Optimizing the Use of Canal Parking Space in Venice

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

Submitted By:
Gregory Bukowski
Briana Dougherty
Russell Morin
Patrick Renaud

Sponsoring Agency:
l'Ufficio Mobilità Acquea

Submitted To:
Project Advisors:
Fabio Carrera
Scott Jiusto
On-Site Liaisons:
Daniela Pavan

Date: December 15, 2006
ve06-canals@wpi.edu
http://users.wpi.edu/~rmorin/Venice
Authorship Page

This project was completed through equal contribution of each group member. The work represented in this report is original unless otherwise cited.

Gregory Bukowski

Briana Dougherty

Russell Morin

Patrick Renaud
Acknowledgements

We would like to first thank our advisors Professor Fabio Carrera and Professor Scott Jiusto for their guidance throughout our work on this project.

Thanks to Daniela Pavan and all the members of the Venice Project Center for their technological and translational help.

Thanks to Manuele Medoro and Andrea Maggio for allowing us to do this project and getting us whatever information we needed.

Thanks to our families for allowing us to come to Italy and supporting us from afar.
Abstract

This project gathered data about the interaction between boat traffic and parking in Venice, Italy in order to identify criteria for the allocation of permanent and temporary parking permits. To monitor and implement these changes, we designed an electronic parking management system to assist the city in reducing the amount of time needed to process permit applications. The implementation of this system will thus benefit both the citizens and the city, and will help decrease the cost of traffic congestion.
Executive Summary

Venice, Italy is served by a transportation system unlike any other in the world. It consists of nearly 200 canals, ranging from a few meters across to the width of a football field and contains an intricate system of taxi, gondola, cargo, and other service boats driving throughout the city. Managing parking permits and controlling boat traffic is therefore a complex task. Impediments to traffic flow are often caused by inadequate room for boats to pass one another. The city has the resources and opportunity to use new technology to better manage the system, but it requires detailed planning and analysis. This project sought to minimize the hindrances to traffic due to parking within the Venetian canals, as well as to minimize the time it takes for a permit to be processed through the design of an online GIS system.

Background: Current Parking Management

Processing permit applications can be a lengthy procedure for Mobilità Acquea since they receive about 1,200 permanent applications and about 3,000 temporary applications a year. Temporary parking permits (see Figure 1) are obtained from boats that typically require only a few days of parking on a specific canal. There is no fee charged for the application or the permit. Permanent parking permits (see Figure 2) are typically obtained for boats that require long-term parking and are usually obtained by those who live or work in a specific area. There is no fee for a permanent parking application, but once a citizen acquires a permanent space they must pay a fee to occupy the space based on the amount of area occupied and renew it yearly. Temporary parking permits for periods ranging from a single day up to several months are requested regularly and are processed in minutes. Receiving a permanent permit is a lengthy process for the citizen because it can take upwards of 10 months to get a response from Mobilità Acquea.

The flow chart in Figure 3 shows the current system permanent permit process used by Mobilità Acquea.


Acquea and the various agencies that work in conjunction with them. Mobilità Acquea has to process all the applications by hand and import them into the computer as well as manually create spots for applicants.

The overall system takes nearly a year to process an application before an applicant will find out if their application has been rejected. An electronic system with a quicker response time would be much more cost effective and save Mobilità Acquea valuable resources.

**Project Objectives and Methods**

To develop and optimize parking in the city and improve the parking management system our methodology focused on three main objectives.

1: To study the current system in place in Venice with regards to the interaction between parked boats and through traffic.

2: To optimize available canal space for parking while preventing a negative effect on traffic flow.

3: To design an electronic system to improve the permit application process and reduce the previously found traffic problems.

**Key Results: Identification of Parking and Traffic Problems**

A thorough study was conducted to assess the current issues related to the interaction between parked boats and through traffic. Our survey area consisted of 7 specific locations

<table>
<thead>
<tr>
<th>Types of Problems</th>
<th>Description of Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Destination Problems</strong></td>
<td></td>
</tr>
<tr>
<td>Blocking of docks</td>
<td>When a boat either parks for too long at a dock, or at a dock it’s not supposed to be at.</td>
</tr>
<tr>
<td>Canal closures</td>
<td>When a canal is closed, it reroutes traffic and causes heavier traffic and parking on neighboring canals</td>
</tr>
<tr>
<td><strong>Travel Restrictions</strong></td>
<td></td>
</tr>
<tr>
<td>Lack of pullover lanes</td>
<td>Blocked docks and illegal parking lead to a lack of pullover lanes, which could lead to double parking and bottlenecking.</td>
</tr>
<tr>
<td>Double parking</td>
<td>Boats need to unload cargo and do not have access to a dock because there is a boat already there.</td>
</tr>
<tr>
<td>Physically narrow canals</td>
<td>Canals that are too small for two-way traffic.</td>
</tr>
<tr>
<td>Parking under bridges</td>
<td>With acqua alta, high tide, the travel lanes get shifted according to where the boats can pass under the bridge.</td>
</tr>
</tbody>
</table>

Table 1: Types of problems found with the interaction between parked boats and traffic
within Cannaregio and Castello to gather data about interaction between parking and traffic. Data gathered from these areas was used to identify a typology of problems that occur on the canals.

The majority of the traffic problems seen were a result of some parking issue. These issues were classified into one of two categories of problems: destination problems and travel restrictions. A table of the specific problems and a brief description can be seen in Table 1. Blocked docks, double parking and bottlenecking were the main issues observed. These were observed by themselves, or concurrently with another issue. Bottlenecking was usually a result of double parking, because double parking causes the travel lanes to narrow leading to a bottleneck effect in the flow of traffic. Double parking typically resulted from blocked docks, because if a boat could not access the dock it needed to, it would double park next to the boat parked there and unload its cargo over the already parked boat. Blocked docks are usually results of boats without a permit for the spot parking there. This is most likely because of the lack of spaces in the canal. People decide to make their own spaces instead of waiting to hear a response from Mobilità Acquea. Permit applications are not too much work for the citizen, but it takes the city a fair amount of time to get the responses out.

**Optimization of Canal Space for Parking**

The team used the data collected from our test areas in conjunction with that collected by Mobilità Acquea to create a series of GIS maps illustrating the most efficient usage of the available canal space. Using the problems identified in the previous section, we analyzed the current parking structure and evaluated how currently parked boats cause traffic problems. A set of general rules for canal parking management was developed to insure that each canal will have the necessary resources to serve its function without causing traffic problems. Each canal segment needs at a minimum one dock for garbage boats, a cargo dock on each side, and one dock for temporary parking to function properly. Through this objective the team was able to identify ways to optimize the use of the water space for parking while working to prevent traffic hindrances.

**Design of the Electronic Parking Management System**

Using the maps showing the optimal layout of canals and the rules for general canal management that were generated in the previous section, the team developed a mock up of an online GIS application to improve the parking management system currently in place in Venice. This proposed system combines the management of permanent and temporary parking permits into a centralized system. An applicant for a permanent permit will be able to apply for a space online and the system will search for the closest available water space, or spazi acquo, to the area requested. An applicant for a temporary permit will be able to find a space in
a similar manner. The flow of this proposed system can be seen in Figure 4. *Mobilità Acquea* receives notification automatically as applications are filed with the system and can choose to manually approve them or allow the computer intelligence to decide which applications to approve.

The electronic parking management system will also accept complaints from its users. If a person identifies a problem with a parked boat or an infraction of a parking regulation, they can submit the complaint to the system with a picture of the problem. These complaints will help validate the data stored in the parking management database and remove parking and traffic problems.

Since there is no fee in place regarding temporary permits, we propose that an application fee of €10 be implemented. This fee will decrease the number of applicants who continually apply for temporary permits to avoid paying for a permanent space. It will also give *Mobilità Acquea* a source of funds that can be used to create and implement our proposed electronic system.

This new electronic system will decrease the amount of city time needed to process an application. The present system currently can take upwards of a year to process an application. As of early December 2006 *Mobilità Acquea* still has applications from 2005 to process. The implementation of an electronic system will cut down on this time dramatically, as shown in Figure 5.

**Project Outcomes**

This Interactive Qualifying Project was conducted to minimize the hindrances to traffic due to parking within the Venetian canals, as well as to minimize the time it takes for a permit to be processed through the design of an online GIS system. By optimizing the use of canal parking space in Venice, *Mobilità Acquea* will be able to better allocate space and canal traffic will have less hindrances. The electronic system will store the data about all types of parking in a central database. This will improve the ability to enforce parking regulations by making information about permanent and temporary parking readily available. Parking regulation enforcement will also be improved by vigilant citizens reporting issues they find with the complaint console. Canal users will be able to obtain parking permits in a timelier manner and the city will save valuable time and resources with the new electronic process. The proposed GIS system will streamline the process of permit allocation for the city. With the implementation of temporary permit application fees Venice will gain a valuable economic resource that could be used to fund the creation of the system.
TABLE OF CONTENTS

AUTHORSHIP PAGE.............................................................................................................. I

ACKNOWLEDGEMENTS....................................................................................................... II

ABSTRACT ........................................................................................................................... III

EXECUTIVE SUMMARY................................................................................................... IV

Background: Current Parking Management ................................................................ iv
Project Objectives and Methods ....................................................................................... v
Key Results: Identification of Parking and Traffic Problems .......................................... v
Optimization of Canal Space for Parking ........................................................................ vi
Design of the Electronic Parking Management System ................................................. vi
Project Outcomes ............................................................................................................ vii

1 INTRODUCTION........................................................................................................... 1

2 BACKGROUND............................................................................................................. 3

   2.1 VENETIAN BOATS .................................................................................................. 3

   2.1.1 Cargo Delivery System in Venice ................................................................. 5

   2.2 PARKING MANAGEMENT PRACTICES ............................................................. 6

   2.3 BOAT TRAFFIC IN VENICE ............................................................................... 8

   2.3.1 Venice Traffic Management and Regulations ............................................... 8

   2.3.2 Traffic Problems in Venice .......................................................................... 10

   2.4 PARKING IN VENICE ....................................................................................... 10

      2.4.1 Parking Regulations ............................................................................... 11

      2.4.2 Overnight Parking Permits ................................................................. 12

      2.4.3 Temporary Parking ................................................................................. 14

3 METHODOLOGY......................................................................................................... 16

   3.1 STUDYING THE INTERACTION BETWEEN PARKED BOATS AND THROUGH TRAFFIC ............................................................................................................. 17

      3.1.1 Obtaining previously existing traffic data ............................................. 17

      3.1.2 Obtaining previously existing parking data ........................................ 17

      3.1.3 Obtaining Information About the Current System ......................... 18

      3.1.4 Validating and Refining Methodology ............................................. 19

      3.1.5 Observing the Interaction Between Traffic and Parked Boats .......... 20

      3.1.6 Archiving Project Information ......................................................... 20

   3.2 OPTIMIZING CANAL SPACE FOR PARKING WHILE PREVENTING TRAFFIC HINDRANCE ............................................................... 20

      3.2.1 Creating Maps of the Current Water Space Usage for Project .......... 21

      3.2.2 Identifying Areas where Parking and Buffers Interfere ....................... 22

      3.2.3 Relocating Spaces to Remove Buffer Zone Conflicts ....................... 22

      3.2.4 Evaluating Current Buffer Zones ...................................................... 22

      3.2.5 Determining Locations for Traveling Lanes ................................. 22

      3.2.6 Identifying Areas Outside of Traveling Lanes Suitable for Boats to Park .... 23

      3.2.7 Identifying Areas to be used as Pull Over Zones ......................... 23

   3.3 DESIGNING A SYSTEM TO IMPROVE THE PERMIT PROCESS ......................... 23

4 RESULTS AND ANALYSIS............................................................................................ 24
# TABLE OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Present temporary parking permit application.</td>
<td>iv</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Present permanent parking permit application.</td>
<td>iv</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Flow chart of the current permit system.</td>
<td>v</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Flow chart of the new electronic system.</td>
<td>vi</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Comparison of the old and new systems.</td>
<td>vii</td>
</tr>
<tr>
<td>Figure 6</td>
<td>The makeup of boat traffic in Venice.</td>
<td>3</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Gondola</td>
<td>4</td>
</tr>
<tr>
<td>Figure 8</td>
<td>A double parked car</td>
<td>5</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Example of Park-It system - shows vehicle information and any violations.</td>
<td>6</td>
</tr>
<tr>
<td>Figure 10</td>
<td>ParkMobil card</td>
<td>7</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Permit only parking sign.</td>
<td>8</td>
</tr>
<tr>
<td>Figure 12</td>
<td>One-way canals</td>
<td>8</td>
</tr>
<tr>
<td>Figure 13</td>
<td>The various speed limits in the city of Venice.</td>
<td>9</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Canal Regulations</td>
<td>10</td>
</tr>
<tr>
<td>Figure 15</td>
<td>An overflow marina on Giudecca</td>
<td>10</td>
</tr>
<tr>
<td>Figure 16</td>
<td>The buffer zones around docks (green), water doors (red), and intersections (blue).</td>
<td>12</td>
</tr>
<tr>
<td>Figure 17</td>
<td>A flow chart showing the current permanent parking permit application process.</td>
<td>13</td>
</tr>
<tr>
<td>Figure 18</td>
<td>Present permanent parking permit application.</td>
<td>13</td>
</tr>
<tr>
<td>Figure 19</td>
<td>A screen shot of the program currently used by the city to issue parking permits.</td>
<td>14</td>
</tr>
<tr>
<td>Figure 20</td>
<td>Present temporary parking permit application.</td>
<td>15</td>
</tr>
<tr>
<td>Figure 21</td>
<td>Study area in Cannaregio and Castello.</td>
<td>16</td>
</tr>
<tr>
<td>Figure 22</td>
<td>The layout of the initial pilot study location.</td>
<td>19</td>
</tr>
<tr>
<td>Figure 23</td>
<td>The layout of the second pilot study area.</td>
<td>19</td>
</tr>
<tr>
<td>Figure 24</td>
<td>The locations of our data collection points.</td>
<td>20</td>
</tr>
<tr>
<td>Figure 25</td>
<td>Parking space map.</td>
<td>23</td>
</tr>
<tr>
<td>Figure 26</td>
<td>Garbage man moving personal boat.</td>
<td>25</td>
</tr>
<tr>
<td>Figure 27</td>
<td>Double parked boat blocks canal.</td>
<td>25</td>
</tr>
<tr>
<td>Figure 28</td>
<td>Narrow canal does not allow two-way traffic.</td>
<td>26</td>
</tr>
<tr>
<td>Figure 29</td>
<td>Current Electronic System.</td>
<td>27</td>
</tr>
<tr>
<td>Figure 30</td>
<td>Comparison of the old and new systems.</td>
<td>27</td>
</tr>
<tr>
<td>Figure 31</td>
<td>New Electronic System Welcome Screen.</td>
<td>28</td>
</tr>
<tr>
<td>Figure 32</td>
<td>Permanent permit application system with surrounding boat information.</td>
<td>29</td>
</tr>
<tr>
<td>Figure 33</td>
<td>A window showing parking space information with the option to file a complaint.</td>
<td>29</td>
</tr>
<tr>
<td>Figure 34</td>
<td>Temporary system account maintenance screen.</td>
<td>30</td>
</tr>
<tr>
<td>Figure 35</td>
<td>Admin Welcome Screen.</td>
<td>31</td>
</tr>
<tr>
<td>Figure 36</td>
<td>A screen shot of the data sheet to gather information about traffic congestion problems.</td>
<td>37</td>
</tr>
<tr>
<td>Figure 37</td>
<td>A screen shot of the form used to collect data on individual parking space usage.</td>
<td>38</td>
</tr>
</tbody>
</table>
TABLE OF TABLES
Table 1: Types of problems found with the interaction between parked boats and traffic..........................v
Table 2: GIS layers we obtained................................................................................................................18
Table 3: GIS layers created...........................................................................................................................21
Table 4: Types of problems found................................................................................................................24
Table 5: The top 10 canals for problematic space .........................................................................................33
1 Introduction

Venice, Italy is the home to one of the most unique transportation systems in the world. Instead of using roads like a traditional city, Venice’s transportation infrastructure is comprised of an intricate network of canals. Even though Venetians travel in boats rather than cars, they still encounter many of the same traffic and parking problems related to any major metropolitan city. Due to the rapid growth of urban populations, certain traffic and parking issues arise. Traffic and parking structures are necessary to the proper development of growing urban areas. Many cities are creating their own solutions to this problem by drawing on the past experiences of others and implementing new ideas.

The overcrowding of canals in Venice is a manifestation of similar problems other large cities also face. Venice is rapidly becoming more inundated by tourists, while the city loses its local population each year. In 1951, the local population was approximately 171,000 residents. Today, the Italian city has fallen to below 63,000 Venetians, while tourism has soared to an estimated 18 million in the past year. As this last number continues to rise, the vast majority want an experience of Venice’s famous canal system. Tourism causes the canals to become congested with public services such as taxi and gondola rides. Those who use the canals for other services such as garbage pick up and cargo deliveries attest that the waterways are unnecessarily congested. Delivery companies, who use docks to load and unload colli, or cargo, agree organized parking would aid this growing problem. Another aspect of the problem is caused by residential parking which must also be along the canal walls. Further compounding the problem is the fact that it can take upwards of 10 months to receive word about whether an overnight parking permit application has been approved. People are not realistically able to wait this long to get permission to park their boats. Organizing the use of temporary space and overnight parking would improve the traffic flow in the city. Venice cannot alleviate the amount of traffic without a more systematic parking structure.

Much has been learned about parking management through trial and error of different systems. Since 2003 a European Union project called Mobilis has provided ample groundwork to improving parking systems throughout Europe. Its goal is to implement transport measures and technology to create an adequate transportation system that helps the European citizen. The EU Mobilis project has recently granted funds to help alleviate some of the parking problems that plague Venice. Studies in Mestre, mainland Venice, have found that a stratified pricing system for parking can diminish demand in areas where parking is most sought after. Other demand management occurs in cities such as Boston, restricting on-street parking in certain high demand areas to residents only. It is common practice in cities to designate specific temporary parking spaces for loading and unloading to alleviate traffic congestion. A previous project by students at Worcester Polytechnic Institute discovered that by centralizing the delivery locations of cargo in Venice and managing when cargo boats can use these locations, cargo traffic on the canals of Venice could be reduced by as much as 90 percent. In recent years, the city has adopted a new set of dock regulations for cargo boats to park temporarily and ease traffic congestion. All docks now have a number and a designated use posted on a sign nearby. Only certain types of boats are allowed to park at specified docks. Garbage boats and gondolas have docks that are tagged.

1 Povoledo, Elisabetta. Vanishing Venice.
specifically for them. For some companies that have issues with parking their service boats overnight, parking lots on the outer parts of the city have been implemented. All these lessons learned throughout the world and within Venice have proven to be useful in designing a parking management system to meet the city’s unique needs.

Despite all the changes that have been applied in the city of Venice, there is still a conflict with traffic and parking. Legal issues with parked boats arise as Venetian authorities find it nearly impossible to enforce parking regulations. People who neglect the current legal system are frequently overusing docking areas and other parking spaces. This often takes away available space for other canal travelers. Maintenance causes the diversion of traffic to other canals and it also displaces all the parked boats in that area. This further aggravates the traffic problems in other areas. If the system of assigning parking spaces was optimized, the flow of traffic would improve and the benefits of previous efforts would be more visible however, there had not previously been a thorough study of the area to determine what space can be used for boat parking without adding unnecessary hindrance to canal traffic. The current process can also take upwards of 10 months to deliver a response to someone who applies for a permit. Minimal research has been carried out to determine the relative demand for parking in different locations of the city at different times of the day. Previously gathered information on the traffic patterns of the city and the newly gathered parking demand data has not been fully utilized to develop an effective parking model that satisfies the city’s needs.

The goal of this project was to address these research gaps and provide *Mobilità Acquea* with a method to better allocate both permanent and temporary parking spaces to remove unnecessary hindrances to the flow of traffic through the canals. The team systematically inspected the current use of canal space for parking and areas where there are traffic flow issues to determine the types of problems that occur. This data was then evaluated to determine the state of the current parking system and the steps needed to be taken to implement an electronic system to optimize parking. The team then used the gathered information in combination with previously existing traffic flow data to design a model web GIS system to assign permanent and temporary parking spaces.
2 Background

The city of Venice’s water mobility office, the Ufficio Mobilità Acquea, and the European Union would like to increase the efficiency of traffic flow on the canals of Venice, but the current system of allocating temporary and overnight parking spaces causes congestion and confusion. This problem is occurring because the current system to allocate parking spaces is not designed to effectively organize how spaces are distributed. People are given the parking spaces they request almost without exception if the space is not already taken by another boat. Bottlenecking and other traffic congestion occurs in many sections of the city where the canals are narrow. Also, when canals are closed, new parking spaces must be found to park the displaced boats. Cities around the world have been facing similar issues with parking cars on their streets. Many methods of managing parking within cities have been developed that may be useful to implement in Venice.

In this chapter the pertinent background information about traffic and parking in the city of Venice and parking management will be discussed in order to gain a thorough understanding of the topic. Information will be given about the current makeup of canal traffic in Venice as well as the traffic and parking regulations the city currently has in place. Parking management systems and some of their previous implementations will be described. In some cases the strategies used in other cities cannot be applied in Venice due to its unique structure. There are electronic methods of managing parking systems that may be useful in Venice. Also, data gathered from previous WPI projects and studies completed by Forma Urbis about parking and travel in Venice will be looked at to obtain a strong knowledge base.

2.1 Venetian Boats

Venice is unlike any city in the world because its transportation system relies entirely on boats. All of these boats are required to be registered with the city and carry documentation of this registration with them at all times. The majority of the traffic seen on the city’s canals is comprised of commercial boats that help keep the city running. Like any city, Venice requires a large supply of consumer goods to function. All of these supplies must be delivered to the city by boats. Venice also needs other services that wheeled vehicles traditionally provide in other cities to be provided by boats. Venice has boats to pick up garbage, fight fires, and transport the injured as well as many other boats that fill the various niches in the city’s economy. The makeup of the boats in Venice as determined during an April 2006 study can be seen in Figure 6.

One major aspect of Venice’s economy is the tourism industry. Tourists have a need to get around the city rapidly to see as much as possible in the limited time they are visiting. There

![Makeup of Canal Traffic (April 2006)](image)

Figure 6: The makeup of boat traffic in Venice
is a wide selection of transportation options available for tourists including waterbuses, taxis, and gondolas. The waterbuses, or *vaporetti*, make frequent stops along many routes throughout the city. A more expensive, but more direct means of getting around the city are the water taxis. Traditional Venetian gondolas are also a favorite mode of transportation for tourists who want to get the most out of their Venetian experience. There are also ferries known as *traghetto* which will carry people across the Grand Canal in a gondola at various points to avoid walking to one of the three bridges that cross the Grand Canal.\(^5\)

All of the goods the city of Venice uses need to be brought into the city on cargo boats. These boats need to park temporarily at docks all over the city to unload their cargo. The cargo boats encounter traffic problems as well as cause them. Many boats park at docks for longer than the 15 minutes they are allowed to. Also, many cargo boat owners leave their boats at cargo docks for extended periods of time. When other cargo boats arrive to use a frequently used dock and there are boats in their way, traffic congestion inevitably occurs.

Along with all the commercial traffic that exists on Venice’s canals, there is also traffic from private boats owned by residents. Venetians normally don’t use their personal boats like someone would use a car in the United States. The primary mode of getting around within the city for Venetian citizens is walking. Personal boats are only used for leisure activities or when transporting something that is too large or difficult to move by hand. Often personal boats will be left in their assigned parking space for months at a time, especially in the winter months. If the spaces for these boats were improperly placed, they can cause ongoing traffic issues.

The different styles of boats are important to understand when learning about the traffic within the city. Past project groups from WPI who have conducted studies relating to the canals of Venice have studied the make-up of which boats use the canals. Each type of boat is given a specific name, and they are generally grouped differently according to size, shape, and use. For example, gondolas are classified as a row boat. Gondolas are very popular in Venice due to the amount of tourists seeking the experience to ride on one (see Figure 7). While the width of this boat type is relatively small, there are other wider gondolas called *traghetto*, which are typically used throughout the Grand Canal. Cargo boats occupy the most amount of space in the canal and also typically cause a majority of congestion within Venice. Cargo boats are divided into four categories. They are grouped by size into small, medium, large, and extra-large boats. Small boats are used to deliver small amounts of merchandise to homes and shops. They are approximately the size of a canoe or rowboat, which is about five meters in length. They have a section in the middle that is used to store merchandise and they can travel through most canals regardless of tides. A medium cargo boat is about twice the length, about 10 meters, of a small boat. They are the most common cargo boats found in the canals, and are classified by the type of cargo they are carrying. These include refrigerated cargo boats, beverage boats, construction boats, garbage boats, and luggage boats. Large boats are 13 meters long and are classified in the same manner as a medium boat. These boats are able to cause the most amount of destruction to other boats within the canal because the weight of the load they carry is made of much heavier material. Extra-large boats are approximately 20 meters long. They travel

---

\(^5\) Imboden, Durant and Cheryl. Venice Transportation.
solely on the Grand Canal because they are too big for smaller canals and they carry large equipment such as cranes and tractors.

Taxi boats are also common in the canals. The average size of a taxi boat is about 9 meters by 2.3 meters and they normally use one or two internal combustion engines. Public Service boats are the emergency boats for fires, and law enforcement as well as postal services. These boats are approximately 1.9 meters wide and have motors similar to taxi boats.6

2.1.1 Cargo Delivery System in Venice

During a 2001 project conducted by students from the Worcester Polytechnic Institute, concerning the organization of the cargo boat delivery system within Venice, cargo boat routes were optimized to help reduce the amount of unnecessary traffic within the canals. This project assessed dock locations and loading procedures at private docks in order to show inefficiencies in the cargo delivery system. In 2001, 385 cargo boats used the Venetian canals and the men unloading cargo stated that unreliable dock availability was a main concern.7 It is not uncommon for several boats to want to dock at the same location multiple times throughout the day, causing congestion along the canal. Cargo delivery men either have to wait for a dock to free up or tie the cargo boat alongside another one already unloading. Although this WPI group delivered a plan to minimize this problem, it has yet to be implemented in practice and these situations frequently still arise today.

Many factors cause congestion of cargo boats within the city. Increasingly high tides over the years create too little clearance for many boats to pass under bridges. A parking system needs to take into account the location of the canals that restrict cargo delivery due to rising tides. Also, traffic can quickly thicken within narrower canals while people are loading and unloading cargo and others impatiently wait by. During this process other cargo boats re-route and seek different paths to reach their destination, creating more congestion in other areas. The 2001 WPI project only answered the question how to efficiently direct cargo deliveries. Obstructions such as double parked cargo boats still arise due to inefficient parking usage while at temporary docks. The 2001 cargo team obtained detailed maps of the canals which aid in parking management. The group also collected information concerning canal rules and regulations in Venice which were useful to this project.

In 1997, another WPI group created a proposal also dealing with restructuring the cargo system in Venice. One main goal of the project was to decrease congestion within the canals and moderate environmental damage along these walls. Much of the data gathered from this project is relevant to the implementation of a new parking structure. Pertinent data includes dock information with dock type, which canal each dock is in, the island it is on, the number of steps, dock width and length, canal width, condition of dock, and how many poles are attached.8

---

6 Cioffi, Carlo M. et al.
7 Duffy, Jill et al.
8 Amlaw, Karolyn et al.
group also used MapInfo to create the location of all docks in the city. The group observed obstructions in the cargo delivery system due to other service boats congesting docking areas throughout the day. The main two types of service boats causing a problem with cargo boats are taxi boats and gondolas. These two boats are very active after noon each day, and traffic jams typically occur between gondolas, taxis, and cargo deliverers between the hours of 12:00 and 5:00. Due to this observed problem, the group proposed that suitable docks be designated for gondolas, cargos, and taxi boats during the afternoon hours. This will limit the amount of congestion at certain docks through the canals of Venice.

2.2 Parking Management Practices

To properly understand how to resolve Venice’s issues with parking, we researched methods used in other cities to manage their parking problems. Large metropolitan areas often face the growing problem of where to allow public parking. Some cities have implemented individual methods to manage their parking systems, but these systems often differ from one to the other even though they seek one common goal of managing residential parking. As the population in these cities increases, so does the number of vehicles. In many cases residents cannot find places to park their vehicles and resort to double parking. The consequence of this is a blocked roadway (see Figure 8). Due to the white car being double parked, the large truck is unable to continue down the road. Since Venice is such a unique city, it is necessary to look outside of Venice for possible parking management systems. There are both electronic and paper based systems in place in other cities that could be applied to the unique Venetian canal system. Both Park-It and T2 Flex are electronic management systems that could be useful in the application of the parking system in Venice. There are also paper based systems that are being used in other cities that could be modified to assist with the parking problems in Venice.

2.2.1.1 Electronic Parking Management Systems

Park-It is a system that is designed for high school and college campuses to manage parking more efficiently. All the vehicle information is kept in a database that can be easily searched using a few key details. Park-It distributes permits, records any violations received, and whether or not they have been paid all automatically. T2 Flex is another electronic system that integrates all aspects of parking management into one program. It incorporates permit management, enforcement, and access control into one compact system. T2 Flex provides concentrated management and operating for all sub-systems from one system. Another system is a “Smart” parking management system. Versions of this system

---

9 Hayes Software Systems.
10 T2 Systems, Inc.
have already been implemented by many European countries in order to manage the parking of cars. It is able to reduce congestion and unnecessary vehicle travel time. These systems use parking guidance information, or PGI, to inform drivers which spaces are available for parking.11

Another electronic parking management system which may be of use to the city of Venice is made by Permit-Sales.com. This company provides an online parking permit assignment that is tailored to fit each individual customer’s needs. Their software is able to handle permit requests, parking violations, parking citations, and many other aspects of parking management. They can also track the issuance of permits and keep an inventory of what permits have been issued. Since Permit-Sales.com uses a modular system that is designed for each customer specifically, Venice could have them develop an online permit system designed to meet the city’s unique parking management needs.12

In Bath and North East Somerset, cities in England, electronic parking management systems have been implemented. The cities use signs similar to other cities that inform drivers where permits are needed in order to park. To obtain a permit an applicant can fill out an on-line form. There are special regulations that apply to these permits. For example, they are only valid in designated parking zones and there is a limit of one permit per household13. Due to a high theft rate of parking permits, Bath and North East Somerset switched to an electronic permit called “Parkmobil” (see Figure 10).

There are many advantages that this electronic permit provides over the conventional paper permit. The main advantage is its security features. If the permit is ever lost or stolen, the card can instantly be deactivated by simply calling the Parkmobil Helpdesk, immediately blocking the permit number and rendering the card useless.14 With the added barcode it makes it easier for parking attendants to identify if a car is parked illegally or if a car is not parked in its proper spot. This permit also makes it easier for people who require more than one permit type. All different permit types can be placed on one Parkmobil card. The use of an electronic parking permit adds ease for both the authorities and for the car owners.

All of these systems have their own useful features. However, none of them meet all of the needs of a system that would fit the needs of Venice. These systems of parking management should prove to be helpful in developing an efficient system in Venice. PermitSales.com is still a possible option for Venice; however, since the city already has a system in place, it would be better to modify the existing system instead of paying to have a new system developed. An original system unique to Venice could be created by utilizing information gained and combining aspects from each of these different systems. An electronic parking management system will be useful in Venice because it will make it easier to assign parking spaces and enforce parking regulations.

11 Eaken, Amanda M. et al.
12 Permit-Sales.com.
2.2.1.2 Residential Parking

Many cities around the world have begun to restrict parking on their streets to residential vehicles. In areas that are mainly residential, only vehicles with a residential permit assigned for that area can park there. They do not use a system of designated spaces, but rather give residents a range of spaces that they are allowed to park in on a first come first served basis. Boston is one city that utilizes this technique to regulate parking. To handle its resident parking needs, the City of Boston uses a permit system. The system consists of permit stickers that are placed on a car owner’s window and road signs that designate permit parking (see Figure 11). To obtain a parking permit, the city of Boston requires that an applicant apply in person and give proof of residence by supplying a bill with their current address.15

Boston not only requires permits for resident parking, it requires permits for street occupation. If a person needs to use public road space for construction, relocation, or rubbish removal applications, that person must apply for a street occupancy permit. The applicant must supply the length of occupation, type of job, and any plans that would allow for pedestrian or vehicular access.16 The applicant must also place notification signs 48 hours prior to work in a commercial zone and 24 hours in a residential zone.17 The utilization and enforcement of these parking management systems helps the City of Boston reduce traffic congestion due to poor parking.

2.3 Boat Traffic in Venice

Boat traffic in Venice is made of a mixture of boats discussed in the previous section. With such a large number of boats in a relatively small area, Venice needs to regulate the traffic on its canals to prevent problems from arising. Even with all these preventative regulations in place, the city still has traffic issues that it must deal with.

2.3.1 Venice Traffic Management and Regulations

Traffic management methods such as those previously proposed by WPI project groups are essential for a city like Venice because it has a relatively small amount of area for traffic flow. Venice uses traffic regulations to manage traffic on its canals. One major aspect of traffic that the city regulates is the circulation of boats. Both the speed and direction of boat circulation is regulated so that traffic will flow properly. The map shown in Figure 12 shows all the one way canals in the city and their directions. The speed limits in and around the city of Venice are shown in Figure 13. These are also intended to limit

15 City of Boston. How to Obtain a Resident Parking Permit.
16 City of Boston. How to Obtain a Street Occupancy Permit.
17 Permit-Sales.com. Secure Online Permit Sales.
wave generation which can cause damage to the canal walls. All of the boat traffic in the canal must stay to the left side of the canal unless specified under other regulations, but this is not strictly enforced. When a boat is approaching a potentially troublesome intersection the captain must sound a horn or other signal to alert other drivers of his presence. A boat’s captain can pass another boat only if he signals this to the other boat. Also, it is unlawful for a boat to pass another on a curve where you can’t see past the boat being passed. The right of way must be given to special boats including ACTV boats and emergency services boats with their sirens turned on.18

The city wants to ensure that goods transport, public transportation, and emergency services are able to perform their roles efficiently without any unnecessary holdups. Canals must have at least 2/3 of their space available for boats to pass through so congestion does not occur. There are also limitations in place inside “traffic limited zones” which control the access of commercial and residential boats. There are signs positioned along the canal walls to give boat drivers information about specific regulations on canals. The name of the canal, its speed limit, allowed direction of travel, maximum allowed boat width, and other pertinent information is available on these signs.18 The map shown in Figure 14 information about travel restrictions on canals based on jurisdiction, boat width, and boat weight. These signs are difficult to read unless a boat driver is very close to the sign and as a result they are not paid close attention.

---

18 Regolamento per la Circolazione Acquea nel Comune di Venezia.
2.3.2 Traffic Problems in Venice

Venice faces many of the same traffic issues as other cities. Narrow canals can cause hindrances to traffic flow in the city just as narrow roads can cause problems. This is especially true for canals that are narrow enough for only one boat to pass easily but are allowed to have traffic flowing in two directions. The problem can be further compounded by parking on the sides of the canal. Also unnecessary trips made by cargo boats on the canals add to the overall traffic congestion in the city. Canal closures also are a large traffic problem in Venice. Traffic is diverted from the closed canal to others that surround it which may not be able to handle the higher volume. Parking in areas against city regulations such as parking too long at a cargo dock or in a buffer zone also causes traffic problems.

2.4 Parking in Venice

Parking in Venice is different from many other cities because all the vehicles within the city must be parked along the sides of the main passages of transportation. There are some marinas on the outskirts of the city that are analogous to parking lots, but they make up a very...
small portion of the available parking. Also, these marina areas are mainly used as overflow parking lots to move boats that are displaced by temporary canal closures. One of these marinas is located on the northern side of Giudecca and can be seen in Figure 15. Another major difference between the parking needs of Venice and those of other cities is that Venice does not need to have parking to accommodate commuters. Venetians either walk or take public transportation to work. Parking in Venice is primarily made up of overnight parking for residential and service boats and daytime temporary parking for service boats. Parking management in Venice is therefore broken into two separate categories: overnight and temporary. Currently the city also needs to have overnight spaces for the service boats, but in the future with the implementation of proposed cargo restructuring, it is possible that many of these spaces will become free for other uses.

2.4.1 Parking Regulations

Venice has laws in place to regulate parking on its canals. The enforcement of these parking laws is not very strong because they are difficult to enforce with the current information available to police about parking. However, if a boat is found to be parked illegally or otherwise in violation of the city’s regulations, it will be impounded and its owner will be fined.\(^\text{19}\) This section will describe the parking regulations in regards to buffer zones and what happens when a canal is closed.

2.4.1.1 Buffer Zones

Along the canals there are several different areas known as “buffer zones” or \textit{vincoli} in which parking is prohibited. Docked boats need to have a space of at least 30 centimeters between them. A space of 3 meters must be left on each side of a private water door to allow the owner to park his or her boat. Parking is not allowed under bridges because it is difficult to travel beneath them with obstructions, such as parked boats. Parking is also not permitted within 3 meters of any convex corner. A buffer of 12 meters centered about the centerline of each dock is also provided so cargo boats can load and unload their cargo unhindered. These buffers are designed to allow ample space for boats to drive around corners and down the lengths of the canals without fear of running into other boats. Examples of these buffer zones can be seen in the map in Figure 16. If a water space is located next to a residential building that does not have grating over its windows, parking will not be allowed there to prevent breaking and entering and protect the privacy of the residents.\(^\text{21}\)

\(^{19}\) Regolamento per la Circolazione Acquea nel Comune di Venezia.
Many valuable pieces of information were learned during our meetings with Mr. Andrea Maggio of *Mobilità Acqua*. We learned that while an owner of a building has the right to park a boat at his or her water door, they still need to apply for and be issued a parking permit to park a boat their overnight. A resident is not given the first choice of spots around his or her home. All the permits are issued as they are applied for. Also, the city does not require that permitted spaces be accessible from land. An applicant is more concerned with actually getting a space than they are with how they will get to that space once the permit is issued.

2.4.1.2 Canal Closures

During our initial assessment of the city, the team located a few canals that were closed for dredging. However, these canals were not drained to be dredged. Instead there were crews working on wet dredging these canals. As a result of this, there were still boats parked on the canals even though it was closed to traffic. Also, the closed canals were located in residential areas where minimal amounts of traffic and traffic hindrances occur. Because of these limitations the team was unable to determine through our data collection how a canal closure affects canal traffic and parking.

Through our discussions with Mr. Maggio from *Mobilità Acqua* we were able to learn what the current procedure for canal closures is. When a canal is going to be closed the city sends a letter to each person with a boat parked on that canal information them that they need to move their boat. Along with this letter is the paperwork necessary to gain access to one of the marinas that are dotted around the outskirts of town. The displaced boats will remain parked in these overflow parking areas until the canal reopens. Upon reopening of a canal, the employees of *Mobilità Acqua* manually move boats parked on the canal in an attempt to better use the available space. This reorganization could be done more efficiently by an automated process.

2.4.2 Overnight Parking Permits

The majority of parking in Venice is comprised of overnight parking for residential and other boats. There is limited space available in the city for adding new parking spaces because
most of the space is already taken up by parking and buffer zones. With the construction of the new parking lot on the western side of Venice, many cargo and taxi boats that currently park overnight in the city will be moved and more space will become available.

Boats cannot be docked just anywhere within Venice. The city has established a set of regulations on “expanses of water,” which govern boat parking on the canals. To use a water space or spazio acqueo, a permit for the appropriate location must be issued by the city. To obtain a permit for a water space, there are currently two different forms. One is for general citizens and one for companies. Someone seeking a permit submits the appropriate one of these forms in writing by the applicant to the General Protocol office in the city. The forms can be obtained online, however still they must be printed out and handed in person. A picture of this form can be seen in Figure 18. The General Protocol acknowledges the receipt of the forms and dates them. The forms are then passed on to the COSAP for general applications or the SUAP for company applications. The applications can take up to 1 month to move from the SUAP and up to 4 months from the COSAP to reach their next destination with Mobilità Acquea. The personnel of Mobilità Acquea manually enter the data from each permit application into the computer. Mobilità Acquea sends the permit request to Municipal Police within 10 days of receiving the application so they can investigate if the space can be issued. Municipal Police usually takes about 2 months to report back to Mobilità Acquea with their findings. The application then sits at Mobilità Acquea for a period of about 3 months while the request is finalized. Then they report back to COSAP or SUAP as to whether or not each space is approved. COSAP and SUAP have possession of the applications for another month before they send the authorization to the applicant to use the space. All of the billing for the water space is handled by COSAP which is in charge of managing the use of all public spaces. The fees for water spaces are calculated based on the number of square meters occupied by a boat. Nominally the cost per square meter is €48 per year, however there are several different categories and reductions that can change.
the price. Traditional boats are granted a 100% reduction in the fee which cause many people to lie about their boat type to save money on parking.\textsuperscript{20} The overall system takes nearly a year to process an application before an applicant will find out if their application has been approved. An electronic system with a quicker response time would be much more cost effective and save \textit{Mobilità Acquea} valuable resources. A flow diagram illustrating the existing system can be seen in Figure 17.

When an application for a permanent water space is approved, an employee of \textit{Mobilità Acquea} opens up the currently implemented system, shown in Figure 19, and manually draws in the space that is to be issued. It is up to the judgment of the operator to decide whether the newly added space will cause a problem with traffic.

Boats docked in an assigned water space must be moored on at least two posts to ensure that they do not drift out of place or become battered against the posts to the point where there is a danger of submerging the boat. No boat owner is allowed to chain his or her boat to a temporary parking location in the event that someone needs to move their boat to use that dock. Anyone who wishes to install posts for mooring his or her boat within their permitted water space must obtain permission from the city before doing so because the posts themselves will occupy public water space.\textsuperscript{21}

Permits for water spaces are renewed for a fee on a yearly basis and if a space is known to be left vacant for a period of six months the permit for that space is voided to ensure that valuable spaces are not going unused. Each permit is issued with identification labels that must be placed on the boat and the posts to which it is moored. Maintenance and repair of a water space are the responsibilities of its permitted owner. Boat owners cannot obstruct or use other expanses of water which they do not have a permit to use.\textsuperscript{19}

\section*{2.4.3 Temporary Parking}

Venice allows some temporary parking within the city without a permit under certain circumstances. Boats that are unloading or loading cargo are given permission to park at docks set aside specifically for cargo boats. Cargo boats are only allowed to park for just enough time to load or unload their goods and cannot be left unattended. In practice many boat owners ignore these rules and leave their boats unattended at docks. There are also specific banks and docks that are permitted to be used by only public transport vehicles including gondolas, taxis, and waterbuses which can’t be used legally by any other boats.\textsuperscript{22}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image.png}
\caption{A screen shot of the program currently used by the city to issue parking permits.}
\end{figure}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Section} & \textbf{Description} \\
\hline
2.4.3 & Temporary Parking \\
\hline
\end{tabular}
\caption{An introduction to temporary parking}
\end{table}

\textsuperscript{20} Città di Venezia COSAP
\textsuperscript{21} Regolamento per la Circolazione Acquea nel Comune di Venezia.
\textsuperscript{22} Regolamento per la Circolazione Acquea nel Comune di Venezia.
The city also regulates temporary parking of boats on the canals through the issuance of temporary parking permits. Temporary parking permits are given to people who require to park for an extended period of time or permission to circumvent city regulations. Permits for stopping along a canal and for transit down a traffic restricted canal are applied for as temporary parking permits. Construction boats and other boats requiring temporary use of the space on the canal must apply for a temporary parking permit. Applications for these permits are brought to the Mobilità Acquea office where they are usually approved or denied on the spot. Currently there are two different applications for temporary parking permits. One permit application is for a period of up to 3 days and the other is for an extended period of time. A newer form is being developed to replace these two different forms with one and can be seen in Figure 20.

An average of 250 temporary permit applications are processed by Mobilità Acquea office on a monthly basis, but the system is not regulated to insure that the temporary permit will not cause unwanted traffic problems. Currently there is no fee charged to the applicant for a temporary parking permit. This potentially allows abuse of the system by continually applying for new temporary permits.
3 Methodology

This project was completed to provide the City of Venice *Mobilità Acqua* with a system to better manage temporary and overnight parking of boats within Venice. Methods of optimizing the general parking system for Venetians and reducing hindrances to traffic flow in the canals were developed. A thorough study was conducted to assess the current parking related issues within the canal space and the gathered information was used to develop a proposal for the implementation of a web-GIS system that will allocate both permanent temporary and parking spaces. A brief survey to determine suitable locations to collect data on traffic congestion was conducted over a wide area of the city in the *sestieri* of Cannaregio and Castello. Later our survey area was refined to 7 specific locations within Cannaregio and Castello to gather data about interaction between parking and traffic. Data gathered from these *sestieri* was used to establish methods of optimizing parking that can be expanded to the remainder of the city. The data collection for this project was conducted from October 27th until November 3rd. The data was initially collected over a broad period of the day and then the data collection times were refined to be when most of the traffic was seen on the canals. The data was collected during the weekdays to get a good picture of the traffic throughout the day. As a result of these constraints on the data collection, the data may not accurately represent the parking situation on the canals on weekends or during other times of the year.

![Figure 21: Study area in Cannaregio and Castello.](image_url)
The following methodology will focus on three main objectives.

1: To study the current system in place in Venice with regards to the interaction parked boats and through traffic.

2: To optimize available canal space for parking while preventing a negative effect on traffic flow.

3: To design an electronic system to improve the permit application process and reduce the previously found traffic problems

3.1 Studying the interaction between parked boats and through traffic

This objective was meant to establish a thorough understanding of the current state of parking and traffic interaction in Venice. Existing data sets were gathered from the Venice Project Center and the city of Venice. Field studies were completed to verify the validity of this data. The data was then be analyzed to determine specific interactions between parking and canal traffic and we categorized the types of the problems that occur.

3.1.1 Obtaining previously existing traffic data

When we arrived in Venice, there was a wide range of data available to us from the Venice Project Center and Mobilità Acquea. One useful GIS layer we obtained splits the canals into segments and gives information about traffic flow direction, maximum allowed boat width, and which boats are allowed on each segment. The city provided us with this layer as well as layers with information on buffer zones where parking is prohibited, the locations of docks, and the locations of water doors.

3.1.2 Obtaining previously existing parking data

We gathered existing data regarding the state of parking in the city when we arrived in Venice. The city provided us with an updated version of the Spazi Acquei GIS layer that gives the locations and sizes of all the parking spaces within the city, who owns the space, and which category of boat is permitted to park there. A more detailed list of all the GIS layers that were obtained can be found in Table 2. To make sure that the parking space data was accurate, we used our field test process as a means of evaluating whether the boats were parking where they were supposed to park.
3.1.3 Obtaining Information About the Current System

The team met with the head of *Mobilità Acquea* of the city of Venice, Mr. Manuele Medoro on October 31st. The meeting was intended to present to him our plan for the project and discuss any elements that he envisions us implementing. During this meeting we clarified the locations and size of the buffer zones which are known as *vincoli*. Mr. Medoro also mentioned that he would like a half meter buffer zone on either side of designated travel lanes. We also discussed installing planks along the sides of public buildings as a means of potentially allowing access to more spots. Mr. Medoro was pleased with our overall plan for the project.

After our meeting with Mr. Medoro, we walked next door and met with Mr. Andrea Maggio who works for Mr. Medoro in *Mobilità Acquea*. Mr. Maggio and the other employees in his office demonstrated the system that is currently used to manage parking in the city and assign parking spaces when a new application is received. Currently *Mobilità Acquea* has a partially developed system that stores all the information about parking permits electronically. We used the layout of this existing system as a basis for the layout of our online permit application.

During a second meeting with Mr. Maggio on November 6th, we further discussed the permit process. He drew a flow chart for us to help us better understand the order of the process. This flow chart and how the process works can be seen in the Background section 2.4.1 Parking Regulations.

Mr. Maggio also discussed the improvements that he would like to see on the current system to make *Mobilità Acquea* run more efficiently. Having the computer automatically assign parking permits would be a valuable feature for *Mobilità Acquea*. A means by which citizens can submit complaints about parked boats was also discussed. Over time this feature would help to validate the city’s data on where boats are parked because vigilant citizens looking for a good

<table>
<thead>
<tr>
<th>Map Layer Name</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Isole</em></td>
<td>Islands of Venice</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Edificato Venezia</em></td>
<td>Buildings of Venice</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Nodi_Intersezione</em></td>
<td>Centers of intersections</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Grafo segmenti</em></td>
<td>Canal segments with regulation information</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Civici Corretti</em></td>
<td>Civic numbers</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Ponti</em></td>
<td>Bridges</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Possible Dock Locations</em></td>
<td>Possible cargo dock locations</td>
<td>WPI E01 Cargo Project</td>
</tr>
<tr>
<td><em>Rii</em></td>
<td>Canals</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Rive</em></td>
<td>Docks</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Sestieri</em></td>
<td>Sestieri of Venice</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Spazi Acquei</em></td>
<td>Overnight water spaces listed in Venice</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Spazi Acquei Aggiornato 2006</em></td>
<td>Overnight water spaces updated 2006</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Tronchetto</em></td>
<td>Proposed parking lot by <em>Tronchetto</em></td>
<td><em>Mobilità Acquea</em></td>
</tr>
<tr>
<td><em>Vincoli_Incroci</em></td>
<td>Buffer zones around intersections</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Vincoli_Porte_Acqua</em></td>
<td>Buffer zones around water doors</td>
<td>City of Venice</td>
</tr>
<tr>
<td><em>Vincoli_Rive</em></td>
<td>Buffer zones around docks</td>
<td>City of Venice</td>
</tr>
</tbody>
</table>

Table 2: GIS layers we obtained
parking space will be eager to point out a boat that is not parked in a proper location if it could potentially free a space for their boat. Travel lanes where parking is prohibited will be useful to the city as they will account for the maximum width boat allowed on a canal. A way to manage canal closures and the displacement of boats would also be needed as they are currently not managed efficiently. Temporary parking permit applications should be automated and their information stored in a database for easier searching and accessibility.

3.1.4 Validating and Refining Methodology

A pilot study was conducted in order to validate our data collection methods and help us begin to characterize the parking problems that occur in Venice. An area around Campo Santa Maria Formosa was designated to be the area for our pilot study. Before the pilot study was conducted, the team worked together to develop field data sheets that would allow us to gather the largest amount of information in the most efficient manner. One of the data sheets developed focused on the study area as a whole and listed all of the traffic congestion issues that occurred there as a result of parked boats. The other data sheet was made to have information about each individual parking space within the boundaries of the study location. These field data sheets can be seen in Appendix A – Field Forms.

The initial pilot study was conducted on Friday October 27th from 9:00 AM until 1:00 PM. Data was gathered at Fondamenta dei Preti on the north side of Ponte del Mondo Novo. A map of this study area can be seen in Figure 22. This study was useful to refine our data collection methods. Each member of the group collected the same data individually. After the data collection period was over, we met as a group and looked over everyone’s data. We then developed codes that would be used to write information on the field forms in the same format regardless of who was collecting the data. We also reviewed the effectiveness of our field forms and edited them to make them easier to use. We removed some unnecessary data fields and expanded the size of others to make them easier to write in.

On Monday October 30th we conducted a second pilot study with all four members of the group in the same location collecting the same data. We collected data on the southern side of Ponto del Mondo Novo at Fondamenta dei Preti because observation on October 27th had shown us that there would more likely be a greater number of congestion issues there (see Figure 23). Also, this study was only conducted from 8:00 AM to 10:00 AM because after reviewing the data from October 27th we determined that the majority of traffic congestion problems
would occur during this time because they saw the highest volumes of traffic. After finishing the data collection for the second day of our pilot study, we again reviewed our data collection methods and the effectiveness of the data collection forms. With the second round of data sheets, our data was much more uniform and no one person’s data contained any more or less information than was necessary. Also, we agreed that the field forms were effective tools to gather the necessary data. We decided that all of the data collection after that point would be collected in separate areas during the same time period of 8:00 AM to 10:00 AM.

3.1.5 Observing the Interaction Between Traffic and Parked Boats

To collect the data on traffic congestion issues caused by parking, seven data collection points were chosen in the area around the border of the sestieri of Castello and Cannaregio. These areas were selected based on physical observations of the areas surrounding them and the relative number of parking spaces assigned near them based on the data in the GIS layers obtained from Forma Urbis. When selecting the study locations we also looked for areas that could potentially have similar traffic congestion issues as seen in the area around Campo Santa Maria Formosa. We did this by extrapolating our knowledge of how canal geometry and relative boat parking affects the traffic flow in a given area. Data was collected at these locations for a three day period from November 1st to November 3rd in order to gain a thorough understanding of the interaction between traffic and parking in each area.

3.1.6 Archiving Project Information

An Excel spreadsheet was created to store all of the gathered data in one location. This spreadsheet contains all of the traffic congestion information, the individual parking space usage information, maps of each study location, and all the pictures that were taken of specific occurrences during data collection. The data can now easily be organized, grouped, or searched as necessary to be analyzed.

3.2 Optimizing canal space for parking while preventing traffic hindrance

In this section of the project, the team used the data collected from our test areas in conjunction with that collected by Mobilità Acqua to create a series of GIS maps illustrating the most efficient usage of the available canal space. Using the problems identified in section 4.1, we analyzed the current parking structure maps and evaluated how currently parked boats encroach on buffer zones where parking is prohibited. The spaces that interfere with buffer zones were relocated in MapInfo, if possible, to locations where they no longer intersect with buffer zones. A map illustrating proposed travel lanes was then constructed using the remaining available
water space. The team identified any areas outside of the designated travel lanes that are large enough to create new parking spaces. The team examined whether current buffer zones are useful or if they could be modified for more efficient parking. The data collected from these procedures in addition to previously gathered traffic information helped to organize an optimal parking layout for the city of Venice. While observing the interaction between traffic and parking, the team observed many parking problems that needed to be addressed. This information can be seen in Section 4.1. A list of all the layers created during this objective can be seen in Table 3.

### Table 3: GIS layers created

<table>
<thead>
<tr>
<th>Map Layer Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>All_Buffers_Deleted</td>
<td>Shows the rii with all buffer zones removed</td>
</tr>
<tr>
<td>Available water space</td>
<td>Shows the rii with only spazi acquai removed</td>
</tr>
<tr>
<td>Overlapping_Buffers</td>
<td>Shows all spazi acquai with areas highlighted in yellow where buffers overlap</td>
</tr>
<tr>
<td>Overlaps only</td>
<td>Shows only the overlapping space in the canals</td>
</tr>
<tr>
<td>Inefficient_Waterdoor_Space</td>
<td>Shows water doors that people have a permit for, but barely overlap</td>
</tr>
<tr>
<td>Overnight_Waterdoors</td>
<td>Shows water doors that couldn’t be used overnight due to lack of room for travel lanes</td>
</tr>
<tr>
<td>Proposed_Planks</td>
<td>Shows places where planks could be added to increase dock utility</td>
</tr>
<tr>
<td>Potential_New_Space</td>
<td>Shows areas within the canals (after re-arranged permits) for new permits</td>
</tr>
<tr>
<td>Color Coded Bufferzones</td>
<td>Shows the color coding of buffers</td>
</tr>
<tr>
<td>Color Coded Waterspaces</td>
<td>Shows the color coding of types of water spaces</td>
</tr>
<tr>
<td>Current Max Boat Width Travel Lanes</td>
<td>Shows travel lanes in the center of the canal using max boat width</td>
</tr>
<tr>
<td>Reconfigured Bufferzones</td>
<td>Shows buffers that have been rearranged</td>
</tr>
<tr>
<td>Split water space layer</td>
<td>Shows all water spaces split along the lines where they intersect with buffers</td>
</tr>
<tr>
<td>Pull_Over_Zones</td>
<td>Shows potential pull over zones</td>
</tr>
<tr>
<td>Color Relocated</td>
<td>Shows all relocated spaces with color coding added</td>
</tr>
<tr>
<td>Relocated WaterSpaces</td>
<td>Shows relocated permits (white is original, yellow is relocated, black arrows connecting)</td>
</tr>
<tr>
<td>New Travel Lanes</td>
<td>Shows new travel lanes based on parked boats</td>
</tr>
<tr>
<td>Impinging Water Doors</td>
<td>Shows all water door buffers that interfere with travel lane</td>
</tr>
<tr>
<td>Parking Grids White</td>
<td>Shows all the grids on certain canals to be used for space allocation</td>
</tr>
<tr>
<td>Parking Grids Colored</td>
<td>Shows all the grids with currently issued spaces colored in</td>
</tr>
<tr>
<td>All Misused Space</td>
<td>Shows all the water space/buffer overlaps</td>
</tr>
</tbody>
</table>

3.2.1 Creating Maps of the Current Water Space Usage for Project

Utilizing the existing GIS layers containing information on the permitted parking spaces and legal buffer zones, we created maps showing the currently occupied water space and the currently available water space. We ignored the overlap between buffer zones and parking spaces at this point and only focused on identifying the canal space that is currently occupied. Travel lanes along the centers of the canal with a width ½ meter wider than the maximum boat width allowed on that canal were drawn in and considered occupied water space. The layers containing all of this information were overlaid on the layer showing the canal areas. Each area that is considered occupied water space was then subtracted from the canal layer to create a new layer that shows only the available water space. An inverse of this map showing only the occupied
water space was also created. When placed together, these two layers show a picture of the entire canal surface area.

### 3.2.2 Identifying Areas where Parking and Buffers Interfere

The layers containing buffer zones and parking spaces were overlaid in MapInfo to find where they intersect. Using MapInfo’s ability to split objects based on where they intersect with another defined set of objects, we split all the parking spaces along the lines where they met the buffer zones. All of the areas that were part of both a buffer zone and a parking space were colored red to indicate that they needed to be addressed. The surface area of these conflicting areas was calculated using MapInfo and compared to the total amount of boats that this overlap displaces.

### 3.2.3 Relocating Spaces to Remove Buffer Zone Conflicts

This section made use of the color coded layer containing the overlap between parking spaces and buffer zones. The areas of Venice surrounding the areas where our data collection was conducted during the previous objective were thoroughly examined to remove any overlaps between parking spaces and buffer zones. Each offending space was manually moved to the closest available space that did not also cause an obvious hindrance to traffic flow. Arrows were drawn in MapInfo from each space’s original location to its new location.

### 3.2.4 Evaluating Current Buffer Zones

The buffer zones were analyzed to see if it is reasonable to change their size or other parameters in order to remove hindrances to traffic flow and allow more parking on the canals. The buffer zones that were primarily seen as an issue were those surrounding water doors. Using the data about the boats currently parked at these water doors, we evaluated whether certain water doors should not have the potential of allowing their owners to park overnight. Removing the ability to park a boat overnight at these water door buffers opens up needed space for travel lanes on the narrow canals where there are numerous water doors on each side of the canal. This data was stored in a GIS layer which shows the water doors and other buffers that could pose a hindrance to travel along the canals.

### 3.2.5 Determining Locations for Traveling Lanes

This section required the use of data on canal dimensions, maximum allowed boat widths, and the layer showing the relocated spaces. Using this information, the most efficient travel lanes were identified by the project team. Travel lanes were determined to be necessary to unhindered travel on the canals during our analysis in section 3.1. These newly created travel lanes take into account canal width, regulations on boat dimensions that are allowed pass through the canal, and whether parking will be established on one or two sides. We made use of the data collected during the initial stages of our project to predict the path that boats will travel based on the conditions it faces. It was determined that boats primarily want to travel under the center of bridges. This is because the majority of the bridges in the city are arches and allow the most clearance in the center. The travel lanes do not necessarily follow the centerline of each canal as they have been previously depicted. We found that boat drivers travel roughly in the middle of the available space on the canal rather than the middle of the canal. If boats are heavily parked on one side of the canal, the travel lane for that canal naturally shifts over towards the other side of the canal. A GIS layer was created indicating travel lanes which are the best path a boat should take for maximum mobility on the canals.
3.2.6 Identifying Areas Outside of Traveling Lanes Suitable for Boats to Park

Once the travel lanes were designated, the team was able to identify any spaces along the canal walls that were suitable for creating new parking spaces. The surface area available at each of these locations was broken into a grid structure to allow for better management of space by the program which is discussed in section 4.3. This grid structure ensures that space is not wasted when available water space is broken into smaller sections to add new parking permits. All of the spaces proposed in this section were entered into GIS layers with the important information about each space. These new spaces were colored coded to identify them as potential spaces in MapInfo.

3.2.7 Identifying Areas to be used as Pull Over Zones

One of the major problems with canals in Venice that was determined in section 3.1 is that even if canals have travel lanes wide enough for one way traffic, they often lack pull over zones to allow the flow of two way traffic. There are a large number of docks in the city that are not used regularly. The buffers around these docks take up valuable space that could be used. The majority of canals only have enough space for one boat to pass through at a time. The unused docks can be used as locations for boats to pull over to the side when another boat is approaching in the opposite direction. The docks that could potentially be used as locations for pull over zones were identified in a new GIS layer.

3.3 Designing a system to improve the permit process

In this section, the team analyzed the present permit process, as discussed in Section 2.4.1, as well as currently existing electronic parking systems to see if they could be adapted to work for Venice (see Section 2.2.1.1). No system that currently exists is capable of meeting the entire city’s parking management needs, so the team developed a model system with all the necessary features. The team also developed a set of potential amendments to current regulations and new administrative parameters that will make the parking system more stable and easier for both the City of Venice and its citizens.

Since none of the existing systems analyzed in the previous section meet the needs of the city, we propose that Mobilità Acquea switch to an electronic based application system. We developed a model of what this proposed system will look like to demonstrate the different functionalities it will have. All of the screenshots of the model program were made using Microsoft Visio. The program is not functional and if it is decided to be implemented, it will need to be programmed. The proposed system will have two main modes, one for the end user and one to be used by Mobilità Acquea. This system is described in detail in section 4.3.
4 Results and Analysis

The following chapter describes the important results and analysis of the project. Section 4.1 details the results of our observations of parking and traffic interactions. It contains a typology of the problems between parked boats and through traffic that are commonly found in Venice. Section 4.2 uses these problems as catalyst to develop ways to better organize the layout of canal parking and reduce the problems. Section 4.3 gives an in-depth description of the model parking management system we created which makes use of the canal space optimization from section 4.2 to help automate water space management and further reduce the problems discussed in the first section.

4.1 Interaction between through traffic and parked boats

During our field study, the team found some specific problems with the interaction between through traffic and parked boats which we classified into two general types: destination problems and travel restrictions. Destination problems are those issues that do not allow a boat owner to get to their final destination. These issues were observed as the blocked docks and canal closures. Travel restrictions are mainly parking issues that obstruct the flow of traffic. These types of restrictions were seen as lack of pullover lanes, double parking, physically narrow canals, and parking under bridges. A table explaining this typology of problems can be seen in Table 4.

<table>
<thead>
<tr>
<th>Types of Problems</th>
<th>Description of Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Destination Problems</strong></td>
<td></td>
</tr>
<tr>
<td>Blocked docks</td>
<td>When a boat either parks for too long at a dock, or at a dock it's not supposed to be at.</td>
</tr>
<tr>
<td>Canal closures</td>
<td>When a canal is closed, it reroutes traffic and causes heavier traffic and parking on neighboring canals</td>
</tr>
<tr>
<td><strong>Travel Restrictions</strong></td>
<td></td>
</tr>
<tr>
<td>Lack of pullover lanes</td>
<td>Blocked docks and illegal parking lead to a lack of pullover lanes, which could lead to double parking and bottlenecking.</td>
</tr>
<tr>
<td>Double parking</td>
<td>Boats need to unload cargo and do not have access to a dock because there is a boat already there.</td>
</tr>
<tr>
<td>Physically narrow canals</td>
<td>Canals that are too small for two-way traffic.</td>
</tr>
<tr>
<td>Parking under bridges</td>
<td>With acqua alta, high tide, the travel lanes get shifted according to where the boats can pass under the bridge.</td>
</tr>
</tbody>
</table>

Table 4: Types of problems found.

4.1.1 Blocked Docks

The most common problem that was found was blocked docks. This was mainly personal boats parking at loading docks and taking up the dock so boats couldn’t load or unload. An example of this occurred quite frequently at S. Maria Formosa 2 during our data collection time, involving personal boats and a garbage boat. The personal boats would dock at the loading dock because it was free and then leave their boat there. Then the garbage boat would show up and need to park to load the garbage and not be able to. This happened on at least two occasions.

The loading dock was blocked by two personal boats. A garbage boat came to dock and collect the garbage but could not access the dock because the personal boat was blocking the dock. The garbage boat has priority to the dock over other boats so the other boats needed to move. The personal cargo boat moved immediately, but the personal boat took 2 minutes to move. This led to a delay in the garbage boat in achieving their destination. This issue can be resolved by an enforcement of the locations of where boats park, or by setting a certain time...
when garbage boats are going to be loading at docks which allows the dock to be used by other boats for loading or unloading.

There was another destination issue at *S. Maria Formosa* 2 also involving a garbage boat. This incident was also due to dock blockage, but was more severe. There was a personal boat parked at the dock, and when the garbage boat came, the owner was not present to move the boat. The garbage boat waited 9 minutes, and after that one of the garbage men got into the personal boat and moved it, as seen in Figure 26, to double park it next to the garbage boat so the garbage boat could park.

### 4.1.2 Lack of Pull Over Lanes

A large number of problems with travel through the canals could have been avoided if boats had the ability to pull over to the side of the canal and allow other boats to pass through. Venice has the majority of the space along its canal walls assigned as buffer zones, parking spaces, or docks. If all the spaces in an area are in use when boats are trying to travel in opposite directions towards each other they have no place to pull over and traffic congestion occurs. Each canal segment should have at least one location designated as a pull over zone to eliminate this problem. Docks that are either unusable or rarely used could be turned into pull over zones to make better use of the available space.

### 4.1.3 Double Parking

Double parking usually results from a boat breaking the 15 minute rule at a dock. There was one instance at *S. Maria Formosa* 2 which was a result of the garbage man moving the personal boat. The personal boat was double parked next to the cargo boat, and a cargo boat docked, directly across from another dock. When another cargo boat tried to pass, shown in Figure 27, there was not enough room to go by and a garbage man had to move the personal boat again, and tied it to the bridge, as the owner returned. These incidents could be resolved by allocating a specific time that these docks are reserved for garbage boats only. If garbage boats are at the docks at certain hours, the rest of the time the docks could be used for temporary parking spaces and this will free up a lot more room for the *Mobilità Acquea* to use to distribute permits.

![Figure 26: Garbage man moving personal boat](image1)

![Figure 27: Double parked boat blocks canal](image2)
4.1.4 Physically Narrow Canals

Physically narrow canals are usually a result of a canal being too narrow for two way traffic, but still being a two-way canal. The only way to fix these canals is to make them one way canals or adjusting the maximum boat width allowed on the canal. An example of this was seen at Campo Dei Miracoli and can be seen in Figure 28 where the boat is too large for the canal and two-way traffic is not possible.

4.1.5 Parking Under Bridges

Parking under bridges is illegal, and can also cause traffic congestion. It is mainly a problem during acqua alta, the high tide, which can raise the water greater than 120 cm. This can cause damage to boats parked under bridges, since they are on the sides of the canal and bridges are arched. They can also cause problems for other boats trying to travel down the canal because as the water rises, any slack in the ropes tying it to the side will allow the boat drift to the middle of the canal, encroaching on the travel lanes.

4.2 Optimization of canal space for parking

In the Background section 2.4.2, the current system of parking in Venice was described in detail. This section examines flaws in the current system and proposes potential ways to fix these issues. A table listing the major problems can be seen in Section 4.1.

The use of the available water space on the Venetian canals could be better managed. Many of the currently issued parking spaces intersect with the buffer zones that are designated for no parking. Through the traffic congestion observation we conducted, which is outlined in Section 3.1, we determined that the overlap between parking spaces and buffer zones can cause traffic issues. A large number of parking law infractions and boats parking in incorrect locations were seen during our observations. Parking at docks for extended periods of time was the most common form of illegal parking observed during data collection. During our observations, we also found locations where improper placements of boats hindered the ability of other boats to travel down the canal. These canals conflict with the law mentioned in Section 2.4 which states that two thirds of a canal’s width must be open to allow the passage of boats through that canal. A list of the major types of problems found during our field study can be found in section 4.1.

The buffer zones around docks and water doors can also present problems to traffic flow. Often there are docks or water doors directly across from one another on a canal. On particularly narrow canals these buffers can take up the entire width of the canal, leaving no space for boats to travel freely. This can present a problem when two buffer zones across from one another are in use for temporary parking at the same time. The problem can be increased further if a permit for overnight parking is issued to the water door owner. One of the GIS layers created highlights the buffers that interfere with the travel lane.
4.3 Design of a system to improve the permit process

The current permit application system in Venice is primarily a paper based system. It is made of two main elements: overnight and temporary parking. All of the overnight applications are submitted on paper and then manually entered into an electronic system that stores all of the data about the parking spaces currently issued. The temporary parking permit applications are submitted on paper and currently stored in a binder. While the process of obtaining a temporary parking permit only takes a few minutes, the city can take upwards of 10 months to process an overnight parking application. Often after 10 months of waiting, an applicant will find their application has not been approved and will need to apply all over again. The system in place also requires a human operator to manually draw in a new created space. There are no automatic checks are in place to determine if a new overnight space or a temporarily permitted space will become a hindrance to traffic or if the newly created space will conflict with any buffer zones. Both of these processes could be improved and combined into one program to save valuable time and resources for Mobilità Acquea. A screen shot of the computer program currently in place in the city can be seen in Figure 29. Detailed descriptions of how the current permit processes work are located in Section 2.4.2. During this objective we designed a model of a new electronic parking permit application system to reduce human intervention by having the system to automatically decide which parking space is best suited for a boat being registered and assigning a given space with only a quick confirmation check by someone from Mobilità Acquea.

This new system not only increases the efficiency of parking in Venice, it also decreases the time necessary to obtain an overnight permit. With this new system the process for obtaining a permanent permit will take only a few days instead of more than 10 months. A graphical representation of the time

![Figure 29: Current Electronic System](image)

![Figure 30: Comparison of the old and new systems.](image)
each system takes for a permanent permit can be seen in Figure 30. Temporary permits, while not having any changes in the time to obtain them, will become much more organized from being managed electronically and will be much less likely to cause traffic problems.

This section describes the features and functions of the proposed system we designed. The system was designed to have similar features to those of the existing system that Mobilità Acquea uses. Mobilità Acquea also expressed an interest in having several new features implemented in the new system. These features are described in section 3.1. Additional useful features were also implemented in the model based on our observations. Some lessons were drawn from other existing electronic parking management solutions which are discussed in Section 2.2. The system is also designed as a means of addressing the problems with the interaction between through traffic and parked boats that are discussed in section 4.1.

The system itself is broken into two main sections: end user mode and administrative mode. These modes are designed to be used by people applying for permits and Mobilità Acquea respectively.

4.3.1 End User Mode

The end user mode allows the applicant to fill out an electronic permit request form. The system gives the user a variety of options including choosing a permanent or temporary application, modifying an already issued water space, or reporting an issue with a water space. The applicant will have to select one of these 4 options from the screen shown in Figure 31.

4.3.1.1 Permanent Permit Application

When an applicant enters the permanent section of the system, he or she will be prompted to identify the location where they would like to receive a permit. The necessary information includes their desired numero civico, Sestiere, and Rio that are closest to the desired space. Applicants are also required to look up the information on their boat by entering their boat identification number and then running a search. All of the information on the boats registered in Venice will be stored in a database. Upon completion of the search, all the boat’s information will automatically be entered into the electronic form. This method is used to prevent applicants from providing false information. Once the boat information is retrieved from the database, the applicant is ready to search the system for an available parking space. The system searches the database of existing parking spaces to determine the closest available space to the specified
location that can fit the applicant’s boat. The user has the ability to look at the information about the boats in the surrounding area as shown in Figure 32. After the user has located their desired space, they fill in their personal and billing information and submit their application. The applicant is given 48 hours to upload a picture of their boat in the space they just acquired to validate that their boat will fit.

Assigning permits in this way helps to remove some of the issues discussed previously. The system will eliminate parking under bridges and parking on narrow canals that hinders traffic. At least one pull over zone and a travel lane the width of the maximum allowed boat will automatically be left free on every canal segment by the program.

4.3.1.2 Complaint Console

Since the city has relatively few permanent spaces available and there are not many new spaces created each year, it is likely that this search will yield no favorable results. The program will then zoom into the area where the space was requested and immediately allow the user to look at the information concerning the boats parked there (see Figure 33). The user will then be able to access the complaint console and file a report if they know any of the information in the system is contrary to reality. The complaint console option of the system will allow citizens to report problems they see with parked boats. This feature is meant to fix any parking issues by making use of vigilant citizens who are eager to obtain their own parking space. The system will require the person submitting the complaint to provide his or her contact information in the event further explanation of the complaint is needed and also to prevent fraudulent complaints from being submitted.
A user from *Mobilità Acquea* or Municipal Police can view the complaints at any time and decide whether to resolve them or order further investigation. When the system receives a large number of complaints about a specific spot it will automatically generate an email to the Municipal Police with the necessary information for them to investigate the issue. This is done to draw attention to the areas causing the most prominent problems.

The complaint system will help the system regulate itself and enforce city regulations without any extraneous effort by the city. Citizens will identify the areas that are the biggest problems for the police to investigate. Over time this feature will increase the optimization of the canals and validate the parking data currently stored in the database.

### 4.3.1.3 Temporary Permit Application

The process for applying for a temporary space with the new system is similar to that for a permanent space. Before the applicant accesses the temporary system, they choose whether they want to fill out a single application or if they want to register to easily fill out multiple applications in the future. To register with the system, the applicant fills in their personal or corporate information and creates a login name and password. Once registered the user will be able to add and store information about all the boats they own into the system from the account maintenance screen (see Figure 34).

Once the applicant has chosen either option they enter the application portion of the system. Here they have to enter their boat information or select an already registered boat. They also supply information about the type of activity they are performing and what type of permit they require. Depending on whether the applicant desires a permit to stop at a dock, a permit for transit on a canal, or both, they will be redirected to the appropriate site.

To obtain a permit to stop at a dock for an extended period of time, the applicant first searches for which dock they wish to use, similar to searching for an empty space in the permanent system. Additional search criteria including the date and time they need the dock and the reason the dock is needed must be provided with this search. The system will then find the dock that best fits the search criteria given. If the user wishes, he or she can apply for the permit or perform another search.

Obtaining a permit for transit is primarily for boats that are not allowed on specific canals because they are made of metal or do not meet the size restrictions of a canal. For a transit
permit, the applicant provides their start and stop destinations and the date and time of the transit. The program will automatically generate the most efficient route based on the size of the boat.

If the applicant requires both of these permits, they will be brought through each application in succession. All of the applications are then submitted electronically to Mobilità Acquea for approval.

### 4.3.1.4 Water Space Modifications

The option of applying for a modification to an existing water space is available to a user in the event that anything changes regarding the boat parked in their space. If the user purchases a new boat, they can register the new boat to their space and apply to augment the size of the space if necessary. The user can also transfer ownership of their space to another person or swap spaces with someone. Applications for water space modification will be sent to Mobilità Acquea to be approved.

### 4.3.2 Administrative Mode

The administrative mode of the program will have enhanced functionality that is not available for normal users of the program. A user at Mobilità Acquea will have the ability to login to the system with an administrator username and password. Aside from having access to all the features available in the end user mode, once logged into administrative mode, the user will be able to see all of the new permits and complaints that are pending (see Figure 35).

A user at Mobilità Acquea will have full access to the information about each space while other users will only have access to the boat type, license plate number, and boat picture. This mode will allow manually adding and removing spaces to retain the current functionality available to Mobilità Acquea with the system they have. A list of the currently pending disputes will be available with options to mark the disputes as settled or request further investigation by Municipal Police. The system will allow Mobilità Acquea to close canals for dredging and will automatically relocate boats to marinas for temporary parking. The system will contact the owners of the displaced boats to give them the information necessary to be admitted to their temporary parking space. The system can automatically reorganize the layout of boats on a canal for optimized traffic flow. This will be done primarily before a canal is reopened after dredging because it will be the best opportunity to move boats without
encountering much resistance. After automatically relocating the boats, it will allow Mobilità Acquea to make any final manual adjustments before accepting the new layout.

The administrative features of the program will further help to remove the problems discussed previously. Administrators will be able to remove any problems such as parking on narrow canals, parking under bridges, double parking, or a lack of pull over zones manually or have the computer optimize the layout automatically. The program will also streamline the canal closure process and allow for optimization of parking on the canals when they are reopened.
5 Conclusions and Recommendations

This chapter summarizes the conclusions reached during this project. Based on these conclusions, we have listed a series of recommendations that will help the city of Venice increase efficiency in its permit allocation system and decrease traffic congestion on the canals.

Many of the currently issued parking permits in the city of Venice intersect with the buffer zones that are placed throughout the canals around water doors, docks, and intersections. The layout of permits on many canals causes traffic hindrances because the two thirds of the canal width required by law are not available for traffic to pass through. A large number of boats do not park in their proper space and many boats park at temporary docks for longer than the 15 minutes they are allowed.

The layout of boats on the canals of Venice should be systematically looked at on a canal by canal basis to determine if they can be reorganized to remove the traffic hindrances caused by improper parking. Every canal segment should have a dock on each side of the canal, a space for boats to pull over, and a space for temporary parking. Docks and other spaces beyond these criteria should be reassigned to better use the available space. Since every canal in Venice will inevitably need to be closed for dredging because of silt buildup, the city can use the opportunity to reorganize the parking layout of the closed canal.

Canals can also be reorganized at any time which will be particularly useful for canals with a high density of misplaced parking permits. The canals listed in Table 5 have the highest density of issues based on calculations performed using MapInfo and should be investigated thoroughly to remove the problems. The enforcement of parking laws should be increased to ensure that the newly optimized parking layouts will work effectively. To better facilitate parking enforcement, a system using radio frequency identification, or RFID, tags should be placed on each boat and at each parking space. The police will be able to quickly identify if a boat is incorrectly parked if the RFID tags do not match.

The rule that states two thirds of a canal’s width should be left available for traffic flow should be amended. Instead of two thirds of the canal width, the maximum allowed boat width on a canal should be kept open for traffic. This change will be especially useful on canals where the width fluctuates greatly along its length and on particularly wide canals where leaving two thirds of the width open is a waste of valuable space.

<table>
<thead>
<tr>
<th>Rio</th>
<th>Overlapping Area (Sq. m)</th>
<th>Total Available Area (Sq. m)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio de S. Aponal</td>
<td>58</td>
<td>112</td>
<td>52%</td>
</tr>
<tr>
<td>Rio de S. Maria Mater Domini</td>
<td>102</td>
<td>299</td>
<td>34%</td>
</tr>
<tr>
<td>Rio dei Ferali</td>
<td>62</td>
<td>189</td>
<td>33%</td>
</tr>
<tr>
<td>Rio de l'Orso</td>
<td>40</td>
<td>124</td>
<td>33%</td>
</tr>
<tr>
<td>Rio de le Romite</td>
<td>112</td>
<td>354</td>
<td>31%</td>
</tr>
<tr>
<td>Rio de la Misericordia</td>
<td>126</td>
<td>404</td>
<td>31%</td>
</tr>
<tr>
<td>Rio de le Torete</td>
<td>20</td>
<td>74</td>
<td>28%</td>
</tr>
<tr>
<td>Rielo S. Antonio-de Ca' Bernardo</td>
<td>10</td>
<td>38</td>
<td>27%</td>
</tr>
<tr>
<td>Rio del Trapolin</td>
<td>102</td>
<td>390</td>
<td>26%</td>
</tr>
<tr>
<td>Rio della Madonnetta</td>
<td>83</td>
<td>331</td>
<td>25%</td>
</tr>
</tbody>
</table>

Table 5: The top 10 canals for problematic space
The currently allocated buffer zones on the canals of Venice have the possibility of causing numerous traffic problems. Many canals have their entire width blocked by water door buffers, dock buffers, or a combination of both. If these buffers are in use concurrently for temporary parking, traffic will not be able to flow freely on the canal. While an owner of a water door has the right to park temporarily at his door and the sole right to apply for a parking permit at that space, he or she cannot park there overnight without a valid permit. The buffer zones around each water door should be evaluated to see if they encroach on canal traffic based on the newly amended law stating that a travel lane the width of the maximum boat width should be left free. Any water door buffers that would block this travel lane should be designated for temporary parking only. Owners of these water doors will still be able to use their doors as necessary to temporarily load and unload necessary goods, but they will not have the opportunity to apply for a permanent space there. The buffer zones around docks should also be individually evaluated to make sure that the travel lane through the canal is not hindered. Places where there are multiple docks within a small area should be individually studied to determine the most useful dock. This dock will become the mainly used dock for that area and all of the remaining docks will be used for temporary parking or overflow from the main dock.

Currently there is not a fee associated with the application for a temporary parking permit. A temporary permit can be used to circumvent the laws of the city by granting temporary permission to ignore certain parking laws. The current system could be abused by a person who continually applies for new temporary permits which give him or her the ability to continually get around obeying regulations. To discourage the abuse of the temporary permit system, an application fee of €10 should be added so people are less likely to apply for permits frivolously. The proceeds from this application fee, which would total over €30,000 per year with the average of 3000 temporary permits applied for each year, can be used to help fund the development of the electronic parking management system we are proposing.

The current parking permit allocation system in place in Venice can take upwards of 10 months to process an application. Time and resources of the city are wasted in processing applications and entering them into the computer. The system that we designed will have the person applying for a permit enter all the necessary information for the application into the computer themselves. The city will no longer need to manually enter the data into the computer and will also not need to needlessly pass permit applications between departments. Our system will automatically disperse information to all the necessary departments in the city. Applying for a permit with our system will take only a few days compared to the months the current system takes. A detailed explanation of how our system will work along with some of the key screenshots that show the proposed layout of the program can be found in Section 4.3. The rest of the screenshots for the proposed program are located in Appendix B. In the future there will be a large number of spaces within the city vacated when cargo and taxi boats are moved to the new parking lot on the western edge of the city. The city should commission the implementation of an online permit application system based on our proposed system model, using the proceeds gathered from the proposed permit application fees, to optimize Venice’s parking permit system before the opening of this new parking lot. In this way, the newly open spaces will be processed by the new system and will have the benefits of being optimized to reduce parking hindrances.
6 Bibliography


7 Appendices

7.1 Appendix A – Field Forms

Parking Study Location Data Sheet

![Parking Study Location Data Sheet]

Figure 36: A screen shot of the data sheet to gather information about traffic congestion problems
Figure 37: A screen shot of the form used to collect data on individual parking space usage.
7.2 Appendix B – Electronic Program Screenshots
End-User- Apply for Temporary Permit
Welcome to the City of Venice's On-Line Web GIS permitting system.

Please select from the following options:
Registration successful, please proceed to the following link to continue.

www.example.com/login
WELCOME to the online service that provides temporary permits for transits and stops. Services provided by the Mobilita Acquea office and the City of Venice.

Hello, John Doe, please select from the following options:

- Account Maintenance
- Transit Permits
- Stop Permits
- Transit and Stop Permits

You currently have 0 registered boats. Select Account Maintenance to add more boats.
## Company Information

- **Company Name:** Canal Space
- **Proprietor:** John Doe
- **Civic Number:** 0000
- **Sestiere:** Cannaregio
- **Telephone Number:** 0039 041 526688
- **Fax:** 0039 041 245896
- **P. Iva:** 01234567890
- **Type of Activity:** Transporto cose conto terzi

## Company Boats

- **Boat Registration:**
- **Boat ID:**
- **Type of Boat:**
- **Name of Boat:**
- **Material:**
- **Length (m):**
- **Width (m):**
- **Contrassogno:**

**Add Boat**
# Account Maintenance

## Company Information

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Name</td>
<td>Canal Space</td>
</tr>
<tr>
<td>Proprietor</td>
<td>John Doe</td>
</tr>
<tr>
<td>Civic Number</td>
<td>0000</td>
</tr>
<tr>
<td>Sestiere</td>
<td>Cannaregio</td>
</tr>
<tr>
<td>Telephone Number</td>
<td>0039 041 526688</td>
</tr>
<tr>
<td>Fax</td>
<td>0039 041 245896</td>
</tr>
<tr>
<td>P. Iva</td>
<td>01234567890</td>
</tr>
<tr>
<td>Type of Activity</td>
<td>Transporte cose conto terzi</td>
</tr>
</tbody>
</table>

## Company Boats

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boat Registration</td>
<td></td>
</tr>
<tr>
<td>Boat ID:</td>
<td></td>
</tr>
<tr>
<td>Type of Boat:</td>
<td></td>
</tr>
<tr>
<td>Name of Boat:</td>
<td></td>
</tr>
<tr>
<td>Material:</td>
<td></td>
</tr>
<tr>
<td>Length (m):</td>
<td></td>
</tr>
<tr>
<td>Width (m):</td>
<td></td>
</tr>
<tr>
<td>Contrassegno:</td>
<td></td>
</tr>
</tbody>
</table>

## Boat Information

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boat ID:</td>
<td></td>
</tr>
<tr>
<td>Enter Boat ID:</td>
<td>(ex. VE 12345)</td>
</tr>
<tr>
<td>Type of Boat:</td>
<td></td>
</tr>
<tr>
<td>Name of Boat:</td>
<td></td>
</tr>
<tr>
<td>Material:</td>
<td></td>
</tr>
<tr>
<td>Length (m):</td>
<td></td>
</tr>
<tr>
<td>Width (m):</td>
<td></td>
</tr>
</tbody>
</table>

- Yes, this information is correct: [ ]

**Add Boat**  
**Search**
# Company Information

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Procuratore</th>
<th>Civ. Number</th>
<th>Stellente</th>
<th>Telephone Number</th>
<th>Fax</th>
<th>Type of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Doe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Account Maintenance

- Add Boat
- Modify
Account Maintenance

Company Information

- Company Name
- Proprietor
- Civic Number
- Tax Identification Number
- Telephone Number
- Fax
- P. Iva
- Type of Activity

Company Boats

- Boat Registration
- Boat ID
- Name of Boat
- Length
- Width
- Material
- Contrassegno

Add Boat

Modify
WELCOME to the online service that provides temporary permits for transits and stops.
Services provided by the Mobilità Acqua office and the City of Venice

Hello, John Doe, please select from the following options:

- Account Maintenance
- Transit Permits
- Stop Permits
- Transit and Stop Permits

You currently have 1 registered boats. Select Account Maintenance to add more boats.
Your request for a temporary transit and stop permit has been sent to Mobilità Acqua. You will receive a confirmation via E-mail or fax shortly. Thank You.
End-User Apply for Permanent Permit
Welcome to the City of Venice's On-Line Web GIS permitting system.

Please select from the following options:

- Complain Console
- Water Space Modifications
- Permanent Permits
- Temporary Permits
End-User File a Complaint about a Water Space
Selected Water Space Information

- Space ID: 1.70
- Type of Boat: Private
- Boat ID: Private
- Length (m): 8.5
- Width (m): 1.5

Type of Complaint
- Incorrect Boat

Brief description of the problem:

Type of Boat: 1 character remaining

Map Legend
- Other Parking
- Taxi Parking
- Private Parking
- Gondola Parking
- Cargo Boat Parking

- Buildings
- Bridges
- Canals
- Available
- Water Spaces
Selected Water Space Information

- Spazio ID: 1,703
- Type of Boat: Private
- Boat ID: Private
- Length (m): 8.95
- Width (m): 1.52

No Photo

Type of Complaint

- Incorrect Boat
- The water space is the incorrect size for the boat parked here

Brief description of the problem:

The program says that there should be a private boat parked here, but a gondola is parked here.

120 Characters Remaining

Map Legend

- Buildings
- Bridges
- Canals
- Available Water Space
- Taxi Parking
- Private Parking
- Gondola Parking
- Cargo Boat Parking
- Other Parking
- Civic Number
- Requested
- Canal
- Requested

Connected
Photo Upload

To make this process easier, please include the boat ID and any identifying marks in the uploaded picture.

Photo 1:
Photo Upload

To make this process easier, please include the boat ID and any identifying marks in the uploaded pictures.

Photo 1: ...

Map Legend

- Buildings
- Bridges
- Canals
- Available Water Space
- Taxi Parking
- Private Parking
- Civic Number Requested
- Gondola Parking
- Canal Requested
- Cargo Boat Parking
- Other Parking
- Selected Water Space
Personal Information

To validate your complaint, please enter your personal information.

Name: [Input]
Last Name: [Input]
Name: [Input]
Telephone: (ex. 1234 567 890)
E-Mail: (ex. JohnDoe@abc.com)

Submit
Your complaint has been sent to Mobilità Acquea for further investigation. You may be contacted if more information is needed.
Administrative Program
Administrative Program- Approve a Temporary Permit
Welcome to the online permitting system of the City of Venice.

Please select from the following options:

- Permanent Permit System
- Temporary Permit System
- Compliant Care
- Water Space Modifications
- Canal Diversions

(0 new requests)
(12 new requests)
(1 new request)
(0 new requests)
(0 Canal closers)
Administrative Program - Look at a recently filed complaint
Welcome to the online permitting system of the City of Venice.

Please select from the following options:

- (0) new requests
- (0) new requests
- (1) new request
- (0) new requests
- (0) Canswer closest
Would you like to send this report to the Police for further investigation?

[No]

[Yes]
Administrative Program- Water Space Modification
Welcome to the online permitting system of the City of Venice. Please select from the following options:

- Permanent Permit System (0 new requests)
- Temporary Permit System (0 new request)
- Complaint Cconsol (0 new request)
- Water Space Modifications (0 new requests)
- Canal Closures (0 Canal Closures)
Space ID: 3,088
Category: Cargo Boat
Name: CROVATO ANTONIO SAS
Last Name: CROVATO
Birth Date: 
Birth Location: 
Cod Fiscale: 06189300270
P. Iva: 06189300270
Civic Number: 4920
Cap: 30122
State: Italy
Boat ID: V9503
Boat Type: V9503
Length (mt): 7.05
Width (mt): 2.02
Motor: (nessuno)
Propulsion: (nessuno)
Sestiere: castello
Canal: rio di s. severo
Date of Approval: 03/09/1990

Add New Picture

Modify  Close Window  View Complaints
Click on a Water Space to View its Information

Water Space Information

- Space ID: 453
- Category: Cargo Boat
- Name: CHANGED NAME
- Birth Date: 
- Birth Location: 
- Cod Fiscale: 
- P. I.V.A.: 
- Civic Number: 
- Cap: 
- State: 
- Boat ID: 
- Boat Type: 
- Length (m): 
- Width (m): 
- Motor: (nessuno)
- Propulsion: (nessuno)
- Sestiere: casello
- Canal: RIO DI S. SEVERO
- Date of Approval: 10/09/1993

Confirm
Do you want to make this modification?

[Yes] [No]
Administrative Program- Canal Closures
Welcome to the online permitting system of the City of Venice.
Please select from the following options:
You are about to close this canal, do you want to proceed?

Yes  No
Do you want the program to move the current boats to optimize water space?
You have re-opened this canal, all permit holders will be notified of its re-opening and if their water space has been relocated.