Re-engineering the Venetian Taxi Transportation System: Efficiency Improvements That Reduce *Moto Ondoso*

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       Each member of the group contributed to this project in a fair manner. Without the dedication and full participation of all members, the following project would not have been a success.

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ABSTRACT

This project, sponsored by the Consorzio Motoscafi Venezia, located in Venice, Italy evaluated the current taxi transportation system in an effort to improve the efficiency of the operation while minimizing its contribution to canal wall degradation. Taxi operations were analyzed, resulting in proposed modifications to boat design, fares, travel routes, and the dispatching system which all will help preserve this deteriorating city while maintaining economic viability of the taxi transportation system. Additionally, this project surveyed taxi drivers to understand their thoughts of current procedures as well as future considerations.

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EXECUTIVE SUMMARY

The aging historic city of Venice is faced with many issues, one of which being *moto ondoso*. This damaging boat wake is a major problem in this unique city where all major modes of transportation are by boat. Canal wall degradation is costly for the city to repair, and puts the foundations of many buildings in danger. In the eyes of many Venetians, the taxi transportation system is largely to blame for *moto ondoso*, As a result, the taxi system is pressured into redesigning the existing system to increase the total efficiency, thus reducing *moto ondoso*. This project focused on optimizing the system by addressing speed, boat technologies, and operating time in order to yield higher profits for the taxi drivers. Implementation of this new system would reduce *moto ondoso* while benefiting the taxi drivers and the city.

Moto ondoso is the damage caused by boat wake, a direct result of lost energy in the motion of a boat. Since taxi transportation makes up one fourth of the traffic in Venice, taxi drivers are blamed for a majority of *moto ondoso*. The boats of the taxi system are mainly comprised of four main manufacturers all producing a deep V-hull. These are designed to perform at higher speeds, not optimum for the city conditions. At the slow speeds, the hull sits lower in the water, producing a lot of wake. The repetitive impact of wake undermines the foundations of buildings around the canals.

The magnitude of this wake is related to the speed of the boat. This effect was a major factor in the adjusting of speed limits. The city of Venice has focused regulations on the limiting of *moto ondoso* by restricting wake producing motions. Some canals are restricted to travel at certain times of the day and to one way travel. The Arsenale, controlled by the navy, is closed to

travel entirely. Also, in the lagoon, there are *bricole*, or posts, that form the boundaries of travel lanes.

The current taxi fare system is also designed to lower speeds. A meter system is used that is based on time, where a proper fare only results when speed limits are followed. The current meter has an initial fee of €8.70 and adds €1.30 every minute of trip time. Other fees that account for more than 4 passengers and luggage also apply. These prices are determined by the city and are non-negotiable for taxi operation; however, if a boat is acting as a rental service, the fares are determined by the taxi driver.

From the demand of boats needed at specific locations, the city divides the amount of work and assigns a specific number of boats to each stop by their organization. The organizations then internally decide what boat is to fill that spot for that day. Within the Consorzio Motoscafi Venezia (CMV), they strive to equalize pay by equalizing work though a comprehensive rotation schedule. The CMV also directly equalizes pay at locations such as the airport, where the income of that day is pooled together and equally split between the drivers who have worked that shift.

Engine Operating Time

- Idling 24%
- Job 43%
- Empty 33%
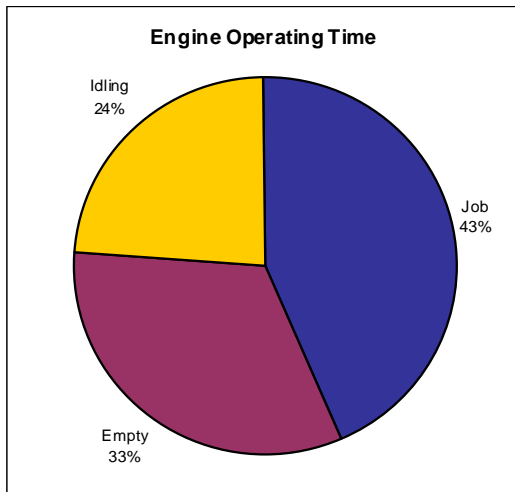
Sponsoring this project, the CMV is the largest consortium, accounting for 44% of the taxis in Venice. Any changes that they make will be influential to others because of their dominance. Due to their willingness to explore new solutions, many drivers are open-minded about breaking the connection to the established system.

In order to determine a more efficient system, a thorough analysis of the current system must be made. Many operations that are common to the drivers were viewed in an unbiased manner in order to comprehend the existing system and identify inefficiencies. Firstly, the taxi fleet was characterized. A catalog was created of the CMV taxis, and knowledge of current boat types and technologies was gained. Alternative technology was researched for efficiency improvements including trim tabs, hull designs, and engine types. Current engines were also cataloged in order to determine the efficiency of various engines.

Through five days dedicated to onboard observations, an important quantification of engine operating time was made. It was determined that 33% of engine running time was spent on trips without passengers. If this percentage can be reduced, operational costs will be reduced and unnecessary *moto ondoso* will be lessened.

Next in the understanding of the current system, there was a need to quantify the economics. This was accomplished first by calculating the costs of common trips using the current fare prices. Because the current fare prices were established in 2003, inflation was applied to these prices in order to estimate possible future prices. Also, the increase in fares over the last 20 years was found by graphing the tariffs to show how the fares have evolved in relation to inflation. Yearly maintenance costs were calculated to determine an hourly rate of operation incorporating gas prices, replacement parts, and general upkeep of the boat. This price was used in cost savings of trip reduction. Demand was quantified using all the calls made to the CMV from March to October. Peak hours during the day and throughout the week were found along with the most common pickup and drop off locations. Finally, a survey was dispersed to taxi drivers in an effort to determine their opinions on the feasibility of proposed changes, as well their thoughts on current practices.

From our observations, three methods to reduce *moto ondoso* through increasing efficiency were identified.
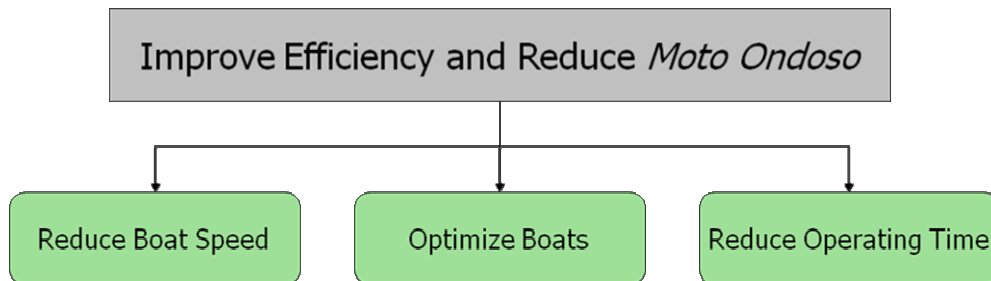
Firstly, reducing boat speed was determined as an obvious factor in reducing *moto ondoso*. To encourage drivers to drive the speed limits, it was found that if updated fare prices with higher weight for the fare per minute, drivers would be less inclined to speed. These proposed fares were calculated to estimate what the 2010 rates should be with inflation; therefore, these prices will be effective from 2007 to 2013.

Secondly, the physical aspects of the boats were identified as a currently inefficient part of the system. Trim tabs provide an easy solution to wake reduction at the higher speeds seen in travel in the lagoon. Though larger than the standard tabs to compensate for a slower speed, these tabs would act to lift the boat out of the water while in motion, decreasing displacement and therefore *moto ondoso*. Hull changes, though more involved and costly, have greater efficiency. Many companies, such as Mangia Onda, have attempted implementation in Venice. The M-hull design shows the most potential; the design incorporates a central keel with dual channels on each side that allow the boat to effectively ride on a cushion of air. The EcoBarca 19 is a product most known in Venice; however it is dissimilar to the current designs in size. If a combination of this new hull technology and a wake breaking V-bow, there would be a much greater acceptance from the taxi driver community. Designers must work with taxi drivers in order to create a design that would be widely accepted. New engines are also becoming more popular in the marine industry. Though behind the automotive industry, hybrid engines are the future of boat propulsion. The combination of a powerful diesel engine and a variable electric motor will allow for smooth accelerations, quiet operation and a much greater efficiency.

Thirdly, reducing operating time was identified as a solution to additionally increase efficiency. Shortcuts are one possible way to reduce this time. One shortcut possibility is to open the Arsenale to taxis as a toll with speed enforcement. This cutoff would eliminate the trip around the eastern tip of Venice reducing *moto ondoso* along those shores. Another possible shortcut is a direct highway to the airport. Presently, this direct route is not permitted due to the shallow depths at low tide. An option is to allow taxis to drive through without penalty. If the low tides pose a major problem, dredging the area could be investigated. As there are many airport trips daily, this highway cutoff would eliminate travel near the cemetery island, Murano, and a small private island, lessening *moto ondoso* near those areas. These shortcuts would also cut travel time down, reducing operating costs.

A final method in reducing operation time is to change the routes of a taxi boat. A typical taxi is assigned to one specific taxi stand for the entire day, where the driver picks up passengers

and then returns without passengers back to the starting stand. The only way to reduce the return trip time would be to redirect taxis to a closer return location, rather than having them return to their initial starting point. This return trip could be shortened if the taxis were able to stop at a station closer to the drop off. However, this might create over-staffing at some locations if the entire group of taxis followed this scheme. An optimized return base plan has been thoroughly analyzed as to the feasibility of implementation. This reorganization would require a dispatch system that would alert the taxis which location to return to after a call is made in order to handle this dispatching efficiently. The method of this post dispatching is done similarly to the call dispatch, where instead the taxi stands are ranked and the taxi is sent to the closest stand where this empty taxi will dock. This post-call dispatching system would be necessary to ensure complete staffing of each station as the system will monitor all the taxi stands. The current GPS system takes position into account by awarding the closest boat to a call; therefore, this new proposed system would be expanding on the current system. Over time, the benefits of the discussed modifications would help reduce operation costs for the drivers while reducing *moto ondoso*.

1. <u>INTRODUCTION</u>

Taxis have evolved to play an important role in public transportation around the world. "Because of their convenience, efficiency, flexibility, and twenty-four hour availability, the taxi service has become an important and indivisible part of the urban public transport in most large cities."[1] Due to the unique physical characteristics of Venice, Italy, water transport is the primary mode of travel for the Venetians and for the fourteen million tourists who visit each year. As horse drawn carriages have been replaced by automobiles, likewise, the row boats in Venice have been replaced by motor boats. Venice has a water taxi transportation system that has also changed greatly through the years. Unlike cars, though, motor boats have the ability of inflicting physical damage to the buildings that line the Venetian canals.

The wakes created by boats are locally referred to as *moto ondoso*. Research has shown that *moto ondoso* is a major contributor of canal wall degradation.[2] Government regulations have
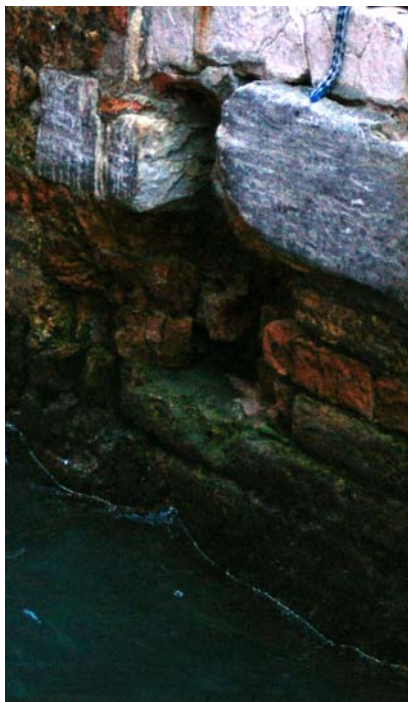
Figure 1 *Moto Ondoso* Damage

directed attention to wake destruction by continually tightening canal traffic restrictions in attempt to slow traffic. Venetians blame the taxis for a majority of the *moto ondoso*. The city has lowered speed limits, altered taxi fares, and introduced harsh penalties.[3] Resultantly, the taxi companies feel pressured into adopting new, more environmentally friendly practices while preserving the economic viability at the same time.

Even with these past efforts to better the taxi transportation system, there are still other methods of improvement available. There are multiple aspects of the system with a potential to be updated, and in doing so, will help reduce *moto ondoso*; they include speed regulation, boat modification, and trip reduction. The Consorzio Motoscafi Venezia (CMV) is at the forefront of modernizing the taxi system in Venice with their global positioning dispatch system. As the largest taxi transport

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[1] Hai Yang, Min Ye, Wilson H. Tang, and S.C. Wong. 2005. Regulating Taxi Services in the Presence of Congestion Externally. *Transportation Research Part A: Policy and Practice* 39, 18.
[2] The Moto Ondoso Index, IQP
[3] Owen, Richard "Venice imposes tourist tax to protect endangered city"
<http://traveltax.msu.edu/news/Stories/ottawacitizen3.htm> 2001

company in Venice, Consorzio Motoscafi Venezia is an essential part in creating an effective transportation system.

This study focuses on the taxi transportation system of the Consorzio Motoscafi Venezia, to propose a reorganization that will reduce *moto ondoso* while preserving economic viability. Alternative techniques have been derived through the assessment of current methods, economics, and research of new applicable technologies.

2. <u>BACKGROUND</u>

"This incredible structure, a real "people's" city, incomparable and in symbiosis with its natural environment must be maintained and safeguard against all forms of degradation, pollution or wrongdoing."[4] This statement made by previous Venetian mayor, Ugo Bergamo, directly relates Venice to its many current issues of the taxi transportation system. Discussion of this chapter includes information on Venice and its taxi system as well as previous efforts to decrease *moto ondoso* and possible future technologies. In order to fully understand and concentrate on current issues in Venetian society, many unique aspects of the city must be understood to create effective solutions for preserving its natural environment.

2.1. Venetian Boats

Canals in Venice are comparable to the streets of any other city; therefore traveling by boat is a necessity. The boats in Venice can be broken up into three main categories: private, cargo, and people transport. Cargo boats are used for transportation of goods. People transport consists of the public ACTV boats, gondolas, and taxi boats. The classic Venetian boat is the gondola, used now only for special occasions and by tourists. Motor boats were introduced in the 1950s, and since then they have become the most popular form of transportation; however, the old city walls are weakened by the wakes produced from these motor boats. Taxi transportation makes up approximately one forth of the boat traffic. Used mainly by tourists, taxi transportation is the easiest and most direct way to one's destination. The demand for taxis has been increasing yearly. Tourists use the taxi service for its convenience even though it is more expensive than other options.

2.1.1. Taxi Boats

Taxis have many distinct physical characteristics that set them apart from other boats as seen in Figure 2. They are composed of either wood and/or fiberglass hulls. A few different types of hull design are commonly found, ranging from older flat bottom boats, to mostly newer fiberglass stepped V-hulls. Taxi boats are typically 9 meters in length, 2.2 meters in width, and 1.3 meters in height. Most engines range from 100 to 200 horsepower diesel engines including

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[4] Bruttomesso, Rinio. Cities on water and transport. International Centre Cities on Water: Venice, Italy. 1995.

Volvo Penta, Styer, Volkswagen, Mercury MerCruiser, and AIFO IVECO. Most boats have a maximum passenger capacity of 18. A typical taxi boat costs €180,000 including the engine.

Figure 2 Taxi Boat

2.1.2. New Technologies

To understand new boat designs, a basic knowledge of the physics of boat wake is important. The magnitude of a boat wake is directly proportional to the amount of wasted energy in the displacement of water. In low wake boat design, less displacement means less total power needed to propel the boat, allowing room to incorporate different engines. In all, a low wake boat design will not only help protect the city, but it will also be more fuel efficient.[6] In a study at Stevens College, effects of a high speed water ferry were studied due to concerns of the erosion caused by the wake
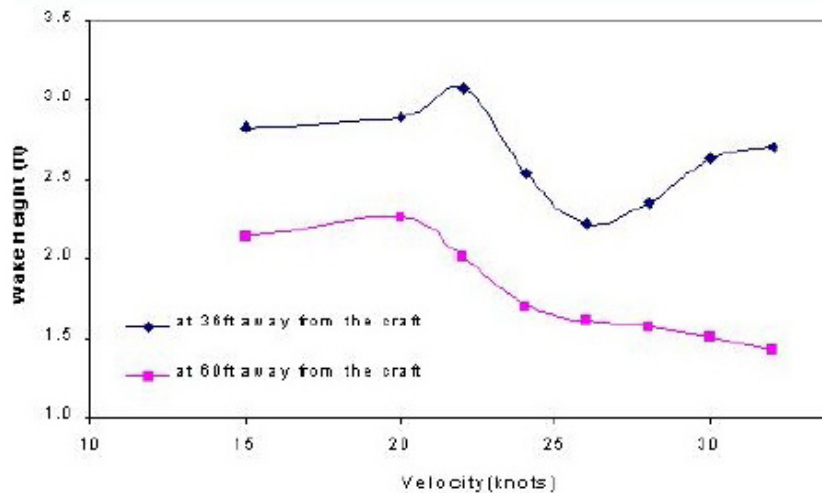
Figure 3 Wake Characteristics [5]

of the ferry. Shown in Figure 3, the wake is plotted in relation to the boat speed. At roughly 27kts (50km/hr), the boat produces the lowest effective wake due to planing. At speeds of 22-24kts (41-45km/hr), as well as a lower speed not shown, a high percentage of the hull is in the

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[5] http://www.state.nj.us/transportation/works/maritime/documents/Wake_Impacts_ StevensPublishedPaper.pdf#search=%22boat%20wake%20vs%20speed%22

[6] Buckley Cpt, Tork . "Alsphere in Venice" http://www.alsphere.at/download/The_Yacht_Report.pdf#search=%22Venice%20Taxi%20boat%20hull%2

water, this is referred to as mushing.[7] Hull performance is maximized at trolling and planing speed. Trolling speed is the type of pace that is found mostly around the small *rii* in Venice; it is where the flow is laminar and attached along the hull. Planing is an efficient speed where there is little power needed from the engine. Planing occurs at a much higher speed, where the force of the flow over the hull will provide lift that pushes the hull out of the water. This speed would be seen on the longer, faster trips around the lagoon.

Many companies have invested into researching low wake hull designs that are nearly ideal for the taxis in Venice. One company who has introduced their design through
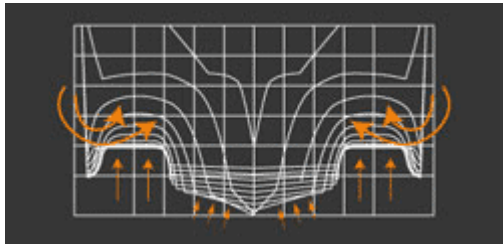
Figure 4 M-hull Design by Mangia Onda

demonstrations in Venice is Mangia Onda® Co. LLC, based in San Diego, CA USA. Their design, called the M-hull is a hull where the planing speed of the boat is much lower while the trolling speed is much higher. The design uses the bow wake to create a high pressure under the boat's dual channels seen in Figure 4. This high pressure helps to create lift which brings the hull out of the water at a lower speed, reducing displacement.[8] Another prospective design positions a large amount of hull surface behind the propeller, seen in Rumery's Boat yard T38 design.[9] This design is also intended for Venice, though smaller in size it could be scaled up for use in the taxi system. However, necessary to its design is an internal engine, which is not currently used in the system. Both designs take account for the slenderness of the small *rii*; with a narrow beam, these boats would be able to transport passengers to previously unreachable destinations.

Along with new hull design, engine technology is a factor in efficiency as well as wake. The 2001 taxi model made by Cantiere Motonautico Serenella uses a Volvo Penta inboard – outboard diesel engine. With 100 horsepower, the boat has an efficiency of 3.3 miles per gallon with a top boat speed of 65km/hr.[10] The length of the boat is 8.97 meters and the beam is 2.19

[1]4 Low, Charles T , "Boat Docking" http://www.boatdocking.com/other/Mushing.html
[8] http://www.mshipco.com/index.php?page_id=3
[9] http://www.rumerys.com/contact.html
[10] http://www.maplebay.com/page67.htm

meters.[11] Having a platform this large, other innovative technology such as hybrid and electric energy would be able to fit in the current boats.

Hybrid energy is becoming more and more popular as the technology of this combination of chemical and electric energy is studied. Less common in marine applications, hybrid engines are seen on the roads and even as taxis in Paris, San Francisco, and New York City.[12] The use of hybrid motors in boat transport has been mostly limited to larger vessels; however a company in Ft. Lauderdale, Florida has begun to implement the technology, using a biodiesel engine in combination with electric thruster motors for maneuverability.
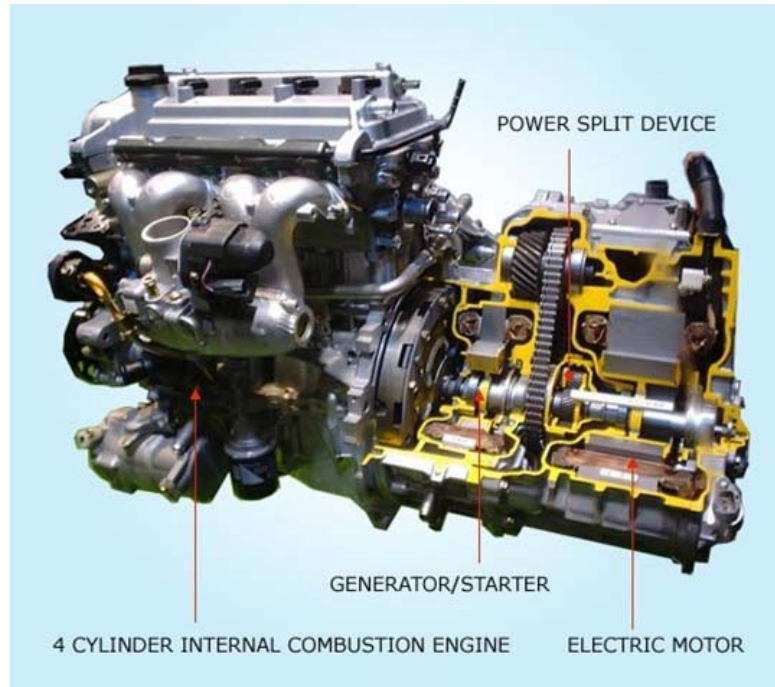
Figure 5 Hybrid Engine

Electric energy is another possible advancement. The trolling speeds in the canals are low, around 7km/hr, allowing the use of electric power to be implemented. Since electric motors have significantly lower torque than an internal combustion engine, their use as the primary source of power may not be possible. However, coupled with combustion engines, electric power has a great potential for use at slow speeds.

2.2. Boat Traffic and *Moto Ondoso*

Of the total traffic in Venice, private boats account for 15%, cargo boats 33%, and people transport boats 52%, as seen in Figure 6. The wake produced by the many motor boats damages canal walls. The deterioration of the city's ancient
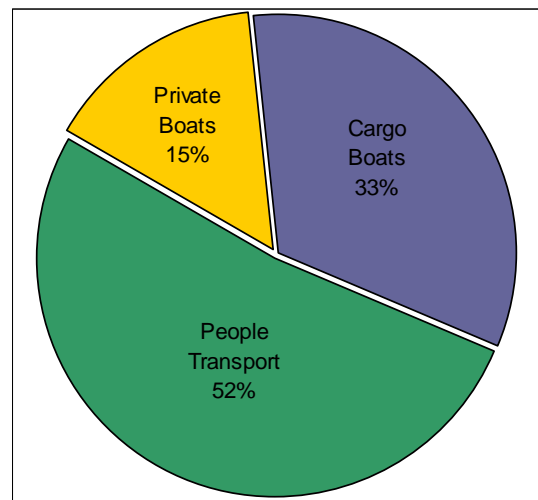
Figure 6 Venice Traffic

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[11] http://www.maplebay.com/page67.htm
[12] http://www.hybridcars.com/hybrid-taxicabs.html

buildings is a major concern for the Venetians. Canal walls undergo constant repair of damaged areas, as well as preventative work to resist further damage. "*Moto ondoso* is blamed for undermining the foundations of canal-side buildings, not to mention buffeting gondolas and their passengers about, occasionally even tossing an unwary gondolier into the drink."[13] The taxi drivers have received a bad reputation of destroying the city because of the large percentage of taxi boats. Although motored transportation is an obvious cause for damage to the walls, it is a necessity to the lifestyle of Venetians. In an effort to relieve some of the *moto ondoso*, the city of Venice has established many regulations.

2.3.   Traffic Regulations

The City of Venice has recognized many major issues, making a strong effort to diminish *moto ondoso* through the use of strict regulations. Reducing speed of a boat is a key factor in minimizing *moto ondoso*; as such, the city has focused efforts on enforcing slower speeds.

Provincial di Venezia Settore Mobilita e Transporti is the regulatory body of public transportation for the area within Venice. Regulations within the city bylaws are classified as transportation *di linea* (by line) and *non di linea* (not by line). Line transportation includes the ACTV bus boats which have scheduled stops. Regulations for public transportation with no scheduled stops consist of: taxis, gondolas, and charter boats.[14]

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[13] Harris, Joseph A., "Turning the Tide" Smithsonian Magazine (2002)
<http://www.smithsonianmagazine.com/issues/2002/september/tide.php>
[14] "Settore Mobilita e Transporti." Provincia di Venezia.
http://www.trasporti.provincia.venezia.it/serv_pubbl_ndl/terra/trnl_amv.html

The legal speed limit depends on boat type and location, seen inFigure Figure 7. The allowed speeds for the bus boats, *Azienda del Consorzio Trasporti Veneziano* (ACTV), are greater than non-lined boats. The speed limit in the Canal Grande di Murano is 7km/hr, and 11kh/hr for ACTV boats. The speed limit is 5km/hr in the other channels and rivers, and 7km/hr for ACTV boats. The reason for this discrepancy is due to the specific low wake hull design of the ACTV boats.
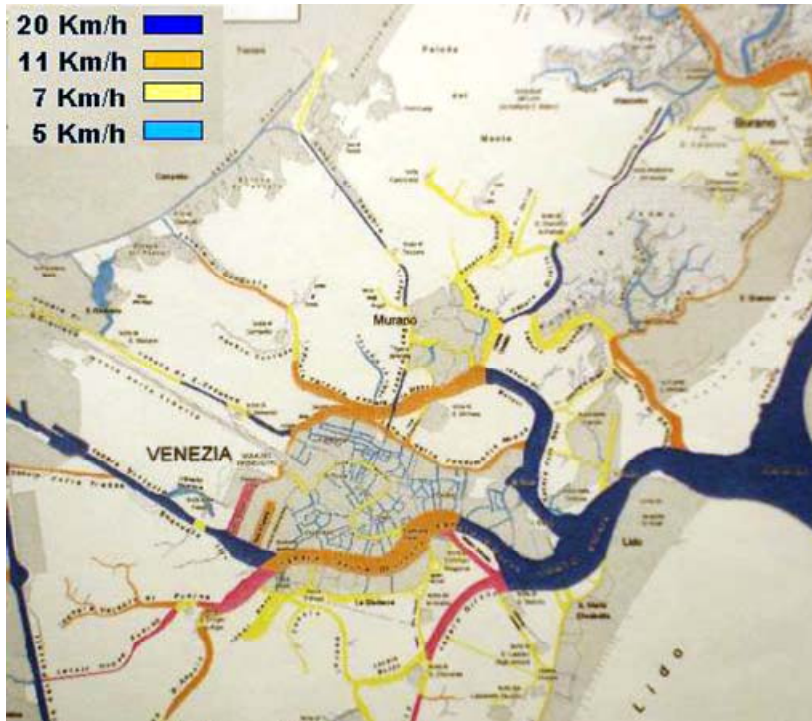
Depending on the number of offenses, taxi boats can become confiscated for a set interval of time. In addition to limiting speed, there are limitations to certain motions. Boats are not permitted to knowingly produce *ondoso motion*, caused by breaking quickly and *restia*, a backward and forward repetitive movement. In addition, these boats are not permitted to drive in close proximity of jobs in the process of restoring buildings and foundations.[15]

Figure 7 Speed Limits

There are also canals which are limited to one-way travel. In other canals travel is completely prohibited, like the *Arsenale*. In the lagoon, travel is restricted to designated paths marked by sets of posts called *bricole*.

One of the major problems with enforcement is the different jurisdictions within the area. The Coast Guard enforces the lagoon, the canal between Giudecca and Venice, and the Grand Canal. The Venetian police enforce regulations within the remaining Centro Storico. The differing jurisdictions create loopholes in which people use to their advantage. Taxis outside of Venice are permitted to work within the jurisdiction of the Coast Guard, but not within Centro

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

Storico where the local police enforce. Due to jurisdiction lines, there is difficulty in enforcing which taxis are permitted to work inside Centro Storico. The presence of illegal taxis within Centro Storico affects the demand for legal taxis, taking work away from legal taxis.

With the enforcement of speed regulations put in place, boat wake has been reduced; however, there is still a large room for improvement. Information presented in the past Interactive Qualifying Project "The *Moto Ondoso* Index", suggests the need for new traffic regulations to reduce the amount of energy released by boat traffic. The study found that stricter enforcement in boat speed would greatly reduce boat wake which plays a pertinent role in decreasing of *moto ondoso*.

2.4.   The Taxi System

Provincial di Venezia Settore Mobilita e Transporti regulates the licensing of taxi drivers. The licensing requires that the drivers must not have been sentenced for any jail time for crimes against patrimony, public faith, public order, or industry and commerce. In addition, applicants must be professionally apt, possessing professionalism pertaining to marine navigation, gained through apprenticeship. After these two qualities have been established, a written examination is given pertaining to: navigation code, regulations of marine navigation, regional laws, dispositions, and geographical knowledge of the provincial territory. The applicant must pass this examination with a score greater than 70% in order to be granted ability to pilot a taxi boat. Another requirement of taxi boats is to be registered with the Italian Registry of Shipping (RINA). This organization certifies that the boats are efficient, safe and maintained so damage in the waterways can be reduced.[16]

All taxi boats are required to be registered with *Comune di Venezia,* and must show proper registration information. This includes a four digit registration number on the hull of each boat and a banner affixed to the window of the passenger cabin displaying the taxi number. While the taxi driver is on duty, a small yellow or green flag is fastened to the bow of the boat.

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[16] ACTV S.p. A. ACTV. 2006 [cited September 9 2006]. Available from
http://www.actv.it/english/azienda.php?pagina=storia.

A yellow flag is show when a boat is a taxi, and a green flag is shown when it is a rental, see

Figure 8. Boats that act solely as taxis are numbered 1-25; those that operate as both taxis and rentals are numbered with three digits; and those that are only rental boats have their own numbering system, 1-40. If a driver is assigned to be a taxi, he is not allowed to also act as a rental, and vice versa. While a boat is acting as a rental, the driver may charge the passengers his own rates; however as a taxi, the driver must charge the rates set by the city.

Figure 8 Flags

The city determines how many taxis are needed at each of the 13 taxi stops. Those needs are distributed between the cooperatives and consortiums. For example, from November 7, 2006 to March 21, 2007 the city requires 13 taxis at the Tronchetto taxi station from 08:00 to 20:00. There will be 2 taxis from the CMV, 1 from the CVT, 3 from Veneziana Taxi, 1 from Serenisima Taxi, and 6 individual taxi drivers at that station.

Currently, the taxi rates are determined using a meter. The meter starts off with €8.70 then adds €1.30 every minute as the trip progresses. Other fees also apply depending on the number of passengers and luggage. Before 2003, the rates were determined by a mixed system where there were flat rates to certain destinations outside the city and then by a time meter within the city. The 1986, 1993, and 2003 rates are seen below and in Appendix A. The 2003 rates are used today.

Figure 9 1986 Fares

Figure 10 1993 Fares

Figure 11 2003 Fares

There are a total of 219 licensed taxis in Venice. Each taxi boat is individually owned and is considered an independent company. Most of the taxi owners choose to be part of a consortium in order to receive benefits including insurance and having their paperwork handled for them. The consortiums make a strong effort to limit competition and equalize work in order to ensure every taxi driver earns the same pay. The largest consortium in Venice, Consorzio Motoscafi Venezia (CMV), has 98 taxis, and there are 35 taxis in the second largest consortium,
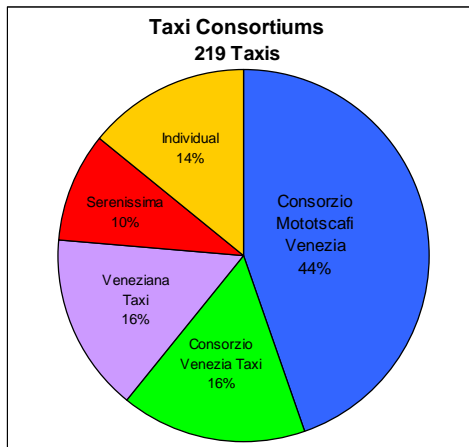
Figure 12 Taxi Breakup

Consortio Venezia Taxi (CVT). In addition, there are smaller groups called cooperatives. The two main cooperatives are Veneziana Taxi and Serenisima Taxi. There are also 31 individual taxi owners who do not belong to any consortium or cooperative. Before there were consortiums, cooperatives were the original support groups taxi drivers formed to help each other fiscally. Taxi owners still choose to be part of cooperatives today for voting power within the consortium and to share additional finances.

A substitute system for the drivers is also in effect. A taxi driver may use a substitute when sick or on vacation. Traditionally, the substitute acts as an apprentice to the driver and usually takes his place once he retires. A substitute must have one year experience onboard a ship as well as motor and deck knowledge. Most gain this experience on the Alilaguna or ACTV

boats and work their way up to taxi driver. An exam is required to prove that they can drive without passengers. Then there is another exam to become a driver with customers. Since the city only allows a specific number of taxi licenses at a given time, one must wait for an opening. Licenses cannot be sold however, they can only be transferred.

Specifically, within the CMV, there are 114 *motoscafi*, 8 of which are only taxis, 90 act as both taxi and *noleggio* rental boats, and 16 are only rental boats. Also, within the CMV, there are 5 cooperatives to which all but 17 drivers belong. As an equalization effort for all the drivers, the CMV has a rotational system to determine which of their taxis will be at a specific station on a given day. The taxis are divided into 16 teams of 6. Each team is assigned to one of the 16 'columns,' see Figure 13. The columns divide the stations and shifts needed to be covered. There is also room in the columns for days off. The teams rotate through each column day by day, completing a full cycle after 16 days. In the winter, there are only 13 columns, as the need for taxis is less. The three teams not in the 13 column-rotation take their boats out of the water. There is also a rotation scheme within each team. After one of 16-day cycles, the order of the taxis within a team will rotate by moving the first two to the back. For
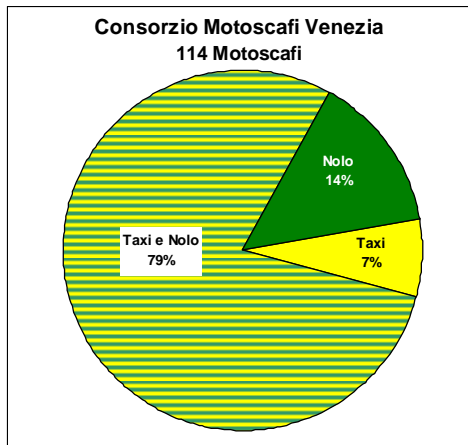
Figure 14 CMV Motoscafi

Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16
APT	SALUTE	RIPOSO	APT	S.MARCO	RIO Nolo	APT	RIPOSO	LIDO	RIALTO Nolo	APT	S.ZACCARIA	RIPOSO
6 ms	3 ms		3 ms	4 ms	1 ms	6 ms		3 ms	2 ms	6 ms L.M.M.G.V.S.	2 ms	
	P.ROMA		SALUTE	RIO Taxi	F.S.		SALUTE	EXCELSIOR	RIALTO Carbon Taxi - Nolo	SALUTE	S.MARCO Taxi	SALUTE
	2 ms		3 ms	2 ms	5 ms		4 ms	3 ms	1 ms	6 ms Dom	2 ms	6 ms
	S.CLEMENTE						RIO Nolo		RIALTO SQUEA Taxi		SALUTE	
	1 ms						2 ms		3 ms		2 ms	
	Notte Ultimi 2 ms S.MARCO TAXI - NOLO										P.ROMA Notte	

Figure 13 Rotation Schedule

example the order for Team 11, from March 25 to April 29 was 250-213-148-232-146-8. For the next cycle, April 10 to April 25, the order was 148-232-146-8-213-250. The order of taxis determines which boat will cover which station within the assigned column. There is also a rotation system for the *noleggio* boats. There are 16 rental boats in the CMV so they simply rotate through the columns daily. There is also a group called "Jolly" which is made up of the

two taxis who are not on a team and one of the rental boats. They also have a rotation schedule through five of the most common columns. These rotations are to ensure taxi drivers make equal pay. Furthering equalization, at the airport station, all money made at the end of the shift is pooled together and split up evenly among the drivers. There is no other system of profit sharing in place. The money one makes at other stations is what he takes home.

As the largest taxi consortium in Venice, the Consorzio Motoscafi Venezia is responsible for forty four percent of the taxis. If major changes in the CMV's taxi system were implemented and proven to improve efficiency, other consortiums and taxi drivers are more likely to adopt the new technology and ideas as well.

3. <u>METHODOLOGY</u>

The goal of this study was to propose a reorganization of the Venetian taxi transportation system that improved the efficiency of the system and reduced *moto ondoso*. This project produced results which suggested new boat designs and operating procedures for the Consorzio Motoscafi Venezia.

The project was conducted with the following objectives in mind:

1. To characterize the current organization of the taxi transportation system
2. To quantify the economics of the taxi system
3. To evaluate taxi transportation alternatives that reduce *moto ondoso* while maintaining financial viability

The data for this study was gathered between October 23, 2006 and December 15, 2006 throughout Venice and the surrounding lagoon, see Figure 5. As late summer into early fall is the highest tourist period, data gathered from the beginning of this time span reflected higher tourism trends than later data collection dates. This study focused on the taxis of the Consorzio Motoscafi Venezia, which accounted for forty-four percent of the taxis in Venice.

Figure 15 Target Area

3.1.   Characterizing the Taxi Transportation System

An assessment of the current taxi system in Venice was accomplished by cataloging boats and observing the current system. Observations by onboard data collection as well as analysis of past data have yielded an understanding of the system.

3.1.1. Cataloging Consorzio Motoscafi Venezia Taxi Boats

A catalog of all CMV boats was created with the purpose of assessing current technologies. Using a list of taxi and *noleggio* boat numbers provided by the sponsor, a database was created. This database includes the registration number from the hulls, taxi*noleggio* numbers, and boat names. Photographs of each boat were taken while the boat was docked or in

motion. Pictures documenting the side of the boat, the interior, and the boat's stern were linked to the corresponding boat in the database. The importance of this catalog was to create a quick way of referencing each boat, depicting a physical description of each boat, including whether they are wood and/or fiberglass, and what technologies are utilized onboard.

3.1.2. Boat Modification Study

The feasibility study of boat modifications was accomplished by collecting information organized by complete redesigning and modifications. Interviews with taxi drivers were used to gather many price lists as well as the feasibility of changing the current boats.

Investigation of boat hull changes was completed by creating a collection of possible future boat types. This was accomplished by researching and contacting many global manufactures. To understand the current investment in boats by the drivers, a collection of various boat prices were gathered through interviews and discussions.

Boat modifications were also researched for either existing technologies of the Venetian boats or newer technologies. The existing technologies were documented in the boat catalog seen in 3.1.1. Of the existing technologies, the effects of trim tabs on wake were focused on, and the effects were then studied.

A method of wake measurement was designed and fabricated, through the use of a commercially available sonar range finder and a data acquisition system. The system would be securely placed over the wall of a canal facing the water, and then record the wake height of a passing boat. Comparisons can then be made of different boats passing at different speeds. The outputs from the range finder are recorded through a data acquisition system and then graphed on a computer. The MaxSonar-EZ1 High Performance Sonar Range Finder by Maxbotics shown in Figure 16 was selected for use due to its low price and high update speed of 40 samples per second. This would provide quantitative understanding of how much energy is released by the taxis to allow for analysis and conclusions of beneficial modifications.

Figure 16 Maxbotics Sonar Range Finder

The engine types of the taxis in Venice were also collected by interviews and collection of RINA boat specifications from many taxis. A collection of these sheets was inputted into a

spreadsheet that was created to show the most common engines used by taxis and the maximum torque fuel consumptions. From this data, operating costs were then derived by applying an average taxi's yearly engine operating time.

Maintenance records from a taxi driver were also investigated to understand the cost of operating a taxi over set periods of time. A database of commonly replaced parts and their operating life expectancy was created. The replacement parts listed were: oil changes, boat washing, outdrive housing, fuel pump, propeller, battery, hydraulic piston, starter motor, and alternator replacement. In this database, the price for each part was then compared for 1500, 5000, 7500 and 10,000 hours of total operation. These numbers were selected to reflect when major maintenance occurs.

In addition, new engine technologies were also researched, where focus was placed on hybrid technology. Many companies were researched and contacted to understand if their systems could be implemented into the taxi transportation system.

3.1.3. Characterizing Taxi Operations

In order to gain an understanding of the taxi system and to quantify unnecessary engine time, five days were dedicated to onboard observation. On each of these days, a team member would shadow Alberto Barbieri, a taxi driver, for his entire shift, recording all events. Firstly, the engine hours of the boat were recorded at the beginning and end of each shift in order to obtain how long the engine was in use during that work period. Next, information of each job was logged. The times that the engine was turned on and off were recorded to account for all of the engine time including idling instances. The time of departure from the station, the time of arrival at the destination, the time of departure from the drop-off location, and the time of arrival at the original station were all recorded to calculate the time of travel with passengers and without passengers. The trip paths were also mapped to understand the routes traveled. The number of passengers, the fare price from the meter, and actually paid fare were recorded for use in fare analysis. All the information gathered was put into Excel, and graphs were plotted that represented how the entire shift broke down. Also, the engine usage was broken down into job, empty, and idling in order to identify and analyze percentages of unnecessary trips and engine time.

Forma Urbis conducted a field study in 1998 regarding traffic in Venice and its lagoon. They recorded the number of passengers on each passing boat, by boat type, from multiple locations. This data was provided in Microsoft Access tables and included all varieties of boats. The data was then sorted according to boat type in an effort to view only the information on taxi boats. The data was then sorted by whether there were passengers or not on board. The amount of empty trips and the trips with passengers were graphed in order to be compared.

3.1.4. Estimating Demand

An understanding of common pickup and drop-off locations and peak client times was needed. The Conzortio Motoscafi Venezia gave the team records of all the calls made from March to October 2006 in Access documents, organized by each month. This data contained information such as the time and date of the call, where the passengers were picked up, the customer or company who requested the service, the number of the taxi that did the job, and where the customers were dropped off. Firstly, the data was imported into Excel. The data was then filtered to eliminate the unnecessary service messages from the computer that appeared in the data. Next, the pickup and drop off locations were reformatted to a standard system by eliminating typos and combining similar locations. The pick-up address column entitled 'address' was put into a new spreadsheet. The second column named 'address ref' pulled all the individual addresses. A list of those individual addresses was obtained. That individual list was then put into another spreadsheet. A column was added next to that list called 'count' which counted the number of times a particular address occurred in that month. The count column was then sorted in a descending order to view the most common address locations. A bar graph was then made with this data. Next, another spreadsheet was made to analyze the calls by date. The dates of month were entered in the first column of the spreadsheet chronologically. The second column was named 'day code' which referenced which day of the week correlated with the date in the previous column. The next column entitled 'count' counted how many calls occurred on a certain day. The information was then graphed with a bar graph to determine high and low points throughout the week and month. In the next spreadsheet, each hour of the day from 0:00 to 23:00 was then put in the first column. The next column counted how many calls occurred that hour. A bar graph was then made of the calls per hour to see where high and low points occurred during a 24-hour day. This entire procedure was then repeated for all of the months. The time occurrences

for each month were combined in another spreadsheet, and a bar graph was created for a more accurate representation.

3.1.5. Administering a Survey

A questionnaire was dispersed to Venetian taxi drivers (regardless of involvement in a consortium) in an effort to determine their opinions on certain aspects. Since most of the changes to the system in reducing *moto ondoso* are directly related to the operations of the taxi drivers themselves, it was important to understand their opinions on certain ideas proposed. This questionnaire was extremely pertinent in determining the feasibility of the suggested changes.

Questions were created to cover topics including: general information of the taxi drivers, their thoughts on the current system, empty trips, fares, and possible changes. The final organization of questions took into account common strategies of efficient survey making. Questions were placed in the following order: basic information questions in the beginning, following were questions concerning the current system, and finally their thoughts on future proposals. Accompanying the survey was a letter describing the purpose of the study. Refer to APPENDIX B.

After the initial survey was created, a controlled pretest was administered in which the survey was given to a select group of taxi drivers. Feedback on the clarity of the questions presented was obtained and taken into consideration in the final revision of the survey. Finally,

Figure 17 Survey

the survey was presented to the Consortio Motoscafi Venezia before it was administered to the taxi drivers to insure that there were no other concerns. The final copy of the survey totaled 20

questions, of which 17 questions were formatted for drivers to circle their answers, and 3 questions were short answer. Both the survey and letter were printed on A4 paper and administered to 60 taxi drivers. A translated version can be found in APPENDIX B.

3.2. Quantifying the Economics of the Taxi System

In order to assess the economics of the current system, many factors related to expenses and incomes were investigated. Methods for determining taxi fares were also examined. This study on economics was extremely important in establishing current profits that must remain constant or increase after a reorganization of this system.

Also, a comparison was made between the taxi boat fares and other forms of water transportation fares. The costs per person and for different sized groups were compared in all modes of transportation. Supplementary prices were examined in order to propose a system that was competitive to the other forms of water transportation.

3.2.1. Distance to Time Calculations

The main goal of this procedure was to determine the taxi driver's theoretical travel time between common destinations. These time calculations were determined by first obtaining MapInfo layers of Venice and its lagoon. Within each layer, distances and speed regulations could be determined for various canals and *rii*. Commonly traveled routes were verified by taxi drivers. This information was applied through MapInfo to calculate the distance between certain locations. For example, the distance between Marco Polo Airport and Piazza San Marco was

Marco Polo to Grand Canal				Grand Canal				Grand Canal to S. Marco			
Segment #	Distance	Speed limit	Time	Node #	Distance	Speed limit	Time	Node #	Distance	Speed limit	Time
	Meters	Km/Hr	Min		Meters	Km/Hr	Min		Meters	Km/Hr	Min
								NI 244 to MP	240.1	11	1.3
42	1481.2	7	12.7	Ni 72-77	124.1	7	1.1				
42	3250.9	20	9.8	Ni 77-84	112.8	7	1.0				
42	300.9	7	2.6	Ni 84-90	46.9	7	0.4				
9	212.3	7	1.8	Ni 90-105	103.2	7	0.9				
19	518.9	7	4.4	Ni 105-133	173.6	7	1.5				
15	690.9	20	2.1	Ni 133-139	76.2	7	0.7				
10	412.6	20	1.2	Ni 139-147	139.3	7	1.2	Marco Polo to San Marco			
4	177.5	5	2.1	Ni 147-152	112.4	7	1.0		Distance	Time	
9	105.3	5	1.3	Ni 152-154	43.4	7	0.4		Meters	Min	
6	37.6	5	0.5	Ni 154-156	49.9	7	0.4	Total	9984.7	62.7	
16	114.4	5	1.4	Ni 156-160	42.8	7	0.4				
22	198.4	5	2.4	Ni 160-170	92.9	7	0.8				
Total	7500.9		42.2	Ni 170-175	66.4	7	0.6				
				Total from 72	2243.7		19.2				

Figure 18 Time Calculation

calculated to be about 10 kilometers. Next, the time was obtained by applying the speed limits to the distances. This was completed by breaking down the distance into sections by the legal speed limit and extracting the time needed to travel each section. The time in each section was then summed together to yield the total travel time for the trip. With the specific route shown in Figure 18, the trip was broken down into three sectors: from Marco Polo Airport to the Grand Canal, through the Grand Canal, and from the Grand Canal to Piazza San Marco. In the example shown, the time to travel from Marco Polo Airport to Piazza San Marco should be about 63 minutes. These times were then used to calculate fare prices to the various destinations.

3.2.2. Time to Fare Calculations

The calculation of the cost of trips was performed using the duration and destinations in combination with the published fare pricing from the city of Venice. The fare prices were based on the *Tariffe Motoscafi Taxi* information sheets issued by the city. In the recent history of Venice, there have been three different fare pricing sheets, 1986, 1993, and 2003. The 2003 tariff sheet is used presently. The 1986, 1993, and 2003 prices were brought to 2006 by adding a compounded interest in order to accurately compare the three. Using Microsoft Excel, a fare program was created that would have the necessary inputs to calculate the cost of the trip. Seen in Figure 19, the input page was simple and provided an easy-to-understand calculated fare.

Figure 19 Fare Calculation

Supplementary sheets inside this program were used to calculate the fares based on the criteria in the fare pricing sheets. After all the costs were summed together, the inflation rates were added to bring the prices to a comparative modern day price.

Using the destination selected and the time calculated from the previous version, a final fare was determined. For example, the routine trip from San Marco to Marco Polo Airport had a total time of 63 minutes;

using the fare calculator the cost for 2006 was €90.29. This fare was found by adding €1.30 every minute to the initial cost of €8.70. Thus 8.70 plus 1.30 times 63 equals €91. To validate this method of fare calculations, the CMV was asked the standard cost of an airport trip with 4 people and no extra charges. The common found price that was charged in 2006 was €90, without the usage of the metering system.

3.3. Evaluating Taxi Transportation Alternatives

In order to weigh different changes and their effects to the taxi system a collection of various data was obtained in order to accurately form a proposal for changes. Using the knowledge of the current system and operating observations, inefficiencies were identified.

4. RESULTS

4.1. Characterization of the Taxi System

4.1.1. Boat Catalog

Figure 20 depicts the boat catalog. As seen below, in the left column is the taxi number of all boats within the CMV. This catalog also contains the registration number corresponding to each taxi boat number. In addition, in the final column, there are links to exterior, interior, and stern photos of each boat. Engine model specifications as seen under the column "Engine Models" can also be obtained from the boat catalog.

Taxi	Registration Number[1]		Engine Models
4	7992	Photo	Iweco 100
7	8850	Photo	Iweco 150
8	8801	Photo	MerCruiser 100
9	8882	Photo	Volvo Penta 100 & 150
11	8802	Photo	VW TDI 150 & 220
14	7875	Photo	VW TDI 150 & 220
19	8868	Photo	
25	7596	Photo	
119	8829	Photo	
120	7874	Photo	
121	8040	Photo	
124	8778	Photo	
126	7708	Photo	
128	8064	Photo	
129	8092	Photo	
130	8491	Photo	

Figure 20 Boat Catalog

4.1.2. Operating Time
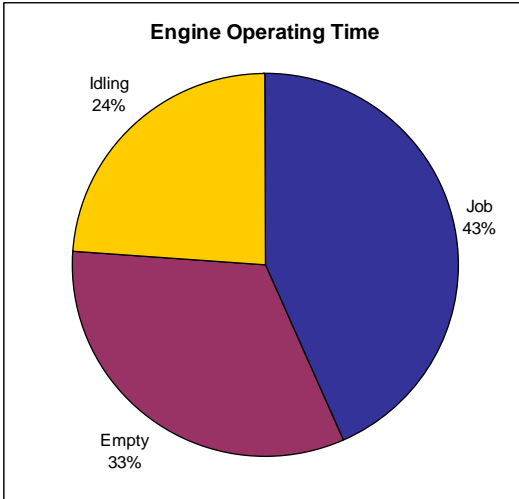
Figure 21 Engine Time

The information gathered from onboard observations shows that more than half of the time the boat was in use, it was without passengers. This breakdown, seen in Figure 21, shows that there is a large amount of time that the boat is either on an empty trip or idling, further proving the necessity to cut down on these instances. On average, 43% of the engine time was used during a job, 33% was traveling without passengers, and 24% was engine idling time. This information is consistent with the data collected by Forma Urbis. Their data shows that in December 1998, 35% of the time a driver was driving without passengers, and 65% of the time March 1998, see Figure 22. Both sets of data show that there is a large amount of time the taxi drivers' travel without passengers. Results from the survey are also consistent with this data. The results show that 45% of the taxi drivers believed that 40-60% of their drive time is without passengers, and 44% thought that they drove 20-40% of the time without passengers.
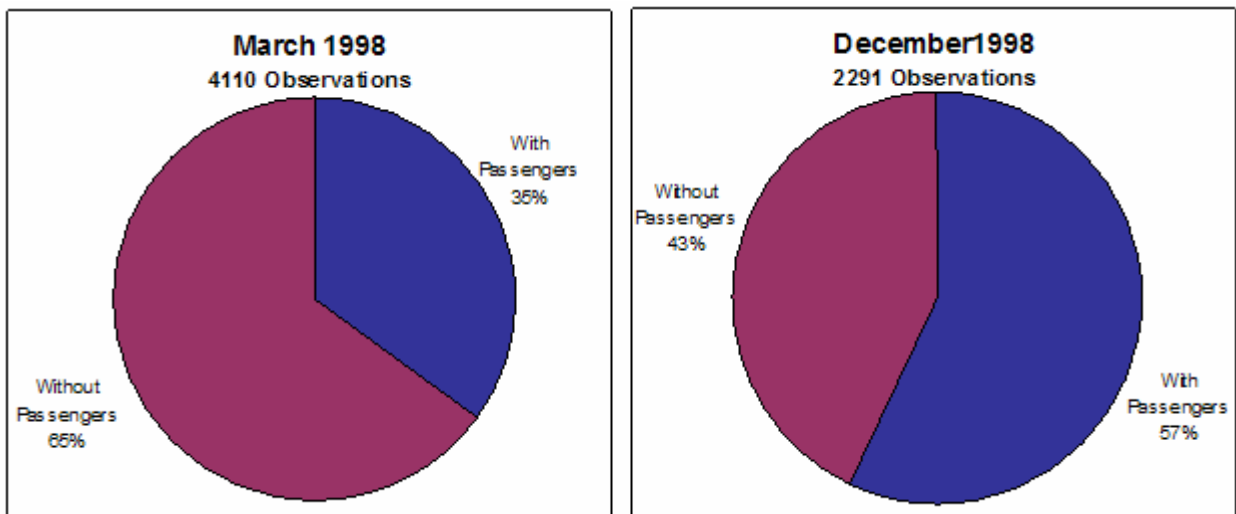
Figure 22 Forma Urbis Data

4.1.3. Demand for *Noleggio* Transportation

Some important information was also drawn from the manipulation of the CMV calls. The peak calling points during the day are at 9AM and 3PM, and, as expected, the peak calls throughout the week are on the weekend. This information shows that the current system meets the existing demand. Change in the number of boats working at one time is not necessary because that demand is met; however, change in their routes is. Also established from the call data, the most common calls are to and from the airport. Those trips account for 25% of all the total calls made to the CMV. Refer to APPENDIX C.

4.2. The Economics of the Current Taxi System

4.2.1. Quantification of Fares

In order to quantify the economics of the taxi system, fares were investigated. Pricing schemes from 1986, 1993 and 2003 were used in determining updated tariffs in order to compare them to today's standards. The proposed fares were suggested based on the 2003 tariffs that were brought up-to-date using inflation rates. The calculations accounted for the fact that fares are not updated every year, so inflation rates for 2007 through 2010 were predicted in order to propose a rate that would maintain economic viability through 2013. Portions of the fare data are shown in Table 1, with the yellow highlight representing the current and the pink displaying the proposed. A complete data sheet can be found in the supplemental CD, displaying different routes and competitor fares.

Year	1986	1993	2003	2004	2005	2006	2007	2008	2009	2010
I-STAT Inflation Rates (%)	6.10	4.20	2.67	2.20	1.98	2.13	2.00	2.00	2.00	2.00
Initial Fares										
1986	€10.09	€15.22	€20.56	€21.11	€21.57	€22.00	€22.47	€22.92	€23.38	€23.85
1993		€13.95	€18.84	€19.35	€19.77	€20.16	€20.59	€21.01	€21.43	€21.86
2003 (after 7 Min)			€17.80	€18.19	€18.55	€18.95	€19.33	€19.71	€20.11	€20.51
2003			€8.70	€8.89	€9.07	€9.26	€9.45	€9.64	€9.83	€10.02
Meter Fare										
1986 (after 7 Min)	€0.60	€0.91	€1.53	€1.59	€1.62	€1.65	€1.68	€1.72	€1.77	€1.81
1993 (after 7 Min)		€1.00	€1.35	€1.39	€1.42	€1.45	€1.48	€1.51	€1.54	€1.57
2003			€1.30	€1.33	€1.35	€1.38	€1.41	€1.44	€1.47	€1.50
Additional Charges										
Luggage										
1986	€1.01	€1.52	€2.05	€2.11	€2.15	€2.20	€2.24	€2.29	€2.33	€2.38
1993		€1.14	€1.54	€1.58	€1.62	€1.65	€1.68	€1.72	€1.75	€1.79
2003			€1.50	€1.54	€1.57	€1.61	€1.64	€1.67	€1.71	€1.74
People after 4										
1986	€1.26	€1.90	€2.57	€2.64	€2.69	€2.75	€2.81	€2.86	€2.92	€2.98
1993		€1.60	€2.16	€2.22	€2.27	€2.31	€2.36	€2.41	€2.46	€2.51
2003			€1.60	€1.64	€1.68	€1.71	€1.75	€1.78	€1.82	€1.86
Night Service										
1986	€3.28	€4.95	€6.69	€6.87	€7.02	€7.16	€7.31	€7.45	€7.60	€7.76
1993		€4.39	€5.93	€6.09	€6.22	€6.35	€6.48	€6.61	€6.74	€6.88
2003			€5.50	€5.65	€5.77	€5.89	€6.01	€6.13	€6.25	€6.38
Holiday										
1986	€3.53	€5.33	€7.20	€7.39	€7.55	€7.70	€7.87	€8.03	€8.19	€8.35
1993		€4.65	€6.28	€6.45	€6.59	€6.72	€6.86	€7.00	€7.14	€7.29
2003			€5.90	€6.06	€6.19	€6.31	€6.45	€6.58	€6.71	€6.84
Call Out within Centro Storico										
1986	€3.28	€4.95	€6.69	€6.87	€7.02	€7.16	€7.31	€7.45	€7.60	€7.76
1993		€4.13	€5.58	€5.73	€5.85	€5.97	€6.10	€6.22	€6.34	€6.47
2003			€6.00	€6.16	€6.30	€6.42	€6.56	€6.69	€6.82	€6.96
Call Out outside Centro Storico										
1986	€4.29	€6.47	€8.74	€8.97	€9.17	€9.35	€9.55	€9.74	€9.94	€10.14
1993		€5.16	€6.97	€7.16	€7.31	€7.46	€7.62	€7.77	€7.93	€8.08
2003			€6.00	€6.16	€6.30	€6.42	€6.56	€6.69	€6.82	€6.96

= Current Fare
= Proposed Fare

Table 1 Fare Calculations

4.2.2. Quantification of Operating and Maintenance Costs

Through interviews with members of the *Consorzio Motoscafi Venezia,* operating expenses, cost of parts, and time of replacement were obtained. As the 150 horsepower Volvo Penta engines are most common in taxis, that engine was chosen as the basis for a calculated hourly cost of operation.

Fuel consumption from the most common engines was collected. The consumption at maximum torque of common engines used was graphed, shown in Figure 23; however, this is an unrealistic value to apply when determining the cost per hours of operation as maximum torque is rarely seen. From the interviews, the average consumption of the Volvo Penta engine seen in the taxi system was 7.5 liters/hour. This value combined with the average operating time of 1500 hours a year yielded the cost per hour of operation.
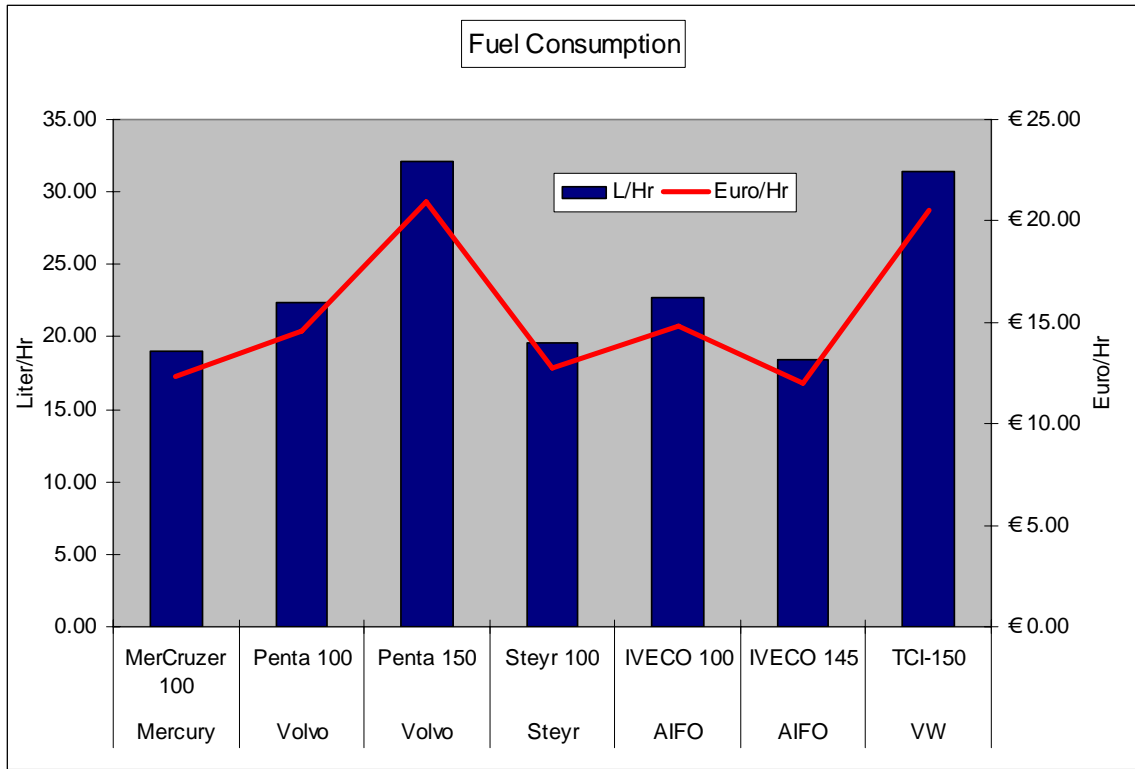
Figure 23 Max Torque Fuel Consumption Rates

Another factor affecting the operating costs is the type of hull. Some expenses do not depend on hull type, but others such as varnishing rely on whether the boat consists of a wood or fiberglass hull. As seen in Table 2, operating costs and additional expenses were totaled to yearly and/or hourly basis. The hourly rate was of utmost importance to this project for quantifying the savings of the return route system.

Maintenance Costs Vovlo Penta 150HP								
	Expense	Change Every		Expenses	Expenses	Expenses	Expenses	Yearly
Total Hours	-	-	-	1500	5000	7500	10000	1500
Fuel	€ 0.665		€/Liter					
Fuel Cost	€ 4.75		€/Hour	€ 7,122	€ 23,741	€ 35,611	€ 47,481	
Oil Change	€ 250	160	Hours	€ 2,250	€ 7,750	€ 11,500	€ 15,500	
Outdrive	€ 10,000	10000	Hours	€ 0	€ 0	€ 0	€ 10,000	
Water Pump	€ 488	700	Hours	€ 976	€ 3,416	€ 4,880	€ 6,832	
Prop(Dual)	€ 718	1500	Hours	€ 718	€ 2,154	€ 3,590	€ 4,308	
Battery	€ 155	3500	Hours	€ 0	€ 155	€ 310	€ 310	
Hydraulic Steering	€ 350	6500	Hours	€ 0	€ 0	€ 350	€ 350	
Starter Motor	€ 800	6000	Hours	€ 0	€ 0	€ 800	€ 800	
Alternator	€ 611	6000	Hours	€ 0	€ 0	€ 611	€ 611	
Fuel Pump	€ 100	10000	Hours	€ 0	€ 0	€ 0	€ 100	
Trim Pistons	€ 800	3000	Hours	€ 0	€ 800	€ 1,600	€ 2,400	
Total				€ 11,066	€ 38,016	€ 59,252	€ 88,692	€ 13,645
Per Hour								€ 9.10
Additional Costs for Wood Boat								
Washing	€ 70	500	Hours	€ 210	€ 700	€ 1,050	€ 1,400	
Finish on Bottom of Boat	€ 350	375	Hours	€ 1,400	€ 4,550	€ 7,000	€ 9,100	
Varnish	€ 1,000	375	Hours	€ 4,000	€ 13,000	€ 20,000	€ 26,000	
Varnish During Riposo	€ 4,000	1500	Hours	€ 4,000	€ 12,000	€ 20,000	€ 24,000	
Total				€ 9,610	€ 30,250	€ 48,050	€ 60,500	€ 9,075
Additional Costs for Plastic Boat								
Washing	€ 70	500	Hours	€ 210	€ 700	€ 1,050	€ 1,400	
Finish on Bottom of Boat	€ 350	375	Hours	€ 1,400	€ 4,550	€ 7,000	€ 9,100	
Polish	€ 350	375	Hours	€ 1,400	€ 4,550	€ 7,000	€ 9,100	
Interior	€ 350	1500	Hours	€ 350	€ 1,050	€ 1,750	€ 2,100	
Polish During Riposo	€ 3,000	1500	Hours	€ 3,000	€ 9,000	€ 15,000	€ 18,000	
Total				€ 6,360	€ 19,850	€ 31,800	€ 39,700	€ 5,955

Table 2 Maintenance

5. ANALYSIS AND CONCLUSIONS

5.1. Reducing Boat Speed

After many onboard taxi observations were obtained, it became obvious that speed limit regulations are not widely followed. On a typical route to or from Marco Polo Airport, many taxi drivers had been observed traveling 30-40 km/h, where the posted speed limit is 20 km/hr. Although excessive speeding is less common in smaller *rii* within Centro Storico, any increase in speed above the posted limit still has much affect on the surrounding canal walls due to the close proximity of the boat to the walls.

In addition to observations regarding speed enforcement, a new fare system was investigated in order to further encourage taxi drivers to obey speed regulations. Previously employed methods of calculating fares from 1986 and 1993 (see APPENDIX A for both fare sheets) were based on set fares for certain drop off and pick up locations. These fare schemes were based on distance and did not help deter speeding. A zoning system much like the London Tube subway system was investigated. Referring to Figure 24, four concentric zones were placed
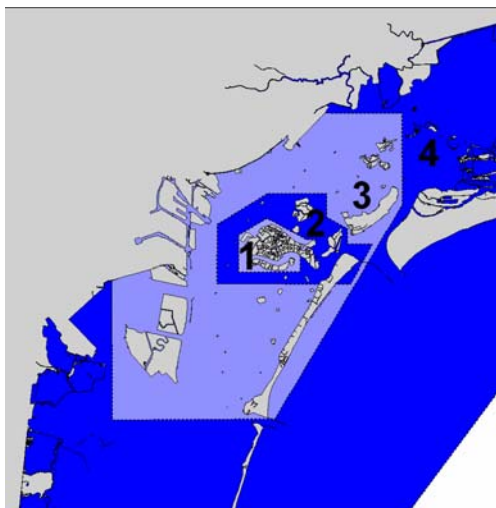
Figure 24 Zone Map

over Venice and the surrounding lagoon. The zones were selected with regard to changing speed limits in addition to destination. Similar to the current taxi fare system, a time based meter would be used to determine the fare and an additional fee would be added as the taxi crosses from one zone to another. The purpose of this fare system would be to try to account for increased speeds outside of Venice, where the change in speed must be taken into account by the price per unit of time. Though this system is financially sound, taxi drivers could still get around speeding.

After some consideration, it was decided that the current fare system that was established in 2003 is best suited for incorporating speed reduction into fare calculation. The current system already utilizes the taximeter so that trips of longer duration from slower speeds result in larger profits for the taxi driver. This creates an incentive to drive the speed limit.

The current licensing process explained previously in section 2.3, helps ensure that taxi drivers are knowledgeable of the topic of *moto ondoso*. Information gathered from the survey of taxi drivers shows that 58 % of taxi drivers are always concerned with *moto ondoso* and 42% are mostly concerned. Since speed limits are clearly posted in the lagoon and *rii,* a lack of knowledge of speed restrictions is not the problem. Stringent enforcement of speed limits should be heightened to establish more control which would contribute to the reduction of *moto ondoso*.

5.2. Modifying Physical Boat Characteristics

Though currently used hulls are modern, they are not designed nor suited for the Venetian setting. Environment is a key factor in hull design, as the optimal conditions vary with location. The lagoon area in Venice can be considered a mild area, seldom having high wake in which the taxi boats would be operating; different style of hulls can be tailored to this condition. Complete hull changes have been identified as having the most impact in the reduction of *moto ondoso*. A hull designed to minimize wake would yield the highest efficiency compared to other modifications. Although it is the most desirable change, it is also the most difficult, involving a significant investment. Currently there are four main manufacturers that supply boats to the Venetian taxi system. Of the main boat manufacturers, Serenella, Ruggero Vio, and Deste are located in the Venice area, while Studio Plastic is located on the mainland in Mestre. The Venice taxi boats are only a portion of their market; as such, the boats are built for a number of various conditions not specific to Venice. With current technology available at competitive prices, they are a good alterative to the current boat designs. Companies pursuing the use of new technology have even gone to the extent to mirror the look of the Venetian taxis. This attempt to merge the existing functionality with current technology will most likely lead the future changes in the taxi system. Companies such as M-Hull and Mangia Onda should be considered when purchasing a new taxi hull as the increased efficiency and low wake design benefit all.

This study also investigated changes to the engines of taxi boats. There is a large disparity in the taxi community of operating efficiency between the different engine types. The use of high horsepower engines was discovered to be based on the acceleration effects, where the drivers experienced smoother acceleration with the higher horsepower engines. A change in the gearing of engine-to-propeller could potentially solve this problem. Currently, the gearing of the boat engines is designed for higher speeds, where the broad range of speeds limits the adjustments at slower speed. If such a change is possible, there would be less need for such a

large engine as the smaller engines are more than adequate for all the speeds seen in the lagoon area. This could potentially have large savings as the fuel consumption is much lower for the smaller engines.

Another possible means to increase efficiency that was studied is the use of hybrid engines. Though its commonality in the automotive industry is increasing, the use of hybrid engines in marine applications is not nearly as popular. Hybrid engines are not readily available; electric propulsion has a large potential in the taxi system. With lower operating noise and higher efficiency, these engines would fit the profile that is seen within *Centro*

Figure 25 M-Hull

Storico. Both Venetians and taxi drivers showed interest in this new technology however due to a lack of local companies using such technology, there are few resources educating the people of the possible advances.

The use of electric propulsion would not only benefit the drivers by its reduced running costs, but also by increasing the controllability of boat speed. With added control the boats would be able to more at any range of the electric engines capability. Currently the taxis have no control at slow speeds. The idle speed of the engine while in forward propels the boat faster than the speed limits, forcing the taxi's to speed unless they are constantly switching between forward and neutral. The use of electric propulsion could completely solve this problem.

5.3. Reducing Operating Time

The third step in reducing *moto ondoso* is to cut down on the operation time of the taxi boats. Reducing the amount of trips a boat takes will lessen the amount of damage incurred by wake. Shortcuts and route changes have been identified as possible options.

5.3.1. Shortcut Analysis

A solution to cutting down operating time is to reduce the distance traveled. This can be done by opening passageways or by creating alternative routes. Three major shortcuts were

identified as having beneficial impacts on the taxis system where their implementation would reduce damages from boat wake.

One possible route change is to redirect taxi travel around the eastern tip of Venice through the Arsenale as seen in Figure 26. The Arsenale is owned by the *Marina Militare* who blocks traffic flow in order to preserve the nearby foundations. However, with a regulated flow of boats, traffic could pass through without causing damage. A toll-based regulation system that penalized speeding would assure preservation. In order to minimize *moto ondoso*, a 5km/hr speed limit would be implemented and enforced. The travel time through the Arsenale,

Figure 26 Arsenale Shortcut

at that speed limit, was calculated to be 10.5 minutes. If the system recorded a time that was substantially less, then a fine could be levied on the driver. The creation of this system could be accomplished by using Radio Frequency Identification System (RFID), similar to those used globally in automobile transportation tolls.

The money collected from the tolls would be used to fund repairs of the Arsenale and possibly other damages resulting from *moto ondoso*. The travel distance around the tip is 5.8km and the distance through the Arsenale is 0.88km, resulting in a trip reduction of 6.62 times. As seen in Figure , boat wake in close proximity to land would be greatly decreased. The benefits will not only include reduced *moto ondoso* around the tip, but also a reduction in trip cost.

The taxi drivers would benefit from the use of this new route by reducing trip time by 10 minutes, seen in Table 3. This would lead to approximately €1.00 savings on fuel for every trip, a 48.5% savings.

	Arsenal Canal	Current Route	Savings
Time (minutes)	10.49	20.35	
Fuel Consumption (L)	1.56	3.02	48.5%
Fuel Consumption (€)	1.04	2.01	

Table 3 Arsenal Savings

Another possible change to the current routes is a highway to the airport as shown in Figure 27. This figure shows how a large portion of the current route is in close proximity to *Murano*, *Cimitero*, and a small private island. The proposed route would greatly reduce the amount of *moto ondoso* to these islands because the route would be at such a distance that the boat wake reaching these islands would be minimal.

The route would save 10 minutes off every trip to and from the airport at a projected speed limit of 30km/hr, as seen in Table 4. This is a distance reduction of 0.8km, utilizing 4.1km of new highway. Using current fuel prices and engine consumption rates, the drivers would save about €1 per trip. Since 25% of all calls to the CMV are to or from the airport, over time, the time and fuel savings would be substantial.
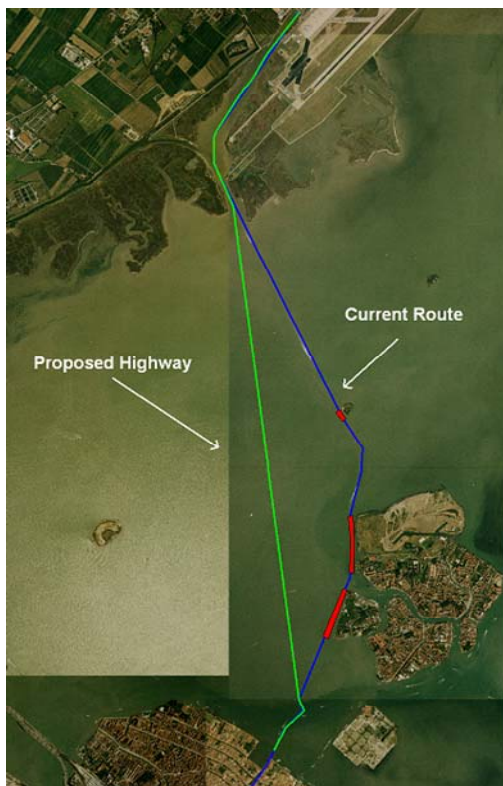
Figure 27 Airport Highway

Currently, the recommended highway cannot be traveled because safety concerns regarding water depth and environmental regulations prohibit this travel path. Future analysis of this is necessary to make the highway possible. The water depths must be accurately mapped in order to determine whether it is safe for boats to travel during low tide.

If this route is determined to be feasible, the next step would be to modify regulations to allow taxi boat travel of this path after construction is complete. This path would be limited to strictly taxi boats because water depths would not be suitable for larger boats. In addition, guide poles and lights would be added to allow for safe travel.

If further study determines the path is too shallow for the taxis, then dredging will be necessary. Dredging costs range from €70 to €100 per cubic meter, as quoted from the city of Venice. The length needed to dredge the whole highway totals 4.1 kilometers long. Using current highway widths, the new route will be 20 meters wide and dredged an additional 1 meter deep, creating an 80 thousand cubic meter area to be dredged. This would cost between 5 and 9 million euro. An

additional fee for installing guiding poles and lights would also be added. The total cost for this project estimates between 10 and 15 million euro.

	Proposed Highway	Current Route	Savings
Time (minutes)	25.58	34.61	
Fuel Consumption (L)	3.80	5.14	**26.1%**
Fuel Consumption (€)	2.53	3.42	

Table 4 Highway Savings

The third shortcut that will reduce trip length is around the eastern side of the *Cimitero*. This route would be a connection from Venice to Murano in two possible paths, one of which

Figure 28 Cemetery Shortcut

follows the coast of Venice and passes the cemetery in close proximity, and the other is a direct route from the *Arsenale* to Murano, as seen in Figure 28. These routes would help to reduce *moto ondoso* to the surrounding islands by redirecting the traffic to the proposed paths which are a distance to any land. While traveling at the speed limit, this new route would reduce the trip length by about 0.8km and time by 5 minutes. As seen in Table 5, using the new path would produce a 32.7% savings of fuel for the taxi drivers.

Currently the proposed route cannot be traveled because city regulations limit the unauthorized travel of boats in the lagoon area. Further analysis of the area will be necessary in order to determine the feasibility of traveling the route under existing conditions. Once it is determined passable, city regulations need to be

	Proposed Route	Current Route	Savings
Time (minutes)	11.1	16.5	
Fuel Consumption (L)	1.65	2.45	**32.7%**
Fuel Consumption (€)	1.10	1.63	

Table 5 Cemetery Shortcut Savings

modified to allow for lagoon travel of this particular area. Installation of guide poles would restrict drivers to certain parts of the lagoon. Installation prices would mirror those previously stated for the airport shortcut.

5.3.2. Shift Start and End

Noticeable trips that could be reduced or changed include the trip to the assigned station at beginning of a shift and the trip at the end of a shift back home or to a parking spot. There is a plan in place for a parking area near *Tronchetto* with space for one hundred taxi boats. This would allow for the drivers who don't live in Venice to park their boats there over night instead of driving home, cutting that trip. It could also be an alternative for those who live in Venice and park down narrow canals. Boat wake in those canals would be reduced. An option for those who live in Venice is to have them start their shift at the closest station to where they live or park. This could create problems with places where too many taxi drivers live, and not satisfying the demand at other areas. A rotation schedule may still need to be used, however it can be redesigned to incorporate this idea. Also, they could park their boat closest to where they end up at the end of the shift and then take public transportation home. Another option to reduce trips is to have taxi drivers who live near each other team-up and have the one furthest away at the end of the shift pick everyone else up along the way. This 'carpool' system could condense those multiple trips.

5.3.3. Return Route Plan

In the effort to reduce the amount of trip time, time without passengers was identified as an operation which can be reduced. Nearly 35% of taxi operating time consists of empty trip time and 24% of idle time, both resulting in wasted fuel. Reduction of this time would cut down on unnecessary *moto ondoso* while additionally benefiting the taxi drivers. The benefits of this reduction will result in a decrease in cost of taxi operations, raising profits.

Empty trip time consists of mainly travel from the drop off point to the driver's initial start point of the day. This empty return trip follows most jobs, thus accounting for a high percentage of travel time. It was found that that the drivers were already aware of this loss and have addressed a simple solution at the Airport, a main CMV stand. Drop offs from boats in other consortiums work out an arrangement with the CMV in order to pick up passengers at a reduced rate so the 60 minute trip returning from the airport to Venice is not wasted. This was a

surprising result that showed the concern for inefficient travel by the taxi drivers. The survey shows the drivers' concern with reducing empty trip time as well. From the survey, 42 % of the drivers would rather stay and wait for the next call and 38 % of the drivers would rather go to the closest station. This simple solution benefits all parties.

Continuing with the practice seen by taxi drivers, the team looked into a method of reducing the return time. The only way to reduce the return trip time would be to redirect the taxis to a closer return location rather than having them return to their initial start point. This return trip could be shortened if the taxis were able to stop at a station closer to the drop off. However, because all taxis return to their initial start location, there would be an over staffing at locations if the entire group of taxis followed this scheme. An optimized return base plan has been thoroughly analyzed as to the feasibility of implementation.

This reorganization would require a dispatch system that would alert the taxis of which location to return to after a call is made in order to handle this dispatching efficiently. The method of this post dispatching is done similarly to the call dispatch, where instead the taxi stands are ranked and the taxi is sent to the closest stand where this empty taxi will dock. This post call dispatching system would be necessary to ensure complete staffing of each station as the system will monitor all the taxi stands. The current GPS system takes position into account by awarding the closest boat to a call; therefore, this new proposed system would be expanding on the existing technology.

Another aspect that the proposed system would need to reflect is even profit sharing. Currently the rotation schedule of the CMV is designed to maintain an even income for all of the CMV taxi drivers. This is mainly accomplished by the rotation schedule previously outlined. An arrangement that assigns the taxis to nearby stations will in fact be a random system; this is due to the variety of call destinations. If such a system was in place, the initial start location will only determine what initial calls are awarded to these taxis. After the first call, their stop locations will be solely based on the destinations of calls and the staffing of nearby stations. This should reflect a similar randomness as the rotation schedule, however due to the lack of position data, a model of this system was not able to be analyzed. Additionally, taxi drivers may be uncertain to the evenness of trips, thus the proposed system must incorporate a simpler means of profit division. Even profit sharing could be accomplished through a central organization by collecting the earnings of each taxi driver, creating a central pool of money. The central pool would then be

divided by the number of total hours worked that day, and returned back to the drivers proportional to their shift duration. This would in effect create a daily earning per hour. The drivers would then be paid in the form of weekly paycheck, allowing for all of their earnings to be accounted. The system would further the efforts currently made by the CMV to share profits evenly.

Temporary parking was also investigated as a method of increasing the number of locations that the taxis could be positioned. It was determined that if taxis are able to find temporary parking at their drop off location, this could reduce unnecessary travel time. The system could incorporate temporary parked boats as having a higher importance than parked boats, giving them a higher order in the ranking. This could benefit the transportation system as a whole and reduce unnecessary movement of parked boats.

This proposed system would require a redesign of the current taxi dispatch system, where the existing dispatch center will need to be updated. During assessment of the current dispatch system as seen in Figure 2929, located at the CMV main headquarters, it was determined that the system is not completely optimized. The system updates the positions of the boats upon receiving an operator command to search for taxi positions. The dispatch system then ranks the boats based on their position

Figure 29 GPS Dispatch Screen

to the call and their previous amount of work that day. The operator then selects the boat for the call and sends a message to that taxi containing the information about the call. After this, the dispatching process is complete. The system constantly displays to the operators all of the functioning taxis on a map of the Venice region and color codes them to their status. This map however is too cluttered to quickly read. A larger display possibly through the use of a projector could be a highly useful modification to the current system.

The major modification to the dispatch system will be a more advanced communication system, where the dispatch system would be able to obtain the positions of the boats at a much higher rate. The system should be able to determine where a taxi is to be dispatched after its drop off. This would be accomplished by monitoring the staffing of the many taxi stands, therefore an input of the taxi stands, their locations, and their staffing requirement.

The system should log the GPS locations of the taxis with respect to time and store this data for post analysis. Currently the dispatch system records the positions for the purpose of looking at past instances; however, this data is lost when the main program is restarted, a common operation, resulting in loss of this data. This information can also be used to produce models of the system, understanding and identifying inefficiencies for future modifications.

The proposed system is broken down into three major sections that would feed information to another. The first of the units that make up the dispatching system would be the main processing unit, where all the data would be collected, and the algorithms that determine where taxis are needed would be processed as well as all other nonuser inputted decisions. The second unit would be the communication system, where all the information that is sent between the dispatch system and the taxis is handled. The third of the units is the dispatching system display. This series of units allows the operators to monitor the system and handle incoming calls. These three systems together make up the complete dispatching system.

The software logic path of this system is broken into three separate functions, the constant monitoring system, the call dispatch system, and the return dispatch system. The call dispatch system is similar to the current system; however the other two will be new advancements requiring hardware changes. The outlined path of the complete dispatch system is seen in APPENDIX D.

The proposed taxi dispatch system has a large effect on the overall reduction of *moto ondoso*. Of the total boat traffic in Venice, the taxi system accounts for 25%. Of this percentage, this study focuses on the CMV, 44% of all taxis, equating to 11% of all traffic. Of this fraction, the proposed dispatching system will work to reduce the amount of empty trip time which accounts for 33% of operating time as seen in onboard data. Therefore, if this system was to be 80% efficient in decreasing empty time, a total reduction of traffic in Venice would be 2.9%.

4. *RECOMMENDATIONS*

The metered fare system is the most effective way to control speeds. Using the meter and obeying the speed limits will allow for appropriate fares. However, new fares should be implemented. Setting the fare sheet to what the prices should be in 2010 with estimated inflation will allow the new prices to be used effectively from 2007 through 2013. The proposed fare prices are as follows:

Servizi di Corsa a Tassametro / Taximeter Service

2007

Tarriffe / Fares

Dritto fisso alla partenza / Fixed rate at departure €10,00
Scatto a tempo (al minuto) / Time tick per minute €1,50

Alle dette tariffe sono applicati seguenti sovraprezzi:
The following overprices are to be applied to the a/m rates:

1) Dritto di chiamata……………………………………………………......……...............€7,00
   Call-out charge

2) Servizio notturno (dalle ore 22:00 alle ore 07:00)……………......……................€6,40
   Night service: overprice per run (10pm to 7am)

3) Bagaglio: per ogni collo trasporto con lati superiori a cm. 50...................................€1,80
   Luggage: per transported parcel having sides over 50 cm.

4) Festivo (non cumulabili con il notturno)...€6,80
   Holidays (not to be added to the night rate)

5) Per ogni persona superiore alle 4 (sino alle 20)..€1,90
   Per person exceeding 4 people (until 20)

6) Servizio sosta: il tassametro continuerà as essere tenuto in funzione.
   Stay Service: the taximeter will continue working.

Regarding boat modifications, a step by step procedure should be followed. Firstly, a modification of trim tabs would be highly beneficial. Discussion with trim tab and boat manufactures would allow for optimized sizing for boats in Venice. After this is implemented, research should be done on new hull designs. Though a radical step, a relationship between these new hull manufacturers and taxi drivers should be established in order to aid in the production of useful designs. Also, existing electric boats would be a positive addition to the fleet of taxis. If these boats are limited to inside *centro storico*, the savings could be immediately noticeable. Future advancements in hybrid technology should not go unnoticed. In the near future, lighter weight batteries will become commercially available, ultimately making hybrid technology more practical in marine applications.

Finally, the optimized route software plan is presented in the chart below. In this chart, the logic behind the decision making process is outlined. If this is to be implemented, the programming of such a system would follow this structure. This type of organization should also be designed for the incorporation of all taxis for future considerations. Though complete unification of all taxis is not practical at this time, the long term goal should be complete unity. Therefore this dispatching should have the ability to function for all taxis. Since the investment will only need to be made once, implementation of complete dispatching will be easily applied if this plan is followed.
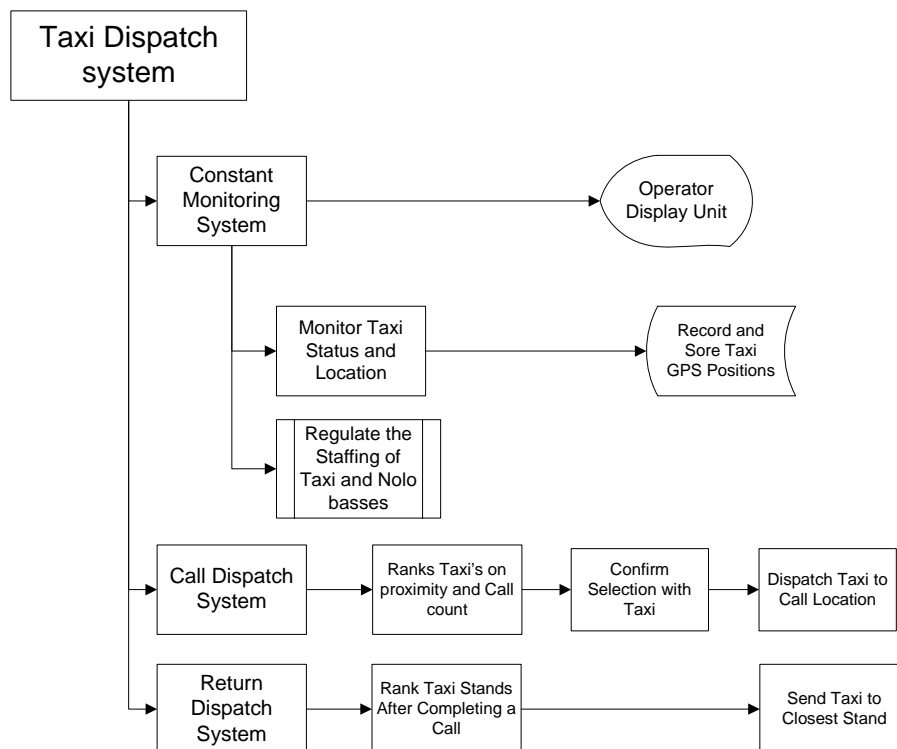
Another method of increasing the profit per trip is to have a shuttle service, where a group of hotels are selected to have a scheduled pickup for transport to the airport or other popular destinations. This would be an easy way to maximize the passenger loading for such trips. The implementation of this lined shuttle should also be hand-in-hand with optimized boat designs. This constant operation would be most efficient with new technology as well as a good example to test out alternative boat technologies such as the EcoBarca 19 by Mangia Onda.

In order to make much of these recommendations possible, a change in the profit distribution must be made. Currently the CMV utilizes the profit sharing system at the airport to equalize pay. Widely accepted, this profit distribution should be applied throughout the entire consortium and eventually encompassing all Venetian taxis.

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This book will be useful in the understanding of different hull design options in decreasing wake. Although it does seem a bit out of date for our project, it does deal with lower speeds and their resulting generation of wake which is highly applicable to the taxi transportation project. This source was found using WorldCat, searching the database with the keyword search of "boat design" and "wake".

Taxi Transportation:

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Bruttomesso, Rinio. Cities on Water and Transport. Venice: International Centre Cities on Water, 1995.

This book discusses the many urban projects dealing with the many problems Venice is facing as a city dealing primarily with water transportation. This book also discusses the development of new urban transportation, which directly relates to our project, and may give us insight on new ideas for a solution. It also provides case studies of implementation in other cities, and the takes a closer look at Venice's own plan for the betterment of urban transportation. I feel this book may also be a little too dated for our project though. This source was also found using WorldCat, with keyword "Venice Transportation".

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Kim, Hyunmyung, Jun-Seok Oh, and R. Jayakrishnan. 2005. Effect of taxi information system on efficiency and quality of taxi services. *Transportation Research Record* no. 1903:96-104.

This resource focuses on the difficulties of monitoring taxis because drivers are so hard to control. Customer interests, expectations, and behavior are viewed while changing scenarios of travel time and fare pricing. The efficiency of a taxi company is modeled and proven to be more proficient with the use of an information system. This will be a reliable source of information about procedures for fair and efficient transport.

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The dispatch system of Singapore was analyzed, in hopes for modification. Before
the project, taxis were dispatched to customers based on the shortest travel *distance* to
the customer. The new system dispatched taxis based on the shortest travel *time* to the
customer. In the end this could lead to happier customers having to wait for less time.
In Venice's situation this could be the difference between a local using the taxis and
taking another form of transportation instead.

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satisfy the both of best worlds. Customers want low fares while drivers want higher
prices. This research discusses the ups and downs of the system and factors affecting
the final decision. The taxi boat project will be very interested in this theory when
possibly proposing new fares and discounts.

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This journal article presents a way of modeling and examining congestion using
mathematics. The equations are to help assess and demonstrate the characteristics of
the taxi system on congested roads. This might be useful if I understand enough of it
to apply their ideas to Venice's transportation problems. This article was found from
a search on ScienceDirect with keyword "taxi transportation".

Yang, Hai, Min Ye, Wilson H. Tang, and S.C. Wong. 2005. Regulating Taxi
Services in the Presence of Congestion Externally. *Transportation Research Part
A: Policy and Practice* 39, 17-40.
The taxi system is subjected to various regulations among cities today. Economic
analysis of the system has paid little attention to congestion and its affects on
competition. This study examines equality and regulations within the system. While
taking into account traffic delays, fares will be investigated in this experiment. This
will prove to be applicable to the Venetian taxi transportation project because they are
very similar studies.

Moto Ondoso:
David Chiu, Anand Jagannath, and Emily Nodine. 2002. *The Moto Ondoso Index:
Assessing the Effects of Boat Traffic in the Canals of Venice.*Worcester
Polytechnic Institute Interactive Qualifying Project.
The *moto ondoso* project studies the energy that is produced by boats traveling
through the Venetian canals. An index was created listing the energy level
production under different circumstances in various locations of the canals. This
source will be helpful when proposing a possible new boat design. Data can be used

to support a certain style hull. This document does not contain information regarding new technology such as taxi boat fares.

Harris, Joseph A., "Turning the Tide" <u>Smithsonian Magazine</u> (2002)
<http://www.smithsonianmagazine.com/issues/2002/september/tide.php>
This article shows how the serenity of Venice is interrupted due to the *moto ondoso* controversy. It is a good source of the Venetians concern about the problems Venice is challenged with, including *moto ondoso*, the rising water levels, floods, and increasing tourism. It also talks about the plan to reduce *moto ondoso* in the Cargo Transportation IQP.

Taxi Boats:

Nautical Know How. Inc. Boating Basics. 1996/2006 [cited September 9 2006].
Available from http://www.boatingbasicsonline.com/course/boating/3_5.php.
This will be a good source when assessing boat design. The website includes many basic concepts about the vessel. Different hull designs and propulsion systems are examined. It describes many traditional designs but does not have a unique proposal for a hull that minimizes wake.

Rumery's Boatyard.<http://www.rumerys.com/frost.venice.html>
This website claims to have the solution to reducing *moto ondoso* with their no wake boats with its specially designed hull, specific materials, and quiet engine. They claim that the smaller engine will allow the boats to go faster with no wake and low fuel usage.

Surveying:

Sirken, Monroe G. 1999. *Cognition and survey research.* New York: Wiley.
This is a research article which studies cognitive psychology. Within the contents are survey methodologies and different aspects on various types of questionnaires.

Transportation System:

ACTV S.p. A. <u>ACTV</u>. 2006 [cited September 9 2006]. Available from
http://www.actv.it/english/azienda.php?pagina=storia.
This site encompasses a wide variety of transportation methods. From buses to trams, the Azienda del Consorzio Trasporti Veneziano describes the business. This will be important when comparing the public transportation to the water taxis.

Duffy, Jill, Justin Gagliardi, Katherine Mirtle, and Amanda Tucker. 2001.
*Re-engineering the City of Venice's Cargo System for the Consorzio Trasportatori Veneziani Ruiniti.*Worcester Polytechnic Institute Interactive Qualifying Project.
This project focused in on changing the cargo transportation routes of Venice. Deliveries were being made daily in an inefficient manner which created more canal traffic and unnecessary *moto ondoso.*

Starratt PE, Wes. "*Breaking The Speed Envelope For Passenger Ferries*." n.d.
    http://www.baycrossings.com/archives/2001/07_August/breaking_the_speed_env
    elope_for_passeger_ferries.htm (accessed Sept. 20, 2006).
In the Bay area in San Francisco they are looking for a new method of a ferry system,
using a new low wake technology by Air Ride Craft, of Tampa Bay Florida. The
article discusses the issues and problems that need to be solved as well as some goals
that this area is looking for solutions. The ships they need are Much bigger than
Venice taxi's, however maybe the same principals can be applied.

Bruno, Michael S, Brian J. Fullerton, Raju Datla, and Peter A. Rogowski. "Field
    and Laboratory Investigation of High-Speed Ferry." *State of New Jersey*. Stevens
    Inst. of Technology. n.d. http://www.state.nj.us/transportation/
    works/maritime/documents/Wake_Impacts_StevensPublishedPaper.pdf#search=
    %22boat%20wake%20vs%20speed%22 (accessed Sept. 19, 2006).
This is a study of the effects from a high speed Ferry in NYC. Data shows how there
are optimal operating speeds, planing and trolling.

Buckley Cpt, Tork. "Alsphere in Venice." *The Yacht Report*, June 2004, 2-3.
    http://www.alsphere.at/download/The_Yacht_Report.pdf#search=%22Venice%20
    Taxi%20boat%20hull%22 (accessed Sept. 19, 2006).
Report on a low wake boat, designed to be narrow and simple for easy use.

Canal Hybrid Ferryboat. Hybrid Vehicles. http://www.hybrid-
    vehicles.net/contactus.htm (accessed Sept. 19, 2006).
Hybrid passenger boats in Florida are using biodiesel.

Low, Charles T. "*Boat Docking*." n.d.
    http://www.boatdocking.com/other/Mushing.html (accessed Sept. 19,
    2006).
A site that gives a description of mushing, which is the inefficient speeds where the
boat is pushing a lot of displacement.

Low, Charles T. "*Wake Management*." June 1995.
    http://www.boatdocking.com/other/ThePortHole.html (accessed Sept. 15, 2006).
A site that explains methods to reduce wake on existing boats

"*M Ship Co*." n.d. http://www.mshipco.com/ (accessed Sept. 15, 2006).
M Ship Co has been a producer of a low wake boats for government and commercial
purposes. Their technology is leading edge and maybe a future for low wake craft.

Smith, Patrick. "*http://www.maplebay.com/page67.htm30' Venetian Water taxi
    2001*." n.d. http://http://www.maplebay.com/page67.htm (accessed Sept. 18,
    2006).
A true Venetian taxi for sale. Given on the website are some of the statistics for the
boat, very helpful.

"*Torpedo 38.*" n.d. http://www.rumerys.com/T38Layout.html (accessed Sept. 19, 2006).

This boat yard has developed a system where the drive shaft is internal and far from the stern. This provides a wake much like that of a sail boat, very low and high cycle low period.

APPENDIX A
Fare sheets from 1986, 1993, and 2003

Assessorato ai Trasporti e SS.PP.
Venezia

ANNO 1986

TARIFFE MOTOSCAFI TAXI
(portata fino 20 persone)

Ordinanza Municipale n. 52782

IL SINDACO

Vista la deliberazione di aumento Tariffe di Taxi Acqueo, adottata dalla Giunta Comunale in data 22/8/86 n. 3571; Visto l'art. 139 T.U.L.C.P. 1915.

ORDINA

1) procedere, entro la data del 1° Ottobre 1986, da applicare le sottoriporte nuove tariffe, mediante utilizzo per i Servizi di Corsa in Centro Storico del Tassometro.

TARIFFE

SERVIZI DI CORSA

Cooperativa S. ... CO
Motoscafi al Servizio Pubblico a r.l.
30124 VENEZIA – San Marco 978

N° 2 4 7

1) Da Fusina o S. Giuliano o P. Sabbioni a Centro Storico	L. 55.000
2) Da Tessera a Centro Storico	L. 60.000
3) Da Burano o Torcello o S. Erasmo a Centro Storico	L. 80.000
4) Da Murano a Centro Storico	L. 48.000
5) Da Lido S.M.E. a Centro Storico	L. 48.000
6) Da Lido Casinò o Aeroporto Nicelli a Centro Storico	L. 58.000
7) Da Lido S.M.E. a S. Marco	L. 25.000
8) Da Lido Casinò o Aeroporto Nicelli a S. Marco	L. 33.000
9) Da Aeroporto M. Polo a S. Nicolò o Lido e viceversa	L. 75.000

SERVIZI DI CORSA IN CENTRO STORICO A TASSAMETRO

a) Diritto fisso per percorsi non superiori di 7 minuti	L. 20.000
b) Importo a tempo con scatto ogni 15 secondi	L. 350

ALLE DETTE TARIFFE SONO APPLICATI I SEGUENTI SOVRAPREZZI:

— Chiamata in Centro Urbano L. 6.500
— Chiamata fuori Centro Urbano L. 8.500
— Servizio notturno, sovraprezzo per corsa L. 6.500 dalle ore 22 ore 07.00
— Bagagli, per ogni collo trasportato con lati superiori a cm. 50, L. 2000
— Servizio sosta: il tassametro continuerà ad essere tenuto in funzione
— Festivo: L. 7.000 (non cumulabile con il notturno)
— Per ogni persona superiore alle 4 (fino alle 20) L. 2.500

Figure 30 Fare sheet from 1986

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DIREZIONE SPORTELLO UNICO
Commercio
Ufficio Servizio Trasporto non di linea su acqua

TARIFFE MOTOSCAFI TAXI

(portata fino a 20 persone) determinate nell'anno 1993
DELIBERA G.C. N. 1526 del 5.5.1993

Motor Boats and Taxies Price-List (established in 1993) – Tariffe der Taxi -Motorboote (festgelegt im Jahre 1993)

LE TARIFFE DEVONO ESSERE ESPOSTE, (IN MODO VISIBILE) NELLA CABINA DEL NATANTE E NEI PONTILI DI STAZIONAMENTO

TARIFFE – PRICE –LIST - TARIFE

SERVIZI DI CORSA – RUN SERVICES – FAHRTANGEBOTE

1)	Da-From-Vom Aeroporto M.Polo, Tessera, a S.Nicolò o Lido e viceversa, vice versa, umgekehrt	L.	107.000 (€ 55,26)
2)	Da-From-Vom Aeroporto M.Polo, Tessera, a Centro Storico o viceversa, vice versa, umgekehrt	L.	87.000 (€ 44,93)
3)	Da-From-Vom Burano o Torcello o S.Erasmo a Centro Storico o viceversa, vice versa, umgekehrt	L.	115.000 (€ 59,39)
4)	Da-From-Vom Murano a Centro Storico o viceversa, vice versa, umgekehrt	L.	70.000 (€ 36,15)
5)	Da-From-Vom Lido S.M.E. a Centro Storico o viceversa, vice versa, umgekehrt	L.	70.000 (€ 36,15)
6)	Da-From-Vom Lido Casinò o Excelsior o Aeroporto Nicelli a Centro storico e viceversa, vice versa, umgekehrt	L.	84.000 (€ 43,38)
7)	Da-From-Vom Lido S.M.E. a S.Elena o Giardini o Riva Sette Martiri o S.Pietro di Castello o S.Marco o viceversa, vice versa, umgekehrt	L.	35.000 (€ 18,08)
8)	Da-From-Vom Lido Casinò o Excelsior o Aeroporto Nicelli a S.Elena o Giardini o Riva Sette Martiri o S.Pietro di Castello o S.Marco o viceversa, vice versa, umgekehrt	L.	47.000 (€ 24,27)
9)	Da-From-Vom Fusina o S.Giuliano o P.Sabbioni a Centro Storico o viceversa, vice versa, umgekehrt	L.	79.000 (€ 40,80)
10)	Servizio di Nolo fuori Centro Storico con ritorno a vuoto al punto di partenza – Tariffa oraria non Frazionabile.	L.	121.000 (€ 62,49)

Freight service out of the Historical Centre and vacant return
To the departure – non – splittable hourly rate

Dienste außerhalb des hist. Stadtzentrums mit leerer Rückfahrt
zum Abfahrtsort – Stundentarif nicht unterteilbar

SERVIZI DI CORSA IN CENTRO STORICO A TASSAMETRO – La tariffa a tassametro è valida nell'ambito del territorio comunale delimitato dalla planimetria.

a) diritto fisso per un tempo massimo di sette minuti — L. 27.000 (€ 13,94)
b) Importo a tempo, dopo i primi sette minuti, con scatto ogni 15 secondi — L. 500 (€ 0,25)

RUN SERVICES IN THE HISTORICAL CENTRE BY TAXIMETER
The taximeter rate is valid in the city territory delimited by the planimetry
Bachwards reported.

a) Fixed rate for a maximum of 7 minutes — L. 27.000 (€ 13,95)

b) Time costs, after the said seven minutes with an increase every 15 seconds — L. 500 (€ 0,25)

FAHRTANGEBOTE IM HIST STADTZENTRUM MIT DEM TAXAMETER – der Taxametertarif gilt im Bereich des auf der Rückseite auf einer Karte aufgeführten Stadtgebiets.

a) Festtarif bis zur maximalen Zeit von 7 Minuten L. 27.000 (€ 13,95)

b) Zeittarif, nach den ersten sieben Minuten mit einer Gebühreneinheit pro 15 sekunden — L. 500 (€ 0,25)
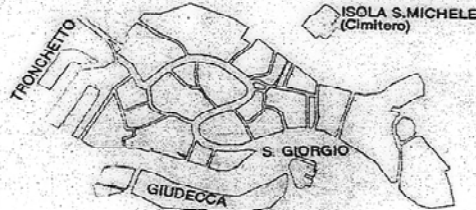
ALLE DETTE TARIFFE SONO APPLICATI I SEGUENTI SOVRAPREZZI:

- Chiamata: in Centro Urbano — L. 8.000 (€ 4,13)
- Chiamata fuori Centro Urbano — L. 10.000 (€ 5,16)
- Servizio notturno: sovraprezzo per corsa L. 8.500 (€ 4,39) dalle ore 22 alle ore 07.00
- Bagaglio: per ogni collo trasportato con lati superiori a cm. 50, L. 2.200 (€ 1,14)
- Servizio sosta: il tassametro continuerà ad essere tenuto in funzione
- Festivo: L. 9.000 (€ 4,65) (non cumulabili con il notturno)
- Per ogni persona superiore alle 4 (sino alle 20) L. 3.100 (€ 1,60)

TO THE AM RATES THE FOLLOWING OVERPRICES ARE APPLIED
- Call in the Urban Centre — L. 8.000 (€ 4,13)
- Call out of the Urban Centre — L. 10.000 (€ 5,16)
- Night service: overprice per run L. 8.500 (€ 4,39) – from 10 pm to 7 am
- Luggage: per each transported parcel having sides over 50 cm. L. 2.200 (€ 1,14)
- Stay service: the taximeter will be kept working
- Holidays: L. 9.000 (€ 4,65) (not to be summed up to the nightly rate)
- Per each person exceeding n. 4 people (till 8 pm) L. 3.100 (€ 1,60)

AUF DIE OBEN ANGEFÜHRTEN TARIFE WERDEN FOLGENDE AUFPREISE ANGEWANDT
- Ruf Innerhalb des Stadtwentrums L. 8.000 (€ 4,13)
- Ruf außerhalb des Stadtwentrums L. 10.000 (€ 5,16)
- Nächtliche Fahrten: Aufpreis pro Fahrt L. 8.500 (€ 4,39) von 22.00 bis 7.00 Uhr
- Gepäck: für jedes transportierte Gepäckstück mit Seiten länger als 50 cm. L. 2.200 (€ 1,14)
- Haltertarif: das Taxameter läuft welter
- Feiertagstarif: L. 9.000 (€ 4,65) (nicht summlerbar m it dem Nachttarif)
- Für jede Person: die vier überschreitet (bis zu 20) L. 3.100 (€ 1.60)

1) Il tassametro deve essere azionato non appena sale a bordo l'utente e inizia il servizio.
1) Das Taxameter muß in Gang gesetzt werden, sobald der Kunde einsteigt und die Fahrt beginnt
2) Per le violazioni in materia tariffaria si procederà ai sensi delle disposizioni emanate con la L.R. 63/93 e relativo Regolamento Comunale di attuazio
2) Bei der Verletzung der Tariffe wird laut der Anordnung des regionalen Gesetzes und der entsprechenden kommunalen Regelung vorgegangen.

Figure 31 Fare sheet for 1993

DIREZIONE SPORTELLO UNICO
Commercio
Ufficio Servizio Trasporto non di linea su acqua

TARIFFE MOTOSCAFI TAXI

(portata fino a 20 persone) determinate nell'anno 2003
DELIBERA G.C. N. 374 del 13.06.2003

Motorboats and Taxies fares (established in 2003) – Tarifs de bateau (determine 2003)

LE TARIFFE DEVONO ESSERE ESPOSTE IN MODO BEN VISIBILE NELLA CABINA DEL NATANTE
E NEI PONTILI DI STAZIONAMENTO

TARIFFE – FARES - TARIFS

SERVIZI DI CORSA A TASSAMETRO – Taximeter Services – Services à taximètre

Diritto fisso alla partenza / Fixed rate at departure / Droits fixes au départ	**€ 8,70**
Scatto a tempo (al minuto) / Time tick per minute / Déclenchement à temps (la minute)	**€ 1,30**
(Lo scatto è contestuale alla partenza) / (the tick is concurrent to the departure) / (Déclenchement au départ)	

ALLE DETTE TARIFFE SONO APPLICATI I SEGUENTI SOVRAPREZZI / The following overprices are to be applied to the a/m rates / Augmentations de prix à appliquer aux tarifs ci-dessus:

1) Diritto di chiamata . . . . € 6,00
   Call-out charge
   Droit d'appel

2) Servizio notturno (dalle ore 22.00 alle ore 07.00): sovraprezzo per corsa . . € 5,50
   Night service: overprice per run – from 10 pm to 7 am
   Service nocturne (de 22.00 h à 7.00 h.): augmentation de prix la course

3) Bagaglio: per ogni collo trasportato con lati superiori a cm. 50 . . . . € 1,50
   Luggage: per transported parcel having sides over 50 cm.
   Bagage: pour tout colis transporté dépassant les 50 cm.

4) Festivo (non cumulabili con il notturno) . . . . € 5,90
   Holidays (not to be summed up to the night rate)
   Augmentation festive (non cumulable à la nocturne)

5) Per ogni persona superiore alle 4 (sino alle 20) . . . . € 1,60
   Per person exceeding n. 4 people (till 20)
   Chaque passager dépassant les 4 personnes (jusqu'à 20 pers.)

6) Servizio sosta: il tassametro continuerà ad essere tenuto in funzione.
   Stay service: the taximeter will be kept working.
   Service de stationnement: le taximètre sera tenu en marche.

- Il tassametro deve essere azionato non appena sale a bordo l'utente e inizia il servizio.
  The taximeter will be activated at the user's boarding.
  Le taximètre sera déclenché à l'embarquement du passager.

- Per le violazioni in materia tariffaria si procederà ai sensi delle disposizioni emanate con la L.R. 63/93 e relativo Regolamento Comunale di attuazione.
  Any transgression will be treated according to the provisions issued from the regional law 63/93 and its municipal regulations.
  Toute violation des prix est à considérer aux termes de la loi régional 63/93 et du rélatif règlement municipal.

Figure 32 Fare sheet for 2003

APPENDIX B

Survey

1.   I have been a taxi driver for __ years.

2.   I work: *as an individual -- in a cooperative -- in a consortium*

3.   I feel that the taxi/nolo fares are:
        Taxi: *too low -- low -- adequate -- high -- very high*

        Nolo: *too low -- low -- adequate -- high -- very high*

4.   Do you think the use of the taximeter is ok:
        <u>In</u> Centro Storico: *yes -- probably yes -- not sure -- probably no -- no*
        <u>Outside</u> Centro Storico: *yes -- probably yes -- not sure -- probably no -- no*

5.   How does your income compare to other taxi drivers?
        within your consortium/coop: *much more - more - equal - less - much less*
        other consortiums/coops: *much more - more - equal - less - much less*
        other individual drivers: *much more - more - equal - less - much less*

6.   Do you feel that working in a consortium/coop impoves your quality of work?
        yes -- probably yes -- depends -- probably no -- no
        Why? _____

7.   What percentage of the your motor operation time do you feel is driving without passengers?
        0-20% -- 20-40% -- 40-60% -- 60-80% -- 80-100%

8.   I prefer my customers to pay with vouchers instead of cash.
        absolutely yes -- yes -- depends -- no -- absolutely no
        Why? _____

9.   Would you like the ability for your passengers to pay directly with a credit card?
        absolutely yes -- yes -- not sure -- no -- absolutely no

10.   Would you like the idea of being able to pass through the Arsenale if there was a small toll you had to pay
        for each trip? *No*
        Yes, if the toll is approximately ___ % of the cost of an alternative route.

11.   Would you like the ability for passengers to share a taxi ride?
        No -- Yes, with a maximum of __ passengers
        Why? _____

12.   When you drive your boat, are you concerned with reducing moto ondoso? *always -- most of the time --
        half of the time -- rarely -- never*

13.   Would you consider a new engine to reduce gas costs?   *absolutely yes -- yes -- maybe -- no --
        absolutely no*

14.   Would you consider a new hull design to reduce moto ondoso?   *Absolutely yes -- yes -- maybe -- no
        -- absolutely no*

15.   For minimizing empty trips, what would you prefer to do at the end of a trip after dropping off passengers?

        *Return to the station of depart, go to the closest station, stay at the place of arrival and wait for the next
        call*

16.   Age: (less than 30)   (30-39)   (40-49)   (50-59)   (60 or older)

17.   Where do you live: *Venezia (incl. Giudecca) -- Lido -- Altre Isole -- Terraferma*

18.   It takes a maximum of ___ minutes to travel from where my house to where I park my boat.

19.   It takes a maximum of ___ minutes to travel from where I parked my boat to the station that I will be
        working at.

20.   Do you think that the taxi/nolo system could be improved?
        absolutely yes -- probably yes -- maybe -- probably no -- absolutely no
        If yes, how? (use the space on the back of this survey to provide your answer)

Worcester Polytechnic Institute

Interdisciplinary and Global Studies Division

Siamo un gruppo di studenti americani del *Worcester Polytechnic Institute* (WPI) e stiamo svolgendo uno studio sul sistema di trasporto taxi a Venezia.

Il progetto è volto al miglioramento dell'efficienza del servizio Taxi/Nolo per la riduzione del moto ondoso a Venezia e questo questionario ci potrà aiutare per capire la Sua opinione e il Suo punto di vista in merito all'attuale sistema di trasporto taxi acqueo.

Speriamo di poter contare anche sul Suo aiuto,

sarà sufficiente completare il seguente questionario.. impiegherete solo 5 min!

Grazie per il vostro tempo e per la vostra collaborazione!

Per maggiori informazioni chiamare il Venice Project Center +39 041 52 33 209

A proposito del Venice Project Centre…

Il VPC è uno dei più importanti dei circa 20 centri che fanno parte della rete che il Politecnico di Worcester, WPI, ha creato in tutto il mondo. Essa comprende centri a Washington D.C., Londra, Bangkok (Tailandia), San Jose (Costa Rica) ed in molti altri paesi del mondo.

Ogni anno, circa 25 studenti di WPI completano una delle due tesi obbligatorie per la loro laurea a Venezia. Dal 1988, oltre 450 studenti di WPI hanno trascorso due mesi a Venezia, completando oltre 100 tesi, raccogliendo ed archiviando su supporto informatico una miriade di informazioni aggiornate su molti argomenti di concreta utilità e collaborando con le più importanti organizzazioni operanti in città, quali il Comune e la Provincia di Venezia, l'Azienda di Promozione Turistica di Venezia, il C.N.R., INSULA S.p.A., l'UNESCO, il Consorzio Venezia Nuova, Thetis, l'Università di Ca'Foscari, lo IUAV, e molte altre.

In particolare, lo spirito del Venice Project Center è sempre stato quello di contribuire concretamente alla salvaguardia, conservazione e manutenzione urbana ed allo sviluppo sostenibile di Venezia. Il VPC conduce "progetti per Venezia" e non semplicemente a Venezia!

Progetto sul miglioramento dell'efficienza del servizio Taxi/Nolo per la riduzione del moto ondoso a Venezia
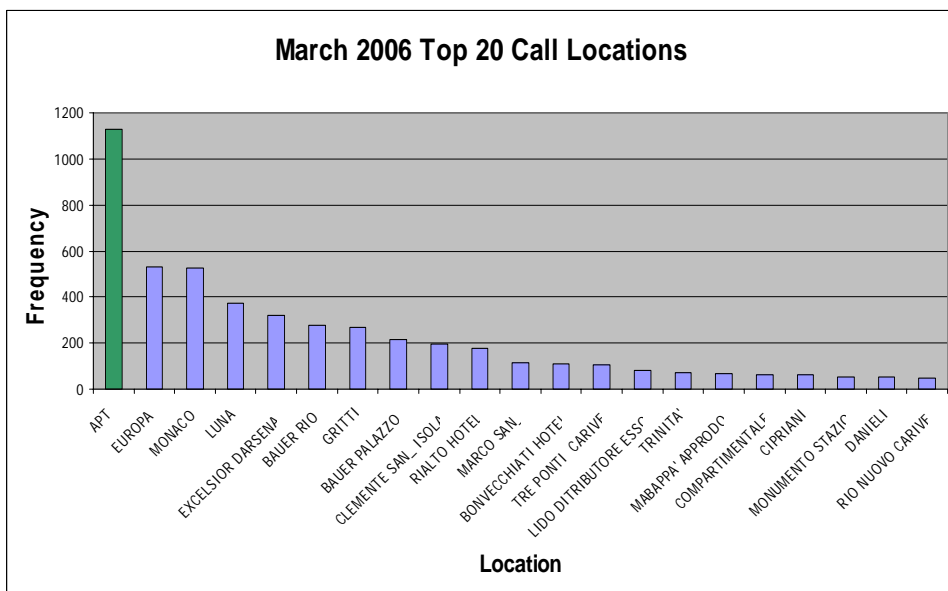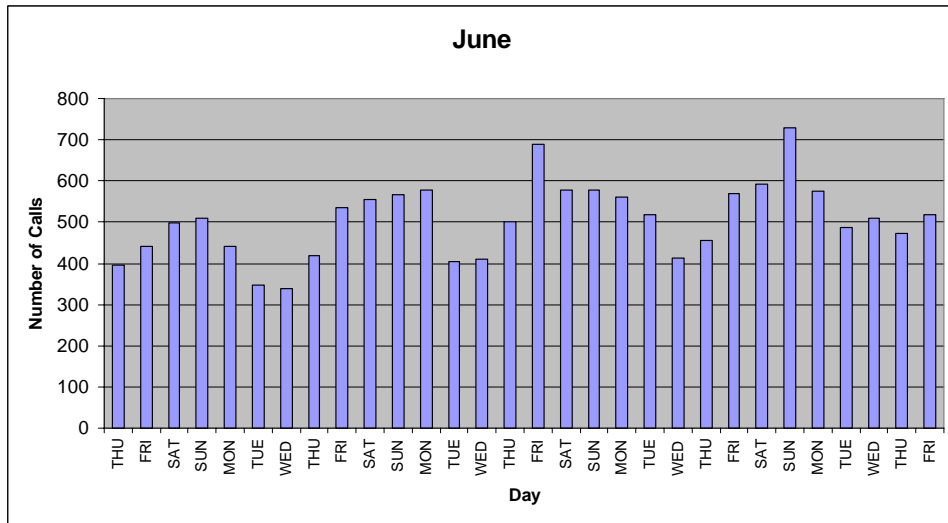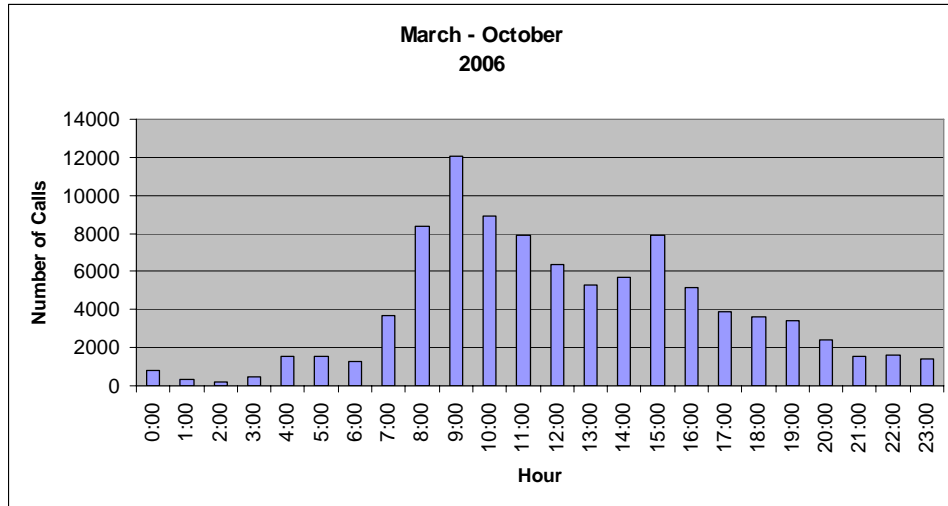
Survey Results

1.　　I have been a taxi driver for __ years.
　　　<1 yr, 2%
　　　1-10 yrs, 67%
　　　11-20 yrs, 22%
　　　21-30 yrs, 7%
　　　31-40 yrs, 2%

2.　　I work: *as an individual (22%) -- in a cooperative(14%) -- in a consortium (20%) – both (44%)*

3.　　I feel that the taxi/nolo fares are:
　　　Taxi: very low (51%)-- low (44%) -- adequate (5%) -- high -- very high
　　　Nolo: very low (11%) -- low (16%) -- adequate (73%) -- high -- very high

4.　　Do you think the use of the taximeter is ok:
　　　In Centro Storico: yes (57%) -- probably yes (33%) -- not sure (5%) -- probably no -- no (5%)
　　　Outside Centro Storico: yes (0%) -- probably yes (2%) -- not sure (4%) -- probably no (9%) -- no (85%)

5.　　How does your income compare to other taxi drivers?
　　　within your consortium/coop: more (7%) - equal (86%)% - less (7%)
　　　other consortiums/coops:　　more (2%) - equal (80%) - less (18%)
　　　other individual drivers:　　more (23%) - equal (16%) - less (61%)

6.　　Do you feel that working in a consortium/coop impoves your quality of work?
　　　yes (55%) -- probably yes (10%) -- depends(18%) -- probably no (12%) -- no (5%)

7.　　What percentage of your motor operation time do you feel is driving without passengers?
　　　0-20% (7%) -- 20-40% (44%) -- 40-60% (45%) -- 60-80% (2%) -- 80-100% (2%)

8.　　I prefer my customers to pay with vouchers instead of cash.
　　　absolutely yes -- yes (7%) -- depends (50%) -- no (33%) -- absolutely no (10%)

9.　　Would you like the ability for your passengers to pay directly with a credit card?
　　　absolutely yes -- yes (25%) -- not sure (6%) -- no (38%) -- absolutely no (31%)

10.　　Would you like the idea of being able to pass through the Arsenale if there was a small toll you had to pay for each trip? *No (40%) Yes, if the toll is approximately ___ % of the cost of an alternative route. (60%)*

11.　　Would you like the ability for passengers to share a taxi ride?
　　　Taxi: No (31%) -- Yes, with a maximum of __ passengers (69%)
　　　Nolo: No (53%) -- Yes, with a maximum of __ passengers (47%)

12.   When you drive your boat, are you concerned with reducing moto ondoso?
        always (58%) -- most of the time(42%) -- half of the time -- rarely -- never

13.   Would you consider a new engine to reduce gas costs?   *absolutely yes (28%) -- yes (58%) -- maybe (9%) -- no (5%) -- absolutely no*

14.   Would you consider a new hull design to reduce moto ondoso?   *Absolutely yes -- yes (23%) -- maybe (18%) -- no (59%) -- absolutely no*

15.   For minimizing empty trips, what would you prefer to do at the end of a trip after dropping off passengers? *Return to the station of depart (11%), go to the closest station (38%), stay at the place of arrival and wait for the next call (42%), other (9%)*

16.   Age: *(less than 30), 12% -- (30-39), 41% -- (40-49), 37% -- (50-59), 10% -- (60 or older)*

17.   Where do you live: *Venezia (incl. Giudecca) (58%)   -- Lido (11%) -- Altre Isole -- Terraferma (31%)*

18.   It takes a maximum of ___ minutes to travel from where my house to where I park my boat.
        0-9 (17%)
        10-19 (48%)
        20-29 (12%)
        30-39 (17%)
        40-49 (3%)
        50-60 (3%)

19.   It takes a maximum of ___ minutes to travel from where I parked my boat to the station that I will be working at.
        0-9 (0%)
        10-19 (55%)
        20-29 (23%)
        30-39 (12%)
        40-49 (7%)
        50-60 (3%)

20.   Do you think that the taxi/nolo system could be improved?
        absolutely yes (68%) -- probably yes (24%) -- maybe (8%) -- probably no -- absolutely no

APPENDIX C

March - October
2006

Number of Calls vs Hour bar chart

June

Number of Calls vs Day bar chart

March 2006 Top 20 Call Locations

Frequency vs Location bar chart with locations: APT, EUROPA, MONACO, LUNA, EXCELSIOR DARSENA, BAUER RIO, GRITTI, BAUER PALAZZO, CLEMENTE SAN_ISOLA', RIALTO HOTEL, MARCO SAN, BONVECCHIATI HOTEL, TRE PONTI CARIVE, LIDO DITRIBUTORE ESSO, TRINITA', MABAPPA' APPRODO, COMPARTIMENTALE, CIPRIANI, MONUMENTO STAZIO, DANIELI, RIO NUOVO CARIVE

APPENDIX D

Outline for the new dispatch system:

Inputs:
> Boat shift schedules
> Taxi locations schedules
> Staffing demand at locations
> Taxi status from inputs on boat
>> IN USE
>> AVAILABLE TRANSIT
>> AVAILABLE DOCK
>> AVAILABLE TEMP
> Call info from operator input
>> Location of pickup
>> Time of pickup
>> Number of people
>> Destination

Constantly happening:
> Update Locations of all boats
> Control the staffing of all Base locations
>> Regulate the staffing at locations
>>> If a base location is under the staffing threshold, then fill the empty space effectively
>>> If a base location is over the staffing threshold, dispatch the boat to a more effective location

> Run a Timing on all taxis with Status AVAILABLE TEMP
>> Monitors the time that a taxi is at a temporary parking space
>> At the maximum legal time limit (15 minutes) alert the taxi driver that he must move.
>> Run return dispatch system

> Monitoring Taxi Status:
>> On delta Taxi status:
>> From IN USE to AVAILABLE
>> System gives the drivers the option for Temp parking allowing them to select the status AVAILABLE TEMP or AVAILABLE TRANSIT.
>> If AVAILABLE TEMP is not selected with in X time
>>> Run RDS

> Monitor Calls list
>> On new call, run CDS

CDS - Call Dispatch System
> Collect positions from all taxis

Rank Boats for specific call
       Criteria for the rating:
              Proximity to call
              Current position
                     Docked At base
                     Docked at Temp
                     Empty in Transit
                     Unavailable: With passengers
              Current Job count
Assign a boat to the call
Add one call to the call count for that boat

RDS – RETURN DISPATCH SYSTEM
           The Return Dispatch System is designed to identify a position for empty
Taxis to return to after completing a job. The sole purpose of this system is to reduce
moto ondoso
       Update positions of all boats
       Rank bases
              Rank Criteria:
                     Proximity
                     Demand
                     Unfilled spaces
       Assign unfilled space to boat
       Dispatch boat to space at base

Proposed Taxi Dispatch system

Operator Display Unit

Record and Store Taxi GPS Positions

Constant Monitoring System

Monitor Taxi Status

Change in Taxi Status results in running Return Dispatch system

Updated Taxi Status Record

Maintain Call Count Record

GPS

Taxi Stat

Boat Demand

Regulate the Staffing of Taxi and Nolo basses

Shift Taxis to Fill demand upon boat count outside thresholds

Cell Dispatch System

Temporary Ranking List

Ranks Taxi's on proximity and Call count

After Selection

Confirm Selection with Taxi

Dispatch Taxi to Call Location

Return Dispatch System

Run a Timer if Taxi selects Temporary parking. Continue after 15' has elapsed

On Change of Status from INUSE to AVAILIBLE

Rank Taxi Stands according to proximity and staffing requirements.

Dispatch Taxi to the selected location