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Boats and Wakes

Alexander DeLong Solomon
Worcester Polytechnic Institute

Alexander Gottlieb Bennett
Worcester Polytechnic Institute

Samuel Scott Hastings
Worcester Polytechnic Institute

Stephen O. Petry
Worcester Polytechnic Institute

Boats are Waking Me Crazy:

An Analysis of Boat Traffic and *Moto Ondoso* in Venice

An Interdisciplinary Qualifying Project
submitted to the faculty of
Worcester Polytechnic Institute
in partial fulfillment of the requirements of the
Degree of Bachelor of Science

Submitted By:

Alexander Bennett
Samuel Hastings
Stephen Petry
Alexander Solomon

Submitted To:

Project Advisors:

Professor Fabio Carrera
Professor Frederick Hart

ve13-boat@wpi.edu
sites.google.com/site/ve13boat/

AUTHORSHIP PAGE

The entire team contributed equally to the writing and editing of all sections of this project.

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These people were crucial for the success of our project.

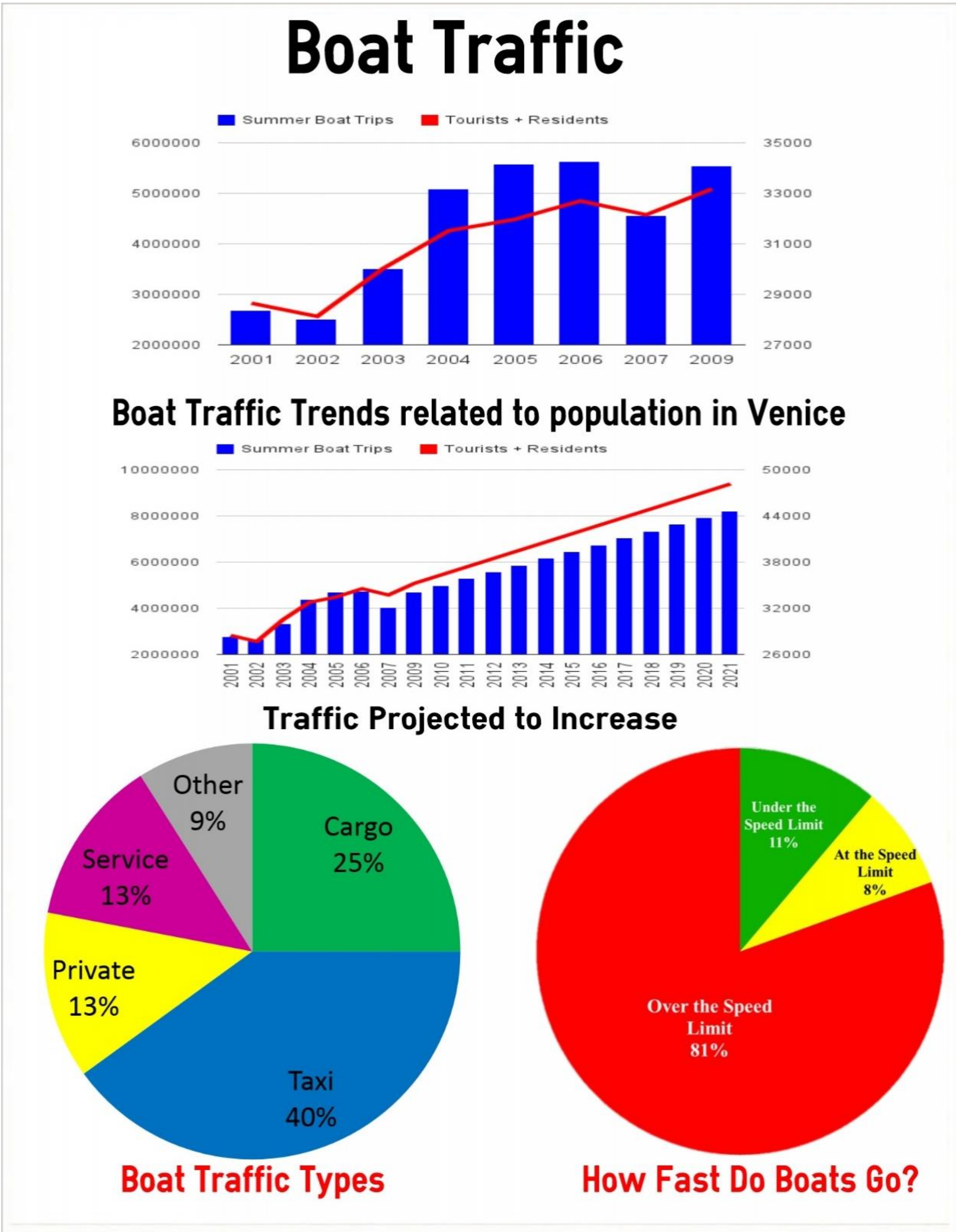
ABSTRACT

Over the past ten years, the number of boat trips being made in the Venetian canals has grown substantially, and is expected to continue to rise in the future. This increase in boat trips represents a major problem for the endurance of Venice, particularly its canal walls due to the phenomenon called *moto ondoso*. *Moto ondoso* is the damage to canal walls caused by boat wakes. There are varying opinions as to how much of canal wall damage is caused by *moto ondoso*, however most can agree that at least 50% of wall damage can be directly attributed to boat wakes.

This project sought to get a better understanding of the past and current levels of *moto ondoso* in the canals, by applying the *Moto Ondoso* Index to COSES boat counts from the past decade. The project then aimed to identify multiple ways in which the City of Venice could reduce *moto ondoso*. The team identified these reduction methods through research, and through observations of our own fieldwork.

The project concluded that there are four major ways the City of Venice can reduce *moto ondoso*, and therefore canal wall damage. These methods include changes to the physical shape of the boats, enforcement of the speed limits in the canals, implementation of a Taxi Re-engineering project, and implementation of a Cargo Re-engineering project. In total, if all of these recommendations were implemented, the team calculated that *moto ondoso* in the canals would be reduced by 57%.

GRAPHICAL EXECUTIVE SUMMARY



Moto Ondoso

Damage caused to Canal Walls from Wake

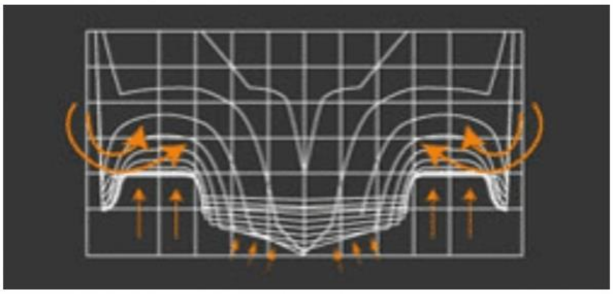
Caused by

Boat Speed

Hull Type

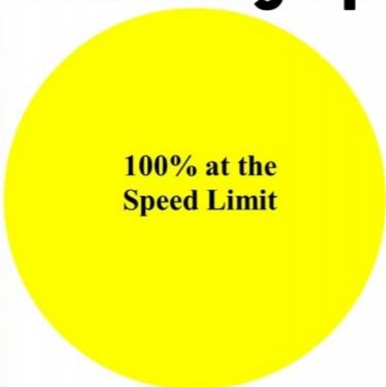
Reducing Moto Ondoso

Change Hull Type



M-Hull Reduces Wake

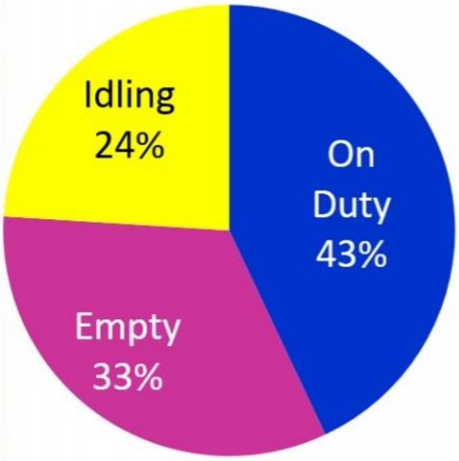
Enforcing Speed Limits



26% Reduction

In Moto Ondoso

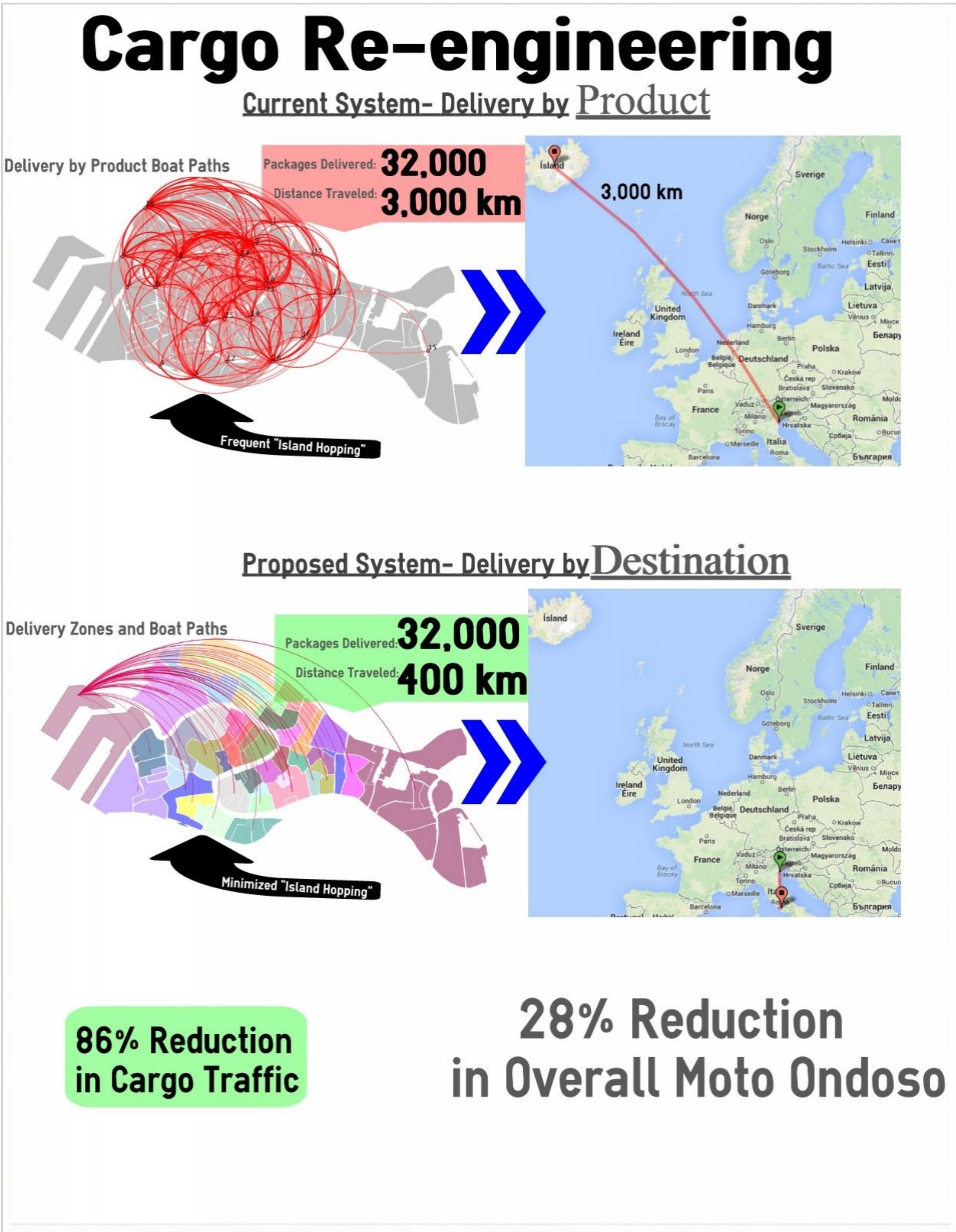
Reducing Taxi Traffic



Taxi App to Reduce Empty Runs

Reduce Moto Ondoso by

14%


Cargo Re-engineering
Current System- Delivery by Product
Delivery by Product Boat Paths
Packages Delivered: 32,000
Distance Traveled: 3,000 km
3,000 km
Frequent "Island Hopping"
Proposed System- Delivery by Destination
Delivery Zones and Boat Paths
Packages Delivered: 32,000
Distance Traveled: 400 km
Minimized "Island Hopping"
86% Reduction in Cargo Traffic
28% Reduction in Overall Moto Ondoso

The Total Economic Benefit

If all plans were implemented!

57%

Reduction of

Moto Ondoso

€400,000

Reduction in Repair Costs per Year

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1. INTRODUCTION

Cities around the world have been plagued by increased traffic. As cities are so densely populated, there is a stronger need for more transportation options such as taxi and public transit. In addition, increased population requires a corresponding increase in the number of delivered goods. With more vehicles on the road, transportation times increase by 66% in some areas.[1] There are cities that have implemented solutions by targeting specific problems such as large cargo trucks. For example, commuting time during the morning commute was reduced by 58 percent in Jerusalem by banning heavy cargo trucks from the highway.[2] These effects are exacerbated in places where a significant portion of the population is not local.

An extreme example of a city where locals are outnumbered is Venice, Italy. Year round, Venice averages 60 thousand visitors daily, which is larger than its resident population.[3] Unlike similar tourist cities, the only means of transport in Venice are by boat or on foot. As a consequence, the cargo necessary to sustain these tourists is delivered by boat. Tourists arrive to, travel through, and experience the city by boat. Before 1950, this was not necessarily a problem; but the introduction of motor boats into the canals had unintended consequences. The turbulence from these boats' motors caused attrition of the canal walls. This problem would be similar to the buildings on a street crumbling down as a cargo truck passes.

Moto ondoso (wake damage) is damage to canal walls caused by motor boats in the Venetian canals. The large number of tourists entering Venice creates a lot of stress on the canal infrastructure due to the constant use of taxis, public transportation, and cargo boats. Because of the high demands of tourists, 46% of all boats in Venice are taxis or public transport, and an additional 36% are cargo vessels.[4] The *moto ondoso* problem is compounded by the fact that the taxi and cargo systems are not operating efficiently. For instance, taxi drivers spend 57% of their time traveling without passengers or simply idling their engine.[5] Even worse, the current cargo system uses 96 boats where only 3 are

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[1] "Moscow traffic rated worst in world," (2013).
[2] Ron Friedman, "Rush Hour Truck Ban Proves Successful," (2010).
[3] Catherine Eade, "Venice tourist warning: 'Cap Visitor Numbers to Avoid Environmental Catastrophe'," *The Daily Mail* 2011.
[4] Giovanni Caniato, *Venezia la città dei rii* (Cierre, 1999).
[5] Robert Accosta, "Re-engineering the Venetian Taxi Transportation System: Efficiency Improvements That Reduce Moto Ondoso," (2006).

necessary.[6] In response to public interest in preserving the canals, Venetian policymakers have set regulations to reduce *moto ondoso*. Currently, new regulations are being added due to international reactions after a German tourist was killed in a boat accident. Joachim Vogel, a professor of criminal law, was riding in a gondola with his family when they were hit by a water bus. In order to safeguard against future accidents, Venetian policy makers will be implementing a 26 point plan that will change some aspects of boat traffic in Venice.[7]

Efforts by Venetian policymakers and WPI IQP groups have made progress towards solving the traffic situation in Venice, but work remains to be done to reach a viable solution. Data provided by previous IQP groups is substantial and incredibly useful, but has not been consolidated. This makes it difficult to access or visualize large trends. Many of the recommendations proposed to Venetian policymakers by previous IQP teams have not been implemented. However, Venetian policymakers have set up speed limits to help limit the creation of *moto ondoso* in the canals. These regulations will be supplemented by the upcoming 26 point plan. While a major step forward, the 26 point plan needs to be analyzed to estimate its effectiveness and to identify areas of improvement. One such area of improvement could be to utilize available technologies to reduce *moto ondoso*. As the next group taking on the *moto ondoso* challenge, we will build on the work of our predecessors, while seeking novel solutions to the problem.

For the 25th anniversary of the Venice Project Center, this IQP will assist Venetian policymakers to produce a framework for reducing the impact of boat traffic on the city in terms of wakes and congestion. To achieve this mission, we laid out specific objectives that will guide us to our end goal. We will start off by analyzing and updating boat traffic counts. With those counts, we will then relate boat traffic to wake impact. Once we have related boat traffic to wake impact, we will explore ways to reduce boat impact. Our project will culminate in the quantification of the economic benefits of a reduction in *moto ondoso*.

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[6] Karolyn Amlaw et al., "Optimization of Cargo Boat Deliveries Through the Inner Canals of Venice," (1997).
[7] Tom Kington, "Venice Tourist's Gondola Death Prompts Canal Crackdown," *The Guardian* 2013.

2 BOAT TRAFFIC IN VENICE

Because Venice was built on a series of islands in a lagoon, the only logical form of effective transportation is by boat. Traditionally, this required hiring a personal gondolier, even for short trips. Mark Twain once described Venice as a place with “no dry land visible anywhere, and no sidewalks worth mentioning; if you want to go to church, to the theater, or to the restaurant, you must call a gondola. It must be paradise for cripples, for verily a man has no use for legs here.”[8] This gondola-driven society lasted well into the 19th century, until the advent of a new type of vessel. In the 1880’s came the first steam-powered boat, the *vaporetti* (water bus), bringing along with it more efficient and easier travel in the city. This efficiency increased again around 1950 with the wide spread introduction of gas-powered boats in Venice.[9] Since that time, gas powered boats have come to dominate boat traffic in Venice. Gas powered boats are now used for almost all types of travel, with the exception of scenic gondola rides.

All boats in Venice can be separated into a few general categories; cargo boats, taxi boats, *vaporetti* (water busses), gondolas, private boats, or service boats. Seen in Figure 1 are two *gondolas* in the background, a large *vaporetto*, and a water taxi in the foreground, and their relative sizes. In terms of the breakdown of traffic, taxis contribute roughly one third, cargo contributes another third, while all other boats make up the final third.[10] The two main reasons for these categories, and the deciding factors as to which category a boat belongs to, is shape and function. The length, width, height, and hull shape are major contributors to how much wake energy the boat dissipates. For example, *gondolas* have a flat hull shape, and produce little to no wake. Function also plays a major role in wake production. Taxis, for instance, often travel at high speeds in order to satisfy their clients. Thus producing more wakes than the same shape boat being used for a function that does not require high speeds. A 2008 WPI IQP studying boat traffic found that these

Figure 1: Boats on the Grand Canal.

[8] Thomas F. Madden, “Venice: A New History”
[9] Dominic Standish, “Venice in Environmental Peril?: Myth and Reality”
[10] Li, Lester, “Turning Traffic Around: An Analyis of Boat Traffic in Venice and its Environmental Impacts”

percentages are not constant throughout the city, as seen in Figure 2.[11] One boat type that is predominant in some areas of Venice is the *gondola*, represented by grey.

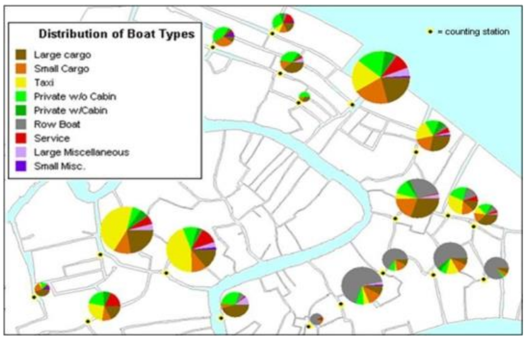

Figure 2: Distribution of Boats in Venice

Traditional boats were designed to accommodate the shallow inner-city canals as well as the mud and sand filled banks. To work with the local environment, traditional boats were designed to have a flat bottom as well as a shallow hull.[12] One traditional boat that still has a presence in Venice is the *gondola* seen in Figure 3.[13] Since the advent of motorized boats, the *gondola* has become one of the well-known traditional boats in Venice. Gondolas are as famous for their unique build as they are as a symbol of Venice. In the past, *gondolas* were used for transporting people short distances in Venice where speed and maneuverability were concerns. Now, *gondolas* are built to take tourists around leisurely, for short distances in Venice. This has resulted in *gondolas* being built for comfort instead of being built for speed and maneuverability.[14]

Figure 3: Venetian gondolas

Another boat that has a noticeable presence is the taxi represented by yellow in Figure 2. Taxis are an important source of transportation in Venice. Taxis are made from either wood or fiberglass. A typical Venetian taxi boat has the ability to seat around ten to eighteen passengers and provides transportation through the Venetian islands and to the airport.[15] Dimensions of a typical taxi boat are 9 meters long, 2.2 meters wide, and 1.3 meters tall, as

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[11] Catanese, Chris, "Floating Around Venice: Developing Mobility Management Tools and Methodologies in Venice"
[12] Sean Candlish, Craig Shevlin, and Sarah Stout, "The traditional boats of Venice: Assessing a maritime heritage," *Worcester: Worcester Polytechnic Institute* (2004).
[13] http://venice2point0.org/gallery/v/wallpapers/KHM_1912+1024.jpg.html
[14] Candlish, Shevlin, and Stout, "The traditional boats of Venice: Assessing a maritime heritage."
[15] Conzorsio Motoscafi Venezia

seen in Figure 4. Engines that are commonly seen on the taxis have a range of 100 to 200 horsepower and run off diesel fuel. [16]

Figure 4: A Venetian Taxi[17]

The taxi system in Venice is responsible for transporting many of the daily tourists in and around the city. In fact, the need for transportation in Venice is so large that taxis and public transportation boats account for 40% of all boats. The individual taxi drivers are grouped together into consortiums, the largest containing 98 taxis. The *Provincial di Venezia Settore Mobilita e Transporti* regulates the taxi licenses in Venice, and also determines the number of taxis required at each of the 13 taxi stands around the city. By doing so, the city ensures each consortium of taxi drivers receives an equal share of taxi business. The taxi system, however, is very inefficient. For example, due to the current system, and breakdown of communication between taxi companies, only certain taxis may pick up passengers in certain areas. Most of the time, a taxi driver must drop off their passengers, and then drive back to the stand at which they are allowed to work. This results in a large number of empty trips for taxis.[18]

As the Venetian economy spread out onto the many islands of the city, the logistics of delivery became more complicated. Each store now requires deliveries of specified items at specified times. Also, the delivery to a particular store must first be made to the island that store is located on. This is because delivery workers often cannot transport large carts up and over the bridges connecting the islands. To fill these needs, the Venetian cargo system is designed to make deliveries based on item. This system has many inherent inefficiencies.

First and most profound, each island requires dozens of separate deliveries for the stores on that island to get the various goods they require. A previous WPI study focusing on the Sestiere of San Marco, found that the island of San Luca received deliveries from 96

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[16] Accosta, "Re-engineering the Venetian Taxi Transportation System: Efficiency Improvements That Reduce Moto Ondoso."
[17] Ibid.
[18] Accosta, Robert "Re-engineering the Venetian Taxi Transportation System"

different boats on a given day. This exemplifies extreme inefficiency because only three boats could have supplied all of the cargo delivered to the island of San Luca that day. This increase in efficiency could have been accomplished by restructuring the cargo delivery system, which will be discussed later.[19]

Gondolas are typically used by tourists to travel around Venice. Gondolas begin their trips at heavily tourist populated spaces, and then move through canals in the surrounding area. Gondolas run from approximately 10 in the morning to 10 at night. Gondolas contribute to traffic by occasionally stopping so that tourists can get a better view of the city.[20] As can be seen in Figure 5, this often leads to congestion.

Figure 5: Gondola Traffic

As with any city, Venice encounters several problems as a result of traffic. The most obvious of these problems is congestion and increased traffic time. Another city with similar congestion problems is New York City. As a result of this congestion, the average commuting time in New York City is 38 minutes. The commuting times in Venice and New York cannot be compared directly however, due to the fact that Venice has 130 times fewer citizens, and about 100 times less land area. Based on this, it would be reasonable to guess that commuting time in Venice would be orders of magnitude less than in New York. Surprisingly, the average commuting time in Venice is very close to that in New York, at 31 minutes.[21]

Another, less obvious problem caused by increased traffic levels, may be one that is unique to Venice. Because the canals of Venice serve as the roads, there is the added problem of the destruction caused by the wakes of passing boats. The structural damage caused by this phenomenon is discussed later, but the cultural impact is another issue. The onset of new motor boats in Venice undoubtedly had positive effects on the economy, but there are also numerous negative effects. The most recent example of this is the increase in cruise ship dockings in Venice. "Defenders of the ships say 5,000 local families are supported by the

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[19] Karolyn Amlaw, "Optimization of Cargo Boat Deliveries Through the Inner Canals of Venice"
[20] David Chiu, Anand Jagannath, and Emily Nodine, "The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice" (Worcester Polytechnic Institute, 2002).
[21] Alosio, Christopher, "Venetian Mobility on Land and Sea"

jobs" provided by the many tourists arriving on cruise ships every day. Those opposed to the ships cite the hydrodynamic effects caused by the ships' passing. A 2010 WPI IQP found that as the huge ships pass the city, some canal depths drop by an average of 11 centimeters, and the speed of the water flowing through the canals increases by 57%.[22]

The dispute between the people advocating for the economic benefit of the boats, and the people citing the adverse effects came to a head on September 21st 2013. 50 protesters dove into the Guidecca canal in an attempt to stop over 35,000 tourists from arriving on 12 cruise ships.[23] This most recent protest symbolizes the tension between Venice and non-traditional boats that dates back to 1881 with public outcry over the first steamboats on the Grand Canal.[24] The city of Venice and its inhabitants are at the same time dependent on the economic stimulus provided by new kinds of boats, and fighting to stop the accompanying destructive forces.

As tourism in Venice reaches nearly unsustainable levels, the traffic system in the city is also strained to similar levels. The thousands of tourists flocking to the city everyday require a specific infrastructure to provide services, souvenirs, food to eat, and means of transport, otherwise they will stop visiting, and the Venetian economy will collapse. The need for tourist related stores has resulted in a 229% increase in the number of tourist shops from 1976 to 2007.[25] To support this economic shift, more taxis, public transportation, and cargo boats are necessary. A 2000 study by COSES (Consortium for Research and Educational Training) concluded that combined, these boats make roughly 25,000 trips each day.[26]

2.1 Traffic Regulations

The *Provincial di Venezia Settore Mobilita e Transporti,* is the branch of the Venetian government that regulates traffic. Regulations are classified by *di linea* (by line) and *non di linea* (not by line). Line transportation includes all scheduled boats such as ACTVs and not by line transportation is a category that consists of: taxis, gondolas, and charter boats.[27] Speed limits, as seen in Figure 6, are based on a number of parameters: boat type and location.

[22] Shane Bellingham, "Cruise Control"
[23] Tom Kington, http://www.telegraph.co.uk/news/worldnews/europe/italy/10326417/Protesters-dive-into-Venices-canal-to-block-cruise-ships.html
[24] New York Times, "STEAM-BOATS IN VENICE"
[25] Aurilio, Laura "A Detailed Look at the Changing Venetian Retail Sector"
[26] Standish, "Venice in Environmental Peril?"
[27] "Settore Mobilita e Transporti." Provincia di Venezia.
http://www.trasporti.provincia.venezia.it/serv_pubbl_ndl/terra/trnl_amv.html

Setting speed limits by boat type is to prevent boats with high wake hulls from causing more wake damage.

Figure 6: Map of Venice speed limits

Changing speed limits by location is common enough around the world. This type of regulation occurs in many cities speed limits are changed when driving in residential zones, near construction, etc. Venice faces a unique situation where the regulations set in place are not just to manage traffic but also to manage the effects of traffic on the environment. Because boats have an impact on the canals of Venice, they are prohibited from consciously producing *moto ondoso*. Boats are also prohibited from driving in proximity of work that is being done to restore buildings and foundations.[28] Regulations have been set to help reduce the impact of traffic on the city, but with any city these regulations are at times not followed.

Taxis abide to regulations that manage where each taxi is allowed to stop, the amount a taxi driver can make, and how fast a taxi can drive. There are 13 taxi stops in the city, the amount of taxis that will be at each stop is decided by separating between the cooperatives and consortiums. There are 219 licensed taxis, and each is either an individual owner or involved in a consortium. The largest consortium, Consorzio Motoscafi Venezia, has 98 taxis, as of 2006, which is about 44% of the taxis in Venice.[36] The reason taxi drivers are assigned locations is to prevent competitive pressures from de-equalizing the taxi system. The taxi

[28] "Settore Mobilita e Transporti." Provincia di Venezia. http://www.trasporti.provincia.venezia.it/serv_pubbl_ndl/terra/trnl_amv.html

fares are currently decided using a meter, in 2006 the meter started off at 8.70 euro, and then added 1.30 euro every minute as the trip progressed. The amount of money a taxi driver can make is decided by the aforementioned assignment of taxis to a particular location. The different consortiums have their own methods of assigning a taxi to a location. For instance, the Consorzio Motoscafi Venezia assigns taxis based on dividing the total number of taxis into 16 teams. Each team has a total of 6 taxis. The teams are assigned to 16 locations around Venice and then are cycled with a period of 16 days. Taxis located at San Marco airport follow a similar system and at the end of the day pool their money together to equalize the pay each makes.

Cargo traffic in Venice makes up approximately 25% of all traffic in Venice.[29] Cargo is typically organized into two types. There is Conto Proprio (their own) which is used to describe cargo boats that are owned by the companies that they deliver to. It is considered illegal for these boats to deliver to other stores. Then there is Conto Terzi (literal translation: behalf of third parties or others), these type of boats legally transport goods for third parties. These boats can then be separated into the different types of cargo that they deliver. There are three main types, non-refrigerated, refrigerated, and unit loads.

Any individual that wants to become a taxi driver must first fulfill three conditions. Applicants cannot have been sentenced to jail time for crimes against patrimony, public faith, public order, or industry and commerce. An applicant must show some sort of professional aptitude usually through the form of an apprenticeship. Finally an applicant must pass a written examination encompassing all knowledge that is required to pilot a water taxi with a score of at least 70%.[30] The city of Venice only allows a specific number of taxi licenses, which is another means of regulating taxis.

Within Venice if a boat driver wants to work in the cargo industry there are six licenses that are available. Five of them are mandatory; the first registers the company with the Chamber of Commerce. The second license is a certification showing that the driver is qualified to operate his vehicle. The third license is a shipping license specific to boat drivers who travel in internal waters. The fourth license handles plates and registration of the boat and the fifth license is a permit to park the boat in the city overnight and it specifies which

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[29] Lester Li et al., "Turning traffic around -- an analysis of boat traffic in Venice and its environmental impacts," In *Technology and Environment*. (Worcester, MA: Worcester Polytechnic Institute,, 2008), http://www.wpi.edu/Pubs/E-project/Available/E-project-122107-161101/.
[30] ACTV S.p. A. ACTV. 2006 [cited September 9 2006]. Available from http://www.actv.it/english/azienda.php?pagina=storia.

parking spot is to be used. The sixth license is only for those boats that are going to operate in *conto terzi*.[31]

In order to maintain the regulations developed by the city of Venice there must be some way to enforce those regulations. The tools that are used to enforce these regulations change depending on which regulation is being enforced.

Enforcement of regulations in the canals is done by two separate organizations. The coast guard enforces the lagoon, the canal between Giudecca and Venice, and the Grand Canal; the jurisdiction of the Venetian police is the rest of the Centro Storico. These different jurisdictions create loopholes that boat drivers can use to their advantage. The regulation of people transport is an issue but it is only one piece of the puzzle.

The death of a German tourist, a professor Joachim Vogel, has caused an international reaction to the traffic conditions in Venice. Professor Vogel "was taking a tour with his wife and three children on August 17th when the gondola they were in was crushed against a dock by a reversing *vaporetto*"[32]. The mayor of Venice announced a 26 point plan that will take affirmative action to improve the conditions in the canals. Among these points are "drug and alcohol tests for boat handlers, following reports that the gondolier involved in the fatal collision had traces of cocaine and marijuana in his blood."[33] An original and translated version of the 26 point plan is available in Appendix B and Appendix C.

2.2 Boat Counts in Venice

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[31] Jill Duffy et al., "Re-Engineering the City of Venice s Cargo System For the Consorzio Trasportatori Veneziani Riuniti," (2001).
[32] Kington, "Venice Tourist's Gondola Death Prompts Canal Crackdown."
[33] Ibid.

In order to better quantify the amount of boat traffic in the city of Venice, a 1992 WPI IQP developed a method for conducting and documenting accurate boat counts. Using their method, data was collected at various intersections around the city. To collect and document the data, the group took note of the canal of entry to the intersection, and which canal it exited to. They also recorded boat type, time, number of passengers, license plate, and amount cargo, as seen in Figure 7.[34] These traffic counts were performed at various locations, or intersections, around the city. At each intersection, each canal segment was given a label, in order to record the turning movement of the boat. After the system was developed and refined by WPI, it was taught to The Consortium for Research and Education (COSES), in the hopes that they would perform counts semi-annually for the foreseeable future.

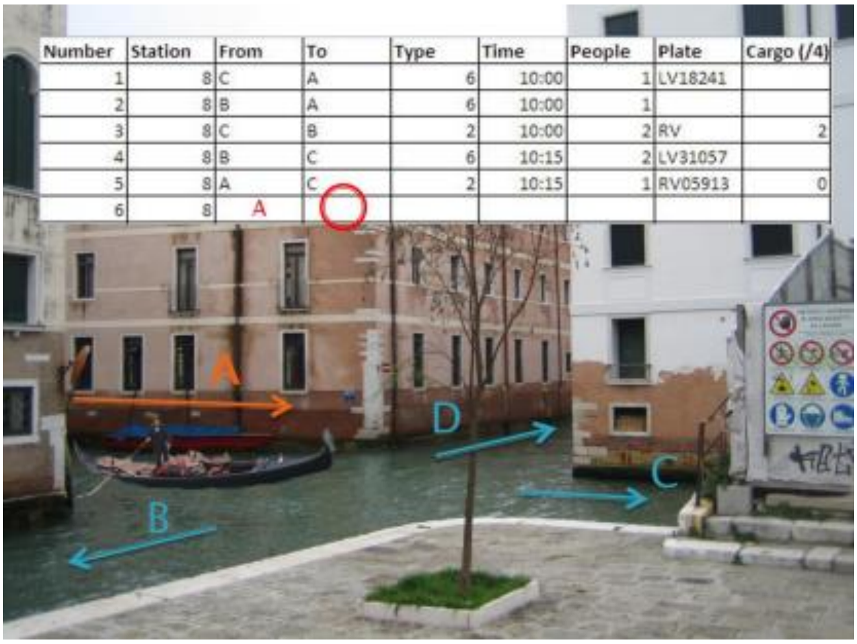

Figure 7: How Boat Counts are performed.

The actual distribution of the ensuing boat counts can be seen in Figure 8. Despite the fact that the counts were not performed in the winter and summer, which would be the ideal counting times, the 15 separate boat counts have provided us with large amounts of data on how boat traffic is distributed in the city. This data is vital to our project because it allows us to visualize large traffic trends over the past decade, and also quantify the wake impact, or *Moto Ondoso*, for previous years.

[34] Balboa, Mark "Turning Traffic Around"

Month	Year 2001	2002	2003	2004	2005	2006	2007	2008	2009
Janruary									
February									
March					25th				
April	5th	19th	11th	9th		14th	6th		
May									
June									
July									
August	31st	30th					31st		
September			5th	3rd	2nd	1st			4th
October									
November									
December									

Figure 8: When Boat Counts were taken

2.3 Analyzing Boat Traffic

First, the team will gather all previous data on boat counts in the City of Venice. This data will be collected from databases created by former WPI IQPs, as well as COSES. All of the turning movement data must then be gathered into one central database. Next, the data must be organized by counting station, or intersection. In order to analyze this data by canal segment, each canal must be associated with a specific turning movement at each intersection. For more details about how boat traffic counts by turning movement are performed, see Figure 9. Once this association is made, the number of boats that performed a specific turning movement is equal to the number of boats that went through the accompanying canal segment. It is also important to note that it is irrelevant whether a boat was coming from, or exiting to, a canal segment, the net effect is the same: one boat in that canal segment. Figure 9 displays COSES boat counts by turning movement, and pure volume. The variable missing from this analysis is boat type.

Figure 9: Boat Traffic by Canal Segment

The second step to analyze boat traffic in Venice is to further break down the traffic by boat type. Because each boat was categorized into types during the actual counts, acquiring the number of each type of boat in each canal segment requires us to essentially bring along the boat type as we divide the traffic by canal segment. We can then gather information on the specific number of each type of boat in each canal segment. Once the team has the data organized by type of boat in each canal segment, the *Moto Ondoso* Index becomes much easier to apply.

The COSES data shows an overall trend for increases in boat traffic. Figure 10 below shows the trend in four different categories of boats. These are not the only categories of boats that exist in the canals they are only the largest percentage.

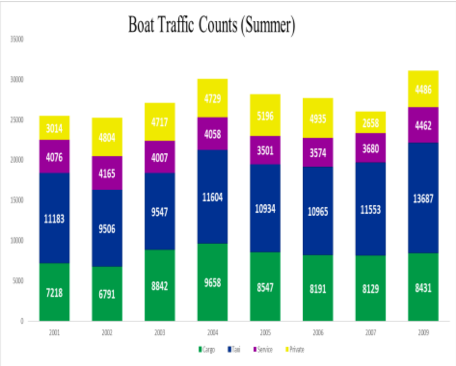

Figure 10: Boat Trips made from 2001 to 2008 by Cargo, Taxi, Service, and Private boats.

These four different categories: Cargo, Taxi, Private, and Service are the types of boats that also produce the most *moto ondoso*. The pie chart in Figure 11 shows the distribution of boat traffic in 2009, which is the last time boat counts were recorded by COSES.

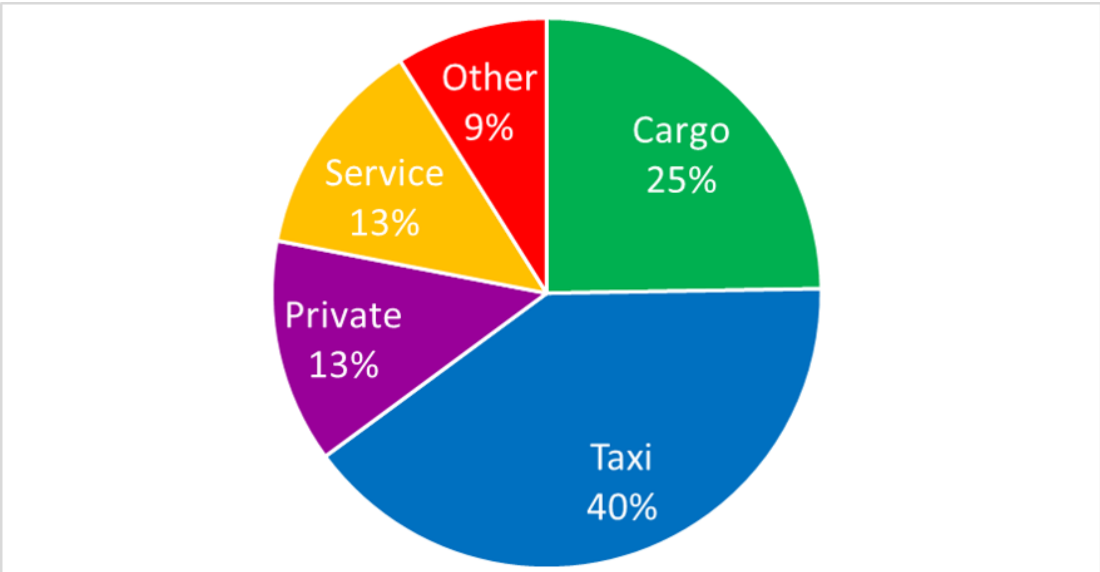

Figure 11: Boat Traffic Distribution 2009

It was also discovered that boat traffic follows the same trend as the population in Venice. Figure 12 compares the trends in tourism and boat traffic for the summer months (August and September). These trends can then be projected outward to hypothesize how many tourist and boat trips will be counted in the future.

Figure 13 shows that boat traffic trends and the population in Venice are increasing together. If the current trend continues then by the summer of 2020 there will be approximately 44000 boat trips made in a single day, this assumes all else being equal.

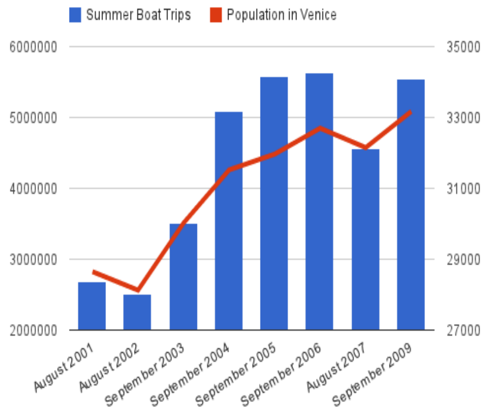

Figure 12: Boat Traffic and Population in Venice

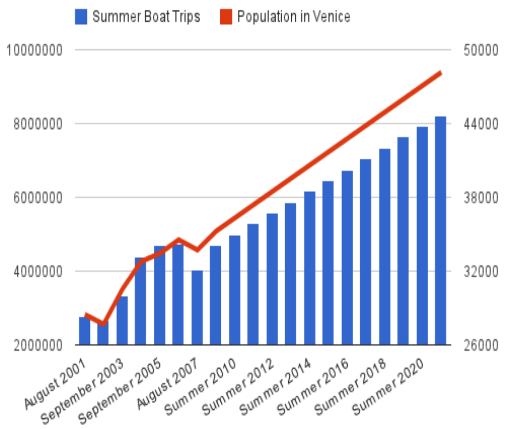

Figure 13: Projected growth of Boat Traffic and Population

Apart from identifying these trends the data that was made available by COSES was organized. The raw data has been gathered and can be found in a single folder on the teams google drive. Two other excel sheets were created in order to summarize the data. The first is a summary of the boat traffic counts for 21 stations. The data contains information regarding the station and counts that were made there. This included the total amount of traffic, traffic by type (such as Cargo, Taxi, etc.), the peak hour of traffic, and the count of that hour. The second excel sheet contains information regarding the total amount of traffic within a specific segment of canal. The stations data set was uploaded to the console and will be used on the website for interactive station data. The interactive station data will go on a map where the user will be able to click on each stations icon and data on the station will pop up. Among the data that will be made available will be a google motion chart. The motion chart in Figure 14 is a cumulative motion chart for the 21 stations that were used. It displays *moto ondoso* vs Total Summer Boat Traffic. The color of each station is unique, and the size of each bubble can be modified but currently depends on the amount of cargo traffic there was for that year.

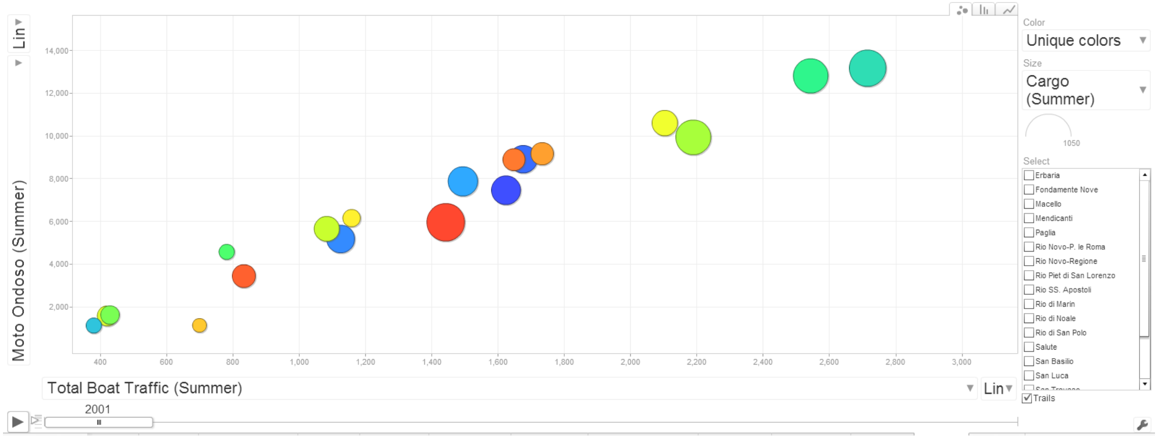

Figure 14: Example of a motion chart that is available online with the station data

The boat traffic data that was provided by COSES was disorganized and for some years incomplete. In order to process the data and display it using infographic tools it first had to be organized. The raw data was collected and put in a single folder that is available online and a summary of station and canal segment data was created in order to easily process the information. For twenty-one individual stations the GPS coordinates for each station were found allowing them to be placed on the interactive tool. Once this data was made available online, further analysis was necessary in order to project boat traffic into the future.

In order to first establish that boat traffic would increase as time progressed it was necessary to first relate boat traffic to tourism. According to the United World Tourism Organization tourism in Europe in 2020 is supposed to increase to 717 million tourists[35]. As Venice is itself a city whose economy relies primarily on tourism a large percentage of those tourists will most likely visit Venice at some point in time. Once establishing that tourism and boat traffic follows the same trends it could then be assumed that boat traffic will increase into 2020. Thus a linear estimate of the small sample size of boat traffic was made in order to project the increases of tourism and boat traffic. The linear estimate projected that per year there will be 883 more boat trips counted. According to the recorded distribution of boat traffic in 2009, of these 883 boat trips, 221 of these trips will be from Cargo boats, 353 will be taxi, and the other 309 boat trips will be made by Private, Service and Other types of boats. The result of these projections is that by 2021, forty-four thousand boat trips will be made within the Venetian canals. The increase in boat trips that were counted has a corresponding increase in *moto ondoso*. Thus with time the traffic situation in Venice will

[35] "Tourism 2020 Vision," http://www.unwto.org/facts/eng/vision.htm.

only get worse and the net result will be more maintenance costs for the canal walls. These projections assume that nothing will be done to change the cargo and taxi systems to make them more efficient.

The motion chart was formatted to display the four types of boat traffic per year, the total *moto ondoso* per station and the total amount of traffic per year. This tool allows the user to choose a station and visualize the type of traffic that is the most proliferate at these stations. The motion chart is also extraordinarily multivariate. Meaning you can change the setting of the chart to try and relate different variables with one another. For instance the amount of Cargo and Taxi traffic could be set on the Y-axis and the X-axis.

Raw data was collected for the different COSES campaigns; each campaign has a database associated with it. Several years were missing from the data we had available to us. This would be the 2002 summer and 2003 spring and summer raw data files. Queries are available for these seasons and years, but the data seems to be missing from our drive. Other types of data that have been uploaded to the console include a summary of boat traffic stations and canal segment data. The canal segment data was organized so that each canal segment would have a total traffic volume associated with it. The canal segments were broken up into which stations they were associated with. All of this data was sent to another team as a supplement to the data that they possessed. Then it was uploaded to the CityKnowledge Console.

For each station and each campaign the peak times in the traffic data were found. For 52% of the time the peak times were between 10:00 AM and 12:00 PM. Below is a graph showing the peak hour for the 2009 campaign. As can be seen in Figure 15 the peak for boat traffic occurs between 9:00 AM and 11:00 AM. Then it decreases heading into the afternoon.

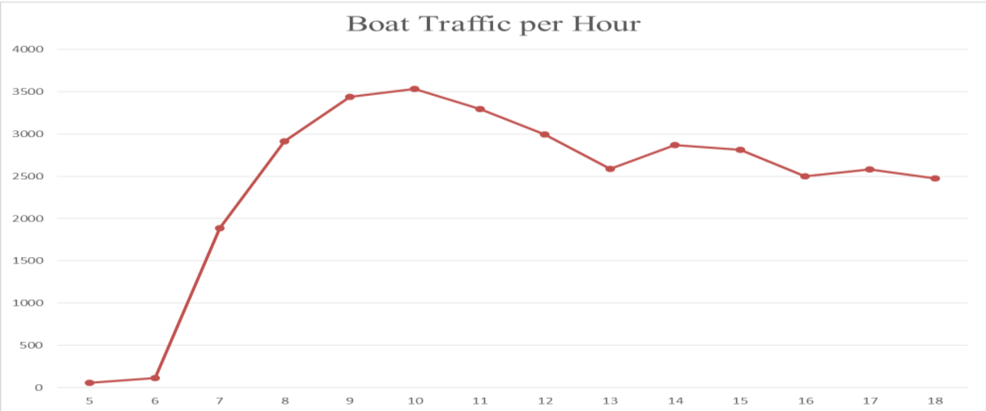

Figure 15: 2009 Campaign, boat counts by Hour

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3. MOTO ONDOSO

Moto ondoso, an Italian phrase literally meaning "wave motion", refers to the damaging wakes produced by all types of motor boats, as seen in Figure 16. This turbulence is the principal cause of damage to the Venetian canals.[36] Because *moto ondoso* is only caused by motor boats, it was not a problem before the 1950s. Since then, however, the canals have been degrading faster than ever before. Historically speaking, *moto ondoso* is a relatively new phenomenon. The first motor boat was not created until the middle of 1886 and did not become widespread for several decades after that.[37] In a city with over 1500 years of history, one hundred years is a blink of an eye.

Figure 16: Ambulance Causing Moto Ondoso

Because Venice was a city built on a lagoon, boats were the natural way to get around. Over time, the Venetians began modifying the natural and changing canals. These modifications eventually became the canal system we know today. When constructing the canal walls, the Venetians had a choice of several building materials. The two main materials they used were brick and Istria stone, a type of limestone similar to marble. In most canals, the Venetians used the Istria stone as a base, and then used bricks to extend the walls above the waterline.[38]

For most of their history, the canals fared well with this mix of materials. The introduction of motor boats, however, revealed an issue. To begin with, the water level in the canals has risen 23 centimeters higher than it was in 1897 thus exposing the brick sections of the wall to water.[39] Additionally, brick, unlike limestone, is porous. The turbulent saltwater began to penetrate the bricks and, over time, erode them as can be seen in Figure 17. As this brick is

Figure 17: Canal Wall Damage

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[36] "Insula Informa," ed. Insula (2000).
[37] "Gottlieb Daimler Memorial in Bad Cannstatt," http://media.daimler.com/dcmedia/0-921-1303725-1-1303019-1-0-0-0-0-1-11694-614318-0-1-0-0-0-0-0.html?TS=1302091862634.
[38] Thomas F. Madden, *Venice a New History* (Penguin Group, 2012).
[39] Insula, "Venice Preservation and Urban Maintenance," ed. Insula.

eroded away, a larger surface area is exposed to the water accelerating the deterioration.

This decay is accelerated by the introduction of corrosive chemicals into the canal. The main components here are sulfuric acid from the Mestre-Marghera industrial zone and sewage from blocked sewer outlets. Sulfuric acid eats away at the stone of the canal, mostly the limestone, and weakens internal support structures severely compromising the integrity of the canal walls. When the outlets become blocked by sediment, sewage that would normally flow freely into the canal is instead trapped in pipes inside the canal walls. From here, it leeches into the surrounding stone weakening it. The industrial zone has been much less active since the late 1970s, and the city has been doing a better job of regularly dredging the canals, so sewage is becoming less of a problem. Unfortunately, much of the damage has already been done; it is just a matter of time before the turbulence wears away those weakened sections.[40]

3.1 Physics of *Moto Ondoso*

When a boat moves through the water, there are two sets of ripples that come off of the boat. One set from the bow, and another set from the stern. The set from the bow, called the wash, is the result of the boat pushing water out of the way as it moves. It is like the rush of air you feel as a car drives by. The set from the stern, called the wake, is the result of the motor churning up the water to move the boat. This is like the wind generated by a propeller plane. As you can guess, the second of these two turbulences is the more energetic. Boats displace a relatively small amount of water compared to the amount their engines must displace to move the boat.[41]

All waves, whether in air or water, are alternating regions of higher and lower pressure. When a boat is traveling through water, its motor churns the water and creates these pressure waves. What we see on the surface as waves are the manifestations of this underwater turbulence. If a boat is in open water, these waves can dissipate and their energy does not damage anything. When confined in a canal, however, there is nowhere for the energy to go but to be absorbed by the walls.

3.2 Measurement of *Moto Ondoso*

Determining the energy of a pressure wave is both very simple and incredibly complex. The simplest way to measure it is to simply put a pressure sensor in the path of the

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[40] Chiu, Jagannath, and Nodine, "The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice".
[41] Ibid.

wave and take a reading.[42] Unfortunately, this method would not work well in the canals. The primary issue is that sensors must be deployed in an array. A pressure sensor takes data at a single point, but the information needed is spread out over a wide area. Additionally, because the canals are so narrow and shallow, the waves diffract and interfere with each other so as to make point reading inaccurate.

An alternative to point measurements is to try to describe total energy of the wake. This is what a 2002 IQP team did[43]. They compared the speed of different boats to the amount of energy they released into the canal. The major factor in the energy of a wake is its amplitude. As you can see in Figure 18: Plot of Velocity vs Wake Amplitude, this increased exponentially as boat speed increases. From these energy calculations, they created the Moto Ondoso Index, a simple system that relates the type of boat and speed to the energy contained in its wake.[44]

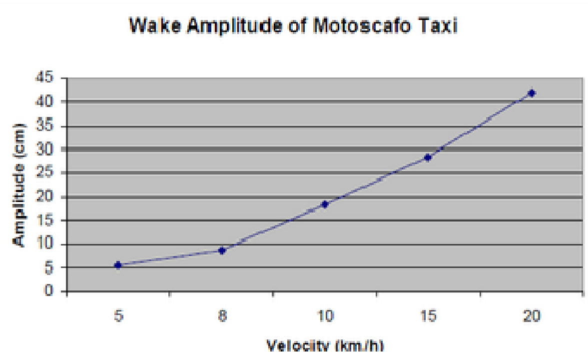

Figure 18: Plot of Velocity vs Wake Amplitude

3.3 Obtaining Average Boat Speed Values

In order to see how *moto ondoso* has changed over time, we needed to know the distribution of speeds for the various types of boats in Venice. We started by identifying several different types of canals with different speed limits. As you can see in section 2.1, there are two main speed limits in the interior canals in Venice, 7 km/h in the Grand Canal, and 5 km/h elsewhere, as well as, 11 km/h zones on the outside of the city. In each of these areas, we took data on the speeds of the five different types of boats included in the MOBILIS data. From this, we got a general distribution of speeds that we could apply to the boat count data.

Looking at the speed data, it is apparent that speeding is a problem. For example, as shown in Figure 19, out of the 188 boats that speed data was taken in the Rio de Ca'Foscari, all boats were going above the speed limit. Additionally, the only way for the city to reduce

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[42] Morgan Elise Gelinas, "Industrial Ships' Wake Propagation and Associated Sediment Resuspension in the Venice Lagoon," (2011).
[43] David Chiu, Anand Jagannath, and Emily Nodine, "The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice" (Worcester Polytechnic Institute, 2002).
[44] David Chiu, Anand Jagannath, and Emily Nodine, "The Moto Ondoso Index: Assessing the Effects of Boat Traffic in the Canals of Venice" (Worcester Polytechnic Institute, 2002).

moto ondoso for private boats would be by enforcing speed limits. This is because there are other measures the city can take for cargo boats, taxis, and service boats because other rules and regulations can be put in place that would reduce their *moto ondoso*.

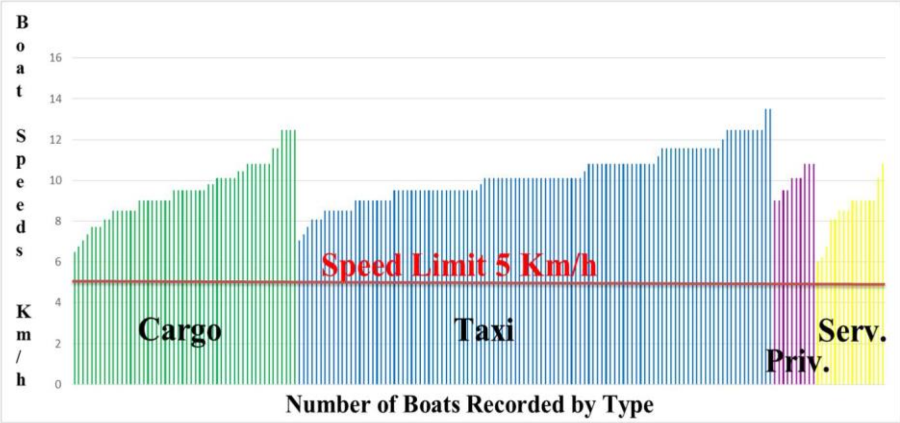

Figure 19: Speed data taken in the Rio de Ca'Foscari

In order to be able to successfully quantify *moto ondoso*, there was a need for speed data for each speed limit where boat traffic counts had been conducted. To get the speed of the various boats, we timed how long it took the boats to pass through a fix length of canal. As seen in Appendix G, we created a detailed form to note all of the travel time of boats. This form served as the place to note the times of all boats that passed. Once the count was completed, we used QGIS to measure the length of canal we had used. Next, we plotted the data in an Excel spreadsheet, seen in Appendix H**,** which would convert the data into km/h. Other speed data in Appendix I show that a vast majority of boats were also speeding in the canal segments where we took data. With the sampling of data, we were able to prove that speeding is a problem in Venice. Since *moto ondoso* increases exponentially with the speed of a boat, speeding leads to an increase of *moto ondoso*. One way to reduce *moto ondoso* in Venice would be to enforce existing speed limits that already exist.

3.4 Applying Moto Ondoso Index to Traffic Data

Once we got the distributions we needed, we applied them to the existing boat counts. This allowed us to analyze the changes not only in boat traffic, but in the amount of energy as well. We began by converting the turning movements recorded by the counts into boats per canal. Additionally, we switched from the COSES designations to our own names for the canal segments. For example, the maneuver COSES "612 Rio Novo (P. Roma)-Da:Stazione ferroviaria- A: Scomenzera" actually is a turning movement from segment GRAN2 to segment GRAN3. For a more complete listing of these maneuvers, please see Appendix L.

Once we had the data separated by boat type and canal segment, we applied our speed distribution and then used the Moto Ondoso Index equations in Appendix K. We did not want to apply Moto Ondoso Index at the speeds and then take the average because given the nature of the Moto Ondoso Index, a small number of high outliers would be able to drastically distort the final number. This gave us a complete picture of the *moto ondoso* when the boat count was conducted. By doing this for all of the COSES boat counts, we were able to get a better idea of how *moto ondoso* has changed. This also gave us a better tool to analyze proposed modifications such as the Cargo Re-Engineering project.

3.4.1 Updated Moto Ondoso Index

When we updated the Moto Ondoso Index to account for the velocity of boats, we gained a better picture of which boats are contribute the most to the *moto ondoso* in the canals. As you can see in Appendix J, the new Moto Ondoso Index values are much higher. In Figure 20, you can see that in the smaller canals cargo boats produce the most *moto ondoso*, but in larger canals, taxis produce more *moto ondoso*. This is due partially to the different characteristics of the boats themselves, but also due to the fact that the different types of boats travel at different speeds. For comparison, you can see in Figure 201 what the Moto Ondoso Index values would be if boats were traveling at the speed limits. As you can see, these values are much lower than what they are at the actual speeds. Another interesting note is that, at these speeds, the taxi has the lowest *moto ondoso* of all these boats.

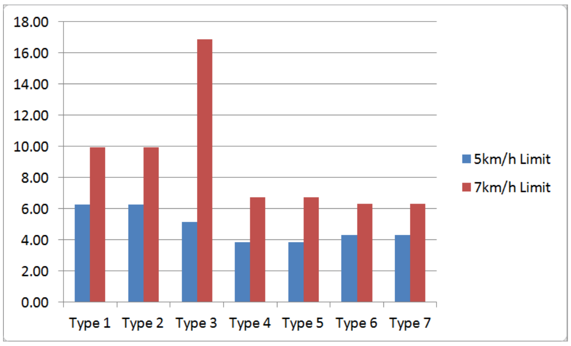

Figure 20: Boat Types Currently

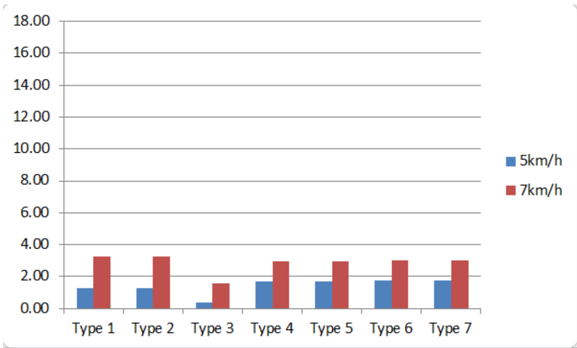

Figure 21: Boat types following speed limit

3.4.2 Historical Traffic Data

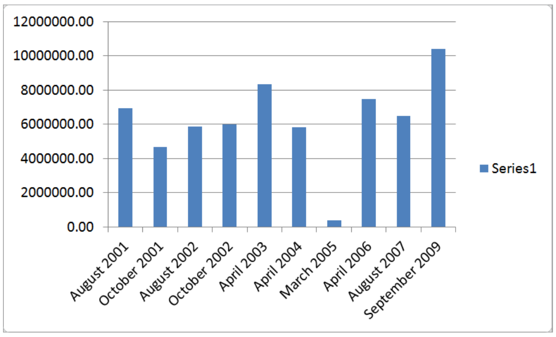

Figure 22: Moto Ondoso Index values

The most obvious thing that can be seen from this data is that *moto ondoso* has been increasing. As seen in Figure 22 Moto Ondoso Index value for September 2009 is 10,388,080 as compared with 6,924,022 in August 2001. This is an increase of 50%. Compared with

October 2001, the lowest value excluding March 2005, September 2009 is an increase of 123%, more than double.

3.5 Visual Tools for Moto Ondoso

There are many things we were able to do with this new data. The main one was the creation of an interactive tool to visualize levels of *moto ondoso*[45]. This tool allowed us to visualize historical levels of *moto ondoso* from all of the COSES campaigns, as well as to examine the effects of various proposed reductions such as fully enforcing the speed limits, or implementing the cargo re-engineering projects. A full discussion of these reductions is in section 4.

3.5.1 Moto Ondoso Visualizer

This visualizer is an incredibly powerful tool for visualizing the changes in *moto ondoso*. It allows the user to quickly and easily see changes in the level on *moto ondoso*. In Figure 23, you can see the basic view of the visualizer. The slider in the bottom right corner allows the user to adjust the campaign. The buttons below and to the left and right of the slider allow the user to switch to viewing current data and viewing historical traffic data respectively. The color of each of the segments, ranging from red to yellow to green, indicates the total amount of *moto ondoso* in that segment at the time of the count. When the user clicks on a segment, they see a popup such as the one in Figure 23.

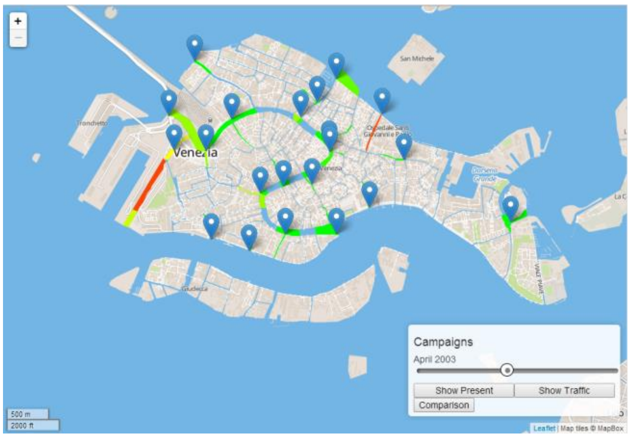

Figure 23: Basic View of Moto Ondoso Visualizer

The markers denote the individual counting stations. These are all the stations that COSES used for their counts, although not every station was used for every count. When the user clicks on one of the counting stations, they see a popup such as the one in Figure 24.

[45] http://traffic.veniceprojectcenter.org/

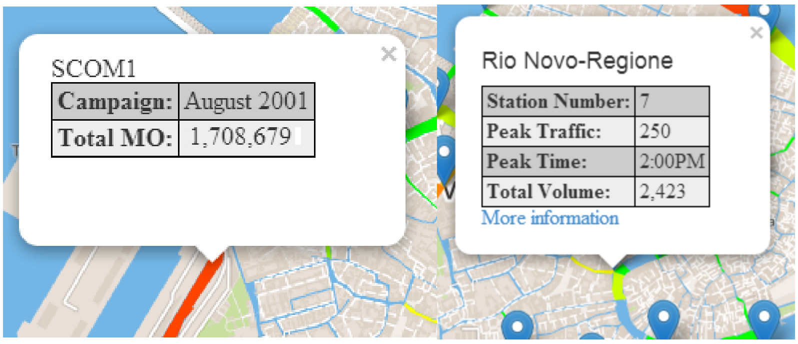

Figure 24: Clicking on a segment

The user is not just limited to viewing on campaign at a time. The bottom button below the slider brings up a split view. This can show two campaigns side by side. This is demonstrated in Figure 25 where you can see the *moto ondoso* data from October 2001 alongside the data from October 2002. This is useful because it not only allows a user to two campaigns side by side, but also to see how reductions on the current level of *moto ondoso* compare with past measurements.

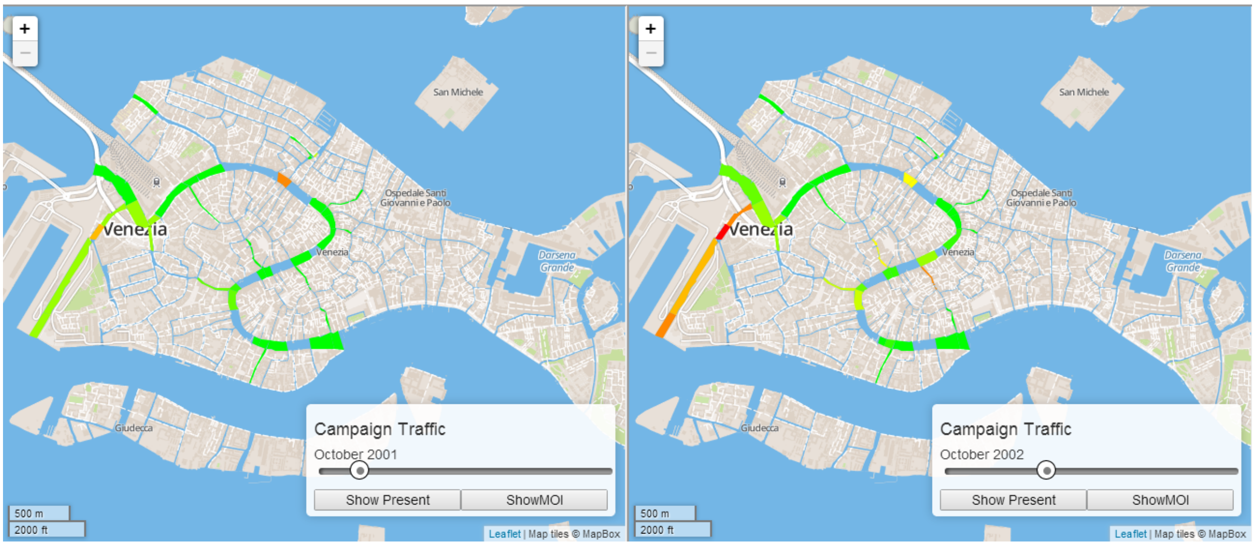

Figure 25: *Moto Ondoso* levels in different campaigns

3.6.2 Moto Ondoso App

In addition to looking back at *moto ondoso* has changed in the past, we would like to see how it will change in the future. To this end, we recommend that a future IQP create the Moto Ondoso App. This app would function in two parts. The first part is a smartphone application that you can see in Figure 26 and the second is a web based visualization tool.

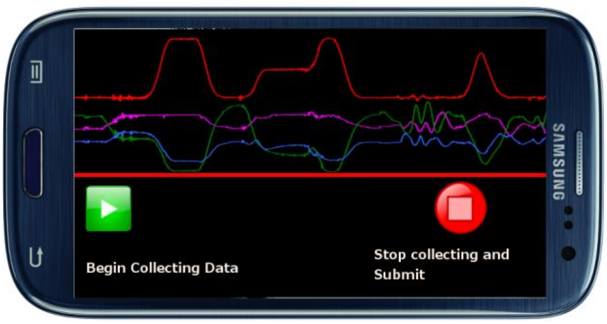

Figure 26: *Moto Ondoso* app

The smartphone app would be very

similar to the current StreetBump app developed for Boston. The user would start the app when they entered a boat. As the boat traveled, the app would record accelerometer readings and track the user's path using GPS. When they pressed the stop button, the phone would upload the data and GPS path to a central server. In order to make sense of the data, the central server would have to do some simple processing to determine the level of *moto ondoso* associated with the readings. This would most likely be related to the integral of the net acceleration, but field testing would need to be carried out to determine the exact method.

The web visualizer would be similar to Venice Noise[46]. As many users contribute readings to the site, it would be able to build up a heat-map of *moto ondoso*. Ideally, the site would allow users to view data based on day, time, and date. On top of this, the site may be able to incorporate data from the Centro Maree. The Centro Maree is an organization that operates several monitoring stations in the lagoon. These stations record data that should be able to be used to roughly calculate the level of *moto ondoso*.

[46] http://www.venicenoise.org/

4 REDUCING MOTO ONDOSO

Moto Ondoso remains a very significant problem in the Venetian canals, and has been increasing over the past decade. If left unchecked, *Moto Ondoso* will continue to destroy the canals of Venice, costing millions in repairs. For this reason, it is not just enough to quantify *Moto* Ondoso, we must also investigate ways to reduce it. In this chapter, our team will discuss research we have done on various ways to reduce *Moto Ondoso*. We will also discuss how we planned to test these methods in Venice. Finally we will discuss the actual results and efficiencies of these different methods.

4.1 Physical Changes to Boats and Engines

Because the physical shape of the boat and engine output are major factors in the creation of wakes, changing the way the boats and engines interact with the water can drastically reduce *moto ondoso*.

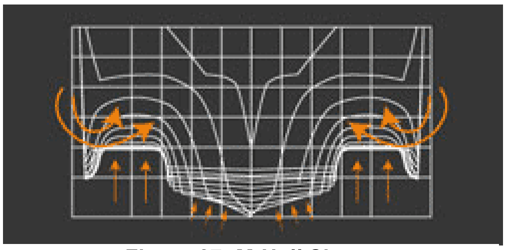
Figure 27: M-Hull Shape

The M-Hull is a new hull shape designed by the *Mangia Onda* (Wake Eater) Company to reduce wake energy. The new hull shape is markedly different from the typical "V" shaped hull, as can be seen in Figure 27. The hull reduces wake energy by using the side skirts to force the wake produced from the center section back under the boat, as opposed to releasing it out the sides. The benefit of forcing the wake back under the boat is two-fold. First, the wake does not disperse out to the side of the boat, potentially causing damage. Second, as the wake is forced back under the boat, it is condensed in spiraling channels, and helps to lift the boat itself higher out of the water, also known as planning. When planning, the *moto ondoso* produced is greatly reduced.[47]

Besides changing the shape of the boat, changing the type of engine can also positively affect *moto ondoso.* The largest benefit of hybrid and electric engines is that while idling, they produce no wakes. A typical gas engine must continue running even at idle, producing extra wakes. Another benefit of electric engines is the reduction in weight. This reduction in weight causes the boat to sit higher in the water, displacing less water, causing fewer wakes.

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[47] Zion Lee, "M-Shaped Boat Hull Helps Save Venice One Wave at a Time," *San Diego Business Journal*, Newspaper Article 2001.

After we have used the *Moto Ondoso* Index to calculate past and current levels of wake energy using the COSES boat counts, we will be able to quantify any reduction possible by physical changes to boats. In order to do this, we will be in direct contact with the company creating the M-Hull design. This will allow us to determine the actual percentage of wakes it can reduce, versus a typical hull shape. We will also examine a past IQP's recommendation to use hybrid engines to reduce wakes produced at idle.

Figure 28: M-Hull Ship

Through the team's research, we identified the M-Ship Company, out of San Diego, California, to be the best option for implementing the M-Hull design in Venice. Our team was in direct contact with the M-Ship Company to discuss the potential of their boats being used in Venice. As a result of this discussion, the M Ship Company is open to licensing its designs and products for production and widespread use in Venice. This company has actually already built and sold two M-Hull boats to the city of Venice. The 65 foot water bus the company sold to Venice can be seen in Figure 28.

Although the team was able to contact the manufacturer of the M-Hull, we were not able to obtain an actual quantification of the wake reduction capabilities of the hull. Also, the team concluded that a widespread implementation of the M-Hull in Venice would be both costly, and time consuming. This widespread implementation could occur through two methods. The first method would be in the form of immediate and mandatory changes to all boats in Venice, resulting in huge upfront costs. The second method would be in the form of slow, long term changes, by mandating that all new boats have this hull shape. This second method would result in wake producing boats remaining in the canals for many years to come. However, this new hull shape does offer promise for future projects, perhaps testing different models, or feasibility studies.

4.2 Using Traffic Regulations to Reduce *Moto Ondoso*

Once the team has determined the extent of speeding in the Venetian canals, as mentioned in section 3.3, we will fully understand how much of a contributing factor speeding is to the *moto ondoso* problem. From there, we will use the *Moto Ondoso* Index to compare current levels of wake energy to expected levels if all boats followed the canal speed limits, seen in section 2.1.

Based on the speed data collection mentioned in section 3.3, it is clear that speeding is a major problem in all Venetian canals. Through our analysis of the *Moto Ondoso* Index as mentioned in section 3.4, the team concluded that speed is also a major factor in the creation of wakes. In fact, as speed increases, *moto ondoso* increases exponentially. In other words, an increased in speed leads to a much greater increase in the *moto ondoso* produced by the boat. Because of this, it was concluded that the potential reduction in *moto ondoso* through the enforcement of speed limits would be profound. Using the *Moto Ondoso* Index, the team calculated that if 100% of boats followed the speed limit, rather than the 19% which do so currently, overall *moto ondoso* would be reduced by 26% in the Venetian Canals.

The total reduction to *moto ondoso* in the Venetian canals by enforcing the speed limits would be 26%. The team concluded that the most efficient way to enforce these speed limits would be a system similar to the ARGOS video system. The ARGOS system used cameras throughout Venice to record boat speeds and dispatch police to issue tickets. A similar camera system would be able to catch speeders throughout Venice, and reduce the prevalence of speeding significantly.

4.3 Taxi Re-Engineering

The taxi re-engineering project was an IQP in 2006 whose mission was to propose a reorganization that would reduce *moto ondoso* while preserving the economic viability of the proposal. The recommendations this team made included changing the physical characteristics of the boat, opening up canals in order to reduce boat travel times, and optimizing the current dispatch system.

The most promising recommendation made by the 2006 IQP was to reduce the large amount of time taxis currently spend travelling empty. Based on the current system of taxi stands, a taxi which picks up a passenger at a particular stand must return to that specific taxi stand in order to pick up a new passenger. This results in taxis spending 33% of their time travelling in the canals with no passengers, essentially creating unnecessary *moto ondoso*. The way the team planned to accomplish this was by changing the taxi dispatch system to allow taxis to pick up passengers in areas where they drop off others, rather than returning to their original taxi stand. [48]

One recommendation the 2006 IQP group had was to find short cuts in the city of Venice that would help reduce traffic. One of these short cuts was a canal called the Arsenale. The Arsenale is owned by the *Marina Militare* which blocks traffic flow in order to preserve the nearby foundations. However, the 2006 IQP discovered that with a regulated flow of boats, traffic could pass through without causing damage. They considered the possibility of using a toll system that would penalize speeders. As can be seen in Figure 29, if Venetian traffic was allowed to travel through the Arsenale it would dramatically decrease travel time.

Figure 29: Opening of Arsenale Canal

Another recommendation that involved changes in travel routes was a proposed highway from the San Marco airport to the city of Venice. The route "would save 10 minutes off every trip to and from the airport at a projected speed limit of 30km/hr." The proposed route can be seen in Figure 30. The route helps reduce the impact of *moto ondoso* on the islands that the current route passes by. The only difficulty with implementing this plan is that the proposed highway is not navigable. In order for it to become navigable it must first be dredged.[49]

[48] Accosta, "Re-engineering the Venetian Taxi Transportation System: Efficiency Improvements That Reduce Moto Ondoso."
[49] Ibid.

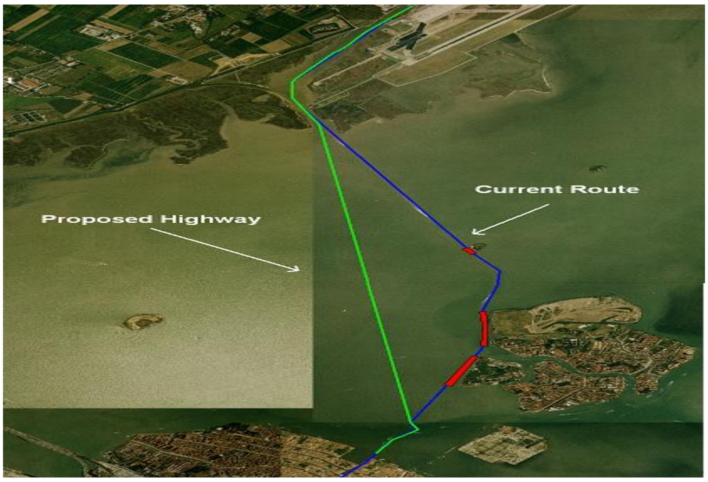

Figure 30: Changed Route to Airport

4.3.1 Revisiting the Taxi Re-engineering Project

Using the COSES data, and the *Moto Ondoso* Index, the team will be able to estimate how much of *moto ondoso* is attributed to taxis. The team will then examine a previous WPI IQP entitled "Re-Engineering the Venetian Taxi Transportation System: Efficiency Improvements That Reduce Moto Ondoso." The team will then determine which areas of the current taxi system could most benefit from a new system, and what components from the new system would be most impactful.

After examining the 2006 Taxi Re-engineering project, the COSES boat counts, and our own field data, the team determined that the area of the taxi system most in need of reform is the dispatch system. Currently, taxi boats spend approximately one third of their time traveling around the city empty. This is due to the way the taxi stand and license systems work, as mentioned in section 2.1. The best way to reduce these empty runs is by revamping the taxi dispatch system. Our team recommends the production of a taxi reservation app, as is present in many other cities. This taxi app would allow passengers to call a taxi to their current location, then, the closest available taxi would pick up the passengers. A system model of a taxi app system can be seen in Figure 31.

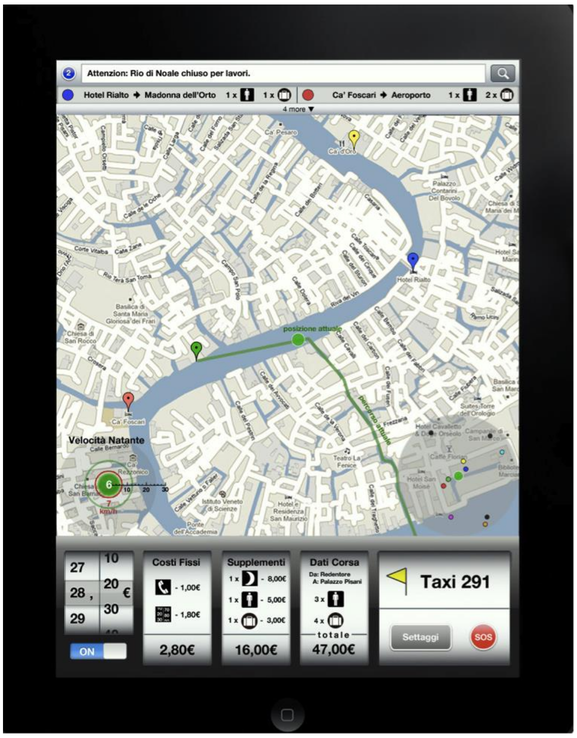

Figure 31: Taxi app

After revisiting the Taxi Re-engineering project, examining their recommendations, and organizing the COSES data to be used for *moto ondoso* calculations, the total benefit of the Taxi re-engineering proposal could be quantified. Using the *Moto Ondoso* Index, the team calculated that if the taxi dispatch system were implemented at 100% efficiency, the reduction in *moto ondoso* would be 14%. This 14% reduction in *moto ondoso* comes from reducing the number of empty runs through a more efficient dispatch system mentioned above.

4.4 Cargo Re-Engineering

The CTVR or (*Consorzio Trasportatori Venezi Riuniti*) is a teamster union that represents about two thirds of the total boats responsible for delivering about 70% of the cargo in Venice.[50] In 2006, this Consortium sponsored a WPI IQP to re-engineer how the islands of Venice receive their deliveries. The inefficiencies in the cargo system were first studied by other WPI IQP teams in the late 90's.

Currently in Venice, cargo is delivered by item as seen in Figure 32. Items are taken from a single warehouse and delivered to each island. Since deliveries are made by item, that causes inefficiencies where there are an excess number of boats making deliveries. For example, a previous IQP in 1997 determined that, for the island of San Luca, there were 96 boats were used to make deliveries to the island. However, it was determined based on the cargo volume of the deliveries that only three boats were truly needed to fulfill the delivery needs of the island as seen in Figure 33.[51] Another issue that is present with the current cargo system is that cargo boats have no guaranteed spot to unload their cargo at the time they arrive to a particular island. This causes boats to have to wait for dock space to open resulting in preventable traffic bottlenecks and *moto ondoso* from the idling engine.[52]

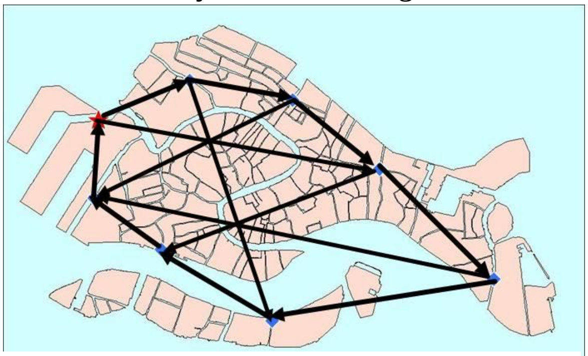

Figure 32: Current cargo system

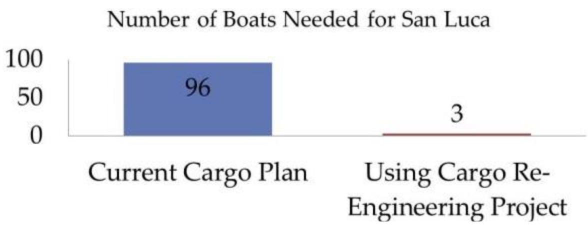

Figure 33: Boats needed for San Luca

[50] Duffy et al., "Re-Engineering the City of Venice s Cargo System For the Consorzio Trasportatori Veneziani Riuniti."
[51] Amlaw et al., "Optimization of Cargo Boat Deliveries Through the Inner Canals of Venice."

Concern about how the current delivery system can be seen by those who work in the industry. In 2001, when an IQP was re-engineering Venice's cargo system, they surveyed cargo workers, asking them a series of questions concerning cargo delivery in Venice. As seen in Figure 34, an overwhelming majority of the workers (92 %) believed that traffic congestion is a problem in Venice. Another question was about delivering items by location instead of by item. A majority of workers (76%) agreed that they would prefer to deliver items by destination instead of by item. Two other questions were asked concerning equipment at docks and the ease of finding locations to dock. Many of the workers (71%) agreed that having equipment to help unload cargo at docks would help to speed up delivery. As seen in Figure 35, an overwhelming majority of workers (90%) disagreed that is was easy to find dock spaces to unload cargo. The survey data taken from cargo workers helps to give perspective on their thoughts about the system that they work in on a daily basis.[53]

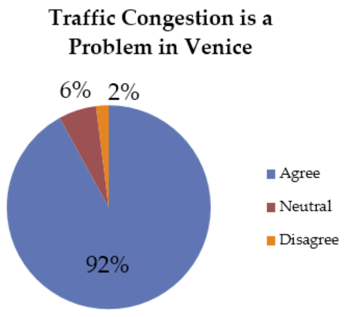

Figure 34: Traffic Congestion Survey

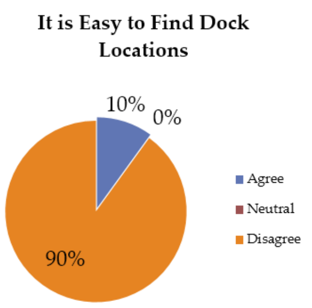

Figure 35: Finding Dock Survey

In 2001, an IQP was tasked to propose a system that would re-engineer Venice's cargo delivery system. The main components of that system were a centralized warehouse and delivery by island instead of by item. Based off the recommendations, the city built a warehouse for all of the items being delivered to Venice located near the bridge on Tronchetto so that trucks could bring items in from the mainland as shown in Figure 36. It provided an essential point for goods to enter Venice and be sorted to the places on each island that needed that particular item.[54]

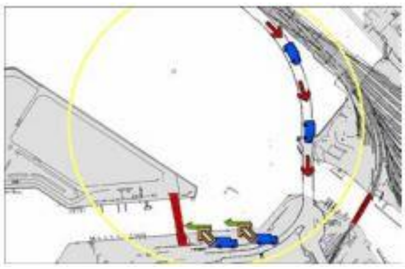

Figure 36: Trucks Headed to Warehouse

[52] Duffy et al., "Re-Engineering the City of Venice s Cargo System For the Consorzio Trasportatori Veneziani Riuniti."
[53] Ibid.
[54] Ibid.

Even though the city has followed suit with the recommendation to build a warehouse for all Venetian cargo, little has been changed pertaining to how cargo is delivered. In 2001, the Cargo Re-Engineering Project recommended that items be delivered by destination instead of by item as shown in Figure 37. This would result in fewer boats being needed to make deliveries in Venice. Now, more time would be spent at the island unloading all of the cargo from the boat and delivering it to the recipients. Another component of deliveries by destination would be the ability to reserve docks to unload the boats. That would help to reduce time that is wasted waiting for a dock to become available.[55]

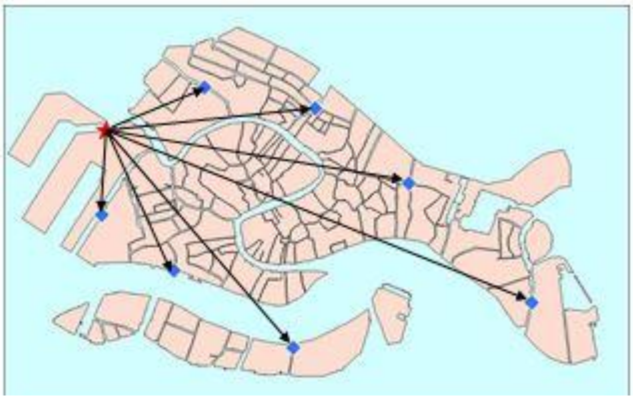

Figure 37: Delivery By Destination

In order to accomplish delivery by destination, the 2001 team sectioned the Islands of Venice into delivery zones, and assigned the appropriate number of boats to each zone in order to fill the delivery demand of those islands. The teams proposed zones and number of boats can be seen in Figure 38.

[55] Ibid.

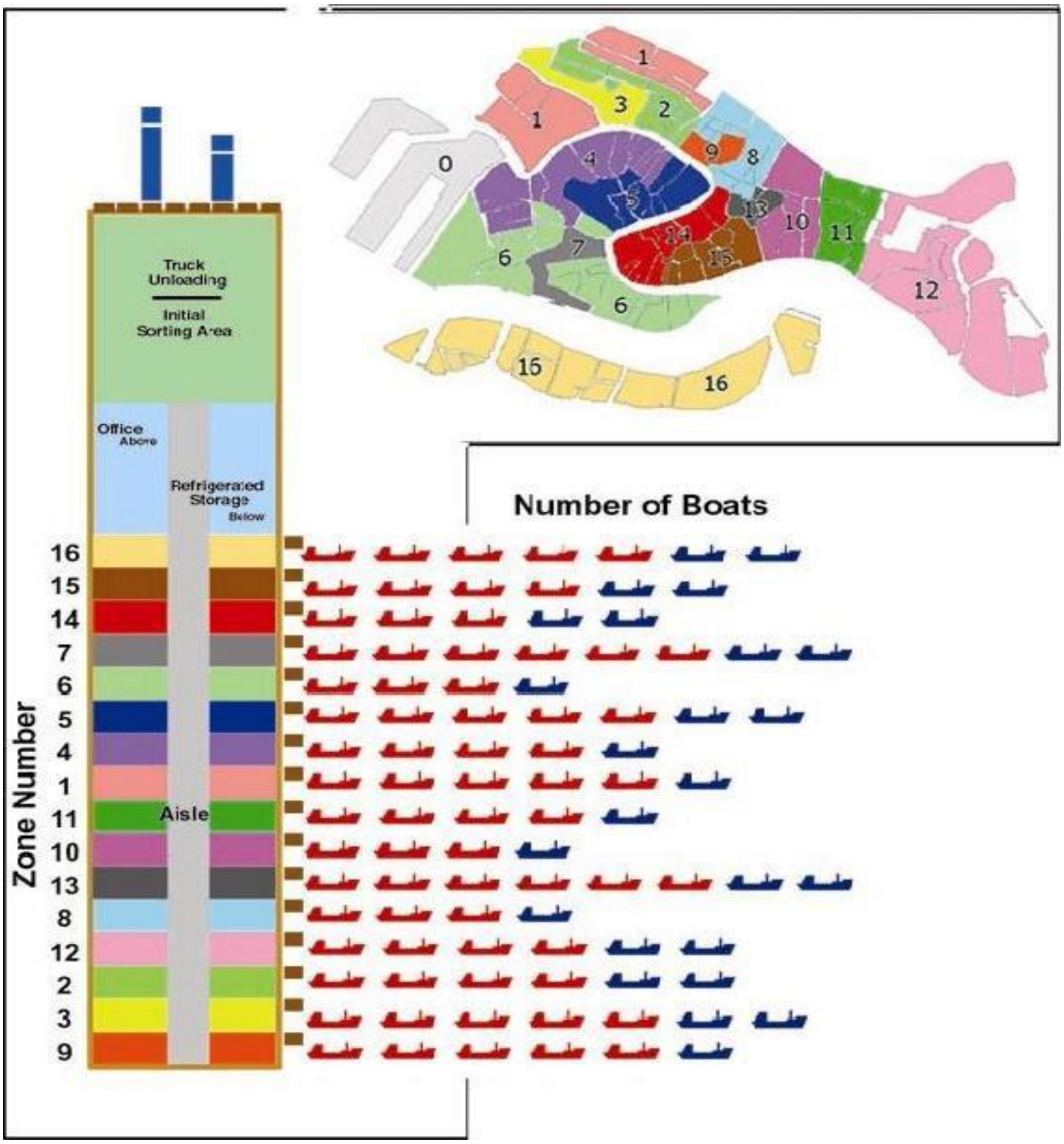

Figure 38: Proposed Delivery Zones

4.4.1 Revisiting the Cargo Re-Engineering Project

The team will review the cargo re-engineering project and will be applying the data that they collected, while also extending upon it. We will be breaking down deliveries not by specific districts but by island. This way we can get a much closer look at the demand for cargo boats per island, and for Venice as a whole.

The team's first step in successfully revisiting the cargo re-engineering project is to understand how delivery demand is distributed throughout the islands. To do this the team will examine store counts made by a WPI IQP team in 2012. The data will be in the form of a map of all types of stores in Venice. The team will then organize this data and determine the number of each type of store on each island. For example, the 2012 IQP team counted 511 souvenir shops in the city of Venice, and any particular island will have a certain number of those on it, as seen in Figure 39.[56]

Figure 39: Souvenir Shops on Island

Once the team has determined the number of each type of store on each island, the next step will be to relate this to delivery data. To do this, the team will use delivery survey data collected by the 2001 Cargo Re-engineering team. Continuing with the example of souvenir shops, an average souvenir shop requires ten packages per day, based on the survey data.[57] The team will then multiply the number of souvenir shops on any given island by ten, to get an estimate for the number of packages that island needs for its souvenir shops. This process will then be repeated for each type of store and for each island. The end result will be the total delivery demand per island for the entire city of Venice. The team will then need to verify the accuracy of this delivery data by comparing it to the 2001 IQP data, as well as delivery data taken in 2006 by an organization called MOBILIS.

The previous cargo re-engineering IQP developed cargo delivery zones as mentioned in section 4.4. While these zones were revolutionary, this team will use the new delivery demand data to create new cargo delivery zones, taking into account changes in the Venetian retail sector over the past 12 years. The new zones will be created in order to minimize single cargo boats making deliveries to numerous islands, known as “island hopping.”

4.4.2 Cargo Re-Engineering Revisited

The cargo re-engineering project was a more labor-intensive part of this project then the above parts. This is because the data from the past project was out dated due to changes in delivery demand. As a result, both their delivery demand calculations, and zone creations were redone.

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[56] Bruso et al., “A Look at the Changes in the Venetian Stores and Tourist Accommodations and Their Impact on the Local Population”

[57] Duffy et al., "Re-Engineering the City of Venice s Cargo System For the Consorzio Trasportatori Veneziani Riuniti."

Using the methods outlined in section 4.4.1, we determined the number of each type of store on each island. After this, we estimated the total delivery demand for each island, as seen in Figure 40. The delivery data can be found in both Appendix N and Appendix O. This graphic makes it clear how delivery demand is distributed throughout the city. Some islands, such as San Silvestro, in the center of the map, require many more deliveries than other islands. This data was also cross referenced with the delivery data from the 2001 IQP, as well as the 2006 MOBILIS data in order to verify its accuracy. The 2006 MOBILIS group observed deliveries at 19 docks in Venice. The team used this data, along with the stores data to quantify the relationship between the numbers of stores on an island to observed deliveries for this island. This relationship was then used to extrapolate delivery demand for those islands MOBILIS did not observe. It was concluded that the new delivery demand was accurate. These calculations can be found in Appendix P.

Figure 40: Delivery Demand For Each Island

The delivery demand for San Silvestro was further broken down by types of products, as seen in Figure 41. As mentioned previously in section 4.4, all of these different types of products are currently delivered by different boats. In the new Delivery by Destination system, all of these products would be placed onto boats destined for San Silvestro, and only San Silvestro.

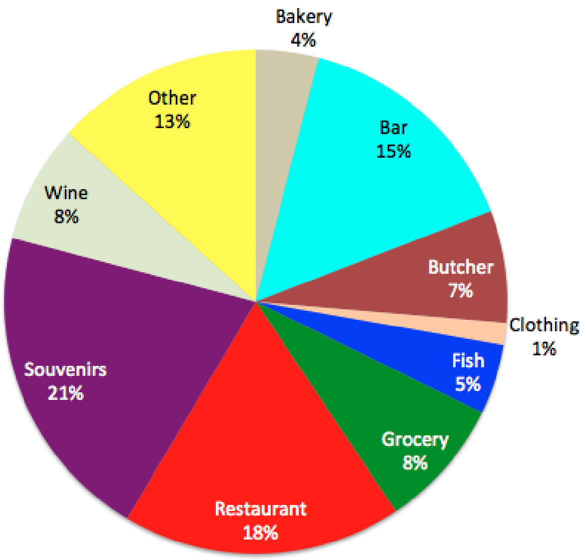

Figure 41: San Silvestro Delivery Breakdown

Using the delivery demand data mentioned above, the team then divided up the many islands of Venice into new delivery zones. The goal of these new delivery zones was to assign specific islands for specific cargo boats to deliver to. Originally, the team planned on having each zone consist of only one island. Upon review of the delivery data however, the team determined this would lead to partially filled boats being used in some cases. The more efficient process would be to group together nearby islands so that combined, they required some round number of full boats. This is more efficient because the distance from the central warehouse to these islands is much larger than the distance between the islands themselves. Therefore, it is more efficient to have one boat cover the large distance from the warehouse to the islands, then cover the short distance to a nearby island, rather than have two boats cover the large distance to the same islands.

As a result of these conclusions, the delivery zones seen in Figure 42 were created. These zones minimize the distance travelled in the Canals of Venice, while still delivering the same number of packages. It is clear from the map that some Zones contain only one island, while others contain several. In cases where a single island required a large number of deliveries, some combination of large and medium cargo boats could be assigned to efficiently fulfill its delivery demand. In the case of islands with smaller delivery demand, they were grouped together with nearby islands with similarly small delivery demand. By doing so, the delivery demand for these grouped islands would require a single large boat, or a single large boat and a single medium boat. As mentioned above, this is much more efficient than each island being assigned a separate boat.

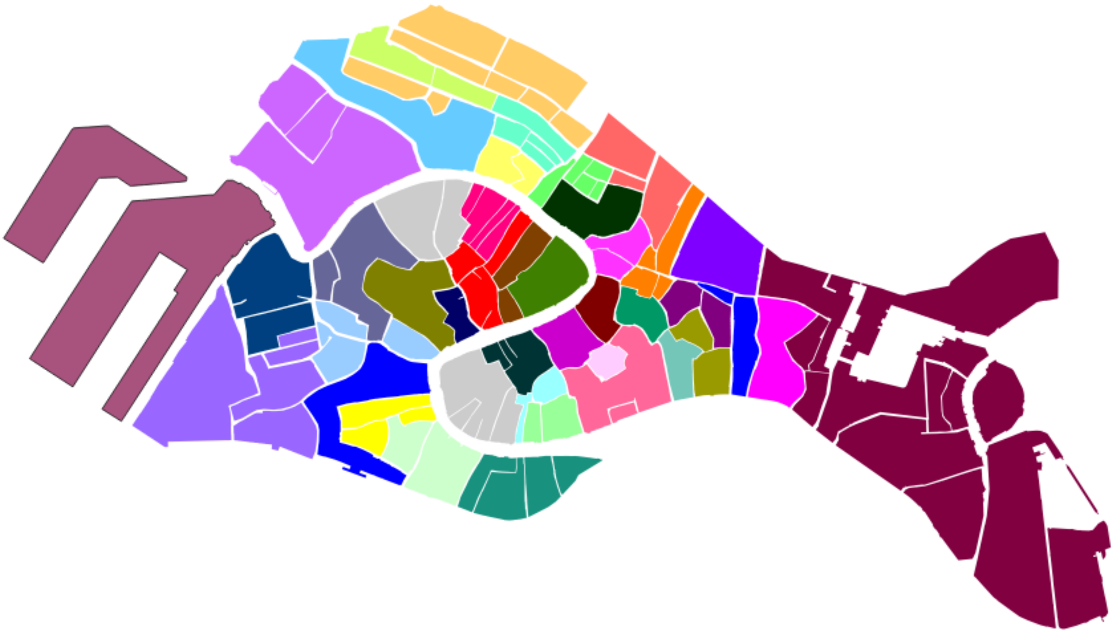

Figure 42: Delivery by Destination Zones

4.4.3 Benefits of Cargo Re-Engineering System

The results from our revisiting of the cargo re-engineering project were very intriguing. The group and our advisors hoped the new Delivery Zones would result in a significant impact in *moto ondoso* levels. Prior to this group's project, the benefits of delivery by destination in terms of a reduction in traffic had never been accurately quantified.

As part of our research on the current cargo system, the team took time-lapse videos at busy docks near the Rialto Bridge. The team then animated this video to keep count of the number and size of deliveries being made for several hours. To do so, the actual packages being delivered to the island were highlighted, and the highlighted packages were kept on screen. A screen shot of this animation can be seen in Figure 43. In this screen shot, a large cargo boat can be seen in the foreground making a delivery of a highlighted package, while a previously delivered package can be seen on the dock. At the end of our observation period, 18 cargo boats had delivered approximately 440 packages to the island. This represents an area that the new delivery by destination system can improve upon. As can be seen in Figure 44, all of the 440 packages delivered during our observation period could have fit onto a single cargo boat. Using the proposed system, the deliveries at the level of a single dock would be improved because much fewer boats would be docking throughout the day.

Figure 43: Dock animation

Figure 44: Dock animation 2.

After comparing the proposed delivery system to the current one on the level of individual docks, the team then compared the different systems at the level of individual boats. The team was able to use the organized COSES data, as mentioned earlier in section 2, to follow a single cargo boat as it was counted at different stations throughout the day. The team found that many cargo boats were counted several times, with some being counted over 30 separate times. The team was then able to map out the paths taken by different cargo boats. One such path can be seen in Figure 45, which shows the path taken by a boat between 6:45 A.M and 5:00 P.M during the Summer 2009 boat count. In addition to tracking the boat paths, the team also developed a distance matrix, which measures the distance from each COSES station to each other station. This matrix can be found in Appendix R. With this data, we were able to calculate the straight-line distance from station to station that any boat travelled. It is important to note that these straight-line distances were an under approximation of the actual distance travelled, as the actual distance through the winding canals would be greater. In Total, this cargo boat travelled 33 kilometers using the current delivery by product system.

Figure 45: Single Cargo Boat in Current System

In order to analyze the benefit of the proposed delivery by destination system on the level of individual boats, the team then looked at a typical day in the life of a cargo boat driver using the new delivery zones mentioned in section 4.4.2. In this new system, a cargo boat would leave the cargo warehouse located on the western island of Tronchetto, travel to its specified zone, and be done for the day. This new boat path can be seen Figure 46. This new boat path represents the increase in efficiency the delivery by destination system can bring to the level of individual boats.

Figure 46: Single Cargo Boat in Proposed System

After the team analyzed the benefit of the system on the level of individual boats, it was not hard to extend the same principles to the entire fleet of cargo boats. Using the same 2009 Summer COSES data, the team was able to track all Venetian cargo boats as they travelled throughout the city. The resulting multitude of boat paths can be seen in Figure 47. In this figure, because there are so many overlapping paths, the darker lines represent more

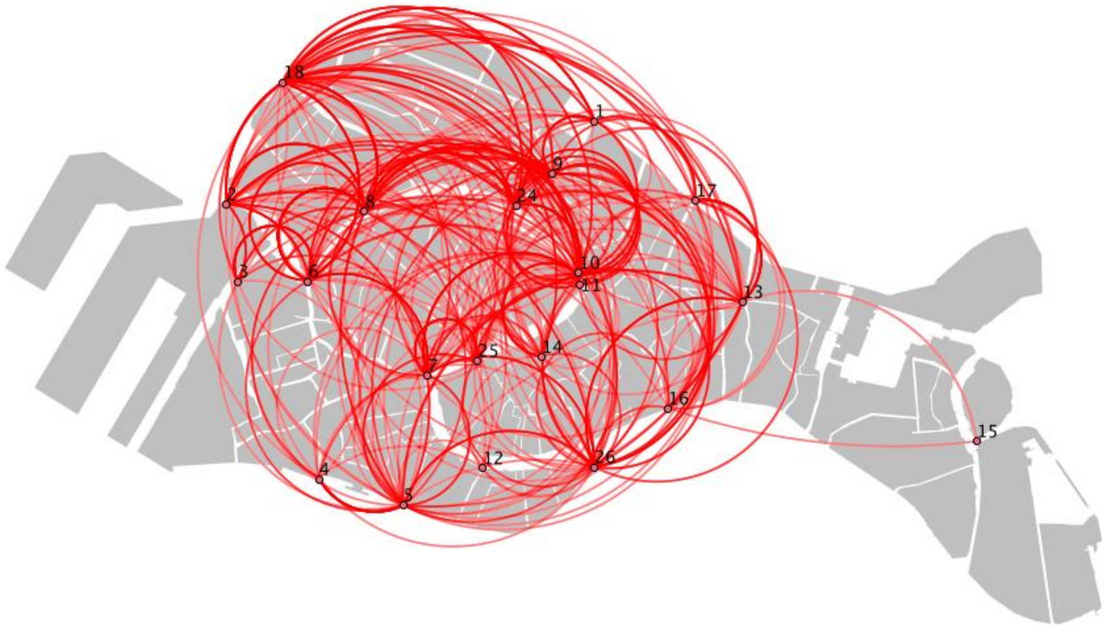

Figure 47: All Cargo Boats in Current System

frequently covered paths. Using the same method to calculate distance traveled as described above, the team calculated that all cargo boats in Venice travel approximately 3000 kilometers in a single day. As a comparison, this distance is enough for the Venetian cargo boats to travel the distance to Iceland every single day. This number, in addition to being an under approximation due to the nature of straight-line distances versus real distances, is actually an even greater under approximation. This is because while COSES was conducting its boat counts, the license plate of a cargo boat was often partially or totally illegible, or copied down incorrectly. As a result, approximately 35% of the cargo boat counts are not useable for distance calculations because the data cannot be separated by boat. However, the 3000-kilometer distance still represents another area where the new re-engineered system can make a profound impact.

By taking the example of a single cargo boat in the proposed system, seen in Figure 46, and extending it to the entire city of Venice, we can visualize the new boat paths of all cargo boats using the new delivery by destination system. These new boat paths can be seen in Figure 48.

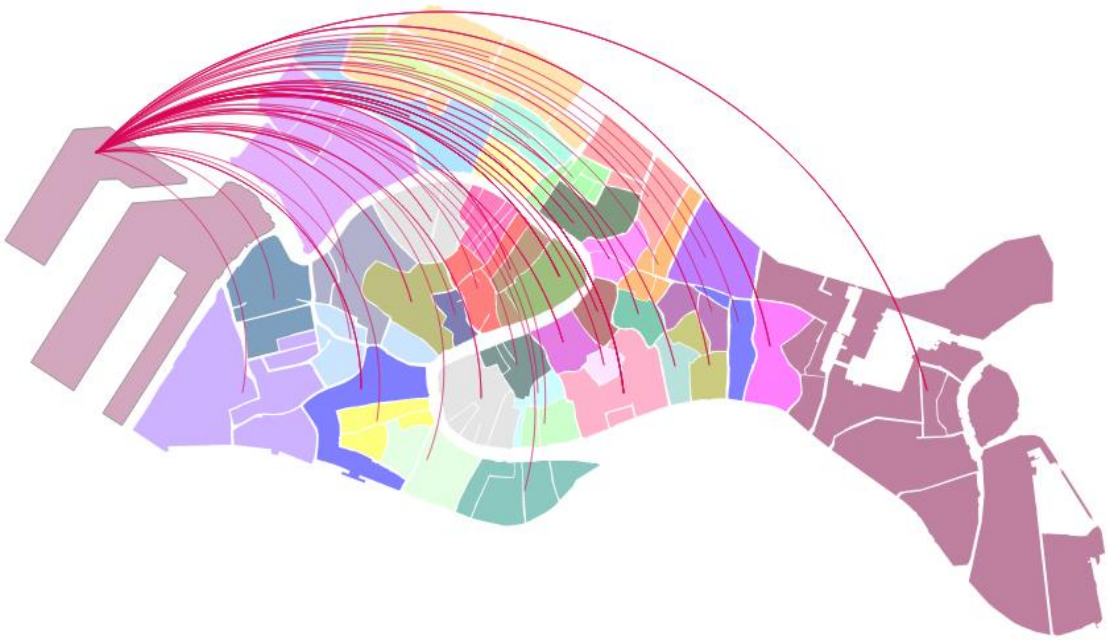

Figure 48: All Cargo Boats in Propopsed System

By calculating the distance traveled by all boats in this proposed system and comparing it to the 3000 kilometers of the current system, we are able to actually quantify the reduction in traffic by using a delivery by destination system. The total distance the team calculated for all cargo boats in the proposed system was 400 kilometers. These calculations, as well as those for the current system, can be found in Appendix S and Appendix T respectively. This means that the proposed system could deliver the same number of packages to the island of Venice while traveling 86% less distance. This huge reduction would be across the board for the cargo system. There would be similar reductions in gas costs, boat repairs, delivery times and so forth. Despite this, there would not be an 86% reduction in cargo delivery jobs, as will be mentioned in section 4.5.

4.4.3 Docks

Since boats are the main form of transportation and delivery of cargo in Venice, there is a need to have docks scattered throughout the city. In the Venice, there are a total of 1650 docks. In order to be able to direct cargo workers to utilize the best docks possible, we mapped all of the docks using GIS software as depicted in Figure 49 and put the data into CSV files as shown in Appendix U. After mapping the docks, the group then determined the best two docks on each island for cargo boats to use for making deliveries. Factors that went into deciding which docks were the best on each island included the width of the canal, the size of the dock itself, and the location in respect to other delivery points in surrounding islands. The most important factor was the width of the canal because we wanted to ensure that a docked cargo boat would not become an impediment to other traffic passing by. With the top identified docks, the group would like to create the ability to reserve docks using an app to ensure that cargo boats will not have to wait for dock space upon arrival for deliveries.

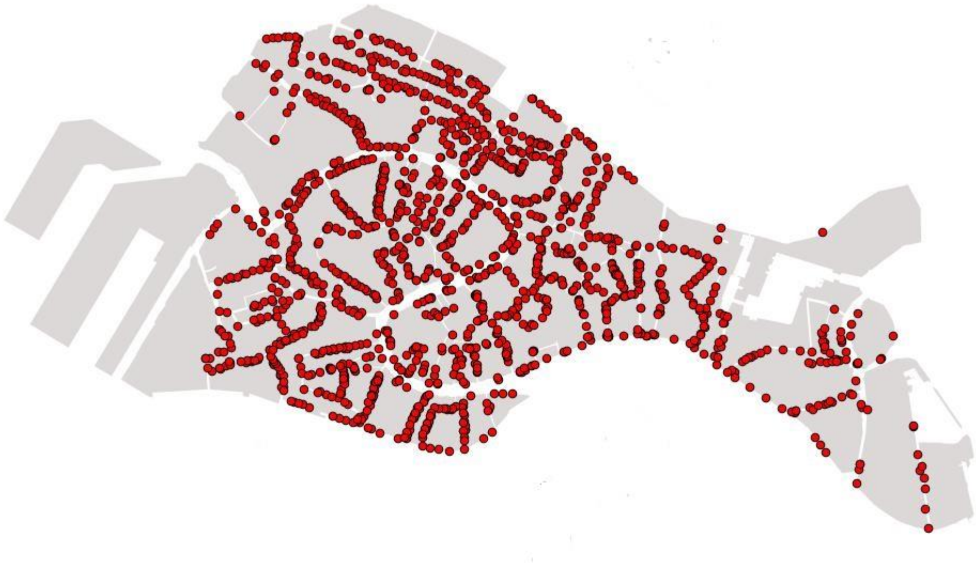

Figure 49: Map of all Venetian Docks

After obtaining all of the information about docks in Venice, we put that information on the CityKnowledge Console and created Venipedia pages as shown in Appendix W. Having information about every dock in Venice will be useful for anyone that is looking for information about a particular dock in Venice. Each page provides specific information about each dock including location information, physical characteristics, usability, and condition. Additionally, there is a map on each page showing the docks location in Venice, as well as, showing other docks of the same type.

After all of the docks in Venice were mapped, we had identified the docks that would be best suited for cargo boats. Once we arrived in Venice, we conducted spot checks on docks that had been identified as the best candidates on each island. While we were conducting spot checks of the docks, we noticed that there were some unforeseen conflicts that currently would not make certain docks usable for cargo boats. These docks were being used for other purposes, such as a *gondola* stand, an ACTV stand, or as a place for Ambulances to park. Some of these docks would not be able to be used for cargo boats since they are already being used for other city services. However, the docks that are being used in a capacity, such as a *gondola* stand, we would recommend seeing if there could possibly be a way for cargo boats to use these docks during times *gondolas* are not in use, such as the morning.

Another thing we noticed while verifying docks throughout the city, it had become apparent that *riva* are not the best docks for cargo boats due to their shape, steps, and ease of parking alongside the dock (depending on the tide). Instead, we noticed that *fondamenta* were the most convenient docks for cargo boats to use because they could pull up alongside the street and easily unload their items from their boat. After noticing that *fondamenta*, were more suitable, more were added to the best docks map as shown below in Figure 50. Adding more *fondamente* to the best docks for cargo drivers will help ensure that Venetian policymakers and cargo boat drivers will utilize these specific docks.

Figure 50: A map of the best docks for cargo boats.

In total, 416 docks were selected as the best docks for cargo boats to utilize when making deliveries. The purpose of selecting these docks was to help cargo boat drivers to choose the best places to dock when making deliveries. Docks were also selected on different parts of many islands to help cargo boats to have a location that is the most convenient to them. Some boats may want to have a dock in a particular location because they will have to make deliveries to other islands within the delivery zones that were established in Figure 51. In order to ensure cargo boat companies that they will be able to dock at one of the desired docks on each island, a mockup of an app was created where they will have the ability to reserve a particular dock. Being able to reserve a particular dock for deliveries will ensure that cargo boats can make their deliveries at a desired time and location, thus reducing wasteful idling or driving. We recommend that Venetian policymakers make the docks we recommended available for cargo boats to reserve and create policies to ensure that others do not use these docks during times the dock may be reserved for deliveries.

Figure 51: Mockup of dock reservation app

4.5 Economic Benefit

Once the wake impact was calculated, we used that data to compare the cost of maintenance to index values. With those data values, we estimated how much money the city of Venice could save based off our recommendations. To show Venetian policymakers how our recommendations will save them money, we visualized the comparison between money saved by preventative measures and money currently spent on maintenance.

In order to be able to quantify how much money our recommendations could save Venice, we will need accurate figures relating the cost to repair the canal walls as shown in Figure 52. In 2007, the Auto-Accretion MQP determined that canal maintenance costs ranged from $189 to $4,766 per square meter of canal wall repaired for small to average sized canals. For large canal segments, the cost per square meter rose significantly to $11,680 per square meter.[58] While in Venice, we will need to see if these costs to repair canal walls have changed significantly from 2007. Additionally, we also need to find out how often repairs are made on any given canal wall.

Figure 52: A canal wall undergoing repairs.

After calculations relating to how much *moto ondoso* is created by each type of boat at different speeds have been made, we will relate the wake energy produced by each type of boat to how much damage each boat type causes. We will also obtain the time intervals for

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[58] Jessica Balesano and Jodi Lowell, "AUTO-ACCRETION POWERED BY MICROBIAL FUEL CELLS IN THE VENETIAN LAGOON," (2008).

canal wall repairs. By using our boat count data, we can calculate how much wake energy has caused the damage that has occurred to the canal wall.

From the recommendations we make to reduce *moto ondoso*, we will calculate how much wake energy our recommendations will reduce in comparison to the status quo. These calculations will show Venetian policymakers how much wake energy could be reduced by the adoption of our recommendations. Venetian policymakers will also be able to see how these recommendations will help keep their canals in better shape.

With the quantifying of the reduction wake energy, we will also show Venetian policymakers what they have to gain financially. Using our energy savings calculations, we will show the policymakers that if they decide to implement previous projects such as the Cargo Re-Engineering Project and the Taxi Re-Engineering Project, will result in economic benefit for the city. The economic benefit will come from the reduction in wake impact that comes from the implementation of these projects. For Venice, the economic benefit will be that over time, they will have to do maintenance and repairs on their canals less often. By having to partake in canal maintenance less often, will save the City of Venice money in the long run.

4.5.1 Quantifying Economic Benefit

Reducing *moto ondoso* in Venice has the potential to economically benefit the city. We found that three areas where the city could reduce *moto ondoso*. The three areas included enforcement of speed limits, reducing empty taxi runs, and making deliveries by destination instead of by item. Once we got repair cost information from the 2013 Canals IQP, as shown in Appendix X, we were able to calculate the cost of *moto ondoso*.[59] With that data, we could determine the cost of one unit of *moto ondoso*, as explained in section 3.2, by comparing the Moto Ondoso Index from the 2001-2006 COSES campaigns with the cost of repairs for the same canals segments involved with the COSES campaigns for that period of time. We then determined the ratio between *moto ondoso* and repairs costs for one year. It was determined that 100 units of *moto ondoso* correlated to 1 euro of repair cost. After determining the cost of one unit of *moto ondoso*, we plugged in our estimated reductions of *moto ondoso* if our recommendations were fully implemented by Venetian policymakers. Since there are other factors that require canals to undergo maintenance, we presumed that *moto ondoso* is responsible for approximately 50 percent of all canal wall damage. This will help to show

[59] 2013 Canals IQP

Venetian policymakers what they have to gain from the implementation of our recommendations.

In order to determine how much money could be saved by the city in canal wall repairs, we had to calculate how much *moto ondoso* could be reduced by enforcing speed limits, reducing empty taxi runs, and making deliveries by destinations. If 100% of all boats in Venice went the speed limit while traveling on Venetian canals, *moto ondoso* would be reduced by 26 percent. Additionally, if empty taxi runs were completely eliminated, *moto ondoso* would be reduced by 14 percent. Lastly, if deliveries were made by destination instead of by product, *moto ondoso* would be reduced by 28 percent. As seen in Figure 53, the total potential reduction of *moto ondoso* would be 57 percent. Using the cost per unit of *moto ondoso* we calculated, we determined that the City of Venice could save as much as 400,000 euros. On top of those savings, the reductions in *moto ondoso* will ensure that canal walls stay in better shape and need to be repaired on a less frequent basis.

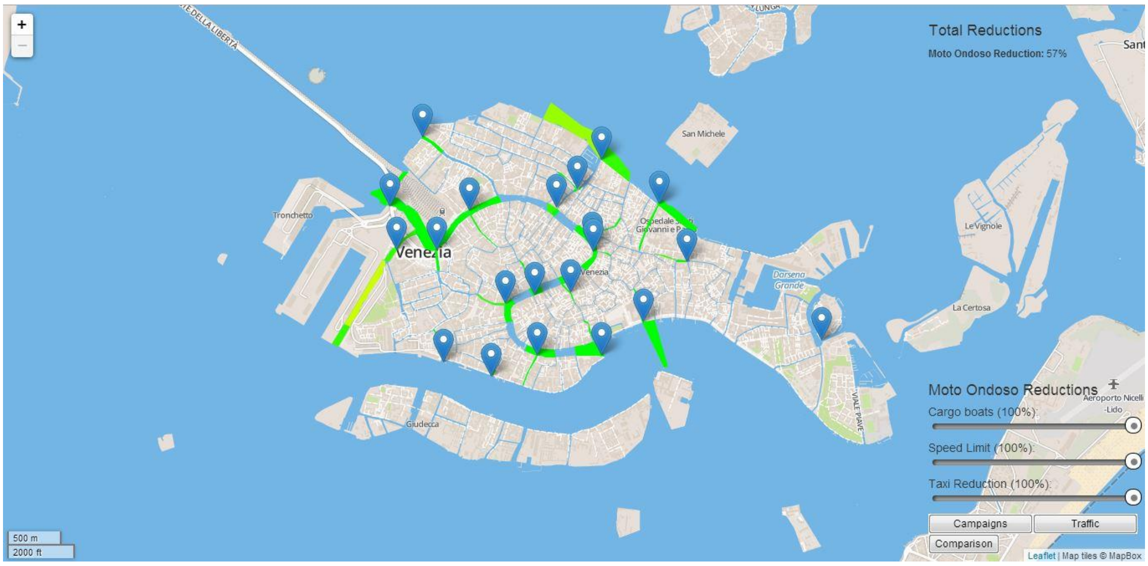

Figure 53: Total reduction of *Moto Ondoso*

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Appendix A: Bibliography

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BOAT TRAFFIC APPENDICES

Appendix B: Italian 26 point plan

PIANO PER LA SICUREZZA DELLA NAVIGAZIONE URBANA

A.Miglioramento delle condizioni di navigabilità

1.Revoca delle concessioni di spazi acquei per l'ormeggio lungo il Canal Grande nel tratto Pontedella Costituzione - Rialto - Rio Nuovo a tutte le unità commerciali (trasporto in conto proprio econto terzi di persone e cose) e loro ricollocazione nella darsena dell'Isola Nuova del Tronchettoo della Misericordia

2.Revoca o revisione delle concessioni per l'installazione di pontili pubblici e privati, non dedicatia servizio pubblico o di pubblico interesse, nel tratto Ponte della Costituzione - Rialto - Rio Nuovo, sporgenti dalla riva oltre una determinata distanza, da individuare secondo la sezionenavigabile nel tratto interessato

B.Limitazione del traffico

3.Divieto di accesso e transito in Canal Grande per tutte le unità adibite al trasporto di cose per conto proprio e per conto terzi da metà mattina sino alle 4 del giorno dopo

4.Obbligo per le unità impiegate in servizio pubblico non di linea per il trasporto di persone - taxie noleggio con conducente - di utilizzo del Rio Nuovo, con introduzione del divieto di transitoin Canal Grande nel tratto Rio di Noale - Rio Nuovo da metà mattinata a sera, con esclusionedei soli taxi in turno

5.Divieto di transito alle unità in servizio pubblico non di linea per il trasporto di persone - GranTurismo in Canal Grande dal Ponte della Costituzione a Punta della Dogana

6.Divieto di transito in Canal Grande alle gondole negli orari in cui è consentito il transito delleunità adibite al trasporto di cose per conto proprio e per conto terzi

7.Divieto di transito in Canal Grande delle unità a uso privato a motore dalle 6 alle 12

8.Divieto di transito in Canal Grande delle unità da diporto dal rio di San Giovanni Grisostomo alrio di San Luca nella prima mattinata, esclusi i titolari di concessione di spazio acqueo compreso nel tratto interessato

9.Introduzione della raccolta notturna dei rifiuti con divieto di accesso al Canal Grande per tutte leunità impiegate da Veritas dalle 8 alle 22, eccettuato il servizio di asporto rifiuti prodotti dalmercato ittico e ortofrutticolo

C.Revisione del servizio pubblico di linea

10.Differenziazione degli approdi destinati alle diverse linee di trasporto pubblico, anche connuove realizzazioni, e riduzione/diversificazione delle fermate dei servizi Alilaguna e dellaLinea dell'Arte in Canal Grande

11.Revisione dei tempi di percorrenza delle linee ACTV 1 e 2 lungo il Canal Grande, valutando la possibilità di uniformare fermate e tempi di percorrenza per regolarizzare i transiti e di unificarele due linee, per evitare sorpassi e ottimizzare gli incroci ai pontili singoli, in coerenza con imotivi dello stato di non collaborazione del personale navigante

12.Miglioramento della manovrabilità e della sicurezza delle unità in servizio pubblico di linea, converifica della possibilità e dell'efficacia dell'installazione di eliche prodiere (bow thruster) einstallazione sperimentale di telecamere posteriori per la piena visibilità poppiera

D.Messa in sicurezza del servizio di gondola

13.Ridefinizione degli stazi di gondole in prossimità dei pontili ACTV

14.Individuazione dei percorsi delle gondole in servizio pubblico da nolo e messa in sicurezza deitratti che interferiscono col servizio pubblico di linea, con prescrizioni circa le manovre diimmissione in Canal Grande e attraversamento

15.Divieto di imbarco di passeggeri per le gondole nei pontili del rio del Danieli (Rio del Vin)

16.Individuazione di una zona protetta e preclusa ad altra navigazione in bacino di San Marco per garantire la evoluzione in sicurezza delle gondola

17.Individuazione univoca delle gondole/sandoli e dei gondolieri/sandolisti in servizio pubbliconon di linea, con applicazione alle unità del numero della licenza/autorizzazione a caratteri benleggibili e dotazione dei titolari e sostituti di un cartellino identificativo

18.Revisione dei traghetti da parada, mantenendo in servizio solo quelli di effettiva utilità emaggiore frequentazione

E.Regolamentazione del traffico

19.Revisione delle regole di circolazione in Canal Grande, con previsione di tratti con divieto disorpasso, obbligo di tenere sempre la destra

20.Divieto assoluto dalle 9 alle 20 di "carovane" di unità in servizio pubblico non di linea adibite altrasporto di persone - gondole, taxi e noleggio con conducente - in Canal Grande, con revisionedella sanzione

F.Controllo del traffico

21.Istituzione di postazioni fisse di controllo con presidio della Polizia Municipale a Rialto e aPunta della Dogana

22.Riattivazione del sistema di telecontrollo ARGOS e attivazione del sistema integrato dimonitoraggio con GPS a fini sanzionatori

23.Obbligatorietà per tutte le unità a motore, diverse dalle unità da diporto non commerciale, e per le unità a remi in servizio pubblico non di linea, per poter navigare in Canal Grande se e inquanto autorizzate, di essere collegate al sistema di monitoraggio con GPS integrato nel sistemadi telecontrollo ARGOS

G.Sicurezza della navigazione

24.Introduzione del divieto di condurre tutte le unità a remi e a motore in movimento utilizzandoapparecchi radiotelefonici, consentendo solo apparecchi a viva voce o dotati di auricolare

25.Introduzione del divieto di condurre tutte le unità a remi e a motore in servizio pubblico non dilinea in stato di ebbrezza in conseguenza dell'uso di bevande alcoliche o in stato di alterazione psico-fisica dovuto all'assunzione di sostanze stupefacenti

26.Introduzione di controlli sistematici dell'idoneità psicofisica di tutti i conducenti di unità inservizio pubblico non di linea, per prevenire l'uso di bevande alcoliche o sostanze stupefacenti

Appendix C: 26 point plan (rough translation)

A. Improvement of navigability conditions.
   1. Revocation of the water spaces for mooring along the Grand Canal in the stretch Bridge of the Constitution - Rialto - New Rio in all business units (transport on own account and third parties of people and things) and their relocation in the harbor of the island of New Boots or of Mercy.
   2. Withdrawal or revision of the concessions for the installation of pontoons public and private, non-dedicated in public service or public interest, the stretch Constitution Bridge - Rialto – Rio New, protruding from the shore beyond a certain distance, to be identified in accordance with Section waterway in the section concerned.

B. Limitations on Traffic
   3. Prohibition of access and transit in the Grand Canal to all units designed to carry things for own account and for third parties by mid-morning until 4 in the next day. (Cargo ships are not allowed on the grand canal from mid-morning until 4 am then at 4 in the morning they are allowed to work.)
   4. Obligation for the units used in the public service non-scheduled passenger transport – taxi and car rental with driver - to use the Rio Nuovo, with the introduction of the ban on the Grand Canal in the stretch of Noale Rio - Rio Novo from mid-morning to late evening, with the exception the of only one taxi at a time.
   5. No transit units in public service is not scheduled for the transport of people – Great Tourism in the Grand Canal from the Bridge of the Constitution at the Punta della Dogana.
   6. No transit to the gondolas on the Grand Canal during the hours in which it is permitted to transit the units designed to carry things on their own account and for third account.
   7. Ban on driving in the Grand Canal the units in use of private motorboats between 6 and 12.
   8. Ban on driving in the Grand Canal of recreational craft from the Rio of St. John Chrysostom to Rio di San Luca in the early morning, excluding holders of concession of water space included in the section covered.
   9. Introduction of waste collection night with a ban on access to the Grand Canal for all units used by Veritas from 8 to 22, except in the service of waste collection produced by fish market, fruit and vegetable.

C. Revision of the public transit lines
   10. Differentiation of the landings for the various public transportation lines, even with new achievements, and reduction / diversification of services Alilaguna stops and Line Art in the Grand Canal.
   11. Revision of travel times ACTV 1 and 2 along the Grand Canal, evaluating the ability to standardize stops and travel time to regularize the transits and to unify the two lines to prevent overtaking and optimize the intersections of the piers individual, consistent with the grounds of the state of non-cooperation of crews.
   12. Improved maneuverability and safety of the public service units in line with verification of the possibility and effectiveness of the installation of bow

propellers (bow thruster) and experimental installation of rear cameras for full visibility aft.

D. Safety of the gondola service.
    13. Redefinition of spaces of gondolas near the piers ACTV
    14. Identification of pathways of gondolas in public service freight and safety of the traits that interfere with public bus service, with requirements on maneuvers entry into Grand Canal and crossing.
    15. Prohibition of passenger embarkation for the gondolas in the piers of the Danieli Rio (Rio del Vin)
    16. Identification of a protected area and precluded other navigation in the San Marco Basin to ensure safety in the evolution of the gondolas
    17. Unequivocal identification of the gondolas / sandoli and gondoliers / sandolisti in public service non-scheduled, with application to the units of the number of license / authorization in clearly legible and endowment of the full and substitute an identification tag
    18. Revision of the ferries from parada, keeping only those in service of effective use and greater attendance
E. Traffic Regulations
    19. Revising the rules of movement in the Grand Canal, with a forecast of traits with no overtaking, the obligation to keep to the right
    20. Absolute prohibition from 9 to 20 in the "caravans" of units in the public service non-scheduled services for the transport of people - gondolas, taxi and car rental with driver - in the Grand Canal, with review of the sanction
F. Traffic Control
    21. Establishment of fixed stations manned control of the Municipal Police in Rialto and Punta della Dogana
    22. Reactivation of the remote control system ARGOS and activation of the integrated monitoring system with GPS for the purpose of sanctions
    23. Compulsory for all motor units, other than a pleasure craft, non-commercial use, and for units rowing in public service non-scheduled, you can surf the Grand Canal giveaway and if authorized, to be connected to the monitoring system with integrated GPS in the remote control system ARGOS
G. Safety of Navigation
    24. Introduction of the prohibition of all units and motor boat in motion using radio-telephones, allowing only devices with speakerphone or headset
    25. Introduction of the prohibition of all units and motor boat in public service non-scheduled while intoxicated as a result of the use of alcohol or while impaired psycho-physical due to drug use
    26. Introduction of routine mental and physical suitability of all drivers drive inservice public non-scheduled, to prevent the use of alcohol or drugs

Appendix D: Station Data

	Code	Station	Segments	Date	Total_Traffic_Volume	Cargo_Traffic_Volume	Taxi_Traffic_Volume	Service_Traffic_Volume	Private_Traffic_Volume	Peak_Hour	Peak_Count
2	1	F.Nove	cmis1,orto3,fnov	05/04/2001	920	0:00	533	124	59	10:00AM	122
3	2	Tronchetto	gran1	05/04/2001	1321	850	109	233	37	8:00AM	193
4	3	Scomenzera	chia1,chia2,scom1	05/04/2001	750	256	166	216	18	8:00AM and 10:00AM	87
5	4	S.Basilio	seba,guid	05/04/2001	1164	155	141	402	42	10:00AM	124
6	5	S.Trovaso	trov3,guid	05/04/2001	1220	134	142	504	34	9:00AM and 10:00AM	128
7	6	Rio Novo-P.Le Roma	novo1,gran3,gran2,	05/04/2001	2437	632	978	556	17	8:00AM	287
8	7	Rio Novo-Regione	cafo2,gran27,gran28	05/04/2001	1690	399	1027	189	44	11:00AM	164
9	8	Rio Marin	marn,gran5,gran4	05/04/2001	1688	492	505	556	65	8:00AM	191
10	9	Rio di Noale	mise6,noal1,noal2	05/04/2001	818	246	507	0	49	11:00AM	146
11	10	Erbaria	gran18,gran17	05/04/2001	1452	380	678	348	16	11:00AM	184
12	11	Rio SS.Apostoli	gran18,apos4,gran16,gran15,g	05/04/2001	509	230	130	0	32	10:00AM	57
13	12	San Vio	vio, gran35,gran36	05/04/2001	1398	265	801	214	75	11:00AM	212
14	13	Rio Piet (San Lorenzo)	late1,late2,lore	05/04/2001	332	46	214	0	68	10:00AM	38
15	14	S.Luca	gran20,luca1	05/04/2001	380	79	137	0	22	11:00AM	41
16	15	Qintavalle	pier3,giar1,quin,ana	05/04/2001	216	54	114	0	41	11:00AM	47
17	16	Paglia	cano	05/04/2001	291	120	95	0	0	9:00AM and 11:00AM	40
18	17	Mendicanti	mend	05/04/2001	903	236	436	148	37	11:00AM	105
19	18	Macello	cann1	05/04/2001	642	304	95	156	55	8:00AM	143
20	24	Rio di Noale	gran11,gran12	05/04/2001	1450	409	632	342	35	11:00AM	180
21	25	Rio di S.Polo	polo4,gran24,gran23	05/04/2001	288	150	114	0	17	10:00AM	45
22	26	Salute	gran41,gran40,mois	05/04/2001	1440	235	759	226	33	11:00AM	186
23	1	F.Nove	cmis1,orto3,fnov	31/08/2001	1676	391	895	531	228	10:00AM	225
24	2	Tronchetto	gran1	31/08/2001	1442	723	190	950	202	11:00AM	134
25	3	Scomenzera	chia1,chia2,scom1	31/08/2001	833	269	171	481	86	8:00AM	87
26	4	S.Basilio	seba,guid	31/08/2001	1158	154	223	451	67	9:00AM	152
27	5	S.Trovaso	trov3,guid	31/08/2001	1733	258	324	753	148	3:00PM	181
28	6	Rio Novo-P.Le Roma	novo1,gran3,gran2,	31/08/2001	2715	679	1195	1202	198	11:00AM	277
29	7	Rio Novo-Regione	cafo2,gran27,gran28	31/08/2001	2543	603	1363	829	213	2:00PM	243
30	8	Rio Marin	marn,gran5,gran4	31/08/2001	2189	617	729	1145	160	12:00PM	227
31	9	Rio di Noale	mise6,noal1,noal2	31/08/2001	1083	315	602	315	142	10:00AM	168
32	10	Erbaria	gran18,gran17	31/08/2001	1624	424	622	762	150	10:00AM	195
33	11	Rio SS.Apostoli	gran18,apos4,gran16,gran15,g	31/08/2001	429	174	132	174	51	11:00AM	65
34	12	San Vio	vio, gran35,gran36	31/08/2001	1648	247	914	474	173	2:00PM	189
35	13	Rio Piet (San Lorenzo)	late1,late2,lore	31/08/2001	781	118	578	118	79	9:00AM and 10:00AM	97
36	14	S.Luca	gran20,luca1	31/08/2001	699	98	95	98	40	3:00PM	114
37	15	Qintavalle	pier3,giar1,quin,ana	31/08/2001	547	118	218	118	187	11:00AM	68
38	16	Paglia	cano	31/08/2001	380	118	77	118	48	10:00AM	49
39	17	Mendicanti	mend	31/08/2001	1494	439	808	455	206	10:00AM	174
40	18	Macello	cann1	31/08/2001	1125	395	186	593	246	3:00PM	130

Appendix E: Canal Segment Data

1	Station	Segments	Segment N	Total Traffic 05/04/2001	Total Traffic 31/08/2001	Total Traffic 19/04/2002	Total Traffic 30/08/2002	Total Traffic 11/04/2003	Total Traffic 05/09/2003	Total Traffic 09/04/200
2	1	1	CMIS1	156	157	327	295	265	315	219
3		2	FNUO4	193	194	548	567	523	517	406
4		3	CMIS1	333	335	591	562	506	558	612
5		4	FNUO2	232	233	256	274	275	318	340
6	2	1	CALA03	409	414	574	511	486	394	427
7		2	GRAN1	562	560	824	681	608	587	574
8		3	CALA02	92	92	334	263	211	297	132
9		4	TRNC01	251	253	254	255	146	244	104
10	3	1	CHIA2	362	361	405	487	427	421	398
11		2	SCOM1	387	388	407	446	414	433	419
12	4	1	GIUD04	589	589	678	736	571	635	688
13		2	GIUD03	484	484	645	664	545	613	604
14		3	SEBA	91	91	150	150	130	186	118
15	5	1	GIUD07	539	539	475	707	497	624	543
16		2	GIUD06	585	584	617	897	665	693	586
17		3	TROV3	96	96	175	263	77	44	36
18	6	1	GRAN3	1017	1018	926	876	853	977	745
19		2	GRAN2	847	854	870	698	742	800	663
20		3	NOVO1	567	567	694	637	623	709	579
21	7	1	GRAN27	548	547	864	548	624	896	787
22		2	GRAN28	636	637	892	644	679	1126	963
23		3	CAFO2	506	506	670	576	584	749	752

Appendix F: How Data was Organized

Name	Date modified	Type	Size
COSES Data unformatted	12/17/2013 3:25 PM	File folder	
Organized Data	12/17/2013 3:36 PM	File folder	

Click on COSES Data unformatted and you will get all data that was received by COSES during their different campaigns.

COSES Data 2001	12/17/2013 3:22 PM	File folder
COSES Data 2002	12/17/2013 3:42 PM	File folder
COSES Data 2003	12/17/2013 3:24 PM	File folder
COSES Data 2004	12/17/2013 3:24 PM	File folder
COSES Data 2005	12/17/2013 3:25 PM	File folder
COSES Data 2006	12/17/2013 3:25 PM	File folder
COSES Data 2007	12/17/2013 3:25 PM	File folder
COSES Data 2009	12/17/2013 3:25 PM	File folder

Click on Organized Data, a Folder with all the Raw Data available and the Canal and Station Data will be available.

Raw Data	12/17/2013 3:43 PM	File folder	
Canal Segment Data	12/14/2013 7:33 A...	Microsoft Excel W...	16 KB
Station Data	12/12/2013 2:20 PM	Microsoft Excel W...	35 KB

Click on Raw Data

1 September 2006	12/13/2013 7:40 A...	Microsoft Access ...	5,824 KB
2 September 2005	12/13/2013 7:40 A...	Microsoft Access ...	5,860 KB
4 September 2009	12/13/2013 6:59 A...	Microsoft Access ...	5,508 KB
5 April 2001	12/13/2013 6:49 A...	Microsoft Access ...	18,648 KB
6 April 2007	12/12/2013 5:09 PM	Microsoft Access ...	4,352 KB
14 April 2006	12/12/2013 5:13 PM	Microsoft Access ...	9,672 KB
25 March 2005	12/12/2013 1:49 PM	Microsoft Access ...	7,832 KB
31 August 2001	12/11/2013 1:51 PM	Microsoft Excel W...	1,772 KB
31 August 2007	12/13/2013 6:58 A...	Microsoft Access ...	5,568 KB
April 2002	12/13/2013 6:51 A...	Microsoft Access ...	20,676 KB
April 2004	12/12/2013 1:47 PM	Microsoft Access ...	54,092 KB
September 2004	12/13/2013 6:55 A...	Microsoft Access ...	4,676 KB

MOTO ONDOSO APPENDICES

Appendix G: Boat Speed Data

Boat Speed Data Form

Date: ____________________ **Day of the Week:** ___________________

Time: _________ to __________

Canal: ______________________

Segment: ________________________

Segment Length (meters): __________________________

Boat Class Legend:

I – Merci **III –** Diporto/Private **V -** Altro

II - Persone **IV –** Servizi

Boat Class	Time (seconds)

Boat Class	Time (seconds)

Boat Class	Time (seconds)

Appendix H: Boat Speed Data for Each Canal Segment

Speed Data 11kph zone 11-05.xlsx - Microsoft Excel

Speeds of Boats

Date	Day of Week	Canal	Segment	Segment Length (m)	Speed Limit of Segment (km/hr)	Boat Class	Time (s)	Speed (m/s)	Speed (km/hr)	Over/Under Speed Limit
5/11/2013	Tuesday	North side of Venice facing airport	N/A	52	11	I	21.5	2.4	8.7	-2.3
5/11/2013	Tuesday	North side of Venice facing airport	N/A	52	11	I	16.5	3.2	11.3	0.3
5/11/2013	Tuesday	North side of Venice facing airport	N/A	52	11	I	14	3.7	13.4	2.4
5/11/2013	Tuesday	North side of Venice facing airport	N/A	52	11	I	8	6.5	23.4	12.4
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	10.5	3.8	13.7	2.7
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	10.25	3.9	14.0	3.0
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	12	3.3	12.0	1.0
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	11	3.6	13.1	2.1
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	11	3.6	13.1	2.1
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	12	3.3	12.0	1.0
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	11.5	3.5	12.5	1.5
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	13.5	3.0	10.7	-0.3
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	10.5	3.8	13.7	2.7
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	13	3.1	11.1	0.1
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	11.5	3.5	12.5	1.5
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	13	3.1	11.1	0.1
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	8.75	4.6	16.5	5.5
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	15.25	2.6	9.4	-1.6
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	15.5	2.6	9.3	-1.7
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	12.75	3.1	11.3	0.3
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	12.25	3.3	11.8	0.8
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	13.75	2.9	10.5	-0.5
5/11/2013	Tuesday	North side of Venice facing airport	N/A	40	11	I	12	3.3	12.0	1.0

Boat Speeds

Speed Data large canal 11-04.xlsx - Microsoft Excel

Speeds of Boats

Date	Day of Week	Canal	Segment	Segment Length (m)	Speed Limit of Segment (km/hr)	Boat Class	Time (s)	Speed (m/s)	Speed (km/hr)	Over/Under Speed Limit
4/11/2013	Monday	Grand	GRAN 4	66	7	I	25	2.6	9.5	2.5
4/11/2013	Monday	Grand	GRAN 4	66	7	I	23	2.9	10.3	3.3
4/11/2013	Monday	Grand	GRAN 4	66	7	I	32	2.1	7.4	0.4
4/11/2013	Monday	Grand	GRAN 4	66	7	I	24	2.8	9.9	2.9
4/11/2013	Monday	Grand	GRAN 4	66	7	I	23	2.9	10.3	3.3
4/11/2013	Monday	Grand	GRAN 4	66	7	I	22	3.0	10.8	3.8
4/11/2013	Monday	Grand	GRAN 4	66	7	I	22	3.0	10.8	3.8
4/11/2013	Monday	Grand	GRAN 4	66	7	I	28	2.4	8.5	1.5
4/11/2013	Monday	Grand	GRAN 4	66	7	I	23	2.9	10.3	3.3
4/11/2013	Monday	Grand	GRAN 4	66	7	I	24	2.8	9.9	2.9
4/11/2013	Monday	Grand	GRAN 4	66	7	I	27	2.4	8.8	1.8
4/11/2013	Monday	Grand	GRAN 4	66	7	I	27	2.4	8.8	1.8
4/11/2013	Monday	Grand	GRAN 4	66	7	I	28	2.4	8.5	1.5
4/11/2013	Monday	Grand	GRAN 4	66	7	I	23	2.9	10.3	3.3
4/11/2013	Monday	Grand	GRAN 4	66	7	I	24	2.8	9.9	2.9
4/11/2013	Monday	Grand	GRAN 4	66	7	I	24	2.8	9.9	2.9
4/11/2013	Monday	Grand	GRAN 4	66	7	I	22	3.0	10.8	3.8
4/11/2013	Monday	Grand	GRAN 4	66	7	I	19	3.5	12.5	5.5
4/11/2013	Monday	Grand	GRAN 4	66	7	I	23	2.9	10.3	3.3
4/11/2013	Monday	Grand	GRAN 4	66	7	I	26	2.5	9.1	2.1
4/11/2013	Monday	Grand	GRAN 4	66	7	I	21	3.1	11.3	4.3
4/11/2013	Monday	Grand	GRAN 4	66	7	I	25	2.6	9.5	2.5
4/11/2013	Monday	Grand	GRAN 4	66	7	I	25	2.6	9.5	2.5

Boat Class	Median Speed
I	9.9
II	11.3
III	10.6
IV	9.9
VAP	10.3
Overall	10.8

Boat Speeds / Graph Data

Speed Data medium-large canal 10-31.xlsx - Microsoft Excel

Speeds of Boats

Date	Day of Week	Canal	Segment	Segment Length (m)	Speed Limit of Segment (km/hr)	Boat Class	Time (s)	Speed (m/s)	Speed (km/hr)	Over/Under Speed Limit
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	25	1.8	6.5	1.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	15	3.0	10.8	5.8
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	17	2.6	9.5	4.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	21	2.1	7.7	2.7
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	22	2.0	7.4	2.4
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	24	1.9	6.8	1.8
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	17	2.6	9.5	4.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	20	2.3	8.1	3.1
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	18	2.5	9.0	4.0
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	19	2.4	8.5	3.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	15.5	2.9	10.5	5.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	18	2.5	9.0	4.0
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	13	3.5	12.5	7.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	17	2.6	9.5	4.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	21	2.1	7.7	2.7
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	23	2.0	7.0	2.0
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	19	2.4	8.5	3.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	19	2.4	8.5	3.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	17	2.6	9.5	4.5
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	18	2.5	9.0	4.0
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	18	2.5	9.0	4.0
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	18	2.5	9.0	4.0
31/10/2013	Thursday	Rio de Ca' Foscari	CAFO2	45	5	I	18	2.5	9.0	4.0

Boat Class	Medi
I	
II	
III	
IV	
Overall	

Boat Speeds | graph data

Speed Data medium canal 10-30.xlsx - Microsoft Excel

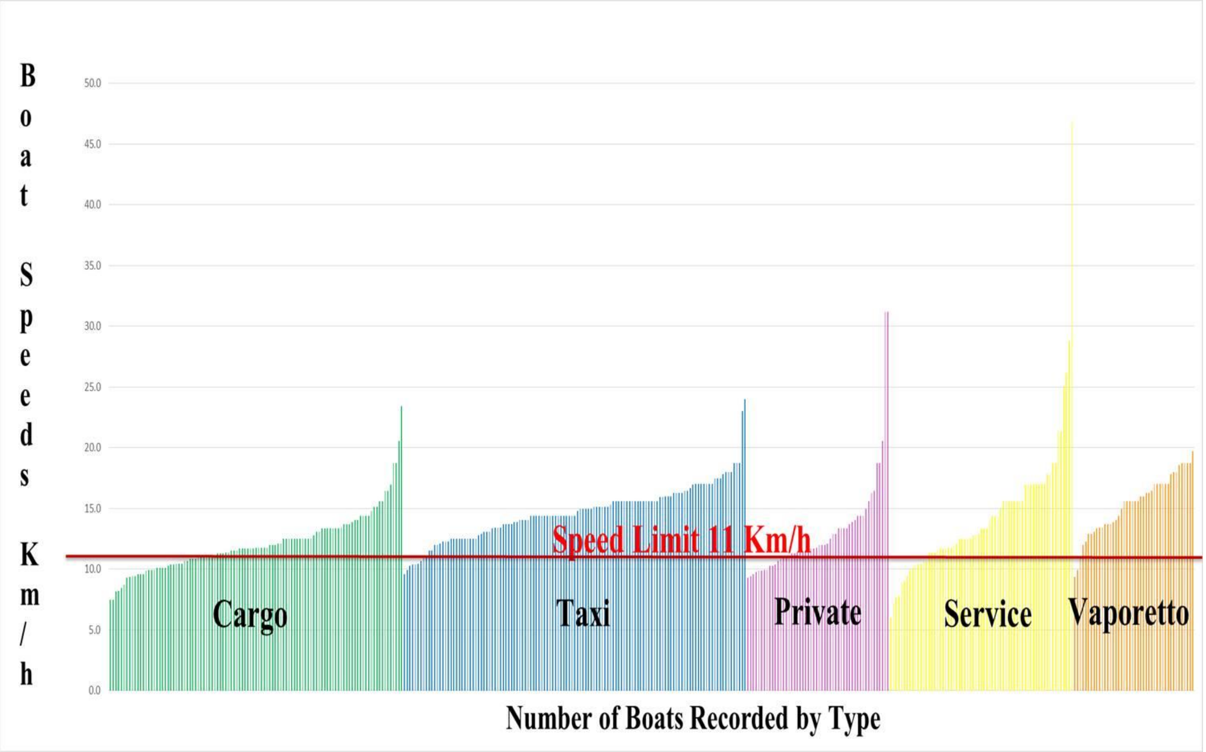
Speeds of Boats

Date	Day of Week	Canal	Segment	Segment Length (m)	Speed Limit of Segment (km/hr)	Boat Class	Time (s)	Speed (m/s)	Speed (km/hr)	Over/Under Speed Limit
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	55	0.9	3.3	-1.7
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	19	2.6	9.5	4.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	20.5	2.4	8.8	3.8
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	22	2.3	8.2	3.2
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	16	3.1	11.3	6.3
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	24	2.1	7.5	2.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	20	2.5	9.0	4.0
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	19	2.6	9.5	4.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	23	2.2	7.8	2.8
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	21	2.4	8.6	3.6
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	20	2.5	9.0	4.0
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	19	2.6	9.5	4.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	23	2.2	7.8	2.8
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	19	2.6	9.5	4.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	40	1.3	4.5	-0.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	42	1.2	4.3	-0.7
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	60	0.8	3.0	-2.0
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	22	2.3	8.2	3.2
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	25	2.0	7.2	2.2
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	31	1.6	5.8	0.8
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	24	2.1	7.5	2.5
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	20	2.5	9.0	4.0
30/10/2013	Wednesday	Rio de SS Apostoli	AP0S3	50	5	I	19	2.6	9.5	4.5

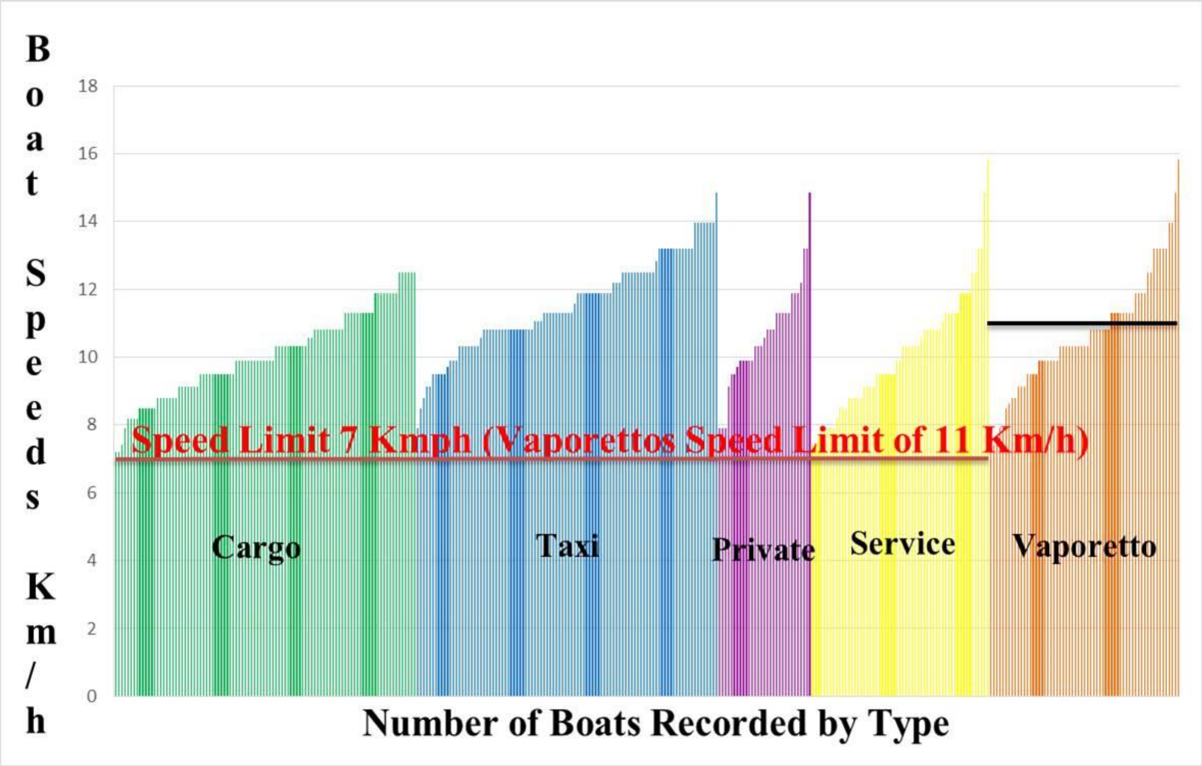
Boat Class	Med
I	
II	
III	
IV	
Overall	

Boat Speeds | Graphics data

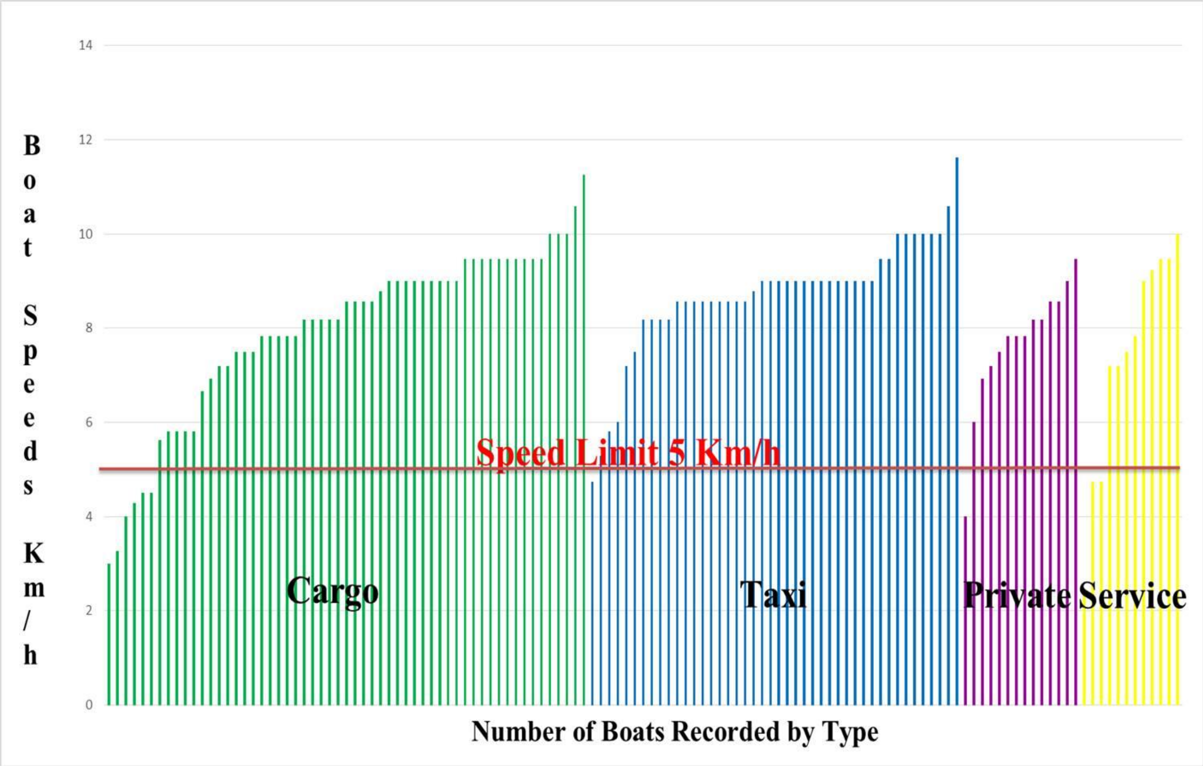
Appendix I: Boat Speed Graphs



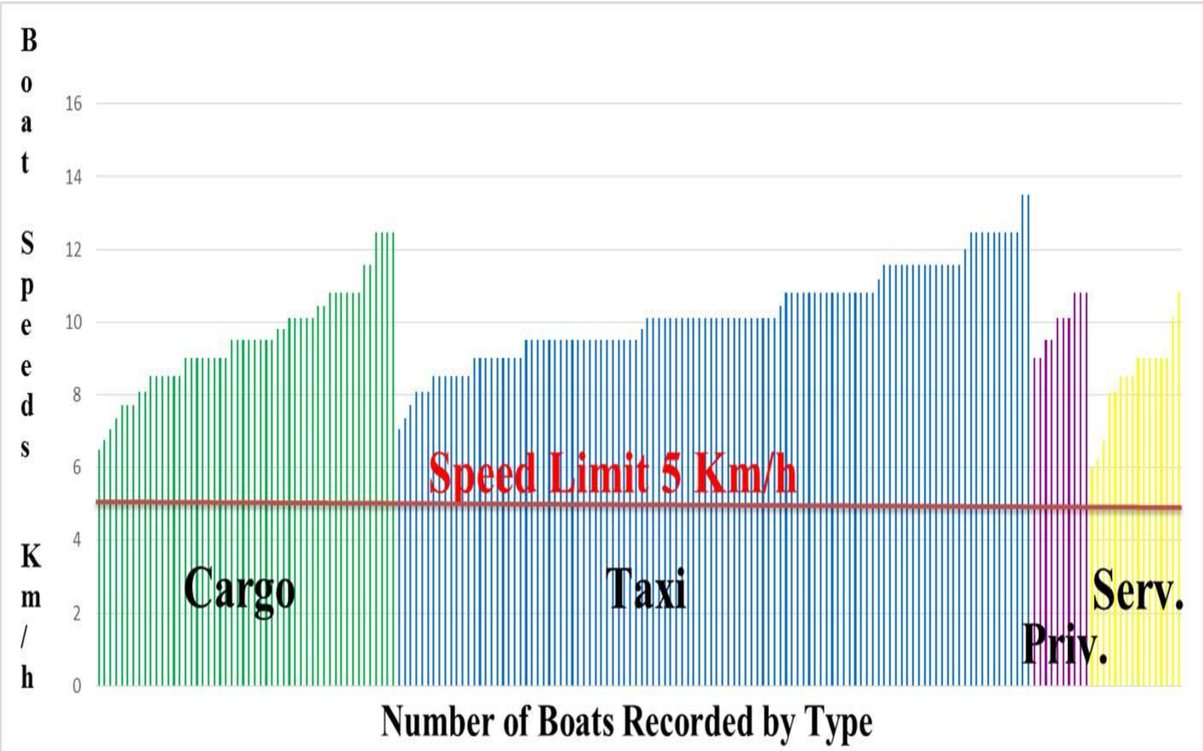
Fondamente Nove



Grand Canal



Rio di SS Apostoli



Rio de Ca’Foscari

Appendix J: Updated and Original Moto Ondoso Index Values

Type	5km/h Zone	7km/h Zone	5km/h	7km/h
Type 1	6.29	9.96	1.28	3.25
Type 2	6.29	9.96	1.28	3.25
Type 3	5.14	16.89	0.36	1.57
Type 4	3.85	6.71	1.68	2.97
Type 5	3.85	6.71	1.68	2.97
Type 6	4.30	6.31	1.74	3.00
Type 7	4.30	6.31	1.74	3.00
Type 8	0.00	0.00	0.00	0.00
Type 9	0.00	0.00	0.00	0.00
Type 10	4.48	6.79	1.68	2.97
Type 11	4.58	13.48	0.36	1.57
Type 12	4.58	13.48	0.36	1.57
Type 13	4.58	13.48	0.36	1.57
Type 14	4.48	6.79	1.68	2.97
Type 15	4.48	6.79	1.68	2.97
Type 16	4.48	6.79	1.68	2.97
Type 17	4.58	13.48	0.36	1.57
Type 18	4.58	13.48	0.36	1.57
Type 19	0.00	0.00	0.00	0.00
Type 20	0.00	0.00	0.00	0.00
Type 21	4.48	6.79	1.68	2.97

Appendix K: Equations for Moto Ondoso Index

Type	MOI
Type 1	0.015*v^2.7638
Type 2	0.015*v^2.7638
Type 3	0.0003*v^4.402
Type 4	0.109*v^1.698
Type 5	0.109*v^1.698
Type 6	0.13*v^1.6126
Type 7	0.13*v^1.6126
Type 8	0
Type 9	0
Type 10	0.109*v^1.698
Type 11	0.0003*v^4.402
Type 12	0.0003*v^4.402
Type 13	0.0003*v^4.402
Type 14	0.109*v^1.698
Type 15	0.109*v^1.698
Type 16	0.109*v^1.698
Type 17	0.0003*v^4.402
Type 18	0.0003*v^4.402
Type 19	0
Type 20	0
Type 21	0.109*v^1.698

Appendix L: COSES Turning Movements

Turn	Start	End
112	CMIS1	FNUO4
113	CMIS1	CMIS1
114	CMIS1	FNUO2
121	FNUO4	CMIS1
123	FNUO4	CMIS1
124	FNUO4	FNUO2
131	CMIS1	CMIS1
132	CMIS1	FNUO4
134	CMIS1	FNUO2
141	FNUO2	CMIS1
142	FNUO2	FNUO4
143	FNUO2	CMIS1
212	CALA03	GRAN1
213	CALA03	CALA02
214	CALA03	TRNC01
221	GRAN1	CALA03
223	GRAN1	CALA02
224	GRAN1	TRNC01
231	CALA02	CALA03
232	CALA02	GRAN1
234	CALA02	TRNC01
241	TRNC01	CALA03
242	TRNC01	GRAN1
243	TRNC01	CALA02
312	CHIA2	SCOM1
321	SCOM1	CHIA2
412	GIUD04	GIUD03
413	GIUD04	SEBA
421	GIUD03	GIUD04
423	GIUD03	SEBA
431	SEBA	GIUD04
432	SEBA	GIUD03
512	GIUD07	GIUD06
513	GIUD07	TROV3
521	GIUD06	GIUD07
523	GIUD06	TROV3
531	TROV3	GIUD07
532	TROV3	GIUD06
612	GRAN3	GRAN2
613	GRAN3	NOVO1
621	GRAN2	GRAN3
623	GRAN2	NOVO1
631	NOVO1	GRAN3
632	NOVO1	GRAN2
712	GRAN27	GRAN28
713	GRAN27	CAFO2
721	GRAN28	GRAN27
723	GRAN28	CAFO2
731	CAFO2	GRAN27
732	CAFO2	GRAN28
812	GRAN5	GRAN4
813	GRAN5	MARN
821	GRAN4	GRAN5
823	GRAN4	MARN
831	MARN	GRAN5
832	MARN	GRAN4
912	NOAL2	NOAL1
913	NOAL2	MISE6
921	NOAL1	NOAL2
923	NOAL1	MISE6
931	MISE6	NOAL2
932	MISE6	NOAL1
1012	GRAN18	GRAN17
1021	GRAN17	GRAN18
1113	GRAN16	APOS4
1114	GRAN18	TEDE
1123	GRAN15	APOS4
1124	GRAN17	TEDE
1131	APOS4	GRAN16
1132	APOS4	GRAN15
1141	TEDE	GRAN18
1142	TEDE	GRAN16
1212	GRAN36	GRAN35
1213	GRAN36	VIO
1221	GRAN35	GRAN36
1223	GRAN35	VIO
1231	VIO	GRAN36
1232	VIO	GRAN35
1312	LATE1	LATE2
1313	LATE1	LORE
1321	LATE2	LATE1
1323	LATE2	LORE
1331	LORE	LATE1
1332	LORE	LATE2
1412	GRAN20	LUCA1
1421	LUCA1	GRAN20
1512	PIER3	GIAR1
1513	PIER3	QUIN
1514	PIER3	ANA
1521	GIAR1	PIER3
1523	GIAR1	QUIN
1524	GIAR1	ANA
1531	QUIN	PIER3
1532	QUIN	GIAR1
1534	QUIN	ANA
1541	ANA	PIER3
1542	ANA	GIAR1
1543	ANA	GIAR1
1612	CANO	BACI04
1621	BACI04	CANO
1712	FNUO8	FNUO7
1713	FNUO8	MEND
1721	FNUO7	FNUO8
1723	FNUO7	MEND
1731	MEND	FNUO8
1732	MEND	FNUO7
1812	SECO01	SECO02
1813	SECO01	CANN1
1814	SECO01	SECO01
1821	SECO02	SECO01
1823	SECO02	CANN1
1824	SECO02	SECO01
1831	CANN1	SECO01
1832	CANN1	SECO02
1834	CANN1	SECO01
1841	SECO01	SECO01
1842	SECO01	SECO02
1843	SECO01	CANN1
1912	NULL	NULL
1913	NULL	NULL
1914	NULL	NULL
1921	NULL	NULL
1923	NULL	NULL
1924	NULL	NULL
1931	NULL	NULL
1932	NULL	NULL
1934	NULL	NULL
1941	NULL	NULL
1942	NULL	NULL
1943	NULL	NULL
2012	NULL	NULL
2013	NULL	NULL
2021	NULL	NULL
2023	NULL	NULL
2031	NULL	NULL
2032	NULL	NULL
2112	NULL	NULL

2113	NULL	NULL
2114	NULL	NULL
2121	NULL	NULL
2123	NULL	NULL
2124	NULL	NULL
2131	NULL	NULL
2132	NULL	NULL
2134	NULL	NULL
2141	NULL	NULL
2142	NULL	NULL
2143	NULL	NULL
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2213	NULL	NULL
2214	NULL	NULL
2221	NULL	NULL
2223	NULL	NULL
2224	NULL	NULL
2231	NULL	NULL
2232	NULL	NULL
2234	NULL	NULL
2241	NULL	NULL
2242	NULL	NULL
2243	NULL	NULL
2312	NULL	NULL
2313	NULL	NULL
2314	NULL	NULL
2321	NULL	NULL
2323	NULL	NULL
2324	NULL	NULL
2331	NULL	NULL
2332	NULL	NULL
2334	NULL	NULL
2341	NULL	NULL
2342	NULL	NULL
2343	NULL	NULL
2412	GRAN12	GRAN11
2421	GRAN11	GRAN12
2513	GRAN24	POLO4
2523	GRAN23	POLO4
2531	POLO4	GRAN24
2532	POLO4	GRAN23
2612	GRAN41	GRAN40
2613	GRAN41	MOIS
2621	GRAN40	GRAN41
2623	GRAN40	MOIS
2631	MOIS	GRAN41
2632	MOIS	GRAN40

REDUCING MOTO ONDOSO APPENDICES

Appendix M:Store Data

	Store Type								
Island	CoinsAndStamps	Computers	ComputerServices	Cosmetics	Costumes	Dairy	Delivery	DryClenaer	Electronics
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	1	8
16	0	0	0	0	0	0	0	0	2
17	0	0	0	1	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	1
21	0	0	0	0	0	0	0	0	1
22	0	0	0	1	0	0	0	0	0
23	0	0	0	0	0	0	0	0	1
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	1
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	1	1	0	0	0	1	1
29	0	0	0	2	0	0	0	0	2
30	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	1
34	0	0	0	1	0	0	0	0	0

Appendix N: Dry Delivery Data

Dry Deliv									
Island	BedAndBrea	Boat Supplie	Books	Butcher	Candy	CarRental	Clothing	Coffee	CoinsAndSta
15	0	0	6	160	0	0	42	0	0
16	0	0	3	0	0	0	6	0	0
17	0	0	0	0	0	0	6	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	10	0	0
21	0	0	0	32	0	0	2	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	2	0	0
26	0	0	0	32	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	10	0	8	0	0
29	0	0	6	192	10	0	38	0	0
30	0	0	0	0	0	0	2	0	0
31	0	0	0	0	0	0	4	0	0
32	0	0	0	32	0	0	2	0	0
33	0	0	3	0	0	0	4	0	0
34	0	0	3	0	10	0	8	0	0
35	0	0	6	0	0	0	4	0	0
36	0	0	0	0	0	0	2	0	0
37	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	6	0	0
42	0	0	0	0	0	0	0	0	0
43	0	0	3	0	0	0	0	0	0
44	0	0	0	0	0	0	2	0	0
45	0	0	0	0	0	0	2	0	0
47	0	0	15	32	0	0	8	0	0
48	0	0	3	0	10	0	4	0	0
49	0	0	0	0	0	0	2	0	0

Appendix O: Refrigerated Delivery Data

Ref Deliv								
Island	Pizzeria	Produce	RealEstate	Repair	Restaurant	Shoes	Souvenirs	Spa
38	0	0	0	0	0	0	0	0
39	5	0	0	0	25	0	0	0
40	0	0	0	0	5	0	0	0
41	20	0	0	0	25	0	0	0
42	0	0	0	0	0	0	0	0
43	5	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0
45	15	0	0	0	15	0	0	0
47	5	30	0	0	115	0	0	0
48	0	0	0	0	45	0	0	0
49	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0
51	5	0	0	0	20	0	0	0
52	0	0	0	0	55	0	0	0
53	5	0	0	0	10	0	0	0
54	0	0	0	0	0	0	0	0
55	0	0	0	0	10	0	0	0
56	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0
60	0	0	0	0	5	0	0	0
61	0	0	0	0	45	0	0	0
62	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0
64	5	15	0	0	130	0	0	0
65	0	0	0	0	15	0	0	0
66	25	15	0	0	40	0	0	0
67	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0
69	5	15	0	0	35	0	0	0
70	0	0	0	0	0	0	0	0
71	0	0	0	0	20	0	0	0
72	0	0	0	0	15	0	0	0

Appendix P: MOBILIS Extrapolation Data

Isand	Number of Stores	MOBILIS_Deliveries	MOBILIS_Deliveries_Per_Store	MOBILIS_Extrapolation_Deliveries	MOBILIS_Extrapolation_Boats
1	0			0	0.00
2	3			32	0.07
3	6			63	0.14
4	3			32	0.07
5	4			42	0.10
6	0			0	0.00
7	7			74	0.17
8	29			305	0.69
9	20			210	0.48
10	0			0	0.00
11	10			105	0.24
12	1			11	0.02
13	0			0	0.00
14	4			42	0.10
15	165	1992	12.07272727	1736	3.94
16	36			379	0.86
17	18			189	0.43
18	9	348	38.66666667	95	0.21
19	2			21	0.05
20	106	1487	14.02830189	1115	2.53
21	44			463	1.05
22	23			242	0.55
23	6			63	0.14
24	23			242	0.55
25	10			105	0.24
26	16			168	0.38
27	15	168	11.2	158	0.36
28	53			558	1.26
29	278			2925	6.63
30	19			200	0.45
31	21			221	0.50
32	13			137	0.31
33	93			979	2.22
34	81	369	4.555555556	852	1.93
35	56			589	1.34
36	28			295	0.67
37	3			32	0.07
38	4			42	0.10
39	15			158	0.36
40	1			11	0.02

Appendix Q: Zones Data

Island ID	Dry Deliveries	Ref. Deliveries	Total Deliveries	Boats Per Day (2013)	2001 Data	MOBILIS Extrapolation	ZONE #
1	0	0	0	0.00	0.1	0.00	1
2	5	0	5	0.01	1.81	0.07	1
3	84	20	104	0.24	3.02	0.14	1
4	4	0	4	0.01	0.02	0.07	1
5	16	5	21	0.05	0.1	0.10	1
6	0	0	0	0.00	0	0.00	1
10	0	0	0	0.00	0	0.00	1
11	44	5	49	0.11	0.03	0.24	1
7	65	20	85	0.19	0.49	0.17	2
8	317	61	378	0.86	0.87	0.69	2
9	159	50	209	0.47	0.34	0.48	3
12	0	0	0	0.00	0	0.02	3
13	0	0	0	0.00	0	0.00	3
14	19	5	24	0.05	0.02	0.10	3
15	1479	297	1776	4.03	6.08	3.94	4
19	16	5	21	0.05	0.06	0.05	5
20	944	139	1083	2.46	1.79	2.53	5
123	4	0	4	0.01	0	0.02	5
57	0	0	0	0.00	0	0.00	6
60	20	5	25	0.06	0	0.07	6
61	317	68	385	0.87	0.03	1.10	6
16	240	30	270	0.61	0.38	0.86	7
17	129	20	149	0.34	0.2	0.43	7
18	105	20	125	0.28	3.02	0.21	8
58	4	0	4	0.01	0.15	0.05	8
59	0	0	0	0.00	0	0.00	8
62	0	0	0	0.00	0.58	0.02	8
63	4	0	4	0.01	0	0.05	8
65	161	26	187	0.42	1.43	0.79	9
70	0	0	0	0.00	1.13	0.00	9
72	182	28	210	0.48	0.39	0.50	9
73	20	5	25	0.06	0.21	0.05	9
21	283	58	341	0.77	0.66	1.05	10
22	284	67	351	0.80	0.6	0.55	10
64	1032	203	1235	2.80	0	3.22	11

Appendix R: COSES Straight-Line Distance Matrix

	From																			
To		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	24	25	26
	1	0	1.737	1.799	2.054	1.95	1.496	1.388	1.134	0.305	0.683	0.748	1.643	1.073	1.088	2.275	1.344	1.449	0.525	1.206	1.569
	2	1.737	0	0.36	1.315	1.58	0.515	1.206	0.634	1.504	1.662	1.683	1.68	2.427	1.612	3.618	2.239	0.624	1.328	1.354	2.091
	3	1.799	0.36	0	0.969	1.261	0.316	0.975	0.664	1.536	1.571	1.579	1.406	2.32	1.612	3.481	2.056	0.917	1.327	1.168	1.848
	4	2.054	1.315	0.969	0	0.418	0.9	0.68	1.233	1.742	1.527	1.49	0.763	2.113	1.174	3.032	1.646	1.801	1.548	0.909	1.268
	5	1.95	1.58	1.261	0.418	0	1.104	0.592	1.345	1.651	1.331	1.282	0.401	1.817	0.926	2.665	1.293	1.993	1.449	0.74	0.903
	6	1.496	0.515	0.316	0.9	1.104	0	0.694	0.411	1.227	1.249	1.254	1.174	2.007	1.129	3.158	1.759	0.911	1.021	0.861	1.561
	7	1.388	1.206	0.975	0.68	0.592	0.694	0	0.795	1.081	0.841	0.807	0.502	1.499	0.542	2.542	1.124	1.481	0.863	0.246	0.878
	8	1.134	0.634	0.664	1.233	1.345	0.411	0.795	0	0.892	1.027	1.051	1.293	1.806	1.047	3.008	1.665	0.681	0.704	0.851	1.575
	9	0.305	1.504	1.536	1.742	1.651	1.277	1.081	0.892	0	0.463	0.523	1.371	1.053	0.834	2.301	1.189	1.314	0.221	0.923	1.35
	10	0.683	1.662	1.571	1.527	1.331	1.249	0.841	1.027	0.463	0	0.062	0.993	0.763	0.428	1.989	0.742	1.612	0.419	0.613	0.893
	11	0.748	1.683	1.579	1.49	1.282	1.254	0.807	1.051	0.523	0.062	0	0.946	0.746	0.375	1.996	0.688	1.652	0.455	0.582	0.826
	12	1.643	1.68	1.406	0.763	0.401	1.174	0.502	1.293	1.371	0.993	0.946	0	1.42	0.577	2.274	0.898	1.984	1.198	0.491	0.514
	13	1.073	2.427	2.32	2.113	1.817	2.007	1.499	1.806	1.053	0.763	0.746	1.42	0	0.962	1.247	0.597	2.346	1.132	1.264	1.014
	14	1.088	1.612	1.612	1.174	0.926	1.129	0.542	1.047	0.0834	0.428	0.375	0.577	0.962	0	2.041	0.629	1.727	0.697	0.295	0.559
	15	2.275	3.618	3.481	3.032	2.665	3.158	2.542	3.008	2.301	1.989	1.996	2.274	1.247	2.041	0	1.441	3.594	2.383	2.334	1.786
	16	1.344	2.239	2.056	1.646	1.293	1.759	1.124	1.665	1.189	0.742	0.688	0.898	0.597	0.629	1.441	0	2.314	1.15	0.9	0.429
	18	1.449	0.624	0.917	1.801	1.993	0.911	1.481	0.681	1.314	1.612	1.652	1.984	2.346	1.727	3.594	2.314	0	1.215	1.551	2.273
	24	0.525	1.328	1.327	1.548	1.449	1.021	0.863	0.704	0.221	0.419	0.455	1.198	1.132	0.697	2.383	1.15	1.215	0	0.73	1.243
	25	1.206	1.354	1.168	0.909	0.74	0.861	0.246	0.851	0.923	0.613	0.582	0.491	1.264	0.295	2.334	0.9	1.551	0.73	0	0.721
	26	1.569	2.091	1.848	1.268	0.903	1.561	0.878	1.575	1.35	0.893	0.826	0.514	1.014	0.559	1.786	0.429	2.273	1.243	0.721	0

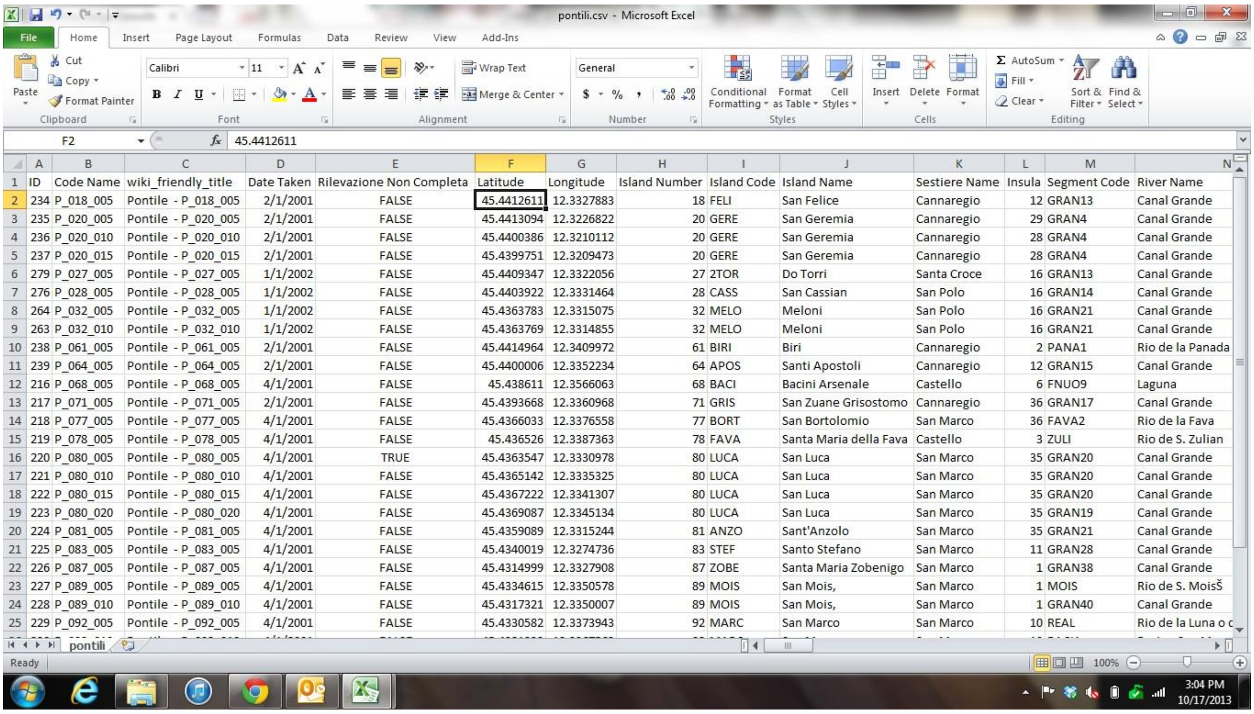
Appendix S: Current System Distance Traveled

STAZIONE	Tipo	ORE	MINUTI	MERCI	TARGA	STA_DA_A	TAXI_NOLO_	MERCI_CP_CT_NO	Distance	Distance_Cleaned
16	2	8	0	C1000	6V30505	1612	NO	CP	0.742	0.742
10	2	9	15	C1000	6V30505	1021	NO	CP	0.419	0.419
24	2	9	15	C1000	6V30505	2421	NO	CP	0.419	0.419
10	2	12	45	C1000	6V30505	1021	NO	CP	0.893	0.893
26	2	16	0	C1000	6V30505	2621	NO	CP	2.273	2.273
18	2	17	15	C1009	RV6323	1832	NO	CP	0	0
18	2	17	30	C1009	RV6323	1823	NO	CP	1.612	1.612
10	2	17	45	C1009	RV6323	1012	NO	CP	1.612	1.612
18	2	18	0	C1009	RV6323	1832	NO	CP	0.681	0.681
8	2	8	45	C1015	6V23552	821	NO	CP	1.027	0
10	2	10	0	C1015	6V23552	1021	NO	CP	0.841	0.841
7	2	10	15	C1015	6V23552	712	NO	CP	1.481	1.481
18	2	9	15	C1016	6V23559	1842	NO	CP	0.911	0
6	2	9	15	C1016	6V23559	632	NO	CP	0.411	0.411
8	2	15	0	C1016	6V23559	812	NO	CP	0.681	0.681
18	2	14	15	C1022	6V30115	1824	NO	CP	0.911	0
6	2	14	45	C1022	6V30115	631	NO	CP	1.227	1.227
9	2	18	30	C1027	RV5999	932	NO	CP	1.314	0
18	1	7	45	C1028	6V14615	1824	NO	CP	0.624	0
2	1	7	45	C1028	6V14615	231	NO	CP	0	0
2	1	8	45	C1028	6V14615	212	NO	CP	0.634	0.634
8	1	9	0	C1028	6V14615	823	NO	CP	0.411	0.411
6	1	9	0	C1028	6V14615	621	NO	CP	0.861	0.861
25	1	9	15	C1028	6V14615	2532	NO	CP	0.295	0.295
14	1	9	15	C1028	6V14615	1412	NO	CP	0.629	0.629
16	1	9	45	C1028	6V14615	1612	NO	CP	0.429	0.429
26	1	9	45	C1028	6V14616	2631	NO	CP	0.826	0.826
11	1	11	15	C1028	6V14615	1142	NO	CP	1.683	1.683
2	2	10	0	C1029	RV6317	212	NO	CP	2.239	0
16	2	13	45	C1029	RV6317	1612	NO	CP	1.15	1.15
24	2	14	15	C1029	RV6317	2412	NO	CP	0.455	0.455
11	2	14	15	C1029	RV6317	1142	NO	CP	1.051	1.051
8	2	14	30	C1029	RV6317	812	NO	CP	0.892	0.892
9	2	8	30	C1036	RV5986	921	NO	CP	1.651	0
5	2	14	30	C1036	RV5986	523	NO	CP	0	0
5	2	14	45	C1036	RV5986	532	NO	CP	0	0
5	2	14	45	C1036	RV5986	532	NO	CP	0.592	0.592
7	2	8	30	C1044	RV263	721	NO	CP	0.694	0
6	2	8	45	C1044	RV263	621	NO	CP	0	0

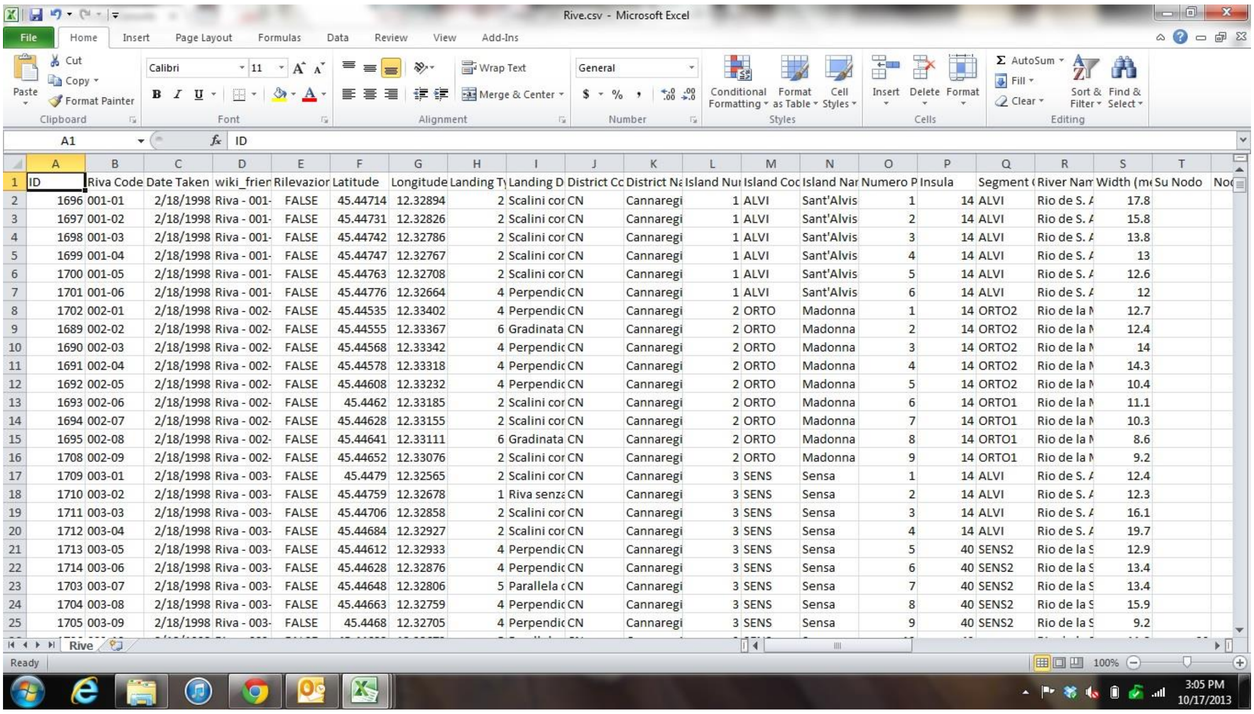
Appendix T: New System Distance Traveled

ZONE	# Large Boats	# Ref Boats	# Small Boats	Ref Distance	Dry Distance
1	0	1	1	2.59	2.59
2	1	1	0	2.09	2.09
3	0	1	1	2.76	2.76
4	4	1	0	1.91	7.63
5	2	1	1	0.83	2.49
6	1	1	0	3.88	3.88
7	1	1	0	2.63	2.63
8	0	1	1	3.19	3.19
9	1	1	0	4.02	4.02
10	1	1	1	1.92	3.84
11	3	1	0	2.77	8.32
12	1	1	0	4.51	4.51
13	1	1	1	2.37	4.74
14	2	1	0	1.37	2.73
15	1	1	0	2.47	2.47
16	2	1	0	3.60	7.20
17	1	1	1	2.66	5.32
18	7	2	1	6.14	24.54
19	1	1	0	1.19	1.19
20	3	1	0	6.35	19.04
21	1	1	1	2.01	4.03
22	2	1	1	3.56	10.67
23	1	1	0	4.42	4.42
24	1	1	0	4.78	4.78
25	2	1	1	5.16	15.47
26	1	1	0	2.47	2.47
27	2	1	0	3.98	7.97
28	1	1	0	2.12	2.12
29	1	1	0	2.00	2.00
30	2	1	1	3.42	10.27
31	1	1	1	4.67	9.34
32	6	1	0	4.16	24.97
33	1	1	0	3.13	3.13
34	2	1	0	4.46	8.92
35	2	1	0	3.85	7.71
36	3	1	0	2.57	7.70
37	1	1	1	3.20	6.39
38	1	1	0	3.49	3.49
39	1	1	0	3.70	3.70
40	1	1	0	2.73	2.73

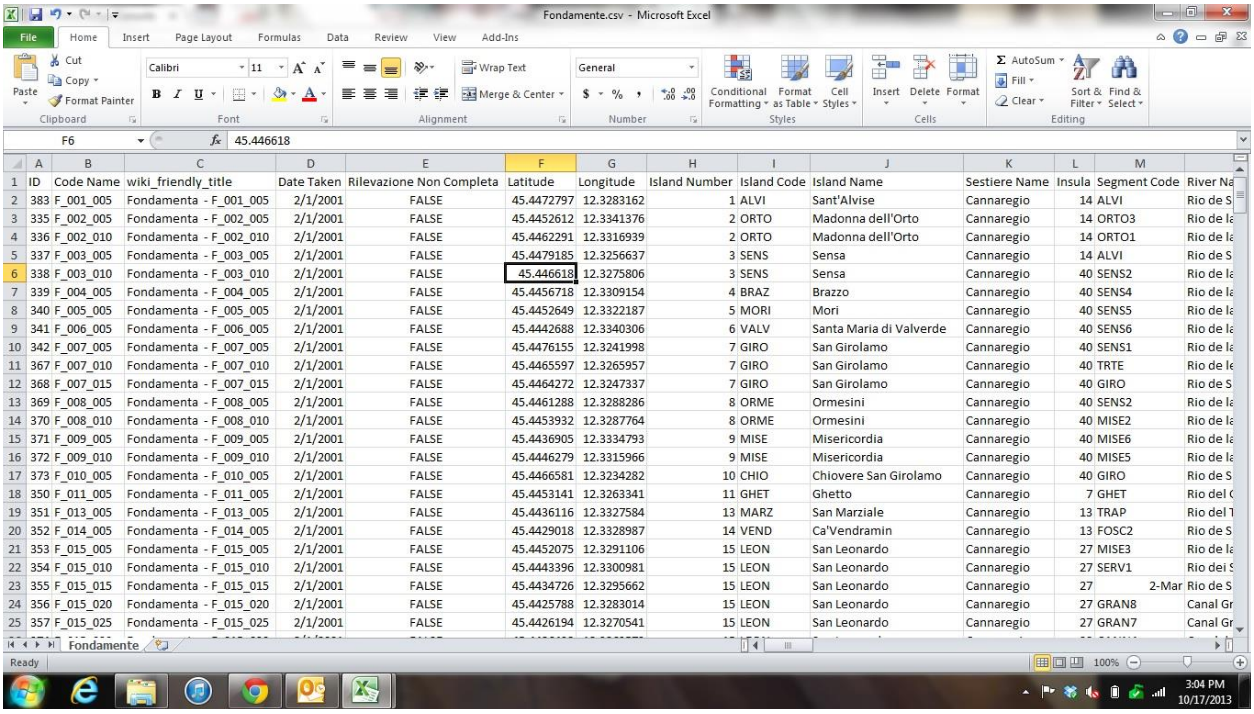
Appendix U: Data for Venice Docks


pontili.csv - Microsoft Excel

ID	Code Name	wiki_friendly_title	Date Taken	Rilevazione Non Completa	Latitude	Longitude	Island Number	Island Code	Island Name	Sestiere Name	Insula	Segment Code	River Name
234	P_018_005	Pontile - P_018_005	2/1/2001	FALSE	45.4412611	12.3327883	18	FELI	San Felice	Cannaregio	12	GRAN13	Canal Grande
235	P_020_005	Pontile - P_020_005	2/1/2001	FALSE	45.4413094	12.3226822	20	GERE	San Geremia	Cannaregio	29	GRAN4	Canal Grande
236	P_020_010	Pontile - P_020_010	2/1/2001	FALSE	45.4400386	12.3210112	20	GERE	San Geremia	Cannaregio	28	GRAN4	Canal Grande
237	P_020_015	Pontile - P_020_015	2/1/2001	FALSE	45.4399751	12.3209473	20	GERE	San Geremia	Cannaregio	28	GRAN4	Canal Grande
279	P_027_005	Pontile - P_027_005	1/1/2002	FALSE	45.4409347	12.3322056	27	2TOR	Do Torri	Santa Croce	16	GRAN13	Canal Grande
276	P_028_005	Pontile - P_028_005	1/1/2002	FALSE	45.4403922	12.3331464	28	CASS	San Cassian	San Polo	16	GRAN14	Canal Grande
264	P_032_005	Pontile - P_032_005	1/1/2002	FALSE	45.4363783	12.3315075	32	MELO	Meloni	San Polo	16	GRAN21	Canal Grande
263	P_032_010	Pontile - P_032_010	1/1/2002	FALSE	45.4363769	12.3314855	32	MELO	Meloni	San Polo	16	GRAN21	Canal Grande
238	P_061_005	Pontile - P_061_005	2/1/2001	FALSE	45.4414964	12.3409972	61	BIRI	Biri	Cannaregio	2	PANA1	Rio de la Panada
239	P_064_005	Pontile - P_064_005	2/1/2001	FALSE	45.4400006	12.3352234	64	APOS	Santi Apostoli	Cannaregio	12	GRAN15	Canal Grande
216	P_068_005	Pontile - P_068_005	4/1/2001	FALSE	45.438611	12.3566063	68	BACI	Bacini Arsenale	Castello	6	FNUO9	Laguna
217	P_071_005	Pontile - P_071_005	2/1/2001	FALSE	45.4393668	12.3360968	71	GRIS	San Zuane Grisostomo	Cannaregio	36	GRAN17	Canal Grande
218	P_077_005	Pontile - P_077_005	4/1/2001	FALSE	45.4366033	12.3376558	77	BORT	San Bortolomio	San Marco	36	FAVA2	Rio de la Fava
219	P_078_005	Pontile - P_078_005	4/1/2001	FALSE	45.436526	12.3387363	78	FAVA	Santa Maria della Fava	Castello	3	ZULI	Rio de S. Zulian
220	P_080_005	Pontile - P_080_005	4/1/2001	TRUE	45.4363547	12.3330978	80	LUCA	San Luca	San Marco	35	GRAN20	Canal Grande
221	P_080_010	Pontile - P_080_010	4/1/2001	FALSE	45.4365142	12.3335325	80	LUCA	San Luca	San Marco	35	GRAN20	Canal Grande
222	P_080_015	Pontile - P_080_015	4/1/2001	FALSE	45.4367222	12.3341307	80	LUCA	San Luca	San Marco	35	GRAN20	Canal Grande
223	P_080_020	Pontile - P_080_020	4/1/2001	FALSE	45.4369087	12.3345134	80	LUCA	San Luca	San Marco	35	GRAN19	Canal Grande
224	P_081_005	Pontile - P_081_005	4/1/2001	FALSE	45.4359089	12.3315244	81	ANZO	Sant'Anzolo	San Marco	35	GRAN21	Canal Grande
225	P_083_005	Pontile - P_083_005	4/1/2001	FALSE	45.4340019	12.3274736	83	STEF	Santo Stefano	San Marco	11	GRAN28	Canal Grande
226	P_087_005	Pontile - P_087_005	4/1/2001	FALSE	45.4314999	12.3327908	87	ZOBE	Santa Maria Zobenigo	San Marco	1	GRAN38	Canal Grande
227	P_089_005	Pontile - P_089_005	4/1/2001	FALSE	45.4334615	12.3350578	89	MOIS	San Mois,	San Marco	1	MOIS	Rio de S. MoisŠ
228	P_089_010	Pontile - P_089_010	4/1/2001	FALSE	45.4317321	12.3350007	89	MOIS	San Mois,	San Marco	1	GRAN40	Canal Grande
229	P_092_005	Pontile - P_092_005	4/1/2001	FALSE	45.4330582	12.3373943	92	MARC	San Marco	San Marco	10	REAL	Rio de la Luna o c

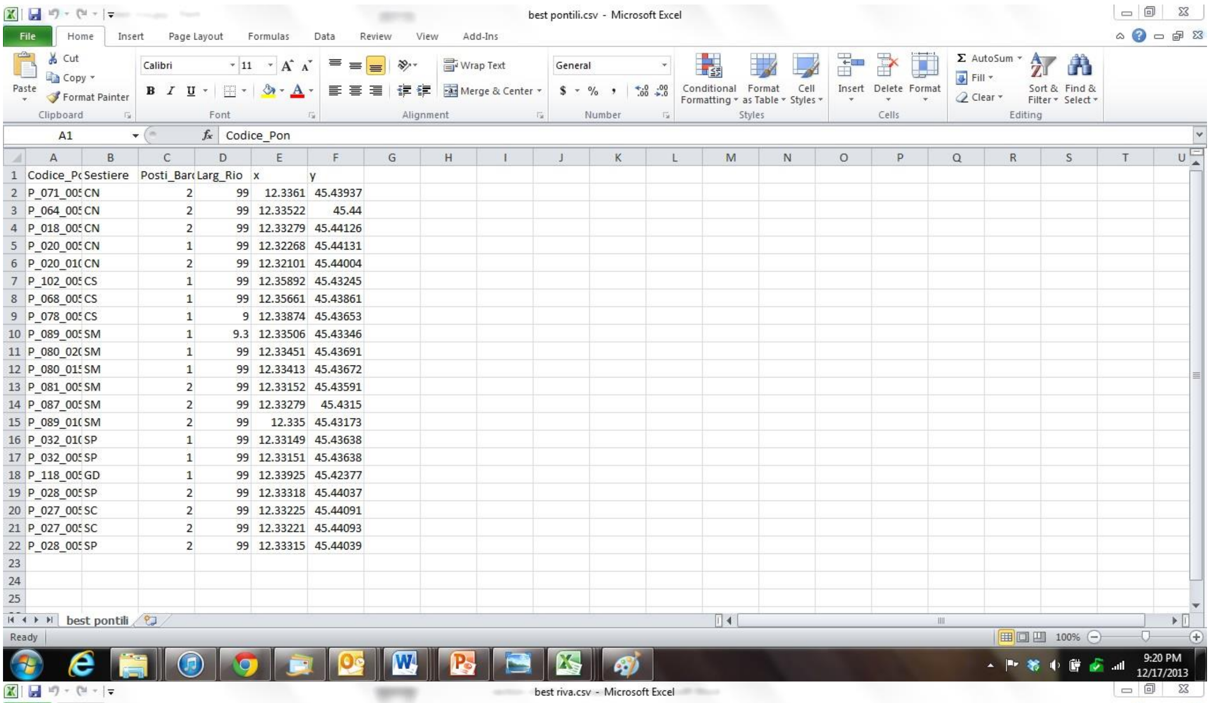

Rive.csv - Microsoft Excel

ID	Riva Code	Date Taken	wiki_frien	Rilevazior	Latitude	Longitude	Landing Ty	Landing D	District Cc	District Na	Island Nu	Island Coc	Island Nar	Numero P	Insula	Segment (	River Nam	Width (me	Su Nodo	Noc
1696	001-01	2/18/1998	Riva - 001-	FALSE	45.44714	12.32894	2	Scalini cor	CN	Cannaregi	1	ALVI	Sant'Alvis	1	14	ALVI	Rio de S. A	17.8		
1697	001-02	2/18/1998	Riva - 001-	FALSE	45.44731	12.32826	2	Scalini cor	CN	Cannaregi	1	ALVI	Sant'Alvis	2	14	ALVI	Rio de S. A	15.8		
1698	001-03	2/18/1998	Riva - 001-	FALSE	45.44742	12.32786	2	Scalini cor	CN	Cannaregi	1	ALVI	Sant'Alvis	3	14	ALVI	Rio de S. A	13.8		
1699	001-04	2/18/1998	Riva - 001-	FALSE	45.44747	12.32767	2	Scalini cor	CN	Cannaregi	1	ALVI	Sant'Alvis	4	14	ALVI	Rio de S. A	13		
1700	001-05	2/18/1998	Riva - 001-	FALSE	45.44763	12.32708	2	Scalini cor	CN	Cannaregi	1	ALVI	Sant'Alvis	5	14	ALVI	Rio de S. A	12.6		
1701	001-06	2/18/1998	Riva - 001-	FALSE	45.44776	12.32664	4	Perpendic	CN	Cannaregi	1	ALVI	Sant'Alvis	6	14	ALVI	Rio de S. A	12		
1702	002-01	2/18/1998	Riva - 002-	FALSE	45.44535	12.33402	4	Perpendic	CN	Cannaregi	2	ORTO	Madonna	1	14	ORTO2	Rio de la M	12.7		
1689	002-02	2/18/1998	Riva - 002-	FALSE	45.44555	12.33367	6	Gradinata	CN	Cannaregi	2	ORTO	Madonna	2	14	ORTO2	Rio de la M	12.4		
1690	002-03	2/18/1998	Riva - 002-	FALSE	45.44568	12.33342	4	Perpendic	CN	Cannaregi	2	ORTO	Madonna	3	14	ORTO2	Rio de la M	14		
1691	002-04	2/18/1998	Riva - 002-	FALSE	45.44578	12.33318	4	Perpendic	CN	Cannaregi	2	ORTO	Madonna	4	14	ORTO2	Rio de la M	14.3		
1692	002-05	2/18/1998	Riva - 002-	FALSE	45.44608	12.33232	4	Perpendic	CN	Cannaregi	2	ORTO	Madonna	5	14	ORTO2	Rio de la M	10.4		
1693	002-06	2/18/1998	Riva - 002-	FALSE	45.4462	12.33185	2	Scalini cor	CN	Cannaregi	2	ORTO	Madonna	6	14	ORTO1	Rio de la M	11.1		
1694	002-07	2/18/1998	Riva - 002-	FALSE	45.44628	12.33155	2	Scalini cor	CN	Cannaregi	2	ORTO	Madonna	7	14	ORTO1	Rio de la M	10.3		
1695	002-08	2/18/1998	Riva - 002-	FALSE	45.44641	12.33111	6	Gradinata	CN	Cannaregi	2	ORTO	Madonna	8	14	ORTO1	Rio de la M	8.6		
1708	002-09	2/18/1998	Riva - 002-	FALSE	45.44652	12.33076	2	Scalini cor	CN	Cannaregi	2	ORTO	Madonna	9	14	ORTO1	Rio de la M	9.2		
1709	003-01	2/18/1998	Riva - 003-	FALSE	45.4479	12.32565	2	Scalini cor	CN	Cannaregi	3	SENS	Sensa	1	14	ALVI	Rio de S. A	12.4		
1710	003-02	2/18/1998	Riva - 003-	FALSE	45.44759	12.32678	1	Riva senza	CN	Cannaregi	3	SENS	Sensa	2	14	ALVI	Rio de S. A	12.3		
1711	003-03	2/18/1998	Riva - 003-	FALSE	45.44706	12.32858	2	Scalini cor	CN	Cannaregi	3	SENS	Sensa	3	14	ALVI	Rio de S. A	16.1		
1712	003-04	2/18/1998	Riva - 003-	FALSE	45.44684	12.32927	2	Scalini cor	CN	Cannaregi	3	SENS	Sensa	4	14	ALVI	Rio de S. A	19.7		
1713	003-05	2/18/1998	Riva - 003-	FALSE	45.44612	12.32933	4	Perpendic	CN	Cannaregi	3	SENS	Sensa	5	40	SENS2	Rio de la S	12.9		
1714	003-06	2/18/1998	Riva - 003-	FALSE	45.44628	12.32876	4	Perpendic	CN	Cannaregi	3	SENS	Sensa	6	40	SENS2	Rio de la S	13.4		
1703	003-07	2/18/1998	Riva - 003-	FALSE	45.44648	12.32806	5	Parallela c	CN	Cannaregi	3	SENS	Sensa	7	40	SENS2	Rio de la S	13.4		
1704	003-08	2/18/1998	Riva - 003-	FALSE	45.44663	12.32759	4	Perpendic	CN	Cannaregi	3	SENS	Sensa	8	40	SENS2	Rio de la S	15.9		
1705	003-09	2/18/1998	Riva - 003-	FALSE	45.4468	12.32705	4	Perpendic	CN	Cannaregi	3	SENS	Sensa	9	40	SENS2	Rio de la S	9.2		



	ID	Code Name	wiki_friendly_title	Date Taken	Rilevazione Non Completa	Latitude	Longitude	Island Number	Island Code	Island Name	Sestiere Name	Insula	Segment Code	River Na
2	383	F_001_005	Fondamenta - F_001_005	2/1/2001	FALSE	45.4472797	12.3283162	1	ALVI	Sant'Alvise	Cannaregio	14	ALVI	Rio de S
3	335	F_002_005	Fondamenta - F_002_005	2/1/2001	FALSE	45.4452612	12.3341376	2	ORTO	Madonna dell'Orto	Cannaregio	14	ORTO3	Rio de la
4	336	F_002_010	Fondamenta - F_002_010	2/1/2001	FALSE	45.4462291	12.3316939	2	ORTO	Madonna dell'Orto	Cannaregio	14	ORTO1	Rio de la
5	337	F_003_005	Fondamenta - F_003_005	2/1/2001	FALSE	45.4479185	12.3256637	3	SENS	Sensa	Cannaregio	14	ALVI	Rio de S
6	338	F_003_010	Fondamenta - F_003_010	2/1/2001	FALSE	45.446618	12.3275806	3	SENS	Sensa	Cannaregio	40	SENS2	Rio de la
7	339	F_004_005	Fondamenta - F_004_005	2/1/2001	FALSE	45.4456718	12.3309154	4	BRAZ	Brazzo	Cannaregio	40	SENS4	Rio de la
8	340	F_005_005	Fondamenta - F_005_005	2/1/2001	FALSE	45.4452649	12.3322187	5	MORI	Mori	Cannaregio	40	SENS5	Rio de la
9	341	F_006_005	Fondamenta - F_006_005	2/1/2001	FALSE	45.4442688	12.3340306	6	VALV	Santa Maria di Valverde	Cannaregio	40	SENS6	Rio de la
10	342	F_007_005	Fondamenta - F_007_005	2/1/2001	FALSE	45.4476155	12.3241998	7	GIRO	San Girolamo	Cannaregio	40	SENS1	Rio de la
11	367	F_007_010	Fondamenta - F_007_010	2/1/2001	FALSE	45.4465597	12.3265957	7	GIRO	San Girolamo	Cannaregio	40	TRTE	Rio de le
12	368	F_007_015	Fondamenta - F_007_015	2/1/2001	FALSE	45.4464272	12.3247337	7	GIRO	San Girolamo	Cannaregio	40	GIRO	Rio de S
13	369	F_008_005	Fondamenta - F_008_005	2/1/2001	FALSE	45.4461288	12.3288286	8	ORME	Ormesini	Cannaregio	40	SENS2	Rio de la
14	370	F_008_010	Fondamenta - F_008_010	2/1/2001	FALSE	45.4453932	12.3287764	8	ORME	Ormesini	Cannaregio	40	MISE2	Rio de la
15	371	F_009_005	Fondamenta - F_009_005	2/1/2001	FALSE	45.4436905	12.3334793	9	MISE	Misericordia	Cannaregio	40	MISE6	Rio de la
16	372	F_009_010	Fondamenta - F_009_010	2/1/2001	FALSE	45.4446279	12.3315966	9	MISE	Misericordia	Cannaregio	40	MISE5	Rio de la
17	373	F_010_005	Fondamenta - F_010_005	2/1/2001	FALSE	45.4466581	12.3234282	10	CHIO	Chiovere San Girolamo	Cannaregio	40	GIRO	Rio de S
18	350	F_011_005	Fondamenta - F_011_005	2/1/2001	FALSE	45.4453141	12.3263341	11	GHET	Ghetto	Cannaregio	7	GHET	Rio del (
19	351	F_013_005	Fondamenta - F_013_005	2/1/2001	FALSE	45.4436116	12.3327584	13	MARZ	San Marziale	Cannaregio	13	TRAP	Rio del T
20	352	F_014_005	Fondamenta - F_014_005	2/1/2001	FALSE	45.4429018	12.3328987	14	VEND	Ca'Vendramin	Cannaregio	13	FOSC2	Rio de S
21	353	F_015_005	Fondamenta - F_015_005	2/1/2001	FALSE	45.4452075	12.3291106	15	LEON	San Leonardo	Cannaregio	27	MISE3	Rio de la
22	354	F_015_010	Fondamenta - F_015_010	2/1/2001	FALSE	45.4443396	12.3300981	15	LEON	San Leonardo	Cannaregio	27	SERV1	Rio dei S
23	355	F_015_015	Fondamenta - F_015_015	2/1/2001	FALSE	45.4434726	12.3295662	15	LEON	San Leonardo	Cannaregio	27	2-Mar	Rio de S
24	356	F_015_020	Fondamenta - F_015_020	2/1/2001	FALSE	45.4425788	12.3283014	15	LEON	San Leonardo	Cannaregio	27	GRAN8	Canal Gr
25	357	F_015_025	Fondamenta - F_015_025	2/1/2001	FALSE	45.4426194	12.3270541	15	LEON	San Leonardo	Cannaregio	27	GRAN7	Canal Gr

Appendix V: Best Docks used for Map Shown in Figure 50



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P_064_00	CN	2	99	12.33522	45.44
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P_020_00	CN	1	99	12.32268	45.44131
P_020_01	CN	2	99	12.32101	45.44004
P_102_00	CS	1	99	12.35892	45.43245
P_068_00	CS	1	99	12.35661	45.43861
P_078_00	CS	1	9	12.33874	45.43653
P_089_00	SM	1	9.3	12.33506	45.43346
P_080_02	SM	1	99	12.33451	45.43691
P_080_01	SM	1	99	12.33413	45.43672
P_081_00	SM	2	99	12.33152	45.43591
P_087_00	SM	2	99	12.33279	45.4315
P_089_01	SM	2	99	12.335	45.43173
P_032_01	SP	1	99	12.33149	45.43638
P_032_00	SP	1	99	12.33151	45.43638
P_118_00	GD	1	99	12.33925	45.42377
P_028_00	SP	2	99	12.33318	45.44037
P_027_00	SC	2	99	12.33225	45.44091
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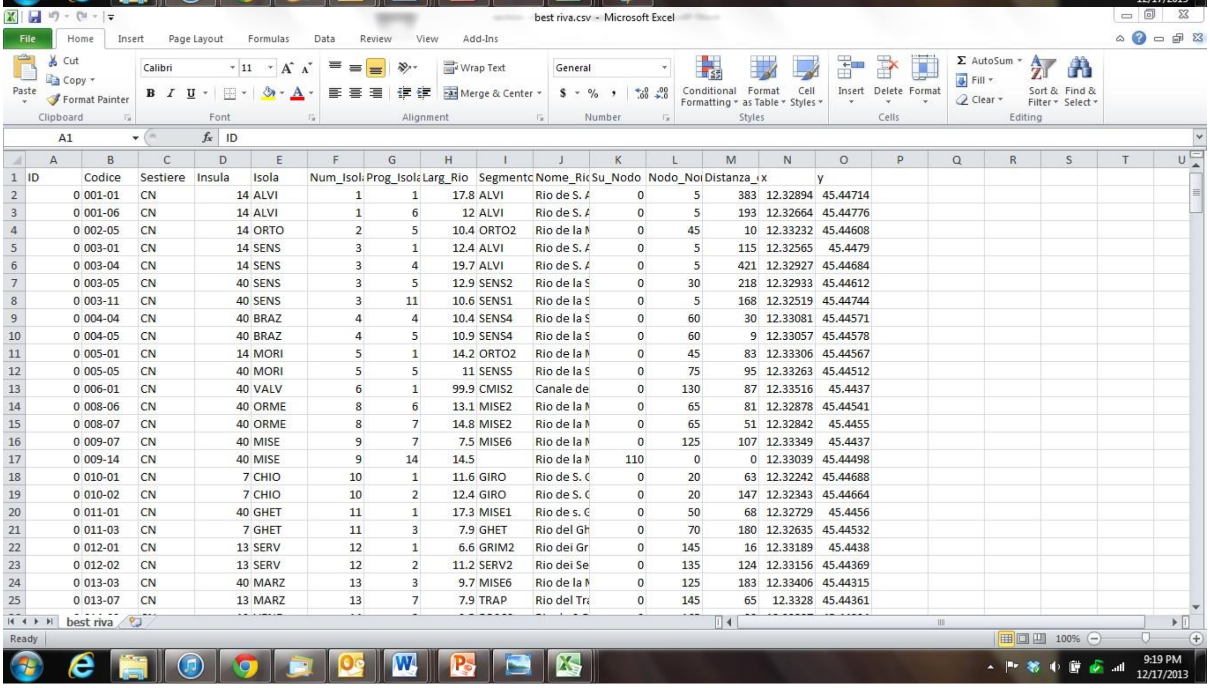
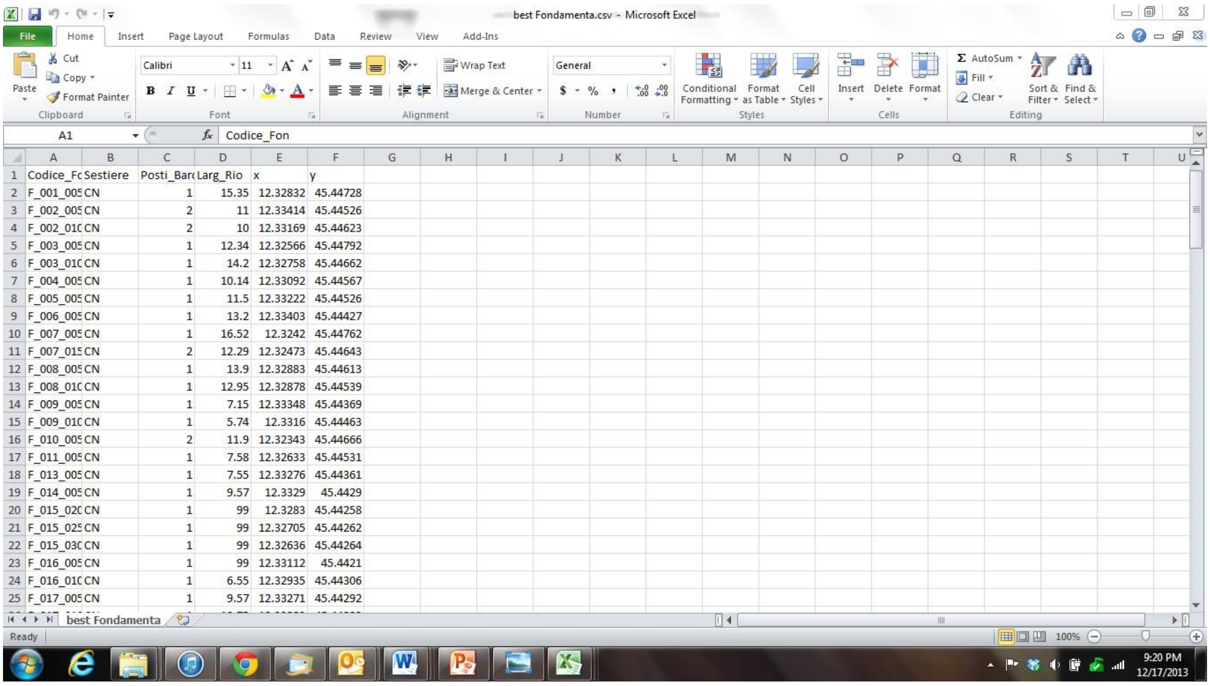
P_028_00	SP	2	99	12.33315	45.44039



ID	Codice	Sestiere	Insula	Isola	Num_Isol	Prog_Isol	Larg_Rio	Segmento	Nome_Ri	Su_Nodo	Nodo_No	Distanza_	x	y
0	001-01	CN	14	ALVI	1	1	17.8	ALVI	Rio de S.	0	5	383	12.32894	45.44714
0	001-06	CN	14	ALVI	1	6	12	ALVI	Rio de S.	0	5	193	12.32664	45.44776
0	002-05	CN	14	ORTO	2	5	10.4	ORTO2	Rio de la	0	45	10	12.33232	45.44608
0	003-01	CN	14	SENS	3	1	12.4	ALVI	Rio de S.	0	5	115	12.32565	45.4479
0	003-04	CN	14	SENS	3	4	19.7	ALVI	Rio de S.	0	5	421	12.32927	45.44684
0	003-05	CN	40	SENS	3	5	12.9	SENS2	Rio de la	0	30	218	12.32933	45.44612
0	003-11	CN	40	SENS	3	11	10.6	SENS1	Rio de la	0	5	168	12.32519	45.44744
0	004-04	CN	40	BRAZ	4	4	10.4	SENS4	Rio de la	0	60	30	12.33081	45.44571
0	004-05	CN	40	BRAZ	4	5	10.9	SENS4	Rio de la	0	60	9	12.33057	45.44578
0	005-01	CN	14	MORI	5	1	14.2	ORTO2	Rio de la	0	45	83	12.33306	45.44567
0	005-05	CN	40	MORI	5	5	11	SENS5	Rio de la	0	75	95	12.33263	45.44512
0	006-01	CN	40	VALV	6	1	99.9	CMIS2	Canale de	0	130	87	12.33516	45.4437
0	008-06	CN	40	ORME	8	6	13.1	MISE2	Rio de la	0	65	81	12.32878	45.44541
0	008-07	CN	40	ORME	8	7	14.8	MISE2	Rio de la	0	65	51	12.32842	45.4455
0	009-07	CN	40	MISE	9	7	7.5	MISE6	Rio de la	0	125	107	12.33349	45.4437
0	009-14	CN	40	MISE	9	14	14.5		Rio de la	110	0	0	12.33039	45.44498
0	010-01	CN	7	CHIO	10	1	11.6	GIRO	Rio de S.	0	20	63	12.32242	45.44688
0	010-02	CN	7	CHIO	10	2	12.4	GIRO	Rio de S.	0	20	147	12.32343	45.44664
0	011-01	CN	40	GHET	11	1	17.3	MISE1	Rio de s.	0	50	68	12.32729	45.4456
0	011-03	CN	7	GHET	11	3	7.9	GHET	Rio del Gh	0	70	180	12.32635	45.44532
0	012-01	CN	13	SERV	12	1	6.6	GRIM2	Rio dei Gr	0	145	16	12.33189	45.4438
0	012-02	CN	13	SERV	12	2	11.2	SERV2	Rio dei Se	0	135	124	12.33156	45.44369
0	013-03	CN	40	MARZ	13	3	9.7	MISE6	Rio de la	0	125	183	12.33406	45.44315
0	013-07	CN	13	MARZ	13	7	7.9	TRAP	Rio del Tr	0	145	65	12.3328	45.44361



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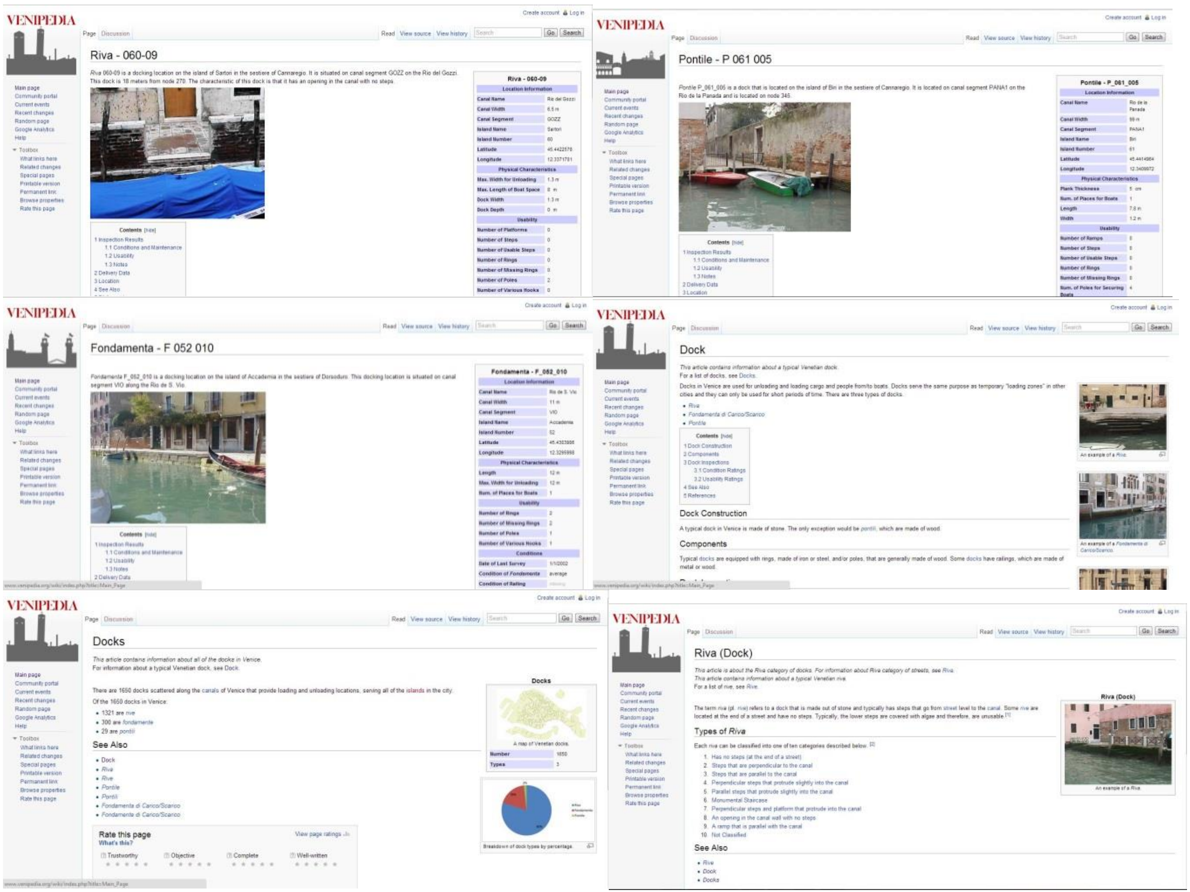
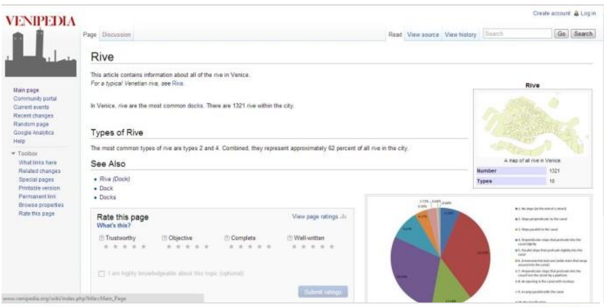
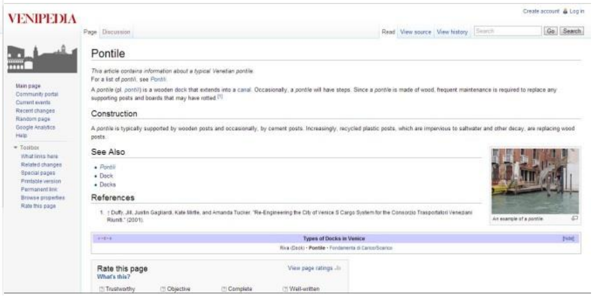
3	F_002_005	CN	2	11	12.33414	45.44526
4	F_002_01C	CN	2	10	12.33169	45.44623
5	F_003_005	CN	1	12.34	12.32566	45.44792
6	F_003_01C	CN	1	14.2	12.32758	45.44662
7	F_004_005	CN	1	10.14	12.33092	45.44567
8	F_005_005	CN	1	11.5	12.33222	45.44526
9	F_006_005	CN	1	13.2	12.33403	45.44427
10	F_007_005	CN	1	16.52	12.3242	45.44762
11	F_007_015	CN	2	12.29	12.32473	45.44643
12	F_008_005	CN	1	13.9	12.32883	45.44613
13	F_008_01C	CN	1	12.95	12.32878	45.44539
14	F_009_005	CN	1	7.15	12.33348	45.44369
15	F_009_01C	CN	1	5.74	12.3316	45.44463
16	F_010_005	CN	2	11.9	12.32343	45.44666
17	F_011_005	CN	1	7.58	12.32633	45.44531
18	F_013_005	CN	1	7.55	12.33276	45.44361
19	F_014_005	CN	1	9.57	12.3329	45.4429
20	F_015_02C	CN	1	99	12.3283	45.44258
21	F_015_025	CN	1	99	12.32705	45.44262
22	F_015_03C	CN	1	99	12.32636	45.44264
23	F_016_005	CN	1	99	12.33112	45.4421
24	F_016_01C	CN	1	6.55	12.32935	45.44306
25	F_017_005	CN	1	9.57	12.33271	45.44292

Appendix W: Venipedia Pages for each Specific Dock




VENIPEDIA
Rive
This article contains information about all of the rive in Venice.
For a typical Venetian riva, see Riva.
In Venice, rive are the most common docks. There are 1321 rive within the city.
Types of Rive
The most common types of rive are types 2 and 4. Combined, they represent approximately 62 percent of all rive in the city.
See Also
Riva (Dock)
Dock
Docks
Rate this page
Trustworthy
Objective
Complete
Well-written
A map of all rive in Venice
Number 1321
Types 10


VENIPEDIA
Pontile
This article contains information about a typical Venetian pontile.
For a list of pontili, see Pontili.
Construction
See Also
Pontili
Dock
Docks
References
Types of Docks in Venice
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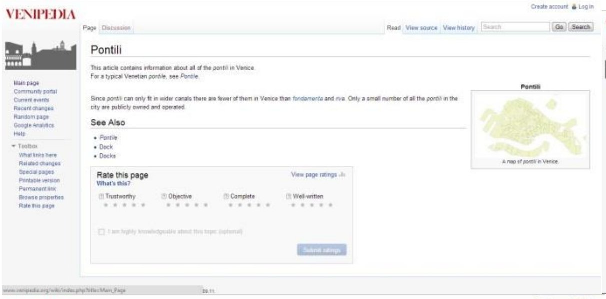
An example of a pontile


VENIPEDIA
Pontili
This article contains information about all of the pontili in Venice.
For a typical Venetian pontile, see Pontile.
Since pontili can only fit in wider canals there are fewer of them in Venice than fondamenta and riva. Only a small number of all the pontili in the city are publicly owned and operated.
See Also
Pontile
Dock
Docks
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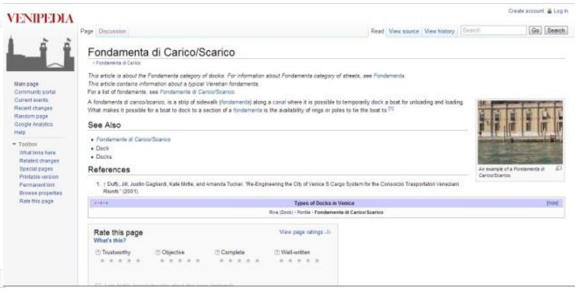
A map of pontili in Venice


VENIPEDIA
Fondamenta di Carico/Scarico
See Also
Fondamente di Carico/Scarico
Dock
Docks
References
Types of Docks in Venice
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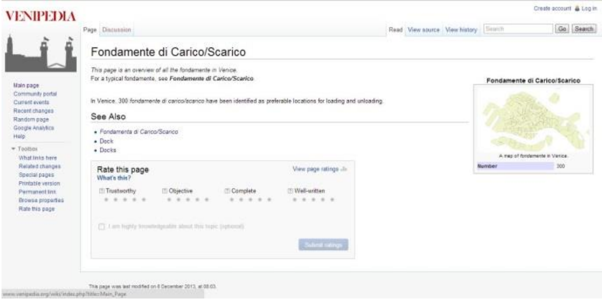
VENIPEDIA
Fondamente di Carico/Scarico
This page is an overview of all the fondamente in Venice.
For a typical fondamenta, see Fondamenta di Carico/Scarico.
In Venice, 300 fondamente di carico/scarico have been identified as preferable locations for loading and unloading.
See Also
Fondamenta di Carico/Scarico
Dock
Docks
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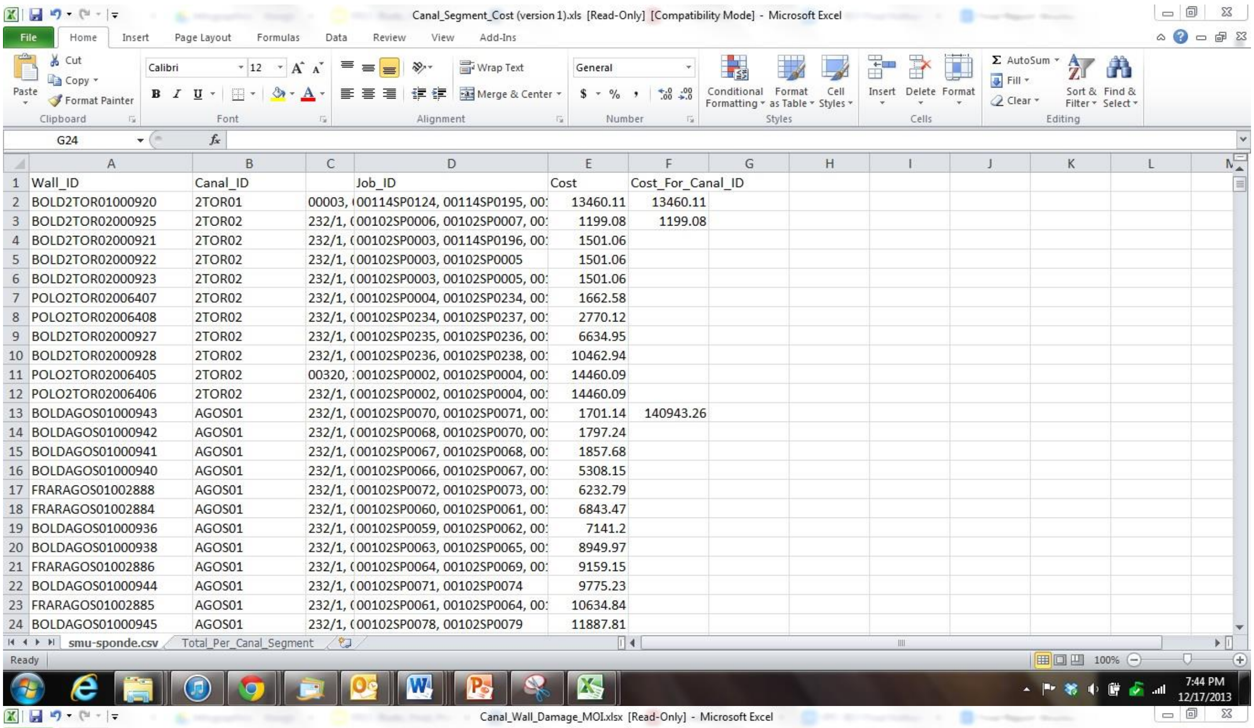
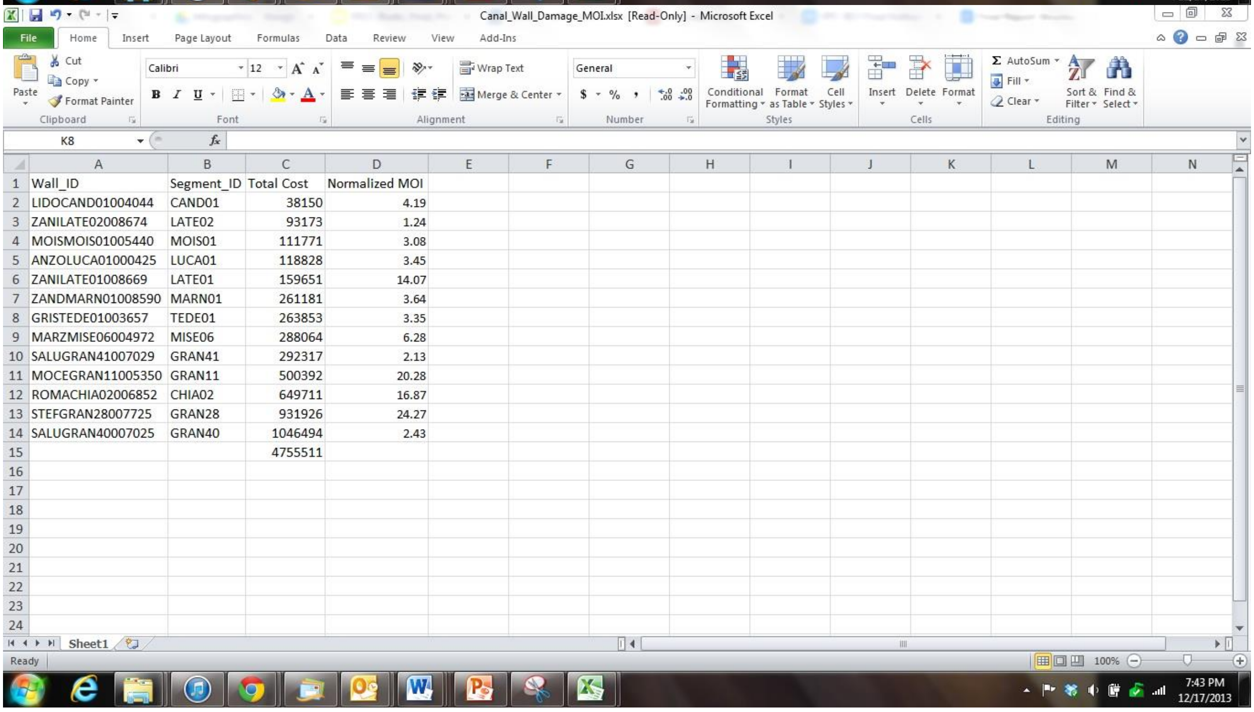
A map of fondamente in Venice
Number 300

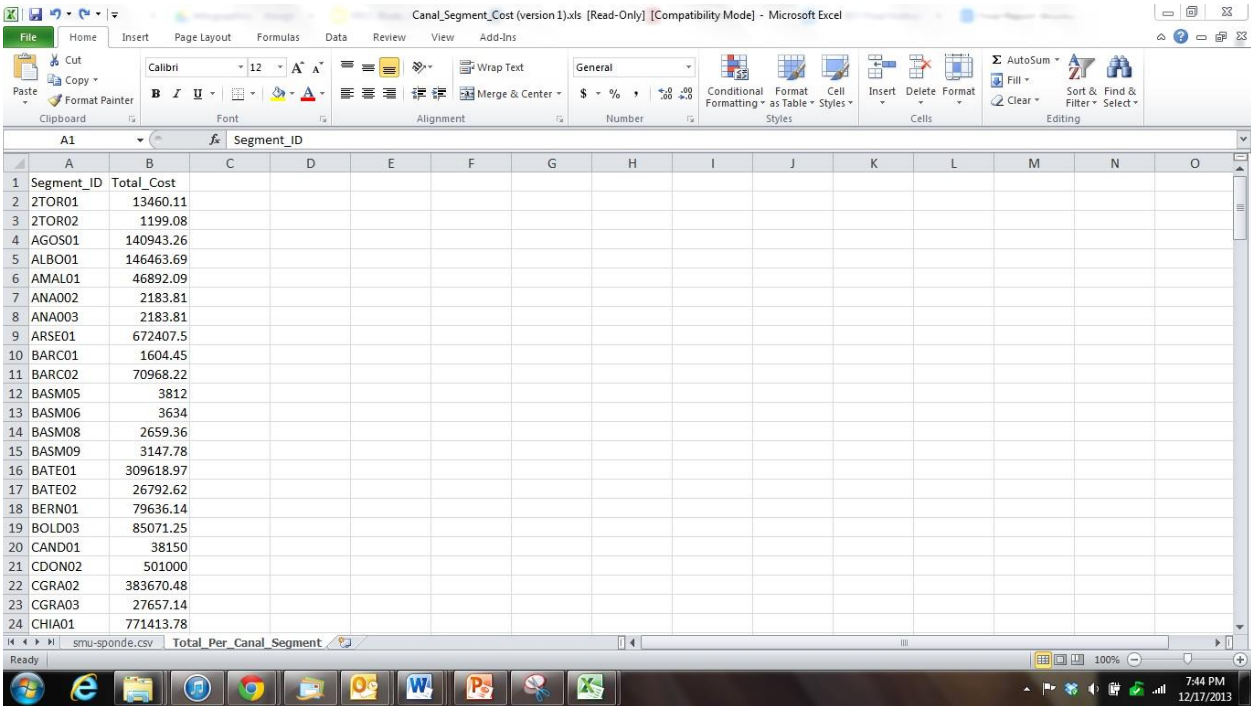
Appendix X: Sheets Used to Calculate *Moto Ondoso* Costs



	A	B	C	D	E	F
1	Wall_ID	Canal_ID		Job_ID	Cost	Cost_For_Canal_ID
2	BOLD2TOR01000920	2TOR01	00003, (	00114SP0124, 00114SP0195, 00:	13460.11	13460.11
3	BOLD2TOR02000925	2TOR02	232/1, (	00102SP0006, 00102SP0007, 00:	1199.08	1199.08
4	BOLD2TOR02000921	2TOR02	232/1, (	00102SP0003, 00114SP0196, 00:	1501.06	
5	BOLD2TOR02000922	2TOR02	232/1, (	00102SP0003, 00102SP0005	1501.06	
6	BOLD2TOR02000923	2TOR02	232/1, (	00102SP0003, 00102SP0005, 00:	1501.06	
7	POLO2TOR02006407	2TOR02	232/1, (	00102SP0004, 00102SP0234, 00:	1662.58	
8	POLO2TOR02006408	2TOR02	232/1, (	00102SP0234, 00102SP0237, 00:	2770.12	
9	BOLD2TOR02000927	2TOR02	232/1, (	00102SP0235, 00102SP0236, 00:	6634.95	
10	BOLD2TOR02000928	2TOR02	232/1, (	00102SP0236, 00102SP0238, 00:	10462.94	
11	POLO2TOR02006405	2TOR02	00320, :	00102SP0002, 00102SP0004, 00:	14460.09	
12	POLO2TOR02006406	2TOR02	232/1, (	00102SP0002, 00102SP0004, 00:	14460.09	
13	BOLDAGOS01000943	AGOS01	232/1, (	00102SP0070, 00102SP0071, 00:	1701.14	140943.26
14	BOLDAGOS01000942	AGOS01	232/1, (	00102SP0068, 00102SP0070, 00:	1797.24	
15	BOLDAGOS01000941	AGOS01	232/1, (	00102SP0067, 00102SP0068, 00:	1857.68	
16	BOLDAGOS01000940	AGOS01	232/1, (	00102SP0066, 00102SP0067, 00:	5308.15	
17	FRARAGOS01002888	AGOS01	232/1, (	00102SP0072, 00102SP0073, 00:	6232.79	
18	FRARAGOS01002884	AGOS01	232/1, (	00102SP0060, 00102SP0061, 00:	6843.47	
19	BOLDAGOS01000936	AGOS01	232/1, (	00102SP0059, 00102SP0062, 00:	7141.2	
20	BOLDAGOS01000938	AGOS01	232/1, (	00102SP0063, 00102SP0065, 00:	8949.97	
21	FRARAGOS01002886	AGOS01	232/1, (	00102SP0064, 00102SP0069, 00:	9159.15	
22	BOLDAGOS01000944	AGOS01	232/1, (	00102SP0071, 00102SP0074	9775.23	
23	FRARAGOS01002885	AGOS01	232/1, (	00102SP0061, 00102SP0064, 00:	10634.84	
24	BOLDAGOS01000945	AGOS01	232/1, (	00102SP0078, 00102SP0079	11887.81	



	A	B	C	D
1	Wall_ID	Segment_ID	Total Cost	Normalized MOI
2	LIDOCAND01004044	CAND01	38150	4.19
3	ZANILATE02008674	LATE02	93173	1.24
4	MOISMOIS01005440	MOIS01	111771	3.08
5	ANZOLUCA01000425	LUCA01	118828	3.45
6	ZANILATE01008669	LATE01	159651	14.07
7	ZANDMARN01008590	MARN01	261181	3.64
8	GRISTEDE01003657	TEDE01	263853	3.35
9	MARZMISE06004972	MISE06	288064	6.28
10	SALUGRAN41007029	GRAN41	292317	2.13
11	MOCEGRAN11005350	GRAN11	500392	20.28
12	ROMACHIA02006852	CHIA02	649711	16.87
13	STEFGRAN28007725	GRAN28	931926	24.27
14	SALUGRAN40007025	GRAN40	1046494	2.43
15			4755511	



Segment_ID	Total_Cost
2TOR01	13460.11
2TOR02	1199.08
AGOS01	140943.26
ALBO01	146463.69
AMAL01	46892.09
ANA002	2183.81
ANA003	2183.81
ARSE01	672407.5
BARC01	1604.45
BARC02	70968.22
BASM05	3812
BASM06	3634
BASM08	2659.36
BASM09	3147.78
BATE01	309618.97
BATE02	26792.62
BERN01	79636.14
BOLD03	85071.25
CAND01	38150
CDON02	501000
CGRA02	383670.48
CGRA03	27657.14
CHIA01	771413.78

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