Re-Engineering the City of Venice's Cargo System For the Consorzio Trasportatori Veneziani Riuniti

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Each team member contributed equally towards the completion of this project. Without the full participation of each member and extensive teamwork the following project would not have been successful.

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Abstract

This project, sponsored by the Consorzio Trasportatori Riuniti Veneziani, located in Venice, Italy assessed the current patterns of the cargo delivery system and demand for goods within the city of Venice, and suggested: new routings and boat assignments based on a point- to- point delivery system, citywide dock locations, new warehouse plans, and loading procedures. Additionally, this project surveyed cargo workers to quantify the widespread support for such dramatic changes within the current system.

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Executive Summary

Currently, in any given day, a Venetian cargo man may spend 89 minutes loading his boat for the day's deliveries and travel for 160 minutes to make 19 different stops throughout the city. The described procedure is not the most efficient use of time, money, or resources. In any business, one aims to maximize production and profit while minimizing excessive use of time and money. This Interactive Qualifying Project was conducted in an effort to restructure the current cargo transportation system in the city of Venice through the development of delivery zones and the optimization of a warehouse. By re-engineering the cargo system, the cargo transportation businesses as well as Venice itself will experience numerous benefits.

Traffic has always been a primary concern of the population of Venice and has now been identified as a major concern of the city's cargo men as well. For the cargo workers, congested traffic signifies extended traveling from one location to the next and limited maneuvering space for docking, turning, and passing along many canals. Noise and air pollution, excessive boat traffic, *moto ondoso*[1], and longer trips on the *vaporetto*[2] are the aspects of boat traffic that directly concern the citizens of Venice. Our study has taken into account the current traffic concerns of the people of Venice and has proposed solutions to help alleviate these problems.

Through observation, this study has found countless examples of traffic problems. During one day of observing a cargo transportation route, a canal was completely blocked off by two boats tied together to remove an old *palina*[3]. The boat crew had to wait

[1] *Moto ondoso*: wakes caused by motor boats
[2] *Vaporetto*: large public transportation boat
[3] *Palina*: post that boats are tied to when docked

approximately 10 minutes for the boats blocking the canal to move before the cargo boat could pass through the canal to make its deliveries. During another instance in a small canal, the cargo boat arrived at the dock at which it needed to unload only 20 pieces of cargo only to find two other cargo boats tied together at the dock already. Without anywhere else to go, the cargo driver had to continuously dodge the constant flow of traffic. On another occasion, as the cargo operator was trying to make his way through a canal, he came upon a group of gondolas that were not moving. As Venice is a popular tourist attraction, clusters of gondolas frequent the smaller, more scenic canals. Completely blocked in by the gondolas, the captain was forced to drive his boat backwards down the canal for approximately 400 meters. Although these inconveniences may seem to be insignificant at first, these small obstacles accumulate over the course of a working day and are multiplied by the number of cargo boats encountering similar problems on a daily basis.

Such heavy traffic of cargo boats in the canals can be accounted for by the chaotic nature of their routes and the inefficient use of their boats. To better understand the excessive traffic problem and to construct a clear picture of a daily cargo route, observations for a full workweek were made on two separate cargo boats. The data that was collected consisted of drop locations, travel times, unloading times, waiting times, and carting times. It was found that between these two boats alone the same area was covered and the same docks, or docks within close proximity, were used to make deliveries to the same islands. Also, a considerable amount of time was spent just on traveling to locations that were spread throughout the city. In many cases traveling through the city, between delivery points, would take up 50% of the total time spent working in a given day. If one takes into account that there are more than 380 working boats[4] in the city all traveling at some point in the day it can be seen just how serious extraneous travel can become. It is no surprise that the canals of Venice are often impassable.

Observations of the current delivery system were made from boats belonging to two separate cargo companies of different sizes. The first company used only one boat to make deliveries each day. This single boat was forced to cover the entire city by itself and wasted much time traveling from each drop location to the next. The second company used three boats and, although there was more work to be done, the owner portioned the city into three parts and assigned one boat to each section of the city. On one of the observed days the single boat owner spent about nine and a half hours completing his deliveries throughout the city, which included over 165 of driving and 55 minutes of waiting for available dock space. During the same day, a boat from the second company spent three and half hours total for his deliveries, which included 69 minutes for travel time and 2 minutes waiting for dock space. Since each boat was filled with approximately the same number of boxes and these boats are paid *solely* on the number of boxes they carry, one can easily see the benefits enjoyed by the company using three boats to deliver to a planned system of separate delivery zones. These benefits were quantified by our study, and the project team sought to increase these benefits by applying a planned system of fixed delivery zones to the whole city that mirrors the system already in use by this one small company.

[4]Working boats: mainly cargo boats and construction boats used for both private companies and transportation on behalf of a third party. (boats of the CTVR fall in the latter category).

Unreliable dock availability was identified one of the reasons for inefficiencies of cargo deliveries in Venice. Frequently, several boats deliver to the same dock locations at the same times during the day. The cargo men are forced to either wait until a docked boat is finished unloading, or tie alongside the docked boat to unload his goods. In the former case, the cargo man is wasting time that he could spend unloading and delivering his goods, and in the latter case he is congesting the canal and preventing other traffic from passing. Both choices are undesirable to maintaining a smooth running city and therefore the choice of what to do is often a hard one for cargo men to make.

A main concern for most of the cargo operators, as identified through a questionnaire administered in the course of our study, was safety at the loading dock of Scalo Fluviale. The Scalo Fluviale is located on one of the few islands in Venice which is reachable by automobile, so it is used as a cargo transfer location between trucks from the mainland and the cargo boats of Venice. The heavily trafficked loading dock at Scalo Fluviale poses numerous safety issues. As cargo boats are loading their goods to be delivered, trucks are crowding the loading area and speeding through the narrow street to seek available locations along the dock. To make matters worse, several cranes are used to move heavier cargo onto boats, including propane tanks, lumber, and large bundles of metal rods used in construction. Although this is a logical way to move large heavy items it is dangerous when there is little space left for a safety zone around the equipment. As there is little room for the movement of goods, these cranes often operate over the cargo men who, without hard hats, are loading their boats.

These safety issues would be solved through the implementation of a warehouse, which has been on the cargo driver's wish list for over a decade. A warehouse would eliminate the need for trucks to enter the actual boat loading area. The amount of time spent loading the cargo boats would decrease, as goods would be sorted within the warehouse according to the sections of the city to which the goods will be delivered. Currently there are several warehouses in use on Scalo Fluviale, including produce, milk, and fish warehouses. At the moment, there are plans for the construction of a warehouse for general cargo on the Scalo Fluviale. Through the course of this study, our team has devised a detailed description of the inter-operation of the warehouse, see **Appendix P**.

The implementation of a warehouse calls for a proper organization of delivery destinations and a proper delivery depends a clear understanding of the basic needs and demands of each type of store in Venice. An economic layout of the city was constructed as a first step towards this understanding. The businesses on each island, 125 in total, were mapped out using exact address locations. The address and type of each business was entered into MapInfo and a layout of the city's businesses was created. To quantify the demand for each individual island, the number of *colli*[5] delivered to each different type of business were determined through sampling. Data collection sheets were handed out to a number of businesses of each type, through the assistance of the president of the CTVR. These sheets recorded the number of *colli* delivered be recorded each day, for one week. Data was also collected from the company that handles the city's UPS express deliveries, which makes deliveries to each of the businesses it services on a weekly basis. By following the UPS cargo men as they made their deliveries, by cart, over the entire city, UPS delivery data was collected. The address of each business receiving deliveries was recorded along with the number of packages received. Similar data was collected from the docks at Scalo Fluviale, and by writing down the addresses presented on the

[5] *Collo: (pl. colli)* unit (box, bag, etc) of cargo.

boxes and comparing those addresses to the business addresses collected earlier in the project, a fuller picture of UPS demand was calculated.

Once an adequate sample of delivery data was collected, businesses were grouped together according to *colli* delivery rates. To group businesses together, the noted number of deliveries made to each different type of businesses was referenced. An average number of *colli* for each business type was calculated. For instance, data was collected for three grocery stores. The average number of boxes received by these stores was calculated for one week. One can assume, then, that a given grocery store would receive this average number of deliveries. As the businesses on each island were mapped during this study, the number of each type of businesses is known. The total number of *colli* delivered to each business type was summed according to island, and then the total number of *colli* delivered to each island was calculated by summing the total deliveries made to each business type. When the total *colli* for every island was summed it was found that in a given week the city receives a total of 183,332 *colli.*

By using the calculated number of *colli* delivered to each island, the project team was able to break the city down into delivery zones. Islands were grouped together based upon their economic activity as well as their proximity to each other. Several islands of low economic demand make up some zones, while other zones contain only a single island of high economic activity. These zones played a large part in the organization of the warehouse as well as the planned routing system for the cargo boats.

Observations made at the loading dock of Scalo Fluviale concluded our estimation of the average size of *colli*. Several boats were observed while loading, and the number of boxes that were loaded was noted. The average size of *colli* was calculated through previous gathering of boat data. A database has been created, containing information on all cargo boats (CTVR and non-CTVR boats alike) concerning their dimensions, see **Appendix C**. By using boats of known dimensions and the number of *colli* loaded to fill those particular boats an average size of one *collo* was calculated, see **Appendix G**.

Using the calculated average size *collo* and the average volume of the CTVR boats, the amount of *colli* that would fit into all the boats, if filled to capacity, was calculated as well as the number of *colli* that can fit into a single average sized boat. The amount of cargo that is able to fit into one boat was crucial to our identification and determination of a routing system for the created zones. After knowing both the number of *colli* delivered to each delivery zone and the number of *colli* that can fit into an average boat, it was possible to estimate the number of boats needed to service each delivery zone. Then, based on the known dimensions of boats in the CTVR and the number of *colli* that must be brought to each defined delivery zone, suggestions were made regarding which boats would most efficiently service each zone. Special considerations were made for islands containing businesses that require deliveries in massive daily amounts, such as super markets. We suggested that boats assigned to these areas be equipped with cranes for unloading pallets and that carters be provided with pallet jacks so that they can move the entire pallet of deliverables without breaking down the pallet.

The assignment of boats to zones is important concerning the operation of the warehouse. As mentioned previously, in the warehouse, the incoming cargo will be sorted according to its destination. Each zone has one bay assigned to the addresses of buildings location on the involved islands. Cargo destined for the businesses of each zone will be placed on pallets, shrink wrapped, and then transported by a forklift to the assigned loading dock. This organization will substantially decrease the amount of time spent traveling throughout the city due to the close proximity of every stop on each boat's route. To further assist in the implementation of a routing system, the exact location of docks that should be utilized were noted. Dock locations were chosen based upon dock conditions as well as the preferences of cargo operators. The most efficient routes to these docks were then mapped.

A questionnaire was presented to cargo operators at the Scalo Fluviale, concerning current conditions and the possibility of future changes to the system and their jobs. The results of the questionnaire showed that eighty-nine percent of the polled workers disagreed that the current system was ideal and needed no change while only 2 percent agreed. In support of our study, seventy-six percent of polled workers stated that they would prefer a point-to-point delivery system apposed to the current citywide delivery system, while only 15 percent would not prefer our suggested method.

In conclusion, our study has not only proved that the current cargo system of Venice contains several inefficiencies but also provided several plans of action to remedy the identified problem areas. Along with sectioning the city into delivery zones and developing a warehouse plan that would support the sorting and storage of each separate zones packages routes, docking locations, and suggested boat assignments were also developed. Calculations concerning the amount of money and time that will be saved each day were also made to prove the true benefits of the re-engineered system.

1 Introduction

The proposed idea of reorganizing the city into delivery zones was revolutionary in 1997 when the idea was first recommended. In the summer of 2001, the concept that stirred the imagination of cargo deliverers in Venice was turned into a reality by this project team. During this project, the city was segmented into delivery zones and a plan for sorting the cargo going to these zones was devised. In essence, the goal of this Interactive Qualifying Project was to re-engineer the Venetian cargo transport system.

The Consorzio Trasportatori Veneziani Riuniti (CTVR) sought help to complete this extensive task. The CTVR consists of approximately 70 percent of the cargo deliverymen in Venice. If a new organized plan is adopted by the CTVR, the majority of the cargo moving power in the city, the adopted plan, upon its proven success, may also be embraced by the rest of the cargo deliverers.

Ultimately, the new plan for the CTVR reflects the needs and desires of the cargo men. To devise a new, working system, each aspect of the current system was examined to the most minuet detail. These details were then analyzed in order to develop any possible changes that could be made to the system. After analysis of the current system, every proposed change was evaluated to determine the most effective, feasible solution for all who will feel the impact of any change. Concerns cargo men express about the current system were also addressed. For example, many cargo men find it hard to locate unoccupied docks to unload their cargo within the city. Ideally located docks of good condition and possible locations for future docks were marked. It is suggested that the city reserve these docks be reserved for cargo use only.

The remainder of this document contains **Chapter 2: Background**, which provides details about the current cargo transportation system of Venice as well as concepts related to cargo shipping and warehouses. Also included in the Background is information specific to our sponsor, CTVR, and information on laws and regulations concerned with cargo transportation in Venice. Next, in **Chapter 4: Methodology**, every step that was taken to complete the proposal is discussed. Following the Methodology, the information obtained during data collection is discussed in **Chapter 5: Results**. **Chapter 6: Analysis and Conclusions**, shows how the collected data were interpreted. In the final chapter, **Chapter 7: Proposals**, recommendations of delivery zones, travel routes, boat assignments, delivery schedules, docking locations, and warehouse plans can be found.

2 Background

This chapter has been compiled to help the reader develop a base of knowledge specific to the current cargo transportation system in Venice as well as an understanding of basic cargo transportation terms and practices. The most important topics covered herein include a broad overview of transportation systems in general and how they are related to the current Venetian system

2.1 The Economy of Venice

Trade has always been a vital part of the Venetian economy since the city's founding. Venice has always been dependent on outside resources as it is a city composed of small islands. Cargo has been delivered using the current method as it has proven to be successful. Although successful, this system does not utilize its full potential of efficiency. Tourism, the number one industry in Venice, creates a need for organization in delivery of goods. With the ongoing influx of tourists growing each year, the demand for outside resources exponential increases. This reason alone makes the current system inefficient, unmanageable, and ready for change which will be proven later in this document. Though this change is not immediately necessary, the more time that passes before it occurs, the harder the change will be to implement.

There are 385 cargo boats throughout Venice. Some of these boats are associated with shipping companies and others are directly involved with the companies and the products that they ship. For example, the McDonald's boat is owned by the McDonald's distributor in the area and not by a cargo company. In Venice, the cargo companies who operate within the city own the majority of the cargo boats. These are the boats that were included in this study, as ultimately these boats will be directly affected by any recommendations made by this study. In this study, any cargo boat that was owned or used by a transportation company was of interest, but the main focus remained on CTVR boats.

2.2 Sponsor Information

Recently formed in the year 2000, the Consorzio Trasportatori Veneziani Riuniti (CTVR) chose to sponsor this study of the cargo transportation system of Venice. The CTVR consists of the president, Luigino Vianello, vice president, and five cabinet members. Although the CTVR members are interested in the findings concerning the current system, the members are mainly interested in any changes proposed to increase the efficiency of the system.

Figure 1:CTVR members

The Consorzio Trasportatori Veneziani Riuniti is an organization similar to a teamster union in the United States. An example of a teamster union is UPS[6]. The 184 boats in the CTVR represent about two thirds of the total boats responsible for delivering about 70 percent of all general cargo within Venice.

General cargo has been overlooked for many years. The dairy, produce and fish distribution companies all have their own warehouses while general cargo has been trying

[6] United Parcel Service

to obtain a warehouse for over 10 years now. As individual companies they had no voice. Forming the CTVR has given them strength in numbers.

In Italy, certain guidelines must be met to establish an official organization. A constitution that includes a list of the founders with signatures is created. To be recognized by the government, an official letter must be submitted with a copy of the constitution. A copy of the CTVR's constitution and a list of its current members can be found in Appendix L.

2.3 Identification of Cargo

When something is packaged and transported from one place to another it is generally called **cargo**. This is an important term that will be used extensively throughout this study. The Merriam-Webster Collegiate Dictionary's definition of cargo is, "the goods or merchandise conveyed in a ship, airplane, or vehicle**."** The information contained in this document deals with the transportation of cargo by boats since in fact boat transport is the only way to move cargo throughout the city of Venice. In Italian, the word for package is *collo*[7]. Throughout the rest of this document, the term *colli* will be used to refer to cargo packages.

2.3.1 Types of Cargo

There are three main types of cargo: *non-refrigerated*[8], *refrigerated*[9], and *unit loads*[10]. In the following sections a closer look will be taken at the two types of cargo that require special transportation; refrigerated and unit loads. The special needs that are

[7] *Colli*: plural for *collo*
[8] Non-refrigerated: dry goods (it. Secchi)
[9] Refrigerated: perishable goods (it. Deperibili)
[10] Unit Load: A group of items packaged together for transport.

relevant to shipping these types of cargo will also be addressed. Section **2.3.1.1 Perishable Cargo** considers the needs of items that must be shipped within a specific timetable or in refrigerated units, and Section **2.3.1.2 Unit Loads** deals with the issues of shipping sizable pieces of freight.

2.3.1.1 Perishable Cargo

Perishable cargo is made up of goods that are liable to spoil or decay. Most perishables are foodstuffs. Examples in this category include: fruit, vegetables, butter, milk, meat, and eggs. If perishable goods are not cared for properly or shipped within a certain time frame then they will spoil before they reach their destination or soon thereafter. Perishable food needs to be kept cold to reduce spoilage and decay due to enzymes and microorganisms [11]. Regulations on shipping perishable cargo in Venice can be found in **Appendix O**.

Refrigeration leaks are a possible concern to consider in relation to refrigerated boats used in Venice. Chemicals used for refrigeration such as Sulfur dioxide, ammonia, Methyl formate, Methyl chloride, Ethyl chloride, and Dichloroethylene can be very dangerous to human life, as well as other forms of life, in very low concentrations and in very short amounts of time. [12] For example sulfur dioxide present in the air at .7 percent by volume can kill a person in 5 minutes. [13] Many refrigerants are also flammable when mixed with air. Refrigerant leaks are not only dangerous, but they are also costly and

[11] Gunther, 895
[12] Gunther 134.
[13] Ibid. 135.

"add to the expense of operation". [14] About 28% of the cargo boats in the CTVR are refrigerated.

2.3.1.2 Unit Load

There are two main types of unit loads: cargo that is in itself one large package, and cargo that is made up of numerous small packages that are bundled together to form a larger unit. The unit load can be heavy, large, or both. A pallet of shrink-wrapped goods is characterized by both qualities.

Figure 2: Unit Load Being Moved by Crane

Shipping the unit load is usually more economical than small units, but when working in small-scale shipping, such as in Venice, it could be more expensive. One reason for this added expensive is that forklifts or cranes may be required to move the unit load. Such machinery, which requires trained workers, is expensive to buy and operate. An example, a forklift, of the machinery used to move unit loads can be seen in Figure 3.

Figure 3: Small Forklift for Moving Pallets

[14] Ibid. 137.

2.4 Cargo Boat Characteristics

Figure 4: General Cargo Boat

There are many kinds of cargo boats throughout Venice, just as there are many kinds of trucks on the roads of any major city. Each boat has specific dimensions, maximum cargo capacity, engine size, and deck space.

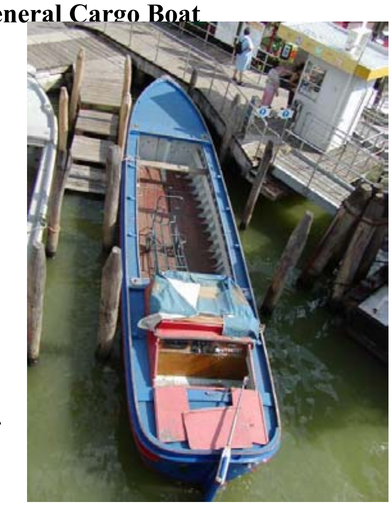


Figure 5: Cargo Hold

The cargo hold of each boat takes up only a certain percent of the total volume of the boat. The length of the boat is measured from the tip of the bow to the end of the stern but the cargo bay does not extend this full length. Space must be left for the engine and helm. After the space for these items is considered the cargo bay only spans about 70 percent of the length of an average boat. The same is true for the width, in this case due to the thickness of the hull the cargo hold and be accounted for 90 percent of the measurement from side to side. The height measurement of the hold is not effected by any internal structures.

2.4.1 General Cargo Boats

Despite the variations in makes and models, most cargo boats are similar in terms of dimensions and other key characteristics. Most cargo boats can be considered two-leveled. All cargo boats have a hollow hull for the storage and transport of cargo, see Figure 5**.** The cargo hold is covered by boards to create a platform that provides another storage area for cargo. The lower cargo hold can be used to aid organization by segmenting the boat, keeping cargo dry in rainy weather or choppy seas, keeping cargo out of the sun and occasionally storing goods overnight. The height to which cargo can be safely stacked on this platform is about one meter. Cargo can be seen stacked in this manner on the boat in Figure 6. The majority of boats in the CTVR can be considered general cargo boats. On a given day, a general cargo boat carries beverages, food, laundry and household goods. There are also specialty cargo boats within the CTVR that carry packing peanuts for Murano glass companies, flowers throughout the city, or furniture for individual clients.

Figure 6: Cargo stacked on boat.

2.4.2 Refrigerated Cargo Boats

About 28% of the cargo boats in the CTVR are refrigerated. Of the 184 CTVR boats, 52 of these boats contain refrigerator units. These 52 boats are an established consortium of their own called the Transportatori Alimentari Consorziati (T.A.C.). The president of this consortium is Stefano Miglioranza.

The majority of the cargo boat is consumed by the refrigerator unit. A small amount of space is still available for the transport of general cargo. This allotted space varies among the refrigerated boats. The general structure of the refrigerated boat can be seen in Figure 7.

Figure 7: Refrigerated Boat

Refrigeration leaks are a possible concern to consider in relation to refrigerated boats used in Venice. Chemicals used for refrigeration such as Sulfur dioxide, ammonia, Methyl formate, Methyl chloride, Ethyl chloride, and Dichloroethylene can be very dangerous to human life, as well as other forms of life, in very low concentrations and in very short amounts of time. [15] For example sulfur dioxide present in the air at .7 percent by volume can kill a person in 5 minutes. [16] Many refrigerants are also flammable when mixed with air. Refrigerant leaks are not only dangerous, but they are also costly and "add to the expense of operation". [17]

2.4.3 Construction Boats

Outside of the CTVR, there are approximately 100 construction boats in Venice. Structurally, these boats are much larger than a typical cargo boat. Though metal boats are banned from Venice, many exceptions are made for these construction boats. Metal

[15] Gunther 134.
[16] Ibid. 135.
[17] Ibid. 137.

boats have been banned from Venice as they are heavy and sit deeper in the water, causing increased wake damage to walls of the canals throughout the city.

Construction boats are responsible for the transport of building materials as well as demolition debris. To aid in the transport of these heavier, bulkier materials, a crane is often embedded in the structure of the cargo boat as seen in Figure 8. Aside from construction boats, cranes are sometimes utilized to transport general cargo in the CTVR. A general cargo boat which was moving beverages at the time this picture was taken, can been seen in Figure 9.

Figure 8: Construction Boat with Crane

Figure 9: Utilization of Cranes in the CTVR

2.4.4 Non-CTVR Boats

Figure 10: Example Vaporetto

Since traffic is a problem in Venice, clearly the cargo boats are not the only boats that congest the canals. The majority of people in Venice at a given time are not residents of the city; therefore, they must rely on the public transportation system. The most common form of transportation, accommodating the most amount of people, is the *vaporetto*[18]. The *vaporetto* is the equivalent to a city's subway system.

Figure 11: Taxi Boat

Like any major city, Venice has an abundance of taxis. These boats often carry as few as two people, but have the capacity to carry as many as twelve. An additional boat on the canals is the *gondola*. An extremely popular tourist activity involves a scenic tour of Venice on a *gondola*. Aside from transportation boats, a department of the city, called AmaV, is used for the removal of

Figure 12: Gondolas

[18] *Vaporetto*- n. ferry

trash from the city. These boats remove trash at designated docks labeled throughout the city.

Figure 13: AmaV Boat

2.4.5 Docking Locations

When delivering cargo, an established area for deposit of goods needs to exist. In Venice, these established areas are docks. There are three kinds of docks found throughout the city:

Figure 14: Riva

- Riva - a stone dock with steps or a street end without steps
- Fondamenta - a sidewalk to which boats can dock
- Pontile - a wooden dock that projects into the canal usually with steps

Figure 15: Fondamenta

Refer to Figure 14**,** Figure 15 **and** Figure 16. In the San Marco Sestieri, every established dock is labeled with a blue plaque by the city. If the dock is designated for a certain type of boat, such as cargo boats or AmaV boats, the plaque will indicate this distinction.

Figure 16: Pontile

The docks in Venice are in various conditions. Some of them are very well maintained and are easy to use for the loading and unloading of cargo into and out of boats. Some, on the other hand, are not well maintained and are in disrepair. During 1997 and 1998 there were extensive surveys done on the condition of docks and during both years only about 60% of the docks were in usable condition. The surveys defined usable condition as a dock at which a delivery can be made with little or no immediate difficulty. About 30% of the docks had difficult ratings. While deliveries could be made, the dock had physical problems that would make deliveries difficult. The remaining 10% of the docks available had major flaws that were so critical that deliveries could not be made at all. It will be important to note which docks are unusable when re-designing the routes the cargo boats will take throughout the city. The most suitable docks for cargo boat deliveries should be noted for each island to ensure that there will not be any problems loading or unloading at any point along a boats route.

Figure 17: Dock Labeled for AmaV use

Figure 18: Rotting Dock

2.5 Cargo Distribution Concepts

Cargo transportation has many facets that are not seen to the everyday receiver or shipper. Many of these facets occur `behind the scenes` in such a way that people are not aware that they occur. Below is a list of some common cargo transportation practices. The following practices provide a paradigm for the current system in Venice and its evaluation of efficient methods. Efficient practices of cargo transportation were considered throughout this study.

2.5.1 Transport Planning

When transporting various goods from one location to another, there are many factors involved in order to determine the most efficient procedure, such as routing, cost benefits, and the demand for goods. When planning delivery routes, distribution of economic activity must be known[19]. The economic demand is imperative in determining the most efficient drop locations for goods, as well as determining the amount of goods that are able to be transported at one time.

2.5.2 The Warehouse

The term "warehouse" has a broad definition ranging from a multi level structure, utilizing a large workforce, to a simple storage room with few employees. In Venice, the different options of storage availability needed to be considered. The amount of land area that can be built upon in Venice is limited. For this reason, the most efficient plan for warehouse construction is vital.

[19] Meyer, 101

2.5.2.1 Warehouse Management

As our plan for reengineering the cargo delivery system concerns the saving of time and money, our plans for warehouse usage concerns these same aspects. In order to have a fully efficient warehouse or storage building, one must consider nonproductive time in order to maximize efficiency. Separate, sub-warehouses for different types of goods, such as refrigerated item, aids in organization as well as management of time spent sorting cargo. Expenses for the warehouse, including the building itself, manpower, machinery, and operating expenses must be evaluated. Most warehouses have a relatively small workforce. Usually, smaller warehouses are more efficient because there is less room for movement of employees, thus less wasted time.[20] In order to save time, goods should be organized according to what needs to come in and leave at the fastest rate. A warehouse that is designed to work around the clock would have an advantage over other storage buildings, as these warehouses would be best utilizing the equipment and the investment that has been made in the building itself.

2.5.2.2 Storage Considerations

Whether goods are being shipped on a cargo boat or stored in a warehouse, the physical packaging of the goods is important to consider as a means of saving time and money. Efficient warehouses do contain a minimum of unused space. When considering a warehouse as a means of storing goods, one must see the productive utilization of warehouse space as the most important aspect of controlling warehouse costs. To use the space to its fullest extent a standard is needed for containers and the amount of goods in

[20] Harmon, 88.

each container.[21] After the appropriate containers are evaluated, the size of storage racks, shelving and bins can then be evaluated. The shipping container is useful in consolidating goods, but also, the potential for damage to the goods must be kept in mind. The item needs to be protected from shock during shipment, storage and handling damage in the warehouse through the use of capable machines for moving the goods. [22]

There are several ways in which goods can be optimally stored in a warehouse. One way is by a random location control. In this sense, items are stored in the available space. The problem with this method arises when the items must be located for delivery. Since not all items are going to the same place it may sometimes be a problem locating specific items on short notice. A fixed location control system allows the same type of products to be stored together when they are to be shipped at the same time to the same location. Either way, a stock locating scheme should be developed to help utilize the most amount of space as well as provide a faster way of obtaining the goods needed at a given time.[23]

2.5.2.3 Just-in Time Delivery System

An inventory management system that has become more and more popular in America and Japan is the just-in time delivery system. Basically, instead of a factory having a warehouse full of materials on hand for their use the materials will be shipped to the factory exactly at the time when they will be used, thus eliminating the need for elaborate warehousing which in turn can reduce costs. The just-in time system has proved

[21] Horsman, 203.
[22] Brown, 2.
[23] Horsman, 130.

to be very economical in Japan and America, as automotive companies have readily adopted it.

In Venice this system is already in affect. Cargo boats act as an extension of the distributor from the mainland. Very rarely do goods come into the city that will not be used immediately. Venice has numerous vendors of perishable goods that must receive deliveries on a regular, set schedule. The demand of goods may vary due to influxes in unpredictable economic activity; however, due to lack of storage space, it is not plausible for a business to order bulk quantities of goods at a time.

2.5.2.4 Rush Delivery

Rush delivery cargo must reach its destination within a short time frame. Because of the time constraints, rushed packages cannot be sorted in the normal fashion and must be sorted separately in a properly equipped warehouse for this consideration. Special areas or conveyor belts should be set aside to deal only with these items so that the packages are not lost among the normal delivery packages.

Rush delivery is not as much of an issue in Venice as it may be in other cities due to the nature of the delivery system. All cargo and packages entering the city in a given day are distributed before the end of business hours that day. Cargo is not stored for later distribution due to the fact that a storage facility for general cargo does not exist.

2.5.3 Packaging Design

When considering the movement of a large amount of goods, how these goods are packaged should be considered. One way in which costs can be lowered and time can be saved is to move goods as a unit load. The unit load has been defined by Professor James

R. Bright as: " A number of items, or bulk material, so arranged or restrained that the mass can be picked up and moved as a single object too large for manual handling, and which upon being released will retain its initial arrangement for subsequent movement. It is implied that single objects too large for manual handling are also regarded as unit loads."[24] There are several types of containers that can be used to carry these unit loads. The largest of containers would be the most efficient.

There are many advantages to moving goods in a unit load. Manual labor will be replaced by machinery, thus increasing the speed at which goods can be delivered. The speed at which the cargo is loaded into boats would also increase if it were shrink-rapped to a pallet and loaded by forklift. Each unit load would be organized so that, upon delivery, the cargo boat drivers would have an easier time organizing the goods for cart delivery. By putting all of the goods in unit loads the amount of packaging would decrease due to fewer individual storage containers and the potential for the damage of goods would also be reduced. [25]

2.6 The Cargo Transportation System in Venice

Canals divide Venice into 125 small islands. The canals of Venice perform the same function as paved streets would in any other city. The canals are Venice's *only* efficient method of major transportation since manpower must be used to move along streets and over bridges.

Figure 19: Scalo Fluviale Loading Dock Area

[24] Apple, 70.
[25] Ibid. 72.

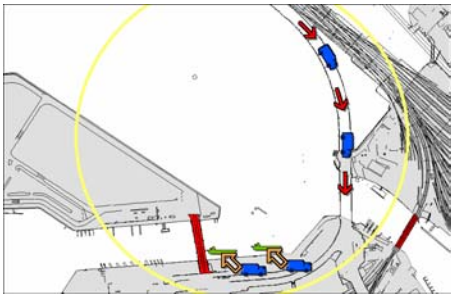


Figure 20: Trucks on main land bridge. Cargo transfer at Scalo Fluviale.

The current system involves trucks bringing goods from the mainland to Scalo Fluviale. There the boats are loaded with cargo, acting as an extension of the delivery trucks, see Figure 20. Boats in the CTVR travel their delivery routes everyday, starting from the loading dock of Scalo Fluviale. Daily deliveries of some items must be made, such as laundry, flowers and perishables. Other cargo such as clothing, jewelry, and glass items are delivered on a less regular basis. Deliveries of lower demand islands may be made as frequently as once a week, to as rarely as once a season.

2.6.1 Conto Proprio vs. Conto Terzi

In Venice there are two main types of cargo boats. The first of the two types of cargo transportation companies is *conto proprio*[26] and is the most common type of cargo transportation boat in Venice. These boats are owned by the companies to which they deliver their goods. For example, the four McDonald's located in the city are delivered to by one McDonald's boat. This boat delivers only to the McDonald's company. In fact, it would be illegal for them to transport cargo for any other parties then the one that owns the boat since they do not hold the Trasporti Cose license, described in 2.6.2 Licenses, that allows such transport.

Boats that are in the business of delivering cargo for third parties are known as *conto terzi*[27]. These businesses have all the licenses that are required for *conto proprio* as well as the Trasporti Cose license previously mentioned that allows them to move cargo

[26] *Conto Proprio*: Transport of goods on behalf of boat owner. Company owned boat.
[27] *Conto Terzi*: Cargo transportation on behalf of a third party. Owner/Operator boat.

or goods for a third party. Every boat in the CTVR is licensed as *conto proprio*. This license not only allows them to work with businesses in the city but also for private citizens of the city that may need to have large items moved that do not fit in small private boats.

2.6.2 Required Licenses

The licenses that must be obtained to own, drive, and park a cargo boat in Venice are outlined in this section. There are a total of 6 possible licenses that can be acquired in relation to the transport of goods. The first five licenses are mandatory, and the sixth license is necessary to operate in terms of *conto terzi*.

The first license registers your company with the Chamber of Commerce. Also from the Chamber of Commerce, the second license is a driver's certification showing that the boat operator is qualified to drive his cargo boat. The third license is a shipping license specific to boat drivers who travel in internal waters. This license is equivalent to a pilot's license in the United States. At least one person on each cargo boat must have this license for the boat's operation to be legal. The fourth license deals with the plates and registration of the boat. The fifth license is a permit to park the boat within the city overnight and specifies the parking spot that must be used.

The sixth license that is obtained for transportation of goods on the behalf of a third party is for a separate license plate, or yellow tag, displayed on the boat as a second form of boat identification, see **Figure 21**. Examples of these licenses can be found in **Appendix M**.

Figure 21: Trasporto Cose tag of Conto Terzi Boat 185/A.

The canals of Venice vary in size with widths ranging from less than 3 meters across within the city to over 70 meters at some points on the Grand Canal. There are canals that can carry almost any kind of traffic and are always heavily traveled. There are also smaller canals that are not heavily traveled and cannot accommodate


Figure 22: One Way Canal Sign

large boats. To ease congestion, some canals are strictly one-way while other canals make use of traffic lights. These canals are usually too narrow to allow more than one boat to travel at a given time. Widths of canals is often reduced so much as to

Figure 23: Parked gondolas reduce canal width.

make them impassable when boats are parked or double parked along one or both sides of canals. This problem is illustrated in **Figure 23**. Canals are often restricted in other ways, such as one-way canals. These canals are prevalent throughout Venice and must be taken into consideration when determining daily routes.

3 Methodology

This project was designed to collaborate with the Consorzio Trasportatori Veneziani Riuniti to evaluate the possible re-engineering of the method of cargo transportation in the city of Venice by specifying possible points of reorganization within the system. The main points of reorganization include: creation of delivery zones for the entire city, assignment of an appropriate number of boats to each zone, identification of current and future dock locations and the location and basic plan for a sorting and storage warehouse.

Each of the following originally set objectives were met by the completion of this study:

- Gather information on the current delivery methods used in Venice.
- Evaluate the benefits of a new cargo transportation system in Venice.
- Estimate the demand for each island contained in the Historical Center of Venice.
- Divide the city into delivery zones.
- Devise system for how the warehouse should operate and a plan for the use of its adjoining dock space.
- Propose several possible changes to the cargo delivery system that will reduce chaos and traffic therefore benefiting both the businesses involved as well as the city.

This chapter is divided into the following sections:
Section 3.1 defines the domain of inquiry of this study and depicts the geographical study area.
Section 3.2 explains how the current practices were observed and what data were recorded. This section also contains information on surveying the boat drivers.

Section 3.3 depicts the details of data collection for the purpose of estimating the demand of the city Venice.
Section 3.4 looks at the characteristics of the current cargo fleet.
Section 3.5 outlines the major points to be included in the proposed plan. The sub-sections include delivery zones, optimal dock locations, and ideas for the proposed warehouse. Also, equations used for making calculations in relation to the new plan.

3.1 Domain of Inquiry and Study Area

The entire Historical Center of Venice, 125 islands in total, was included in the scope of our study area. An emphasis of study was placed on the cargo loading area on the island of Stazione Marittima. On Stazione Marittima, Scalo Fluviale, the loading area, is the located.

Figure 24: Domain of Inquiry and Stazione Marittima

The docks throughout the city were also an area of study emphasis. Docks are the second location that cargo boats spend a majority of their workday. To fully understand the current system of cargo transportation, boats would have to be observed for a full day of work. The study area is then extended to the canals cargo boats travel throughout the city.

3.2 Review of Current Practices

In the following section, an explanation of how information and data concerning the current cargo transportation system of Venice was gathered. The first step in this project was to decide whether or not the reengineering of the current cargo system was necessary. In order to determine the need for reorganization, every detail of the current system was examined. Many observations and tasks were conducted to gather necessary information concerning the cargo industry's boats, the routes that they use, and the working conditions on both the loading docks of Scalo Fluviale and throughout the city. Particular attention was paid to how each boat was loaded, the method the packages were unloaded from the boats, and the overall efficiency of each task. Information was also gathered through a questionnaire completed by many of the boat operators in the city.

3.2.1 First Meeting with Sponsor

To establish contact with our project sponsor after arriving in Venice, a meeting was held with Luigino Vianello, the president of CTVR. As our sponsor does not speak a word of English and none of the members of this team speak Italian, a severe language barrier existed. During the meeting, our advisor, Fabio Carrera, acted as an interpreter. Many questions that we formed during our project preparation in the United States were answered during this meeting. Major concerns of the members of the CTVR were brought to our attention.

3.2.2 Observation of Loading Dock Area

The loading dock area at Scalo Fluviale was observed on two separate weekdays of typical volume. During the first observation, general practices of the current system were noted. Observations were made between the hours of 3AM and 7:30AM. The dock was observed from an overlooking bridge adjacent to the loading area at this time to determine the mode of operation at the dock. Sorting procedures were also observed and recorded, including estimations for the amount of time required to load random cargo boats. Every truck that entered the loading area at during this time was recorded.

During the second sitting at Scalo Fluviale, quantitative data was collected. Data was recorded at Scalo Fluviale between the hours of 4:45am and 9:15am, the hours of highest traffic at the Scalo Fluviale. The number of boats at the loading dock was recorded every fifteen minutes, as well as the number of trucks present in the unloading zone along the boat dock. During this same time, total *colli* amounts for several boats were collected. The *colli* amounts were used to determine the average *collo* size.

3.2.3 Observation of Delivery Procedures

To determine the current delivery procedures throughout the cargo system in Venice, we accompanied cargo boats as they made their deliveries throughout the city. Two different companies within the CTVR, were observed during this study.

The first company observed was Vianello Trasporti. The company owner is Luigino Vianello, president of the CTVR. His company completes all of its deliveries in one boat. His workers consist of his son Jonathan and his nephew Michele. The cargo boat was accompanied for six consecutive workdays, excluding Saturday and Sunday as these are not normal workdays. Cargo men who chose to work on these days are working on odd, side jobs. The majority of cargo boats in Venice make deliveries five days a week. The sixth day on the dry goods boat was observed to determine if a weekly schedule existed.

Rialto Trasporti was the second company that was observed. Stefano Miglioranza is the president of T.A.C. (Trasportatori Alimentari Consorziati). This company consists of three refrigerated boats. One of the three refrigerated boats was observed for six workdays. On the sixth day, all three boats from the company were observed. The three refrigerated boats are owned by the same company and split the cargo deliveries among themselves to cover the city. All three boats were observed on a single day to show that these boats do not overlap routes or docking locations.

Observations were carried out on all the cargo boats during typical days of delivery. In order to observe an entire workday, we needed to be at the loading area at Scalo Fluviale at 7:00AM. The overall loading procedure at the dock was observed. The amount of *colli* loaded was individually counted, and the amount of time spent loading these *colli* was recorded. After the loading process had been completed, the route traveled and the docking locations for the day were mapped. Types of cargo unloaded at each docking location were noted. Several timetables were constructed for procedures such as traveling to locations, waiting for docks, unloading of goods, and carting of docks. The time and duration of the cargo boats deliveries throughout the city were observed. The time to make the round trip was recorded as well as the total number of stops made during the day. While observing the Vianello Trasporti, the workday ended as late as 6PM, while on the Rialto Trasporti boats, the workday ended by noon.

3.2.4 Investigation of Current Routes

The examination of the currently used routes provides an insight as to what canals are more efficient than others for making deliveries. Cargo boat drivers will be comfortable with the current routes since they have been working on them regularly. The traffic on the currently used canals may be lighter and the docks available may be in better condition or more easily accessible than other docks in the area. For all the above reasons the current routes were investigated and mapped to ensure that the proposed plan made use of the benefits the commonly used canals provide. Having an extensive knowledge of the existing cargo traffic routes was extremely helpful during the re-engineering phase of our project.

3.2.4.1 Existing Route Information

It was difficult to obtain cargo companies' boat routes from the companies directly. Most companies do not keep track of their routes due to the sporadic nature of their current delivery system. The only way to obtain the exact route used on a given day was to accompany the cargo boat as it made its rounds through the city. The routes of the accompanied boat were recorded at the time of travel. The route information was entered into Mapinfo, and through the use of these maps, overlapping routes were identified among the boats. The maps of current cargo routes helped in the planning of new routes by providing information on commonly used canals and docks.

3.2.4.2 Current Route Data Collection

Because the CTVR boat companies did not keep current lists of the routes that they used, we were not able to collect any lists of current cargo boat routes. To collect information on the current cargo boat routes, we chose to mark down the route the boat took when we were accompanying the boats throughout the city. Although this accompanying only gave us a small number of routes, the data still proved very useful. The data showed which docks and canals the boat drivers favored. Sometimes boats traveled to docks further from their destination because the closer docks, although easily accessible, lacked the proper facilities at the dock to allow easy unloading.

Data collected also contained canal specific information. Some canals were bypassed due to low, impassable bridges. Others were not used for other reasons, such as the width was too small or that the canal contained a tight bend. Some canals that could be used without any problem were avoided due to the high traffic.

Overall, making the maps of the current cargo boat routes aided us in producing the number stops the average boat makes, and in understanding how many islands on average are delivered to in one day. These maps gave us a good idea of which canals cargo boat drivers prefer to use, as well as which parts of the islands they find easier for unloading.

3.2.5 Location and Identification of Docks

In the City of Venice, all cargo boats must load and unload at docks throughout the city. Throughout the Sestieri of San Marco there are docks labeled for licensed cargo boat use only. All of the docks throughout the city restrict the time allowed for docking to 15 minutes to minimize the time sometimes spent waiting for dock space. The locations of docks have been studied through previous IQP's, though this information has since been outdated.

Other information necessary to our knowledge of the docks included the physical capabilities of each dock. If certain deliveries require special equipment or a minimum of space for loading and unloading, we needed to know what docks have that capability at present and which docks could have capabilities in the future. In anticipation for a new routing system, docks were chosen for every island, based upon the location and the physical qualities of the dock. These docks are proposed to be the primary docks for making deliveries to specific islands.

3.2.6 Questionnaire of Involved Parties

A questionnaire that was given to the current cargo transportation workers was a critical element to determine their feelings on certain issues. One of the goals of this project was to create a new cargo system that will be implemented and used, however if the current workers do not agree with some aspects of our new proposed plan then it is unlikely that it would be implemented. Further, we need to ascertain worker's feelings about their current work conditions.

Our questionnaire, see **Appendix S**, consisted of one printed side of an A4 sheet of paper. The questionnaire contained a brief description of our status as students conducting a study of the cargo transportation system of Venice. The questions covered a wide range of topics that covered all facets of the cargo transportation system. In particular, questions concerning the existing system and possible alterations to the current system were emphasized. Eleven of the fourteen questions consisted of a statement with 6 possible levels of agreement; strongly agree, agree, neutral, disagree, strongly disagree, and don't know. Two other questions were simple yes/no questions, and the remaining question was a numerical answer question. We made sure to exclude all references to the CTVR so as not to get a biased opinion from anyone due to their involvement or non-involvement in that organization.

The questionnaires were given to the cargo boat workers at the loading zone on Scalo Fluviale. At Scalo Fluviale, an Italian cargo worker aided in the distribution of the questionnaire. The worker knew the specifics of our current project and could help explain things to other workers who had questions about why the questionnaire was being completed. The questionnaires were handed out on a weekday between the hours of 7-8:30. Over 100 forms were handed out, and 50 were returned. With approximately 250 cargo workers on the dock in a certain day this was a sufficient return. No further questionnaires were handed out.

3.3 Quantification of Demand

The single force that drives cargo shipments in any city is demand. In this respect, Venice is a city like all others. To better understand the city's cargo transportation we identified where the areas of demand are located within the city as well as what is delivered to these areas. A mixture of field data and existing data was used to complete the extensive task of quantifying the demand of the islands in Venice. It was decided that it would be easier to re-engineer the current cargo practices in Venice using a map detailing the demand throughout the city. By using maps of the business distribution of each island, we were able to determine the demand of every island in the city based on the number of deliveries made to each business. A projected total number of *colli* (cargo) delivered to each island, or the demand of each island, was then calculated. After the calculation of each island's demand was made the number of boats required to deliver to each island was calculated. Much of the data used to quantify the demand of each island was collected from the study area. There was very little existing data on the subject.

3.3.1 Analysis of Existing Data

Unfortunately, there is not an abundance of data concerning the demand shipments of goods throughout Venice. Some general information was obtained from published literature, see **Appendix I**, but accurate demand high, medium, and low demand were contained in the published literature. The charts gave good starting locations from which to work, and a source for comparison when our demand estimation was complete.

The majority of useful information could have come from the cargo companies themselves in the form of delivery receipts. Unfortunately numbers could not be extracted. General citywide charts depicting areas of, we were unable to obtain these useful pieces of information.

We have compared the data that we collected from the study area to the data previously collected during other studies to determine whether or not our data was valid. It was difficult to determine if the previous data was at fault or if our data was insufficient when, in some cases the data did not match. To decide where the error lay, the manner in which both sets of data were collected was examined. Possible sources of bias or error were determined and based on these mistakes the accuracy of the data was estimated.

3.3.2 Collected Data

Much information was needed to fill in the holes left by the obtained existing data. It was necessary to go into the field and collect the missing information. As time progressed it became apparent that a map of each island's business distribution must be obtained. Since maps containing this information did not exist at the time, address and location of each business in Venice was recorded. Each business was then assigned a category, which was based on the type of business. To complete the calculation of each island's demand, it was necessary to know the number of boxes delivered to each business in a normal week. The number of deliveries made to each business was acquired directly from businesses within the study area. With help from a CTVR cargo operator, data collection sheets were handed out to individual businesses of various types. These sheets requested the number of boxes received by the business in a given week. Many businesses throughout Venice obtain their goods through express deliveries, one being UPS. To acquire information concerning these types of deliveries, the UPS men were followed on their daily routes for one week. As a delivery was made, the address and number of boxes was noted.

3.3.2.1 Creating Business Distribution Maps

First, a list of business types was developed to aid in the identification of each located business. A code of one or two letters was assigned to each business type to simplify data collection in the field. Both the list of business types and their codes can be found in Appendix H. A map of each island contained in the Venice Historic Center was then printed. The maps included representations of all buildings located on the islands and all bridges leading to the islands to insure that no area of any island was mistakenly overlooked.

CAT.	CODE	BUSINESS	ITALIAN
1	GE	**Glass Expensive**	**Vetro Caro**
2	W	**Watch**	**Turno**
3	J	**Jewellery**	**Gioielli**
4	SA	**Stationary**	**Immobile**
4	CL	*Collection*	*Collezione*
4	PE	*Pet*	*Animale*
4	CU	*Cultural*	*Culturale*
5	GT	**Glass Trinket**	**Vetro Ninnolo**
5	SV	*Souvenir*	*Ricordo*
6	M	**Mask**	**Maschera**
7	T	**Tobacco**	**Tabacci**

Table 1: Example Business Types and Categories

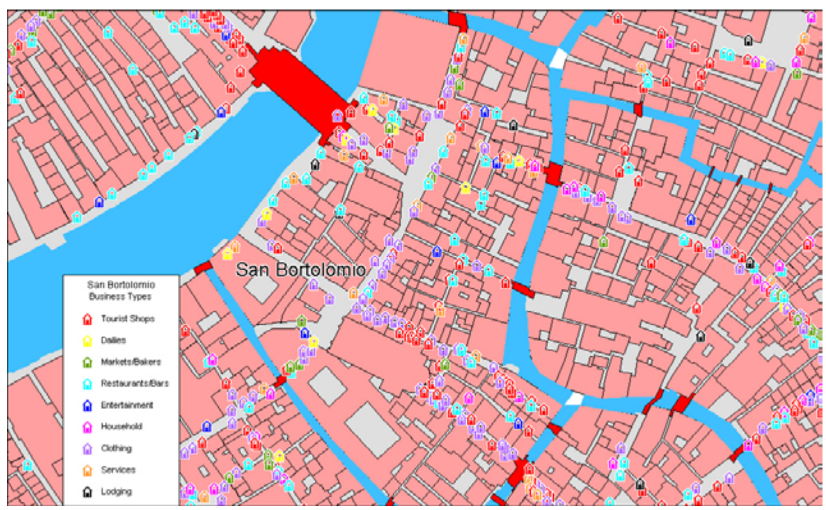
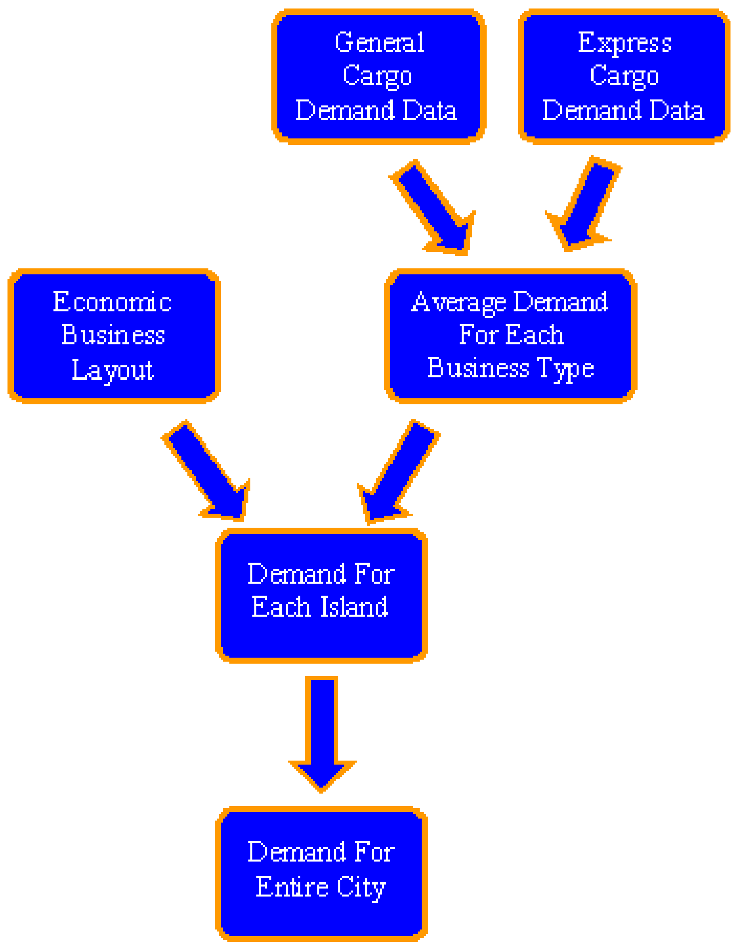


Figure 25: Example Mapped Island

Maps were then taken into the field for data collection. As areas were covered on an island, the streets observed were crossed out. When a business was located its address and type were recorded and its location was marked on the map. After all areas of the island had been investigated, the addresses and business types for that island were entered into an Access database, see **Appendix F**. This database was linked to an address layer in MapInfo, and a new layer was created to provide the study with a visual representation of the business distribution of each island.

3.3.3 Quantification of Demand by Island

To establish zones for the new cargo transportation plan, it was necessary to know how much cargo is delivered to each island. Zones requiring about the same amount of deliveries per day would be optimal for both the delivery companies and the prospective warehouse. The CTVR will benefit from evenly balanced zones as evenly balanced zones will ensure that no one company does all the work or that another company will not have anything to do. Evenly balanced zones will minimize wasted space in the proposed warehouse because all storage areas will be equally filled.



Following completion of data collection described in sections **3.2 Review of Current Practices**, **3.3.1 Analysis of Existing Data**, **3.2.3 Observation of Delivery Procedures**, and **3.3.2 Collected Data**, the information was entered into Excel or Access and estimation of the demand of each island began. The easiest way to develop an accurate estimate of the demand of each island is to first estimate the demand of each type of business in Venice. For example, a clothing store receives fewer deliveries than a restaurant. In order to obtain business information concerning the number of *colli* received in a given week forms were handed out to shop keepers. The shopkeepers counted and recorded the number of *colli* received each day. At the end of the week the forms were collected. Due to the differences in demand, each type of business must be addressed because a general average of packages per business will not be accurate for further calculations of island demand. After the average number of packages had been developed for each type of store, using collected forms, the total demand for each island was developed by adding all of the store deliveries together.

Once the demand for each island had been calculated and the total number of *colli* seemed logical several graphs were developed. The graphs depict the density of delivery by island, type of cargo by percent and package number by island, and the time it takes to reach destinations throughout the city.

3.4 Characterization of Cargo Fleet

This section describes many of the various characteristics of the cargo fleet itself and how this information was acquired. The characteristics of the cargo boat fleet were both obtained from the Venetian Government and obtained in the field through our own observations. These characteristics include:

- Boat type, make, model, and year
- Length, width, and height above water
- Capacity of cargo hold in meters^3

- Cargo carrying deck space in meters^3
- The maximum gross weight the boat can carry
- License plate number and operating license number
- A photograph of each boat

The previous information was entered into Access and a catalog was developed. This catalog depicts the exact number of boats and cargo space at the disposal of the CTVR. This catalog also aided us in the re-engineering phase by providing the study with a clear and easy guide to each and every boat contained in the CTVR.

3.4.1 Collection of Boat Specific Data

Boat specific data was very important, because during the re-organization it was necessary to know many of each boat's characteristics, such as length, width and dimensions of the cargo hold. This data was collected from the City of Venice's transportation department, which keeps records of all boats licensed throughout the city. This list of data collected from the city was then sorted down to two smaller groups, one being all of the available cargo boats in the city, and the other being the CTVR boats. The CTVR list was cross-referenced to all other CTVR boat data previously collected. All of this data was entered into Access for easy manipulation.

3.4.2 Determination of Average Capacities

The determination of each boat's cargo volume was easily calculated given the length, width, and height of the cargo hold area in each boat. In addition to the cargo space each boat contains below deck, there is also room for cargo to be placed on top of this cargo area. We can approximate the above deck cargo space by taking the dimensions of the cargo hold and multiplying by the height to which the cargo can usually be safely stacked, about 1 meter.

To find the total volume of a cargo boats hold **Equation 1**, below, was used. This equation was determined through observation of cargo boats and loading capacities described in 2.4 **Cargo Boat Characteristics** of the Background chapter. The first half of the equation represents the lower hold's cargo carrying volume while the second half of

$$\text{Average Boat Capacity} = [\text{Cargo hold}]+[\text{Above deck}]$$

$$\text{Volume}=[\text{Length}*(.7)*\text{Width}*(.9)*\text{Height}*(.85)]+[\text{Length}*(.7)*\text{Width}*(.9)*1]$$

Equation 1: Cargo Carrying Volume

the equation deals with the volume of cargo that can be stacked on the top layer of the cargo boat. According to the percent volume of the boat that the cargo hold takes up in the average boat the full measurements of each boat needed to be reduced, using a percent of the total measurement, to account for the space is taken up by the cockpit, engine, and hull. In Equation 1 it was assumed that 70% of the length (0.7), 90% of the width (0.9) and 85% of the height of the boat is dedicated to the cargo hold. For the above-deck capacity it was estimated that cargo could be stacked to the height of one meter on top of the planks.

3.5 Design of new Cargo Transportation System

The ultimate goal of this project was to re-engineer the cargo transportation system of Venice. In order to complete this goal, a new system was designed. When designing the system, the current set-up and all limitations were taken into consideration. The purpose of this objective was to create a new plan for the cargo of Venice with the boundaries in mind.

3.5.1 Warehouse Strategies

Information concerning the plan for a warehouse near the Scalo Fluviale loading area was obtained. Once the warehouse is built, cargo can be brought to a central location, sorted, and then dispersed. At this central location, the cargo will be reorganized and broken down into delivery zones in the city by address, and be delivered accordingly. When the possibility of a warehouse was considered, the cargo men's opinions as well as the practicality of the warehouse were be taken into account.

Due to the large number of refrigerated items being shipped, the warehouse should have a refrigerated section for perishable cargo as well as a separate bay for each delivery zone's cargo to be stored until pickup. The warehouse should have large easily accessible docks for loading near the storage bays.

3.5.2 Definition of new routes

One of the largest parts of this study was to define new routes of cargo transport. Current routes consisted of a boat stopping at many different islands and dropping off only a few pieces of cargo before moving on to the next location. Proposed new routes consist of boats taking a complete load of cargo to a small, defined set of closely located businesses. This modification will cut down on dock waiting times, traffic, and wasted travel time. The commonly used canals were taken into account as well as the commonly used docks. Heavily trafficked canals were avoided as much as possible. Obviously, canals that do not allow the passage of cargo boat were avoided completely.

3.5.3 Estimation of Boats by Re-engineered System

First, the economic demand of the entire city was compared to the volume of cargo space available through the CTVR boats. A total number of boats to be used was calculated by dividing the total number of *colli* by the number of *colli* that can fit in the calculated average sized boat.

To figure out how many *colli* could fit in one boat the size of the average *collo* first needed to be determined through observation and data collection. Observations were made at the loading dock of Scalo Fluviale on a typical day in order to calculate this value.

Different types of boats were randomly picked at the loading dock, and a count was kept of every *collo* that was placed into each boat. Then a judgment was made as to how much of the boat's useable volume was filled. Knowing the exact or average volume of each boat included in the database, we then were able to conclude how much space (in m^3) the *colli* loaded into the boat took up. Then the volume of loaded *colli* was divided by the total number of *colli* loaded. This resulted in an average *colli* volume. **Equation 2** illustrates these calculations.

Average *Coll* Volume=(Boat Volume)*(% filled)/(# *colli* loaded)

Equation 2: Average *Collo*

Once, the total number of required boats for the entire city was known each individual island was investigated separately and the proper number of boats were assigned to them. These assignments are only suggestions and as we will be offering up all the needed information the CTVR companies can break up the cargo any way they see fit.

3.5.4 Determination of appropriate schedule for deliveries

After the new boat routes were defined, it was possible to determine an appropriate schedule for deliveries. The approximate schedules will aid businesses in planning for when to expect their deliveries and pickups. The schedules were created by looking at the location of the drop points and how long it will take to reach them from the warehouse. The time to load and unload the boats was also taken into consideration to reduce waiting time at docks and traffic at docks.

4 Results

The following chapter consists of sections that describe the source of collected data and illustrate the data through graphs, charts, and tables. Example calculations are included in many sections and extensive calculations can be referenced in noted appendices. Detailed procedures and explanations for the collection of each type of data presented can be found in **Chapter 3 Methodology**. Although a small amount of prose in some of the following sections refers to analysis of collected data, the majority of the interpretation of collected data can be found in **Chapter 6Analysis**.

4.1 CTVR Meeting Data

The data collected from the initial meeting with the sponsor provided a jumping off point for research on the current system. The CTVR constitution was obtained during this meeting. The CTVR constitution contains information on the founders of this organization. Among the information contained in the constitution includes the date of birth of each founder, where they reside, what company they work for as well as their qualifications. A separate letter, containing the proclamation of the formation of the CTVR , as well as the current list of members was also included. Of the 184 boats listed in the newly formed CTVR, 64 boats were handwritten at the bottom of the sheet. This document demonstrates the currently disheveled state of the cargo union. The president of the CTVR also relayed many statistics concerning the current system. Currently, there are 184 boats in the CVTR, 100 construction boats, and 101 Non CVTR cargo boats. The CTVR boats transport 70% of the total cargo in Venice each day, which is approximately 250,000 tons of cargo. These boats have a schedule for loading at the

Scalo Fluviale. Other information received through the sponsor was used in analysis of any changes proposed for the current system.

3:00 AM	Dairy Products
4:00 AM	Dry Cleaning/ Textiles
6:30 AM	Food, Perishables
8:30 AM	Construction
9:00 AM	All other cargo

Table 2: Cargo Loading Schedule

4.2 The Average Collo

Knowing the volume capacity of each cargo boat available to the CTVR was extremely important, however this number was useless without being able to determine from the volume how many *colli* (or boxes) the cargo boats could hold. Most every merchant in Venice receives a certain number of boxes, and a method was determined to link the volume of each boat to a number of boxes it could hold was the idea of the *average collo.*

The average *collo* is basically a determination of the average sized box that gets moved through the Venetian cargo system. This estimated value gave a way in which the volume of each boat, found in catalog, could be linked to the number of *colli* the boat could carry.

4.2.1 Average *Colli* Size

Eighteen boats were observed in the manner described in **Section 3.4.2 Determining Average Capacities**, and after data manipulation there were 18 values for the average *collo* size based on these boats. Of these 18 boats, the maximum and minimum were discarded to for statistical validity, and the other 16 were then averaged to yield a value for the overall average *collo*, **0.08m^3**.

4.3 Cargo Fleet Information

Data concerning the CTVR fleet was an important form of data that was collected during the study period, see, **Table 3**. The number and identity of each boat in the CTVR was needed prior to the beginning of fieldwork to aid in the collection of data.

lum	Sub	Titolare	Indirizzo	Località	Natante	Targa	PERS	MAT.	LUNGH	LARGH	ALT	VOLUME
7	- B	BARICH A. & FIGLIO - TRASPORTI	CANNAREGIO, 5981	30123	VENEZIA	6V23387						35.7076
7	- C	BARICH A. & FIGLIO - TRASPORTI	CANNAREGIO, 5981	30123	VENEZIA	6V23727	1+5	LEGNO	1160	239	100	34.6203
12		BOTTARO GIOVANNI	CANNAREGIO, 3444	30121	VENEZIA	6V14707						35.7076
17		BRESSANELLO LUCIANO	VIA CHIOGGIA, 1	30176	MARGHERA	6V23567	24	LEGNO	1080	219	100	29.5354
18		BRESSANELLO LUCIANO	VIA CHIOGGIA, 1	30176	MARGHERA	6V23979	1+3	LEGNO	1000	216	73	19.6902
19		BUBACCO ROBERTO	CALLE DAL MISTRO,	30015	MURANO -	6V14352						35.7076
20		BUSETTO ANTONIO	VIALE S.MARCO, 109	30171	MESTRE	6V30331						35.7076
21		CRISTIANO BRUSSA TRASPORTI	CANNAREGIO, 1030	30121	VENEZIA	6V3996						35.7076
24	- B	BRUSATO MASSIMILIANO	S.POLO, 631/A	30123	VENEZIA	6V30381						35.7076
24	- C	BRUSATO MASSIMILIANO	S.POLO, 631/A	30123	VENEZIA	6V14278						35.7076
25	- A	BRUSATO M. & C. SAS di	CANNAREGIO, 6366	30121	VENEZIA	6V30058	3+3	LEGNO	1150	240	147	50.6642
25	- B	DEI ROSSI ROBERTO	CASTELLO, 1552	30122	VENEZIA	6V30395						35.7076
26	- A	COOP. SCARICO FARINA A R.L.	CASTELLO, 347	30122	VENEZIA	6V3607						35.7076
26	- B	COOP. SCARICO FARINA A R.L.	CASTELLO, 347	30122	VENEZIA	6V3828						35.7076
26	- C	COOP. SCARICO FARINA A R.L.	CASTELLO, 347	30122	VENEZIA	6V30023	4	LEGNO	1208	278	94	39.4198
28	- C	BUSATO ADRIANO & C. S.N.C.	S.POLO, 2336	30125	VENEZIA	6V13844						35.7076
28	- D	BUSATO ADRIANO & C. S.N.C.	S.POLO, 2336	30125	VENEZIA	6V13637						35.7076
28	- E	BUSATO ADRIANO & C. S.N.C.	S.POLO, 2336	30125	VENEZIA	6V14022						35.7076
29		BUSETTO ANTONIO	VIALE S.MARCO, 109	30171	MESTRE	6V23685	1+5	LEGNO	1160	292	101	42.7206
30		DE COL ANGELO	GIUDECCA, 866	30123	VENEZIA	6V30210						35.7076
31		DE GIORGIO GIAN-PAOLO	CASTELLO, 2694	30122	VENEZIA	6V23970	1+5	PRFV	1160	230	105	34.9824
32		DEI ROSSI MASSIMO	VIA DELLE	30100	CA' SAVIO -	6V30181						35.7076
34		DITADI GIANFRANCO	VIA OLMO, 281	30037	OLMO DI	6V23678	2+4	LEGNO	1160	239	100	34.6203
35		DITADI GIANFRANCO	VIA OLMO, 281	30037	OLMO DI	6V23808	1+5	LEGNO	1160	230	105	34.9824
36	- B	CAVALLARI PAOLO	VIA VARRONE, 6	30172	CARPENED	6V23514	4+2	LEGNO	1190	263	105	41.0362
37		DITADI PAOLO	VIA ROMA, 131-1	30038	SPINEA	6V23233						35.7076
39		DE BIANCHI ADRIANO	S.CROCE, 1531/A	30125	VENEZIA	6V14635						35.7076
40		DEI ROSSI TRASPORTI DI DEI	VIA DELLE	30100	TREPORTI	6V23971	1+5		1160	230	105	34.9824
41		DEI ROSSI MASSIMO	VIA DELLE	30100	CA' SAVIO -	6V23512	6	LEGNO	1310	285	115	53.6153

Table 3 : Sample Page from Boat Database

Determined through numerous document sources and through cargo workers who possessed knowledge of the boats belonging to the CTVR, fleet data was collected. Individual Boat information that was collected included;

- The Trasporti Cose[28] tag number
- The license number
- The owning company and address
- The number of persons licensed to be aboard
- The length width and height
- The material of which it is made

[28] This is the license issued by the city of Venice for each cargo boat that transports items through the city. In essence it is a type of co-license plate for each cargo boat.

- Numerous technical data about the motor and mechanics.

In all, there are currently 184 boats in the CTVR. As this number is subject to change, even over the course of their one year's existence, we also kept a database of every licensed cargo boat in the city of Venice, 385 total, see **Appendix C**. A separate database was created that included only CTVR boats. This database was converted into an Access report consisting of two versions. One version is categorized by Trasporti Cose numbers while the other version is categorized by company name, see **Appendix D**. A complete record of all boats in the CTVR provides the CTVR with an easier way to keep an up to date list of CTVR companies in the future. Pictures were taken of 99 CTVR to create a pictorial catalog of CTVR boats, see **Appendix E**. The pictorial catalog is organized by Trasporti Cose plate numbers and contains basic information such as owning company, address, and cargo carrying volume.

4.3.1 Fleet Percentages

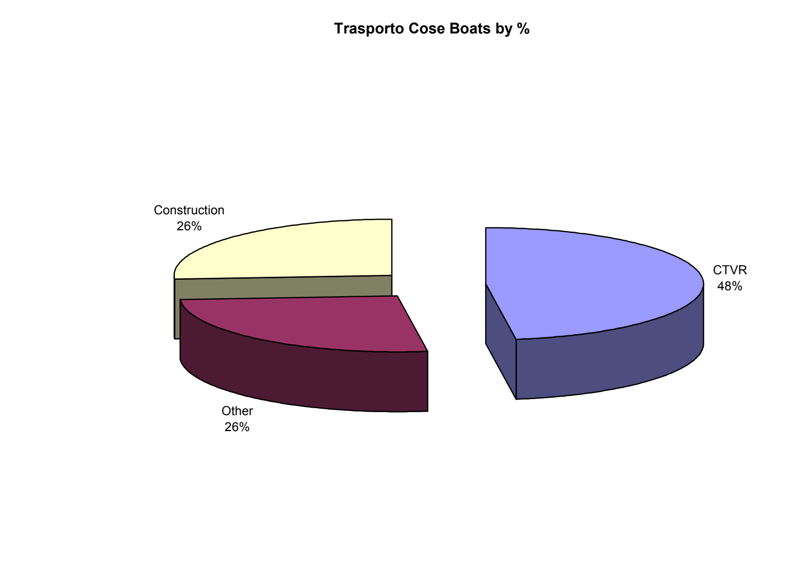


Figure 26: Licensed Boats

Out of the 385 licensed Trasporte Cose boats, 100 are construction boats, 101 are non-CTVR cargo boats, and 184 boats belong to the CTVR. According to these numbers the CTVR makes up two thirds of the total licensed boats, but when the sizes of the boats are considered the CTVR is responsible for 70% of the volume of cargo transported in Venice. Also, it was discovered that there are about 100 illegal boats operating in Venice.

4.3.2 Fleet capacities

At this point, since we had a definite value for the volume for each boat in the CTVR and a value for the average *collo* size, it was necessary to link the two values together to determine how many *colli* could be transported each day. This value was first computed for each boat in the CTVR, and then these values were totaled to compute the total number of *colli* the CTVR could process in a day.

The average CTVR cargo boat was determined to hold approximately 441 *colli*. Knowing that there are 184 boats in the CTVR, it is seen that the number of *colli* that can be held by all of the CTVR boats is 81,142 *colli*.

$$\text{Colli per boat} * \text{Total Boats} = \text{CTVR Fleet Capacity}$$
$$441 * 184 = 81{,}142$$

Equation 3: CTVR Fleet Capacity

Through observation it was determined that the figure 441colli per boat should be treated as the maximum capacity because efficiently loaded boats do not usually 350 *colli*. To efficiently transport goods the boat should be filled with approximately 350 *colli*. By filling the boats with only 350 *colli*, over stacking that may cause reduced visibility for the driver, hinder unloading and docking processes, and loss of cargo over board into the canals will be avoided. Each of these occurrences was observed in the field due to overload boats.

4.3.2.1 Refrigerated

	Length	Width	Height
F1	3.5 m	1.5 m	1.5 m
F2	1.5 m	1.5 m	1.5 m

Table 4: Refrigerated Unit Measurements

Figure 27: Refrigeration Unit on Boat

Within the CTVR is an organization called TAC. TAC is also a union made up of Trasporti Cose cargo boats. The difference between TAC boats and CTVR boats is that all TAC boats contain a refrigeration unit. The total amount of refrigerated cargo that the CTVR fleet can carry is equal to the volume of the 52 TAC freezers since no refrigerated cargo should ever be transported un-refrigerated. There is no record as to the size of boat freezers is in the collected catalog data, and no extensive measurements of refrigeration units were made in the field. Only two refrigeration units were measured with any accuracy. Although, through observation it was determined that the majority of refrigeration units used by TAC are made by the same manufacturer and this manufacturer uses the same dimensions for the width and height of all its units. These dimensions are 1.5 meters by 1.5 meters. The length of the refrigerators varied greatly, though. An extremely rough average can be taken from the data collected from the two refrigerated units. This would give the average cargo refrigerator the length of 2.5 meters and a volume of 5.625m^3. From observation it is known that this figure is a bit on the low side as not many refrigerated boat contain units of 1.5 meters or less in length. For example a refrigeration unit of average size can be seen in **Figure 27.** Its length is of about 3 meters, but the calculated figure will be used since it is based on the only concrete data collected. If the average refrigerator volume is multiplied by the number of TAC boats, 52, the total capacity of refrigerated cargo carried by the members of the CTVR, inclusively TAC, is found to be: **292.5 meters^3**.

4.3.2.2 Non-refrigerated

Taking the calculated volume of refrigerated cargo that can be stored by the CTVR, shown above as 292.5 meters^3, and subtracting from the total volume calculated by multiplying the total number of boats, 184, by the average volume, 35.7meters^3, you get the capacity of dry cargo the CTVR can carry. The calculated total volume of dry cargo the CTVR can handle is found to be **6277.5m^3**.

4.4 Scalo Fluviale Daily Activity

The hours of operation for general cargo, the only type of cargo without its own warehouse, are 3am until late in the afternoon. There is no closing time at the dock. The majority of the work done at the dock, however, falls between 6am-10am. At the first observation of the loading area, during the hours of 3:20AM and 7:25, there were 116 trucks observed entering the loading area and 85 boats.

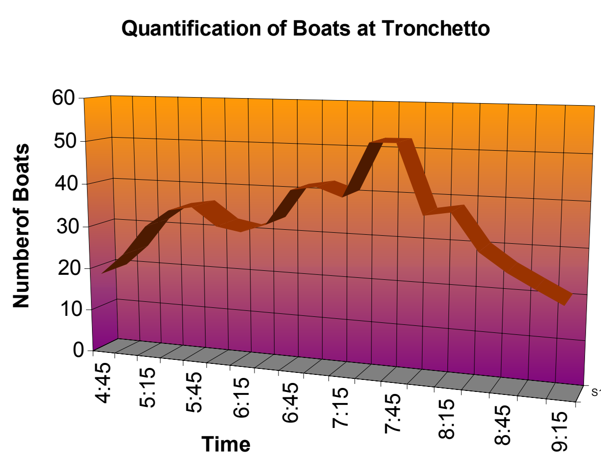


Figure 28:Quantification of Boats at Scalo Fluviale

Through observation, the Scalo Fluviale has been proved as an inefficient loading area for the cargo boats as well as for the trucks that deliver to this location.

As seen by examining **Figure 28**, the peak traffic time for boats appears at 7:45AM, with 52 boats docked. The boat traffic at Scalo Fluviale follows a bell curve, with traffic lows during at the hours of 5:00AM and 9:00AM, when there were approximately 20 boats docked.

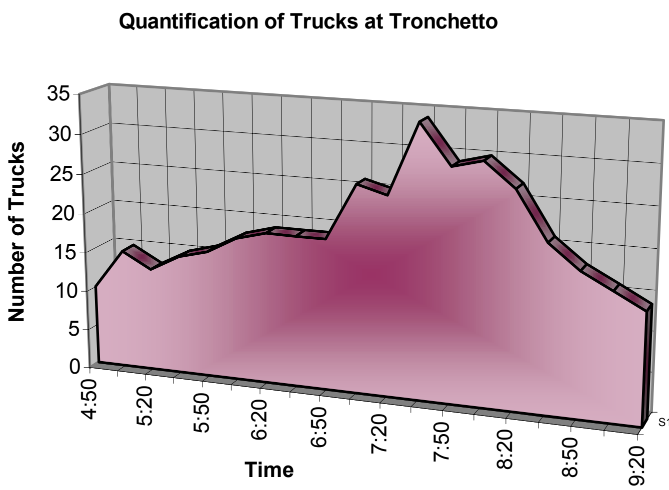


Figure 29: Quantification of Trucks at Scalo Fluviale

The number of parked trucks through a typical working day was recorded simultaneously with the number of boats parked. The number of trucks parked was recorded every fifteen minutes. As seen below**, Figure 29**, the peak hour for truck traffic is at 7:35 with 34 trucks parked at the Scalo Fluviale. As seen with the boat traffic, there is a bell curve that illustrates the number of trucks at the Scalo Fluviale, with low periods of traffic at 4:50AM and 9:20AM. At these times, there were 10 trucks and 14 trucks, respectively.

To evaluate the traffic of both the trucks and the boats simultaneously, **Figure 30** depicts the recorded numbers between the hours of approximately 5:00AM and 9:00AM. The peak hours as well as the low traffic hours of both the trucks and boats are similar.

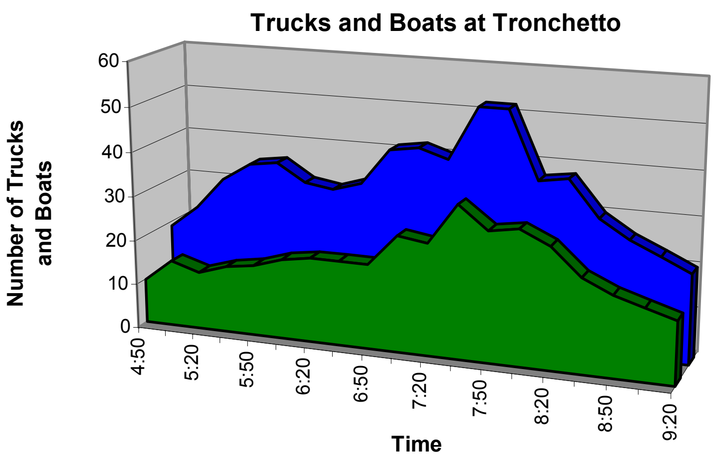


Figure 30: Trucks and Boats at Scalo Fluviale

Aside from quantitative data collected from the loading area observations, general practices were noted. Safety at the loading area has been a major concern to the cargo men. The current procedure at the loading area is chaotic. Boats tie up to each other five or six wide while loading, see Figure 31. In order to load some of these boats, cranes are utilized that extend from the dock over numerous parked boats. These cranes move large cargo overhead. This protrusion of boats reaches far out into a heavily trafficked canal. The area that traffic has to maneuver about the loading cargo boats is narrow, and the wakes caused by speeding boats can sometimes cause cargo to fall into the canal.

Figure 31: Loading dock at Scalo Fuviale

4.5 Delivery Information

Through observation the differences between express delivery cargo and general delivery cargo were obtained. Although some of the differences are quite subtle, they can indeed by very important. The type of carts used by the different delivery companies is also an important thing to consider. The different types of businesses that are serviced by each type of cargo company are also a factor to consider, as different businesses have varying hours of operation.

4.5.1 Carting

Most general cargo companies use simple but large carts, see Figure 32 . Smaller carts are used for deliveries consisting of a small number of *colli* or in areas of high pedestrian traffic, see Figure 33. They do not often cart over bridges. General cargo boats avoid carting over bridges as much as possible because the majority of the businesses they service receive enough cargo to fill a single cart each day and it is not logical to lift a full cart over a bridge to make only one or two delivery, unless it is necessary. In most cases it is only necessary to cart over bridges if a canal is closed for construction purposes and the alternate route to the delivery location is much more of a hassle then going over a single bridge.

Figure 32: Large simple cart

Figure 33: Small cart

One the other hand, express cargo companies have the opposite carting habits because their clients only receive one or two packages at a time. Express clients are widely distributed and only receive deliveries once or twice a week. Carting is done over a larger area because it would be far too time consuming and expensive to travel with the boat to each drop location. The majority of an express workers day, therefore, is taken up by carting. Express carts are large and usually have a small set of wheels extended from the front of the cart to aid in carting over bridges. The extended wheels add leverage so that the cart can be lifted off its larger set of street wheels and rolled forward onto the next step. Pedestrian traffic posses a great deal of problems to express carters. The carters must constantly yell to get people's attention so that they will move out of the way allowing room for the cart to pass.

4.5.2 General Cargo

The majority of goods moved by general cargo delivery companies consist of food products of all types, beverages, and food preparation products such as baking tins and paper boxes for packaging purchased food and laundry. Some general cargo boats deliver and pick up goods as well. The businesses general cargo boats service include restaurants of all sizes, bars, cafes, grocers, hotels, and all types of specific food stores such as bakeries or butcher shops.

4.5.3 Express Delivery

Express delivery goods consist of personal shipments of goods on a small scale. Express clients rarely get more then one or two packages at a time. Examples of the number of deliveries made to several types of businesses can be seen in Table 5. Products ordered by offices,

ID CODE	BUSINESS TYPE	BUSINESS NAME	SESTIERI	ADDRESS	*COLLI* RECEIVED
HOT1	H	Hotel Atlantide	CN	375A	10
EL1	EL	Nokia	CN	1414	4
LI1	LI	C'e' bassetti	CN	1815	1
C3	C	M..Junior	SP	2806	2
J2	J	P. Mattiuzzi	SM	234	1
GT3	GT	Industrie Batt.	SM	1320	1
MU1	MU	Regazzo SNC	CS	4700A	2
HD1	HD		SC	1173	1

Table 5: Example Express Deliveries

personal packages and letters, supplies for art studios, tourist shops merchandise, and occasionally food products are among the goods shipped by express cargo companies. These types of goods obviously differ greatly from the types delivered by general cargo. Because of the varied and sometimes unusual items shipped through express companies, the packages are not as uniform as those shipped by general cargo and are often fragile.

4.5.4 Impediments to Cargo Transportation

There are numerous obstacles observed that the cargo men face on their delivery routes. The cargo men must maneuver through many busy canals, around bridges too low for passage during high tides, and around canals under construction, to reach the many points of delivery on their routes. These obstacles lead to extended travel times. On one day, Vianello Trasporti spent 165 minutes traveling from each location to the next. The height of bridges over canals is a limiting factor of canal usability. Bridges are a necessity to travel the city by foot, but can often become a hassle when navigating canals in a large cargo boat during high tides. Many bridges do not leave much room for stacking cargo. Figure 34 shows just how little room there is when passing under bridges. Furthermore, during the hours of high tide, some canals are impassable for larger boats due to the low clearance of bridges. In these cases cargo men are faced with no other alternative than to seek alternate routes to reach their intended destination. A chart of the tides of the year 2001 can be found in **Appendix R** to give an idea how often high tide falls during working hours.

Figure 34: Cargo Man ducking under Bridge

It is not unusual for one cargo boat be to forced to wait for dock space to unload and deliver its packages while another cargo boat finishes its business at the same dock. Boats frequently overlap routes with other boats, so they are constantly competing for the same dock location. As seen in Table 7, on one day, 65 minutes were spent waiting for available dock space. At one point, the cargo man had to untie a boat and move it from a dock location to unload his goods.

As cargo men wait idly in the canals, traffic starts to build. The smaller, narrower canals become congested quickly. On one observed day, an abandoned boat had drifted into the middle of a small canal. The cargo man had to stop, retrieve the boat and tie it to a near location in order to proceed through the canal. Several times, a shorter route could have been used, but the cargo man was forced to use a longer route due to closed canals. These canals are often closed due to dredging. At one point during observations, a boat ambulance came through, and the wake that was created was enough disturbance to knock boxes into the water.

4.5.5 Traffic Regulations

Canal information necessary for route restructuring was collected and examined. Data concerning canal sizes and usage was collected. A map depicting the one-way canals in the city was constructed, and can be viewed above in **Figure 35**.

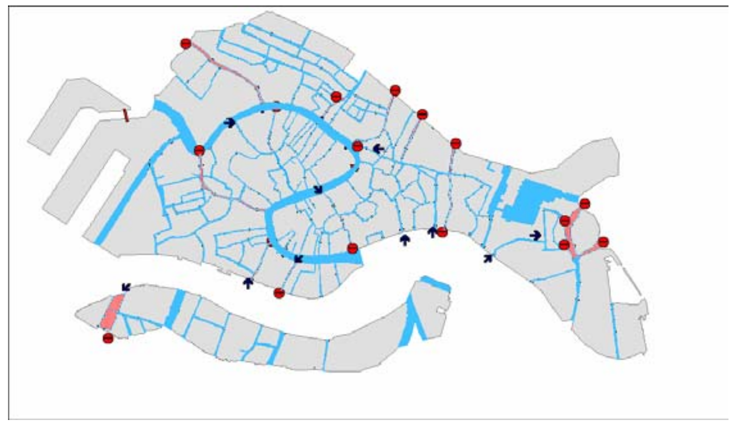


Figure 35: One Way Canals

Data was also collected from previous maps concerning canal rules and regulations. A replication of the original map from MapInfo

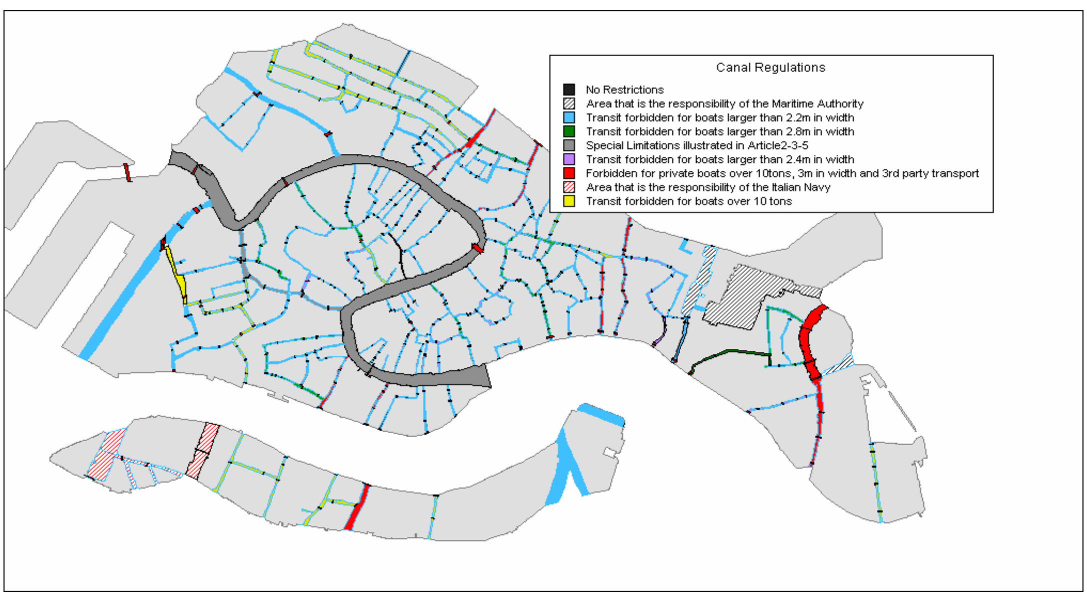


Figure 36: Canal Regulations

can be viewed below in **Figure 36**.

Information was obtained concerning which canals are unusable at high tide due to low bridges and high waters. Hours of high and low tide for the city of Venice for the complete year of 2001 can be viewed in **Appendix R**. Several canals are unusable during these high tide hours due to low bridge heights. The heights of bridges in Venice were obtained from previous data collection and can be viewed in **Appendix Q**.

4.5.6 Effects of Tides

Floods cause problems when it comes to carting. Carts must be pushed through water and there is a chance that the cargo on the cart may become wet or partial submerged. When the water becomes too deep for carting on the street level it may be possible, though difficult, to cart along raised walkways. Raised walkways are often narrow and heavily trafficked. A map of raised walkways and high streets is located in **Appendix R**.

While it is known what areas of the city are passable by raised walkways during times of high water, and by extension what areas are not, there is not extensive database that contains information on the order in which docks flood during these times. High water is a major problem for docking cargo boats since the majority of the steel rings and grates used for tying the boat to the dock are located at or below the dock platform. If these ties are underwater it becomes difficult and dangerous to dock a boat. When docks are submerged too much for docking alternant dock locations must be found or deliveries cannot be made.

4.6 Observation of Delivery Routes

Data was collected while accompanying two separate cargo companies on their daily routes. Several processes throughout the day were timed and recorded, including

		Travel			Wait			Unload			Cart			*Colli*
Start L.	End L.	Start	End	Duration	Start	End	Duration	Start	End	Duration	Start	End	Duration	*Colli* #
Scalo Fluviale	Rio Nuovo	8:10	8:19	9	NA	NA	0	8:19	8:19	0	8:19	8:20	1	1
Rio Nuovo	Calle Cavilli	8:20	8:32	12	NA	NA	0	8:32	8:34	2	8:34	8:38	4	10
Calle Cavilli	Rialto Market	8:49	8:52	3	NA	NA	0	8:55	9:00	5	9:00	9:05	5	38
					NA	NA	0	9:05	9:09	4	9:09	9:16	7	45
					NA	NA	0	9:16	9:19	3	9:19	9:28	9	50
Rialto Market	Misercordia	9:32	9:35	3	NA	NA	0	9:35	9:36	1	9:36	9:41	5	11
Misercordia	Alloggi Sardegna	9:41	9:46	5	NA	NA	0	9:48	9:48	0	9:48	9:51	3	6

Table 6: Sample of Daily Cargo Route Information

traveling, waiting, unloading, and carting. See **Table 6** above for an example. The example table, represents a portion of one day's route.

This data was collected on June 8, 2001 aboard Vianello Trasporti boat. Table 7 consists of the total amount of time spent on each task during the workdays observed.

Task	Thu 6/7	Fri 6/8	Mon 6/11	Tues 6/12	Wed 6/13	Thu 6/14
Travel min	165	104	135	136	160	105
Wait min	65	0	0	3	19	2
Unload min	209	37	35	17	21	21
Cart min	NA	117	170	108	90	90
Total *Colli*	212	392	386	347	617	107

Table 7: Observation Data for Vianello Trasporti

For complete data concerning the two boats for one full week, see **Appendix A**.

The exact docking locations throughout the daily routes were mapped and represented on MapInfo. An example route used on June 8 can be seen below in Figure 37. Route maps for the entire week on each boat can be found in **Appendix B**.

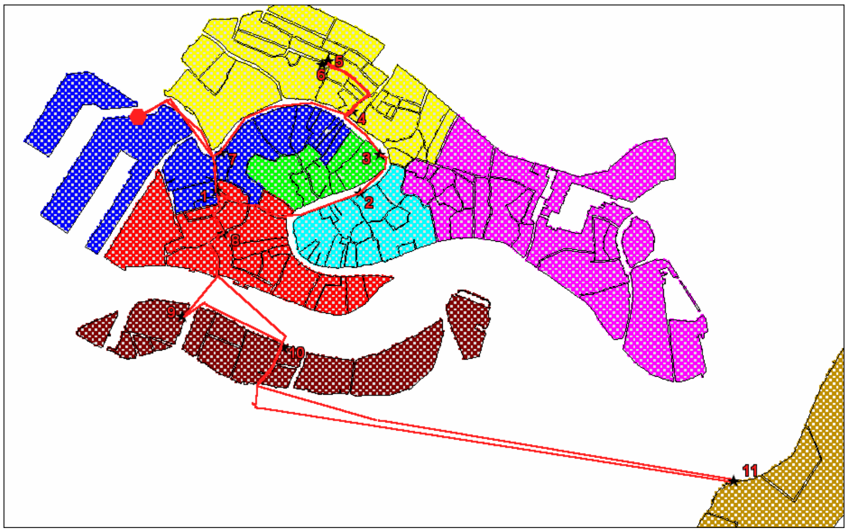


Figure 37: Single Boats Citywide Route

A comparison of this small company was made to a company that owned and made use of three separate boats. The company split its cargo between the three boats and the routes utilized to service separate areas of the city are shown in **Figure 38**. The boats used by this company do not overlap routes and only travel to small portions of the city on any given day. For example only one boat will go to San Marco and Castello while another boat will go to Murano or the Lido. The boats also rotate their routes through the week and therefore evenly distribute the use of the boats over the week. Each boat should travel the same number of miles and use the same amount of gas.

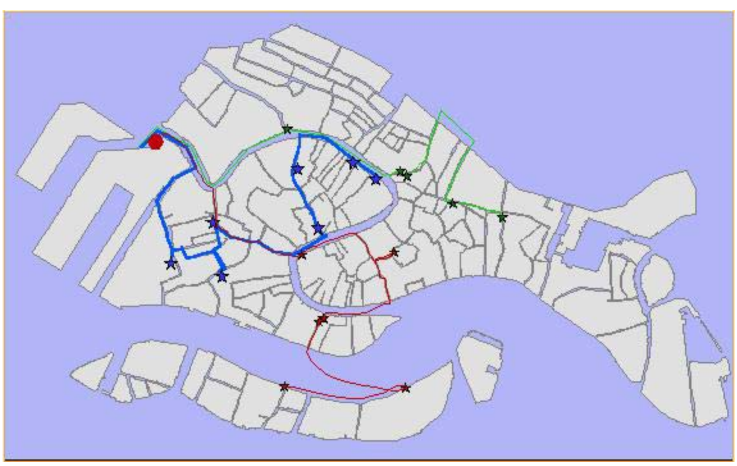


Figure 38: Routes of Three Organized Boats

Another advantage of organized boat routes is the reduction in travel time. When a boat delivers to only one area of the city it will spend less time traveling from one location to the next. In the following figures the true effects of this system verses the single boat system can be seen. The single boat spent 38 % of its day, 9.5 hours, traveling through the city. The three organized boat routes only spent about 20% of their days traveling, 3.5 hours. The three boats, together, delivered 735 *colli* while the single boat only delivered 432 *colli*. This is the most advantageous of the benefits as in little over the time that the single boat spent delivering the

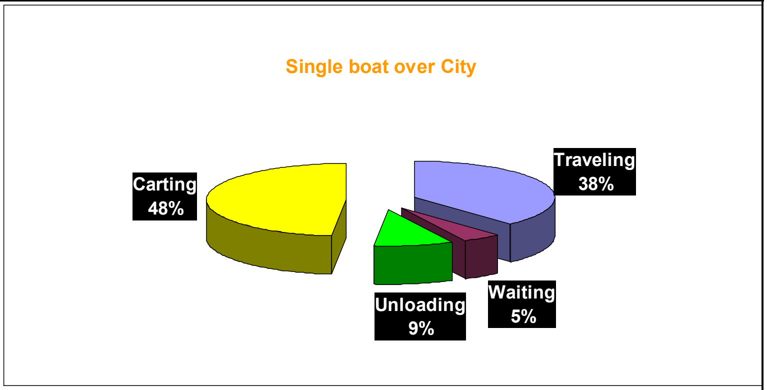


Figure 40: Single Boat Day by Percent

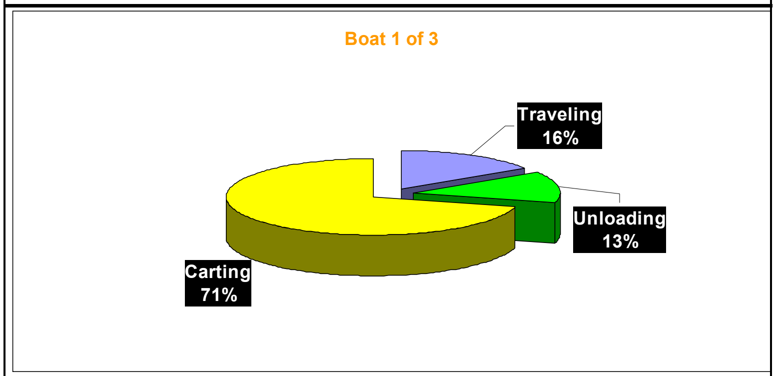


Figure 39: One boat of Three Organized Boats

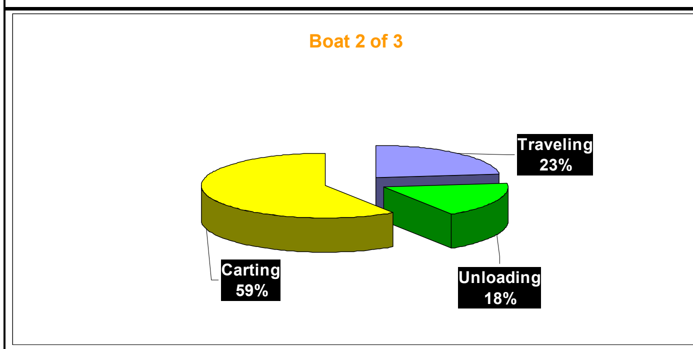


Figure 41: Second boat of Three Organized Boats

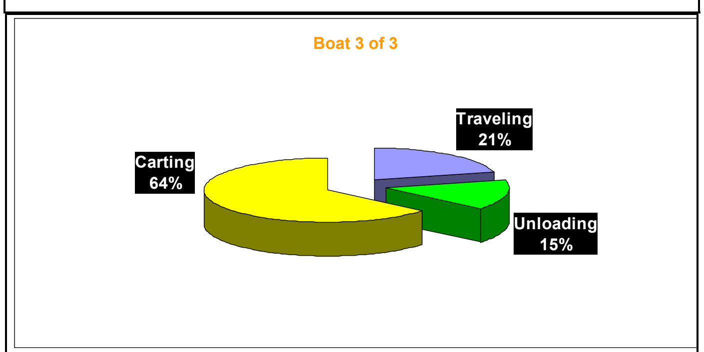


Figure 42: Third boat of Three Organized Boats

three boats delivered almost twice as much cargo.

4.7 Questionnaire results

A key element, the questionnaire, was important to help us to understand the worker's perception of the current system and their feelings on certain changes that were made as possible recommendations. The questionnaire was given to cargo workers with the aid of another cargo worker that could explain the purpose of the survey and its rationale. Over 50 completed questionnaires were returned over the study period, which is a good sample considering the average number of general cargo workers at the dock in a given day is about 250.

4.7.1 Question Concerning Boat Traffic

The questionnaire identified that nearly every cargo worker polled saw several major flaws with the current system. Of the 14 questions asked, four questions were concerned extracting information with the existing system and its approval or disapproval by the workers. Eight questions concerned their willingness to change to adapt to a new system, and 2 questions asked how long the worker had worked on the boat and whether or not he owned the boat on which he worked.

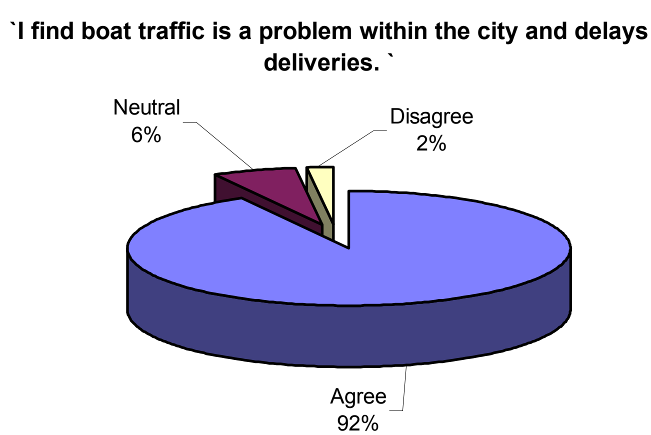


Figure 43: Opinions concerning boat traffic

The first question was the first of twelve that consisted of a statement and then a worker could mark his range of approval to the statement. This was the major format of the questionnaire. Results showed that of nearly every cargo worker strongly agreed with this statement, over 46 workers showed agreement, with only 1 disagreeing.

4.7.2 Question Concerning Dock Availability

The second statement concerned the ability to find an open dock location throughout the city. Its wording ` I find it is never a problem locating a place to dock and unload within the city. ` was planned so that the worker would not tend to disagree with the statement to show that he finds this problematic. This type of response insured that the worker did not just simply check every strongly agree box. Many workers (44 in all) disagreed with this question, showing that it is a problem to find a free dock throughout the city. Five results were received where they agreed with this statement showing that it was easy to find a docking space. This number only represents 10% of those surveyed however.

4.7.3 Question Concerning Dock Reservation

The third statement ` I believe that docks reserved for cargo boat use during delivery hours would aid in faster deliveries.` received overwhelming approval. No workers disagreed with this statement whatsoever, and there were 47 workers who agreed with this statement.

4.7.4 Question Concerning Dock Equipment

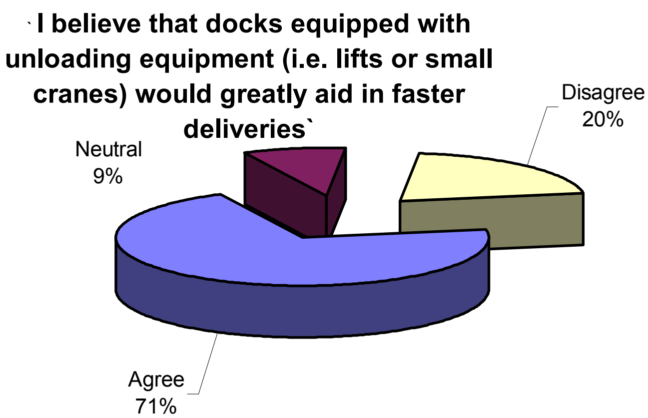


Figure 44 Question Concerning Dock Equipment

The fourth statement concerned possible infrastructure improvements that could be made to the docks, and whether they would be helpful. Not all workers expressed agreement with this statement, although the majority did agree. Over 70% agreed, however 9% were neutral and a shocking 20% disagreed.

4.7.5 Question Concerning Point-to-Point Delivery

The fifth statement was also somewhat split although overall agreement was shown. Worded like so ` I would rather deliver a full boat of cargo to a set area within the city than to many locations throughout the city`, it showed their feelings to a proposed new system change. 75% of the workers agreed, however 9% were neutral and 15% disagreed.

4.7.6 Question Concerning order at Scolo Fluviale

Statement number six, also resulted in overwhelming agreement, with 39 workers agreeing with the statement, however here were still several workers that strongly disagreed with this statement. Upon closer inspection, see Figure 45, it is seen that if the results are sorted among those who own or do not own the boat on which they work the data shifts: Nearly all workers that did not own the boat agreed, however, workers that own their own boats seemed to disagree more. This was an interesting result, however overall 75% of the workers still agreed with the idea.

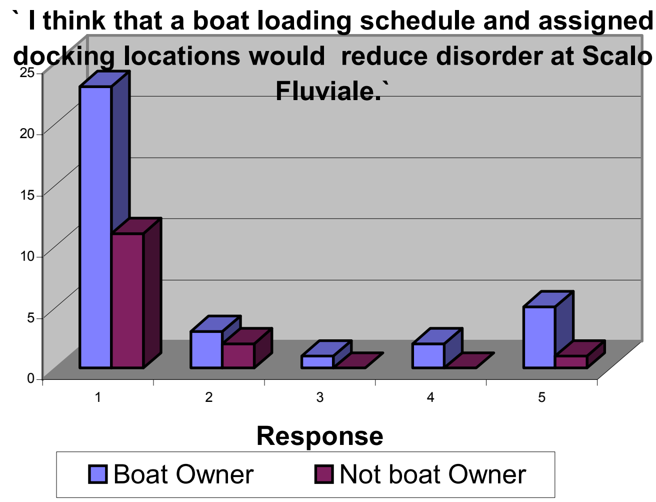


Figure 45: Question #6 Sorted by Owner

4.7.7 Question concerning Safety at Scalo Fluvial

The seventh statement ` I am concerned about my personal safety while loading at Scalo Fluviale.` concerned the safety of the workers while they are loading their boats at the loading dock. Overall results for this statement were of great approval, 42 workers agreed, 2 had no opinion and 3 disagreed.

4.7.8 Question Concerning Warehouse Possibilities

The eighth statement concerned the possibility of a warehouse available for general cargo usage, and whether it would be beneficial to the cargo workers. Worded as follows: `I think a warehouse on Tronchetto (similar to the ones used by milk and fish) would be beneficial for General Cargo delivery.` was extremely well received by the cargo workers as one may have expected. 42 workers agreed, 5 had no opinion, and only 2 disagreed, showing that a warehouse is something that the workers think would be very helpful to them on a daily basis.

4.7.9 Question Concerning Warehouse Employment

The ninth statement was not as clear-cut as each other statement thus far in the questionnaire. This question `I would be willing to work in a warehouse with general cargo delivery instead of on a boat` was intended to give us how willing the cargo workers would be to work in a warehouse instead of on a boat. The results from this question were very split: 15 workers agreed, 9 were neutral and 17 disagreed. This definite split in data tells us that many workers would not like to be taken from their boats and put into the warehouse. This result is very important and will need to be considered in our analysis.

4.7.10 Partial Economic layout

As mentioned in the **Chapter 4 Methodology,** each business of the city was mapped and entered into Access. The Access tables were linked to MapInfo and the map in Figure 46 was created showing every business location of the entire city. The areas of

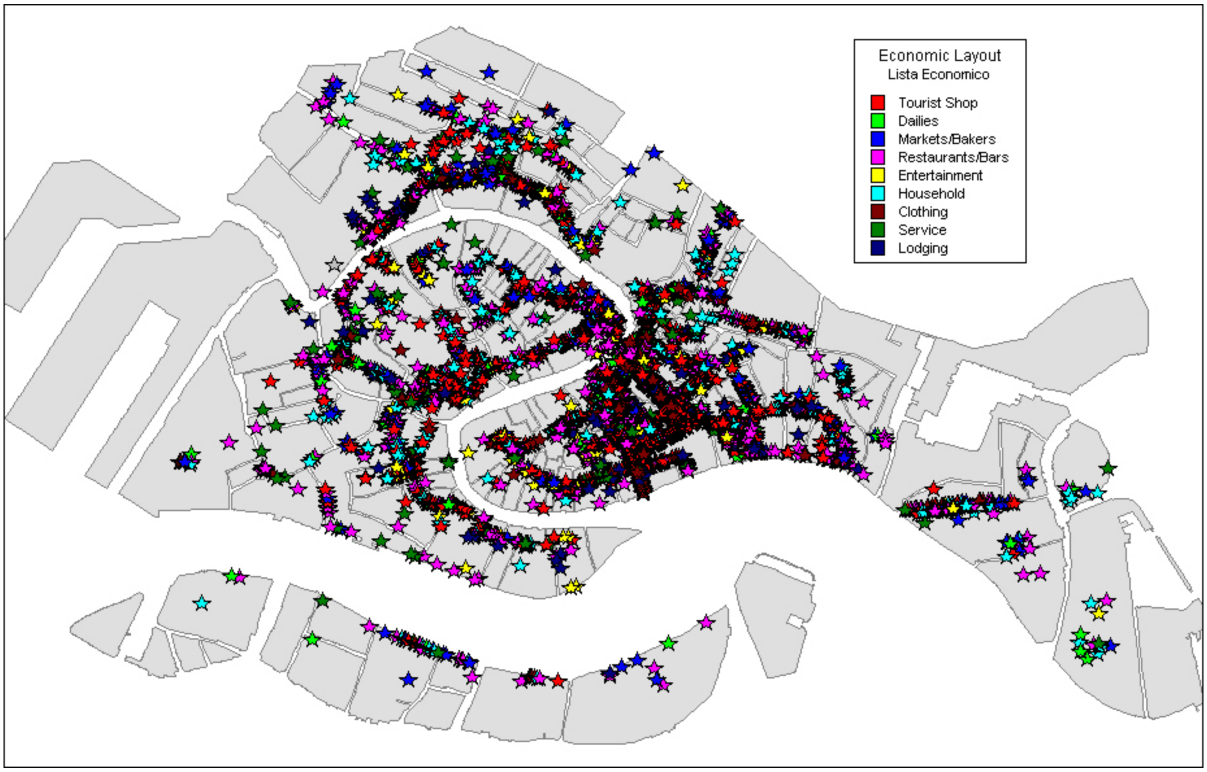


Figure 46: Business locations within city

high and low demand can easily be seen and the areas where no businesses are located stand out plainly. A larger map can be found in **Appendix K**.

Through this mapping, the number of each type of business was discovered. As an example, a closer look will be taken at island 93, San Filippo e Giacomo.

Category	Type	Number
1	Tourist Shop	29
2	Dailies	2
3	Markets/Bakers	4
4	Restaurants/Bars	13
5	Entertainment	6
6	Household	4
7	Clothing	8
8	Service	3
9	Lodging	4

Table 8: Total number of businesses by type, island 93.

The total number of each type of business located on this island can be seen in **Table 8.**

More detailed information on the number of *colli* received by all types of business in a

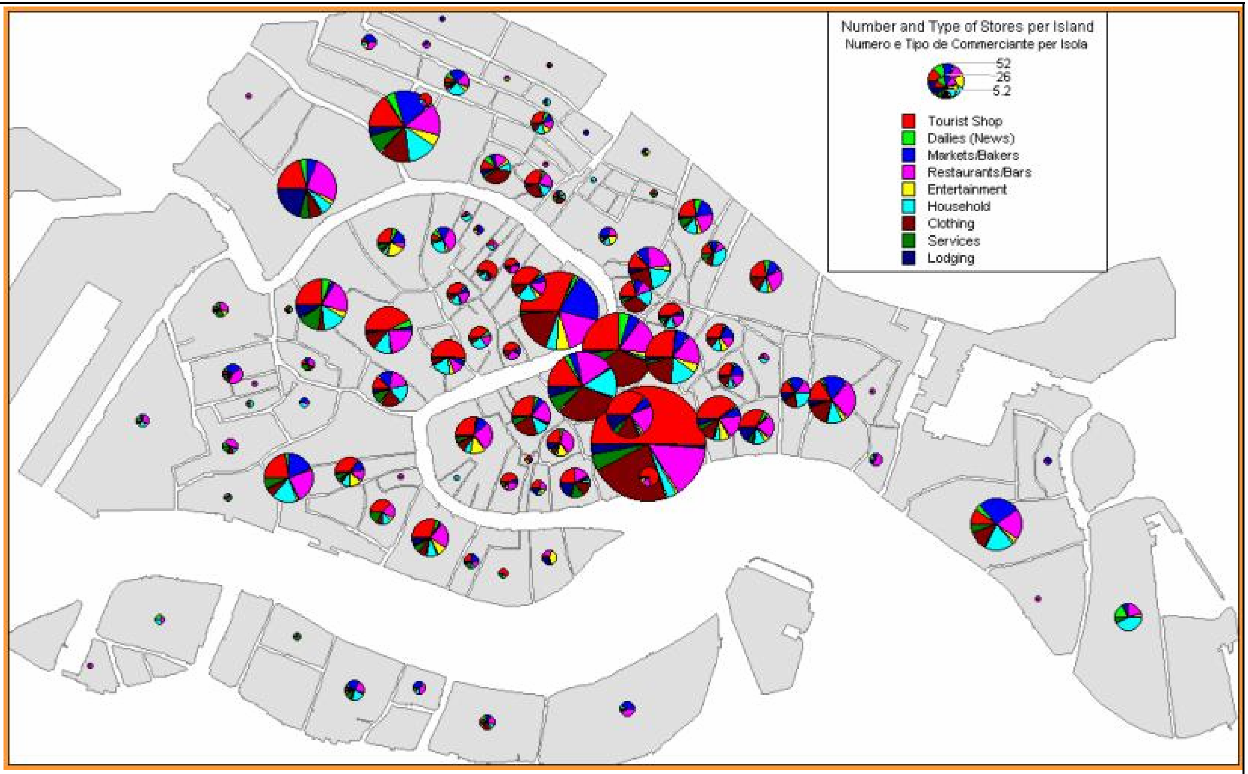


Figure 47: Distribution of Businesses and Type by Percent

given week, how many of each type of business are located on each island can be found in **Appendices H, I, J,** and **K**. Above is a map of the city's businesses and the how the number of each businesses relate to each other by island.

5 Analysis

The following section consists of an analysis of the results that appeared in **Chapter 6.** Much of the information collected was intended to be combined with other data. This chapter explains how data was combined and then analyzed.

5.1 Island Demand

A major portion of this project was to determine the demand for cargo shipments throughout the city of Venice. In order to complete this major objective, several other tasks needed to be completed and the resulting data was compiled.

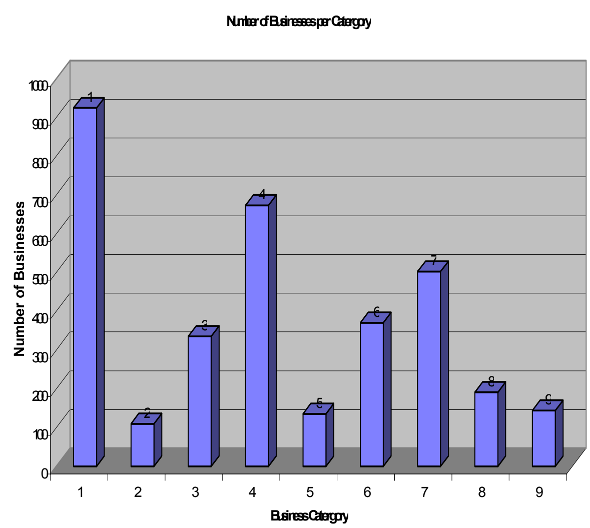
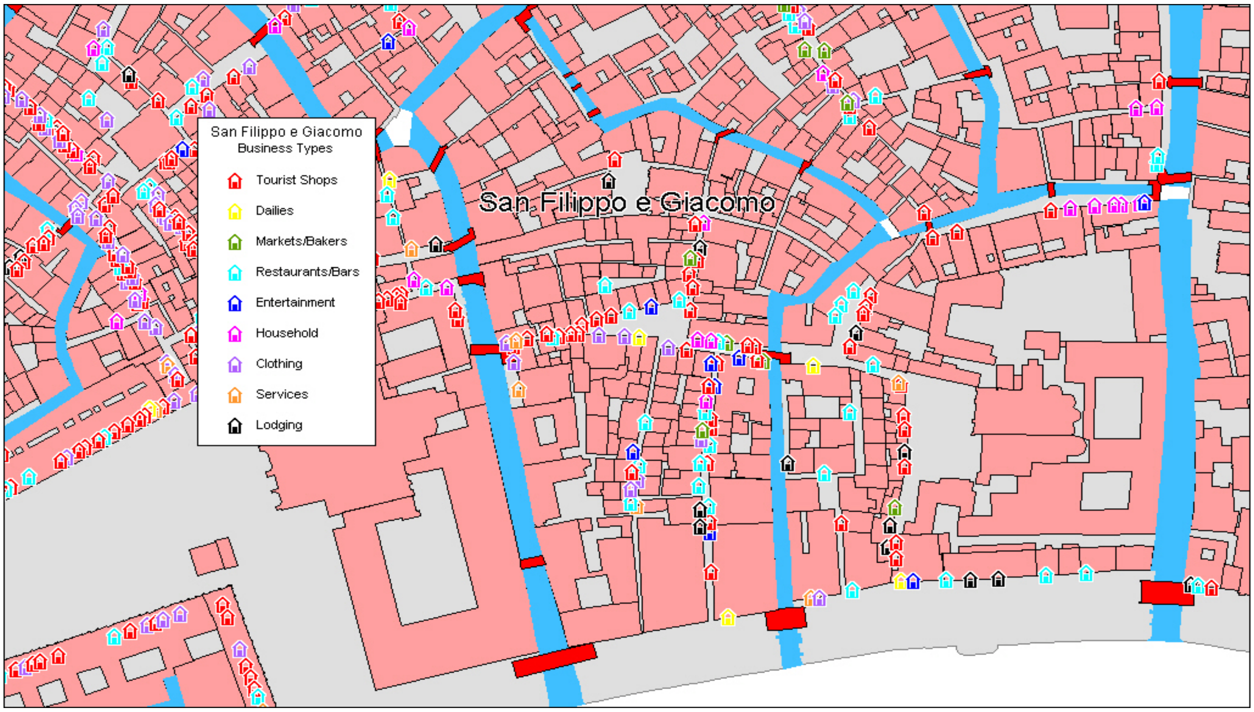
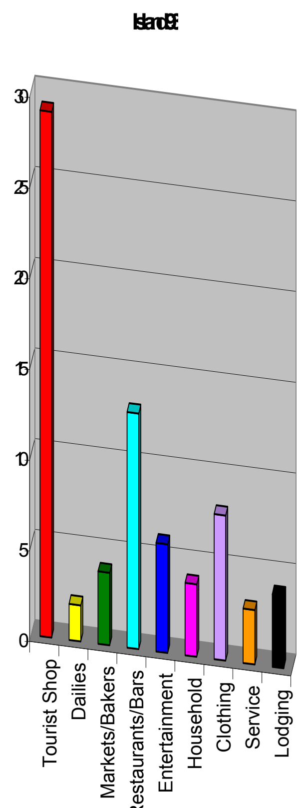


Figure 48: Number of Businesses per Category

The economic layout of the city was completed so that a clear picture of the locations of every business and business type throughout the city could be constructed.

Figure 49: Island 93





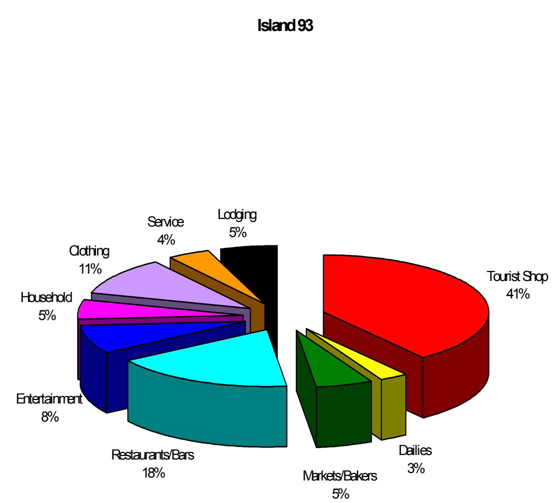


Figure 50: Island 93 Bar Graph by Category

Figure 51: Island 93 Pie Chart by Category

An example of the data collected and compiled can be viewed on the previous page. Figure 49 is an example of the businesses that were mapped on each island, sorted by nine categories that were created. A sample bar graph and pie chart can be see for Island 93 as well, see Figure 50, and Figure 51. As this island is located in a tourist district, it no surprise that the number of tourist shops exceed all other types of shops.

This graph, however, needed to be coupled with demand data for every business to determine where and how much demand lies in the city. The demand data was a combination of two different data collections: time spent observing general cargo boats and time spent observing express deliveries. Once all data was collected these two methods were fused together for each business type, so as to create an average number of shipments per week. With a number of deliveries per week for each business type and the location of every business and its type throughout the city, this data was combined to show where all demand for cargo lied throughout the city. Once completed, all special cases were considered. An example of a special case that occurred in this study was the location of several foodservice distributors throughout Venice. These distributors were not mapped during the economic layout portion, because these establishments often do not have any visible markings, as they are just warehouses. The locations and delivery data of these establishments were determined through interviews completed with several cargo workers with knowledge of the subject. This data was then entered in addition to all other demand data to create an accurate picture of the entire city.

5.2 Daily Demand for Deliveries per Island

The overall city cargo demand graph sorted by island is shown in Figure 52. This graph depicts which islands have a high demand for cargo (darker ranges), and which islands have a relatively low demand (lighter ranges). The establishment of the cargo demand on each island is necessary in calculating appropriate zones for the city, that are described later. Throughout the demand process, it was necessary to separate refrigerated and dry goods, as refrigerated goods usually have special shipping requirements, which indicates different variations of boats that must be used. The areas of dry demand and refrigerated can be viewed in Figure 53 and Figure respectively. Figure 55 depicts a graph of

Figure 52: Dry Economic Demand

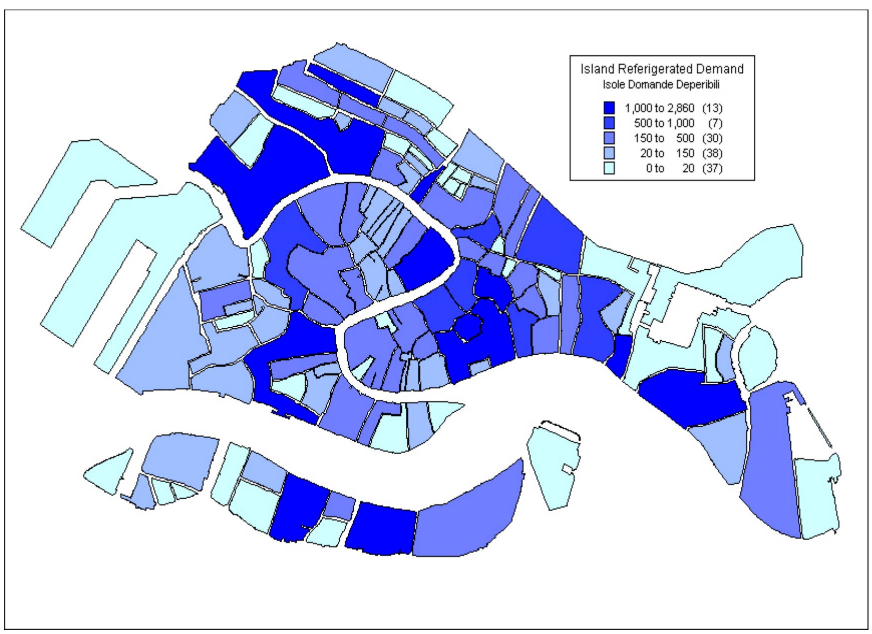


Figure 53: Refrigerated Demand per Island

the ratio for each island of dry cargo demand vs. refrigerated cargo demand. At first it seems as if the ratio for each island is approximately the same, however, upon closer inspection one can notice that some islands have a relatively high refrigerated demand as well. This information will be useful when establishing boats throughout sections of the city. The number of total businesses on a particular island does not necessarily directly correlate with the relative demand of that island. An island may have numerous shops, yet have a low demand, or vice versa. For example, an island with a high number of tourist shops may have a smaller demand than a much less densely populated island with a supermarket, since the demand of goods for a supermarket is so much higher than a tourist shop. The figure below depicts these tendencies. It is noted how some islands have very small stars (indicating a small number of shops) however, they still have a very high demand (as indicated by the color ranges).

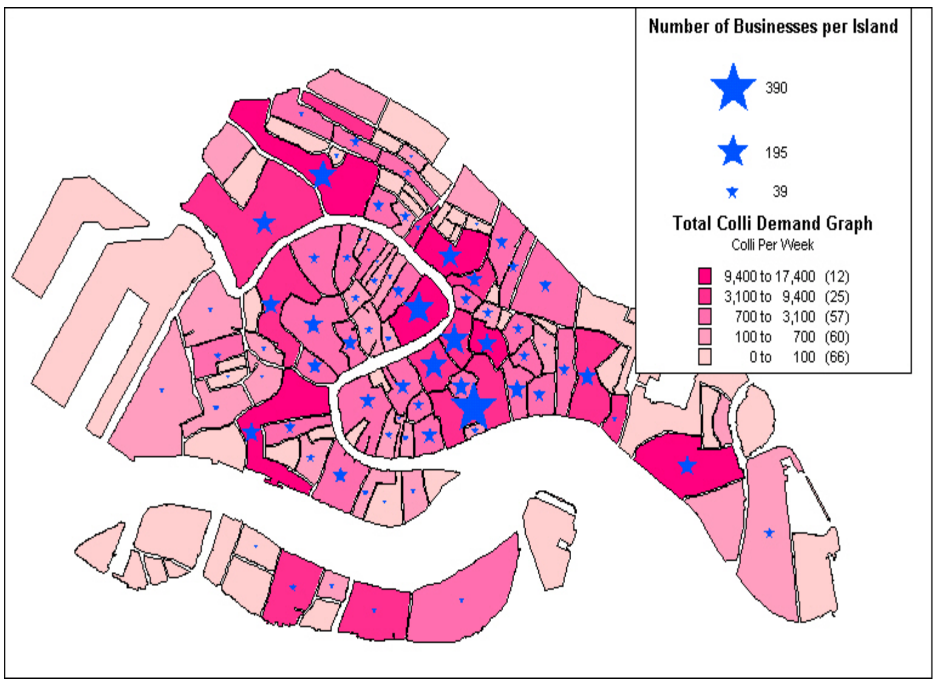


Figure 54: Number of Businesses vs. Demand

5.3 Zones

From Figure 52 and Figure 53, it can be seen that some islands have a much smaller demand for deliveries than other islands. The dry and refrigerated demands per island were combined, as seen in Figure 55, to show the combination of demands. As one can see, the dry demand for each island is distinctly larger than the refrigerated demand. These results assisted in identifying the number of general cargo boats versus the number of refrigerated boats needed per island. The demand for each island was taken into account to assign appropriate zones throughout the city,. Using the calculated demand for each island, the entire city was divided into sixteen relatively equivalent zones. As seen in Figure 56, zones consist of a range between one island to as many as sixteen islands. Each delivery zone is sectioned by color code.

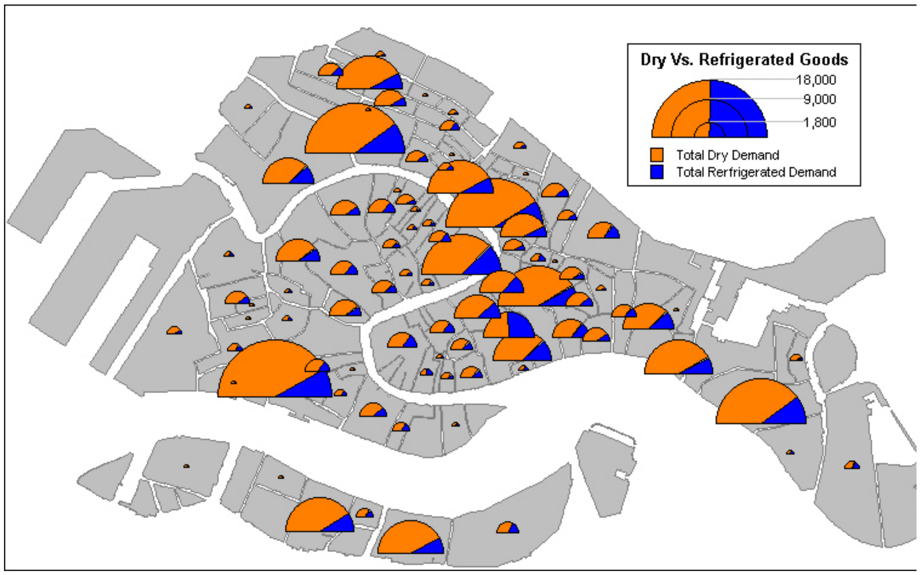


Figure 55: Dry vs. Refrigerated Demand per Island

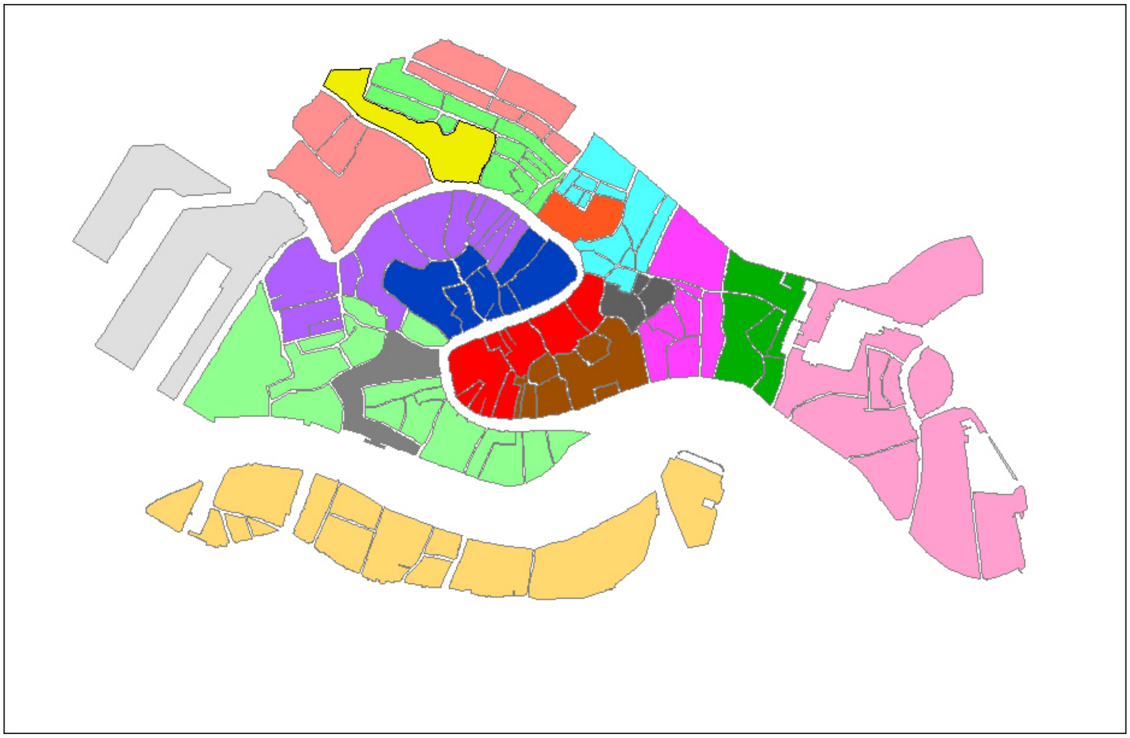


Figure 56: Delivery Zones based upon Economic Demand

5.3.1 Island Assignments

Islands were assigned to each zone based upon the economic demand of that zone. As seen in previous figures, the zones vary in size when considering the number of islands involved in each zone, see Figure 57.

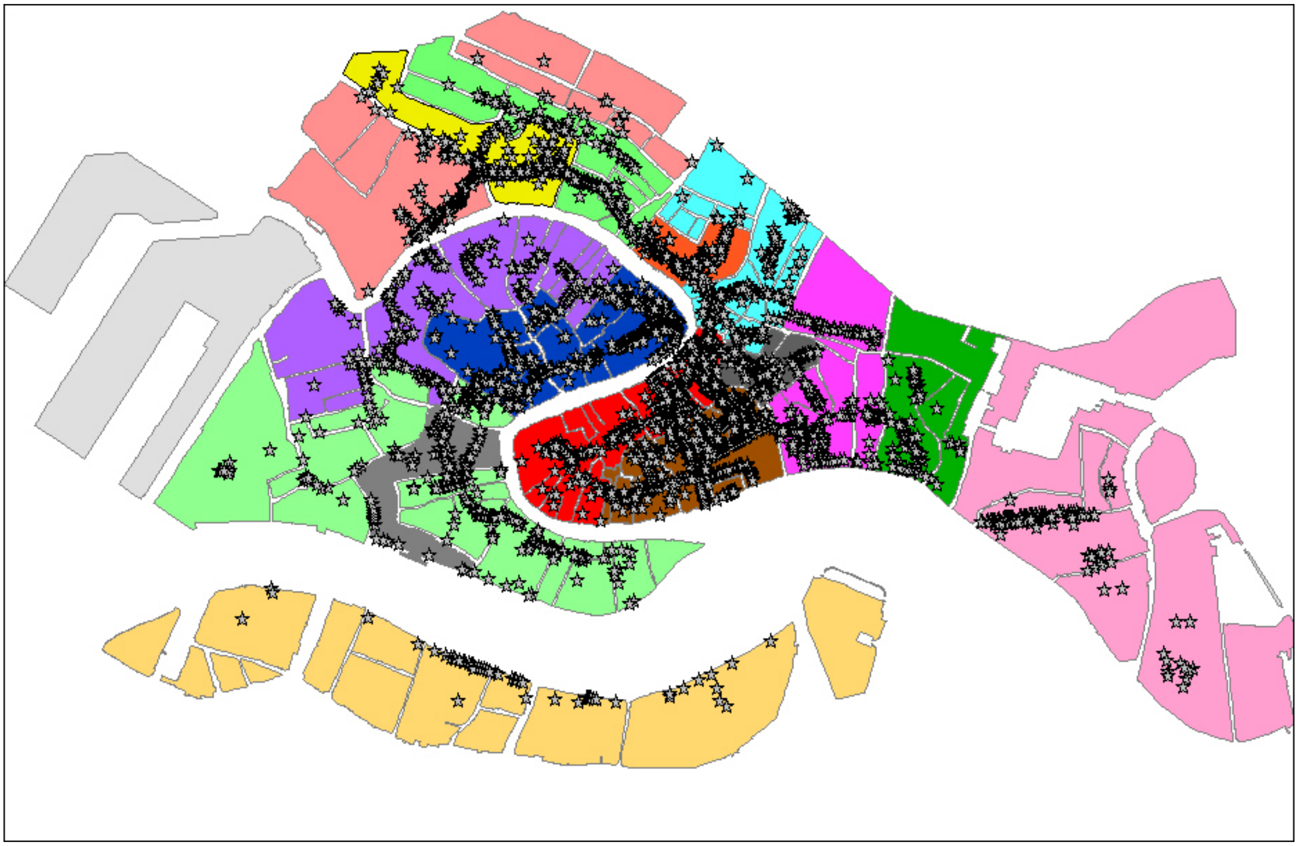


Figure 57: Number of Businesses per Zone

5.3.2 Daily Number of Boats per Island

To adequately deliver to the entire city of Venice, given the 184 boats in the CTVR, the boats in the CTVR must be assigned to specific zones. Several calculations were used to identify the number of boats needed for each of the sixteen zones in Venice.

Nome_Isola	Codice _Sestiere	Zone_Number	#Businesses	Total *Colli*	Boats Needed
Tronchetto	SC	0	0	0	0
Stazione Marittima	SC	0	0	0	0
Sant'Alvise	CN	1	1	224	0.1
Madonna dell'Orto	CN	1	2	4	0
Sensa	CN	1	3	6688	3.03
Brazzo	CN	1	2	61	0.02
Mori	CN	1	4	226	0.1
Santa Maria di Valverde	CN	1	1	0	0
Ghetto	CN	2	7	92	0.04
San Girolamo	CN	2	10	1114	0.5
Ormesini	CN	2	27	1951	0.88
Chiovere San Girolamo	CN	2	0	0	0

Table 9: Sample Calculation of Boats needed per Zone

As seen in Table 9, numerous calculations were required to determine the number of boats per each zone.

5.3.3 Dock Locations

An analysis of current dock locations was appropriate in determining the optimal usage of docks in our final reengineering of the cargo transportation

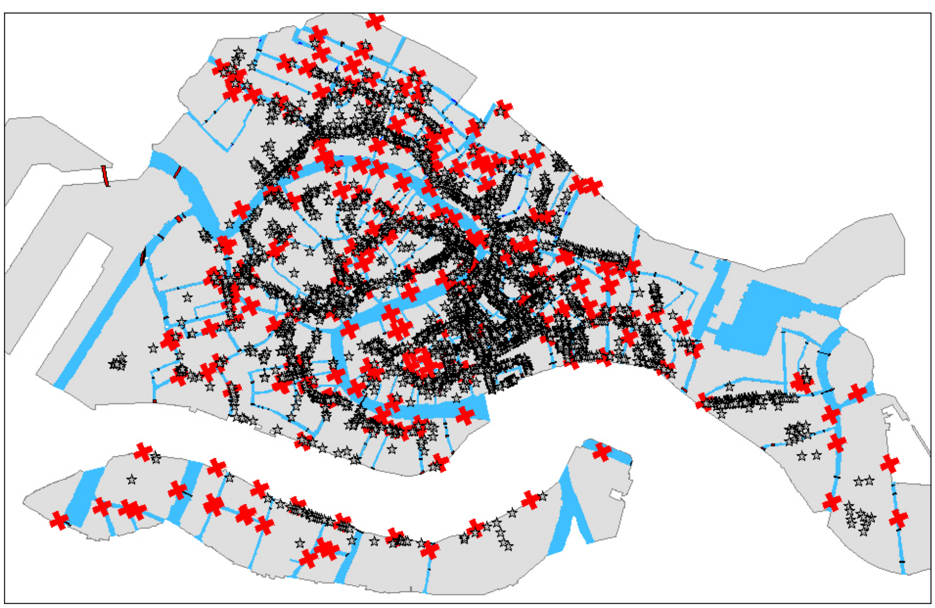


Figure 58: Optimal Dock Locations per Island

system. Dock locations were chosen according to current preferences of the cargo men, as well as dock proximity to business locations. As seen in Figure 58, there are several dock locations chosen for each island, with each dock centered near business clusters.

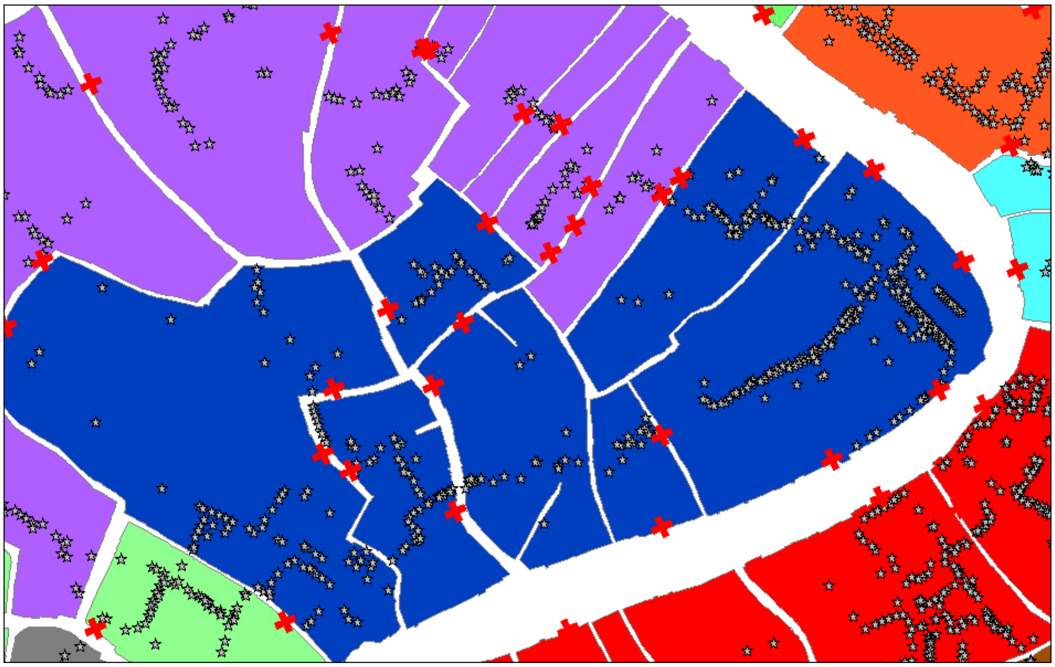


Figure 59: Sample Zone with Dock Locations

5.4 Analysis of Expenditures

Analyzing costs was a key factor in determining the benefits of the implementation of a new cargo distribution plan as well as the feasibility the plan. To analyze the cost benefits of the plan, the difference between current costs and reduced costs pending the implementation the proposed system were determined. The cost of the gasoline costs, physical handling costs of cargo goods, and the expenditure of time used to make cargo deliveries was also analyzed. With current expenditure data the time and money saved when the new system of delivery is implemented was shown.

5.4.1 Reduction of Boat Expenses

One key reduction in costs as a result of our plan may be the reduction in the expenditures used on gasoline and travel time. Figures for the amount of gas used in one week and the price of diesel per liter were collected. The hours that the operator traveled for the week were totaled and an average cost of gas per hour of operation was calculated. If boats spend less time traveling then less money will be spent on gas. Since a point-to-point delivery system minimizes the hours of boat operation much money will be saved due to the use of less gasoline.

5.4.2 Reduction of Handling Expenses

Since boats will fill to capacity each day and fewer boats will be used overall one can assume that there will be a reduction in overall handling costs. There would be a decrease in costs if it was possible to consolidate the goods going to one place and make use of the boat's entire capacity. Current handling fees were obtained from our sponsor. These fees apply to both the number of colli shipped, the type of colli, and the weight of the colli. It was possible to estimate a cost decrease or extra money made, when a boat is filled to capacity, if we considered a reorganization of the cargo system.

Another factor to examine concerning handling fees is the hourly wage of each man employed to move cargo. If the time it takes to move cargo from one place to another is reduced, the amount of money that is spent paying men to move it can also be reduced. Through the use of an organized warehouse the loading time at the beginning of the day should be reduced to almost nothing. All organization of packages will be done before the boat arrives and when the boat does arrive the packages will be shrink wrapped to a pallet and dropped into the boat using a mini crane. Unloading and carting times will also be reduced as all the packages on each cart will be delivered one condensed cluster of business instead of several business distributed over one or more islands. The time spent carting, loading, and unloading were all observed and recorded. The reduction in handling time can be estimated and the money saved is simply the product of the hourly wage of each worker and the total time by which handling is reduced per day.

5.4.3 Reduction of Wasted Time

As there was currently an unorganized system of cargo delivery, there was much time that was lost to idle activities such as travel and waiting for dock space. When time is wasted, it generally can be concluded that money is being wasted as well. Data to complete calculations concerning wasted time spent waiting for dock space and traveling from one delivery location to the next was also collected through observation. During travel the boat is literally burning money through gas but the monetary value of the time spent traveling can also be modeled using the price the cargo boat owners charge for one hour of a boat's rental. Theoretically, a boat could be rented by the hour after all deliveries for the day had been made. In this case, every hour spent merely traveling within the city from one delivery point to the next or waiting for dock space can be calculated as money lost. To calculate this figure the hourly rental fee was obtained from boat owners and the times spent traveling and waiting for dock space during an average day were collected through observation.

5.4.4 Reflection on Feasibility and Practicality of Plan

With any proposal, the feasibility of the plan must be assessed before implementation. When the proposal was finished we looked at it from the standpoint of the companies expected to work with the new plan and the people of Venice who are expected to live with the new plan. The plan was modified when it looked as though the plan would not work in the favor of the involved parties.

The required work force for the proposed plan was considered. The plan did not create or eliminate a large number of jobs. The increased concentration in carting as a result of completely full cargo boats being unloaded at one location was considered. If the boats are being unloaded early in the morning the noise and traffic may disturb residents of the area. The schedule of deliveries was adjusted to reduce this factor as much as possible. Another thing that was considered was the feasibility of building and running a warehouse in the city. CTVR feels that the city should be responsible for providing the proposed warehouse. Seeing that there was a plan being proposed to the city at the time of this study it is very likely that the warehouse will be a reality at some point in the future and that the city will take responsibility for at least some of the expense. The city would be justified in paying for a warehouse that would provide a number of benefits to support its expense. The reduction of traffic, increased safety for workers, reduction of wake damage, and faster more accurate delivery should be enough to convince the city a warehouse is positive. If these reasons are not enough the CTVR may use its power as a union to organize a strike or protest that would bring the city to the realization that the city can not function without the cargo boats' currently provided services.

All in all, we are sure that the plan has no fatal flaws that will bring the system down quickly. We are reasonably certain that the plan will save the CTVR companies money and reduce the hassle of delivering goods. We are hopeful that the cargo boat drivers will be willing to accept the plan and are content with the changes that are proposed. We are convinced that no part of the new system reduces the standard of living in any part of the city. Furthermore, we anticipate that the plan will run smoothly and all the details are specified.

5.4.5 Average Capacities

One important numerical figure that needed to be extrapolated from these catalogs was each boat's cargo volume. Cargo volume was important in relation to this study, because it was determined through interviews with cargo workers that the limiting factor of loading a boat was almost always the boat's cargo carrying volume opposed to a boat's maximum safely loadable weight.

The equation described in **Section 3.4.2 Determination of Average Capacities** was used to calculate the volume of the boats for which all dimensions were know. Since the exact dimensions of many boats were not available to us we could not calculate their exact volumes. For such boats, we used an average volume computed from all boats with available data. The average volume was calculated to be 35.707m^3. This calculated volume was used to determine the total cargo carrying capacity of the CTVR cargo fleet. This calculated total is **6,568.8 m^3** and represents the total volume of all cargo boats that are members of the CTVR.

6 Proposal

The follow chapter consists of three levels of possible plans of action to re-engineer the current cargo transportation system. The first set of proposals includes plans of actions that are independent of the boat operators themselves. The second proposed plan of action shows the steps that can be taken by boat operators to begin organizing themselves for the final, third, proposal that establishes the inner workings of a warehouse and develops a plan for the entire CTVR fleet to work together in an organized manner.

6.1 Short Term Actions

To begin the primary steps of re-engineering the current cargo system and to start reducing the inefficiencies now present, we suggest the following steps to be taken. Issues such as safety at the loading docks must also be addressed immediately and are therefore also contained in this section.

6.1.1 City involvement

One of the major reasons for the overwhelming number of the cargo boats present on the canals of Venice is due to the city licensing far too many boats for the city's demand. We first recommend that the number of *conto terzi* licenses be capped and that no more licenses are distributed in the future even as the number of active licenses decreases slightly over the years. New licenses should only be awarded when the number of active boats becomes too small to effectively service the city.

The city must begin to take more drastic measures when enforcing existing laws and regulations pertaining to cargo delivery boats. To begin with, boats that are not licensed to move cargo for third parties but still operate within the city, there are about 100 of these, should be heavily fined when caught breaking the law or using the loading dock at Scalo Fluviale. These boats must be discouraged from operating within the city as the total operating fleet, licensed and unlicensed, must be reduced to produce a more efficient system.

The time limit of fifteen minutes allotted for the use of docks should also be more closely regulated. Boats should be equipped with clocks that mark the time that they arrived at the dock. Boats that spend too much time docked should be ticketed. Boats traveling down restricted canals or traveling down one-way canals the wrong way should also be ticketed. Money collected from fines and tickets should be put towards the building of the warehouse on Tronchetto.

Although docks around the city are already reserved for *conto terzi* boats many cargo drivers find these docks occupied by construction boats for the majority of the day. Some construction boats are licensed by the city as *conto terzi* and are technically allowed to dock at these locations but will remain at the reserved docks for the entire day. We recommend that the city reserves separate docks for cargo delivery only during peak delivery times or that stricter regulations are made in regard to the use of the docks now in reserved.

6.1.2 Improving Safety

There are major concerns in relation to the poor safety practices now prevalent at the Scalo Fluviale loading dock. The major concerns include the over crowded docking space, parking lot, and the use of cranes during times of peak activity.

We suggest that a schedule for the loading of goods be established and followed until the implementation of the warehouse on Tronchetto. Through observation and data collected from cargo workers, it was found that the majority of goods could be given time slots in which they should be at Scalo Fluviale to pick up their cargo. Dry cleaners and laundry should arrive first, at 5:00AM or earlier, to pick up their daily loads. Foods and perishable items should load next from 6:30AM to 8:30AM. After the food boats have been loaded and leave the docks construction boats that require the use of cranes may arrive at the loading area to receive their supplies. Construction boats that use cranes to load should be relocated to the construction boat loading site on next to Piazzale Roma.

Figure 60: Construction Loading Dock

As mentioned in the Background Chapter, at the current time boats that need the help of cranes to load their daily goods are working over boats that are being loaded by hand. The workers of the smaller boats do not wear hard hats and are often forced to work under the cranes due to the lack of space for the parking of boats. If the crane using boats load last, after the majority of

Figure 61: Construction Loading Dock

other boats have left the dock for the day, the cranes will not be in operation over numerous people and boats unequipped to be working near such heavy, dangerous machinery.

If a loading schedule is not feasible and crane using boats must load during the hours that most other boats are still present a the docks then stricter rules must be followed as to the use of large cranes. The safety areas around the cranes should be enlarged and barricaded. When the crane is operation the safety area around the crane must be cleared. Cargo men in the area directly next to or under the crane must be made to wear hard hats.

7 Intermediate Actions

As it will be hard to make a large jump from a minimally organized system to a completely re-engineered system of transportation of good over night secondary steps must be taken to help organize the system until a warehouse can be built. These steps rely completely on the cargo men's willingness to cooperate and help each other. Nothing can be done in the middle stages of the transition by anyone but the workers themselves, as until the warehouse is built there is no one standing behind the scenes directing the plan. This intermediate stage is primarily designed for the cargo companies to help each other save time and money. As a result available resources will be used more efficiently and traffic throughout the city will start to be reduced.

We propose that a few boat owners who only own one or two boats, there should be between three to five boats total between the different owners, get together and help each other make their deliveries. Cargo can be split between the cooperating boats based on *sestieri* and islands beyond the historical center of Venice. For example, all cargo going to Murano each day can be loaded into one boat and all cargo going to St. Mark's can be loaded into another. Many companies working in Venice that own more then one boat already use this simple system and benefit greatly.

To keep payment for services fair the companies should try to trade the same number of packages between boats. This way there would be no need to split up payment between the cooperating companies because each company is paid for the number of *colli* delivered and their total number of *colli* will stay about the same. The boats should deliver to the further locations on a rotating schedule, so no one company is paying more for gas then any other.

8 Long Term Actions

To maximize the efficiency of cargo delivery in the historical center of Venice many large changes must be made over time. An extensive plan must be developed that concentrates on the detailed workings of a warehouse, payment of services to companies involved, scheduling of deliveries from both distributors of the main land as well as the boats going to the city, and the distribution of goods throughout the city. A complete plan inclusive of all these elements would take months to develop and years to implement. In the short time allowed for this study the skeleton of such a plan was forged. This plan is detailed enough to give future studies a starting point to create a more refined and detailed plan.

8.1 Proportioned Delivery Zones

As part of the analysis portion of this study the total number of *colli* delivered to each island was calculated because before goods can be organized and shipped it is necessary to know the final destination of all goods.

The city of Venice has been broken up into sixteen potential zones of equal daily delivered cargo. Each of the proposed zones receives enough cargo each day to fill between five and seven average sized boats. At least two refrigerated boats should be included in the total number of boats destined for each zone. A picture of each zone and a complete list of the number of boats needed to service each zone can be found in **Appendix J**. A list of proposed assignments for specialized boats to zones of special need can also be found in the abovementioned appendix. The islands included in each zone are also listed there.

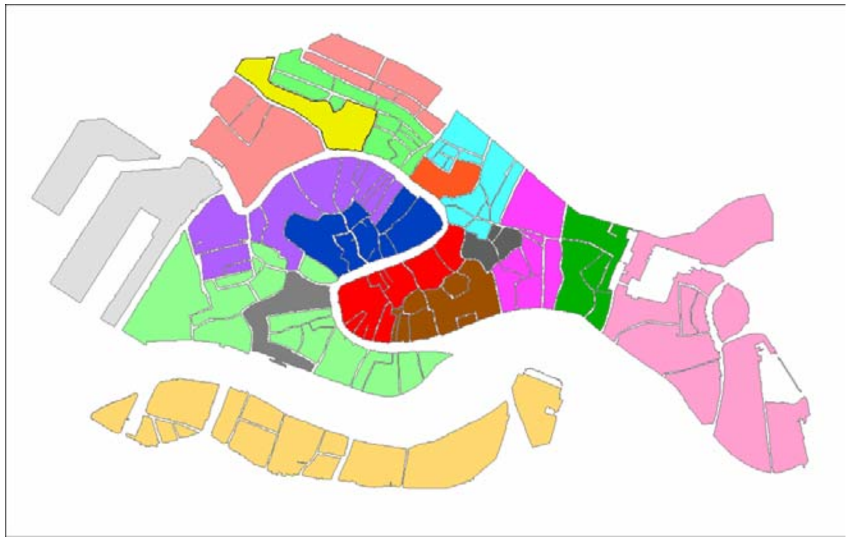


Figure 62: Island Zones by Demand

The zones are not only based upon the demand of each island but the proximity of the islands to each other. Islands of high demand are treated as their own zones, while islands with low demands are grouped together into one zone. These sixteen zones represent the optimal delivery organization for the CTVR boats. As been proved through this study, time and money are saved when deliveries are organized. As opposed to traveling throughout the entire city to make the day's deliveries, the cargo men's deliveries will be designated to certain sections of the city. The cargo man will be transporting the maximum amount of goods that his boat can contain.

Through this study, optimal docking locations have been determined. Several designated docks per island have been selected, based upon demand locations as well as preferred dock locations by the cargo men. Placing dock locations in the proximity of several high demand business locations will aid the cargo man in his carting of deliveries. The workers as well as the cargo operators will be carting their goods for this section. The amount of time carting from the boat to the appropriate business locations will be decreased. Each of these dock locations should be identified as a reserved dock for the CTVR. Docks using a system similar to this one already exists in the S.Marco sestieri. The identification of each dock should be color coded according to the zone. The color code should be visible on the boat that is assigned to that zone location. These boats have priority over the dock, with no time restrictions. Other boats have a fifteen-minute restriction for that docking location. As the docks are assigned to this particular boat, there is no need to be concerned with the amount of time this boat will be spending at this one dock.

The islands in each zone are of close proximity and grouped in such a way that all the islands of each zone can be easily reached by one or two short routes. As it has been suggested which docks on each island of the city be utilized and possibly reserved for the use of *conto terzi* deliveries an example of how 5 boats, using these docks, can service one zone is illustrated in Figure 63.

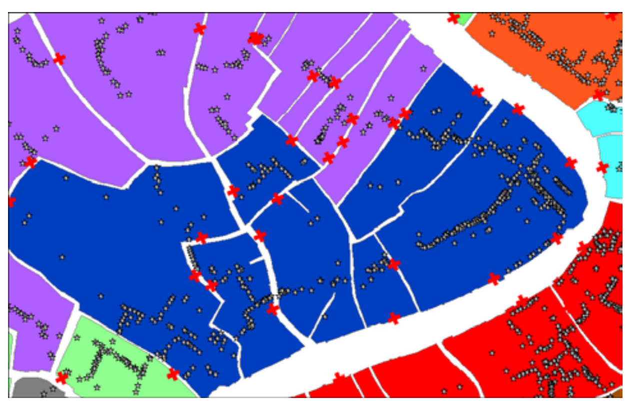


Figure 63: Sample zone with Suggested Dock Locations

8.2 Implementation of warehouse facilities

The construction and operation of a general cargo warehouse is specific to our proposed reorganization of the current cargo transportation system. A plan for three warehouse buildings on the island Tronchetto, for use by general cargo delivery, was passed on June 15, 2001 by the City Cabinet. The lots that are included for this plan consist of lots BB1, BB2, and BB3. Currently, these warehouse plans are awaiting approval of the City Council. According to these plans,10,000m^2 is available for cargo storage in the warehouse. The structure of the future warehouse needs to be evaluated so as to efficiently utilize the space available. We have proposed a specific organization as well as operation of the future warehouse. The primary goal of the proposed warehouse operation is to successfully package incoming goods according to individually assigned CTVR boats. The following step-by-step procedure will best serve to exemplify the proposed operation.

As seen with the current loading dock at Scalo Fluviale, congestion of trucks in the area adds to the chaotic nature of the dock. To rectify this problem, there should be a separate entrance for trucks, in the rear of the warehouse,

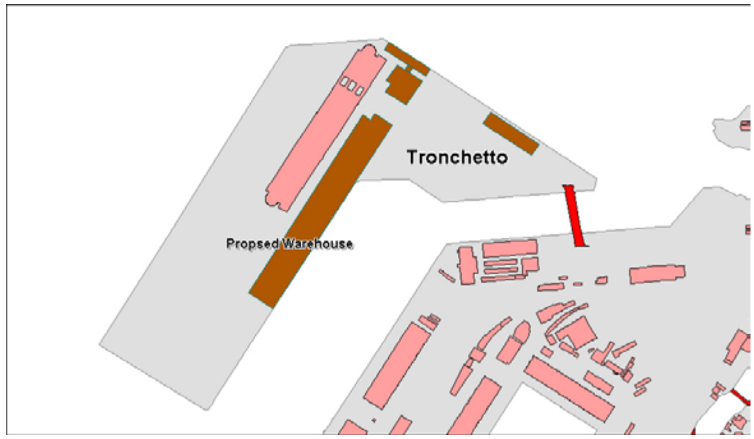
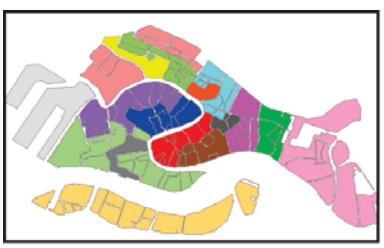
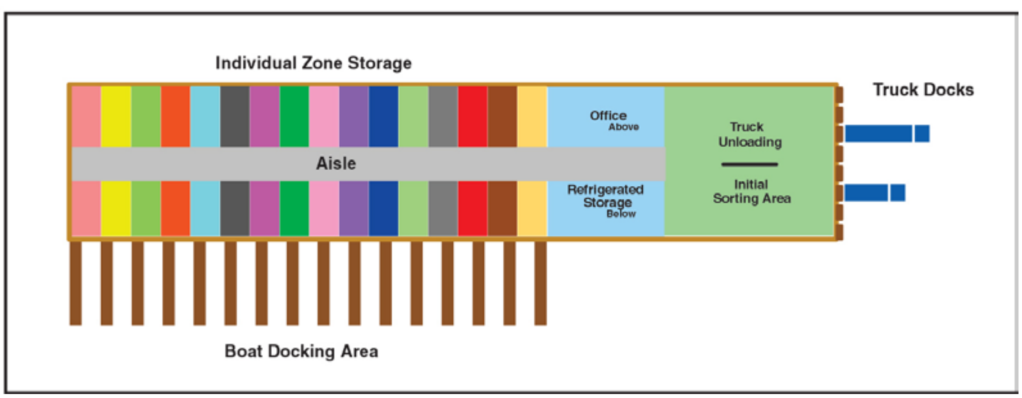


Figure 64: Warehouse buildings proposed for Tronchetto

for the trucks to pull in to deposit their goods. Mobile pallet jacks, awaiting the truck's arrival, will remove pallets from the truck and bring them to an organization site within

Figure 65: Color Coded Warehouse





the warehouse. This organization site will be a sectioned area of the warehouse where incoming pallets will arrive. These pallets will be broken down and sorted according to delivery zones. Once sorted according to delivery zone, these pallets will be moved by forklift to the appropriate zoning locations within the warehouse. A floor plan representing this layout is shown in Figure 66. As mentioned before, sixteen delivery zones have been developed from the 125 islands of Venice. Likewise, there will be sixteen sections of the warehouse for organization of zone pallets. A subsection of the warehouse or another building located on one of the proposed lots should be equipped for the storage of the refrigerated items. If it is not possible for the refrigerated sections to be located in the main warehouse the separate building with refrigerated facilities should be located as closely as possible to the main warehouse.

The distributors could arrive the previous day, or at night, to provide an adequate amount of time for goods to be organized for the next morning when the cargo men come to pick up their daily deliverables. In this way, the truck driver will not have to spend time unloading the cargo at the warehouse as is currently been observed.

At the zone areas within the warehouse, the pallets are broken down again and sorted according to boat assignment. The organized pallets are then rewrapped and delivered to the awaiting boats. There should be space for two boats from each zone to dock at the same time. If *pontile* docks are built

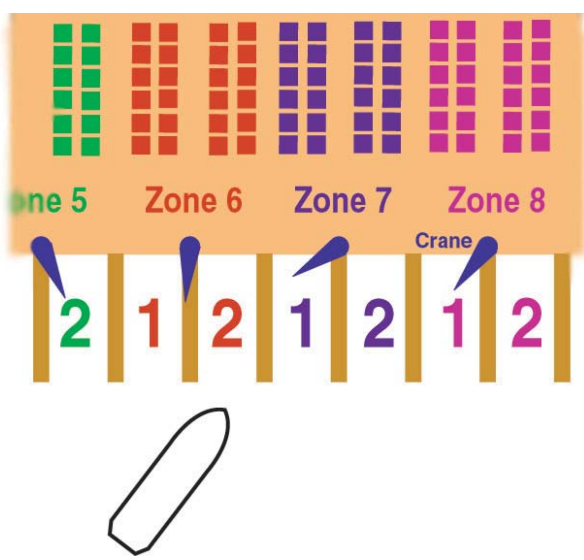


Figure 66: Detail of zone organization areas and

one boat can dock on either side making the total number of docks to be constructed only sixteen. A crane for every zone's dock would assist in the loading of pallets onto the boats.

The warehouse may provide other employment for the cargo workers. Manpower will be needed at the unloading area of trucks, sorting areas for all goods, and the sorting areas for appropriate zones. Cargo men may prefer to work at night as opposed to the early morning hours that they currently operate.

9 Assignment of Boats to Zones

There are approximately five boats assigned to each delivery zone. The calculations for boats to zones were based upon the average amount of cargo that the boat could accommodate. Most of the cargo man's deliveries for the day will be delivered at this one location. Goods brought in from the warehouse will be designated for individual boats, based upon the zones that have been created. As mentioned previously, the docking locations for assigned boats will be color coded according to zone. The CTVR boat that has priority to that specific docking location will also be assigned the appropriate color code.

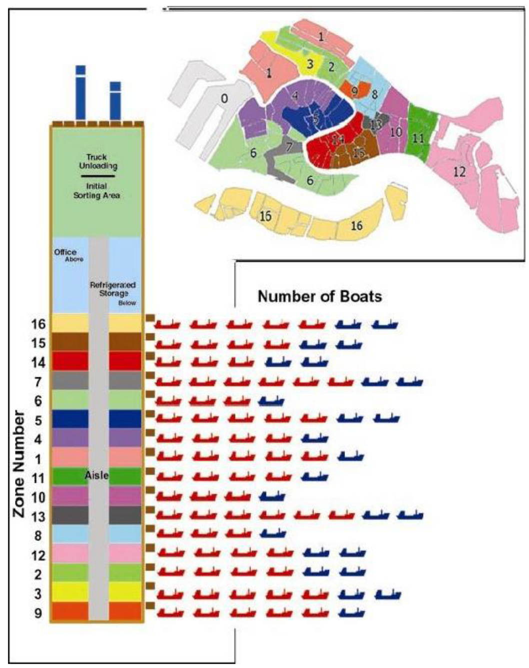


Figure 67: Proposed Warehouse Plans with Assigned Boats

10 Benefits

As the cargo man is paid primarily on the number of goods he delivers and not the amount of time spent delivering, money can made in a shorter period of time.
Time spent traveling will greatly decrease. This decrease in travel time will benefit the cargo man as well as the city of Venice. The cargo man will spend less time searching for docking locations, thus causing a general decrease in traffic in the canals. The decrease in traffic among the canals will have an effect on the ongoing concern of the wake damage occurring along the city's establishments.