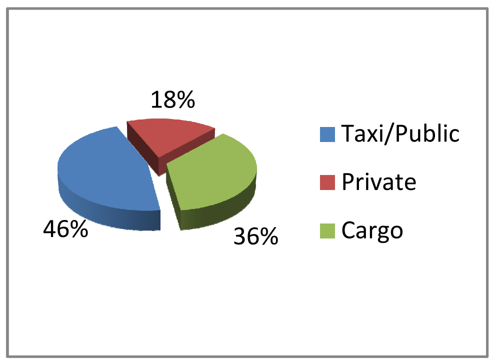

Figure 6: Break-up of Venetian Boat Traffic

2.1.1.1 Taxi/Public Transportation

As discussed above, public transportation accounts for the largest portion of boat traffic in Venice. It can be broken down into three main groups: taxis, gondolas, and scheduled bus-boats, each of which act in unique ways.

Taxi boats, seen in Figure 7, operate as do taxi-cabs on land. A taxi boat waits at a stand for customers to hire it to take them to a specific location. In Venice, the taxi must return to the stand it began at before picking up

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[12] Bhan, R, et. al. *The Inventory and Analysis of the Bridges and Pedestrian Traffic in Dorsoduro, San Polo, and Santa Croce Sestieri of Venice*

[13] Chiu, D., et. al. *The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice*

more clients. This creates a strange flow pattern in which each taxi will begin at a specific location, move through the best route to a new location (this new location changes with every trip), and then return to the starting location. Taxi boats usually run from early morning to late evening, when people are usually outside and moving about the city.

Figure 7: Taxi Boat

Before motor boats became popular, wealthy Venetian families owned gondolas and hired gondoliers to row them about the city (see Figure 8). These boats are now used by tourists who are seeking a traditional Venetian experience. Because tourists use the gondolas, they tend to slow down or stop directly in front of major tourist attractions, narrowing canals, causing congestion and traffic jams.[14] Gondolas begin their trips in locations with high numbers of tourists, and then move through canals in the surrounding area with paths that depend on the tide, and end by returning to a gondola drop-off point. Gondolas run from approximately 10:00 a.m. until 10:00 p.m., as these are the hours when most tourists are walking outside.

Figure 8: Gondola

[14] Chiu, D., et. al. *Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice*

Figure 8: Gondola

The **scheduled boats** in Venice consist of *Vaporetti*, *Motoscafi*, and the *Gran Turismo* (seen in Figures 9 a b, and c, respectively). Each of these boats follow established routes around Venice on regular, predetermined schedules. The schedules give these boats very consistent, predictable behaviors. Scheduled boats run from early morning until late evening, except for the night line, which connects major stops during the hours that other boat lines are shut down.

Figure 9: A) Vaporetto **B) Motoscafo** **C) Gran Turismo**[15]

2.1.1.2 Private Transportation

Although private boats (see Figure 10) constitute only 18% of Venetian boat traffic, their behavior is still worthy of mention. Because boats require much effort for every trip, they are seldom used for everyday tasks like commuting. Instead, Venetians use them for pleasure trips[16], which do not often have set origins and destinations, are not necessarily on the fastest course, and frequently take boats into the lagoon. Due to the nature of their use, private boats tend to run during daylight hours.

[15] Picture from boat monitoring manual in Appendix C

[16] Chiu, D., et. al. *The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice*

Figure 10: Private Boat

2.1.1.3 Cargo Transportation

Cargo transportation comprises 36 percent of Venetian boat traffic and peaks before noon because most cargo is used for restocking food and supply stores. Cargo in Venice is delivered by item; each boat is filled with one type of cargo and travels to every location requiring those products. This results in multiple cargo boats (see Figure 11) servicing the same locations. However, the recommendations of a recently completed Worcester Polytechnic Institute (WPI) student project[17] are being implemented, and the City of Venice is constructing a warehouse near the bridge that connects the islands to the mainland. Cargo entering Venice will first be taken to the warehouse, then sorted and shipped from there by destination, rather than item. This will result in a different traffic pattern, in which cargo boats will begin at the same location, and from there fan out across the city, rarely crossing paths, and eliminating 90 percent of the current cargo traffic[18].

[17] Duffy, J., et. al. *Re-engineering the City of Venice's Cargo Transportation System for the Consorzio Trasporatori Veneziani Riuniti.*
[18] Chiu, D., et. al. *The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice*

Figure 11: Cargo Boat

2.1.1.2 Environmental Impacts of Boat Traffic

After WWII ended, motorboats became popular in Venice. At first these appeared to be excellent tools for improving Venetian life, but as time passed it became evident that wake generated by the boats washed against canal walls and building foundations, speeding erosion. This became known as *Moto Ondoso*. *Moto Ondoso* has become a serious threat to Venice, as several buildings collapse yearly due to the erosion of building foundations along the canals. In December, 2001, the erosion had reached such an advanced stage that Venice was declared to be in a state of emergency.[13]

Figure 12: Damage to Building Foundation Resulting from Moto Ondoso (see footnote 15 for source)

Much has been done to battle the negative effects of boat traffic. The project discussed in section 2.1.1.3 will greatly reduce the wake generated by cargo boats. Additionally, a WPI student project completed in 2002[19] calculated the energy released by common boat types at various speeds, with different payloads. These calculations were indexed, and can be used to compare damage caused by different boats.

[19]Chiu, D., et. al. *The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice*

2.1.2 Canal Maintenance

Canals in Venice are subject to tidal flows, and as time passes sediment builds up in the bottom of them. This blocks sewer pipe exits, causing the pipes to break and drain into foundations, speeding erosion. Additionally, the sediment can build up enough that the canals become impassable to some boats.[20]

The City of Venice alleviates these problems by dredging the canals regularly. When a canal is dredged, most of the sediment that has collected in the canal is taken out and deposited elsewhere. This necessitates closing a canal for up to several months, causing traffic detours and back-ups for boats. However, dredging saves much money by avoiding future problems that would arise if the canals were neglected.

2.1.3 Previous Boat Traffic Studies

In the 1998 lagoon traffic study[21] Worcester Polytechnic Institute students completed the development of a boat monitoring method. It was passed to the City of Venice, who used it to begin performing biannual boat traffic counts in order to obtain data for the construction of a boat traffic model. During the development of the boat monitoring method, the 29 intersections shown in Figure 13 were chosen as monitoring locations. Most of these sites were not on major thoroughfares like the Grand Canal, but were located instead on the busiest inner canals, where there were large numbers of boats in small areas.

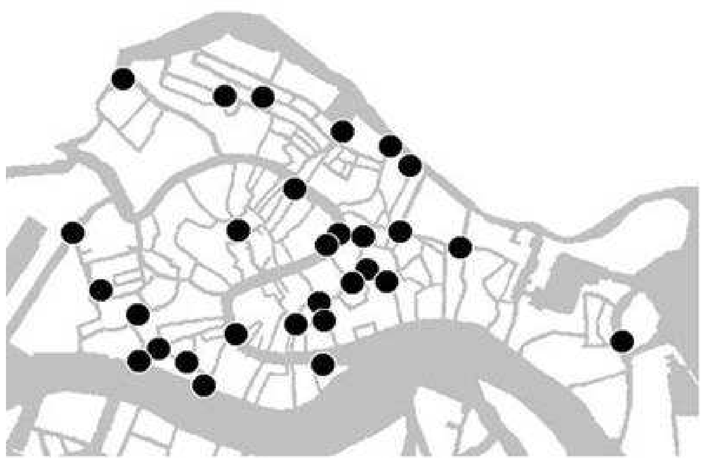

Figure 13: Twenty-Nine Previous Boat Counting Locations [22]

[20] Cioffi, C., et. al. *Development of a Computerized Decision Support System for the Scheduled Maintenance of the Inner Canals of Venice.*
[21] Butler, A., et. al. *Planning and Implementation of Campaigns for the Quantification and Analysis of Venetian Lagoon Traffic.*
[22] Carrera, F., et. al. *Street Performances: the Role of Visual Analysis in the Micro-zoning of Public Space in Venice, Italy.*

For each boat count performed data were obtained on every boat that passed through each site. The data obtained included the type of boat, the turning maneuver (e.g. from A to C in Figure 14), the boat's license number and name, the number of people and amount of cargo, the material of the boat's hull, and the time at which it passed. The license numbers, turning maneuvers and times allowed those performing the counts to reconstruct paths that boats took and determine traffic flow patterns in Venice. The data on boat type, number of people, amount of cargo, and boat material were used to determine which areas boats with certain characteristics are likely to travel.

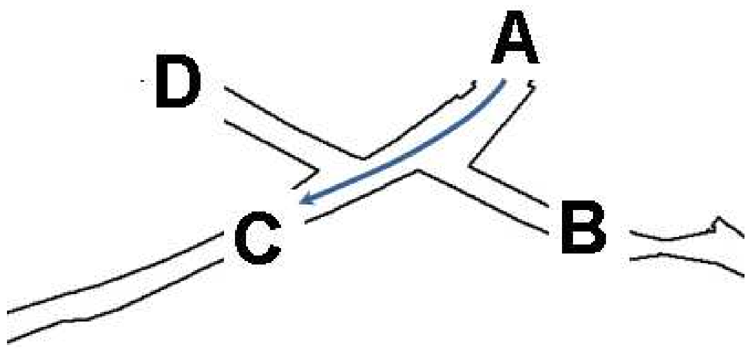

Figure 14: Example of Turning Maneuver[23]

After boat traffic patterns were determined, a model known as the MANTA model was constructed to simulate boat traffic in Venice. This model functioned, but it was not very sophisticated or useful for analysis. Consequently, the City of Venice hired the Redfish Group to construct an interactive autonomous agent boat traffic model.

2.1.4 Autonomous Agent Boat Traffic Model

Autonomous agent models are created to simulate real-life phenomena in order to allow thorough and accurate analysis of the phenomena. An agent in a model represents an individual entity in reality. For example, in a car traffic model, the agents are the cars. In a wolf and sheep predation model, some agents are wolves and other agents are sheep. The agents are autonomous, because they are programmed to obey certain behavioral rules, and when programmed correctly, the model can be started and left to run independently. The output will be a simulation that accurately represents real-life situations, assuming the agents have been adequately programmed with **behaviors that capture the important characteristics of the individuals being modeled**. . Additionally, the behavioral rules or the environmental settings can be changed, and the model output will change to represent the new situation. In the model the Redfish Group is constructing for the City of Venice, the agents are the boats and the environment is the network of canals in Venice.

[23] Carrera, F., et. al. *Street Performances: the Role of Visual Analysis in the Micro-zoning of Public Space in Venice, Italy.*

2.1.4.1 Data Used for Modeling

The data used in this autonomous agent model was that obtained in the biannual counts at the 29 intersections. This data identified the overall traffic volume in the city, typical turning maneuvers made by boats in the monitored intersections, and what boat types frequent which areas of the city. However, this data was not enough to reconstruct the paths boats take between the monitoring locations. As a result, turning maneuvers were assumed to be random at the intermediate intersections within the model.

2.1.4.2 The Agents

Each agent in this boat traffic model is programmed to behave as a certain type of boat. This means that some are programmed to behave as gondolas, others as private boats, and others as each boat type discussed in Section 2.1.1. The agent type distribution matches the boat type distribution currently existing Venice. Additionally, agents can be programmed to obey rules, such as speed limits or one-way routes. Attractors can be built into the program to draw certain agents to them. For example, a famous tourist attraction on a canal can be programmed as an attractor for gondolas, because gondolas are likely to stop there in real life. Each agent will also be capable of selecting the best path among alternatives. If a canal is closed in the model, each agent will be able to choose a different path to reach its destination.

2.1.4.3 Using the Model

When completed, this model will be very useful for Venetian decision-makers who are attempting to regulate Venetian boat traffic. They will be able close canals or make them one-way in the model, and observe the effect it has on traffic. The effects of changes in speed limits or public boat schedules can also be observed. This model will help decision makers know what to expect from changes in regulations. Ultimately, this model can be used to determine which directional rules, speed limits, public boat-line paths and boat restrictions will lead to the least amount of damage due to *Moto Ondoso*.

2.2 METHODOLOGY

As much had been done to gain understanding of boat traffic patterns and their effects, we sought to deepen knowledge of them, using previously developed data collection methods. With our data, we supported the creation an autonomous agent boat model intended to aid boat-traffic decision makers in Historic Venice, the area seen in Figure 15[24].

In order to support the creation of the boat traffic model, we obtained boat traffic data from as many intermediate intersections as possible, and delivered it to the Redfish Group, who used it to expand their model. When completed, this model will be interactive, and will realistically simulate boat traffic using programmed boat behaviors, traffic volume data, and boat-path data.

Figure 15: Study Area - Historic Venice

The following sections of this chapter describe the methodology we used to collect the boat data we delivered to the Redfish Group.

2.2.1 SUPPORTING CREATION OF A BOAT TRAFFIC MODEL TO AID DECISION-MAKERS IN VENICE

While in Venice, we collected data at 19 canal intersections, which we passed to the Redfish Group to support the development of the autonomous agent model discussed in Section 2.1.4. The model had data from 29 major intersections, but was lacking information from intermediate intersections.

2.2.1.1 INTERMEDIATE INTERSECTION DATA

Prior to our project, the City of Venice and previous Worcester Polytechnic Institute student projects had recorded data at 29 major intersections. Although these data were useful, information was lacking from intermediate intersections, reducing the accuracy of modeling efforts. We collected data at 19 intermediate intersections using cameras and manual counting methods, in order to improve the accuracy of the autonomous agent model that the Redfish Group was constructing.

2.2.1.1.1 BOAT TRAFFIC DATA COLLECTION LOCATIONS

Professor Fabio Carrera**,** a leader in the development of the boat monitoring method and selection of previous boat monitoring locations, recommended intermediate intersections to our group based on information gaps and volume of traffic through intersections. Throughout the course of our project, we monitored 19 locations.

[24] Copyrighted Google Maps <www.google.com>.

These locations were all positioned between major intersections that had previously been monitored, **so that data from them would be useful in completing the Redfish model.** The monitoring locations can be seen in Figure 16.

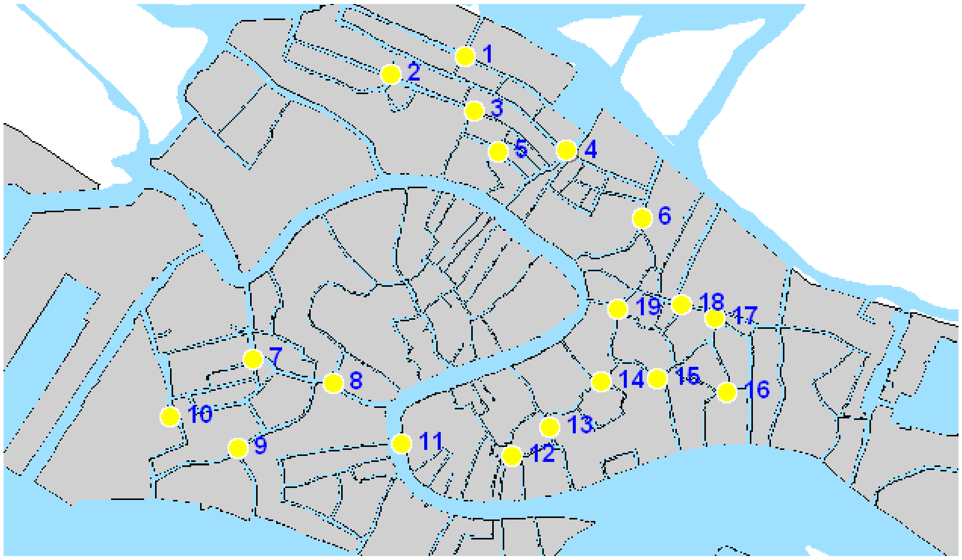

Figure 16: Boat Monitoring Locations

For each monitoring site, a manual counting location was specified from which the majority of the intersection could be seen. Additionally, a camera location was determined at each intersection from which boat interactions and cornering movements could be seen. Lastly, all canals entering an intersection were labeled. The northernmost canal was labeled "A," the next one in the clockwise direction "B," and so on until each canal was labeled, as in the example shown in Figure 17.

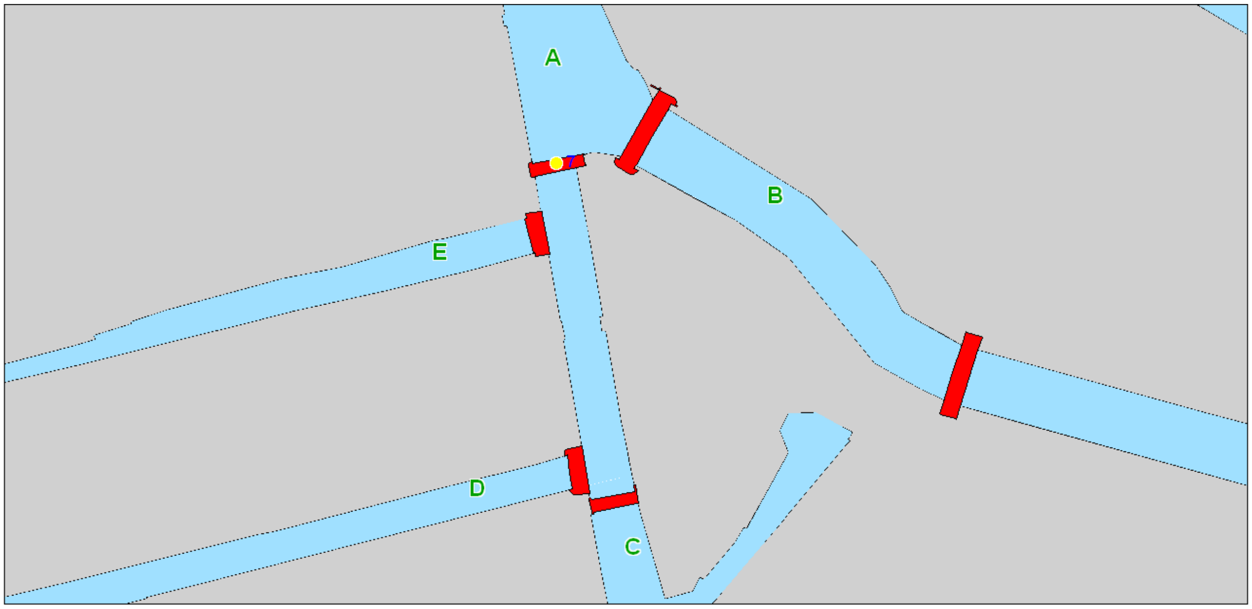

Figure 17: Boat Counting Location Seven

2.2.1.1.2 Boat Traffic Data Collection Schedule

Boat traffic data were recorded on weekdays to remain consistent with previous boat counts. Of available weekdays, Friday was neglected because it is just before the weekend and is therefore not representative of a typical weekday. Wednesday was neglected because cargo shipments are unusual due to the fact that many food stores in Venice are closed Wednesday afternoons. This schedule allowed for boat counts to be conducted on Mondays, Tuesdays, and Thursdays, which were assumed to be equivalently representative of typical weekday cargo behaviors.

The counts were completed between 10 a.m. and noon, because this is when boat traffic peaks according to past studies.

2.2.1.1.3 Intermediate Intersection Data Collection

When intermediate intersection counts monitoring began at 10 a.m. and a boat monitoring form was filled out that can be seen in Appendix B. For each boat, the turning maneuver, type, time of passage, license number, name, number of people and load, hull material and important notes were recorded. To record turning maneuvers, group members referred to maps with labeled the intersections as discussed in Section 2.2.1.1.1, and entered which canal the boat exited, and which canal it entered. To record type, group members used the classification system developed by Worcester Polytechnic Institute, in which different types of boats are labeled with different numbers, as found in Appendix C *Manuale Statzione XX*. This data was transcribed into Microsoft Excel and delivered to the Redfish Group to be incorporated into their model.

Following the two hours of manual data collection, fifteen-minute videos of the intersections were obtained. Cameras were placed to obtain a view of as much of the intersection as possible. Our group did not transcribe data from these videos. Instead, they were sent to the Redfish Group, where those constructing the model analyzed them to determine how boats maneuver through corners, and how boats interact with each other (e.g. a rowboat always has the right of way). An example of a completed form and a still of intersection 5 can be seen in Table 1 and Figure 18 respectively.

Table 1: Example Filled Out Boat Monitoring Form

Maneuver		Type	License		Name	Characteristics		Material	Time	Notes
From	To	#	Prefix	Number		% Filled (/25)	# Of People	Wood(W) / Metal (M) / Plastic (P)		
A	B	3	V	10240			3	W	10:01	
B	A	NR	6V	30615	CA'CORNER		1	W	10:02	
C	B	NR	6V	23685	TODICRIEA	4	2	W	10:02	
B	A	3	NR	NR					10:03	
A	B	3	VE	8822					10:04	
B	C	1	RV	06428	VESTA		1	M	10:04	

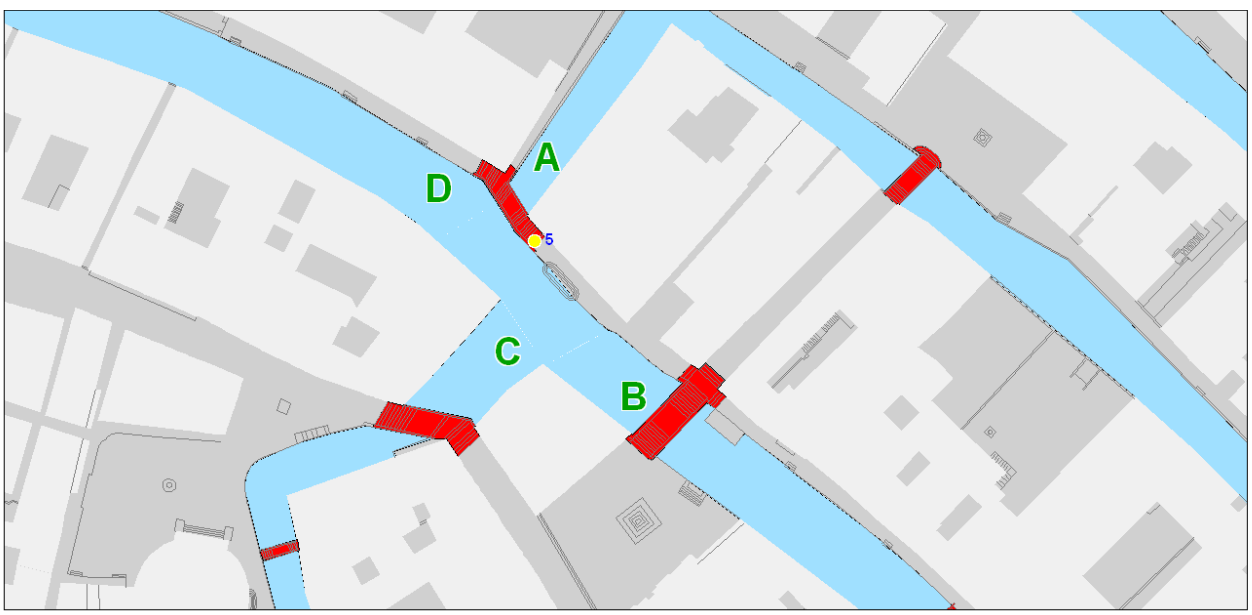

Figure 18: Boat Counting Location Five

2.2.1.1.4 Boat Traffic Data Collection Calibration

Before boat traffic data were recorded, team members were "calibrated," so if all team members were to all watch the same intersection for the same time, they would each record the same results. To calibrate ourselves we studied the boat classification referenced in Section 2.2.1.1.3, and then recorded data as a group in 15 minute periods, until we usually agreed on boat classification, turning movements, etc. When we began to agree on this, we watched the intersection individually for the same exact 15-minute period. After the time ended, we compared results. Once all of our data agreed to within 5% for each type (boat type, maneuver, etc.) we considered ourselves to be properly calibrated to begin data collection.

2.3 Boat Traffic Results

We observed boat traffic at 19 intermediate intersections in Historic Venice in order to enhance a boat traffic autonomous agent model that was under construction. The following sections display the data we obtained.

2.3.1 Intermediate Intersection Counts

The 19 monitoring locations were positioned between major intersections that were observed previously. At each location, the turning maneuver, boat type, hull-material, and time of passage were recorded for every boat that traversed the intersection. When possible, the license number, amount of cargo, number of people on board, and useful notes were recorded. From this information we determined the traffic volume, the break-down of turning maneuvers and what types of boats are present in every intersection. In addition, we determined which intersections are rarely used.

2.3.1.1 Volumes and Boat Types at Intersections

At each intersection, the most basic information obtained included the type of boats, and the volume of traffic through the intersection. The size of each pie chart represents the traffic volume in that intersection, and the wedge colors show the boat types in the intersection. These data are displayed in the map in Figure 19. The raw and summarized data used to construct these graphs can be found in the appropriate excel workbooks files included in the electronic appendix of this project. Figure 19 shows that most intersections in the western portion of the *Cannaregio* district have low traffic volumes, and no gondolas, which is probably due to the narrow canals and residential nature of that section of the city. Moving eastward in the *Cannaregio* district and into *Castello*, the average volume at each intersection increases, as does the percentage of gondolas. This is due to the high tourist concentration in that portion of the city. In *Santa Croce*, *San Polo* and *Dorsoduro*, traffic volumes were high, with no gondolas and many of taxis. We believe the lack of gondolas is due to the residential nature of this portion of the city, and the high concentration of taxis is a result of people moving to and from *Piazzale Roma*.

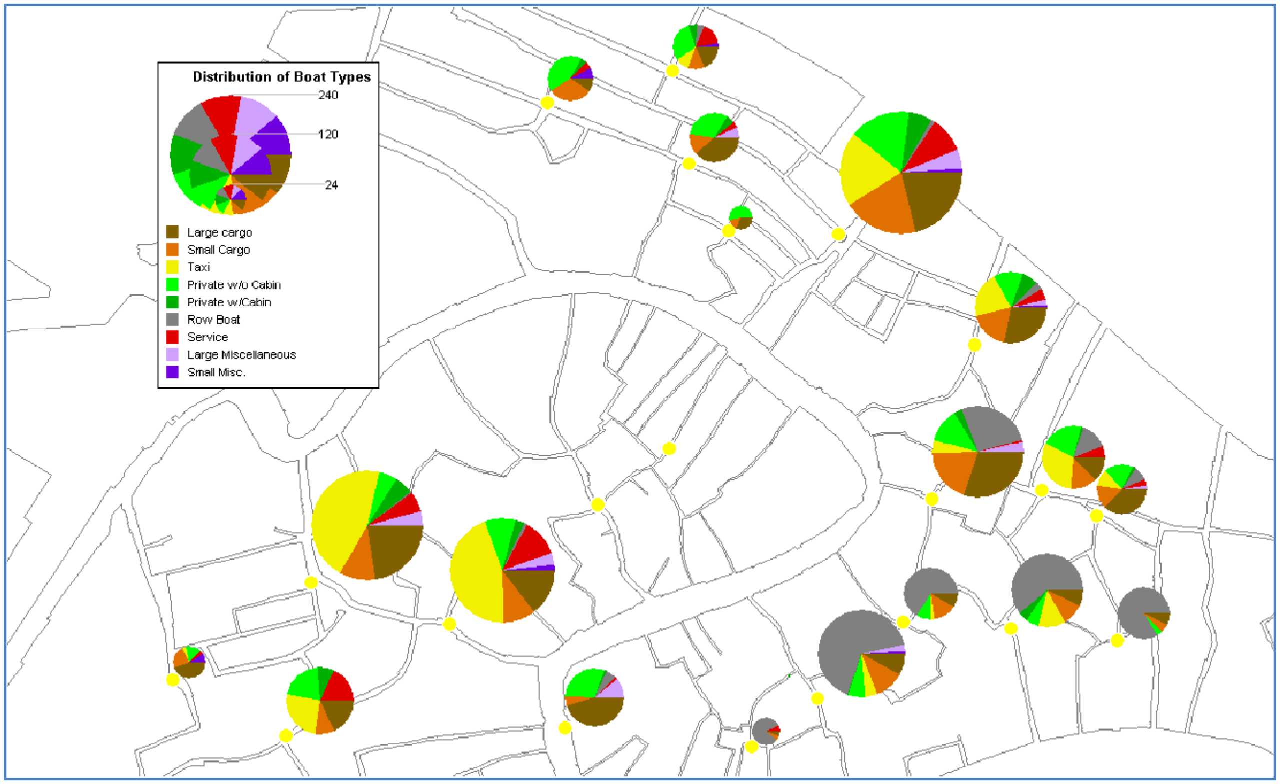

Figure 19: Boat Type and Volume Distribution per Monitored Intersection

2.3.1.2 Boat Turning Maneuvers

Other observations consisted of turning maneuvers made at each intersection. For each intersection this was broken into percentages of each possible turning maneuver. An example of this break-up can be seen in Figure 20, which is a pie chart of the distribution of turning maneuvers at monitoring location 3 (see Figure 19), a four-way intersection.

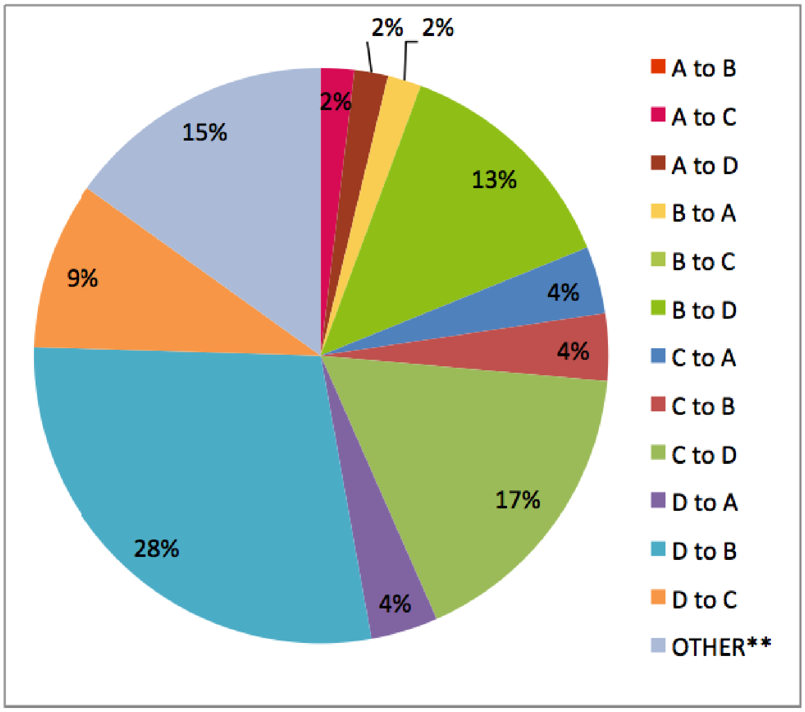

Figure 20: Distribution of Turning Maneuvers at Monitoring Site Three

2.3.2 Observed Boat Behaviors

Using the videos we recorded, the Redfish Group will obtain data such as how boats interact with each other, the shy distance boats' drivers leave between their boat and other objects, and how boats move through corners.

2.3.2.1 Interaction of Boats with Other Boats

Boats in Venice tend to interact in set patterns. For example, when boats are approaching blind corners, the driver blows a horn or shouts to warn other boats of their approach. Any drivers who hear the warning move their boats to places where they will be safe from the boat entering the blind area. Additionally, rowboats have right of way over all other boats, but rowers frequently move aside in an open area to allow faster boats to pass them. The Redfish Group will be able to obtain quantitative data on these and other patterns of interaction from the videos we obtained.

2.3.2.2 Shy Distance Between Boats and Other Objects

Boat operators do not wish to damage their boats or anyone else's boat or property by colliding with them. Therefore boat drivers try to leave some space, known as a shy distance, between their boats and other objects. However, many of our videos show boats maneuvering in such tight places that drivers slide their boats along other boats or canal walls to arrive in the desired position. The Redfish Group will use these videos to determine the shy distance of boats in Venice. We believe the data from these videos will show a direct correlation between boat speed and shy distance.

2.3.2.3 Motion of Boats Through Corners

The Redfish Group will use the videos we collected to observe how boats move through corners. These data are important because various boat types complete turns differently, and each boat corners differently from intersection to intersection. For example, large boats approaching small canals frequently perform multiple-point turns in which they move backwards and forwards small amounts, turning a little with each movement, until they are ready to move into the canal. This type of maneuver often disrupts traffic flow. At intersections where there is sufficient space, these same boats maintain their speed and take smooth lines through corners.

2.4 Boat Traffic Data Analysis

This chapter will discuss how the data presented in Chapter 2.3 assisted the Redfish Group in enhancing the boat traffic model that is currently under construction.

2.4.1 Alterations in the Autonomous Agent Boat Traffic Model

Before this project, the autonomous agent boat traffic model incorporated data from the 29 prior boat monitoring locations, as is discussed in the background section 2.1.4.1. However, this data was only from major intersections, it was purely quantitative and did not include behavioral information. The following sections discuss how the boat traffic data obtained in this project filled in what was missing, and how it was applied to the model.

2.4.1.1Quantitative Modifications to the Model

All data collected on the boat monitoring form (full form shown in Appendix B) were used to make quantitative modifications to the model, in order to improve the model's accuracy. In the current model, the paths that boats take between the 29 previous monitoring locations are unknown, resulting in incorrect, random paths between locations. The data on volumes and turning maneuvers at intermediate intersections, presented in Sections 2.3.1.1 and 2.3.1.2 will help the Redfish Group reconstruct paths that boats actually take, and will result in a more accurate model.

Additionally, the random paths in the current model could have a gondola appear at monitoring locations in the western portion of the *Cannaregio* district. According to the data displayed in Section 2.3.1.1, this would not happen in the canals of Venice. Once our data are incorporated into the model, these errors will not occur in traffic simulations.

2.4.1.2 Behavioral Changes in the Model

In the current model there are no behavioral rules governing boat interactions. For example, when two boats pass each other in a canal, they drive right through each other. Obviously this is not possible in Venice. Additionally, there are patterns of boat interaction, which are presented in Section 2.3.2.1, and shy distances that most boats respect, as discussed in Section 2.3.2.2. These are all behaviors that agents in the model will be programmed to obey, resulting in more accurate traffic flow patterns in the model.

Another flaw in the current model is the method that boats use when cornering. All boats move into the middle of the intersection, spin around their center so they are pointing in the correct direction, and then proceed down the next canal. As discussed in Section 2.3.2.3, there are different boat-cornering techniques that boats use in Venice, none of which are accurately represented by this model. After the data obtained from our videos is incorporated in the model, boats will move more accurately through corners, resulting in better representations of traffic flow through intersections.

3.1 Venetian Pedestrian Background

While most cities are struggling to separate pedestrian and vehicular traffic, Venice, due to its lack of roads, has achieved the ideal separation. Boats operate in canals, while pedestrians move across islands on streets and cross canals on bridges. However, even with this separation, Venice has several pedestrian traffic difficulties, as will be discussed in the ensuing sections.

3.1.1 Tourism and Venetian Pedestrian Traffic

The City of Venice is a popular tourist location. Its native population is only 65,000, while its yearly tourist population has reached 14,000,000, an average of about 38,000 per day. These tourists greatly increase the volume of Venice's pedestrian traffic, and make pedestrian traffic monitoring difficult due to the unpredictable nature of tourist outings.

3.1.1.1 Pedestrian Types

Grava (2003) claims there are three basic types of pedestrians: Brisk Walkers, Meanderers, and those who tarry. Brisk Walkers are usually on tight schedules, with known "origins and destinations". They know the quickest and shortest routes to their goals, creating linear, predictable paths. Due to this linearity and predictability, monitoring and modeling Brisk Walkers are very simple tasks. Meanderers have known "origins and destinations," but are not on tight schedules. They take their time and admire the scenery, occasionally stopping to chat with acquaintances. Their paths are not as linear and predictable as those of Brisk Walkers, making monitoring and modeling more difficult tasks for Meanderers than for Brisk Walkers. Those who tarry are the most difficult to monitor and model. They have no schedules and no known origins or destinations. Their paths are random and virtually unpredictable. Those who tarry walk a little, then stop to look at a piece of artwork, then stroll a little, and stop at an outdoor café, creating a very difficult task for those attempting to study them.[25]

Most Brisk Walkers in Venice are Venetians, people on their way to or from work who know where they are going. They take the fastest routes, and avoid areas dense with tourists due to the slow pace and congestion usually present. Most Meanderers are also Venetians, who are probably running errands or enjoying a slow walk, and have time to stop and chat with friends. Most tourists, however, belong to those who tarry. They do not hurry, and want enjoy the sights. The immense number of outdoor cafés, squares and monuments in Venice supply ample opportunity to pause and appreciate the scenery. Because more than one third of pedestrians in Venice on an average day are tourists[26], Venice presents a challenge for those wishing to monitor pedestrians.

[25] Grava, S. *Urban Transportation Systems: Choices for Communities.*
[26] Carrera, F., et. al. *Street Performances: the Role of Visual Analysis in the Micro-zoning of Public Space in Venice, Italy.*

3.1.2 *PLATEATICI* AND VENETIAN PEDESTRIAN TRAFFIC

Throughout Venice there are numerous squares and wide thoroughfares belonging to the Venetian government. Space from these areas is rented to shop and café owners, who place tables and kiosks outside to attract customers. These are known as *plateatici*. While *plateatici* raise money for the Venetian government[27] and improve business for shop owners, they frequently restrict pedestrian traffic by encroaching on walkways. As *plateatici* are usually located in busy areas to attract as much attention as possible, the traffic restrictions they cause frequently result in congestion and traffic jams.

Figure 21: Pedestrians in Venice

Currently, the Venetian government charges the same rate for spaces abutting walls as for spaces further into the pedestrian walkway. However, the government is considering switching to a new system[28] in which the cost per square meter would be directly proportional to the degree that traffic is restricted by the table or kiosk, forcing shop owners to rent only as much space as necessary, because with every unnecessary square meter, the price per square meter increases.

3.1.3 PEDESTRIAN MONITORING

Pedestrian monitoring has been implemented in cities worldwide in order to obtain safe and efficient walkways for people choosing to walk, whether for commuting or pleasure. Before commencing a pedestrian study in a city, a pedestrian monitoring technique must be carefully selected or developed to ensure its effectiveness in the chosen study area.

3.1.3.1 PAST PEDESTRIAN STUDIES IN VENICE

Although one would expect that Venetian pedestrian traffic would have been studied as it is a very safe environment for pedestrians, very little has been completed in this field. One past study that was completed on pedestrian traffic in Venice was part of an Interactive Qualifying Project for Worcester Polytechnic Institute[29]. This study obtained all the data required for the project, but the method used is not capable of collecting the data required to build an accurate model of Venetian pedestrian traffic.

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[27] Carrera, F., et. al. *Street Performances: the Role of Visual Analysis in the Micro-zoning of Public Space in Venice, Italy.*

[28] Carrera, F., et. al. *Street Performances: the Role of Visual Analysis in the Micro-zoning of Public Space in Venice, Italy.*

[29] Bhan, R. et. al. *The Inventory and Analysis of the Bridges and Pedestrian Traffic in Dorsoduro, San Polo, and Santa Croce Sestieri of Venice*

3.1.3.2 Adapting a Pedestrian Monitoring Technique

Our project adapted pedestrian monitoring techniques from a 2006 New York City study. These techniques include data collection, speed monitoring, and determination of peak flow times.

3.1.3.2.1 Data Collection Technique

The New York City study used a video recording technique for data collection, as video recording and analysis is more accurate than manual recording, because videos can be reviewed multiple times and stored for future analysis. Because 15-minutes is the standard duration of traffic monitoring sessions,[30] the study obtained 15-minute videos. From these videos, rules for pedestrian behavior, volume counts and speed data can be obtained. The only serious drawback of this technique is the immense amount of time required for video analysis.

3.1.3.2.2 Speed Monitoring Technique

To obtain data about pedestrian speeds, 20-45 foot segments of sidewalk were marked off. Someone monitoring traffic timed the first pedestrian to enter the study area, recorded how long it took the person to move through, and calculated the pedestrian's average speed. The gender, age, group size, etc. of the timed pedestrian were then recorded. After all data for the first pedestrian were collected, the person completing the speed study would monitor the very next pedestrian who entered the study area. In this way a random sample of data was collected of all pedestrians moving through the study area.

3.1.3.2.3 Determination of Peak Flow Times

To determine peak flow times, the New York City study monitored traffic through 12 hours of the day. Pedestrian counts were performed in 15-minute intervals throughout the day, and the hours of peak flow were determined from these counts.

3.1.4 Pedestrian Autonomous Agent Model

Developing solutions to mobility problems, such as the restriction of pedestrian flow due to *plateatici*, requires a thorough understanding of traffic flow, which effective models can help provide. Additionally, autonomous agent models can simulate the effects of changes in the environment or the pedestrian characteristics in the model. Therefore an effective pedestrian traffic autonomous agent model could be utilized by Venetian decision-makers who determine how much space is rented to shop and café owners for what price. For a description of how autonomous agent models are programmed, see boat section 2.1.4.

[30] Kutz, M. *Handbook of Transportation Engineering.*

3.2 Pedestrian Methodology

This portion of our project began a new type of pedestrian traffic study in Venice. We gained an understanding of Venetian pedestrian traffic by monitoring and characterizing pedestrians in Venice. We used this understanding to experiment with a pedestrian traffic autonomous agent model specifically intended for modeling flow around *plateatici*.

To understand Venetian pedestrian traffic, we developed a pedestrian monitoring method suited to Venice that used cameras for data acquisition. The videos obtained supplied data sufficient for modeling. We then programmed an autonomous agent model with the aid of the Redfish Group, intended to simulate Venetian pedestrian traffic flow. This model is capable of simulating various traffic flow patterns based on traffic volume, programmed agent behaviors, etc.

3.2.1 Understanding Pedestrian Mobility in Historic Venice

Before our project, pedestrian mobility had not been thoroughly evaluated or modeled in Historic Venice. We developed a pedestrian monitoring methodology in order to understand pedestrian traffic in Venice.

3.2.1.1Monitoring Pedestrians in Venice

Because no significant pedestrian studies had been completed in Venice, very little was known about Venetian pedestrian habits such as common paths, walking speed, attraction to souvenir kiosks, etc. Therefore the monitoring technique we developed can be used to determine rules about how pedestrians in Venice behave.

3.2.1.1.1 Choosing a Monitoring Location

Due to time constraints and limited manpower, we decided to monitor and model traffic flow in one public square. We chose *Campo San Filippo e Giacomo* because this *campo* was as large as our team could monitor, it contains many *plateatici* and souvenir shops, and is frequently used by tourists and Venetians alike.

3.2.1.1.2 Monitoring Method

As video monitoring is accepted as the most accurate means of monitoring pedestrians[31] and as it would supply all the data we required, we chose to use videos for data collection. The videos gave us data on pedestrian volumes, habits, speed of traffic and common pedestrian paths.

3.2.1.1.2.1 Camera Locations

Campo San Filippo e Giacomo is a triangle, with a major entrance in each corner, and a minor entrance on each of the three sides, as seen in the map in Figure 22.

[31] Burden, Amanda M. *New York City Pedestrian Level of Service Study Phase 1.*

Figure 22: Map of *Campo San Filippo e Giacomo*

We decided to monitor the three major entrances, A, B, and C, and also the side entrance d. No traffic was observed moving through e or f for several hours, so we assumed the traffic flow to be negligible through these entrances. We used three consumer-grade cameras to obtain data. We positioned one in entrance f looking across entrance A to the souvenir shops on the far side of the *campo*, and its view can be seen in Figure 23. The second camera was placed in entrance B looking into the *campo*, as can be seen in Figure 24, and the third was stationed near the door of Hotel Rio and spanned the side of the *campo* from C to B, and can be seen in Figure 25.

Figure 23: Camera View into Study Area from Shop Corner between Entrances A and f

Figure 24: Camera View from Entrance B

Figure 25: Camera View near Entrance C from Hotel Rio

3.2.1.1.2.2 Data Collection Methodology

We decided to monitor pedestrians on one weekday and one weekend day from 7:00 to 21:00 each day, to observe how traffic changes throughout the day and with the day of the week. We took 15-minute, simultaneous videos from each camera at the beginning of every hour, and used the 45 minutes between recording to download videos. We used 15-minute videos because 15-minutes segments are the traffic monitoring standard[32].

We developed a data collection form for each of the three cameras, and also one overall form used to compile data. These can be seen in Appendix D, and were used to collect data on stops at souvenir and newspaper kiosks, café tables, souvenir shop windows, pedestrian speeds, path counts, and volume counts.

3.2.1.1.3 Video Analysis

[32] Kutz, M. *Handbook of Transportation Engineering.*

After the videos were obtained, each one was watched multiple times to obtain as much data as possible. The data was obtained as discussed in the ensuing sections.

Two **souvenir kiosks** and one **newspaper kiosk** could be observed from the video positioned in entrance B. Each B-video was watched to determine how many people stopped at souvenir kiosks and at the newspaper stand per 15-minute session. A "stop" was defined as any time a person significantly altered course or speed to look at something in the kiosk or stand.

From the camera facing the C entrance a small strip of **café tables** could be observed. For each C-video the number of people sitting at the tables at the beginning, the number who sit and the number who stand during the video, and the number sitting at the end of the video were recorded.

From the A-videos two souvenir shops are visible. Each A-video was watched, and the total number of **people who stopped at the shop windows** was recorded. A "stop" was defined as any time a pedestrian significantly altered course or speed to look at something in a shop window.

Both the C-camera and the A-camera faced walls with pedestrian walkways before them. For each video, two columns in the walls were chosen as distance markers. When these videos were watched to obtain data on **pedestrian speed**, the group member transcribing data timed how long it took the first pedestrian to cover the space between the distance markers, and calculated the pedestrian's speed. Additionally, the group member recorded the pedestrian's age, group size, whether they were a Venetian or a tourist, and whether they had luggage, a stroller, or cargo. After this data was recorded, the group member selected the very next pedestrian to cross the distance markers, and recorded these data again. In this way a random sample of pedestrian speeds and characteristics was obtained. In addition, age was considered when collecting speed data, and one of five categories was entered. The pedestrian was either categorized as a child, a teenager, an adult, elderly or, if the person was with someone of a different age category, the group member entered mixed as the age. People were defined as elderly if they appeared to be over sixty or showed mobility impairments due to age. Lastly, to determine if a pedestrian was Venetian or tourist, we used the guidelines established by a past WPI Interactive Qualifying Project[33]. Tourists frequently appear lost or disoriented, and wander around watching the scenery, while Venetians appear to know where they are, and they usually walk in a very determined fashion.

There are 14 possible **paths** through *Campo San Filippo e Giacomo*. All paths to and from d and the A to C and C to A paths on the shop side of the square can be seen in the B-videos. The B to C and C to B paths, and A to C and C to A paths on the café side of the square can be seen in the C-videos. When group members are performing

[33] Braghin, E., et. al. *Estimation of the Excursionist Tourists in Venice.*

path counts they simply count the number of people who take each path. Lastly, the A to B and B to A count can be calculated using the other path counts.

There are four entrances to the campo we monitored. The A-video was used to perform **volume counts** for the A entrance, the C-video was used for the C entrance, and the B-video was used the B and d entrances. A volume count simply consists of counting the number of people who enter the *campo* and exit the campo through an entrance.

Before we began individual video analysis, we **validated our video analysis techniques** by each extracting data from the same three videos, and confirming that our volume counts agreed to within 5% and our path counts agreed to within 10%. We allowed for a higher variation in the path counts because determining where some people enter or exit the square relies on an educated guess, rather than plain observation.

3.2.1.2 Characterizing Pedestrians and Pedestrian Behaviors in Venice

The data obtained from the pedestrian videos were sufficient to characterize pedestrians and their behaviors. By obtaining net volume, path data, stop data, speed data, etc. we were able to determine times of peak and minimum flow, the percentage of people who stop at shops, and the speed of traffic through the campo. Additionally, we were able to use the videos to determine how one pedestrian in Venice affects another. We determined this by having one group member stand in traffic and observing how tourists and Venetians moved around our group member, noting an approximate shy space, space left between oneself and surrounding objects

For the purposes of data transcription and characterization, we defined Venetians as people who appear to know their origin and destination, and the best path to connect the two. They walk very quickly, with a confident bearing, and they are not interested in attractions in the square. Tourists were defined as people who do not seem to know where they are coming from or where they are going. They usually walk slowly, with a meandering path and more casual bearings than Venetians.

3.3 Pedestrian Study Results

During two fourteen-hour days of data collection in *Campo San Filippo e Giacomo*, we obtained videos that yielded the times of maximum and minimum traffic flow, commonly used paths through the square, crowd composition, and pedestrian behaviors on a Wednesday and a Saturday.

3.3.1 Volumes of Traffic Flow through the *Campo* at Different Times

The volume of traffic moving through the *campo* varies over the course of the day, as can be seen in Figure 26. On both Wednesday and Saturday the lowest traffic volume occurred between 7:00 and 8:00, and then reached a peak at 13:00. Both days it dropped to a local minimum between 15:00 and 17:00. The traffic peaked again between 18:00 and 20:00 with approximately the same volume as the peaks at 13:00. Throughout most of the day, Saturday's volume was 150-200 people higher than Wednesday's volume, most likely due to the high number of tourists who visit the city on weekends. The form used for data collection can be found in Appendix D.

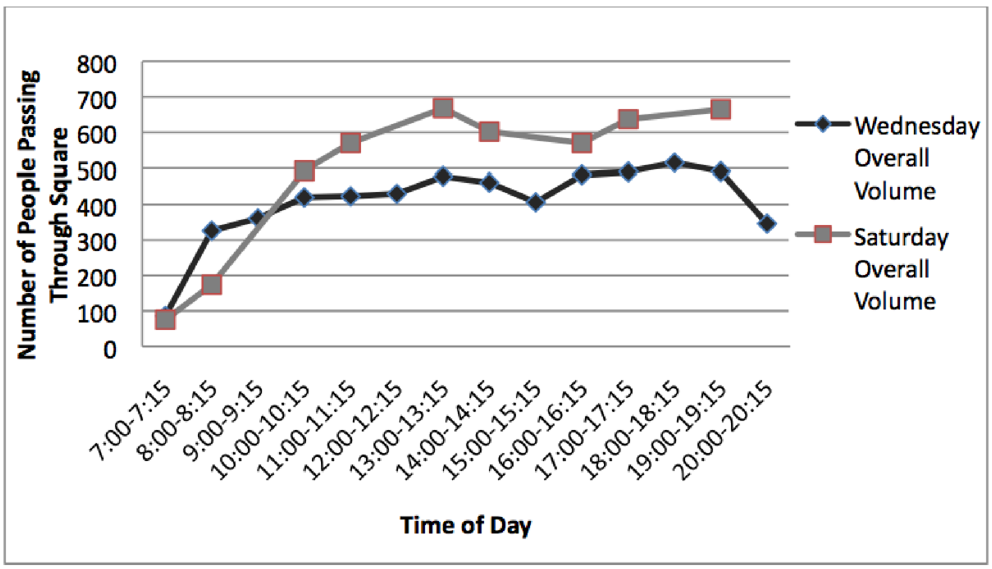

Figure 26: Overall Traffic Volume through Campo San Filippo e Giacomo

3.3.2 Paths Through Campo San Filippo e Giacomo

There are 14 paths through the *campo*, as seen in Figure 27. The most frequently traveled are A to B and B to A. These paths have a higher volume of traffic than the other 12 combined, and are referred to as the major paths (the other 12 are referred to as the minor paths because they are less traveled). This is probably due to the fact that A leads to *Piazza San Marco* and B leads to the *San Zaccaria* boat stop. The path usage throughout the day on Saturday can be seen in Figures 28 and 29, and that of Wednesday can be found in Appendix E. In the chart in Figure 29, the A to C (neg) path is the path that moves around the well, kiosks, and near the shops (*negozio*), and the A to C (café) path is the path directly from C to A that winds through the café tables.

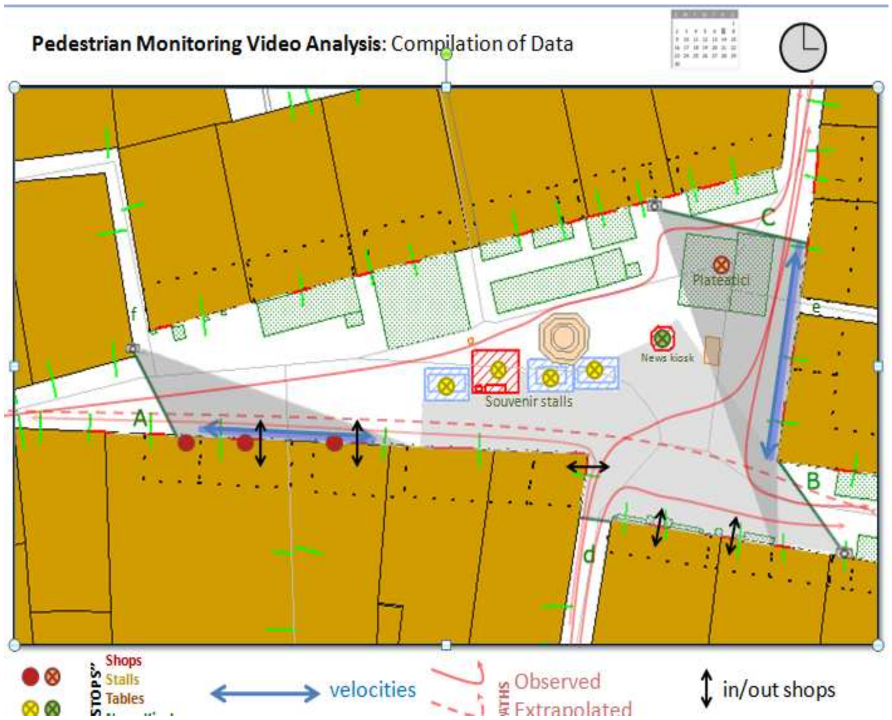

Figure 27: Paths through Campo San Filippo e Giacomo

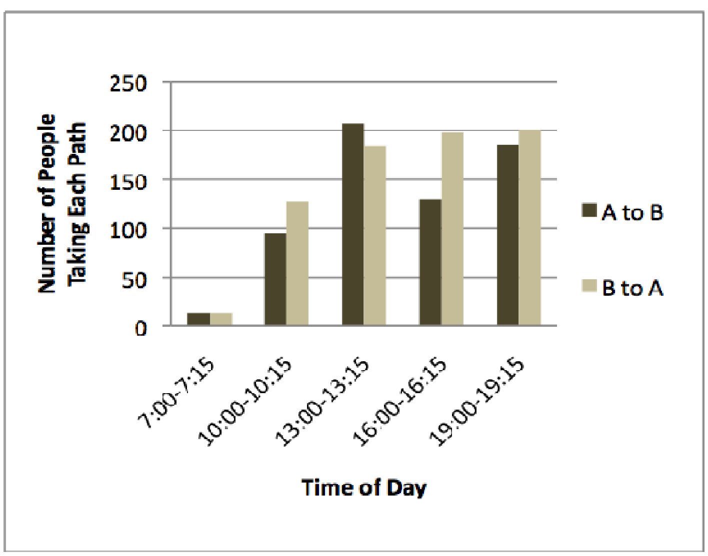

Figure 28: Saturday Path Counts: A to B and B to A

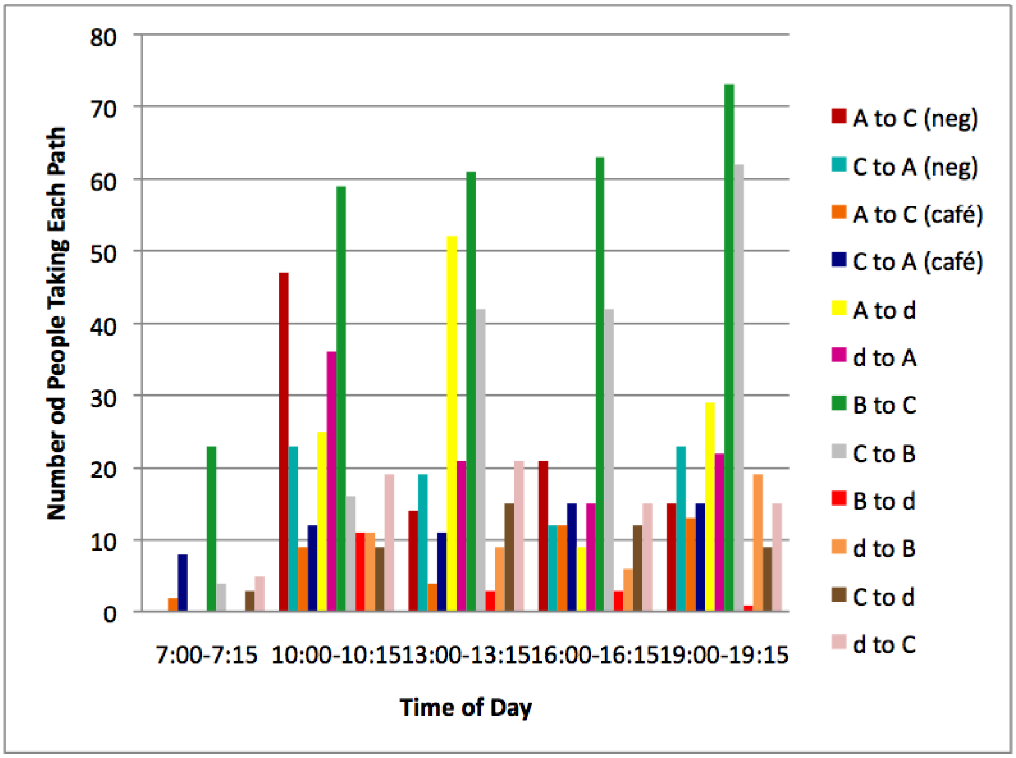

Figure 29: Saturday Path Counts: Minor Paths

As is evident from these charts, B to C, C to B and A to d are the minor paths that are most frequently traveled.

3.3.3 Crowd Composition

In the early morning the vast majority of pedestrians passing through *Campo San Filippo e Giacomo* are Venetians, as can be seen in Figure 30. Between 8:00 and 11:00 the percentage of tourists steadily increases, remaining at approximately 50% on both Wednesday and Saturday. Throughout most of the day, Saturday's crowd is composed of between 5 and 20 percent more tourists than Wednesday's crowd.

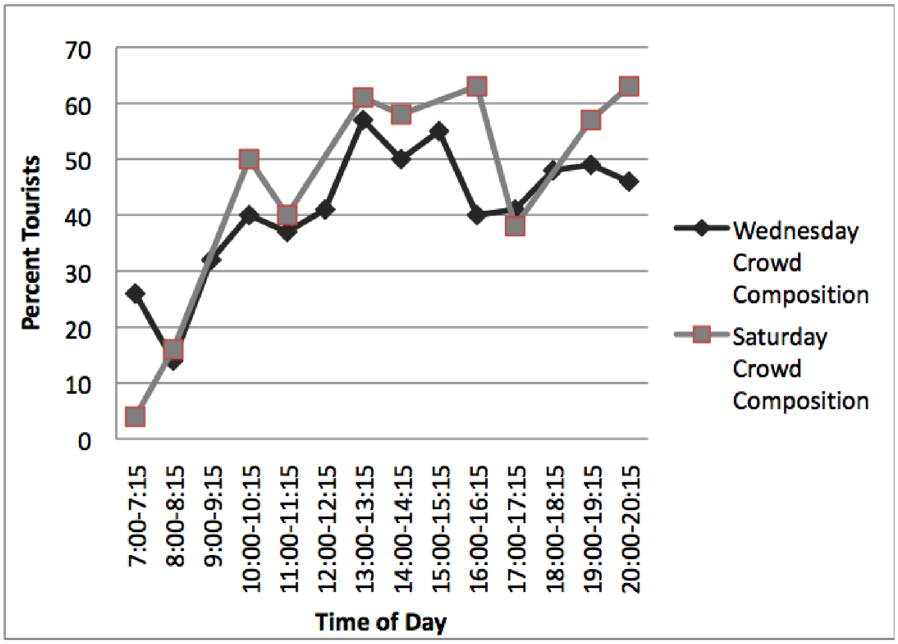

Figure 30: Percentage of Tourists in Campo San Filippo e Giacomo over Time

3.3.4 Pedestrian Behaviors

The video monitoring technique allowed us to collect data on how frequently pedestrians stop at cafés, shops and souvenir kiosks, how fast different types of pedestrians move, and how pedestrians interact with each other and with objects in the walkway.

3.3.4.1 Pedestrian Attractions

Figure 31 is a chart of the number of stops per hour for each unit of that type. For example, we monitored two of the three souvenir stands in *Campo San Filippo e Giacomo*. Between 14:00 and 14:15, an average of 21 people stopped at each souvenir stand, for a total of 42 stops. Because we took the average for each stand, we can extrapolate this data to the last souvenir stand for modeling purposes, and assume that 21 people stopped at this one as well.

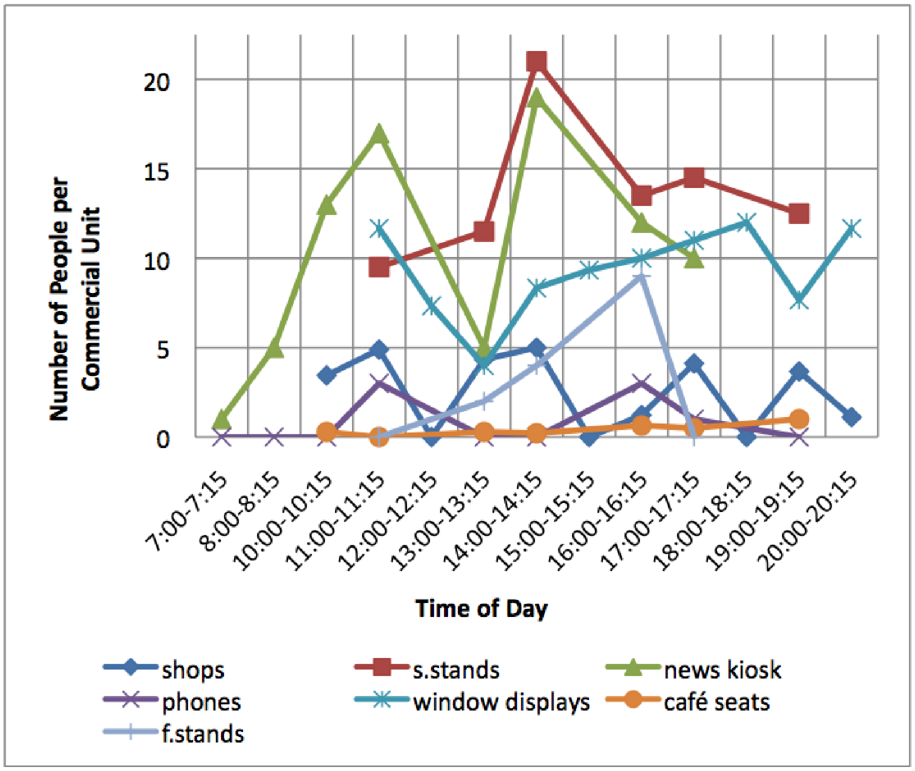

Figure 31: Stops at Attractions V. Time of Day

Figure 31 also shows the operating hours of each of the attractions. The newspaper kiosk opens and closes the earliest, due to the nature of its business. All other attractions begin operation at 10:00 and do not close until at least 19:00. Note that the stops at most of the attractions reach a local minimum at 13:00, which is when the first traffic volume peak occurs. Use of the newspaper kiosk and souvenir stands peak when the traffic is at its afternoon minimum.

3.3.4.2 Pedestrian Speeds

Different types of pedestrians move at different speeds. In *Campo San Filippo e Giacomo*, elderly Venetians and small groups of tourists are the slowest types of pedestrians, with very similar speed patterns. Of the observed pedestrians, elderly Venetians had an average speed of 1.1 m/s, as did the small groups of tourists. Both types also had a minimum speed of 0.3 m/s and a median of 1.1 m/s.

Large tour groups are the next fastest pedestrian type, with an average speed of 1.2 m/s, followed by Venetians with cargo, who have an average speed of 1.4 m/s. Both of these groups show a relatively small range of speeds. The fastest people in *Campo San Filippo e Giacomo* are the typical Venetians, with an average speed of 1.5 m/s. This category also contains the greatest range from maximum speed to minimum speed. This data is summarized by the bar graph in Figure 32. For frequency histograms of the different types of pedestrians, turn to Appendix E.

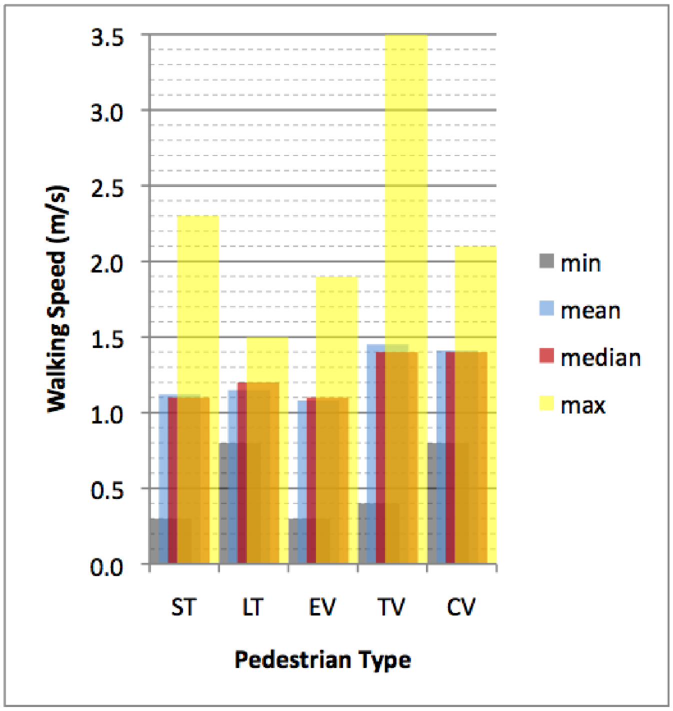

Figure 32: Speed Comparison of Different Types of Pedestrians

3.3.4.3 Pedestrian Group Sizes

Different types of pedestrians tend to move in different-size groups. The most frequent Venetian group-size is one, at approximately 80% of all Venetian groups. A much smaller percentage moves in groups of two or three, and a negligible amount travel in groups greater than three, as can be seen in Figure 33.

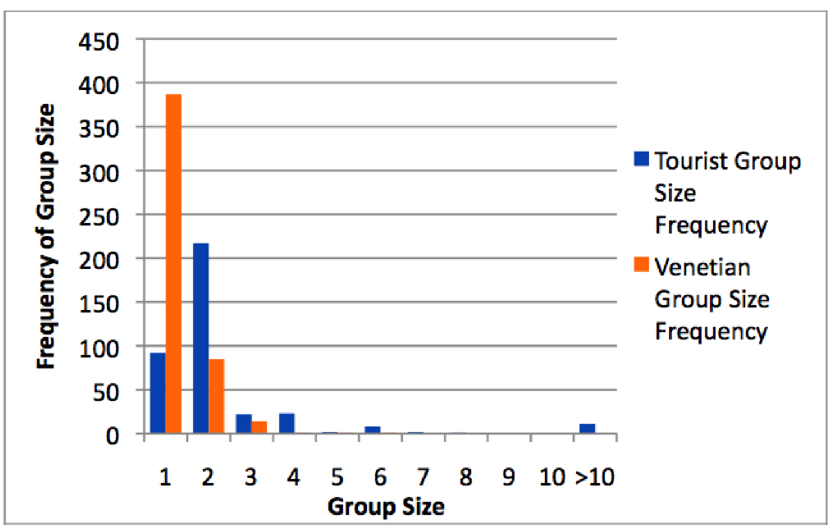

Figure 33: Group Size Frequency of Venetians and Tourists

Although a significant fraction of tourists move as individuals, their most common group size is two. However, tourists have a much greater range of group sizes than Venetians. Of the small tourist groups, groups less than ten, six is the largest size frequently seen. However, a significant number of groups are large tourist groups, ranging from 11 to 50 people.

3.3.4.4 Pedestrian Interaction

Pedestrians in Venice have a very small shy space, the distance they leave between themselves and either people or obstacles in their way. The average shy space observed in *Campo San Filippo e Giacomo* was 0.14 meters. On average, the Venetian shy space is 0.145 m, while that of tourists is 0.133 m. Since shy space data for both Venetians and tourists slightly varies, we decided to pool the data to evaluate the average shy space of pedestrians as a whole. We found that the results represented an indirect relationship to the current volume of the square. At times of low traffic, when pedestrian volume was less than 400 people over a 15-minute interval, our data displayed an average shy space was 0.180 m. The average shy space in medium traffic volume, 400 to 550 people, is 0.143 m, and the shy space during high traffic volume, greater than 550 people, is 0.131 m. From this data it appears that Venetians have a larger shy space than tourists. Additionally, the shy space of pedestrians in Venice decreases as the traffic volume increases, as can be seen in Figure 34.

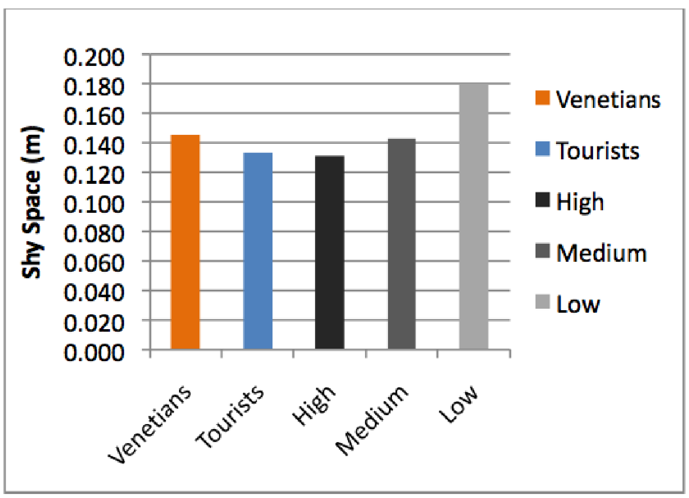

Figure 34: Shy Space of Pedestrians in Venice

3.4 Pedestrian Study Analysis

We used the data from Section 3.3 to develop an autonomous agent model of *Campo San Filippo e Giacomo,* designed for the purpose of helping the Venetian government manage the leasing of *plateatici*. To construct the model, we used the data obtained to characterize pedestrians in Venice, and programmed the model to reflect the characteristics of different types of pedestrians in Venice.

3.4.1 Characterization of Pedestrians in Venice

We classified pedestrians based on various trends observed. This method is known as characterization. Once the groups and their trends were established, we were able to program the agents in the model to behave likewise in order to give a realistic representation of pedestrian traffic in Venice.

3.4.1.2 Venetians and Tourists

As discussed in Section 3.2.1.2, we split pedestrians in Venice into two basic groups, Venetians and tourists. We identified five sub-groups of Venetians and tourists that displayed different behaviors from other groups. Among Venetian, the elderly and people with cargo move or behave differently from typical Venetians. Among tourists, small groups and large groups behave very differently.

Typical Venetians, those who appeared to be familiar with their surroundings**,** usually travel as individuals, with an average speed of 1.45 m/s. Venetians have the largest range of speed of any pedestrian type, with a difference of 3.1 m/s. The average Venetian also has a shy space of 0.145 m.

Elderly Venetians were defined as people who appeared to be over 60, or those who showed mobility impairment due to age. Elderly Venetians have the same behavioral traits as typical Venetians, except for their traveling speed. Elderly Venetians have an average speed of 1.08 m/s, and a range of 1.6 m/s. Due to the small amount of available shy space data, the shy space of elderly Venetians was not calculated.

We considered a **Venetian with cargo** to be a Venetian either pushing a cart, towing a souvenir stand, or transporting another similar item. Venetians with cargo have the same traits as typical Venetians, except for their size and traveling speed. Venetians with cargo have an average speed of 1.41 m/s, with a fairly small range of 1.3 m/s. Venetians with cargo take up a large amount of space compared to typical Venetians and elderly Venetians. Similar to the elderly Venetians, there was not enough available shy space data to calculate the average shy space of Venetians with cargo.

Small tourist groups were defined as groups of 1 to 10 tourists. We included individuals in this classification because throughout monitoring and data transcription we observed that their behavior did not differ significantly from that of small groups of tourists. Small tourist groups followed each of the general tourist rules outlined in Section 3.2.1.2. Additionally, they frequently stopped to consult maps. Small tourist groups have an average speed of 1.12 m/s. The range of speeds of small tourist groups is a moderate 2.0 m/s. They have approximately the same minimum speed as typical and elderly Venetians, but they have a fairly low maximum speed, of only 2.3 m/s. Finally, the average shy space for tourists is 0.133 m/s.

We defined a **large tourist group** to be more than 10 tourists traveling together. In large tourist groups, individual tourists maintain the tourist behavior outlined in the previous Section 3.2.1.2, but the groups behave quite differently. Large tourist groups are usually led by one person who knows his origin and destination, and the best path to connect the two. However, they can only move at the pace of a typical tourist moving through the square, so they display mixed characteristics. As a group they usually moved directly through the timing area without stopping, with an average speed of 1.15 m/s, slightly higher than small tourist groups. Additionally, large tourist groups have a very small speed range of 0.7 m/s. Since individuals in a large tourist group strive to remain within close proximity of other members, there is a constant congestion, in the vicinity of this group. Lastly, the shy space of tourists in large tourist groups was taken to be equivalent to that of tourists in small tourist groups, because as individuals the tourists behave similarly.

3.4.2 Crowd Composition

Figure 30 shows the percentage of tourists in *Campo San Filippo e Giacomo* for each hour of Wednesday and Saturday. However, for modeling purposes the percentage of each of the five characteristic groups of pedestrians must be known. The ratio of elderly Venetians to the total number of Venetians does not change over the course of the day. The same is true of the typical Venetians and Venetians with cargo. Additionally, the ratio of tourist groups to the total number of tourists does not change over the course of the day. Therefore, these ratios were entered as constants in the model.

3.4.3 Traffic Volume and Path Analysis

The overall volume of traffic through the *campo* changes throughout the day; see Figure 26. As the volume increased, the overall average shy space of pedestrians in the square decreased, as shown in Figure 34. Also, one might expect that a high volume of traffic would lead to a large number of stops at attractions, but this is not always the case, represented in Figure 31.

For five monitoring sessions throughout each day we computed the percentage of each path traveled. For example, during the 13:00 session on Wednesday, 122 people entered at B. Of these people, 66 percent exited through A, 27 percent through C, and 7 percent through d. These values were also calculated for those entering through A, C and d (For a complete chart displaying these data, see Appendix E). These data were used to program agents to take correct paths in the model.

3.4.4 Pedestrian Autonomous Agent Model

The last portion of data analysis was to develop an autonomous agent model of the *campo* based on the quantitative results outlined in Section 3.3 and the behavioral analysis presented in Section 3.4.1.

3.4.4.1 Our Completed Model

Our pedestrian model of *Campo San Filippo e Giacomo* includes *plateatici*, souvenir kiosks, the newspaper stand and the well in the center of the square as obstructions to the pedestrians. Agents were programmed as two basic types of pedestrians: Venetians and tourists. The Venetian agents move at the average speed of typical Venetians, 1.45 m/s, and tourist agents move at the average speed of small groups of tourists, 1.12 m/s. Each pedestrian agent is a 0.5 m-diameter circle. The model is set to simulate traffic at 13:00 on Wednesday. The traffic volume is equal to that observed, 505 people through the square per 15 minutes, and the path usage is set to equal that observed. Additionally, the crowd composition is equal to that observed at 13:00 on Wednesday. Due to lack of programming knowledge among the team and limitations of NetLogo no other traits were included. A screenshot of the model is included in Figure 35.

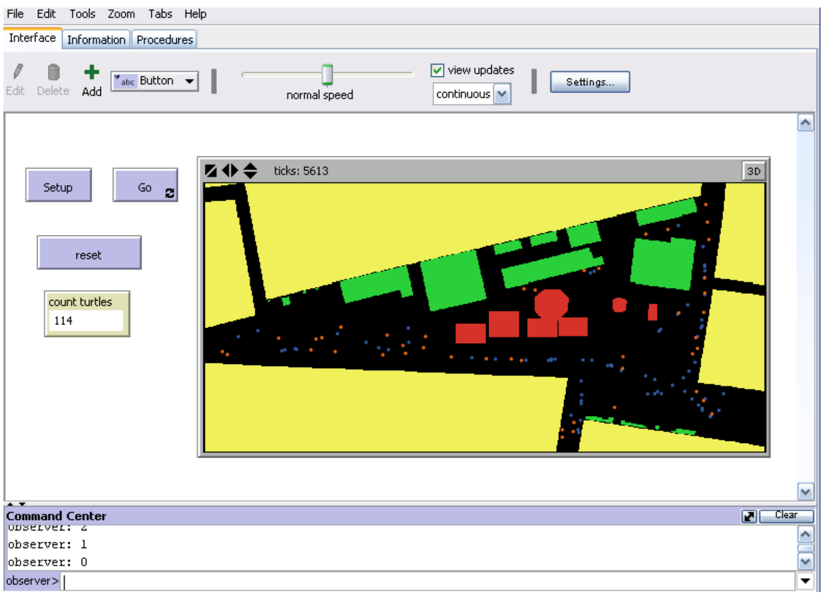

Figure 35: Screenshot of Pedestrian Autonomous Agent Model

This model qualitatively simulates traffic volume and path usage observed in the square at 13:00 on Wednesday. The interactions between pedestrians mimic those observed in *Campo San Filippo e Giacomo.* Additionally, the volume of people in the square at a given time is approximately equal to those observed in the videos from 13:00 on Wednesday. Agents avoid the obstacles and each other. The paths they use are precisely those found in the videos. Although the agents are programmed to move at the observed speeds, they take more time to traverse the square than the pedestrians in the *campo* actually do. The general qualitative accuracy observed in the simulation produced by our model validates the monitoring methodology we developed and suggests the promise of more sophisticated versions of such models for exploring policy alternatives. A 3-D rendering of the model can be seen in Figure 36.

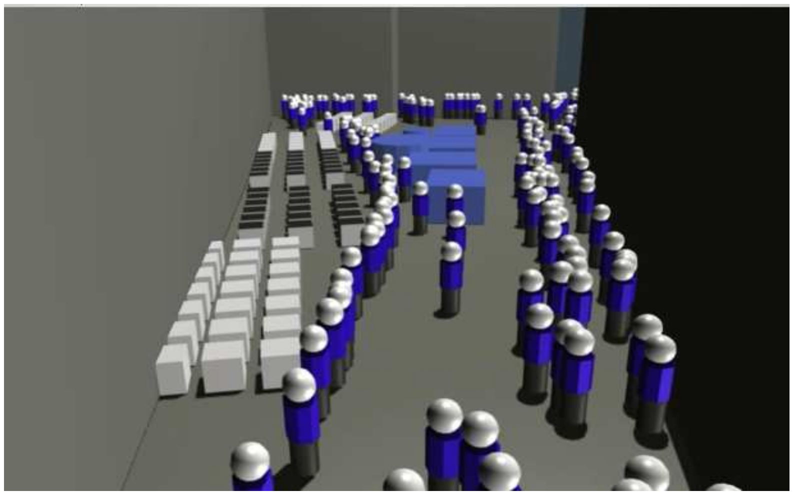

Figure 36: 3-D Rendering of Autonomous Agent Model

Although our model accurately simulated many qualitative aspects of pedestrian traffic in *Campo San Filippo e Giacomo,* it agents lacked characteristics necessary for a more realistic representation of pedestrian traffic within the square. No agents stop in the square, nor do any pedestrians slow down near the various attractions in the square, both of which were behaviors frequently observed in the *campo.* The pedestrians do not move in groups, and groups cause the vast majority of traffic flow problems in the square. Finally, the simulations from this model never show any minor traffic back-ups, which are frequent occurrences in *Campo San Filippo e Giacomo.* These shortcomings should be corrected by simply including more of the characteristics explained in section 3.3.

Table 2 contains a list of agent properties and Table 3 contains a list of model properties that we believe would create a sufficiently sophisticated model for accurately simulating Venetian pedestrian traffic and the effects of *plateatici* on it. Additionally, this table lists the properties currently included in our model, and which properties it is possible to program using NetLogo.

Table 2: Useful Properties for Agents

Property of Agents	Do Our Agents Have It?	Is NetLogo Capable?
Types of pedestrian (elderly venetian, small tourist groups, etc.)	YES – Have Venetians and tourists	YES – Capable of having as many types as necessary
Size (different size for different types of pedestrian, e.g. venetians with cargo are large)	NO – Have only one size for every type	NO – If agents are different sizes, they will walk over each other
Speed (each agent type set to observed speed)	YES	YES
Groups (agents move in group sizes)	NO	YES
Shy Space (space that pedestrians leave between themselves)	NO	NO

Table 3: Useful Properties for Model

Property of Model	Does Our Model Have It?	Is NetLogo Capable?
Obstructions with adjustable size (café tables, souvenir kiosks, etc.)	NO – Have the obstructions, but the size is not adjustable	YES
Adjustable volume for each hour of the day	NO – Only have 13:00 on Wednesday, Nov. 5	YES
Adjustable paths for three-hour segments of the day	NO – Only have 13:00 on Wednesday, Nov. 5	YES
Adjustable crowd composition (percent of each type of pedestrian)	NO – Only have 13:00 on Wednesday	YES
Attractions (each attraction has strength draw observed)	NO	YES – Each attraction can be made to attract different types of agents

4.0 Conclusions and Recommendations

One result of this project is a pedestrian monitoring methodology effective in Venice, a place with many tourists, narrow alleys, and public squares filled with souvenir kiosks and outdoor café tables. Applying this methodology provided the data essential to constructing an accurate autonomous agent model of pedestrian traffic in Venice; pedestrian types and causes of traffic congestion are among the most useful produce of our observations. While in Venice we also collected data describing boat paths and their qualitative behavioral to improve the realism of the Redfish Group's autonomous agent boat model.

4.1 Monitoring and Modeling Pedestrians in Venice

The pedestrian monitoring methodology we developed proved effective in Venice. Pedestrian traffic studies frequently use videos because they are accurate and reviewable, which is why we chose to use them. However, few pedestrian monitoring studies face the challenges we found in Venice. We needed a method able to monitor large, open areas, rather than sidewalks, and we needed to be able to reconstruct many different paths, in order to make our model accurate. Additionally, we needed to be able to obtain large amounts of qualitative, behavioral data - the interests of pedestrians, the paths they took, how quickly they moved, group sizes, etc. - in order to be able to accurately program agents in the autonomous agent model that we constructed. When this methodology is used in the future, we recommend including an overhead camera for data collection, as it would ease path reconstruction, speed measurement, population counts, and crowd density observations.

4.2 Pedestrian Traffic in Venice

Pedestrian traffic flow congestion in Venice is usually caused by one of three obstacles: people blocking thoroughfares, outdoor souvenir kiosks, café tables, etc. or public spaces that are occupied by other obstacles such as a phone booth.

Tourists travel through most of Venice in groups. Small tourist groups tend to stop in streets and squares to consult maps or to decide as a group which way to go. These stopped groups force other pedestrians to move around them, often causing traffic backups. Large tourists groups usually travel at a quick pace, but they frequently stop in open areas to re-group, resulting in up to 50 people milling about, forcing other pedestrians to walk around or through their group.

Souvenir kiosks, café tables and other public spaces occupied by private structures frequently encroach on pedestrian thoroughfares, resulting in narrow walkways and slowing pedestrians. Additionally, they are usually placed in areas of heavy traffic, as shop owners seek to attract as much business as possible.

One other type of obstacle to pedestrians is public structures that are not commonly used. For instance, one of two possible paths to go from entrance C to entrance A in *Campo San Filippo e Giacomo* (see Figure 27) is a smooth curve through the center of the square. However, in the middle of this path there is a set of pay phones. These payphones are rarely used and take up valuable public space in the *campo*.

To further improve modeling of pedestrian behavior, . we recommend that the City of Venice conduct a two-week pedestrian characterization study. This study would focus on separating pedestrians in Venice into certain characteristic groups that could have behavioral rules assigned for modeling. If the study lasted two weeks, pedestrian flow patterns could be documented over different days of the week, and in different types of weather. If this study were completed, the City of Venice could build pedestrian traffic models without having to perform studies to characterize pedestrians prior to construction. The only data that the city would have to obtain for a new model would be volumes, paths, and crowd composition.

We recommend that the City of Venice implement our monitoring technique in other crowded areas in Venice to determine volumes, paths and crowd composition for different times of day and days of the week. If the previous recommendation were acted upon, video analysis would be brief and simple because pedestrian types would already be defined.

We recommend that the City of Venice use pedestrian autonomous agent models to develop a pricing scheme for *plateatici* that makes the price of a space directly proportional to the amount it restricts pedestrian flow.

4.3 Boat Traffic in Venice

Our boat traffic monitoring improved the realism of the boat traffic model that the Redfish Group is constructing. Our work adds location-specific data at 19 new intersections as well as a considerable volume of qualitative observations.

We recommend that the City of Venice perform a day-long intermediate intersection count similar to the biannual traffic counts performed at the 29 major intersections originally monitored in Venice. This effort would yield boat traffic data at the intermediate intersections for an entire day, and all the sites would be monitored simultaneously, making it possible to trace individual boats. Additionally, it would provide turning information at intermediate intersections for different volumes of traffic.

We recommend that our boat video-monitoring technique be altered so the videos can be used to easily obtain data such as boat speed and motion through corners. We believe an overhead camera would be the best solution to this as it would allow the horizontal motion of boats to be observed through corners.

Once the Redfish Group's autonomous agent boat model is finished, we recommend that the City of Venice use it to model the impacts of changes in regulations. The model can simulate the effects of changing the directionality of canals, closing certain canals, changing speed limits, etc. Ultimately, the outputs of the model could be paired with data from the 2001 Worcester Polytechnic Institute project[34] that indexed the amount of energy released into the canals by different types of boats to determine which set of regulations releases the least amount of energy into the canals. This would reduce *Moto Ondoso*.

4.4 Venetian Traffic

To date, no study has tied boat and pedestrian traffic together, although they frequently interact at places like boat drop-offs, and pedestrian paths are largely influenced by the location of boat stops. We recommend a study that examines the interactions of boat and pedestrian traffic in order to build models to simulate these interactions and guide policy makers. Understanding the link between the two forms of transportation would make it possible to fully understand each type individually. Fully comprehending both types of traffic could lead to Venice having one of the smoothest, most efficient transportation systems in the world.

[34] Chiu, D., et. al. *The Moto Ondoso Index: Assessing the Effects of Boat Traffic on the Canals of Venice.*

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Appendix A: Annotated Bibliography

Amlaw, Karolyn, Kervin, Carie L., Mondine, Ignacio and Vepari, Charu. Optimization of Cargo Boat Deliveries Through the Inner Canals of Venice 1997

This report delves into one of the most prominent sources of boat traffic throughout Venice. It provides data both previously recorded, and data recorded during the teams stay in Venice. The team analyzed primarily boat traffic due to cargo boats throughout the city, and the system used to deliver goods to the various islands of Venice. It offers possible changes in the system that can increase efficiency of deliveries greatly. According to the team a small island that currently gets deliveries from 96 boats each day can be reduced to getting deliveries from only 3 boats, more filled and more specialized to that island. This data released valuable boat traffic data that can add to our team's analysis. Unfortunately, the information may be too outdated since it is believed the city is currently implementing change to their delivery system to a more beneficial system offered in the project.

Bhan, Rahul, Deliso, Ashley, Hubbard, Stephanie and MacLeod, Greg. The Inventory and Analysis of the Bridges and Pedestrian Traffic in Dorsoduro, San Polo, and Santa Croce Sestieri of Venice. 1998

This past Venice IPQ documented important specs for every bridge in the three sestieri, and then the students went on to begin monitoring pedestrian traffic in the same area. For this reason it will prove very useful to our project. Thus far it is the only pedestrian traffic study that we have found in Venice, and it will probably act as a template for our pedestrian studies in Venice.

Braghin, Eduardo, Calvo, Carlos R., Gozubuyuk, Ark and Hodos, Mark B. Estimation of the Excursionist Tourists in Venice 1999

This project estimated the number of tourists who visit Venice for the day and do not spend the night. They developed a method for determining who was a tourist and who was a Venetian, and then they developed a method for determining which tourists were residential tourists, and which ones were excursionist tourists. This project will prove useful if any of our pedestrian counts focus on tourists in Venice because it will help us to determine who is a tourist and who is a Venetian.

Bu, Fangping, Diogenes, Mara C., Greene-Roesel, Ryan and Ragland, David R. Estimating Pedestrian Accident Exposure: Automated Pedestrian Counting Devices Report 2007

This report explored the use of automated methods used to detect and count pedestrians. It focused on examining automated methods to count vehicular traffic and the appropriate adaptation to collect pedestrian data, given a separate set of requirements and collection circumstances such as the accuracy levels, budget and data need specifications. The technologies explored included piezoelectric sensors, acoustic, active and passive infrared, ultrasonic sensors, microwave radar, laser scanners, and video imaging. The strengths and weaknesses of each technology were explored. The report concluded that that infra-red beam counters, passive infrared counters, and piezoelectric pads were the most effective in pedestrian counting studies.

Bukowski, Gregory J., Dougherty, Briana E., Morin, Russell W. and Renaud, Patrick. Optimizing the Use of Canal Parking Space in Venice 2006

This project focused on how parking affects traffic in Venice, and how the current method of applying for a parking permit could take up to ten months for a reply. This project recommended new methods of applying for a permit and also for marking out parking spaces. This analysis that this project used could be very useful in determining the effect of having public areas in squares and streets taken by cafes and markets.

Cappe, Marni. Breaking Gridlock—Lessons from London's Success Story. http://www.irpp.org/po/archive/feb04/Cappe.pdf

This report is also very useful for Move 1 of the Introduction, but more importantly, it is essential to understanding potential methods of resolving traffic issues. This article discusses the "congestion charge" enacted in London (5 pounds to enter the center of the city) and how there are 50000 less cars in the city on a daily basis and traffic back up times have dropped by 30%. This article will help us understand traffic and the people involved in it.

Caruso, Russell W., Cryan, Marc P., Holton, Amy E., Pancheri, Francesco Q. and Schady, Marianne. An Assessment of the State of Tourism in Venice: A Quantitative Estimate and Characterization of Excursionist Tourists 2000

This report supplies insight of the current status of Tourism in the City of Venice. It depicts various types of tourists throughout the city, depending on their trip criteria and background. The report analyzes how far along the "'Life Cycle' of Tourism" Venice rests. The report makes available various data both evaluated from previously established sources, and recorded during the teams seven week stay in Venice. The data released in the report shows the various paths taken by each type of tourist defined in the paper. This report supplies valuable information to our project in the form of pedestrian data. The paper highlights ratios of civilians to tourists in various spots throughout Venice, which will help us to make decisions on the most valuable spots to retrieve data throughout the city.

Central London Partnership. Legible London Initiative 2007

This site provides a summary on how London is taking further initiatives to improve pedestrian mobility around the city, specifically congested areas. This source is helpful because it provides information about other cities around the world that are trying to reduce congestion and what they have come up with

Cioffi, Carlo; Dulac, Vicky L; Marsano, Jose F; Reguero, Robert R. Development of a Computerized Decision Support System for the Scheduled Maintenance of the Inner Canals of Venice 1997.

This past IQP was very useful in determining canal maintenance procedures. Knowledge of these procedures will help our group in creating boat traffic models, because canal closures greatly affect boat traffic routes.

Chiu, David, Jagannath, Anand and Nodine, Emily. The Moto Ondoso Index: Assessing the Effect of Boat Traffic in the Canals of Venice 2002

This paper is about an IQP that was completed in Venice in 2002. This team analyzed and catalogued the effects of different variables, such as boat size, payload, speed, etc. on the amount of energy released in a boat's wake. Should our group end up making an Autonomous Agent Model about Moto Ondoso, this IQP is probably where we will obtain most of the data required for the model.

Cornehls, James V; Taebel, Delbert A. The Political Economy of Urban Transportation. National University Publications, Kennikat Press, Port Washington, New York, 1977.

This book only touched on one topic that was relevant to our project. For the most part it is a very in depth book about the political economy of urban transportation in the United States. It includes very specific references to certain policies in action in 1977, and therefore is not applicable to Venice.

Diogenes, Mara C., Greene-Roesel, Ryan, Arnold, Lindsay S. and Ragland, David R. Pedestrian Counting Methods at Intersections: a Comparative Study 2007

This report examined a study conducted by US Berkley on pedestrian traffic geared towards improving pedestrian safety. The study took place in San Francisco and involved an assessment of the accuracy of various types of pedestrian counting methods including manual counts using sheets, manual counts using clickers, and manual counts using video cameras. The report concluded that manual counts resulted in underestimated pedestrian volumes with an error range from 8-25%, with the majority of the error occurring at the beginning and end of each period of observation.

Duffy, Jill, Gagliardi, Justin, Mirtle, Katherine and Tucker, Amanda. Re-engineering the City of Venice's Cargo Transportation System for the Consorzio Trasporatori Veneziani Riuniti 2001
This project group analyzed the cargo transportation system in Venice and realized that the current system of shipping cargo by item was incredibly inefficient, and created a proposal for the city of building a warehouse on the edge of the city, and then shipping cargo out from there by destination. This new plan would reduce cargo traffic by 90%. This IQP may give us some ideas for models that we can make with the information we have, and some of the information in it may actually be useful for creating models.

Fastlane. Integrated Design Ltd. Pedestrian Counting Application Manual: Setting New Standards in Entrance Control
This article explored the Integrated Design Ltd. Pedestrian Counting System used to manage traffic flow primarially within public buildings. The technology implements a sectional counting system with gates that monitor the entrances and exits of a designated area. Upon collecting staffing levels within different sections of the monitored area, the system can be used to monitor seasonal variances and predict required staffing and stock levels within a venue. The manual examines the IDL system and its implementation within an indoor area.

Grava, Sigurd. Urban Transportation Systems: Choices for Communities. McGraw-Hill, 2003.
This is a very large book that is almost like a textbook. It covers many basic concepts in traffic patterns and types of traffic. It is very useful to understanding our project.

Kelly Brandon Design. Wayfinding
This is a brief but thorough description of wayfinding from a business. It will help our group understand wayfinding, should we make any models around it.

Kenworthy, Jeffrey; Newman, Peter. Sustainability and Cities: Overcoming Automobile Dependence. Island Press, 1999.
This is a book that takes an in-depth look at traffic from the basis of Sustainability. Many of the principles listed in this book apply to Venice, and are helpful in understanding the current traffic conditions in Venice.

Li, Lester, Carbonneau, Michelle L., Balboa, Marc J. and Billiar, Kristen. An analysis of traffic and its environmental impact 2007
This report analyzes a broad overview of the boat traffic throughout Venice. It looks at each different type of boat (divided into 21 distinct types), and analyzes the amount of pollution the boats cause (mainly in the form of *Moto Ondoso*) at various speeds. It shows the severity and danger of the *Moto Ondoso* of most of the canals throughout Venice. It also supplies data of the average speed boats travel throughout the various canals, showing higher speeds produce greater wake, which, in turn leads to added *Moto Ondoso*. This project will aid us in supplying a large majority of the information we will need to possibly publish findings from previous years.

Lindsey, Patrick, Lindsey, Greg. Using Pedestrian Count Models to Estimate Urban Trail Traffic 2004
This is a journal article that explores pedestrian traffic counting models to observe the multiuse of urban greenway trails. Specifically, it examines green trails along an Indianapolis, Indiana trail system with a goal of examining traffic impacts on trail maintenance and the partitioning of funding and resources for trail management.

National Association for the Protection of Italy's Historic , Artistic and Natural Heritage,. Motorboat Waves: The Impact on Venice and on Its Lagoon 2007
The Venice chapter talks about the cause and effect of *Moto Ondoso* on the city, and what has been done to rectify this situation. This source also has helpful information on the speeds and regulations of some boat traffic within the canals and what is done to enforce these laws.

Peponis, John. Space Syntax (2005). http://www.informedesign.umn.edu/_news/dec_v04r-p.pdf

This newsletter explains the basics of space syntax. If we decide to use space syntax in our project, this article will help us understand what is necessary for it and will help us to not have a "black box experience" when using space syntax.

Raford, Noah and Ragland, David R (2003). *Space Syntax: An Innovative Pedestrian Volume Modeling Tool for Pedestrian Safety.* http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1009&context=its/tsc

This paper describes how space syntax was used to model pedestrian traffic in Oakland California. It describes much of the methodology and how space syntax works. Should our group advance pedestrian traffic data very much in Venice, this will be a great reference in understanding space syntax and will be a great springboard for us. One of the primary reasons it will be useful is because it gives much of its methodology.

Thibideau, Jessica L., Scanio, Corina C., McDonald, Theodore B. and Accosta, Robert F. Re-engineering the Venetian taxi transportation system -- Efficiency improvements that reduce Moto Ondoso 2006

This project is geared to the idea of diminishing *Moto Ondoso* by altering the Taxi Transportation system. The paper offers information on the various sizes of taxis travel through Venice, the types of hulls the taxis have, and most importantly breaks down the working time for taxis. The project shows that Venetian taxis idle for 24% of the time they are out during the day, and they drive around empty for 33% of the time, showing taxis have fares only 43% of the time their engines are running. The project shows that a good portion of this downtime is virtually mandated by the state through, seemingly poorly developed, regulations. The project also offers variations that can be made to the boats like adding trim tabs, or using M-hulls instead of V-hulls to diminish wake produced. This project will help us greatly in our efforts to try to propose a new system to the taxi drivers as a way to not only save the buildings of Venice, but also a way to save the taxi drivers money.

U.S. Census Bureau. Cumulative Estimates of Population Change for Metropolitan Statistical Areas and Rankings 2008

This website provided useful and reliable data on the populations of metropolitan areas similar in size to that of "Old Venice". The text also contains how the population has changed from 2000 to 2007. This information is pertinent to our project because it will help us relate the size and population of Venice's islands to those of metropolitan areas in other parts of the world, including the United States.

U.S. Department for Transportation, Federal Highway Administration. Focus on Congestion Relief 2006

This website is useful in fulfilling our task of developing efficient methods of monitoring and recording pedestrian traffic. The Department of Transport offers a brochure of previously established methods which have been practiced in the attempts of controlling, and making London's foot traffic less stressful.

APPENDIX B: BOAT MONITORING FORM

Date: / /2008 Station: X

Time: 10:00 - 12:00

	Maneuver		Type	License		Name	Characteristics		Material	Time	Notes
	From	To	#	Prefix	Number		% Filled (/25)	# Of People	Wood(W) / Metal (M) Plastic (P)		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

CARTA INTESTATA?

APPENDIX C: *MANUALE STATZIONE XX*

RILEVAMENTO
del TRAFFICO ACQUEO
nel Centro Storico di Venezia

XX - Località

Ottobre/Novembre 2004

A CURA DI:

PER:

COMMISSARIO DEL GOVERNO

Delegato al Traffico Acqueo

NELLA LAGUNA DI VENEZIA

Manuale per i Rilevatori

INTRODUZIONE

ISTRUZIONI GENERALI

DATA RILEVAMENTO: 6 E 12 OTTOBRE 2004
ORARIO: **7:00 – 19:00**

MATERIALI INDISPENSABILI da PORTARE sul CAMPO:

- **Questo MANUALE**
- **MODULI di RISERVA (20 pagine)**
- **Almeno un BINOCOLO (o MONOCOLO) per Stazione**

MODALITÀ di EFFETTUAZIONE dei RILEVAMENTI:

TUTTI i rilevatori dovranno essere in posizione presso la loro postazione entro le 8:30 di Domenica 09 Luglio. Le ore del mattino, che sono le più trafficate, dovranno essere monitorate da TUTTI i rilevatori contemporaneamente. Lo stesso dicasi per le ore pomeridiane, in cui si suppone vi sia il "controesodo" di imbarcazioni che ritornano a casa. Nelle ore centrali, durante l'ora di pranzo, dovrebbe verificarsi una "pausa" del traffico, durante la quale i rilevatori potranno turnarsi per mangiare e riposarsi. Le scelte dei turni e dei momenti precisi in cui sia necessaria la presenza di tutti i rilevatori dipendono dal livello di traffico di ciascuna stazione. L'importante è che TUTTI siano presenti nei momenti di maggiore intensità.

PROBLEMI? : Telefonate immediatamente ad uno dei numeri riportati in calce.

MODALITÀ di RESTITUZIONE dei MODULI COMPILATI:

Tutti i Manuali e Fascicoli contenenti i Moduli Compilati sul campo dovranno essere riportati presso la sede del Venice Project Center (Cannaregio 4400) entro MARTEDÌ 25 Luglio **al più tardi.**

MODALITÀ di PAGAMENTO

A consegna avvenuta, ci riserviamo di effettuare un controllo di qualità sui dati raccolti prima di pagare i rilevatori, onde scoraggiare rilevazioni scadenti. A controllo avvenuto, i rilevatori dovranno presentarsi personalmente per la riscossione di L. 200.000 e per firmare una ricevuta del pagamento. Il pagamento verrà comunque effettuato non oltre 7 giorni lavorativi dal momento della consegna.

INSERIMENTO DATI

I rilevatori che sono disponibili all'immissione dei propri dati potranno concordare una data per tale lavoro al momento della riscossione del primo pagamento. Il periodo preferibile per l'inserimento dei dati sarebbe il mese di Agosto, ma sarà possibile concordare date alternative. Ad inserimento avvenuto e verificato, ogni rilevatore che abbia inserito i propri dati recepirà la somma ulteriore di L. 20.000 per ora, dietro ricevuta.

CARTA INTESTATA?

MANUALE PER I RILEVATORI

ISTRUZIONI PER LA COMPILAZIONE DEI MODULI

ISTRUZIONI PER LA COMPILAZIONE

(vedi anche MODULO Facsimile pre-compilato come esempio)

MANOV.

VIENE DA = INDICARE LA LETTERA CORRISPONDENTE AL CANALE DI PROVENIENZA DEL NATANTE;

VA A = INDICARE LA LETTERA CORRISPONDENTE AL CANALE DI DESTINAZIONE DEL NATANTE;

In caso un'imbarcazione attraversi uno solo dei canali monitorati per poi fermarsi, inserire la lettera "X" in Va A. Similmente, se una barca posteggiata nei pressi della stazione di rilevamento dovesse partire ed imboccare uno dei canali monitorati, inserire la lettera "X" in Viene DA.

NOTA: **Fare riferimento alla mappa a tutta pagina allegata, su cui sono visibili le lettere A, B, C, ecc., corrispondenti ai canali da monitorare.**

TIPO

INSERIRE UN NUMERO, DA 1 A 18, CORRISPONDENTE ALLA TIPOLOGIA DEL NATANTE.

Nel caso in cui il natante sia un BARCHINO o un GOMMONE segnare nella casella GOM (Gommone) le lettere "B" se barchino o "G" nel caso in cui sia un gommone ricordandosi comunque di segnare contestualmente la "Tipologia" 6 nella casella precedente.

NOTA: **Fare riferimento alla legenda in calce al modulo ed al Catalogo Barche (con foto) in questo manuale.**

TARGA

Utilizzare il Binocolo o Monocolo per la lettura della targa. Le targhe dovrebbero essere posizionate sul lato destro a prua della barca e sul lato sinistro verso la poppa della barca, ma esistono numerose eccezioni. I natanti da diporto NON hanno normalmente la targa.

Inserire il numero di targa, suddiviso in PREFISSO, NUMERO e CODA. Qualora, come spesso succede, alcune lettere o cifre siano occultate da parabordi, pneumatici od altro, lasciare spazi vuoti corrispondenti alla lettera o cifra illeggibile.

NO = Circa il 50% delle imbarcazioni non è tenuto ad avere la targa. In particolare, le imbarcazioni da diporto, soprattutto se con motori fuoribordo NON hanno mai la targa. Se, dopo accurata osservazione, il rilevatore conclude che un'imbarcazione non è dotata di targa, barrare la casella NO.

N.R. = Qualora, per qualsiasi motivo, il rilevatore non fosse in grado di determinare la presenza o meno di una targa indicare che la targa non è stata rilevata barrando N.R. (Non Rilevata).

Prefisso = Non sempre è presente, ma se c'è termina sempre con una LETTERA. Può contenere una o due lettere. Talvolta può essere costituito da un numero seguito da due lettere. Prefissi più comuni: 6V, VE, V, 2VE, 3VE, CI (Chioggia)…
NOTA: **Fare riferimento alla legenda del Modulo ed al Catalogo Barche.**

Numero = Può contenere fino a 5 CIFRE. Se il prefisso è 6V, il numero dovrebbe essere di 4 o 5 cifre. Se il prefisso è VE, il numero dovrebbe essere di 4 cifre. Se il prefisso è V, il numero dovrebbe essere di 4-5 cifre.
NOTA: **Fare riferimento al Catalogo Barche.**

Coda = Qualsiasi LETTERA dopo il NUMERO va registrata come CODA. Può contenere fino a 2 LETTERE. Code più comuni: A, D, ND, VE, PD, TV, ecc…
NOTA: **Fare riferimento alla legenda del Modulo ed al Catalogo Barche.**

NOTA: **Fare riferimento alla legenda in calce al Modulo di Rilevamento, al Catalogo Barche ed agli Esempi di Targhe contenuti in questo manuale.**

NOME

Utilizzare il Binocolo o Monocolo per la lettura del NOME dell'imbarcazione. Moltissime barche hanno un nome, normalmente da donna, dipinto a prua o a poppa, su ambo i lati. I taxi hanno il nome dipinto sullo specchio di poppa. Spesso, oltre al nome, le barche da trasporto riportano anche il nome o la sigla di una ditta od impresa; in questo caso, annotare il NOME nella casella omonima e l'eventuale sigla od impresa nella casella NOTE. Se fosse leggibile solo il nome della ditta od impresa, inserirlo nella casella NOME direttamente.

CARICO

Utilizzare il Binocolo o Monocolo per determinare il CARICO di MERCI e/o PERSONE a bordo del natante. Il carico merci è relativo alle imbarcazioni di tipo 1 o 2, mentre TUTTE le imbarcazioni hanno sempre un carico di PERSONE potenzialmente rilevabile.

MERCI

N.R. = Se il livello di carico di un natante merci NON è rilevabile, barrare N.R. (Non Rilevabile). Ad esempio, le barche-frigorifero occultano il carico a bordo…

/ 4 = Questa casella deve contenere un numero da 0 a 4. Se il livello di carico di un natante merci è rilevabile, indicare il volume di carico in QUARTI (/4) relativamente alla capacità massima della stiva visibile. Una barca vuota sarà quindi registrata con un carico Merci uguale a 0 (quarti), mentre una piena avrà un carico uguale a 4 (quarti). Una barca mezza piena otterrà un valore di carico di 2 (quarti), e così via.

PERSONE TOT.

N.R. = Se il numero di persone a bordo di un natante NON è rilevabile, barrare N.R. (Non Rilevabile). Ad esempio, alcune barche con la cabina chiusa ed i vetri scuri impediscono di vedere le persone all'interno. Le navi da crocera non si prestano al conteggio dei passeggeri, e così via …

con EQ. = Questa casella deve contenere un numero da 1 a *n*, ove *n* è il numero totale di persone a bordo, compreso l'Equipaggio ed il Pilota. Ove possibile, si suggerisce di usare il CONTAPERSONE in dotazione per contare i passeggeri e l'equpaggio, compreso il guidatore. Altrimenti è preferibile una <u>stima</u> piuttosto che niente.

MATERIALE

È LA VOCE MENO IMPORTANTE DEL MODULO. IN CASO DI BISOGNO, QUESTO PARAMETRO PUÒ TRANQUILLAMENTE ESSERE TRALASCIATO. SE C'È TEMPO, PERÒ, PREGHIAMO DI INDICARE IL MATERIALE DI COSTRUZIONE DELL'IMBARCAZIONE, BARRANDO L'APPOSITA CASELLA.

FE = BARCA IN FERRO O ALTRO METALLO

LE = BARCA IN LEGNO

G/P = BARCA IN GOMMA (ES. GOMMONE) O PLASTICA, INCLUSA LA VETRORESINA

SERV. PUBBL. (SERVIZI PUBBLICI)

LE IMBARCAZIONI CON AUTORIZZAZIONI SPECIALI SONO DOTATE DI CONTRASSEGNI CHE È IMPORTANTE RILEVARE.

TAXI/GT = SIA I TAXI CHE I LANCIONI GRAN TURISMO (GT) SONO AUTORIZZATI DAL COMUNE DI VENEZIA AL TRASPORTO PERSONE ED ESIBISCONO DEI CONTRASSEGNI AUTOADESIVI CON SUSCRITTO IL NUMERO DI AUTORIZZAZIONE. QUALORA IL N. DI AUT. SIA VISIBILE (CON BINOCOLO), INSERIRE NELLA CASELLA TAXI/GT TALE NUMERO. SE SI DISTINGUE LA SAGOMA DEI CONTRASSEGNI (RETTANGOLO E STRISCIA DI COLORE GIALLO PER I TAXI E TRIANGOLO ROSSO O GIALLO PER I GT), MA NON SI RIESCE A DISTINGUERE IL NUMERO, SEMPLICEMENTE BARRARE LA CASELLA.

NOTA**: Fare riferimento al Catalogo dei Contrassegni (con Foto) accluso.**

LINEA = NEL CASO DI NATANTI ACTV DI LINEA, INSERIRE IL NUMERO DI LINEA NELLA CASELLA (AD ES. 1, 52, 82, 6, ECC.). NEL CASO DI ALTRE LINEE (ALILAGUNA DA/PER AEROPORTO, VENEZIA/FUSINA, LINEA BLU DA/PER CASINÒ) BARRARE LA CASELLA E DESCRIVERE NELLE NOTE.

MERCI = MOLTE IMBARCAZIONI MERCI ESIBISCONO UNA TARGHETTA IN PLASTICA CON LA DICITURA TRASP. COSE SEGUITA DA UN NUMERO DI AUTORIZZAZIONE. QUALORA TALE NUMERO SIA VISIBILE, INSERIRLO NELLA CASELLA, ALTRIMENTI, SE SI VEDE LA SAGOMA GIALLA MA NON SI RIESCE A LEGGERE IL NUMERO, SEMPLICEMENTE BARRARE LA CASELLA.

NOTA**: Fare riferimento al Catalogo dei Contrassegni (con Foto) accluso.**

NOTE

Tempo permettendo, utilizzare questo spazio per fornire ulteriori informazioni utili all'identificazione del natante, come ad es. Nomi di Impresa, colore (se particolare), caratteristiche inusuali (ad es. presenza di gru, ecc.), tipologia di merce a bordo, ecc. Indicare manovre "strane", come retromarce, inversioni ad "U", oppure per indicare barche che si fermano nel bel mezzo di un'intersezione per pescare, ecc.

ORA

Onde evitare di dover inserire l'orario di passaggio di ogni imbarcazione, la colonna ORA non è dotata di linee orizzontali in quanto il rilevatore è tenuto a tirare una linea ogni 15' indicando solo gli intervalli orari ogni 15 minuti. Ad esempio, all'inizio del conteggio, il rilevatore scriverà 08:30 nella casella ora, procedendo poi a registrare tutti i passaggi di varie imbarcazioni (con relative manovre, tipologie, targhe, ecc.) senza mai scrivere altro nella colonna ORA fino alle ore 08:45, quando il rilevatore tirerà una linea orizzontale in corrispondenza dell'ultima imbarcazione indicando la fine dell'intervallo di 15' nella colonna ORA. Immediatamente sotto alla linea divisoria, il rilevatore scriverà immediatamente 08:45 per poi continuare così fino alle 09:00, e così via.

PROVINCIA DI VENEZIA - RILEVAZIONE FLUSSI DI TRAFFICO ACQUEO LAGUNARE Stazione n.: ___**12**____

Data __**09/07/00**________ Iniziali Rilevatore A G Dalle _ **8,30** **19,30** Condiz. Meteo. **SERENO**

N.	MANOV. viene DA	MANOV. va A	TIPO vedi note	B/G B.chino G.mone	TARGA barrare no	TARGA barrare n.r.	Prefisso 1	Prefisso 2	Prefisso 3	numero 1	numero 2	numero 3	numero 4	numero 5	Coda 1	Coda 2	NOME o eventuale sigla o impresa	CARICO merci n.r.	CARICO merci /4	CARICO persone tot. n.r.	CARICO persone tot. con eq.	MATERIALE barrare Fe	MATERIALE Le	MATERIALE P	SERV. PUBBL. (contrassegni) Taxi/GT	SERV. PUBBL. Linea	SERV. PUBBL. Merci	NOTE	ORA ogni 15' barrare
1	A	C	3					V	E	8	5	6	1				GIUSEPPINA				4			X	251				8,30
2	C	A	2					6	V	1	2	6	3	5			IRENE		3		1		X				42	DITTA EDILE TIZIO	
3	B	A	6	G	X																1								
4	B	A	4					V	E	3		2	5				S. MARCO				20		X			X		SERVIZIO AEROPORTO	
5	C	B	10					P	S	1	2	3									2			X				POLIZIA	
6	B	A	16					V	E	8	1	6	2								45					52			
7	D	A	6					V	E	2	5	3	6		D						2			X					
8	B	C	8		X												SISMONDA				2			X					
9	A	X	7			X											MAYFLOWER			X				X				Vetri Fumè	
10	C	D	1				3	V	E	6	7	3					Termoidraulica 3	X				X						Carico Coperto da Telone	8,45
11	A	C	6	B	X																1							Brube	
12																													
13																													
14																													
15																													
16																													
17																													
18																													
19																													
20																													
21																													9,00
22																													
23																													
24																													
25																													

TIPOLOGIE:

Trasp. MERCI: 1= >10m, 2= <10m; **Trasp. PERSONE:** 3=Lancia/taxi, 4=Lancione GT, 5=Natante Turistico (2 piani), 6=Barca Diporto SENZA cabina, 7= Diporto CON cabina; **VELA:** 8; **REMI:** 9; **SERVIZI:** 10;

NAVI (da mare): 11=Nave/Navetta, 12=Rimorchiatore/Peschereccio; 13=Chiatta/Zattera; **LINEE ACTV**: 14=Motonave/Ferry, 15=Vaporetto, 16=Motoscafo; **ALTRO:** 17= >10m, 18= <10m

MATERIALE: **Fe**=Ferro, **Le**=Legno, **G/P**=Gomma o Plastica (vetroresina); **TARGA: Prefisso**= 6V, VE, V, 2VE, 3VE, CI, ecc.; **Coda**= A, D, ND, VE, TV, PD, ecc.

TIPO 1 – UNITA' MERCI GRANDE

TIPOLOGIA	TARGHE	NOTE
Mototopo, topo grande, motobarca, barcone, topa entrobordo, cofano grande, patana grande, sampierota grande)	*Più frequente*: 6V: 1nnn, 3nnn, 4nnn, 13nnn, 14nnn, 23nnn, 30nnn, 4nnnn; V: da 10nnn a 13nnn e 0nnnA; *più raro*: VE: da 2nnn a 8nnn.	In caso di rilevazione parziale della targa, riportare qualche altro elemento utile (nome, scritte laterali), nelle note specificare la presenza di cabina (cisterna, cella frigorifera, gru, altro)

TIPO 2 – UNITA' MERCI PICCOLA

TIPOLOGIA	TARGHE	NOTE
Sampierota, topetta fuoribordo, patanela, barchino, cofanetto, zatterino	*Più frequente*: 6V: 1nnn, 3nnn, 4nnn, 13nnn, 14nnn, 23nnn, 30nnn, 4nnnn; V: da 10nnn a 13nnn e 0nnnA; *più raro*: VE: da 2nnn a 8nnn.	In caso di rilevazione parziale della targa, riportare qualche altro elemento utile (nome, scritte laterali), nelle note specificare la presenza di cabina (cisterna, cella frigorifera, gru, altro)

TIPO 3 – MOTOSCAFO TIPO TAXI

TIPOLOGIA	TARGHE	NOTE
Lance in legno o vetroresina senza indicazioni di appartenenza a enti pubblici o privati (mezzi in servizio pubblico, regolari – con striscia gialla - o abusivi)	*Più frequente*: VE: da 2nnn a 8nnn; *più raro*: 6V: 13nnn, 14nnn, 23nnn, 30nnn;	Rilevare sempre la targa ed eventualmente il nome, sempre il nome se non si riesce a rilevare la targa, indicando se esiste la striscia gialla

	V: da 10nnn a 13nnn e 00nnA.	

TIPO 4 – LANCIONE GRANTURISMO

TIPOLOGIA	TARGHE	NOTE
Grossa lancia con posto di comando centrale, spesso scoperto, e posti per passeggeri a prua e a poppa, spesso coperti, (mezzi in servizio pubblico, noleggio regolari – con triangolo giallo – o abusivi, linea – con tabelle; mezzi in servizio privato per alberghi – CIGA – e attività turistiche – vetrerie di Murano)	*Più frequente*: VE: da 2nnn a 8nnn *più raro*: 6V: 13nnn, 14nnn, 23nnn, 30nnn; V: da 10nnn a 13nnn e 00nnA.	Rilevare sempre la targa ed eventualmente il nome, sempre il nome se non si riesce a rilevare la targa, indicando se esiste la striscia gialla o se c'è indicazione di linea o il nome dell'attività turistica proprietaria (CIGA, etc.)

TIPO 5 – NATANTE TURISTICO (2 PIANI)

TIPOLOGIA	TARGHE	NOTE
Motoscafo per comitive turistiche, completamente chiuso o con ponte superiore scoperto	*Più frequente*: VE: da 2nnn a 8nnn; 3VE nnn; CI nnn; 2CI nnn; *Più raro*: nXXnnn; 6V 000n, 13nnn, 14nnn, 23nnn, 30nnn;	Rilevare sempre la targa e anche il nome ove possibile, almeno il nome se non si riesce a rilevare la targa

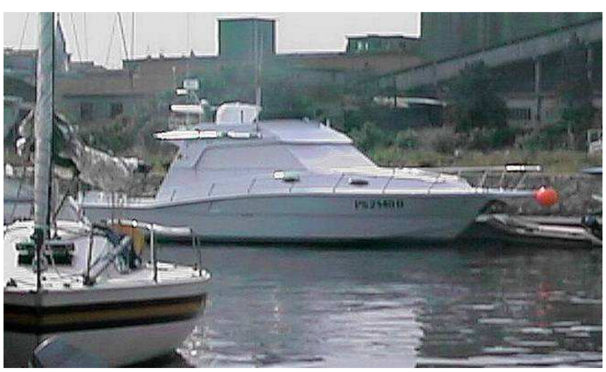
TIPO 6 – BARCA DA DIPORTO SENZA CABINA

TIPOLOGIA	TARGHE	NOTE
Barchino, cacciapesca, cofano, zatterino, gommone, unità da diporto a motore adtte	*Più frequente:* senza targa	Indicare se non ha targa

ad escursioni giornaliere (marche di costruzione più frequenti: Boston Whaler, Brube, Dese, Gobbi, Studio 5)	*più raro*: V: da 10nnn a 13nnn e 00nnA; VE: da 2nnn a 8nnn, nnnn D, nnn ND; N: 1nnnn VE, nnnn TV o PD o altra provincia; nVE: nnn, nnn D; CI: nnn D; nCI: nnn D; *ancora più raro:* nXXnnnnD	

TIPO 7 – BARCA DA DIPORTO CON CABINA

TIPOLOGIA	TARGHE	NOTE
Unità da diporto a motore ad 1 o più ponti con cabina adatte alla permanenza in mare per più giorni	*Più frequente*: V: da 10nnn a 13nnn e 00nnA; VE: da 2nnn a 8nnn, nnnn D, nnn ND; *più raro:* N: 1nnnn VE, nnnn TV o PD o altra provincia; nVE: nnn, nnn D CI: nnn D; nCI: nnn D; *ancora più raro:* nXXnnnnD	Indicare se non ha targa e l'eventuale nome con compartimento marittimo di registrazione (specchio di poppa) soprattutto se di altra nazionalità



TIPO 8 – BARCA DA DIPORTO A VELA

TIPOLOGIA	TARGHE	NOTE
Unità da diporto a vela di qualsiasi dimensione	*Più frequente:* V: da 10nnn a 13nnn e 00nnA; VE: da 2nnn a 8nnn, nnnn D, nnn ND;	Indicare se non ha targa, se naviga a vela e l'eventuale nome con compartimento marittimo di registrazione (specchio di poppa) o sigle sulla vela soprattutto se di

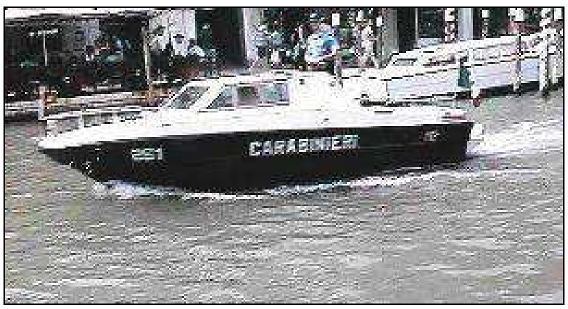
	più raro: N: 1nnnn VE, nnnn TV o PD o altra provincia; nVE: nnn, nnn D CI: nnn D; nCI: nnn D; *ancora più raro:* nXXnnnnD	altra nazionalità

TIPO 9 – UNITA' A REMI

TIPOLOGIA	TARGHE	NOTE
Barca tipica veneziana (gondola, sandolo, mascaretta, etc.) più canoa, kayak, jole, veneta	Senza targa	Specificare se appartiene a gruppi sportivi organizzati (scritte laterali)

TIPO 10 – UNITA' PER SERVIZI

TIPOLOGIA	TARGHE	NOTE
Unità militari: Polizia, Pompieri, Carabinieri, Capitaneria di Porto/Guardia Costiera, Guardia di Finanza, Servizio fari, Esercito, Marina Militare *Unità di servizio:* Raccolta Alghe, Piloti Portuali, Ormeggiatori, Vigili Urbani, Servizi Funebri, Servizio Traduzioni Carcerati, Ministeri diversi, Università, Magistrato alle Acque, Regione Veneto, ULSS, Comune di Venezia, Provincia di Venezia Italgas, AMAV, ENEL, Telecom, PPTT, Vigilanza Privata, Ambulanze	*Targa speciale:* PS nnn, VF nnn, nnn CP nnn, CP nnnn, VAI nnn; MBN nnn, EIG nnn, MSE nnn *Targa normale:* VE: da 2nnn a 8nnn; 6V: 1nnn, 13nnn, 14nnn, 23nnn, 30nnn; V: da 10nnn a 13nnn e 00nnA.	Rilevare sempre la targa e il nome, in alternativa se difficoltoso solo il nome, sempre specificare il servizio di impiego o l'ente proprietario nelle note come indicato sull'unità (sui fianchi o a poppa)



TIPO 11 – NAVI E NAVETTE

TIPOLOGIA	TARGHE	NOTE
Nave marittima in metallo di grossa e media stazza	Senza targa, solo nome e compartimento marittimo.	Rilevare il nome e compartimento marittimo, specificando se nave da passeggeri (nave traghetto, catamarano, nave da crociera, aliscafo, etc.) o da carico (ro-ro, cisterna, rinfuse secche, etc.)


STRINTZIS LINES


VIRTU FERRIES
www.venezialines.com
SAN PAWL

TIPO 12 – PESCHERECCI E RIMORCHIATORI

TIPOLOGIA	TARGHE	NOTE
Piccole navi da pesca e navi per rimorchio o spinta in navigazione isolata	*Pescherecci più frequente:* VE nnnn, nVEnnnn, CI nnn, nCInnn *Rimorchiatori più frequente:* senza targa, solo nome; *più raro:* VE nnnn, CI nnnn, 6V nnnn	Rilevare sempre la targa e anche il nome ove possibile, almeno il nome se non si riesce a rilevare la targa

TIPO 13 – CHIATTE E ZATTERE

TIPOLOGIA	TARGHE	NOTE
Natante fluviale o lagunare a basso profilo, eventualmente con gru e natante di metallo rettangolare, solitamente trainato da altra imbarcazione	*Pescherecci più frequente:* VE nnnn, nVEnnnn, CI nnn, nCInnn *Rimorchiatori più frequente:* senza targa, solo nome; *più raro:* VE nnnn, CI nnnn, 6V nnnn	Rilevare sempre la targa e anche il nome ove possibile, almeno il nome se non si riesce a rilevare la targa

TIPO 14 – MOTONAVE E FERRYBOAT ACTV

TIPOLOGIA	TARGHE	NOTE
Motonave o nave traghetto di linea	Sempre VE nnn o nnnn	rilevare il nome in alternativa alla targa

TIPO 15 – VAPORETTI ACTV

TIPOLOGIA	TARGHE	NOTE
Vaporetto ACTV	Sempre VE nnn o nnnn	rilevare il nome o il numero in alternativa alla targa

TIPO 16 – MOTOSCAFI ACTV

TIPOLOGIA	TARGHE	NOTE
Motoscafo ACTV	Sempre VE nnnn	rilevare il nome o il numero in alternativa alla targa

TIPO 21 – PILOTINA BLU ACTV

TIPOLOGIA	TARGHE	NOTE
Motoscafo ACTV	Sempre VE nnnn	rilevare il nome o il numero in alternativa alla targa


Actv
109

TIPO 17 – ALTRA UNITA' GRANDE LUNGHEZZA > 10 M

TIPOLOGIA	TARGHE	NOTE
Tipo merci grande o in caso di difficoltà nella classificazione	Qualsiasi	In caso di rilevazione parziale della targa, riportare qualche altro elemento utile (nome, scritte laterali), nelle note specificare la presenza di cabina, cisterna, cella frigorifera, gru, altro).

TIPO 18 – ALTRA UNITA' PICCOLA LUNGHEZZA < 10 M

TIPOLOGIA	TARGHE	NOTE
Tipo merci piccola o in caso di difficoltà nella classificazione	Qualsiasi	In caso di rilevazione parziale della targa, riportare qualche altro elemento utile (nome, scritte laterali), nelle note specificare la presenza di cabina, cisterna, cella frigorifera, gru, altro).

ESEMPI DI TARGHE

SERVIZI PUBBLICI TURISTICI

CONTRASSEGNI

TAXI

COMUNE DI VENEZIA

Imbarcazioni autorizzate al trasporto **persone**.

Contrassegno adesivo **rettangolare** di colore **giallo** e fascia dello stesso colore lungo tutto il finestrino.

Dimensioni: 40 cm.

Numero autorizzazione a destra del rettangolo

(es. nella foto a fianco N° Autorizzazione = **167**).

TAXI

COMUNE DI CHIOGGIA

Imbarcazioni autorizzate al trasporto **persone**.

Contrassegno adesivo **rettangolare** di colore **giallo** usualmente senza fascia.

Dimensioni: 40 cm.

Numero autorizzazione a destra del rettangolo

(es. nella foto a fianco N° Autorizzazione = **65**).

NOLEGGIO CON CONDUCENTE

COMUNE DI VENEZIA

Imbarcazioni autorizzate al trasporto **persone**.

Contrassegno adesivo **rettangolare** di colore **verde** e fascia dello stesso colore lungo tutto il finestrino.

Dimensioni: 40 cm.

Numero autorizzazione a destra del rettangolo

(es. nella foto a fianco N° Autorizzazione = **15**).

NOLEGGIO CON CONDUCENTE

COMUNE DI MIRA o DOLO o ALTRO

Imbarcazioni autorizzate al trasporto **persone**.

Contrassegno adesivo **rettangolare** di colore **rosso** usualmente senza fascia.

Dimensioni: 40 cm.

Numero autorizzazione a destra del rettangolo

(es. nella foto a fianco N° Autorizzazione = **8**).

NOLEGGIO CON CONDUCENTE

TRONCHETTO - SENZA LICENZA

Imbarcazioni adibite al trasporto **persone senza alcuna licenza**.

Contrassegno adesivo **rettangolare** di colore **bianco** e fascia dello stesso colore lungo tutto il finestrino con la dicitura:

“Consorzio Motoscafi Isola Nuova”

Dimensioni: 40 cm.

Numero a destra del rettangolo

(es. nella foto a fianco N° = **01**).

GT (Gran Turismo)

COMUNE DI VENEZIA o CHIOGGIA o ALTRO

Imbarcazioni autorizzate al trasporto **persone.**

Contrassegno adesivo **triangolare** di colore **rosso** o **giallo** generalmente posto sui finestrini laterali della cabina di comando.

Dimensioni: 35 cm. Circa per lato.

Numero autorizzazione al centro del triangolo

(es. nella foto a fianco N° Autorizzazione = **21).**

MERCI (Barche da trasporto)

COMUNE DI VENEZIA o CHIOGGIA

Imbarcazioni autorizzate al trasporto **merci**.

Contrassegno in plastica rettangolare di colore **giallo** generalmente posto ai lati del coperchio vano motore

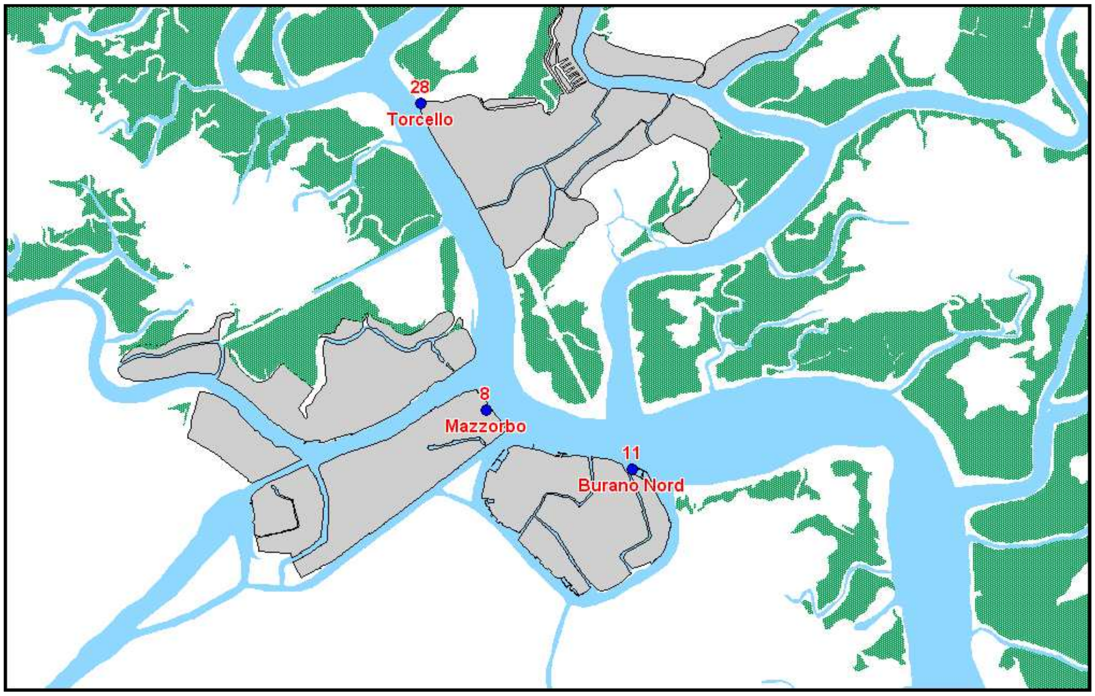
Dimensioni: 50 cm. Circa per lato.

Numero autorizzazione a destra del rettangolo

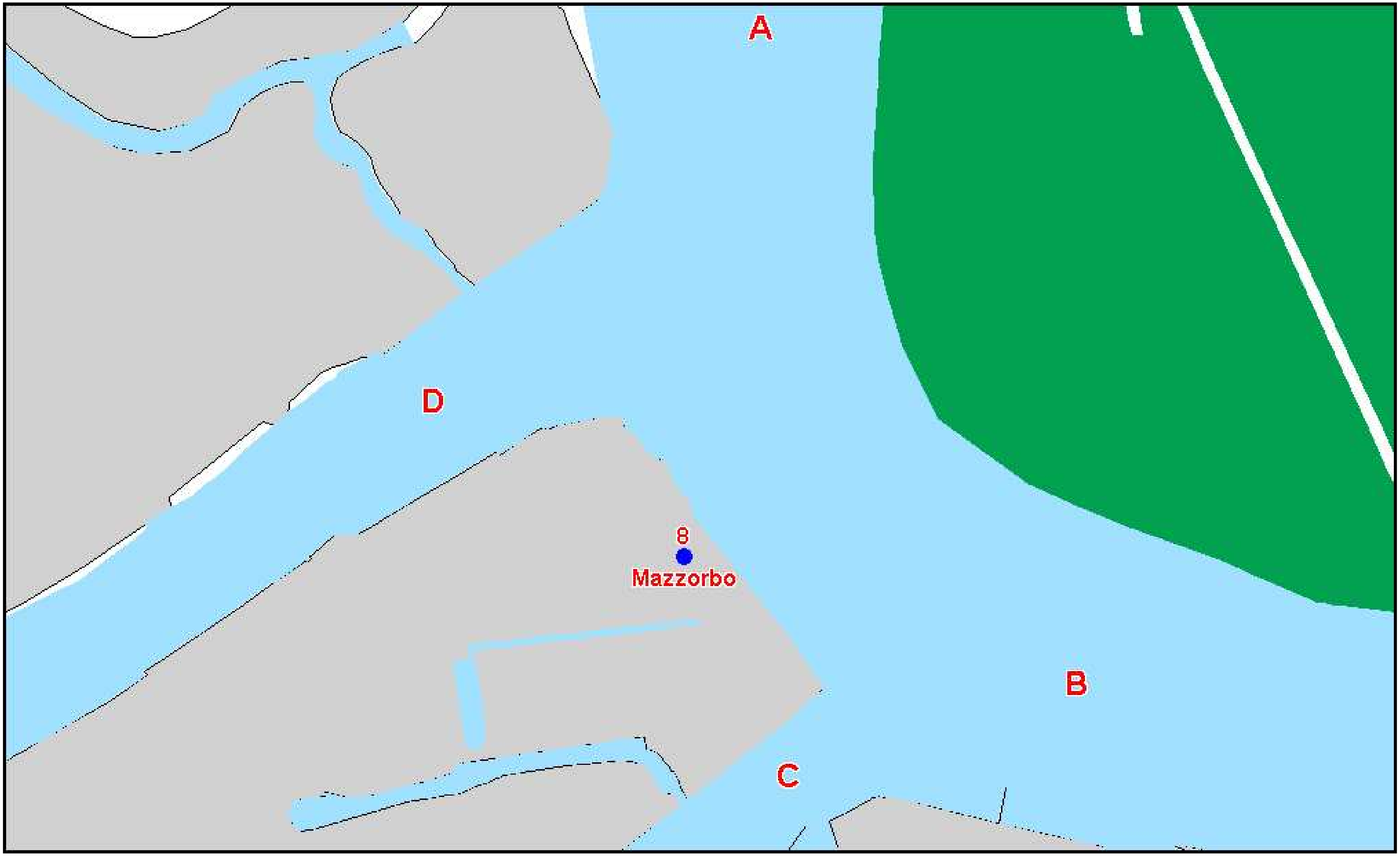
(es. nella foto a fianco N° Autorizzazione = **54/B**).

STAZIONE X

LOCALITA'



MANOVRE



APPENDIX D: PEDESTRIAN MONITORING FORMS

Video Analysis Form for A-Videos

Date: 5/11/2008

	OVERALL VOLUME THROUGH A		**DATA FOR SHOPS ACROSS WAY**	**AVERAGE SPEED DATA**	
TIME BLOCK	**IN**	**OUT**	**Total Number Who Stop**	**Ave. Speed (m/s)**	**Ave. Group Size**
7:00-8:00					
8:00-9:00					
9:00-10:00					
10:00-11:00					
11:00-12:00					
12:00-13:00					
13:00-14:00					
14:00-15:00					
15:00-16:00					
16:00-17:00					
17:00-18:00					
18:00-19:00					
19:00-20:00					
20:00-21:00					

Video Analysis Form for B-Videos

Date: 5/11/2008

	OVERALL VOLUME THROUGH B		**OVERALL VOLUME THROUGH d**		**NUMBER OF PEOPLE TAKING EACH PATH**								**STOPS AT EACH LOCATION**				
TIME BLOCK	**IN**	**OUT**	**IN**	**OUT**	**d to A**	**d to B**	**d to C**	**A to d**	**B to d**	**C to d**	**C to A (neg)**	**A to C (neg)**	**Newspaper Kiosk**	**Souvenir Stands**	**Food Stand**	**Telephone Booth**	**Notes**
7:00-8:00																	
8:00-9:00																	
9:00-10:00																	
10:00-11:00																	
11:00-12:00																	
12:00-13:00																	
13:00-14:00																	
14:00-15:00																	
15:00-16:00																	
16:00-17:00																	
17:00-18:00																	
18:00-19:00																	
19:00-20:00																	
20:00-21:00																	

Video Analysis Form for C-Videos

Date: 5/11/2008

	OVERALL VOLUME THROUGH C		NUMBER OF PEOPLE TAKING EACH PATH				CAFÉ TABLE DATA				AVERAGE SPEED DATA	
TIME BLOCK	IN	OUT	A to C (café)	C to A (café)	B to C	C to B	Seated at Start	Total Who Sit During Video	Total Who Leave During Video	Seated at End	Ave. Speed (ft/s)	Ave. Group Size
7:00-8:00												
8:00-9:00												
9:00-10:00												
10:00-11:00												
11:00-12:00												
12:00-13:00												
13:00-14:00												
14:00-15:00												
15:00-16:00												
16:00-17:00												
17:00-18:00												
18:00-19:00												
19:00-20:00												
20:00-21:00												

Speed Data

Camera A

Date 5/11/08

Age Ranges: 1 - Child; 2 - Teen; 3 - Adult; 4 - Senior; 5 - Mixed

Type: 0 - Unknown; V-Venetian; T - Tourists; U - Unsure

Cart: N - None; S - Stroller; C - Cargo; L - Luggage

Time of Day	7:00						8:00						9:00						10:00					
	Time (s)	Speed (m/s)	Group Size	Age	Type	Cart?	Time (s)	Speed (m/s)	Group Size	Age	Type	Cart?	Time (s)	Speed (m/s)	Group Size	Age	Type	Cart?	Time (s)	Speed (m/s)	Group Size	Age	Type	Cart?
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
	Average Time (s)						***Average Time (s)***						***Average Time (s)***						***Average Time (s)***					
	Average Speed (m/s)						***Average Speed (m/s)***						***Average Speed (m/s)***						***Average Speed (m/s)***					

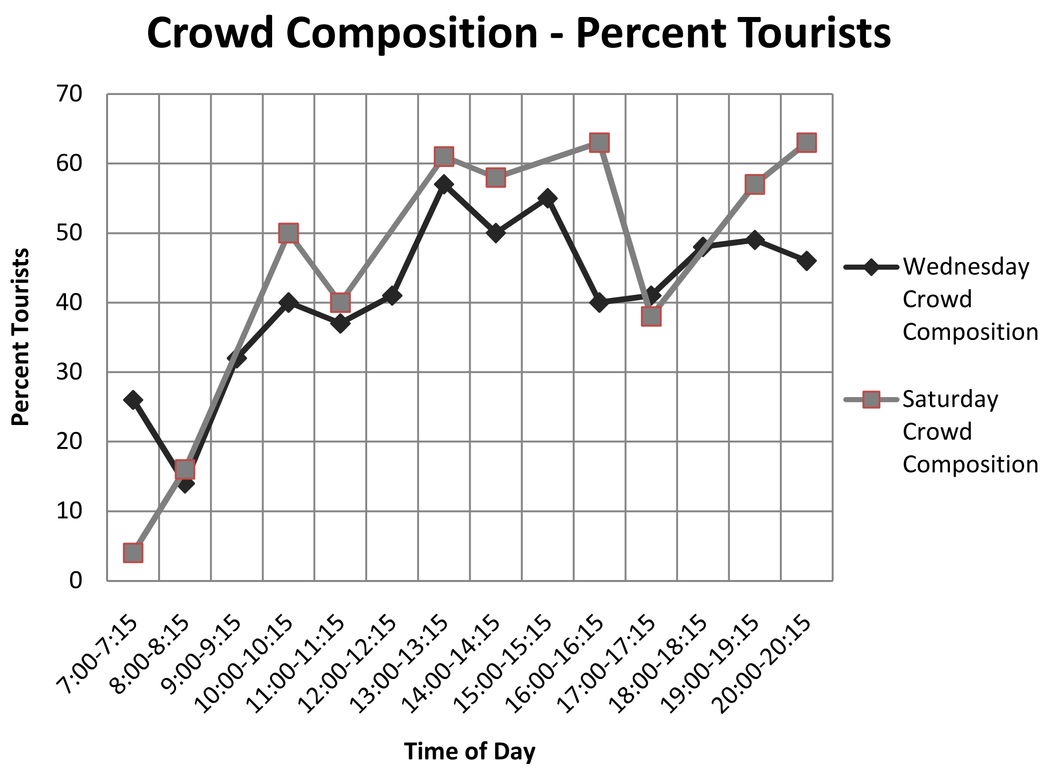
Overall Analysis Form Part 1

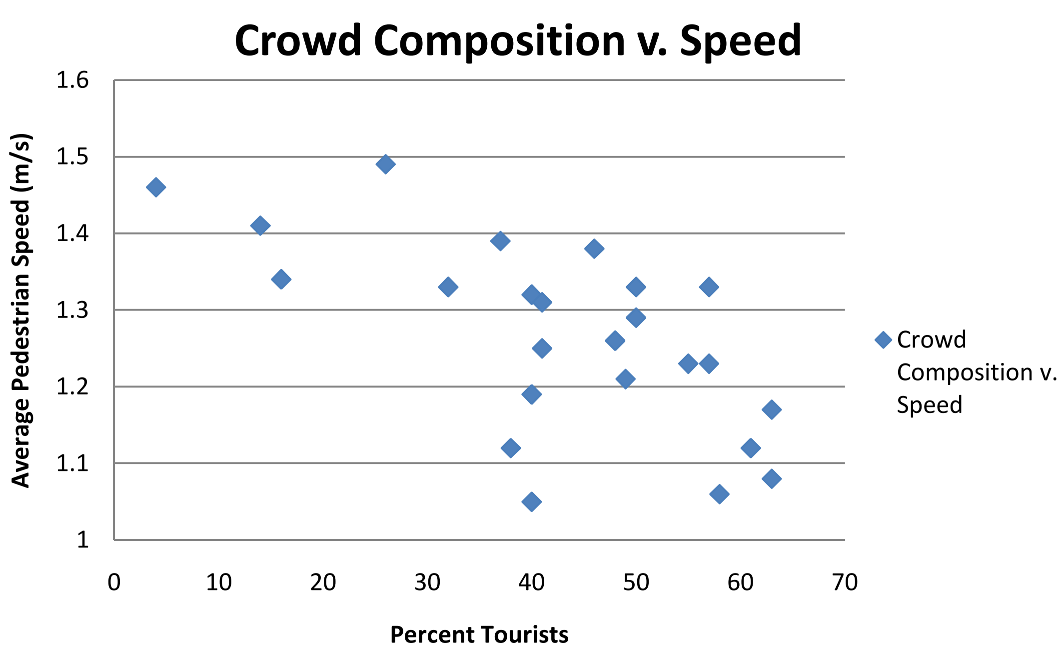
	OVERALL VOLUME THROUGH EACH ENTRANCE								NUMBER OF PEOPLE TAKING EACH PATH														
TIME BLOCK	A (in)	A (out)	B (in)	B (out)	C (in)	C (out)	d (in)	d (out)	A to B	A to C (neg)	A to C (café)	A to d	B to A	B to C	B to d	C to A (neg)	C to A (café)	C to B	C to d	d to A	d to B	d to C
7:00-8:00																						
8:00-9:00																						
9:00-10:00																						
10:00-11:00																						
11:00-12:00																						
12:00-13:00																						
13:00-14:00																						
14:00-15:00																						
15:00-16:00																						
16:00-17:00																						
17:00-18:00																						
18:00-19:00																						
19:00-20:00																						
20:00-21:00																						

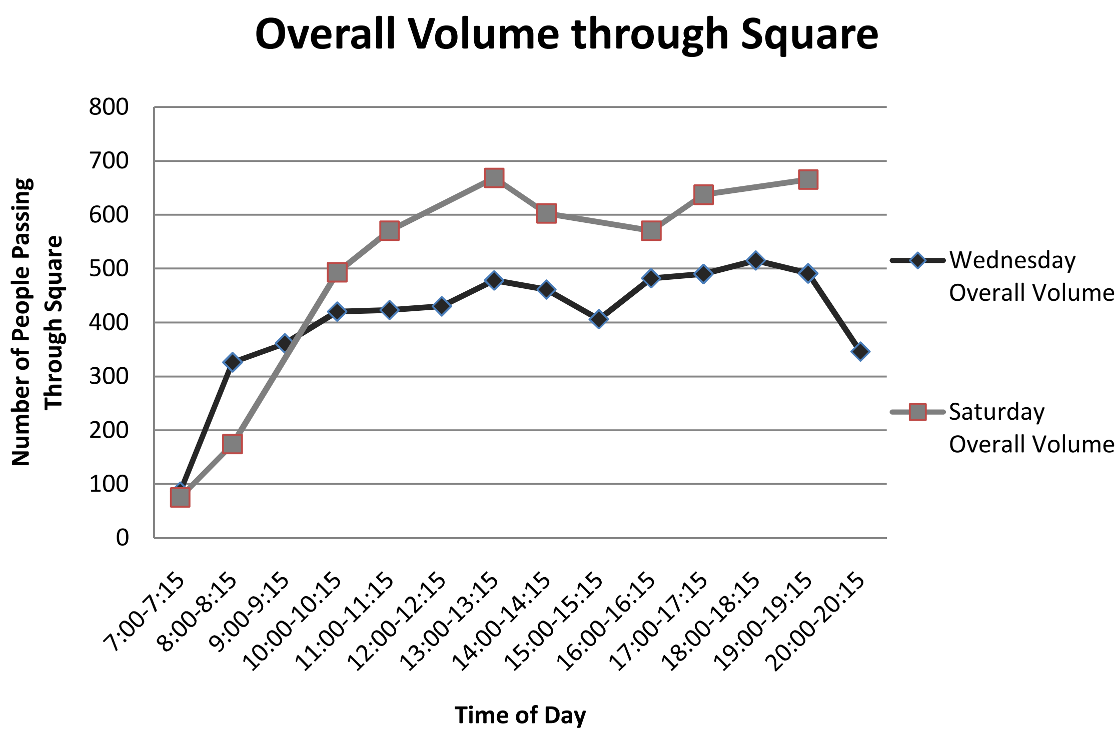
Overall Analysis form Part 2

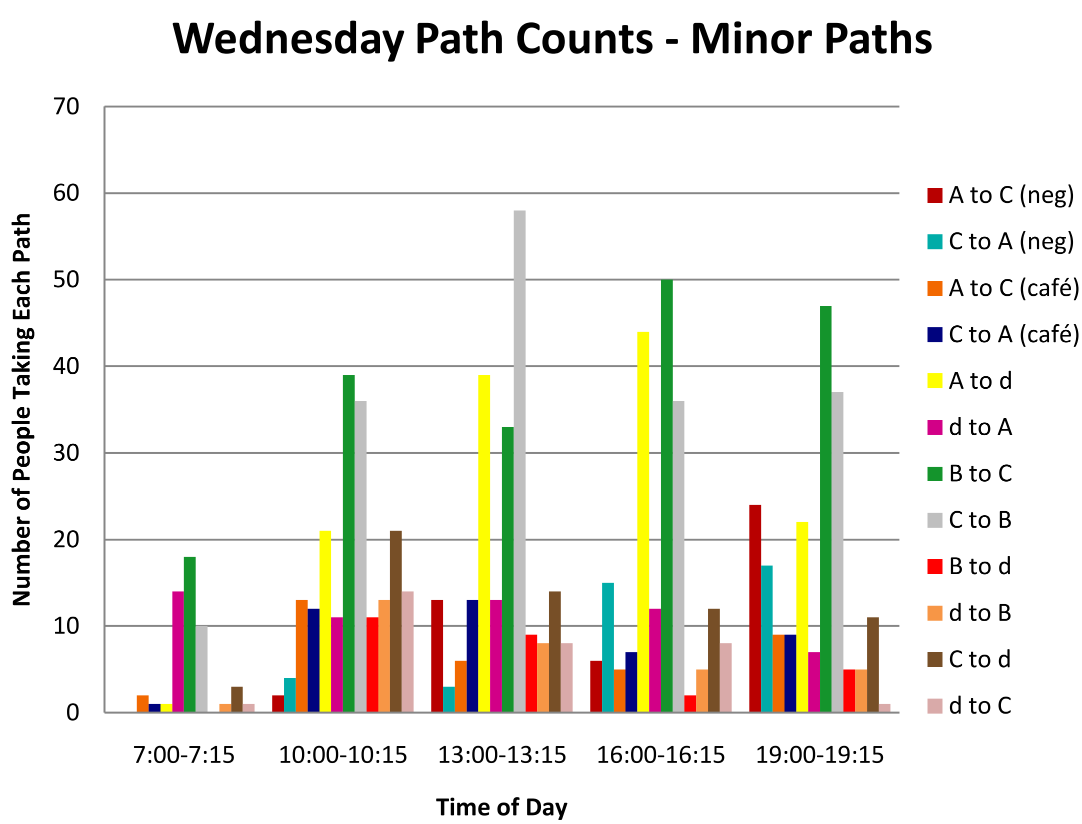
	AVERAGE SPEED DATA		DATA FOR SHOPS ACROSS WAY	STOPS AT EACH LOCATION		CAFÉ TABLE DATA			
TIME BLOCK	Ave. Speed (m/s)	Ave. Group Size	Total Number Who Stop	Newspaper Kiosk	Souvenir Stands	Seated at Start	Total Who Sit During Video	Total Who Leave During Video	Seated at End
7:00-8:00									
8:00-9:00									
9:00-10:00									
10:00-11:00									
11:00-12:00									
12:00-13:00									
13:00-14:00									
14:00-15:00									
15:00-16:00									
16:00-17:00									
17:00-18:00									
18:00-19:00									
19:00-20:00									
20:00-21:00									

Appendix E: Pedestrian Analysis Charts

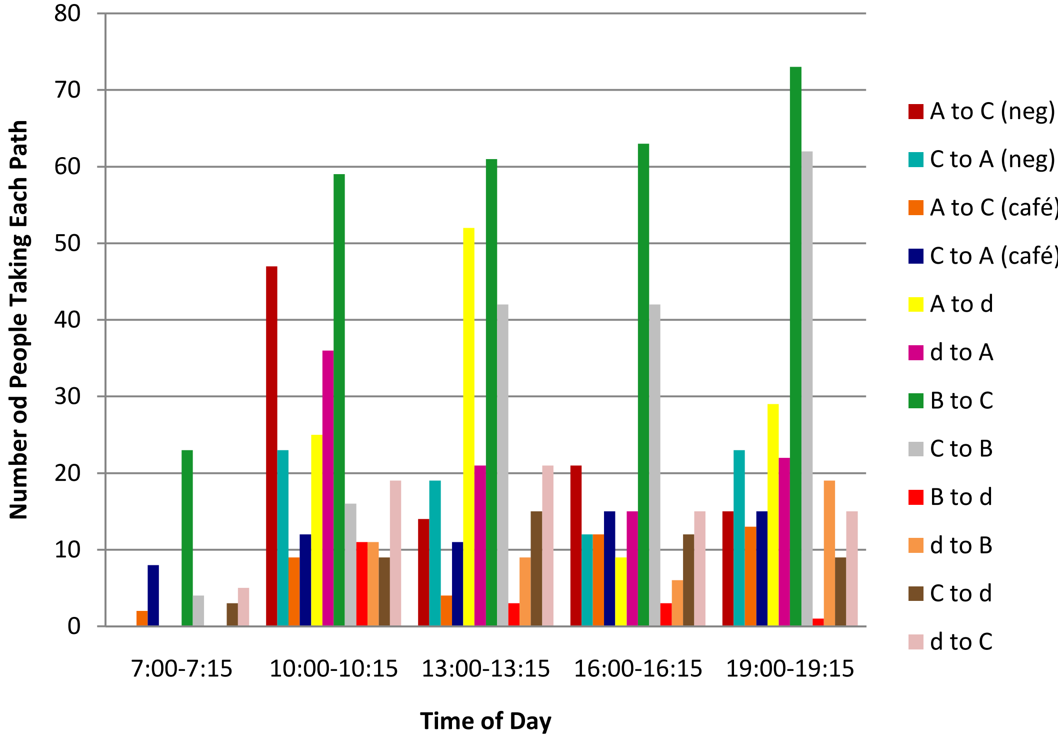




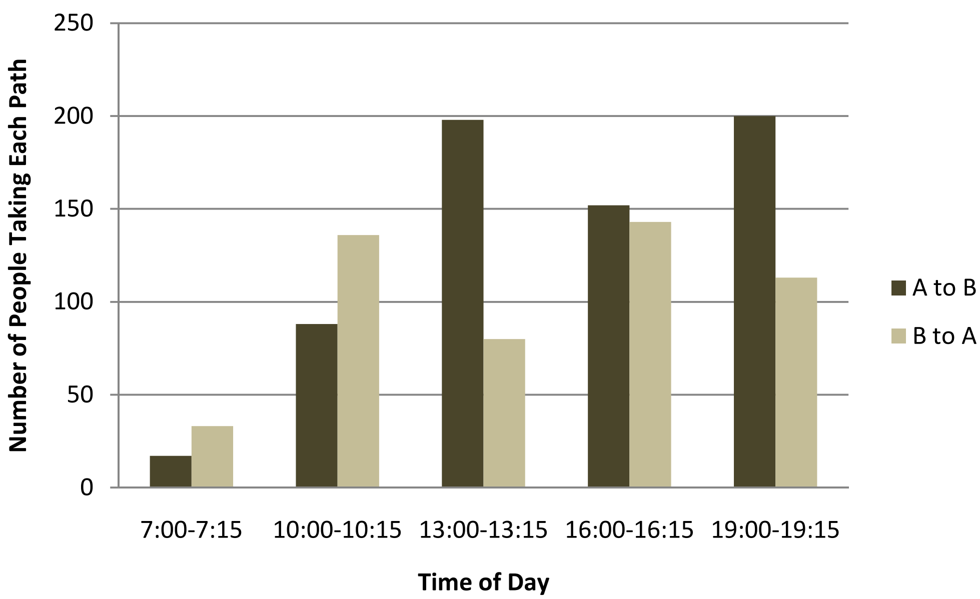

Overall Volume through Square
Number of People Passing Through Square
800
700
600
500
400
300
200
100
0
7:00-7:15
8:00-8:15
9:00-9:15
10:00-10:15
11:00-11:15
12:00-12:15
13:00-13:15
14:00-14:15
15:00-15:15
16:00-16:15
17:00-17:15
18:00-18:15
19:00-19:15
20:00-20:15
Time of Day
Wednesday Overall Volume
Saturday Overall Volume

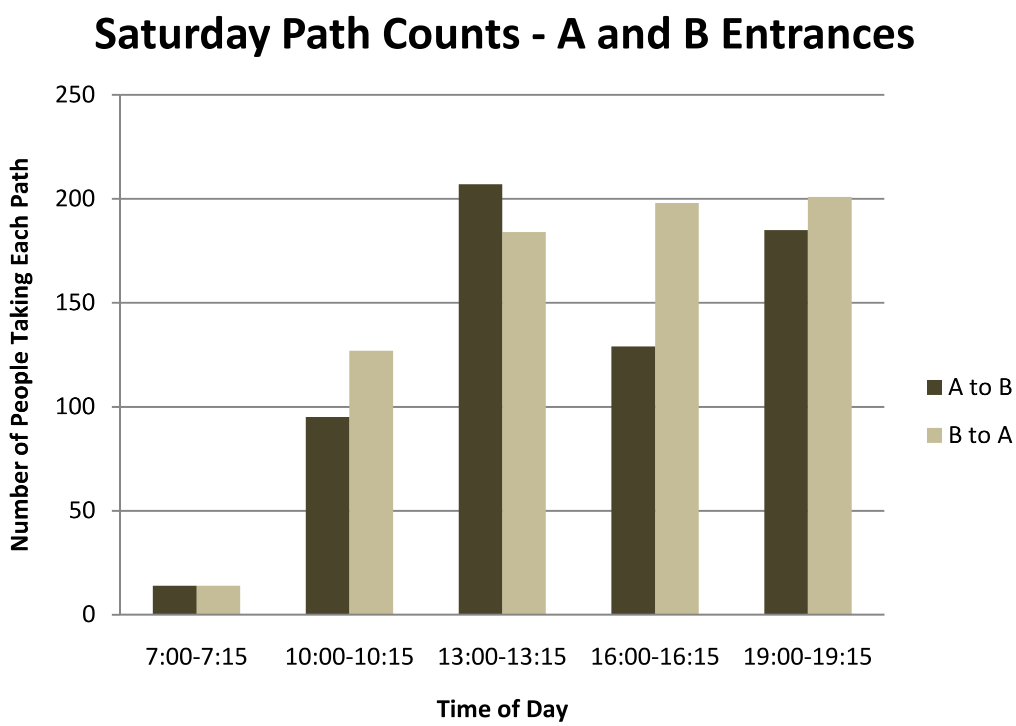

Wednesday Path Counts - Minor Paths
Number of People Taking Each Path
70
60
50
40
30
20
10
0
7:00-7:15
10:00-10:15
13:00-13:15
16:00-16:15
19:00-19:15
Time of Day
A to C (neg)
C to A (neg)
A to C (café)
C to A (café)
A to d
d to A
B to C
C to B
B to d
d to B
C to d
d to C

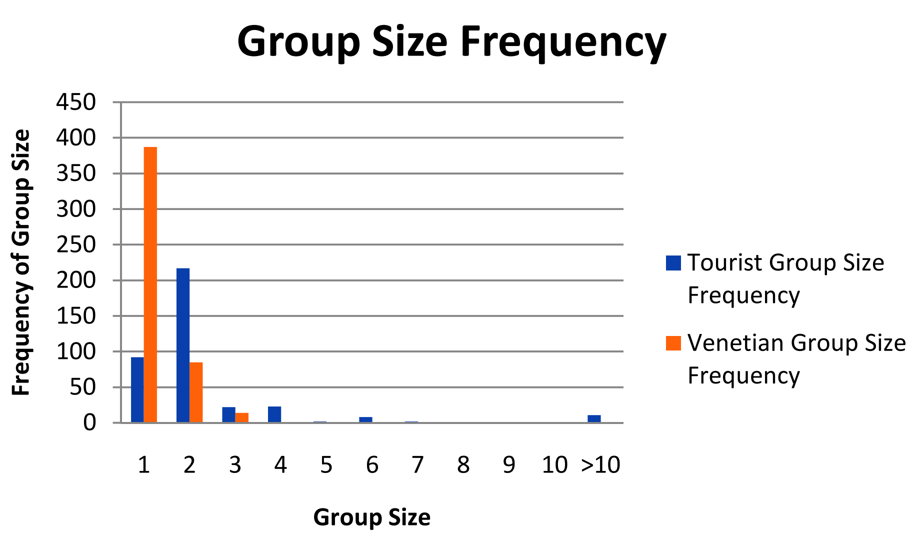
Saturday Path Counts - Minor Paths

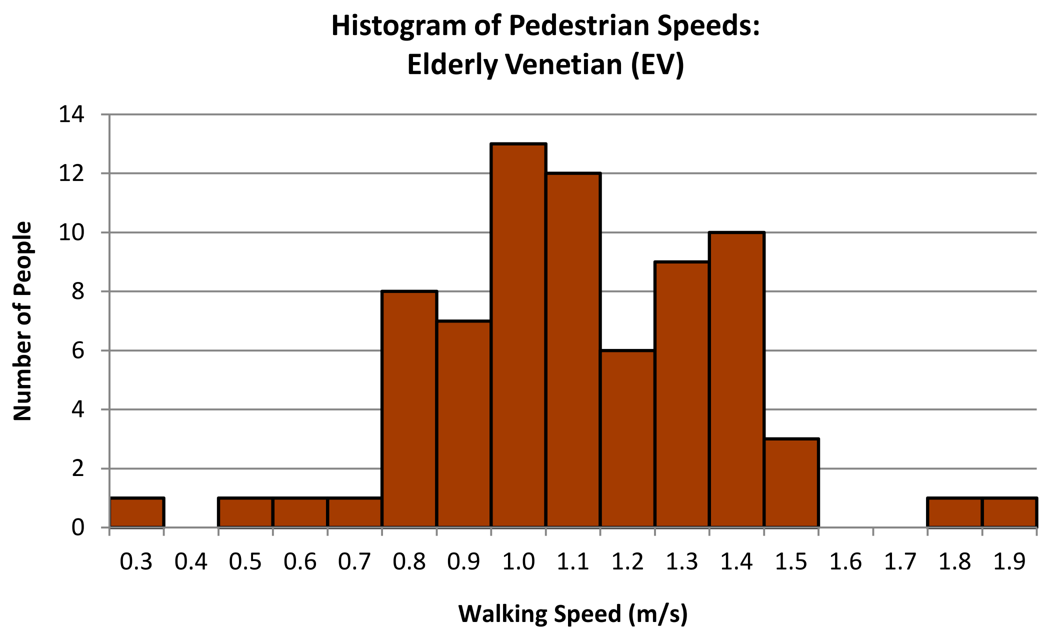


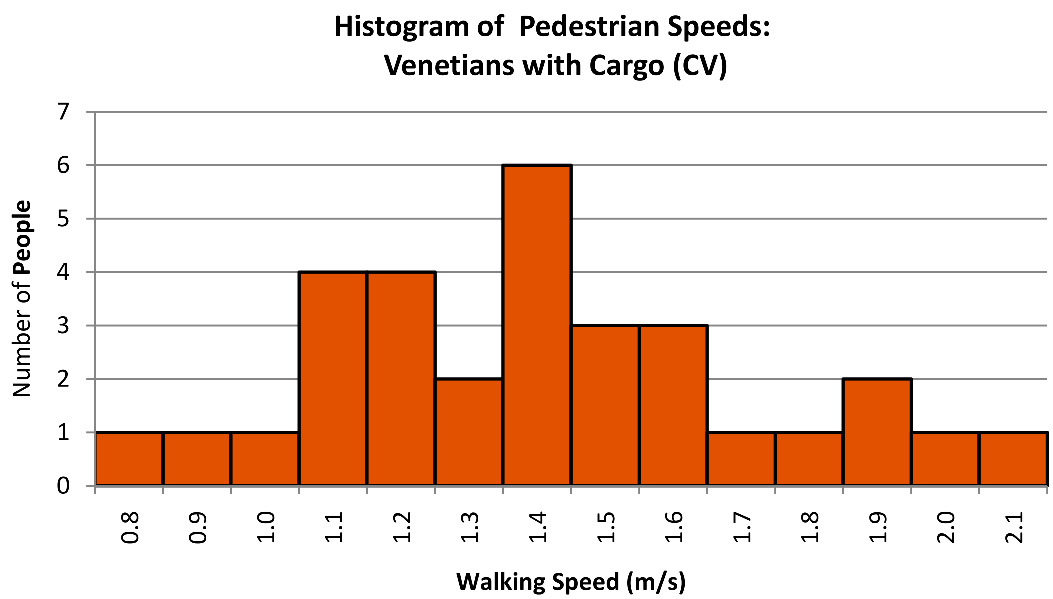
Wednesday Path Counts - A and B Entrances

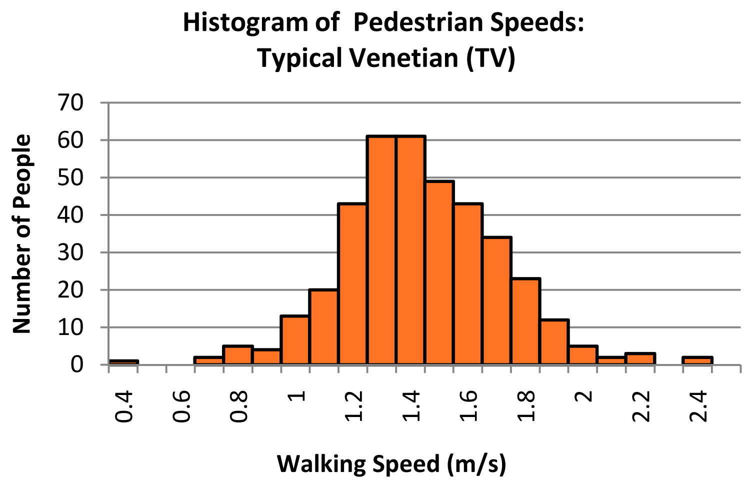


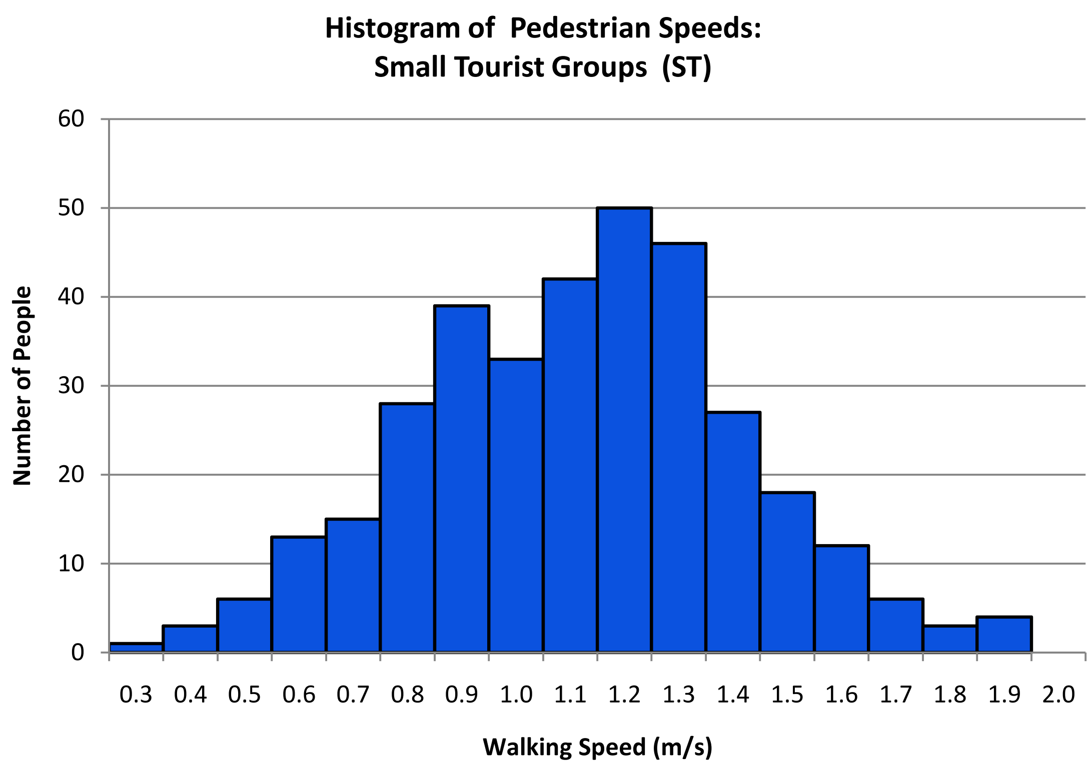

Saturday Path Counts - A and B Entrances
Number of People Taking Each Path
250
200
150
100
50
0
7:00-7:15
10:00-10:15
13:00-13:15
16:00-16:15
19:00-19:15
Time of Day
A to B
B to A

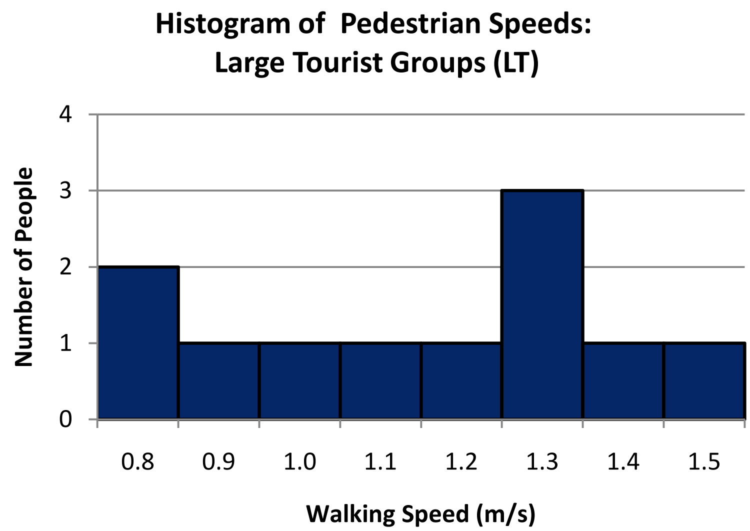

Group Size Frequency
Frequency of Group Size
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
>10
Group Size
Tourist Group Size Frequency
Venetian Group Size Frequency

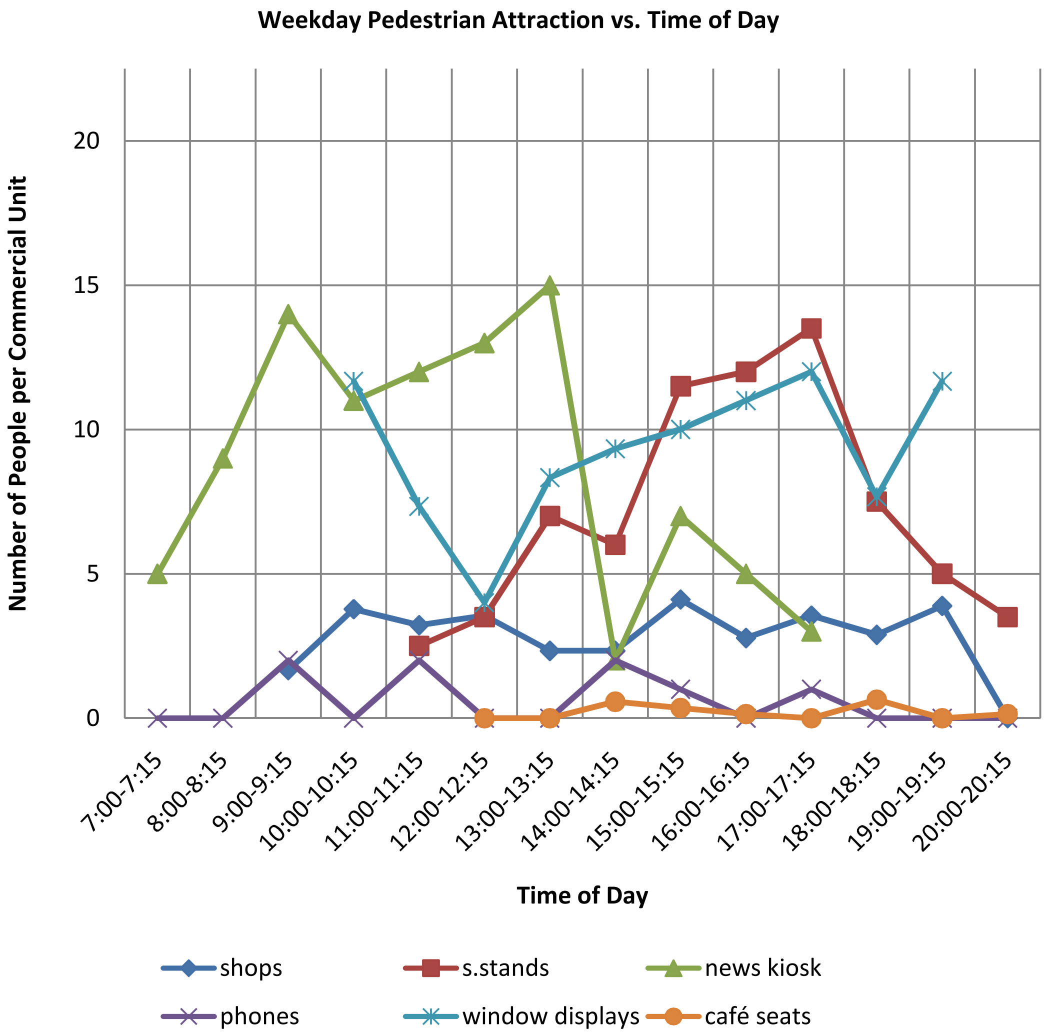

Histogram of Pedestrian Speeds:
Elderly Venetian (EV)
Number of People
0
2
4
6
8
10
12
14
0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
Walking Speed (m/s)

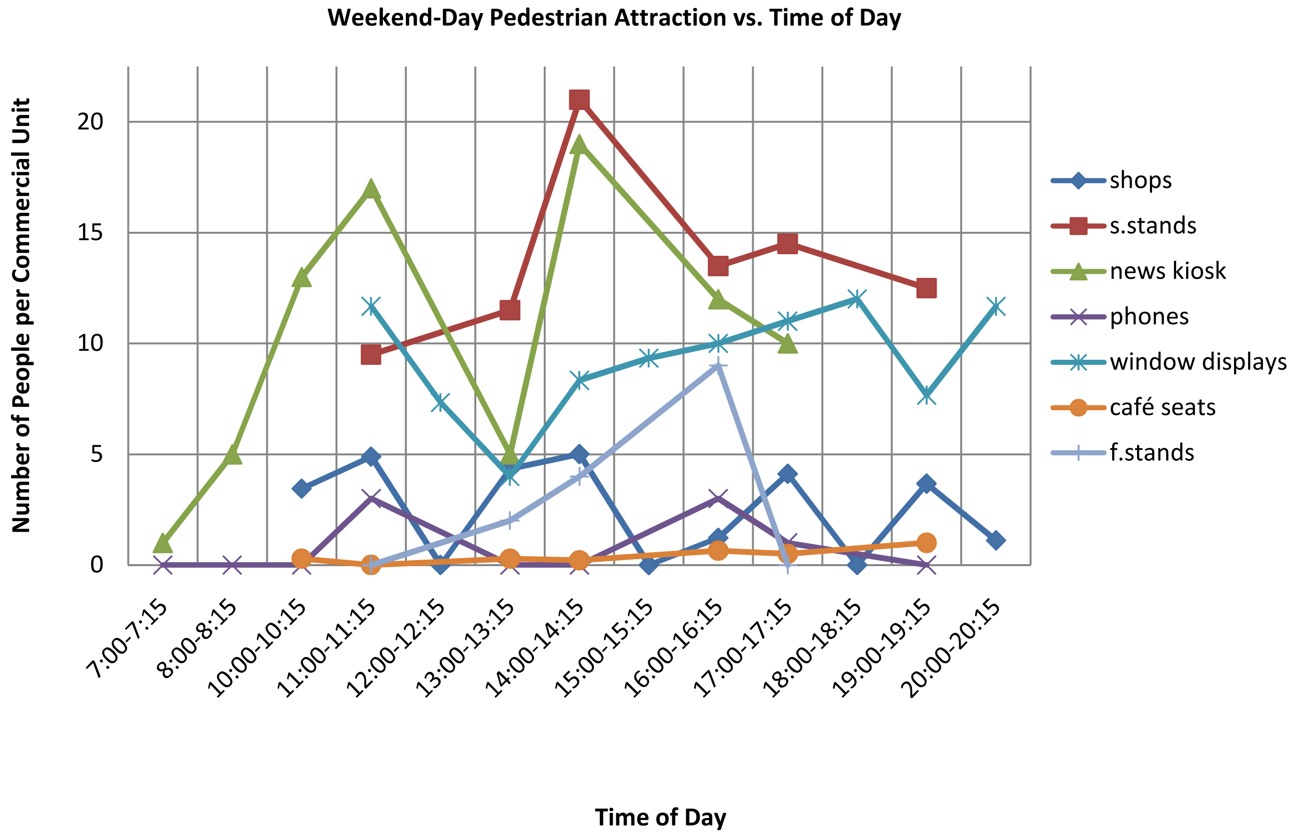

Histogram of Pedestrian Speeds:
Venetians with Cargo (CV)
Number of People
0
1
2
3
4
5
6
7
0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1
Walking Speed (m/s)

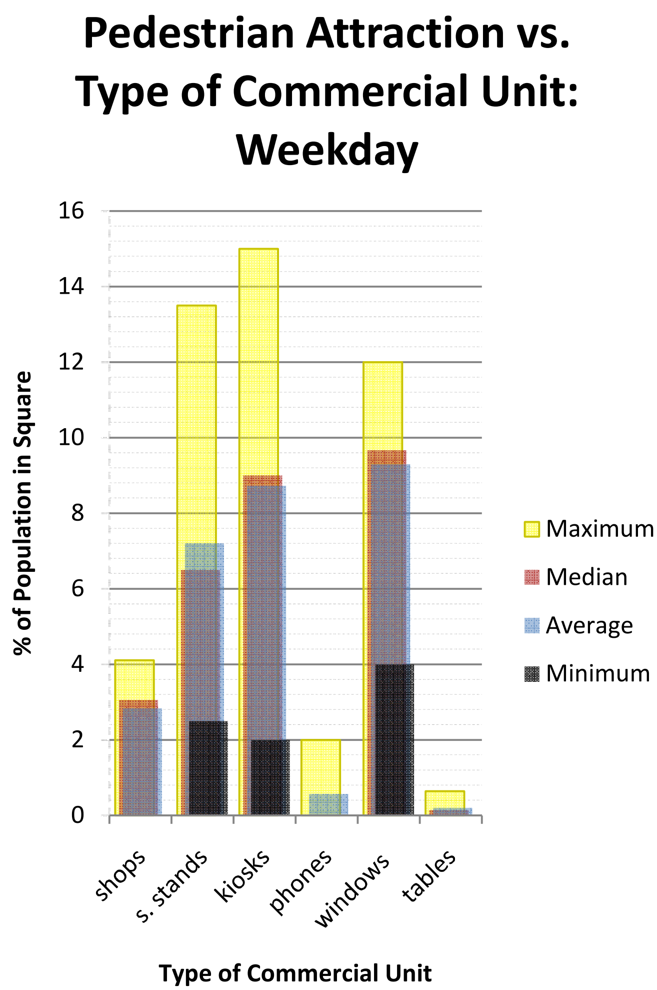

Histogram of Pedestrian Speeds:
Typical Venetian (TV)
70
60
50
40
30
20
10
0
Number of People
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
Walking Speed (m/s)


Histogram of Pedestrian Speeds:
Small Tourist Groups (ST)
60
50
40
30
20
10
0
Number of People
0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Walking Speed (m/s)

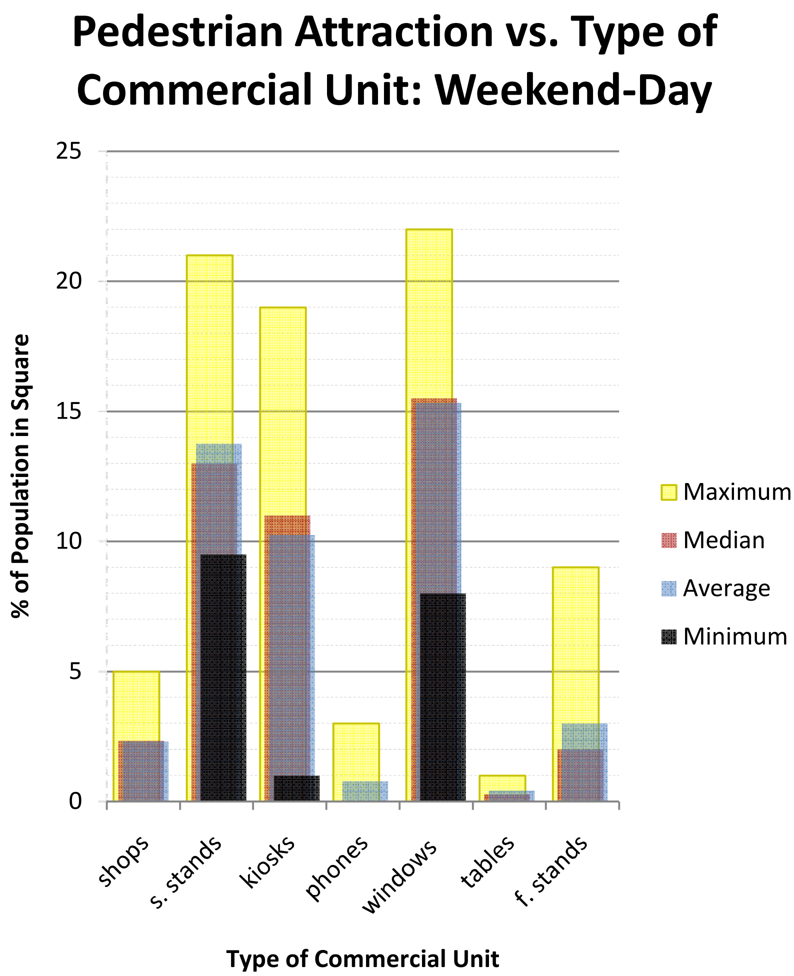

Histogram of Pedestrian Speeds:
Large Tourist Groups (LT)
Number of People
0
1
2
3
4
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Walking Speed (m/s)


Weekday Pedestrian Attraction vs. Time of Day
Number of People per Commercial Unit
0
5
10
15
20
7:00-7:15
8:00-8:15
9:00-9:15
10:00-10:15
11:00-11:15
12:00-12:15
13:00-13:15
14:00-14:15
15:00-15:15
16:00-16:15
17:00-17:15
18:00-18:15
19:00-19:15
20:00-20:15
Time of Day
shops
s.stands
news kiosk
phones
window displays
café seats

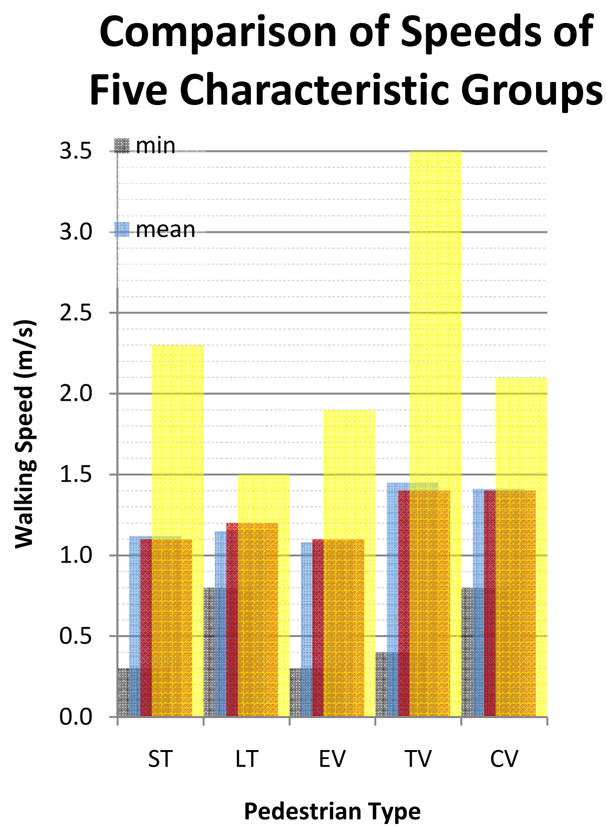

Weekend-Day Pedestrian Attraction vs. Time of Day
Number of People per Commercial Unit
0
5
10
15
20
7:00-7:15
8:00-8:15
10:00-10:15
11:00-11:15
12:00-12:15
13:00-13:15
14:00-14:15
15:00-15:15
16:00-16:15
17:00-17:15
18:00-18:15
19:00-19:15
20:00-20:15
Time of Day
shops
s.stands
news kiosk
phones
window displays
café seats
f.stands

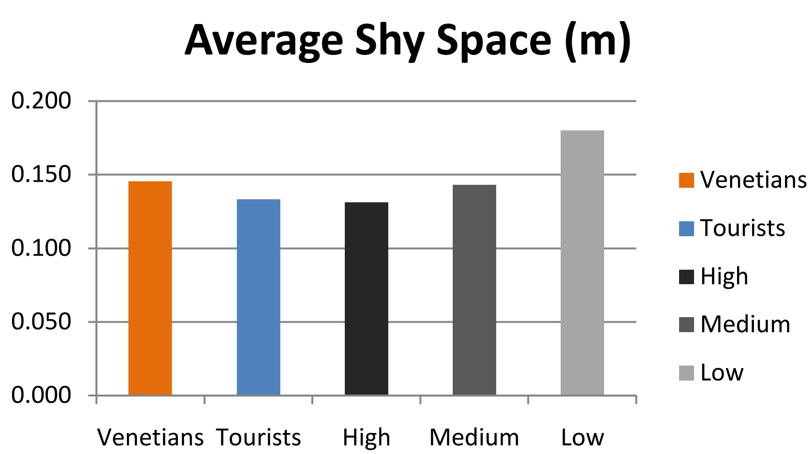


Pedestrian Attraction vs. Type of Commercial Unit: Weekday
16
14
12
10
8
6
4
2
0
% of Population in Square
shops
s. stands
kiosks
phones
windows
tables
Type of Commercial Unit
Maximum
Median
Average
Minimum



Pedestrian Attraction vs. Type of Commercial Unit: Weekend-Day
25
20
15
10
5
0
% of Population in Square
shops
s. stands
kiosks
phones
windows
tables
f. stands
Type of Commercial Unit
Maximum
Median
Average
Minimum


Comparison of Speeds of
Five Characteristic Groups
min
mean
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Walking Speed (m/s)
ST
LT
EV
TV
CV
Pedestrian Type


Average Shy Space (m)
0.200
0.150
0.100
0.050
0.000
Venetians
Tourists
High
Medium
Low
Venetians
Tourists
High
Medium
Low

APPENDIX F: NETLOGO CODE

```
;;; Before programming any functions we must first setup our breeds and give patches and turtles their characteristi

breed [tourists tourist]
breed [venetians venetian]
globals[
free?
current-fillset
t
goal?
done
]
patches-own [
building?
obstacle?
plateatici?
walkway?
path?
sourcesink
exit-distance
corner?
]
turtles-own[
goal
moved?
turn?
speed
]
to setup
  clear-all
  ask tourists [ set turn? false set moved? true ]
  set-default-shape turtles "circle"
  ask patches [set walkway? false set free? false]
  import-pcolors "buildings.png"                ; Load Buildings Layer
    ask patches [set building? pcolor = 46 ]    ; Set up building layer to set corresponding patches as buildings
  import-pcolors "obstacles.png"                ; Load Obstacles Layer
    ask patches [set obstacle? pcolor = 104.7 ]  ; Set up obstacle layer to set corresponding patches as obstacles (
  import-pcolors "plateatici.png"               ; Load Plateatici Layer
```

```
  ask patches [set building? pcolor = 46 ]     ; Set up building layer to set corresponding patches as buildings
import-pcolors "obstacles.png"                 ; Load Obstacles Layer
  ask patches [set obstacle? pcolor = 104.7 ]  ; Set up obstacle layer to set corresponding patches as obstacles ( News
import-pcolors "plateatici.png"                ; Load Plateatici Layer
  ask patches [set plateatici? pcolor = 64.9]  ; Set up plateatici layer to set corresponding patches to plateatici
import-pcolors "SourcesSinksPaths.png"         ; Load Source Sink Layer
  ask patches [
    if pcolor = 43.9 or pcolor = 44.9   [ set sourcesink 1 ] ; Set patches at entrance C to be labled as 1
    ;if pcolor = 44.9  [ set sink   1 ]
    if pcolor = 74.9 or pcolor = 85.9   [ set sourcesink 2 ] ; Set patches at entrance B to be labled as 2
    ;if pcolor = 85.9  [ set sink 2   ]
    if pcolor = 62.7 or pcolor = 46     [ set sourcesink 3 ] ; Set patches at entrance d to be labled as 3
    ;if pcolor = 46    [ set sink 3   ]
    if pcolor = 134.9 or pcolor = 136.8 [ set sourcesink 4 ] ; Set patches at entrance A to be labled as 4
    ;if pcolor = 138 [ set sink 4   ]
  ]
import-pcolors "paths.png"                            ; Loads the path layer, Paths allows for agents to avoid walls
  ask patches[set path? pcolor > 10 and pcolor < 20]  ; Sets up patches with paths
import-pcolors "Corners.png"                          ; Loads the Corners Layer, Corners also assist in having agents a
  ask patches [set corner? pcolor = 44.9
    set pcolor black
    if building? [set pcolor 46]                      ; Places buildings
    if obstacle? [set pcolor red ] ;[set pcolor 104.7]; Places obstacles
    if plateatici? [set pcolor 64.9]                  ; Places plateatici
    ;if corner? [ set pcolor yellow ]
    if pxcor < 1 or pxcor > 532 or pycor < 1 or pycor > 255 [set building? true]     ; Stops agents from walking on the
    if building? = false and obstacle? = false and plateatici? = false [ set walkway? true set free? true]
    set exit-distance [ 0 0 0 0 0 0 0 0 ]             ; Sets up the array exit-distance for the floodfill (first spot i
    ;set path-distance 0
  ]
  set t 1
  while [t <= 4]
  [
     flood-fill patches with [sourcesink = t]         ; Floodfills sinks ( exits ) exit-distance variables 1 - 4
  ]
     flood-fill patches with [path? = true]           ; Floodfills paths          exit-distance variable 5
     flood-fill patches with [corner? = true]         ; Floodfills corners        exit-distance variable 6
```

```
   create-agents
end

to create-agents
  ;ask n-of 30 patches with [walkway? and free?] [sprout-tourists 1 [set size 1 set color pink set turn? false] ask to
end



; floodfill is used to setup a shortest path algorithm in a program to help an agent follow a path in the direction of
;     goal instead wandering in circles almost aimlessly
to flood-fill[pset]
 if is-patch? pset [set pset patches with[self = pset]]
 ask patches [set exit-distance replace-item t exit-distance 9999 ]  ; initializes current value of array exit-distanc
 let n pset                                 ; sets a variable n equal to the set of patches called (Sinks, Paths,
 ask n [set exit-distance replace-item t exit-distance 0 ]   ; Sets all patches being floodfilled to have an exit-dist
 while [count n > 0][
   let nnext patch-set [neighbors with [item t exit-distance = 9999 and walkway?]] of n
         ;creates variable nnext which equals patches surrounding the sink or previously filled patches that are also
   ask nnext [set exit-distance replace-item t exit-distance min [item t exit-distance + distance myself] of n]
         ;sets exit-distance of those surrounding patches to 1 higher then the previous value in the loop
   ;ask nnext [set pcolor scale-color red item t exit-distance 150 0]
         ;;; To visualize how a floodfill works uncomment the previous line and run the setup command
   set n nnext                        ; Makes n the newly edited patches
   set current-fillset n
   show count current-fillset
   ;tick
]
  set t t + 1        ; increments t to finally exit the while loop in Setup
end

to go
  tick
  move-turtles
  make-turtles
end
```

```
to move-turtles
  ask turtles [
    ;if moved? = false [rt 180]
    if goal = 1 [set goal? 1]    ; Because goal is a turtle variable I created goal? as a global to call it outside of
    if goal = 2 [set goal? 2]
    if goal = 3 [set goal? 3]
    if goal = 4 [set goal? 4]
    if turn? = false [
      let possible-moves neighbors with [item 6 exit-distance < [item 6 exit-distance] of myself and item 5 exit-distan
      if any? possible-moves [
        face one-of possible-moves
              ; The turtle faces a square that is within 3 patches of a path and closer to the closest corner (or at be
        ifelse not any? other tourists-on patch-ahead .1 [fd speed set moved? true][set moved? false]
              ; Moves the turtle to that spot as long as no one is on the patch
        if corner? = true [ set turn? true ]
              ; Breaks the "tloop" if the turtle reached a corner
      ]]
     if turn? = true[
      let possible-moves neighbors with [item goal? exit-distance < [item goal? exit-distance] of myself and item 5 exi
      if any? possible-moves [
        face one-of possible-moves
               ; same as previous but agent now aims for its goal
        ifelse not any? other tourists-on patch-ahead 1 [fd speed set moved? true][set moved? false]
        ]
        ]
        ifelse moved? = false [lt 90 fd .01][]  ; if another agent is in the way this agent will move around
        ]
end
```

```
to make-turtles
;;; Creates Tourists or Venetians based on values we recorded.  270000 is the number of ticks counted by NetLogo in 15 minutes for this
;;; Agents get created on a source patch their size is initialized to 1 and they are set to either orange or blue (Venetian or Tourist)
;;; New agents must retrieve a goal and a speed characteristic
  if random 270000 < 51 [ask one-of patches with [ sourcesink = 1 ][sprout-tourists 1 [set size 1 set color blue set turn? false] ask t
  if random 270000 < 70 [ask one-of patches with [ sourcesink = 2 ][sprout-tourists 1 [set size 1 set color blue set turn? false] ask t
  if random 270000 < 21 [ask one-of patches with [ sourcesink = 3 ][sprout-tourists 1 [set size 1 set color blue set turn? false] ask t
  if random 270000 < 146 [ask one-of patches with [ sourcesink = 4 ][sprout-tourists 1 [set size 1 set color blue set turn? false] ask
  if random 270000 < 39 [ask one-of patches with [ sourcesink = 1 ][sprout-venetians 1 [set size 1 set color orange set turn? false] ask
  if random 270000 < 53 [ask one-of patches with [ sourcesink = 2 ][sprout-venetians 1 [set size 1 set color orange set turn? false] ask
  if random 270000 < 15 [ask one-of patches with [ sourcesink = 3 ][sprout-venetians 1 [set size 1 set color orange set turn? false] ask
  if random 270000 < 110 [ask one-of patches with [ sourcesink = 4 ][sprout-venetians 1 [set size 1 set color orange set turn? false] a
  ask turtles [
    ask patch-here [ set done sourcesink ]
    if done = goal [ die ]
    ]  ;  This block removes any agents that have reached their goal
end
```

```
to get-goal
;;; Using our observed values we set goals for each agent dependent on where they were created (where they are coming from)
;;; and the percentages of paths recorded beginning from where they were made
  let goalchoice random 100
  if sourcesink = 1 [
    if goalchoice < 18 [set goal 4]
    if goalchoice >= 18 and goalchoice <= 83 [set goal 2]
    if goalchoice > 83 and goalchoice < 100 [set goal 3]
    ]
  if sourcesink = 2 [
    if goalchoice <= 66 [set goal 4]
    if goalchoice <= 92 and goalchoice > 66 [set goal 1]
    if goalchoice > 92 [set goal 3]
    ]
  if sourcesink = 3 [
    if goalchoice <= 45 [set goal 4]
    if goalchoice <= 72 and goalchoice > 45 [set goal 2]
    if goalchoice > 72 [set goal 1]
    ]
  if sourcesink = 4 [
    if goalchoice <= 77 [set goal 2]
    if goalchoice <= 84 and goalchoice > 77 [set goal 1]
    if goalchoice > 84 [set goal 3]
    ]

end

to reset
  ct        ;Clears turtles
  create-agents
end

to get-speed
  if color = blue [ set speed .0049 ]    ; Sets the speed of tourists to .0049 patches per tick
  if color = orange [ set speed .0059 ]  ; Sets the speed of venetians to .0059 patches per tick
end
```

APPENDIX G: DESCRIPTION OF ELECTRONIC APPENDICES

PEDESTRIAN DATA AND ANALYSIS

The first of the attached files contains the pedestrian data and analysis spreadsheets used to collect pedestrian information in *Campo San Filippo e Giacomo*. These spreadsheets include information on pedestrian volumes, routes, speeds, characteristics, and the number of people utilizing *plateatici*.

BOAT DATA

This file contains information collected at each of the 19 intermediate intersections that were monitored. This information includes the boat's maneuver, type, license, name, percent filled, number of people, material, and the time it completed its maneuver.

BOAT ANALYSIS

The third attached file includes the total number and types of boats that appeared at each intermediate intersection that was monitored. The types include large cargo, small cargo, taxi, private boat without cabin, private boat with cabin, row boat, service boat, large miscellaneous, and small miscellaneous.

PEDESTRIAN MODEL

The next attached file is the NetLogo model. The NetLogo file must be left in the folder along with the .PNGs included in order to work correctly. The model shows an approximation of traffic flow at 13:00 on Wednesday November 5^{th}. The model has an accurate layout of *Campo San Filippo e Giacomo* retrieved using mapping software. The number of agents entering and exiting the square at each entrance is accurate to the data recorded.

MAPINFO

The final attached files are the MapInfo files. These files can be used to view maps of both our counting locations throughout historic Venice. The files can also be used to view the layout of *Campo San Filippo e Giacomo*. In MapInfo the user can choose to view only certain layers in order to better understand the layout of the map.