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Cellular Bell Towers

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Abstract

In Venice, there are rising concerns related to the effects of cellular antennas on aesthetics and health. In collaboration with the *Settore Sicurezza del Territorio*, we evaluated bell tower structures to resolve this issue. By surveying all antenna and bell tower locations, we compiled data and useful information into functional databases that we created. In comparing the two locations, we found that bell towers are feasible antenna sites, and provided the *Comune* with motives to relocate present antennas.

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Authorship Page

Our project team, consisting of Leonard Baker, Marina Carboni, Luis Flores, and Lisa Lanzillotti combined our individual strengths throughout this project. Every aspect was fruit of our brain-storming, as we were as open-minded as possible. Therefore, we assert that all tasks were distributed evenly in the completion of E'00 Interactive Qualifying Project, “Cellular Bell Towers”.

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Executive Summary

One hundred and six towering structures stand prominently throughout Venice, depicting years of tradition and religious history. These are *campanili*, or bell towers, which are landmarks for the churches in Venice. The bell towers are invaluable given their portrayal of the architectural trends that marked the eras of the Venetian republic. Unfortunately, the maintenance of these bell towers has diminished, and they are in need of repair. Today, these bell towers are being considered as possible solutions to the emerging problems correlated with cellular antennas. As the number of cellular customers increases, the number of providers and antennas do as well. Related to these increments, are increasing concerns of aesthetic damage and associated health problems.

Cellular antennas are tall and are extremely noticeable on buildings or steel structures, therefore detracting from the beauty of the city. Along with aesthetics, the health concerns relating to cellular antenna radiation are troublesome. This radiation has been correlated with psychosomatic diseases caused by the visual presence of antennas, as well as associated with multiple pathologies that related to exposure from electromagnetic radiation. Presently, there are 61 antennas and three providers: TIM, Omnitel, and WIND. As two new companies are contracted to operate in Venice, the number of antennas will continue to increase. To appease these concerns, it was suggested to place cellular antennas inside of the bell towers that exist throughout Venice.

The main goal of this project was to determine the feasibility of concealing cellular antennas within the bell towers of Venice. The evaluation of this subject was completed for the Ecology Department of Venice, or the *Settore Sicurezza del Territorio.* This organization monitors the environmental status of the *Comune di Venezia*. The effects on the health and aesthetics as a result of these antennas have been a cause of concern for this department. In response to this, a proposal for placing the antennas into the bell towers of Venice was recommended, and our team completed an investigation on the subject matter.

To begin, we explored all of the topics concerning technicalities of cellular antennas, bell tower structure, health-related issues, laws involved, and the individuals that could affect the outcome of this project. With this foundation of knowledge, we assessed both bell tower locations and antenna sites.

There are one hundred six bell towers throughout Venice. However, by our definition of what is structurally required of a bell tower for antenna placement, there are ninety-seven perspective sites. In evaluating each of these, we took the data we felt necessary for our purposes. This included specific heights, surrounding building heights within a certain radius, the accessibility of the tower, and photographs. At the same time, we also evaluated 34 existing antennas within Venice. The data collected on these included: conformation of the location, panel directions, and the visibility of the antenna from 1-4 points (north, south, east, or west).

Once data was collected, we entered it into separate databases that we created. These databases were then used to create two catalogs; both an antenna and bell tower catalog. Each would have future use by the *Settore Sicurezza del Territorio* as functional resources.

In our bell tower analysis, we found that they were feasible for antenna placement. For our purposes, feasible is defined as a bell tower with a belfry, which abides by antenna site regulations. We prioritized those bell towers that fulfilled these requirements into five levels. The two highest priorities were not near sensitive sites (schools and hospitals), and were either at optimum height or not. The next two levels were near sensitive sites, and were again either at optimal height or not. The fifth level priority were those that did not meet regulations.

In terms of antenna analysis, by first analyzing them based on health found that 38% of them were located near sensitive sites. In addition, we found that 68% of them were visible. We then defined degrees of visibility, where the 4th degree of aesthetic damage was the worst (visible from all four sides). Out of those antennas found visible, we found that 48% of them were at the highest degree of damage. Finally, we analyzed whether any of these antennas were out of compliance with new Venetian regulations (that were imposed after the installation of these antennas). We found that there were five (at least) not in compliance.

Based on our research, we feel that bell towers are viable antenna locations for many reasons. First, the belfry could conceal the antennas. Second, the bell towers are usually surrounded by *campos*, and are amongst the tallest structures in Venice therefore placing the as far away from the population as possible. Third, there are many bell towers distributed throughout Venice to offer the providers adequate coverage. Finally, the profit made from the rent of the bell towers could go towards the restoration of the church.

With this information we made recommendations to the *Comune* concerning how they should approach their attempt to move present antennas to the bell towers, as well as future antennas to bell towers. We suggested first that they establish plans of coverage for the five providers and supplied them with examples. Next, we proposed that, by utilizing our catalog as a resource, they put together a catalog of their own that is fully descriptive on each bell tower locations, specifically catering the information to the needs of the providers. Finally, we go into detail on how they should first approach the providers with information, incentives and then regulations; and second, how they should approach the church by education and incentives.

While some research teams have come here with hopes of stopping Venice from slowly sinking into the sea, we have focused our attention on a more immediate threat. Damage to aesthetics is very real and becomes ever more evident as technology makes its mark on those things admired, specifically the art and architecture of Venice. After all, it is the art and architecture that motivates researchers to rescue Venice from the hungry Adriatic. In this way we hope to protect this unique city and provide a seamless interaction between cellular technology and Venetian culture to produce a mutually beneficial relationship between the two.

Chapter 1 Introduction

While the economic focus of Venice has evolved from salt-trading to welcoming tourists, communications have always played a significant role in the lives of its citizens. As the use of conventional phones slowly diminishes, mobile telephony is emerging as the main form of communication. Today, Venice holds one of the highest cellular phone per capita rates in the world. To satisfy this demand for cellular service installation of antennas has increased. In response to this there are rising concerns linked to the harmful effects on aesthetics and health. This has become an issue for the Ecology Department of Venice, the *Settore Sicurezza del Territorio*, which plays a major role in the supervision of this technology. Presented with this problem, we were asked to assess the feasibility of Venice's bell towers, or *campanili*, as alternate locations for antenna placement.

The orientation of antenna locations is a result of Venice's structural design. Its building density and large population, relative to available land, limits installations to roof tops and small, open areas. This layout increases the visibility of the antennas. These metal structures protrude from the grandiose buildings and diminish the beauty that has long been a part of Venetian history. It is important to preserve this history that is represented within the architecture. Therefore finding a solution to this problem is imperative.

In addition to interfering with the aesthetics of Venice, there are also health concerns linked with the non-ionizing radiation propagated by the antennas. It has been associated with certain health risks such as forms of cancer, physiological and mental defects, alteration of DNA, birth defects, and has been directly correlated with psychosomatic trauma. While the studies on the relation between health and non-ionizing radiation have been inconclusive, there is an ever present concern connected to this radiation that drives scientists to continue research in this area. Since the extent of health risks are unknown it is important to take actions now to preventative measures.

In hopes of resolving these problems it was our goal to assess bell towers as alternative locations for antenna placement. This process entailed the evaluation of both the antennas and the bell towers in Venice. First it was important to establish the extent of antenna damage based on the aforementioned concerns. This provided us with proof and motivation for the need of a solution. Having accomplished this the next step was to research the characteristics of bell towers and determine their capability to offset the problems. We established this basis initially to ensure our main criteria were met. Lastly, it was essential that we investigated those attributes that define a practical antenna site. Once we completed this we were able to draw conclusions on the overall feasibility of bell towers as suitable antenna locations. Thus to service the community of Venice, we prepared comprehensive recommendations to address the current situation.

Chapter 2 Background

In order to provide ourselves, as well as the reader, with the knowledge required to make the proper assessment of the feasibility of placing antennas in bell towers, we introduce some basic guidelines and technical terminology. In the following sections we explore the topics of cellular telecommunications, associated health risks, relevant legislation and regulations, information on bell tower structure and history, and the hierarchy of the Catholic Church in Italy.

Our understanding of the following material is what will guide us through our decisions and thought processes en route to our goals for the project. Understanding the history of cellular communications, the technology used at antenna locations, and the technology of the overall cellular system will help our team make realistic assessments on the equipment needs of the cellular providers. A knowledge of the laws and regulations protecting Venice's people from cellular antennas will give our team insight towards one of the major problems of the antennas: the concern of health. Most importantly, our team must realize the historical, structural, and spiritual significance of the bell towers. After all, our main goal is to assess the feasibility of bell towers as alternate locations for the antennas while maintaining respect for the historical and spiritual meaning of them.

2.1 History of Cellular Telephony

Cellular telephones, or cell phones, are prevalent in our everyday lives. While some use them in business, others carry them for social purposes or to help in an emergency. What are generally overlooked are the strides that mobile communications have made since their introduction. These services started out as simplex radio systems and developed into full duplex mobile communications involving pagers, phones, and computers. In the 1920s the earliest mobile radios were tested, and by 1934 the United States government created the Federal Communications Commission.[1] Government and private enterprises turned their attention to wireless transmission by the first quarter of the 1900s, but it was not until the 1980s that mobile communications became popular.

The first mobile radiotelephone service was offered in 1946. This system, called Mobile Telephone System or MTS, was not very practical.[2] These first car phones were large pieces of equipment that resided in the trunks of cars and consumed large amounts of power. At that time, mobile devices used six different channels in the 150 MHz range and used 60 kHz spacing between each other.[3] The purpose of the spacing of the channels was to stop signals from interfering with each other. If two signals are too close, they will degrade the quality of one another producing cross talk and fading. However, due to significant interference,

[1] Cellular Defined. 27 Mar. 2000, Farley, Tom, http://www.privateline.com/PCS/history.htm

[2] Cellular Defined. 27 Mar. 2000, Farley, Tom, http://www.privateline.com/PCS/history.htm

[3] *ibid.*

the number of channels was reduced to three.[4] In addition to these problems, communicating in itself was not easy.

A conversation on these original phones required a great amount of patience. Initially, the functionality of the telecommunication system was similar to that of a walkie-talkie. In order for the recipient to hear the caller it was necessary for the caller to hold down a button while speaking. A system such as this, known as simplex, did not allow overlapping voices.[5] That is, the two people talking could not converse at the same time because the channels for transmission and reception were the same. Despite this drawback, it was quite easy to place a call.

Arranging a telephone conversation using the simplex system was straightforward. The person making the call would dial an operator. This process consisted of a radio transmission to the nearest receiver. This transmission was delivered over telephone line to the operator and ultimately would reach the person on the receiving end.[6] Given the simple system, there were many improvements to be made.

Between 1948 and 1978, many advancements were made in the telecommunications industry. In 1948, the Richmond Radiotelephone Company introduced the first automatic dial system that removed the necessity of the operator to place calls. In the 1950s, Ericsson introduced the first mobile units in Stockholm, Sweden. These first European systems drained a car's battery and it was not until transistor based systems appeared in the 1960s that battery friendly components could be installed.

Bell Labs introduced the Improved Mobile Telephone System, IMTS, in 1964.[7] This system worked in full duplex, permitted direct dialing, provided automatic channel selection and reduced call bandwidth to 25-30 kHz. By 1969, Bell Labs had implemented frequency reuse so that a mobile phone user could carry on a conversation while traveling great distances by connecting with different antennas.[8] These developments were the groundwork for the system that exists today.

The first national system, Advanced Mobile Phone Service or AMPS, was put into place in North America in 1978. This system officially coined the term "cell" because of the shape of its coverage. The cells were honeycomb shaped areas, where each point of the honeycomb is an antenna.[9] This new network worked in the 800 MHz band.[10] Systems emerged all over the world, and it was at this time that Europe made great strides in mobile communications.

Europe initially consisted of a conglomerate of phone systems. In 1981, the Nordic Mobile Telephone System, NMT450, was put into use in the Nordic area working at a 450 MHz frequency. In 1985,

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4 http://www.privateline.com/PCS/history.htm

5 *ibid.*

6 *ibid.*

7 *ibid.*

8 *ibid.*

9 http://www.privateline.com/PCS/HowPCSworks.htm

10 http://www.privateline.com/PCS/history.htm

Great Britain started using the Total Access Communications System, TACS, which operated at 900 MHz. Soon, C-Netz from West Germany, Radiocom 2000 from France, and the Italia RTMI/RTMS were put into operation. The problem was that none of these networks were compatible with each other. In the mid-1980s, Europe was looking into a completely compatible, unified system.[11]

Groupe Speciale Mobile, GSM, is Europe's fully digital system developed in the mid-1980s in response to compatibility issues. Today, it is known as the Group System for Mobile Communications, but is still referred to as GSM.[12] It was introduced commercially in 1991, operating at 900 MHz frequencies, and it is a statistical marvel. By October 1998, GSM had one hundred million total users, was gaining five million new users each month, was operational in 120 countries, and 60% of all digital mobile phones produced were GSM.[13] In the early 1990s AMPS in America was running out of capacity and the answer to this problem was a GSM-like system.

Between 1994 and 1997 the Federal Communications Commission in the United States auctioned off new frequencies that are collectively called the PCS band. This band operates at a higher frequency than GSM, 1800 MHz. It has set standards for Time Division Multiple Access, TDMA, and Code Division Multiple Access, CDMA, which are two systems for transmitting digital signals.[14] The advantage of PCS is the fact that it maintains AMPS compatibility. AMPS is considered a first-generation system; PCS and GSM are second-generation systems. Today in Europe there is an effort to create a third generation system; however, AMPS, PCS, and GSM are the current options.[15]

Moving from radiotelephones to small, portable, handheld phones that people can take everywhere is a big technological advance. While the American system is still held in some analog facets and the European system is completely digital, both systems are still making vast improvements.

2.2 Antenna Technology

The information about cellular communications most pertinent to our project is that of the antennas and the equipment that coexists with them at their installed antenna locations. This knowledge was needed to assess the structure of a bell tower and its compatibility with installation requirements. It was also important to address the site requirements for the companies in order to assess locations for needed and preferred characteristics. Understanding these characteristics helped us to evaluate the feasibility of specific bell tower locations.

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11 http://www.privateline.com/PCS/history.htm

12 IEEE Spectrum

13 *ibid.*

14 http://www.privateline.com/PCS/history.htm

15 IEEE Spectrum

2.2.1 Antenna Equipment Requirements

Typical installation sites for the antennas, as defined by and for WIND, a cellular service provider, include roof tops (indoor or outdoor), raw-land, and mini/micro sites. The generic roof top requirement is defined as, "…a building or an existing structure where the antennas can be installed and a room (inside the building itself), a terrace, or a shelter could be used in order to place radio equipment."[16] For an indoor roof top installation, two sites are possible: a room or a shelter. In both of these cases the supplier must evaluate the structure for load bearing capacity of the equipment. Also, if space inside is not available, the recommendation is to install the equipment outdoors unless a suitable shelter can be made without slowing the process to get a permit.[17]

The typical roof top room and shelter requirements for radio equipment are as follows. For indoor installation, the width of the room must be at least 2.5 m, the length 3 m, and the height must be greater than 2.5 m. The typical pieces of equipment that require a room or shelter of this size are three Base Transmission System (BTS) cabinets, a power supply rectifier that can handle 220 volts AC and 48 volts CC, batteries with lives of two, four, or eight hours, transmission equipment, air conditioning units, control rack, alarm, and distribution box.[18]

An outdoor roof top installation has requirements different from those of the indoor. An outdoor installation is typical if there is no suitable room or shelter available for the equipment. The BTS cabinets must be rated as "all climate" for this. The minimum space for this is a width of 6.0 m, a depth of 1.0 m, and a height of 1.8 m.[19] These measurements take into account a clearance area in front of the cabinets and a free air space behind the cabinets. Also taken into consideration is the space needed for the transmission equipment and the cable trays.[20]

There are two typical set-ups for a raw-land installation. The first is a pole with a shelter and the second is a pole with outdoor equipment. For a pole with a shelter the requirements are the same as those for a sheltered roof top installation. The outdoor installation requires it to be waterproofed and an investigation must be carried out as to a base for the equipment.[21]

A mini/micro antenna site is an antenna mounted below a rooftop or about five to seven meters above the ground. These antennas have purposes different than those of rooftop or raw-land antennas. Typically, a BTS with an integrated antenna is mounted with LOS (line of sight) of the coverage area. Often, the integrated antennas are placed in big stores, fairs, main streets and other such places, mostly indoor. The

[16] WIND Site Requirements
[17] *ibid.*
[18] *ibid.*
[19] *ibid.*
[20] *ibid.*
[21] *ibid.*

external antenna is usually used for small open areas such as squares or busy streets and is usually mounted on shop signs, street lights, or wall mounted.[22]

The actual configuration of the mini/micro antennas can be indoor or outdoor. The outdoor does not have the antenna integrated into the BTS and is usually allocated on a streetlight or balcony while the indoor would be an integrated antenna in the BTS. The dimensions of the BTS with a non-integrated/integrated antenna are a height of 500/600 mm, a width of 400/500 mm, a depth of 160/220 mm, and a weight of 25/35 kg. Also taken into consideration at these sites is the possibility of multiple antennas.[23]

2.2.2 Antenna Requirements

The actual antennas at each installation site have their own specifications which are also divided into roof top, raw land, and mini/micro installations. For a standard roof top installation the requirements are as follows:[24]

- The standard site is composed of three sectors with orientations of 0°-120°-240°
- The standard cable is forty meters long
- The total oscillation of the structure at the top is about one degree
- The antenna must be mounted with a down-tilt kit which allows vertical rotation
- The length of the mast has to be chosen to guarantee the ability to change antennas in the future
- The standard antenna for GSM 900 MHz is 1.3-1.9 m in length

A raw-land installation also has standard antenna requirements for the antenna mounting. They are as follows:[25]

- The standard pole is 25 meters with three sectors (three arms with six or nine antennas), one or two parabola
- The length of the mast must guarantee the ability to change antennas in the future
- Typical parabolic antenna diameters are 60, 100, or 200 cm
- The standard number of antennas on an arm is two with the possibility of three
- The arms must be able to turn 0°-360° in the horizontal plane and -15° to + 15° in the vertical plane
- The distance between antennas on the arms must be three meters for DCS 1800 MHz and five meters for GSM 900 MHz

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22 WIND Site Requirements

23 *ibid.*

24 *ibid.*

25 *ibid.*

2.2.3 Antenna Types

In broader terms, there are two types of antennas, omni-directional and directional. Omni-directional antennas can transmit signals with 360 degrees of freedom. The problem with this is that due to the physics of the transmission, there is a cone of empty signal space at the top and bottom of these antennas. The strength of omni-directional antennas lies in the horizontal plane that contains 360 degrees of freedom. However, in the vertical plane, these same antennas have less than 180 degrees of freedom. In the past, omni-directional towers were widely used, but now their use has faded because of the benefits of directional antennas.

Directional antennas, as seen in Figure 1, transmit signals in specific directions. Depending on their configuration, three or six directional antennas on a pole, they have 120 degrees of freedom or 60, respectively per antenna. The benefits of a directional antenna are that it does not waste signal energy transmitting in a direction that is not needed and there is no cone of vacant transmissions at the top or bottom. It is important to realize that the antennas used can serve for both analog and digital, but the same antennas do not handle AMPS, PCS, and GSM.

Figure 1 Three-panel directional antenna

2.2.4 Miscellaneous Antenna Information

In an interview with Ericsson representatives, we gained insight on the general desires of cellular providers regarding antenna installations. To begin with, most companies desire an antenna height of twenty-five to thirty meters. For this reason, extremely tall buildings and extremely short buildings are not usually used for antennas. Also, there are hundreds of different types of antennas with different propagation properties. However, if any of these antennas are cornered on the inside of a building there will be extreme signal loss. We also learned that different systems have different transmission radii. GSM and TACS have a radius of 800-900 m and DCS and UMTS have a radius of 500 m.

One reason for the amount of antennas in Venice, and any other area with high concentrations of cellular phones, is for capacity. Each antenna can only handle a finite number of conversations. Because of this none of the antennas used actually reach their potential transmission radius. By placing more antennas with shorter transmission radii, the cellular companies increase their capacity for handling phone calls. Also, geography and building density affect how many antennas a company will use. Buildings obstruct the signals that are transmitted by the antennas. While the antenna characteristics are most important to our project cellular technology in general will provide insight into the big picture.

2.3 Cellular Technology

Communications in general, and cellular technology specifically, is a very complicated subject. Whether systems are analog or digital, or if a system is AMPS, PCS, or GSM, and how the actual transmissions work is relevant to our pursuit. This will help us understand the significance of the different cellular frequencies and methods of transmission. Also we will know how much we have to take into consideration when assessing bell towers as locations for antennas.

Analog and digital technologies are very different methods of transmitting information. The main difference is that analog information occupies more space than digital information. The purpose of using digital technology is to increase capacity on the frequencies that are used in cell phones.[26] With an analog signal, one can only transmit a single source of information at a particular frequency. For example, if a mobile device transmits an analog signal at 1800 MHz, then there is no other information that can be sent at that frequency without distorting the signals and making them unrecognizable at the other end of the transmission.[27] However, there are two ways to send digital information; one is Time Division Multiple Access, TDMA, and the other is Code Division Multiple Access, or CDMA.

With TDMA, many signals are sampled at discrete points, thousands of times a second. A TDMA transmission at 1800 MHz could contain the information of three conversations. By sampling each conversation successively, the transmission is cycling through the three signals at different times.[28] Sampling is the method by which a signal is measured at distinct points. At the receiver end of the TDMA signal is a converter that pieces the three conversations back together based on time stamps. Time stamps are binary codes attached to the signal to specify the point in time at which the sampling occurred. CDMA also uses binary codes, but not as binary time stamps, to digitize information.[29]

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[26] Cellular Defined. 27 Mar. 2000, Farley, Tom, http://www.privateline.com/Frequencies.htm

[27] http://www.privateline.com/PCS/Frequencies.htm

[28] Cellular Defined. 27 Mar. 2000, Farley, Tom, http://www.privateline.com/PCS/Multiplexing.htm

[29] *ibid.*

With CDMA technology the conversations are not sampled as in TDMA, but it still handles three conversations on the same frequency using binary keys. The three conversations are digitized into packets where each packet receives a key and are all sent through the 1800 MHz frequency. Instead of using time measurements to realize which pieces of information go together, the information keys of the packets are used to piece the conversation together.[30] Regardless of how the data is sent, be it analog, TDMA, or CDMA, the same antennas handle the information.

There are three basic types of cellular frequencies. AMPS, or Advanced Mobile Phone Service, are the traditional cellular frequencies that start at 824 MHz and end at 894 MHz. PCS, Personal Communication System, runs in the frequencies between 901 MHz – 941 MHz, which is called Narrowband, and between 1850 MHz - 1990 MHz, which is called Broadband. GSM, the Group System for Mobile Communications, runs at the frequencies between 890 MHz - 960 MHz.[31] It is the set of frequencies that makes each system unique, mobile phones distinctive, and decides the system of antennas used.

Microwave communications is a technical subject. To simplify, analog and digital are merely two methods of transmitting. Whether a phone is AMPS, PCS, or GSM compatible simply indicates the frequencies a phone will use as well as the system of antennas. Also, the antennas will receive information regardless of whether it is analog or digital. Though microwave frequencies simplify life through communication, the radiation emissions by these frequencies provoke health concerns.

2.4 Health Risks

We live in an environment of radiation that is produced by nature, man-made machines, as well as our own bodies. There are many types of radiation sources such as visible light, ultraviolet rays from the sun, the infrared rays of heat lamps, microwaves (which includes cell phone radiation), radio waves, and ionizing radiation.[32] These all contribute to an atmosphere of radiation that, in significant amounts, is known as electromagnetic smog. As stated by the *Settore Sicurezza del Territorio* the man-made radiation within this invisible smog is additive, thus resulting in high numbers of microtesla (radiation measurements) in certain areas of Venice. Due to this increase, the “smog” that is correlated with multiple health pathologies such as cancers, Alzheimers, psychological and behavioral disturbances, birth defects, and more creates concern.

Of importance in this report is cellular phone and base station antenna radiation. This radiation is similar to that of microwave radiation, and therefore poses potential health risks on the general public. The non-ionizing radiation of cellular phones has been studied in regards to many health problems by a diverse assortment of experiments. In spite of these experiments, no significant evidence has been found attributing RF (radio frequency) radiation from cellular phones and antennas to these health problems.

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30 http://www.privateline.com/PCS/Multiplexing.htm

31 http://www.privateline.com/PCS/Frequencies.htm

32 National Institute of Health Fact Sheet: What We Know About Radiation. 28 Mar. 2000. http://www.nih.gov/health/chip/od/radiation/

2.4.1 Non-ionizing Radiation

Unfortunately, with the increased exposure to man-made radiation, health risks have become a pertinent question. Within this pool of man-made radiation is that from cellular phones and their base stations, which have become increasingly important in today's world. It has been reported that 60% of the radiation emitted by the cellular phone during use is absorbed into an individual's head.[33] It is misconceived by most people that the radiation is emitted from the antenna on the phone, instead its epicenter is in the center of the phone as shown in Figure 2.[34]

Figure 2 The intensity and location of radiation emitted from a cellular phone

These frequencies can be better understood in comparison to frequencies of other common radiation sources. Some examples of other sources are: the AM radio frequency at about 1 MHz, the FM radio at 100 MHz, microwave radiation at about 2450 MHz, and X-rays (ionizing radiation) at one million MHz.[35] Cellular phones and antennas produce a non-ionizing radiation that occurs at the frequency of 824-1990 MHz.[36] The frequency of GSM phones occurs in the range of 890-960 MHz.[37] As one can see, the frequency of the ionizing radiation (such as X-rays) in comparison to the radiation of cell phones and their base station is significantly stronger. Therefore, realizing that with higher frequency comes more damage, it is easy to understand that the radiation energy of ionizing sources is much more detrimental to humans than that emitted from cellular sources. Figure 3 is taken from a review written by John E. Moulder, of Radiation

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33 Rose, Angie. *Studies Dismiss Cell Phone Health Risks.* Jun 1999

34 http://www.lessemf.com/cellphon.html.

35 Moulder, J. E., *et al.* "Cell Phones and Cancer: What Is the Evidence for a Connection?" Radiation Research 151 (1999): pp. 5-6.

36 *ibid*

37 *ibid.*, p. 5-6

Oncology at Medical College of Wisconsin, on cellular phones in correlation with human health.[38] From this figure, it is easier to comprehend where the cellular communications frequencies fit in with respect to radio, microwaves, x-rays, and power lines. As one can see, it is in range with the radio and microwave frequencies but far below x-rays. The figure also gives an accurate depiction of the difference between ionization radiation and non-ionizing radiation.

Ionizing radiation is so powerful that it has genotoxic effects, meaning that it can actually break chemical bonds, such as those in DNA. The non-ionizing energy of cellular phones and their antennas is not as potent, yet still worries both scientists and the general public. Countless studies have been done to expose the health risks involved in the use of cellular phones, as well as the risks of living, playing, working, or going to school near the antennas. There are accusations that the radiation emitted by cellular telephones and their antennas is linked to health pathologies such as: various forms of cancers, birth defects, miscarriages, interference with pacemakers and other hospital equipment, behavioral and physiological changes, decrease in

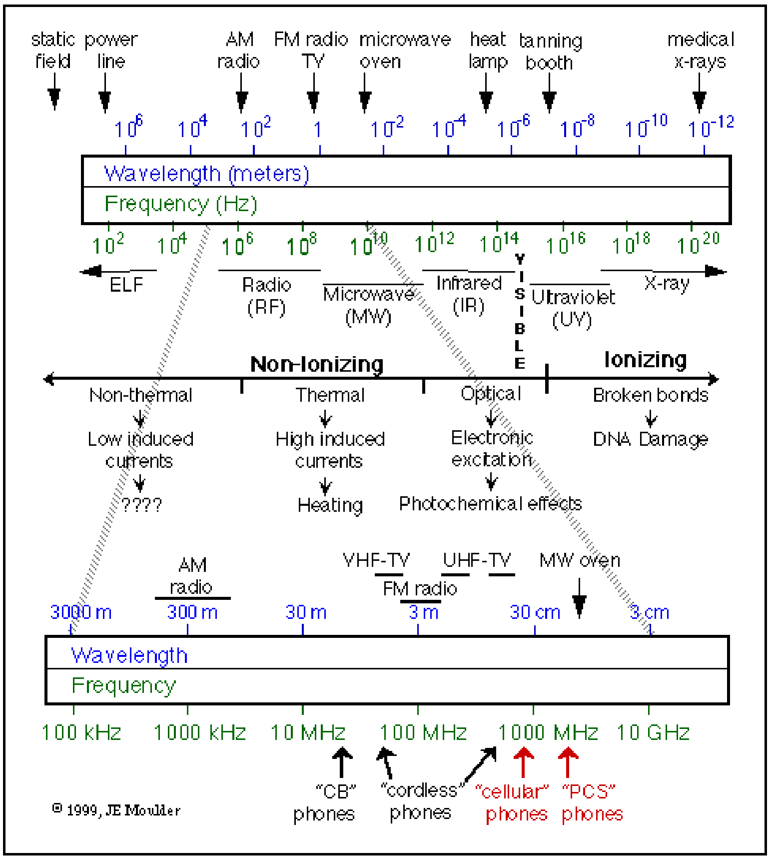

Figure 3 Electromagnetic spectrum

[38] Moulder, p. 11

reaction times, and headaches. Studies have been done in terms of the biology, physics and epidemiology of this RF (radio frequency) radiation all over the world in attempt to see if these health problems can be attributed to cellular radiation.

2.4.2 Health Studies

In 1996, Australian studies by Hocking and colleagues, published in the Medical Journal of Australia, claimed that they had significant evidence that living near TV broadcast towers caused an increase in childhood leukemia. However, their study was based only on a single metropolitan area, and their data was calculated as opposed to being measured which introduces error. Follow up studies in Australia as well as the UK opposed this claim. The studies in the UK found no evidence leading to a connection with cancer. Also in contradiction to this study, McKenzie and colleagues published in the Australian and New Zealand Journal of Public Health, a study that looked at the same area in the same time period. They made more precise measurements of the radiation that people were exposed to in the various areas. They did find increased childhood leukemia in one area, but not in similar areas near the antennas.[39] In a review done by the International Commission of Non-Ionizing Radiation Protection (ICNIRP), it was found that all but five out of thirteen studies done on the correlation of childhood leukemia and power lines came up with reported risk estimates.[40] As one can see there are various findings. But there is not enough scientific evidence to make a cancer correlation.

In a 1995 article done by an Israeli epidemiologist, Goldsmith, a correlation between low-level radiation (such as cellular), mutations, birth defects, and cancer was proposed.[41] However, even the author admits that his review is based on "non-peer-reviewed sources" and that it has a bias.

Other exemplary studies are by: Braune, *et al*, who proposes that the use of cell phones raise blood pressure[42], or Mann and Roschke who intended to prove that exposure to mobile phone signals could affect sleeping patterns.[43] Wang and Lai studied how rats exposed to a radiation showed defects in long-term memory.[44] All of these studies are scattered and use a wide range of experimental models and parameters. None of the experimental evidence has been replicated enough to have an impact in the scientific community. In addition, most of them have been criticized and contradicted. For example, the ICNRP reported that all

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39 Hocking, , B. *et al*: "Cancer incidence and mortality and proximity to TV towers." Med J Austral. 165: 601-605, 1996

40 ICNRP Guidelines. "Guidelines for Limiting Exposure to Time-varying Electric, Magnetic, and Electromagnetic Fields". 494-526, 1998.

41 Goldsmith, JR. "Epidemiologic evidence of radiofrequency (microwave) effects on health in military, broadcasting and occupational studies". International Journal of Occupational and Environmental Health 1: 47-57, 1995.

42 Braune, *et al*, (from Moulder's review)

43 Mann and Roeschke, (from Moulder's review)

44 Wang and Lai, (from Moulder's review)

of these studies, as well as others, were done under poor exposure conditions, and had deficiencies in their methodologies.[45]

Moulder, *et al*, describes this indecisiveness in his review involving the multiple studies that have been done on RF radiation in terms of biophysics, epidemiology, and laboratory studies. In terms of his biophysical evaluation he found that the expectation of the thermal properties of frequencies used by the current generation of cell phones causes biological activity is implausible. He shows that the current epidemiology studies do not suggest an association between cancer and RF radiation, and are also few in number and are subject to deficiencies in experimental parameters such as exposure assessment. He claims that cellular studies have been chiefly limited to genotoxicity studies, (which is the study of the RF radiation effects on human DNA, Lymophocytes, etc). In his review of studies by Hai and Singh, Bernhardt, *et al*, Mae, *et al*, and William, *et al* on the subject, he found that though some of them suggest the possibility of genotoxicity, a majority of the evidence advocates that RF radiation is not genotoxic. Also, he found that studies done on long-term exposure of animals present no persuasive evidence suggesting a negative effect on health in general or that RF radiation is genotoxic in animals.[46] His overall conclusion was that the cancer-RF radiation correlation was weak as suggested by the following table:[47]

Criteria	Current State of Evidence
Amount and quality of epidemiological evidence	Limited data of poor to fair overall quality
Strength of association in the epidemiology	None to weak – relative risks of 0.6-2.5
Consistency of epidemiology	Studies show no consistent associations between exposure and any specific types of cancer; and consistently show no association between exposure and overall cancer
Exposure response relationship	Even studies which show an association show little or no evidence for an exposure response relationship
Amount of laboratory evidence relevant to assessment of genetoxicity	Extensive genotoxicity studies in cell culture, but only limited whole-animal exposure studies
Strength of laboratory evidence for genotoxicity	Cellular studies strongly unsupportive, animal studies moderately unsupportive
Amount of laboratory evidence relevant to assessment of epigenetic activity	Few relevant cellular studies, some animal studies
Strength of laboratory evidence for epigenetic activity	Some unreplicated evidence for epigenetic activity at high (possibly thermal) exposure levels
Coherence with the physics of RF radiation	Significant biological effects are implausible at the sub-thermal power levels
Overall	Nothing in the epidemiology, biology or biophysics suggests an association; but few standard long-term animal exposure studies, and no strong epidemiology

Table 1 Moulder's "Weight of Evidence Criteria for RF Radiation and Cancer"

45 ICNIRP Guidelines, p. 496

46 Moulder *et al*, p. 529

47 Ibid

Moulder's expert opinion on the subject seems to agree with that of the ICNIRP, that there is no conclusive evidence to connect low or high levels of radiation with multiple diseases. However, even with Moulder's extensive analysis of why these studies can not be scientific fact, related health concerns cannot be dismissed. Both the ICNIRP and Moulder agree that caution should still be taken.

In America, these findings have been reported to the general public as fact. Though these reports are aimed to alert people of dangers, they do not include that their findings are based on experiments that have not been replicated enough to have any scientific backing. In addition to the lack of replication, they are based on testing of animals that can not be adequately compared to humans until many studies have been done ending with the same results. Also, the experimental parameters do not accurately represent a person's everyday exposure or the distances at which they are exposed.

The only studies that had conclusive evidence were that of the effects of cellular phones and antennas on pacemakers, as well as psychological trauma. There is no evidence that cellular phones or base station antennas will interfere with cardiac pacemakers. Studies by DL Hayes, *et al*, supported the fact that the only way for pacemakers to be negatively affected is if a pacemaker is placed directly over the antenna. In regards to the psychological trauma, the placement of the base station antennas near peoples' houses can cause them to feel that they are sick and become hypochondriacs. In Poalo Vecchio's review, he writes of such a psychosomatic disease citing evidence from renowned scientists McMahan and Meyer (1996).[48] In his article, he describes how many doctors try to treat patients who complain of multiple illnesses. However, when they run tests on these people they find that nothing is wrong. The one thing they all have in common though is that they live near, as well as fear, antenna base stations. Though this seems trivial, it is still a common psychological disease.

2.5 Health Precautions

Although there is no concrete evidence of health risks in regards to cellular phones and base stations, there is also no evidence that rules them out as possible contributors. Scientists still alert the general public to take the proper precautions. The cellular consumer can purchase products for their phones to prevent the effects of radiation on themselves. Such products are the Radiation Phone Shield (Figure 4), or a Cellular Hands-Free Ear Mic. (Figure 5). The Phone Radiation Shield can be purchased for any type of phone (GSM, PCS, etc), and is said to be able to deflect up to 99.9% of the radiation emitted by the ear piece of the mobile phone.

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[48] Vecchio, Paolo. "Campi Elettromagnetici Ad Alta Frequenza: Problemi Sanitari e Percezione Dei Rischi". 86, n.4: 4/99;33-46.
Vecchia, Paolo. "Campi Elettromagnetici Ad Alta Frequenza: Problemi Sanitari e Percezione Dei Rischi". 86:4, April 1999, 33-42.

Figure 4 The Phone Radiation Shield

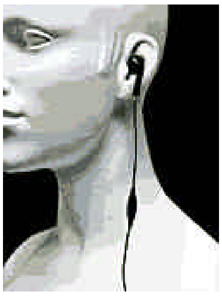

Figure 5 Cellular Hands-Free Ear Mic

With regards to the base station antennas, as a health precaution, they need to be placed where there will be limited exposure to people. Unfortunately, to achieve desired coverage, providers need to place them close to residential areas. There have been multiple court cases and Acts declared by local governments in retaliation to these antennas. As soon as there is a proposal of an antenna placement, residents in the neighborhood become irritated. One example of a citizen taking action was noted in the *Detroit News* when Joseph Pasjek became outraged by the talk of an antenna placement in his neighborhood.[49] With the support of the local city government, the citizens were working on a proposal for the cellular providers to pay for a radiation monitor. The citizens felt that it was unfair that the providers monitored themselves. Due to the fact that they could not stop the antenna from being placed in their neighborhood, they felt that they should be able to monitor the base stations to see how accurate and honest the cellular providers really were.

In addition to being concerned with health risks, people also have concerns with close-by antennas lowering their property value, and damaging the aesthetics of the tower facilities.[50] It is the aesthetics, as well as the health concerns that are the motivation for this project. However, in order to move these antennas, we one must recognize the rules and regulations involved.

2.6 Legislation in Europe

It was evident that, towards the end of the last century, the European Community has been working in the direction of consolidating a European Union (EU). This means that the members of the European community are not only partners, but are also merging economically and politically. The member States of

[49] Fracassa, Hawke. *Detroit News.* "Rests Safety Concerns Rise With Jump in Warren Cell Phone Towers". Macomb County.

this organization are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. Along with uniting their economy through the creation of the new standard European currency, they have thrived to set a basis in the legislative field. To accomplish this, legislative committees were formed to draft proposals on different subjects.

As with any issue facing the Council, a Commission drafts a proposal to present the central body of the EU, who is dealing with the problem. Upon the acceptance of this proposal by the members, it is then distributed to the Member States as a list of recommendations. In 1998, with the subject of electromagnetic pollution, the Commission offered a Proposal for a Council Recommendation: on the limitation of exposure of the general public to electromagnetic fields 0 Hz-300 GHz. In this document, the Commission suggests that measures must be taken for the prevention of exposure to, and education of, the general public in the matter of electromagnetic pollution. It states that the European Parliament (EP) will "[combat and] limit the exposure of workers and the public to non-ionizing electromagnetic radiation".[51] To accomplish this, the following steps are to be taken. First, companies shall "asses activities which involve exposure to non-ionizing radiation," and come up with measurements to protect their employees from this radiation.[52] Also, it is "imperative to protect members of the general public in the Community against established adverse health effects" connected to electromagnetic exposure.[53] Along with this, the Community will attempt to create a standard framework for the Member States to work within their regulations. To achieve this, the Community will propose to the Member States several restrictions and reference levels that the Community has found acceptable through the advice of competent organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP). If the Member States follow these guidelines they will be provided with a "high level of protection" in accordance to recent research.[54]

The Member States will be expected to comply with these regulations and restrictions, and to individually take enforcement measures. The Member States are also responsible for the education of the citizens of the Community on the dangers and hazards of electromagnetic pollution consistent with the findings of organizations such as the ICNIRP. Finally, when the Member States have complied with these regulations, after a period of three years from the realization of this proposal, they have to "prepare reports on the adoption and implementation of measures" in response to the recommendations made by the Commission.[55]

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50 http://www.law.berkeley.edu/journals/btlj/articles/12_2/Martin/html/text.html

51 Proposal For A Council Recommendation (1998), pg.16

52 *ibid.*

53 *ibid.*

54 *ibid.*

55 *ibid.*, pg. 20

Italy has been a pioneer in this field, and has already started the process of implementation of the recommendations presented by the Commission. As a matter of fact, due to the large number of mobile phone users in the country some regions made their legislation previous to the document drafted by the EU.

2.7 Legislation in Italy

As mentioned above, the topic of electromagnetic pollution is becoming increasingly important to Europe and the world. Countries such as Italy have pioneered in their efforts to prevent the general population of their countries from suffering any of the hazards that are possibly associated with electromagnetic signal propagation.

In Italy a decree was passed through the *Ministero dell' Ambiente* (Department of the Environment) called the *Regolamento recante norme per la determinazione dei tetti di radiofrequenza compatibili con la salute umana* (Regulations on the determination of limits for radio frequencies compatible to human health). This decree, number 381, passed September 10, 1998, is the blueprint for region specific laws and regulations. The contents of the mandate will be discussed further on in this section. In synthesis, the law states that companies that desire to install cellular antennas must comply with some other regulations. In addition to building and construction regulations, the companies must thoroughly study the law and the equipment response behavior in order to maintain their signal transmission within a 100 kHz to 300 GHz and a 6 V/m electromagnetic field. This 6 V/m range is recommended because it exposes the population to the least amount of radiation possible.[56] In addition to offering the basic scientific concepts behind cellular technology, the decree also places most of the authority in law enforcement and specifics on each of the regions.

Venice is a *Comune* within the region called Veneto. The region of Veneto created a *Legge Regionale* (Regional Law) about this matter in 1993. The title of the law, "*Tutela Igienico Sanitaria della Populazione dalla esposizione a radazioni non ionizzanti generate da impianti per Teleradiocomunicazion*" (Sanitary-hygenic tutelage to the population on the exposure to non-ionizing radiation generated by Teleradiocommunication installations), demonstrated the electromagnetic risks involved. This law is meant to set the standards for control over the companies that put up the cellular antennas. To do this, a special committee is made in order to study what each provider is doing and to analyze how their equipment works in order to comply with the frequencies mentioned above. This document also comments on the actions that need to be taken in order to properly and legitimately examine a company's installations; as well as the companies' duties to renovate their networks within an allotted period of time.

From the telecommunications regulations came three specific laws that are now found in the *Regolamento Edilizio* (building codes), Article 80, of Venice. The first law states that a cellular antenna on a freestanding tower cannot be within ten meters of an inhabited building in the horizontal plane. This is a law that takes into consideration health concerns and protects residents from electromagnetic radiation and is based on a decree passed through the *Ministero dell' Ambiente*, which states that no person can be exposed to an electromagnetic field of more than 6 V/m. The second law also takes into consideration health and says that within fifty meters of the antenna there can be no inhabited building taller than it. The third states that an antenna installed on top of a building cannot, itself, be more than ten meters high.[57]

In 1998 and 1999, there were regional follow-ups to the national law. This document contains the specifications of where and how the antennas are meant to be located. Also, these documents stipulate the steps needed to research the design and make sure that the regulations are being met. There are many committees that help set the standards of technology. If these tasks are not completed within the allotted time, the regional government has the right to put pressure on the companies to comply with the law and eventually, if the company does not change, the regional government has the right to seize its equipment.

These regional laws and follow-ups stand on certain basic principles created for the consumer and population benefit. The three main principles are the following: *principio di minimizzazione* (principle of minimization), *principio di giustificazione* (principle of justification), and *principio di ottimizzazione* (principle of optimization).[58] The first principle, that of *minimizzazione*, states that people in laboratory and the general public must be exposed to the minimal amount of pollutants as possible (here electromagnetic radiation is the pollutant.) In this case the minimum frequency in the electromagnetic field is in a range from 100 kHz to 300 GHz.[59]

The principal of justification states that if it is found, through arbitration, that a lab worker or an individual has to be exposed to radiation greater than that stipulated before, then such radiation in minimal amounts may be used. These kinds of justifications are mostly given exclusively to lab workers, provided that extra security measures are taken.[60]

The third and last principle, the principle of optimization, states that in planning the placement of the antennas and setting their frequencies, companies may modify their frequencies within the range in order to optimize the service. This principle may be broken down into two principles: As Low as Technologically Achievable, ALATA, and As Low as Reasonably Achievable, ALARA. The principle of ALATA states that companies are to strive to offer a design in the lowest radiation rates as possible with the technology offered in the market. This principle is to be applied for the minimization of exposure of radiation. ALARA, is a principle that states that through arbitration the companies must demonstrate that the use of too low of a frequency is out of the question due to detriment in service. This principle, and that of justification go hand in hand. All the previously mentioned principles are sub-divisions of a general principle called *principio di*

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56 Regolamento recante norme per la determinizaione dei tetti de radiofrequenza compatibili con la salute umana. (1998)
57 *Regolamento Edilizio*
58 Parere in ordine alla applicazione del Principio di Minimizzazione delle Esposizioni ai campi elettromagnetici in area urbana (1998)
59 *ibid.*, pg. 2
60 *ibid.*, pg. *3*

cautela,, principle of caution, which states that human well-being supercedes all other principles in order to prevent possible problems.[61]

It is interesting to see that in the United States these laws are looked at under a different light. From studying the Telecommunications Act of 1996 (TAC) it is apparent that special care is given to ensure the companies right to provide cellular services and therefore protecting the consumers right to this service. In the following section both the opinions of people and the counter opinions of the US Telecommunications Act will be analyzed, to offer a more global perspective on this issue.

2.8 The US and Italy

In 1996, the Congress of the United States passed a bill, the Telecommunications Act of 1996, pertaining to the various aspects of telecommunications. Issues such as cable television usage and distribution were among the subjects talked about. The topic regarding cellular antennas was also a subject treated in the previously mentioned act. This law is drafted with a true consumer aim, looking to ensure the American public right to have cellular telecommunication devices and the best service possible.

Clearly, the act shows that state and local governments have the right to accept or decline petitions by companies to place cellular antennas within that institution's legislative boundaries. It is virtually the same in Italy where this study will be carried out. The process is simple, yet can be very controversial at times. Each company that desires to place an antenna, either on a building or a specialized tower, must write a petition along with a detailed study of the locations where they want to place their antennas. This petition is then presented to the municipal government, city council or planning board.

At the city council, two facets of the petition are reviewed. One aspect in the process is to make sure that the building or installation of these antennas does not conflict with any building and construction regulations. Also, the petition must satisfy the urban design codes, which are intended to ensure that a building or addition does not interfere or conflict with the urban design of the location in question. Urban design covers aspects including aesthetics and functionality.

In the case of Italy, and Europe in general, the aesthetics are taken much more seriously due to the fact that the different architectures of the cities are remains of significant episodes of history of the western world. In Italy, after or during the process, the petition must also be presented to the department of ecology of the city. The department of ecology in Italy serves as an institution to foresee the possible effects of the antennas on the environment, particularly their effects on people. They are the organization that provides regulations on the exposure to radiation.

In the United States, the latter step is not pertinent. It is up to the local government to refute the petition by offering the federal government substantial evidence proving that the placement of the antennas would be detrimental to the aesthetics and urban design of the zone where the antenna is located. The

[61] Parere in ordine alla applicazione del Principio di Minimizzazione delle Esposizioni ai campi elettromagnetici in area urbana (1998)

Telecommunication Act of 1996 states that if the local government denies the company a permit to place the antennas due to alleged health hazards, the company has the right to appeal the decision to a Federal court. The companies will more than likely win the trial in response to 47 U.S.C. §332(c)(7)(B)(iv). This sections says: "No State or local government… may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such regulations." In other words, the local government is limited to the extent that they can protect their community from possible health risks.

For Italy, and the rest of the European community, the importance lies on the health risks to which the citizens may be exposed to by the antennas. The Telecommunications Act of 1996 places a strong emphasis on offering the customer the best service possible, and health concerns fall into second place. Also, through the drafting of the Act it appears that the Federal Government places pressure on local government to allow the installation of antennas, rather than asking the companies to ensure the community that all possible aspects involved in placing an antenna have been taken into account.

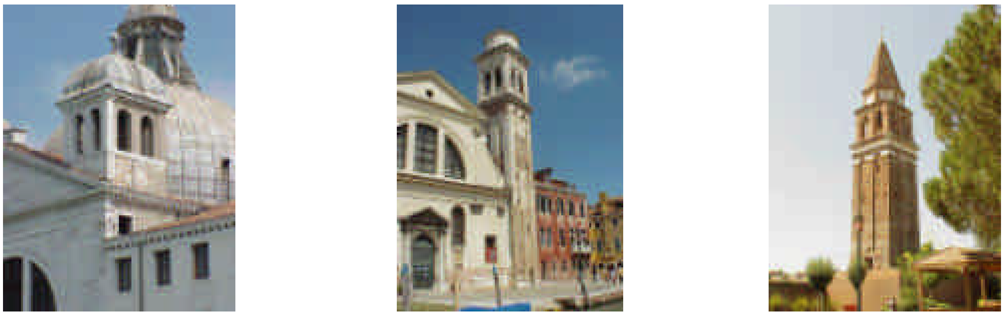
In Italy, the regional government has much more room to make their decisions because their objective is to guarantee their citizens well being. This is why placing the antennas in or on the bell towers appears to be an alternative in antenna positioning. In this way, every aspect of the issue is viewed: maintenance of cellular service and reduction of possible health hazards, while still abiding by the regulations and laws involved in this issue.

2.9 Bell Tower Structure

In addition to understanding the technology of antennas and cell phones, the health concerns involved, and the laws, we must also understand bell tower structure for our project. Its components as well as its various shapes and dimensions need to be analyzed to determine whether or not it is possible to place antennas within them. The Italian term for bell tower is campanile, coined from the Venetian term for bell,

(a) (b)

Figure 6 An archway (a), and a belfry (b) *campana*. Bell towers can either be freestanding structures or attached to a church. There are two variations of the structures that house the bells: a sole belfry placed directly on top of the church or a simple unsheltered archway. Examples of these can be seen in Figure 6. In terms of towers, there are three types: a tower without a base that protrudes from the roof of a church (Figure 7a), a tower that has a visible base and is connected to the church (Figure 7b), and finally a tower that is independent of any other structure (Figure 7c). We will be considering all of the aforementioned types of bell towers except for those that are merely an archway.



(a) (b) (c)

Figure 7 A bell tower protruding from the roof of a church (a), a bell tower attached at a side to a church (b), and a bell tower independent of other structures (c)

There are four main components to the *campanile*: the base, intermediate chamber and ringing chamber (shaft), the belfry, and the spire as can be seen in Figure 8. The most important component to this project is the belfry. The belfry is both functionally and aesthetically the best place for a cellular antenna. It is the section at the top where the bell is placed. Each belfry has a range of one to three openings on every side allowing the bell to be visible to the public. The main structural objective of the belfry is to optimize the

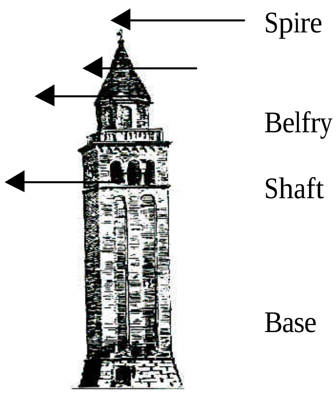


Figure 8 Campanile di San Polo

sounds of the bell. Therefore, there must be careful consideration of the material and construction of the belfry. The material must be waterproof and the openings may be covered with netting to protect the bells from corroding.[62]

The shaft is the "tower" part of the *campanile*. It is comprised of two sections - the intermediate and ringing chambers. The intermediate chamber is designed to enhance the bell ringer's ability to produce sound. The chamber captures the sounds of the bells allowing the ringer to hear the melody of the bells. Also, if the bell tower has a clock, the mechanical parts of the clock are placed in the chamber. The ringing chamber was so named because it is the actual area where the act of ringing the bells takes place.[63]

2.10 Bell Tower History

The bell towers of Venice are landmarks for the locations of the churches. They are representative of the community and its history. Therefore, it is important to understand their significance when working with them. In many ways, the *campanili* represent Christianity. Even today, they hold the original bells used to announce religious rituals and Venetian celebrations. Throughout Venice's history, there were many engagements in battle. In these times the *campanili* were used as look out points. Most importantly, the bell towers depict the architectural history of Venice. The architectural design of the *campanili* varies with the styles of the times showing the changing trends in architecture throughout history. There are seven periods that depict the ideas of the times: Romanesque, Byzantine, Gothic, Renaissance, Mannerism, Baroque and Neo-classicism.[64]

Figure 9 Campanile di San Giacomo dell' Orio

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62 A Method for the Evaluation of Venetian Bells and Bell Towers p. 15

63 *ibid.*, 19

The Romanesque style emerged in the seventh century. It is a mimesis from the Roman style that spread throughout Europe. During the Romanesque period of art, emphasis was placed upon building large brick structures with limited window openings and little decoration. This style of architecture only began to thrive in Venetian culture at the end of its popularity in the rest of Europe. Today, many of the *campanili* representative of this period are no longer in existence. Either their structure has deteriorated or they were rebuilt and represent another style. The *campanile* of *San Giacomo dell' Orio* represents this style (Figure 9). [65]

The Byzantine style of architecture surfaced from the Roman Empire in the eighth century and lasted until the twelfth century. This style was very influential in all aspects of Venetian art. In the *campanile*, the architecture can be distinguishable by its low roofs, large belfry openings, and an overall tall structure. This can be seen in Figure 10.[66]

Figure 10 Campanile di Santa Maria Assunta di Torcello

The Gothic style originated in Northern France. At the end of the Romanesque era the Mendicant orders brought the Gothic style to the Venetians. It became popular during the fourteenth and fifteenth centuries. The Venetian style was a mix of Mediterranean and European Gothic elements. Gothic architecture had to be modified by the Venetians because their terrain could not house the elaborate, heavy buildings of the European Gothic. This style is characterized by its strong presence of color and light, use of delicate materials, vertical elements, and flying buttresses. A beautiful representation of the Veneto-Byzantine style is the *Campanile di Santa Fosca* (Figure 11).[67]

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64 *ibid.*

65 A Method for the Evaluation of Venetian Bells and Bell Towers p. 25

66 *ibid.*, p. 24

67 *ibid.*, p. 29

Figure 11 Campanile di Santa Fosca

Beginning in Florence in the fifteenth century, the Renaissance was a period of rebirth, emphasizing the ideals of humanism. Its architectural style was based on "the science of proportion" and the relationship of "man-nature". This style is distinguished by the use of marble and stone structures, as well as the use of classical columns of the Doric, Ionic, and Corinthian with semicircular arches for windows and doors. The *Campanile of San Francesco della Vigna* (Figure 12) has a pyramidal top resting on a square base which is representative of Gothic style.[68]

Figure 12 Campanile di Francesco della Vigna

Mannerism is a modification of the Gothic style and is considered to be a refinement of it. The architects Palladio and Sansovino made extensive use of Mannerism. The characteristics of proportion and symmetry were still used, but both artists supplemented it with their own style. Palladio used colonnades, porticos, and facades where as Sansovino used a variety of columns. Although Mannerism is not strongly present in the architectural structure of bell towers, it can be seen at the *Campanile di Santissimo Redentore* (Figure 13), designed by Palladio.[69]

68 A Method for the Evaluation of Venetian Bells and Bell Towers, p. 30
69 *ibid.*, p.31

Figure 13 Campanile di Santissimo Redentore

The Baroque style emerged as a continuation of the freedom of creativity unleashed in the Mannerist era. This was a decorative style using extreme detail and extensive art to decorate the structures. The architecture of early Baroque is similar to Mannerism and it is often hard to distinguish between the two. The Baroque style was most influential during the seventeenth and early eighteenth centuries. *The Campanile di San Moise* and the *Campanili of Santa Maria de Salute* (Figure 14) both depict characteristics of the Baroque era.[70]

Figure 14 Campanile di Santa Maria della Salute

Neo-classicism was a simpler form of architecture in comparison to the strong decorative existence of the Baroque style. It began in the eighteenth century and continued into the middle of the nineteenth century. Its name means new classic style, literally a rebirth in art. Neo-classicism is closely related to Roman designs of the Renaissance period. It is difficult to distinguish between the two. Roman columns and round arches are related to the Neo-Classic elements. This style can be observed at the *Campanile di San Pantaleone* (Figure 15). [71]

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[70] A Method for the Evaluation of Venetian Bells and Bell Towers. p. 32

[71] *ibid.*, p. 33

Figure 15 Campanile di San Pantaleone

2.11 Bell Tower Jurisdiction

In many Christian denominations the bell tower is a landmark of the church, representing its community. They are a constant reminder to all those who look into the sky of their beliefs. The Catholic Church, which is the prevalent denomination in Italy, owns most of the bell towers in Italy. Therefore, for Venice specifically, the possibility of an antenna being placed inside a bell tower depends heavily upon the consent of the Catholic Church.

The pope is the head of the Roman Catholic Church, and has the final power in all matters of doctrine. Although he does not have the final say in property matters, he does have the ability to declare that cellular antennas inside of a bell tower is improper use of church land. With the religious authority lying in the hands of the pope, the Catholic Church is then divided into several sub-organizations. These organizations are either religious or administrative. Both branches will influence the decision-making on cellular antennas in bell towers. The religious sector will review the moral aspect while the administrative sector will favor the business opportunity.[72]

The order of these organizations begins with the diocese. The diocese is the "fundamental unit of organization" in the church and the bishop is the leader.[73] In total, there are around 1800 diocese and 500 archdiocese. The bishop is a liturgical figure who conveys the Holy Orders and administers confirmation. He also distributes administrative responsibilities to his vicar general, other officials, and respective parishes. Falling under the bishop is the clergy, who are split into secular and religious organizations. The secular clergy serve as pastors and the religious clergy are dedicated to the religious orders.

On a local level, the Curia can be found. This branch is parallel to the municipal government in a country. Political, economic, and social policies of small size are dealt with in this organization. Small committees and agencies are created to focus on individual needs and aspects concerning the smooth running

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72 www.fwkc.com?encyclopedia/low/articles/r/r02200/034f.html

73 *ibid.*

of the Church.[74] In Venice, the *Commissione per i Beni Ambientali ed Architettonici Ecclesiastici* is the commission for the environmental and architectural possessions of the church.[75] Specifically, this branch deals with the property aspects of the Church and would be the ones to make a preliminary decision on cellular antennas in bell towers.

2.12 Summary

In its entirety, the background section attempts to give the reader detailed information for an understanding and appreciation on the various subjects that are addressed and evaluated in this paper. The research also served the purpose of allowing the team members to establish the proper approach to solving the problem. The cellular history and technology sections show the complications of these systems and the large range of possible installations available. This is important to know when determining the data needed to be taken in the fieldwork defined in the methodology. The health related aspects, bell tower structure, and useful laws were all important in the assessment of this alternate antenna location. Finally, a breakdown of the church government within Venice was valuable to know in order for us to recommend who should be approached on the matter. Armed with this basis of knowledge, we took the next step which was to outline our Methodology.

74 www.fwkc.com?encyclopedia/low/articles/r/r02200/034f.html

75 CID s.r.l., Centro di Informazione e Documentazione del Patriarcato di Venezia. Patriarcato di Venezia: Annuario Diocesano 1999.

Chapter 3 Methodology

Due to the introduction of UMTS the total number of providers in Venice will increase to five. With these additions there will be a rise in competition for cellular coverage, thus an increase of antennas. The unique architecture and geographical structure of Venice is an obstacle for the cellular providers to overcome. Venice is thickly built and populated; therefore, many antennas must be placed throughout the city in specific areas, rather than having one servicing all of the customers. Often, these antennas are not well hidden and are plainly visible to the human eye. Unfortunately, this detracts from the aesthetics of Venice on which the city relies heavily for tourist attraction. Another concern is the electromagnetic radiation emitted from the antennas. While this radiation has not been directly associated to any pathology, these antennas have proven to be associated with psychosomatic behaviors. Motivated by these societal problems, it was our goal to apply our technical skills in assessing the feasibility of bell towers as alternative antenna locations in Venice.

3.1 Key Companies, Agencies, and Personnel

In achieving our project's goals we completed several tasks with the aid of the *Settore Sicurezza del Territorio* (Sector of Territorial Safety) of Venice, and Dr. Anna Bressan, director of the *Settore Sicurezza del Territorio* of Mestre. Both offices provided information and tools that we used in order to organize and determine what field data should be collected. For example, they provided general maps of Venice, antenna locations of the three providers, and most of the building heights (measured to the gutter of the building) within Venice. Other parties that may eventually have interest in our project are the three present cellular providers of Venice (TIM, Omnitel, and WIND), the two upcoming providers of Venice (of which only the company Blu is known), Ericsson, the *Agenzia Regionale per la Prevenzione e Protezione Ambiente Del Veneto* (ARPAV) and the Curia. Though we did not contact any cellular providers (we were not allowed to) our data may be useful for them in the future. Ericsson, who in Italy provides cellular antenna locations for cellular providers, supplied us with information that aided in our bell tower analysis. ARPAV, the Regional Agency for the Prevention and Protection of the Environment of Venice, is the certified government organization employed by the *Comune* of Venice to take accurate measurements of radiation fields for the city. They gave us a template of their antenna database for us to refer to when we created our own. Though the Curia is not directly involved at the moment, if the providers utilize our data, they become a main figure involved in the antenna installations. Ultimately, whether bell towers are feasible or not, they can not be used without the consent of the church government.

3.2 Geographical Area of Research

To fully understand the extent of our project, we must define the area we researched over a period of two months. The actual *Comune* of Venice is defined as *Centro Storico*, the Mestre, the Lido, Pellestrina, and the islands (*Isole Laguna*) of Murano, Burano, Torcello, S. Erasmo, Vignole, and Mazzorbo as seen in Figure 16.

For the antenna cataloging, we surveyed antennas on *Centro Storico*, the Lido, Pellestrina, and the islands of Murano and Burano. In terms of assessing the bell towers we surveyed *Centro Storico*, the Lido, Pellestrina, and the islands of Murano, Burano, Torcello, S. Erasmo, Vignole, and Mazzorbo. The bell towers

Figure 16 Area of research

and antennas of Mestre were not assessed constraints. This was because Mestre, in comparison to *Centro Storico*, the Lido, Pellestrina, and the islands, is much more spread out. We felt that it was beneficial to focus on the concentrated regions, and if time permitted, we could move onto the Mestre. At Torcello, S. Erasmo, Vignole, and Mazzorbo there were no antennas, but their bell towers could not be ruled out as possible antenna locations.

3.3 Overview of Objectives

Our main objective was to research whether or not bell towers were feasible antenna locations. To do this we researched the one hundred six bell towers and thirty-one antennas of Venice to collect data that we compiled into databases. These databases, which we created, were then used to produce catalogs on the bell towers and antennas. These databases and catalogs would be tools and resources for us, as well as the *Settore Sicurezza del Territorio*. Specifically, the antenna database could be continually used to keep track of incoming authorizations from the cellular providers by the *Settore Sicurezza del Territorio*. If feasibility is determined we will provide motivation to move the antennas to bell towers based on aesthetics and health using laws and regulations as parameters. Throughout this chapter, we describe the procedures considered, the materials used, and our methods of analysis for the data we collected.

3.4 Defining a Feasible Bell Tower

Before achieving our goals, we had to define a feasible bell tower. For our purposes, a bell tower can be defined as a tower-like structure, either free standing, attached to other buildings on its side, or attached to a building's roof. It houses bells in the belfry, has four walls, and a shaft. However, some structures that are considered bell towers are merely archways with bells hanging from them as shown in Figure 17. Unfortunately, these are not useful to our project because they can not house equipment, they have no shaft for the cables, and they can not hide the antennas enough to be aesthetically pleasing. The belfry was our first choice in terms of aesthetics and it requires no external construction.

Figure 17 Archway bell tower

For a bell tower to be considered feasible they must fulfill certain requirements as described previously in the background:

- The belfry must be six meters above the roofline of the surrounding area.
- There must be an area of 2.5 m in width, 3 m in length, and 2.5 m in height available for the equipment.
- The bell tower structure must satisfy the new regulations, such that within a 50 m horizontal radius of the tower there can be no inhabited building taller than it.

With these general requirements in mind, we eventually surveyed the bell towers. Once their feasibility was established we could the best locations for antenna installation. To make our final analysis and recommendations we compared the present antenna locations to the bell tower options.

3.5 *Bell Tower Data Collection*

We gathered a significant amount of information on the bell towers that were placed in our database. This included several height measurements, qualitative information such as the accessibility of the bell tower and whether or not it had a door, and pictures. We used this information to assess their feasibility, to create a composite catalog, and to propose optimal antenna sites.

3.5.1 Method of Measurement

Our method of measurement relied on the properties of similar triangles and a tape measure. The tape measure we used was three meters in length and accurate to the millimeter. By holding it at arms-length, we compared the point of desired height with a measurement on the ruler as seen in Figure 18. By setting this proportionality:

Equation 1 Similar Triangle Proportionality

one can determine the unknown height. Our method of measurement is accurate to within 2% of the actual heights of the bell towers.

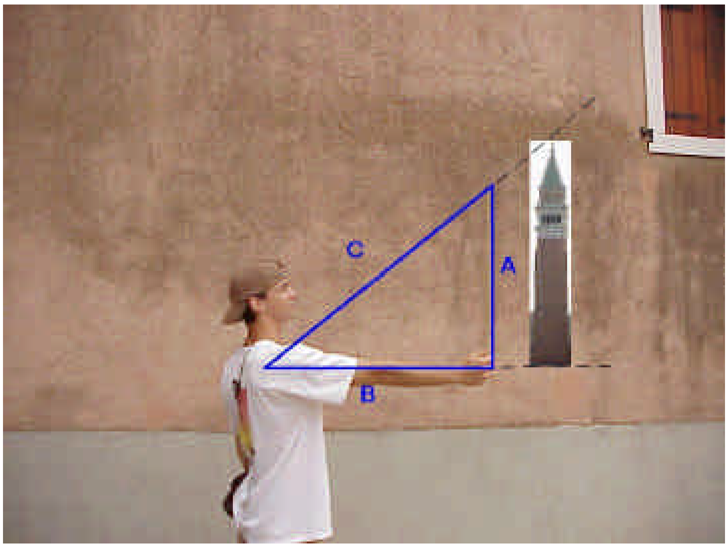

Figure 18 Similar Triangle Method

3.5.2 External Bell Tower Assessment

We assessed the bell towers by measuring heights, estimating unknown heights of surrounding buildings, and determining accessibility. The measured heights were the peak, the gutter, and the bottom of the belfry. We took the belfry height because this part of the bell tower is our main focus for antenna installation, the gutter and peak heights were used for reference. It was a challenge for us to obtain the heights of the structures encompassing the bell tower. However, it was important to do so because the surrounding heights would be needed when we finished our fieldwork and began to analyze bell towers as feasible locations for the antennas. Approximately 68% of the building heights in Venice were known prior to our fieldwork. Within in a fifty meter radius we were able to estimate the unknown heights by comparing them to known heights. This information was contained on a map that we used as a reference in the field. An example of one of these maps can be seen in Figure 19.

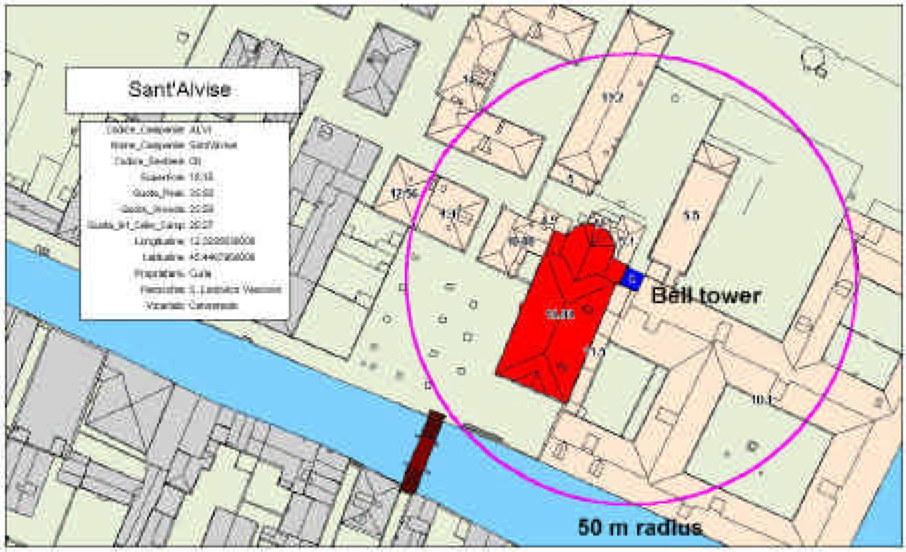

Figure 19 Bell tower field map

Other information taken during the fieldwork was the accessibility of the bell tower. We determined accessibility by recording if a door existed and the side that it was on. This information was recorded for reference. For equipment reasons, it may be important for a company to know if the bell tower that they are interested in is accessible for equipment reasons. We used the bell tower field form shown in Figure 20 to keep track of this information as well as the team member measuring the tower, their arm length, and their three bell tower measurements (which were taken twice). We also took three pictures of the bell towers to gain a visual perspective of the structure. These pictures included: a full-length picture of a face, a full-length picture of a corner, and a close up picture of the belfry.[76] These photographs, show the dimensions of each bell tower as well as an idea of the amount of space available in the belfry. This type of information is pertinent to companies for evaluation of a site.

[76] Ericsson TLC s.p.a.

				Date:	
	Bell Tower Name	**Bell Tower Name**	**Bell Tower Name**	**Bell Tower Name**	**Bell Tower Name**
Personal					
Name of Measurer					
Length of Arm (cm)					
Heights					
to Peak					
to Gutter					
to Belfry Bottom					
Accesibility					
Front					
Right					
Left					
Back					
Doors					
Front					
Right					
Left					
Back					
Building Heights?					
Picture?					
Notes					

Figure 20 Bell tower field form

3.5.3 Internal Bell Tower Assessment

As part of our bell tower fieldwork we had anticipated on entering the bell towers to evaluate the base, the shaft, the belfry, and to take panoramic pictures from the top of the tower. Unfortunately, we could not gain access to the towers. However, late into our stay in Venice we were granted admittance into four bell towers in Cannaregio by Adriano, a student working on his thesis, which involved the bell towers of Venice. With this, we were able to take pictures of the ground floor, the shaft, stairs, belfry, and the panoramic view from the top. Ultimately, we would like to prepare a layout of one of these bell towers of Cannaregio, just as a company who is selling the site to a cellular provider would, to demonstrate the effectiveness of our project.

3.5.4 Bell Tower Data Entry

Once we finished the surveying, we then started entering our information into our bell tower databases that were created with the guidance of Dr. Anna Bressan, director of the *Settore Sicurezza del Territorio* of Mestre. The databases served to hold information for future reference and investigations on bell towers as possible antenna sites. We had two sources of information for our catalog: one was the field forms and maps we created and the other was the book *Patriarcato di Venezia: Annuario Dioscesano 1999* (Patriarch of Venice: Annual Diocese).[77] The book was the source of owner and parish information for the bell towers.

[77] *Patriarcato di Venezia: Annuario Dioscesano 1999*

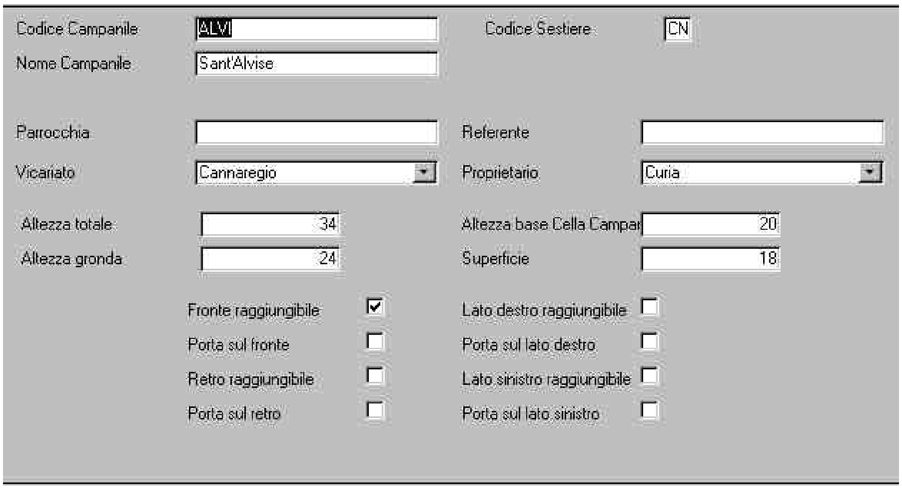

Figure 21 Bell tower database form

The first bell tower database, or image database, contained the pictures that we took of the bell towers along with our completed field maps. The second database, or informational database, held all of the information about the bell towers that we collected in the field. A screen shot of this final form can be seen in Figure 21. This form let us input data into four database tables. The first table, *Campanili*, held the name of the parish, if the bell tower was accessible from the front, back, left, or right, and whether there was a door on the front, back, left, or right sides. The second table, *Campanili* MI, held all of the known information in MapInfo about the bell towers obtained from the *Settore Sicurezza del Territorio*. This included the base area and the gutter heights of the bell towers that were useful to compare with our measurements. The third table, *Chiesa*, also contained the parish as well as the head of parish, the owner of the bell tower, and the vicariate, the organizational level above a parish. This information is important to have in the catalog so that cellular companies and the *Comune* would know whom to approach for antenna installation. The fourth table kept our calculated peak, gutter, and belfry measurements, as well as the base area of the bell towers (calculated in MapInfo by known values obtained from the *Settore Sicurezza del Territorio)*. Once these two databases were completed we were able to combine them to make our catalog. A copy of this form in English can be found in Appendix C. The inputting of the data took three weeks (the fifth through the seventh weeks).

3.6 Antenna Data Collection

In addition to the electromagnetic radiation created by antennas, they also give rise to aesthetic problems. Due to this it was important for us to gather and organize all antenna information possible to help the *Comune* assess the antennas. Therefore a main objective of our project was to catalog the antennas throughout Venice. With the tools provided by the *Settore Sicurezza del Territorio*, we collected data on the existing antennas, and put it into our own database. From these databases, we formed a catalog to systematize the antennas and to use as a reference when comparing them to bell towers.

3.6.1 Antenna Field Work

Our first step in completing the antenna catalog was to survey the antennas. We did this to have the exact locations of the antennas and panel directions with respect to the rooftops, to record the visibility of the antennas and to take photographs of them.

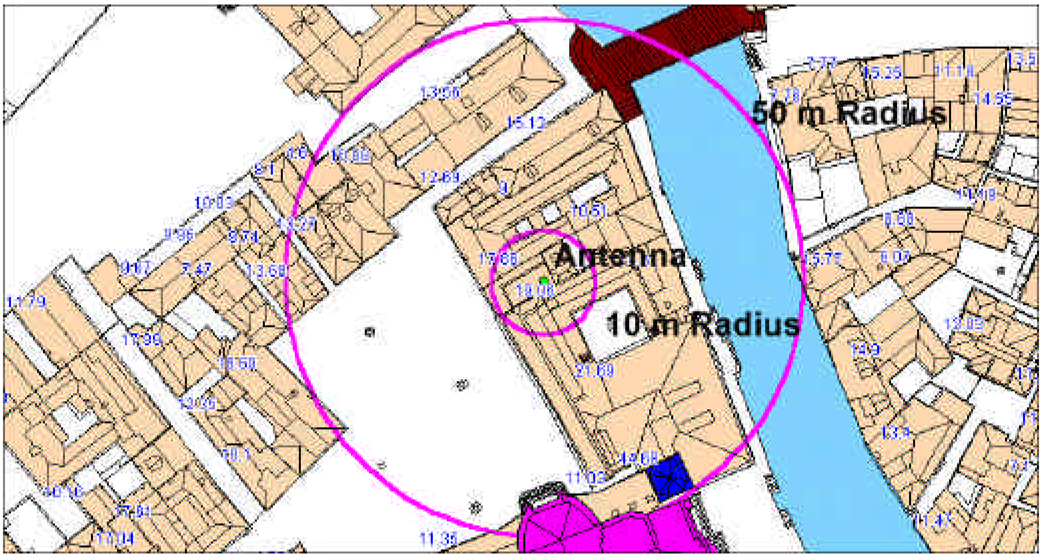

Figure 22 Sample antenna field map

To record the antenna location and panel directions we used maps of the antennas. These maps gave us a general idea of where the antenna would be located, by representing the antenna as a dot in the center of ten and fifty meter radii. As part of our assessment we marked the exact location on the map in order to make a credible analysis. We also recorded the visibility of the antennas on the field maps. We noted the visibility to characterize the aesthetic damage caused by the antenna. To do this we marked on the map whether or not the antenna was visible from the north, south, east, and/or west. An example of an antenna field map can be seen in Figure 22.

Photographs are also part of our catalog and were acquired during the surveying of the antennas. Pictures of the antennas were needed so that we could portray the diminishing effects of the antennas on the aesthetics of Venice by producing before and after pictures of the antenna locations. By this, we mean an after photo edited in a graphics program to show the area without the antenna and a before photo (the photo we took) that is the same area with the antenna. All of this information was entered into our antenna databases after nine days of fieldwork was completed.

3.6.2 Antenna Data Entry

Once the surveying was finished, we started entering our information into our two antenna databases. These databases came together to produce our antenna catalog. We had two sources of information for them: one was the information gathered during our field work and the other was the information contained in the antenna authorizations given to us by the *Settore Sicurezza del Territorio*. The authorizations are the actual permits filed by the cellular providers to install the antennas and were the source of most of the technical information such as antenna makes and models, latitudinal and longitudinal locations, and the equipment used.

Our first antenna database, or the image database, contains the photographs that we took of each antenna. The pictures were taken based on the best possible representation of the aesthetic damage caused by the antenna, and its close proximity to residential and tourist areas to emphasize health concerns. This would include the original photos of the antennas and the edited photos that showed these same locations of Venice without the antennas.

The second antenna database, or informational database, contained four tables. The first table, *Celle,* or Cell, kept a record of the make and model of the antenna, the height of the antenna, if the antenna is inside or outside, the direction of the panels in degrees from north, and if it is near a sensitive site. A sensitive site can be defined as a hospital, school, or any area where the same group of people are constantly exposed to radiation. The second table, *Radio Base*, held the cabinet specifications: the height, width, and length of the cabinets and the number of cabinets for the antenna. The third table, *Torre*, or Tower, contained the height of the tower and the size of its footprint. The fourth table, *Visibilitá*, or Visibility, contains information on the visibility of the antenna from the north, south, east, or west. Once we completed these two databases, we were able to bring them together to produce our catalog of the sixty-one existing antennas in Venice. An example of the antenna database in English can be viewed in Appendix B. The inputting of the antenna data took one month.

3.7 Summary

The main components of this chapter illustrate our process of determining the feasibility of bell towers. Our database served as a tool to organize data collected in the field, as well as in the completion of our catalogs. All pertinent information for further analysis will be extracted from this data and represented in the results.

Chapter 4 Results

Following the data retrieval from the procedure outlined in the methodology, we gathered and compiled the information to produce results that we could analyze efficiently. Our major priority was to report the findings on the feasibility of bell towers as locations for antennas. This included our antenna and bell tower data along with obtaining professional input. Ultimately, it was necessary to represent the assembled data in ways that could be used to assess bell tower locations and make comparisons between them and present antenna locations. In the following paragraphs, we discuss the presentation of this data. The use of tables, databases, and maps were an integral part in conveying the information.

4.1 Field Work Equipment Testing

To assess the bell towers we needed to measure several different heights. Two methods of measurement were considered: an optical tape measure and the similar triangle method. The optical tape measure can measure distances by looking into the eyepiece and focusing two lenses, much like a pair of binoculars. The individual holds the device up to his or her eyes and focuses on an object with a rotating dial which shows the value of the measurement in feet. To use this device one member stood at a known distance away from the bell tower, and found the hypotenuse measurement with the device. With these two distances, we used the Pythagorean Theorem to find the actual height. However, the second method, that of similar triangles which was described in the methodology proved to be the more accurate of the two.

It was essential to have validation for our data to make future assumptions on it. Therefore, to ensure that our methods for accumulating information were accurate, sample test runs were done among all of the team members on measurements of the bell tower heights to the peak, and the gutter in terms of accuracy and precision. The tests were performed on the San Marco bell tower that has a known height of 98.6 m.

We immediately ruled out the optical tape measure as a possibility for taking accurate measurements. When the test run was performed, each team member calculated measurements with great differences. The calculations for each team member were as follows: thirty-three feet, sixty-nine feet, forty-nine feet, and fifty-six feet.

In addition to the lack of precision in the measurements that we each took, the optical tape measure was ruled out for several other reasons. First, when focusing the optical tape measure, it does not focus on a specific object, but on a general area. Second, the optical tape measure had a maximum range of one hundred and fifty feet, which would not be sufficient for our measurements since some towers were most probably taller than that. Third, the dial of the optical tape measure itself was not very accurate. It started at six feet and, at that point, was accurate to four inches. Once the dial reached thirty feet, the accuracy dropped to twelve inches. When it reached sixty feet it was found to be accurate only to ten feet, which is a significant deviation. Past sixty feet the accuracy continues to drop. At eighty feet it is accurate to twenty feet, and finally at one hundred feet the accuracy is only fifty feet. For these reasons, the optical tape measure was ruled out as a possible device for measuring bell towers.

Our second method of bell tower measurement, similar triangles, proved to be accurate. A table and a scatter plot (Figure 23) demonstrating our accuracy with this method were made in Excel showing the variations among team members' measurements versus the actual height. As shown, each of the three sets of points represents a trial taken. Three trials were performed to reduce error of the test. The purple line of circles represents the actual height of the San Marco bell tower (98.6 m) while the other four shapes are the calculated heights measured by each team member. Our averages were 99.51 m, 96.33 m, 101.84 m, and 104.53 m for a total team average of 100.55 m. To make this data useful it was necessary to calculate the percent error among each team member and take an average of those errors. The range in error among each team member was .92%, 2.3%, 3.2% and 6.01%. The total percent error was 1.98%. This percent was applied to all of the measurements taken in the field.

Figure 23 San Marco equipment test results

Since we would be measuring the gutter height of the bell tower in the field, we decided to also practice these measurements in the test run. However, this height of the San Marco bell tower is not recorded, so we used it to test our precision between each other. The conditions for testing this were the same as for the accuracy test, where each team member measured the gutter heights three times. The average of all three trials, between team members was used to demonstrate precision between group members in a second scatter plot (Figure 24). The averages of all team members, for all trials was 76.57. As one can observe from the plot, the closest member to the average by the third trial was 0.23 m away and the farthest taken measurement was 1.36 m away from the average height. Both of these errors lie below our 2% accounted error calculated from the accuracy tests. Also, as one can see in the plot, each team member's measurement begins to merge with the average by the third trial. This demonstrates our precision amongst each others' measurements.

Figure 24 Gutter measurement precision test

4.2 Bell Tower Data

As a result of this data collection, we have complete informational and image databases of ninety-seven bell towers. The information contained in the two databases was used to create our catalog of the bell towers and was used for analytical purposes. This database and catalog is valuable for companies to have necessary data when considering a location, as well as a functioning reference tool for the *Comune* to utilize when companies approach them about bell tower locations. The informational database contains all field data collected as well as some qualitative facts. The visual database consists of three photographs of the bell towers, and a detailed map.

4.2.1 Bell Tower Catalog

Each page of the catalog includes important, collected data such as the heights, area of base, and accessibility to the bell tower. Also noted are the owners of the bell towers, the parish, the vicariato, and references. This information is for contact purposes since permission for antenna placement from the owner is needed. An example page of the catalog is illustrated in Appendix C. There is a map displaying the exact location of the bell tower, with a fifty meter radius drawn around it. It was produced to show the heights of buildings within this radius for two reasons: to demonstrate if the bell tower, as a potential antenna location, was within Venetian regulations, and to show the cellular providers what obstacles the may be facing for installation. The complete catalog can be seen in a separately bound document.

4.2.2 Field Results

As defined in the methodology, a suitable bell tower must have a belfry. Once our surveying was completed, we found that ninety-seven of Venice's bell towers met this requirement and were distributed throughout Venice. From those, there were eight that we could not measure for various reasons leaving eighty-nine bell towers for further analysis. A breakdown of the bell towers not used and the reason why is listed in Appendix H.

Photographs taken during fieldwork are an integral part of our catalog for the layout and presentation of each evaluated structure. We attempted to take photos of the side view, corner view, a close up of the belfry, and, when possible, a panoramic view from the inside of the belfry. Of ninety-seven bell towers visited, we were not able to obtain pictures of the sides for seventeen of them, a corner-view shot for twenty-four towers, and a belfry view for seven. These views could not be taken because they were not visible from the ground. Also, it was only possible to attain panoramic views of four bell towers in the sestiere of Cannaregio. This is because it was difficult to get permission, from the individual pastors in charge of each bell tower, to allow us within the bell tower. Though this is not many, they were taken to give companies a better understanding of any obstacles around the tower.

Also at the end of our data collection, we created many miscellaneous statistical results for reference. The average peak, gutter, and belfry heights of the bell towers are 37.12 m, 31.66 m, and 25.26 m, respectively. The tallest and shortest heights of bell towers can be seen in Table 2.

Measurement	Calculated Value (m)	Bell Tower
Tallest Peak	98.8	San Marco
Shortest Peak	8.00	Sant'Erosia
Tallest Gutter	74.12	San Marco
Shortest Gutter	6.5	Sant'Erosia
Tallest Belfry	54.19	San Marco
Shortest Belfry	4.5	Sant'Erosia

Table 2 Tallest/shortest bell towers

4.2.3 Ericsson Collaboration

We met with representatives from the company Ericsson to obtain both their opinion on bell tower feasibility and other relevant information. From this meeting, we obtained a variety of information, including their professional opinion confirming that bell towers are feasible locations for antennas. As proof, they revealed to us that presently there are antennas inside two bell towers of the Lido and Pellestrina, and Giovanni Laterano (a church in Rome), which is shown in Figure 25.

Figure 25 San Giovanni in Rome, the antennas are hidden behind fiberglass on the outermost columns

Ericsson also offered to perform a simulation that showed the possible coverage obtained if antennas are placed in bell towers. They will attempt to show the current cellular coverage of particular antennas and the areas where they are lacking service. Hopefully, the simulation will show that bell towers are in strategic locations for the companies to obtain coverage in these lacking areas. This simulation (done the last week of our project) was ultimately another form of evidence of the feasibility of the bell towers.

4.3 Antenna Data

In addition to bell tower fieldwork, we collected data on thirty-one antennas within Venice for cataloging purposes and analysis of their present locations. The raw data that we collected can be seen in our database and was formed into a catalog. The database was developed to hold information that we collected as a team, as well as any pertinent information extracted from the authorizations, and as a functional reference for the *Settore Sicurezza del Territorio.* Often, the authorizations were hard to read and understand. However, this database organizes everything in a straightforward manner. The organization of the database is useful because with the number of antennas increasing in Venice, the *Settore Sicurezza del Territorio* will be able to add to the database and keep active files on these and any new antennas. At the moment, the *Settore*

Sicurezza del Territorio has only twenty-three authorizations for the antennas. When new authorizations come in they can be entered into the database and the catalog updated for full documentation of all the antennas.

4.3.1 Antenna Catalog

In total we surveyed thirty-one antennas, twenty on *Centro Storico*, two were in Murano, one was in Burano, seven were on the Lido, and one was on Pellestrina. Of these, eleven antennas are owned by TIM, Omnitel owns eleven, and WIND owns nine. We obtained twenty-four photographs as the other seven were either inside the buildings, or not visible from the ground.

We created a catalog from our databases (the database is shown in Appendix B) and is composed of all authorized antennas in Venice, though all information for each may not be complete. This catalog contains visual and numerical data. The visual portion consists of maps and photographs of the antenna. The maps confirm the exact antenna locations, the direction of the panels (represented by arrows), and how close buildings are to it. There is also general information for each antenna, such as its code, address, latitude and longitude and owner. The technical data included are the make and model of the antenna, the degrees from north of each sector and the height of the antenna. Based on our information sources as well as fieldwork, our catalog currently is composed of twenty-three antennas, with completed information on sixteen of them. The entire catalog can be viewed in a separate bound document.

4.3.2 Visibility

We noted the visibility of each antenna from north, south, east, and west positions. This was done for assessment of aesthetic damage. Out of the thirty-one antennas visited, only twenty-one were visible. Figure 26 illustrates how many antennas were visible from four sides, three sides, two sides, and one side. It shows that eleven were visible from all four sides, three from three sides, four from two sides, and three from one side, and that ten were not visible at all. It is important to note that there were twenty-four photographs taken and yet only twenty-one visible antennas. For two of these three antennas, the superintendent allowed us on the roof of the building, but otherwise the antennas are not visible from the ground. The other photograph was taken only because a resident allowed us into his house to take the photo of an antenna that stood next to their house. The address for each antenna, along with whether or not the *Settore Sicurezza del Territorio* has an authorization is recorded. And finally whether the antenna is visible or not is indicated. If the antenna was visible, the number of points (north, south, east, and/or west) it is visible from was specified.

Figure 26 Number of antennas and visible sides

4.4 Summary

In conclusion, our major results were our catalogs, as we placed and organized all of our collected and researched data within them. We visited one hundred six bell towers, and have a complete catalog page for eighty-nine of them. In addition, we visited thirty-four antennas and collected complete information on twenty-one of them. We created these catalogs for our analysis as well as for a functional resource of the *Comune*.

Chapter 5 Analysis

Collectively as a team, we have walked throughout all of Venice, from the northernmost latitude of 49° N to the southernmost latitude of 45° N, to evaluate its one hundred six bell towers along with thirty-one cellular antennas. During our assessment, we collected data on the bell towers and the antennas and took over seven hundred photographs, all of which were entered into databases. We designed these databases to ultimately create both a bell tower catalog and an antenna catalog. These bound catalogs were produced for our research as well as the reference and future use of the *Settore Sicurezza del Territorio*. They were also created to help us establish our goals, which were to assess bell towers as locations to move existing antennas into and for future installments. We proposed bell towers as the new location of choice for the reasons of aesthetics, health, and Venice's new regulations on antenna placement.

In order to survey both the antennas and the bell towers in an organized fashion, as well as for this analysis, we separated Venice into different sectional areas as defined in the Methodology. These sections are the *Centro Storico*, the *lidi* (the Lido and Pellestrina), and the *Isole Laguna*, or the islands of Murano, Burano, Torcello, Vignole, Mazzorbo, San Erasmo, and San Michele.

We will analyze our collected data, organized into these regions, on our proposed alternate location, the bell towers. Previously, after the completion of our bell tower assessment and the catalog, we found that, by our definition there were ninety-seven possible bell towers. After our analysis we targeted seventy-seven bell towers that are feasible antenna locations. To reach this conclusion, the bell towers were categorized into five different levels of priority. These priorities were based on the criteria of existing laws, antenna placement requirements, and how close they were to sensitive sites. As explained in the following analysis, these priority levels, based on the above criteria, range from those bell towers that are "legal" (they meet the current regulations for antenna placement), in the optimal height range, and are not near sensitive sights to those that are "legal", not in the optimal height range, and are near sensitive sights. The lowest priority is considered the "illegal" bell towers. The priorities are as follows from highest to lowest:

- Legal bell towers that are not near a sight and are at the optimal height
- Legal bell towers that are not near a sensitive sight and are not at the optimal height
- Legal bell towers that are near a sensitive sight and are at the optimal height
- Legal bell towers that are near a sensitive sight and are not at optimal height
- Bell towers that do not meet current regulations

In addition to Ericsson's professional opinion, they have also offered to run a simulation of our data to offer further evidence of bell towers as sufficient antenna locations. Ericsson performed a simulation depicting the coverage of thirteen real antenna locations (ten on buildings, three in privately owned bell towers) in Venice. Furthermore, they showed the kind of coverage a cellular provider could get if they were to place seven additional antennas in bell towers. This illustrated that the companies could obtain much more coverage using bell towers rather than roof tops. It also demonstrated that electromagnetic radiation would be above the surrounding rooftops. This made it evident that the height of the bell towers allows the antenna signal to soar over the rooftops, therefore making it a beneficial antenna location for health concerns and performance. These simulations can be seen in Appendix E.

Now that we have determined that bell towers are suitable sites, we will provide motivation for the *Settore Sicurezza del Territorio* to move the current antennas based on reasons of aesthetics, health, and present-day regulations on antenna placement. First, we will show that a certain percentage of the present antennas are near sensitive sites (schools, and hospitals), and/or are located in areas where there are high concentrations of the population. Next, we will discuss the aesthetic damage caused by the antennas that deface the architectural history of Venice. Finally, we will illustrate that a portion of the present antennas of Venice, though grand-fathered in their locations, are not presently within the bounds of Venice's new regulations.

The following sections provide our detailed analysis showing the basis for our belief that bell towers are viable, and our investigation of why antennas should be moved to the bell towers.

5.1 Bell Tower Evaluation

To evaluate bell tower locations, we established a set of criteria. These standards were based upon existing laws, sensitive sites, and specifications of antenna placement. Each of these conditions were taken into consideration and used to break down the eighty-nine possible bell towers into five different priorities. In the flow chart shown in Figure 27, the priorities were reasoned based on: 1) whether or not they complied with current antenna regulations, 2) if they were near a sensitive sight, and 3) if they were in the optimal height range.

Figure 27 Bell tower prioritization flow chart

As shown above, the "illegal" bell towers, or those not in compliance with new Venetian regulations on antenna placement, are automatically ruled out first. The remaining were considered usable bell towers though categorized in priorities. The ideal situation for a site according to our assessment is the “legal” bell tower that is of optimal height and is not situated near a sensitive site as seen in the green box.

5.1.1 Bell Towers Not Feasible

Under newly established Venetian law, an antenna must be taller than all of the buildings within a fifty-meter radius. Given that the belfry is our intended location for antenna panels, we applied the regulation to our measured belfry heights. There were twelve bell towers that did not comply with this law and were therefore removed from our consideration. This left us with seventy-seven possibilities of feasible bell towers that meet Venetian regulation.

For this elimination, only the *Centro Storico* and Murano could be considered, as we had no building heights for the *lidi*, or the islands. With the help of Access, an analysis was done to indicate which bell towers were rejected. Shown in Appendix A is a map of the *Centro Storico* and Murano highlighting the twelve bell towers out of regulation.

5.1.2 Prioritization of Feasible Bell Towers

Once the impractical bell towers (by law only) were determined, we evaluated the remaining seventy-seven bell towers by prioritizing them for relocation into four distinct priorities. We decided that there are two criteria to take into account when making this prioritization. The first is health concerns and the second is optimal antenna performance. To achieve this, the sensitive sites were compared with bell tower locations, along with an assessment of belfry height for panel placement.

5.1.2.1 Sensitive Sites

Initially, it was our thought that because bell towers are often located in *campos*, they are furthest away from residencies and sensitive sites. According to our research on antenna placement and related health concerns, a desirable location is one that is both hidden and as far away from households and sensitive sites as possible. For this part of the analysis, we could only analyze the *Centro Storico*, (as we did not have sensitive site locations for Murano) which has sixty of the seventy-seven feasible bell towers. We created a parameter by which any bell tower within a two hundred meter radius of a sensitive site is considered a health concern and therefore a low priority (third or fourth priority level) location. The reasoning for a two hundred meter radius is based on the fact that an antenna propagates signals up to five hundred meters depending on both obstacles and the performance the company wants it to have.[78] Therefore, it is safe to assume that the signals are present within two hundred meters of the antenna.

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[78] Ericsson TLC s.p.a.

Using MapInfo to create this map, we illustrated the location of sensitive sites in relation to that of the bell towers with two hundred meter radii. The map of those bell towers located near sensitive sites is shown in Figure 28:

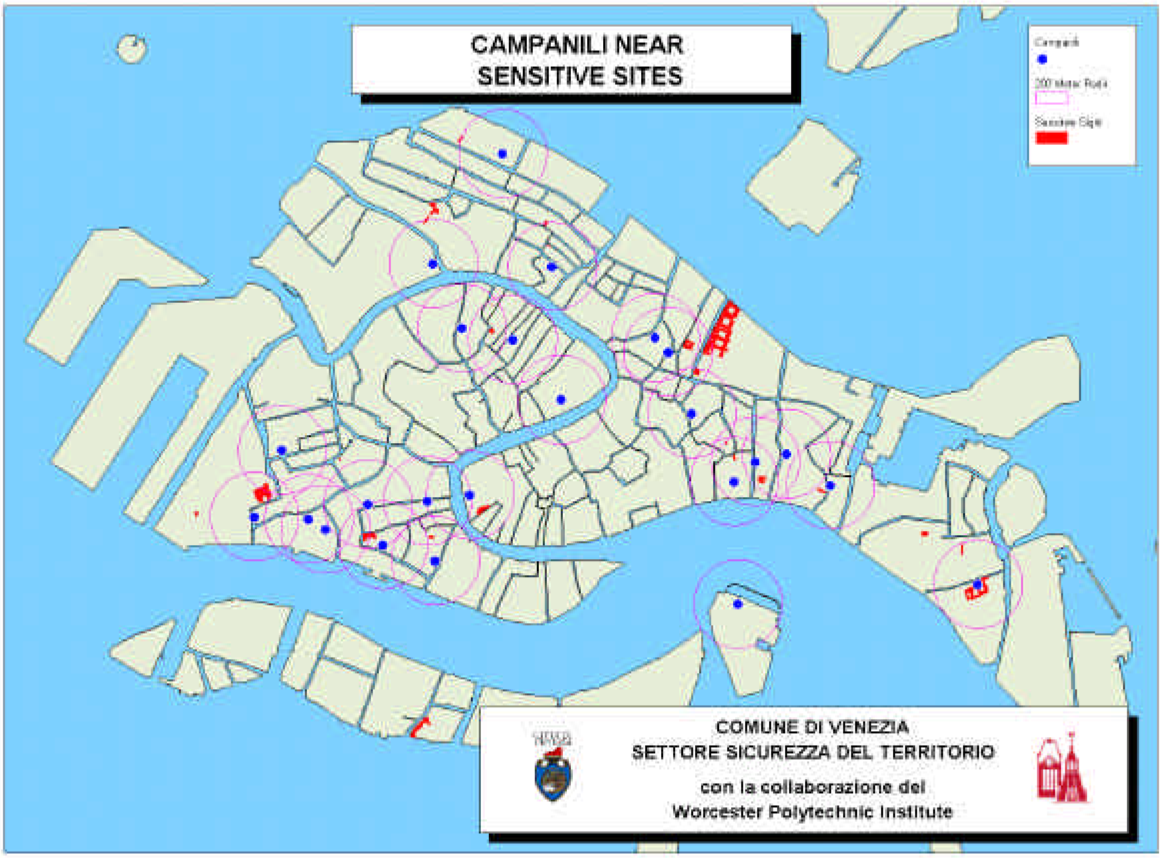

Figure 28 Bell towers near sensitive sites

From this map, it was concluded that twenty-three bell towers (shown in blue) have a sensitive site (shown in red) within their vicinity. This means that 38% of the prospective bell towers considered are of low priority. Although this percentage may seem high, there are still thirty-seven bell towers of the *Centro Storico* not near sensitive sites, and seventeen more that were not considered. This indicates that there are ample amounts of bell towers to consider as antenna sites, as well as confirms that more than half of them are feasible locations in terms of health concerns. As indicated by the priority flow chart, the suitable bell towers both located near a sensitive site, as well as those that are not, can be branched out even further by analyzing the tower in terms of optimal height.

5.1.2.2 Optimal Antenna Height

The next level in prioritization was based upon a height requirement for antenna panel placement to maintain optimal performance. According to Ericsson, excellent cellular coverage is attained when an antenna is six meters higher than surrounding buildings within a radius of fifty meters. This allows for optimal cellular performance because having an antenna too close to other buildings will affect its propagation.[79] We felt that this standard is an important factor to take into account for the future usability of our project.

It is important to note that cellular companies are willing to allow a few obstacles to be taller than the antenna.[80] This is a general rule used by companies to pinpoint the best antenna site. In order to analyze the bell towers with this information, we added six meters to the belfry height and compared this to the surrounding buildings within in a fifty meter radius. In our analysis we allowed for two obstacles. Again, with the help of MapInfo and Access, we determined that sixty-four bell towers fit optimal antenna placement standards. A map showing the forty-nine bell towers of *Centro Storico* that are in the optimal height range can be seen in Appendix A. With sixty-four of the "legal" bell towers in the optimal height range, 83% of the suitable bell towers can be advantageous locations for the cellular providers.

5.1.3 Final Bell Tower Assessment

Levels of prioritization were established for our analysis of the bell towers based on regulations, health, and performance requirements as explained above. To summarize, the criteria are in order from most to least desirable is as follows:

1) Legal, not near a sensitive site, meets optimal height
2) Legal, not near a sensitive site, does not meet optimal height
3) Legal, near sensitive site, meets optimal height
4) Legal, near sensitive site, does not meet optimal height
5) Illegal (not feasible)

All of the bell towers meeting the criteria from levels one through four are usable locations. It is important to remember the breakdowns that established these levels. Whether or not the tower was within regulation was the first parameter that took our bell tower count from eighty-nine to seventy-seven. Next, whether or not it was near a sensitive site was determined, and finally if it met optimal height requirements for antenna installation. Those that fall into the first category met the positive aspects of all of these requirements. All of the bell towers placed in the lower priority section are still feasible (numbers two through four), but they do not meet the best standards. Those in the fifth level did not make the first requirement and are not even considered as possibilities.

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[79] Ericsson TLC s.p.a.

The breakdown by priority levels of the possibilities is as follows: fourty-five in the first priority, nine in the second priority, nineteen in the third priority, four in the fourth, and twelve in the fifth. These are represented as percentages of the total possibilities in Figure 29.

Figure 29 Bell tower priorities by percent

From the chart one can see that 52% of the bell towers within Venice are of the highest priority which means that they are legal, are at optimum height for antenna placement, and are not near sensitive sites. The next level comprises 10% of the possible bell tower locations and can be described as legal, not at the optimum height for antenna placement, and not near a sensitive site. The next two levels are near sensitive sites. Of these, 21%, are both legal and at the optimum height, and 4% are legal and not at the optimum height. All of these levels add up to a total of seventy-seven feasible bell towers. This is 87% out of the perspective bell towers in Venice. The remaining 13% of the perspective bell towers fell into the fifth, or illegal antenna site level, which meant they were not feasible at all. With these results the *Settore Sicurezza del Territorio* has many options for alternative antenna placement as well as future antenna placement. This assessment will be important for them to know when approaching the five cellular providers.

Now that bell towers have been determined to be ideal and are prioritized according to the standards of law, health, and technical aspects, the *Settore Sicurezza del Territorio* now has an alternate antenna location to approach the companies with. However, before they do approach the providers, they must have significant motivations behind their proposal. Through the following analysis on antennas, we provide them with researched motives for relocation, specifically those of aesthetics, health, and regulations.

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[80] Ericsson TLC s.p.a.

5.1 Motives for New Antenna Locations

As mentioned previously, there is a total of thirty-four antennas, each owned by one of the three companies TIM, WIND, and Omnitel, which we located and assessed within Venice. After we surveyed the antennas, both technical and general antenna data was gathered from authorizations, and the antenna catalog was completed, we were able to analyze the antennas. This analysis was done to provide motives for the *Settore Sicurezza del Territorio* to relocate the antennas based on three premises: 1) if it is located near a sensitive site and/or near high concentrations of the population, 2) if it is damaging to the aesthetics of Venice, and 3) if it is not within new Venetian regulations.

5.1.1 Health Concerns

Antennas and their radio base stations have been connected with psychosomatic illnesses, and have been indirectly associated with many other health concerns. Due to these anxieties, it is important to keep the antennas as far away from the population as possible. Therefore, we propose that antennas should not be located near sensitive sites, and/or highly concentrated areas of the population. Figure 30 is a representation of the thought process used in this section of our analysis:

Figure 30 Antenna analysis flow chart

Based on the first part of this thought process, we mapped the locations of the twenty-one antennas in *Centro Storico* (excluding Giudecca) in relation to the location of sensitive sites, as we had no data to do any other regions within Venice. A two hundred meter radius was drawn around each antenna to determine if it was close to a sensitive site or not. The map of the *Centro Storico* region shown in Figure 31 contains the eight antennas that we found to be near sensitive sites. Of these eight antennas, there are one TIM, four Omnitel, and three WIND. Unfortunately, we can not give a percentage value of all the antennas located near sensitive

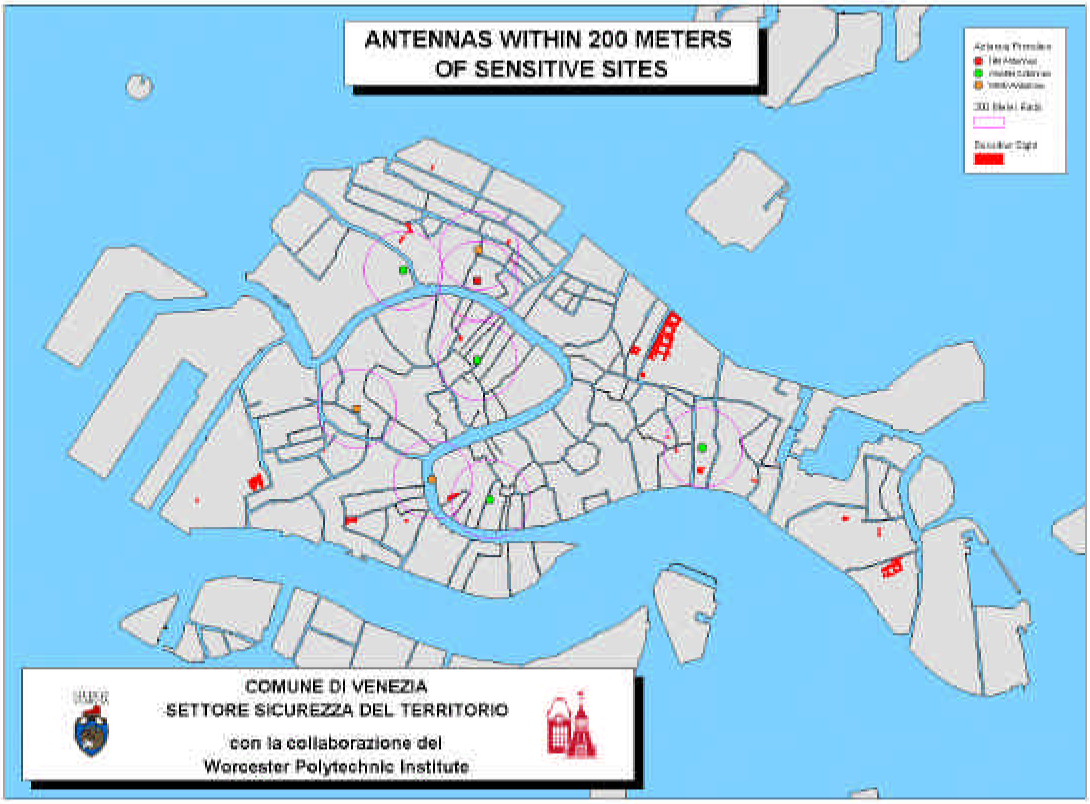

Figure 31 Antennas near sensitive sites

sites, but out of the twenty-one antennas we could assess, we consider eight of them, or 38%, a health concern.

In terms of population density, we mapped out the antenna and bell tower locations in relation to the population as it is distributed throughout Venice. This was to illustrate that the bell towers are better locations than the present antenna locations in terms of health concerns because there was more of them within low population concentrations.

To do this we mapped out the population density only in *Centro Storico*, and once again excluding Giudecca, (as we had no data for other regions), with the population values obtained by the *Comune*. The numbers we received are somewhat abstract in theory but are still very accurate. For the privacy of their citizens, the *Comune* will not reveal the number of people living in an individual residence. Instead, they produce a value of the total number of people living in a random amount of grouped residencies. For example, one data point on these maps may represent a known number of *i* people at *x* addresses, while another point my represent a known number of *j* people at *y* addresses. In the map shown in Figure 32, *Densità di Popolazione nel Centro Storico* (The Population Density of *Centro Storico*), a red dot represents *x* number of households containing 75 people (as shown in the legend).

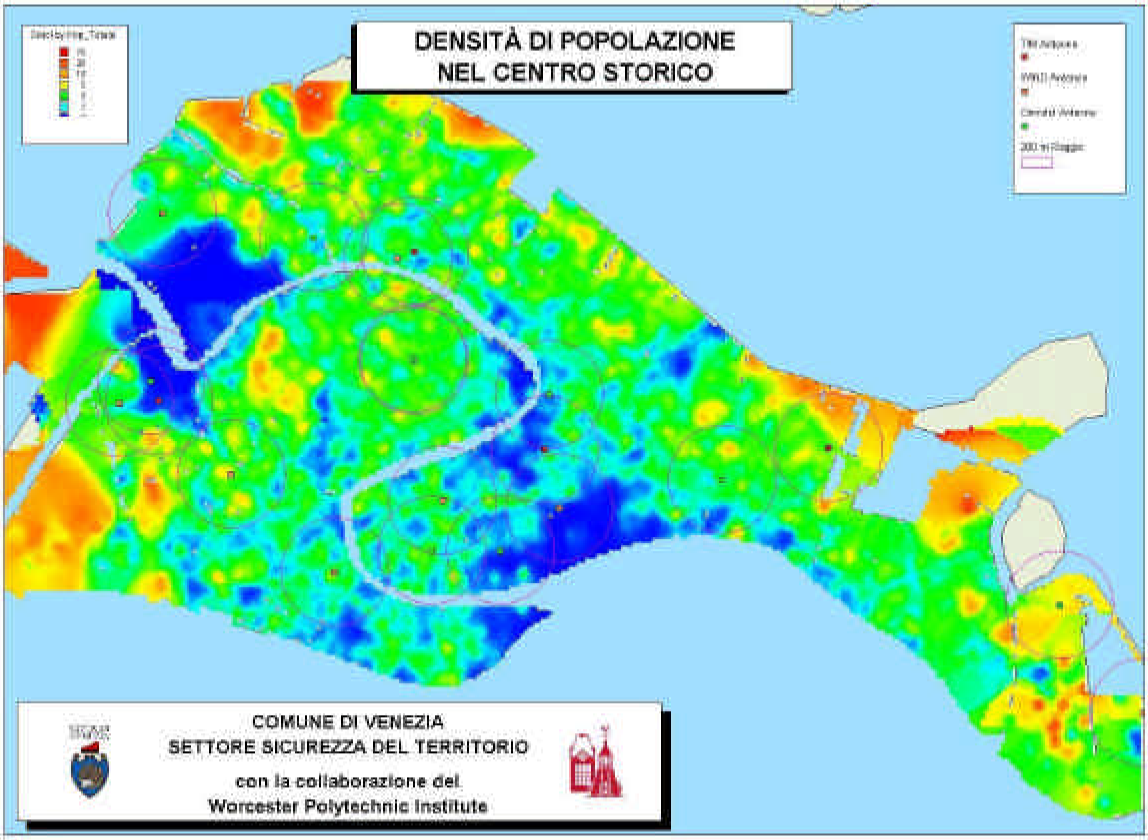

Figure 32 Total population density of *Centro Storico* compared to antenna locations

Once this was accomplished for both the general population and the population of children 0-13 years old, we added either the antenna or bell tower layer with the two hundred meter radius around each. If, within the radius of either the bell towers or antennas, there is a high population density, then it may be considered a health concern. Medium and low densities are also health concerns but to a lesser degree. It is impossible to locate an antenna were there are no people, so the lesser the population density the better. Figure 32 shows the population density in relation to the antenna locations.

In this map, blue represents no residents, the greens to oranges are a low to medium density, and red is the highest density. Of the twenty-one antennas pictured here, ten are within low to medium densities, ten others are in medium densities, and the last one is in a high density. Therefore, about 46% of them are in the low to medium densities of people, about 49% are in the mid densities, and only about 5% are in an area of high density. These values are demonstrated in Figure 33 on the following page.

The comparative map, shown in Appendix A, portrays the population densities at the fifty-five "legal" bell tower locations on *Centro Storico* (excluding the five of Giudecca). Most of the bell towers are located in the medium densities, four are located in areas of low to medium densities, and only two are located in high densities. Therefore, there are only about 7% that are located in low to medium areas of

Figure 33 Number of antennas in each density range

density, 89% are in areas of medium density, and 4% in areas of high density. Figure 34 is a pie chart illustrating these values.

Based on these two maps, the population density of *Centro Storico* is generally spread evenly throughout. However, there are a few spots of very high and very low densities. Because the population of Venice is evenly spread out, it cannot be demonstrated that the antennas are too close to large groups of people and the bell towers are not. It can be said that there are more bell tower locations allowing more options to place the antennas in the lowest population densities as possible. However, we took the analysis a

Figure 34 Number of bell towers in each density range

step further, by mapping the same fifty-five bell towers and twenty-one antennas of *Centro Storico* in relation to the population density of children ages 0-13. These are also shown in the maps in Appendix A. The scale is of lesser values for these maps than of that for the general population. From the first map, which correlates the antenna locations to the population of children 0-13 years of age, one can see that there are about 30% in low densities, 70% in the medium densities, and zero in the higher densities. In comparison, one can observe that 30% of the bell towers are in the low densities, about 64% are in the medium densities, and only about 6% are in the high densities.

From these two maps, we found that the population of children was also evenly spread throughout, and that children this age were few in number. The antenna map shows that a majority of the antenna locations are in low to medium concentrations of children. The bell towers are found in all concentrations though a majority of them were in low to medium concentrations. Again, this demonstrates that the bell tower locations offer many possibilities to place the antennas in the least concentrated areas possible.

In conclusion, we found that the concentration of people in Venice is evenly spread and therefore it is difficult to keep the antennas as far from the population as possible. However, on average, bell towers are the highest structures in Venice and are usually surrounded by *campos*. For these reasons they are both vertically and horizontally far from the population and are therefore better than present antenna locations. This is demonstrated in the simulation done by Ericsson shown in Appendix E.

5.1.2 Aesthetics

In addition to raising health concerns, the antennas of Venice also cause aesthetic damage to its architecture. Our definition of an aesthetically damaging antenna is one that is visible. With this in mind, a visible antenna is any cellular antenna that a person, with no prior knowledge of it, could easily locate in passing. An example of such antenna is shown in Figure 35, which shows an Omnitel antenna on the island of Burano.

Figure 35 An Omnitel antenna on the island of Burano

On the other hand, a non-visible antenna can be defined as any antenna that is not seen by the commoner's eye. Today, companies are hiding their antennas more and more by covering them with fiberglass that blends in with the background, or simply camouflaging the antenna to match what it is attached to, such as a wall of a tower as visualized in Figure 36. This antenna is a Wind antenna located on Piazzale Roma.

Figure 36 A paintied WIND antenna at Piazzale Rome

To demonstrate the aesthetic damage caused by the antennas, we created "before" and "after" photos of the antennas we surveyed in field work using photo editing software in order to illustrate what the area would look like if there were no antenna present. An example of this is shown in Figure 37.

The first picture shows the area with the antenna in it. This particular antenna is visible from the north, south, east, and west. The second picture shows what the location would look like if the antenna were removed. These photographs are visual proof of the aesthetic damage caused by antennas. More can be seen in Appendix D.

Figure 37 A before and after picture of an antenna on Pellestrina

To further demonstrate the aesthetic damage of antennas, we recorded the visibility of the antennas during fieldwork. To do this, we noted if it could be seen within a fifty-meter radius from the north, south, east, and/or west as described in Chapter 4. We then defined degrees of aesthetic damage. If the antenna was visible from only one side it was considered in the first degree of aesthetic damage. If it was visible from two sides then it was of second-degree aesthetic damage, and so on until the fourth degree of aesthetic damage, which is the worst case. To help one visualize this thought process the following chart in Figure 38 has been provided:

Figure 38 Antenna prioritization flow chart

Out of the thirty-one antennas assessed in fieldwork, we found that twenty-one, or 68%, of them were found to be visible and ten of them, or 32%, were not. The eleven visible antennas of *Centro Storico* are labeled in the map in Figure 39. Of these there are two TIM, five Omnitel, and four WIND.

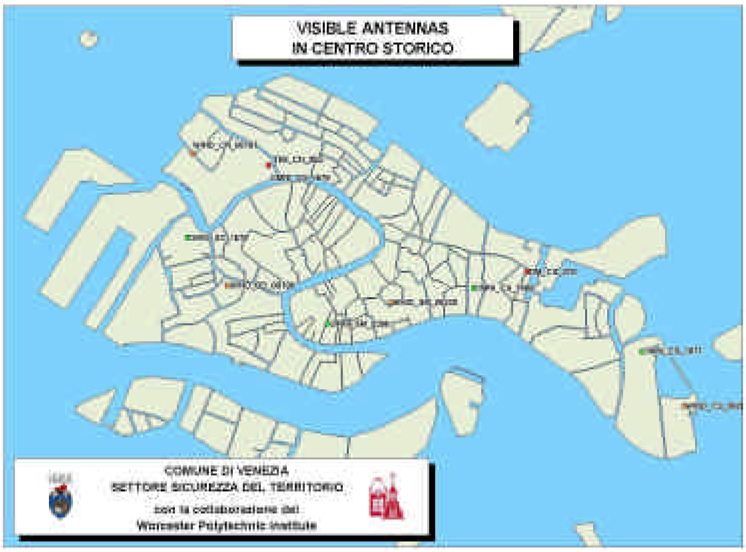

Figure 39 Visible antennas in *Centro Storico*

Based on the visibility data (whether it was visible from the north, south, east, and/or west) collected on these antennas, the following percentages were found. Out of the twenty-one visible antennas, ten antennas, or 48% of them, were visible from all four sides, which designated them as the fourth degree of aesthetic damage. Exactly three antennas, or 14% of them, were in the third degree of aesthetic damage; and four antennas, or 19% of them, were in the second degree of aesthetic damage. The final four, or last 19%, fell into the least aesthetically damaging category, or the first degree of aesthetic damage. The pie chart shown in Figure 40 illustrates these percentages.

From this data, we can see that a majority of the antennas in Venice are indeed visible, and therefore could be moved based on aesthetic reasons. Based on the degrees of aesthetic damage, 48% of the antennas in Venice fall into the most severe degree. If only aesthetic reasons were considered in antenna relocation, then they should be moved in order of degree of severity. Venice has such unique architecture that draws tourism, which in turn fuels its economy. Therefore, aesthetics alone is enough reason to motivate the city to move the present antennas into hidden locations.

Figure 40 Amount of antennas in each degree of aesthetic damage

5.1.3 Venetian Regulations

Our third rationale for moving the antennas is in terms of the new Venetian laws that were created with aesthetics and health in mind. To review, these two laws state that no freestanding antenna can have an inhabited building within a ten meter radius of it (regulation 1); also, no building within a fifty meter radius of any antenna can be higher than that antenna (regulation 2). Though the present antennas are grand-fathered in their present locations and cannot be forced to leave, some of them are not in compliance with new regulations and it is important to note them. To analyze these antennas we did the following shown in Figure 41:

Figure 41 Antenna movement flow chart

There are a total of six freestanding antennas in Venice. Of these six, there were four antennas not in compliance with the first regulation, all of which are owned by TIM. For regulation 2, we were only able to check on thirteen antennas out of the thirty-one since those were the only antennas we could obtain heights for based on the authorizations. Of these thirteen, we found that only one was not in compliance with this regulation. The locations of five of these antennas are shown in the map of Figure 42.

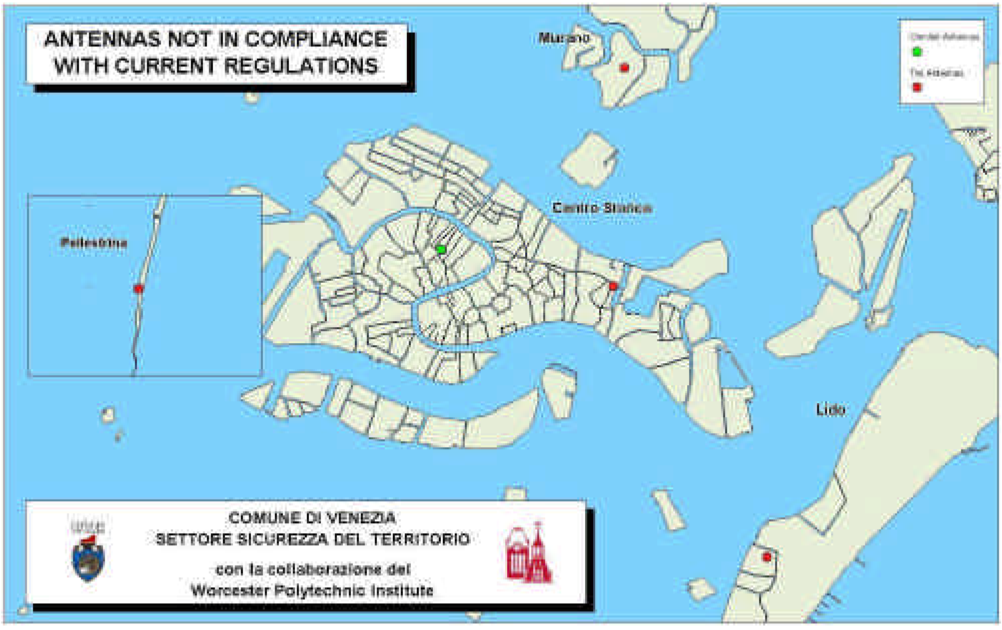

Figure 42 Antennas not in compliance with current regulations

They are spread throughout Venice with one on Murano, two on the *Centro Storico*, and two on the Lidi. The antennas shown above could be recommended for relocation based on the fact that they are not in compliance with the new Venetian regulations. It is important to note that there could be even more antennas in this category, but we did not have enough information to evaluate them.

5.2 Summation

The goal of this analysis was to show that bell towers are feasible locations for antenna placement and to provide motives for relocating present antennas or establishing new ones in the towers. Bell towers proved to be feasible locations for these reasons:

- There are ample bell towers to choose from for coverage and to place them in low concentrations of people
- Bell towers are surrounded by *campos*, and are generally the tallest structures of Venice
- The belfry of the structure could easily conceal the antenna
- There are seventy-seven bell towers within Venetian regulations for antenna sites
- 83% of them are at optimal height for antenna placement

Next we established why present antennas should be moved. These are:

- A third of them are located near sensitive sites
- 68% of them are aesthetically damaging
- Five (at least), though grand-fathered in their present location, are out of new Venetian regulation

From this analysis the *Settore Sicurezza del Territorio,* is provided with both reasons to move antennas, as well as evidence that bell towers are good locations for antennas. In the following section, we will make recommendations on how they could best utilize our research for their purposes.

Chapter 6 Recommendations

In considering the reasons of health concerns, aesthetics, and new Venetian regulations, we set out to define whether or not bell towers are feasible locations for antenna placement. To accomplish this we surveyed both bell towers and antennas, created catalogs of them and compared the two locations. From this process we determined that bell towers are feasible sites for antenna installation, and continued to make assertions for the *Comune's* benefit. We assessed existing antennas and bell towers according to aesthetics, health and regulation parameters. These were a basis to formulate relocation plans to the bell towers as well as to provide sites for new antennas. At this point, we went one step further by making suggestions as to how the *Settore Sicurezza del Territorio* should apply our research and approach both the church government, or the *Curia*, and the companies, (TIM, Omnitel, WIND, Blu, and one new unknown provider). When the *Settore Sicurezza del Territorio* approaches these organizations they must be knowledgeable in every aspect of their proposal and be prepared for any question these cellular providers or bell tower owners may pose. In the following sections, we will explore the conflicts and concerns that all three parties may face during the process, as well as recommend a plan of action for the *Settore Sicurezza del Territorio* to take into consideration.

6.1 Antenna Placement

We felt that it would be useful to provide the *Settore Sicurezza del Territorio* with some ideas on types of information and avenues to pursue when approaching cellular companies. From our breakdowns of antenna and bell tower properties in our analysis, we developed various plans dealing with antenna placement. An innumerable amount of strategies exist which can be implemented based upon our results. However, by our own assessments we proposed two plans on possible antenna assignments. These show the flexibility of the bell tower locations and how the *Comune* could solve the various issues addressed throughout this project. Hopefully, these proposals will help them initiate further analysis on the possibilities for antenna placement. Our first suggestion includes moving all of the present antennas, and then assigning sites to the new providers. The second is to concentrate on evenly distributing bell towers for future installation. During this process we attempted to disperse bell tower locations according to our prioritized levels in analysis. These plans focused on the *Centro Storico*, since this is where the concentration of antennas and bell towers are located. There are sixty bell towers and twenty-three antennas. TIM has six antennas, Omnitel has eight, WIND has nine and there are two more providers to come. Ideally, each of these providers should have an equal number of antennas; therefore we used nine as the number a provider should have.

Before allotting bell tower locations, we attempted to understand the current cellular provider's coverage to place credibility to our thought process. This was important because we wanted to maintain their present coverage as best as possible. Maintaining this coverage is an ideal situation because it makes moving the antennas a realistic possibility. However, it was difficult for us to make judgements on what the coverage is. This was especially hard when trying to relocate antennas into bell towers while following the priority list. We realized that simply moving the antennas to a nearby location to maintain coverage, as initially thought, was not definitive enough. It was important for us to know a limit on how far to move an antenna to a higher priority even if a lower one was closer to the present antenna location. In order to do this we plotted the individual locations in the *Centro Storico* of all three providers. For the providers, a mark of the halfway point between each of their antennas was made. Assuming that each provider has coverage over all of *Centro Storico* we used the halfway points as markers to designate where we thought one antenna's coverage may extend. Once these maps were made we noticed a correlation between providers and their respective antenna locations. From this, we felt that we could partially understand their coverage. This estimation allowed us to better place antennas when creating the proposals. The map we used for the Omnitel antennas is shown in Figure 43, those for TIM and WIND are in Appendix G.

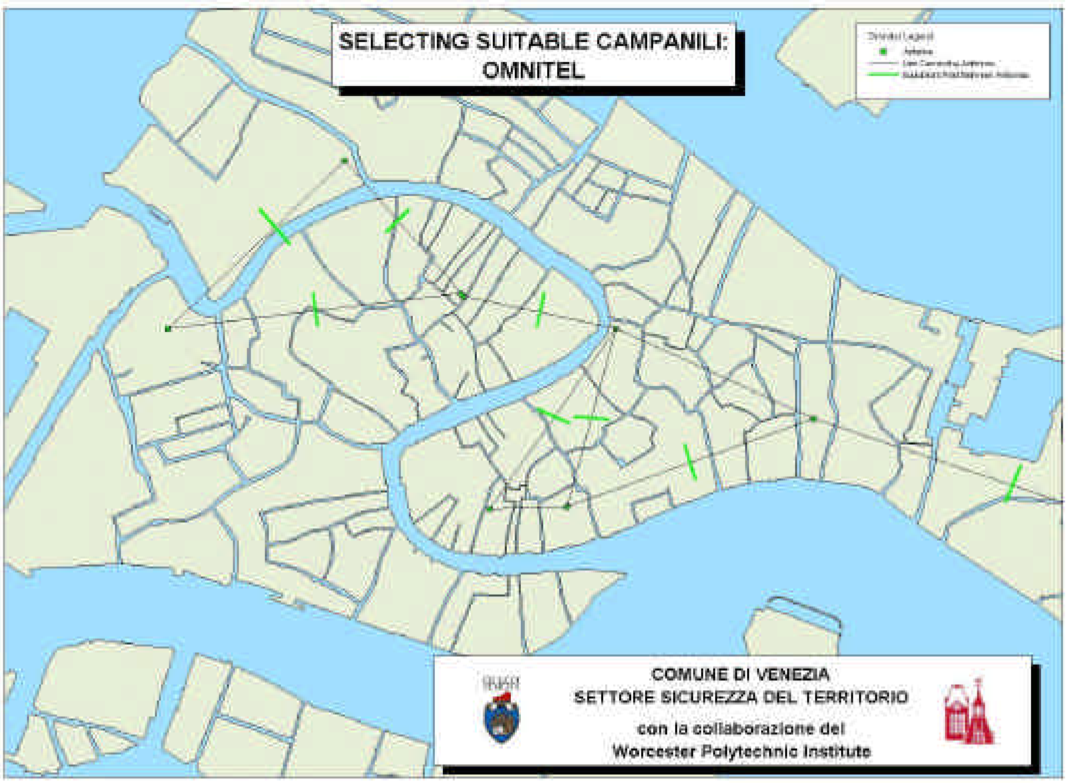

Figure 43 Selecting suitable bell towers for Omnitel

6.1.1 Plan 1

Our first proposal is to initially move all of the existing antennas and distribute the sixty bell towers to new and current providers. This is the ideal outcome because aesthetically the antennas would be hidden in the best possible manner and exposure to radiation would be minimized. We moved all the antennas by first relocating the two out of regulation and then the existing antennas within regulation. We then assigned the new providers locations. There were some situations where our estimated coverage was used to make difficult judgements. These included when there was a cluster of antennas or when a high priority bell tower was slightly farther away from an antenna than a low priority one. With both situations we attempted to place an antenna in the highest priority bell tower without compromising coverage.

An example of when our estimated coverage was used is shown in Figure 44. There is a TIM and WIND antenna within the vicinity of each other surround by scattered bell towers, most of lower priority. The dashed lines indicate the estimated TIM and WIND coverage. Here, we had a dilemma on whether or not to give away two third priority bell towers or a third priority and a second priority. Due to the orientation of the coverage we chose the bell tower of San Felice for TIM and the bell tower of San Stae for WIND.

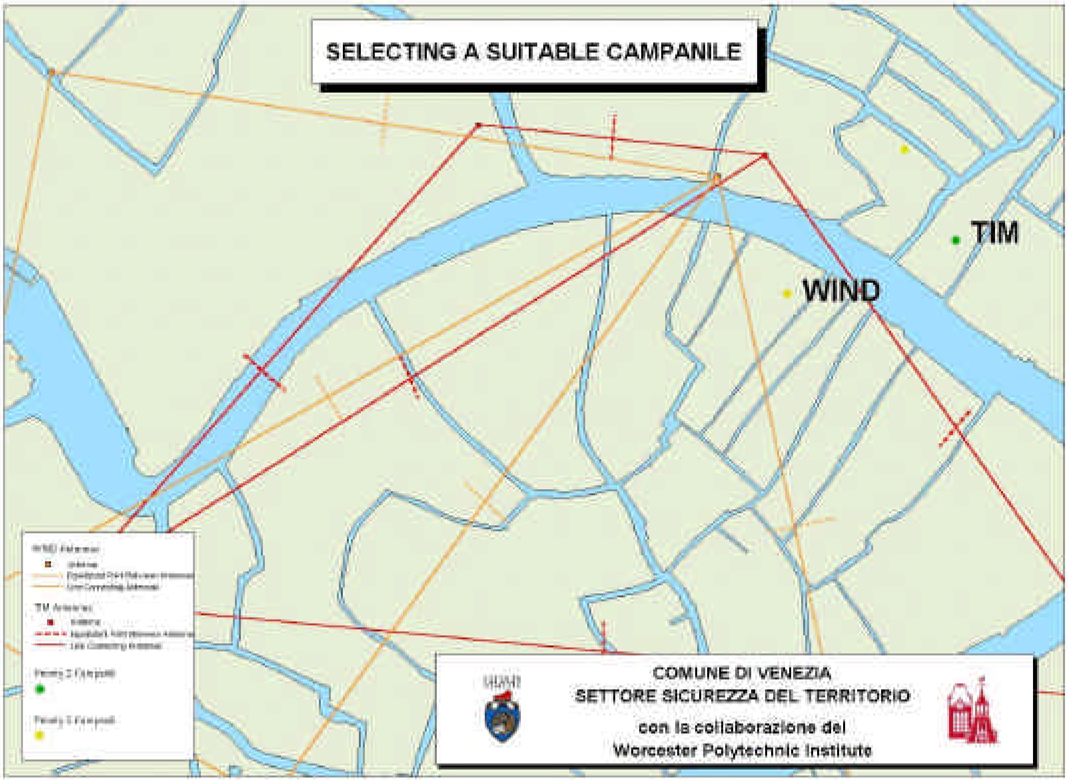

Figure 44 Using maps such as this, we determined which bell tower would be most suitable according to the antenna's current location

Lastly, the two new providers were also assigned bell towers. We knew that one company is named Blu, and we named the other New Company . To distribute these locations, we evaluated the three perceived coverage plans of the providers. We looked for key points such as where they seemed to have the most coverage. After studying them we located the areas that seemed to have the highest concentration, those being the sestiere of Santa Croce, San Polo and San Marco. We used this to give the new companies more bell towers in those areas, and not as many in others. Blu and New Company received nine locations each. This plan can be seen below in Figure 45. Twenty-three first priority, seven second priority, thirteen third priority and one fourth priority bell towers were used.

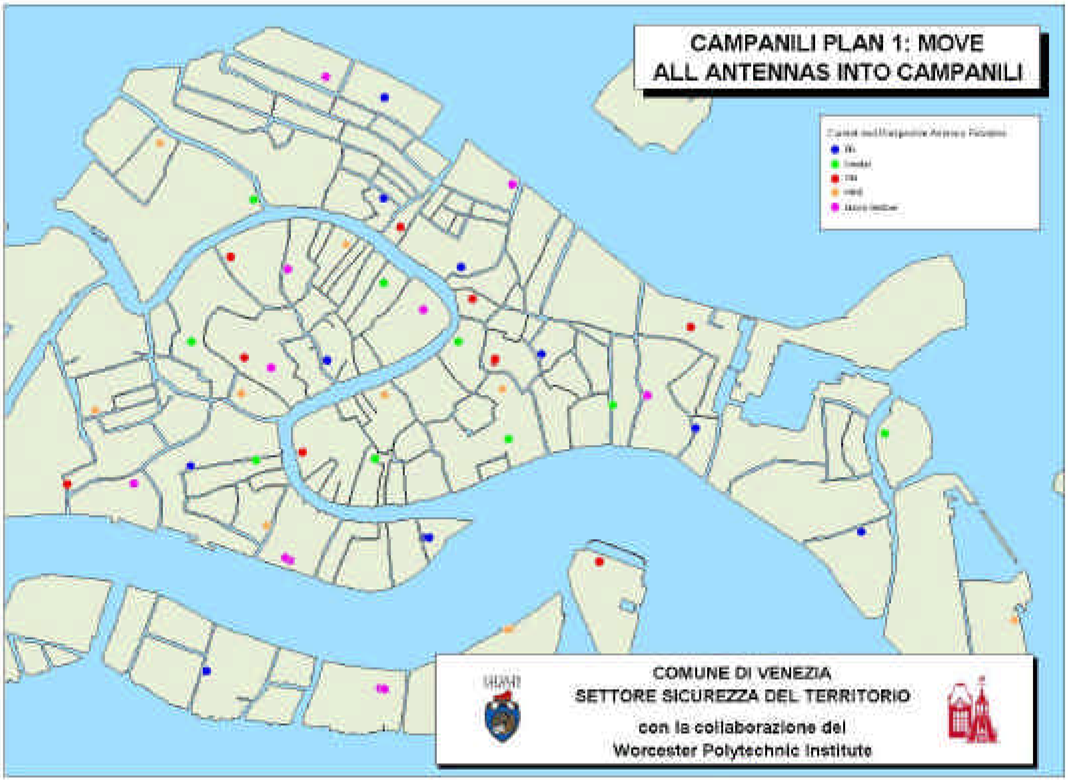

Figure 45 First plan of bell tower distribution

6.1.2 Plan 2

Our second proposal accounts for the possibility that only the existing antennas not in compliance with new regulation will be moved. We anticipated that the present cellular providers are not going to be cooperative with the idea of moving any of their antennas from their existing locations. The expense to them is greater than $50,000 and, unless the benefits outweigh the costs, will most likely not agree to the proposal. Unfortunately, although this plan is realistic, it does not significantly improve the current aesthetic situation nor does it improve health risks. However, it does serve to prevent any further damage to Venice.

To begin we moved the two antennas out of regulation and then proceeded to distribute the rest of the bell towers to the two new providers. There were two main things to account for which were: 1) each provider received nine antennas and 2) their current cellular coverage. The first is important because we wanted to show that bell towers provide ample space for antenna placement. The second criteria considers those antennas which will not move. We did not want to give companies locations where they already had coverage. For example, when we distributed TIM bell towers we looked at areas where they needed service. After moving the two out of regulation, we gave the two incoming companies, Blu and New Company locations. To do this we consulted the coverage plans reviewed earlier and attempted to mimic the present locations of antennas. Next, TIM only has six sites, therefore we assigned them three more bell towers for a total of nine locations. TIM was given sites where they seemed to lack coverage in comparison to WIND and Omnitel. Since Omnitel has eight antennas, we assigned them one more bell tower for a total of nine. This map can be seen in Figure 46.

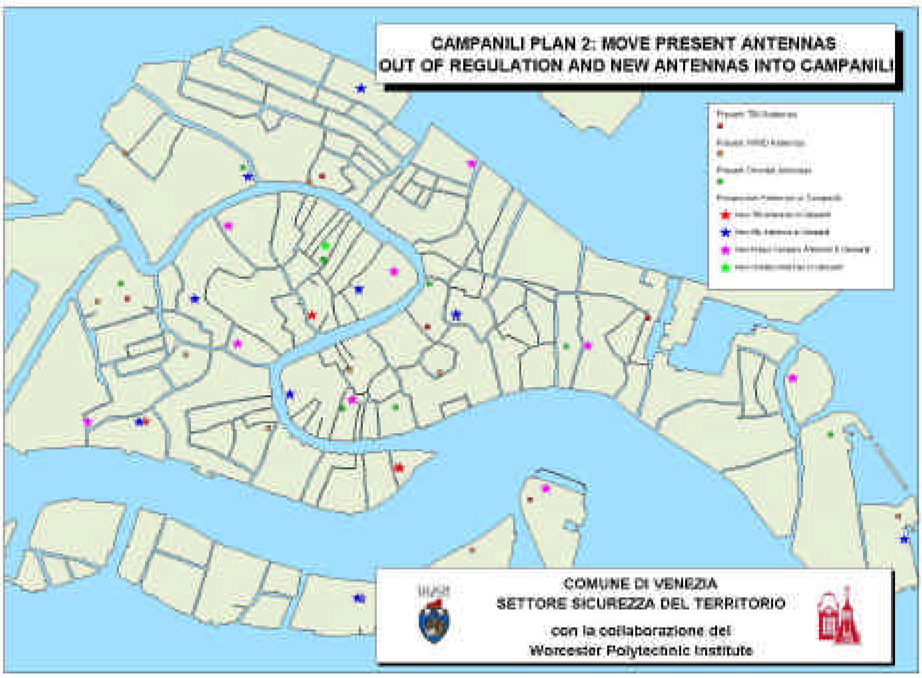

Figure 46 Second plan of bell tower distribution

6.1.3 Plans' Evaluation

As further analysis, we can only establish that these plans should be used as mere suggestions. They are a basis of ideas for the *Settore Sicurezza del Territorio* to formulate their own proposals. It is the type of analysis that we feel they should make on the locations. Although we made the best educational assumptions according to our capabilities, we are not experts. The field of cellular technology is quite complicated and only professionals with specific equipment and software programs can make accurate evaluations on antenna sites. A major reason for this is that each company uses different systems, those being DCS, GSM and TACS, that operate on different frequencies. Based on this and other reasons, the individual providers have their own locations that give them strategic coverage. Therefore, without this knowledge, it would be unreasonable for us to claim that these plans could be implemented. However, we are suggesting that approaches such as these are the best avenue.

6.2 A Mock Proposal

From our conferences with Ericsson, we obtained a sample format of how they propose a site to a company. If the *Settore Sicurezza del Territorio* organizes projected plans on coverage in the bell towers to show the companies, they should be prepared with ample information relevant to each site. Every site they propose is usually illustrated within four sections. The first section shows antenna installation and other general information and a street map with its location marked. The second section displays a photograph of the site, along with the height and coordinates of any obstacles within the vicinity of the site. The third section displays an aerial view of the site and its immediate surroundings, as well as a map of the buildings within its surrounding. The final section of the proposal gives a panoramic view as seen from the exact antenna location to the north, south, east, and west to give the cellular provider an idea of the type of area the location is in, as well as any obstacles they may be up against.

We feel that the *Settore Sicurezza del Territorio* should present the bell towers as antenna locations to the cellular providers in the same way. For their benefit, we created our own version of this proposal on San Georgio dei Greci, shown in Appendix F.

6.3 Approaching Cellular Providers

The *Settore Sicurezza del Territorio* can approach the companies once they have reviewed our research, proposed plan of coverage, and our catalog illustrating bell tower locations. We feel that they should address the companies first in order to investigate the source of the problem before approaching the solution. It is important to have a projected plan with them before addressing the *Curia*. There are different tools that the government of Venice uses to deal with issues such as this one. The three which we are proposing to use are education, incentives and regulation. Based on these tools, we are making suggestions that the *Settore Sicurezza del Territorio* may want to consider when they approach the companies.

6.3.1 Education

Initially, the *Settore Sicurezza del Territorio* should state their intentions concerning alternate locations for present as well as future antennas, and then explain why they are concerned about antenna locations.

They should divide the discussion, just as we have, into reasons of health, aesthetics, and regulations, and technical aspects. In the end of the discussion they should offer the companies incentives for implementing their proposal.

In terms of health concerns, the companies are well aware of all the studies that have been conducted, as they research the topic themselves. In light of this fact, the *Settore Sicurezza del Territorio* can state that bell towers are the best location health wise considering their positioning relative to residents. In addition they can explain that although in the past there have not been strict health regulations on antenna placement, new ones have recently been instituted, and there may be more in the future.

In terms of aesthetics, the *Settore Sicurezza del Territorio* should explain that the antennas detract from Venice's architectural beauty, which is what attracts tourism and fuels the economy. As proof through visual aid, they can then show the "before" and "after" photos that we created, of certain antennas (as show in Appendix D). The photographs were taken of the antennas as they appear on the buildings and were then altered to show the building without the antenna. These clearly demonstrate the negative effect the antennas have on the historical significance and architecture of Venice.

To remind the companies, the *Settore Sicurezza del Territorio* should restate the two new regulations. They are that no building within fifty meters of an antenna can be higher than it, and second that no freestanding antennas can have any buildings within a ten meter horizontal radius. They can then present the company with our maps showing their antennas not in compliance with new regulations.

Next, we recommend that they use the Ericsson simulation to further exemplify the benefits of bell tower locations. Most importantly, they should illustrate that, in terms of technical aspects, bell towers are excellent antenna sites. The simulation illustrates to the company that the height of the bell towers allows the antenna to be placed at a higher elevation resulting in fewer obstacles and better coverage. The increase in height portrays that residents (in the surrounding area) are exposed to less radiation. The simulation also shows an increase in current coverage if antennas were placed in specific locations.

This would lead the *Settore Sicurezza del Territorio* into their final summation of why the bell towers are plausible locations for the antennas. Using the maps we created, they can show all of the feasible bell towers that are available. Also, based on our research the *Settore Sicurezza del Territorio* can then inform the companies of the benefits the bell towers offer. These are: a height range optimal for antenna performance, they are all within Venetian regulations, and they are the best possible location in terms of health concerns. We have produced many maps that the *Comune* can utilize to illustrate these findings. These are found in Appendix A.

As a final possibility, the *Settore Sicurezza del Territorio* may also want to get an estimate price of what it would cost the company to install an antenna in the belfry of the bell towers. Most likely, it is cheaper than many of their present locations. This is due to the fact that the bell towers are already at the optimal locations for antenna performance and therefore would not need to build a tower for more height. Instead they would only need to be attached to the belfry. At this point, the *Settore Sicurezza del Territorio* could give an example of a feasible bell tower site using the format shown in Appendix F as we described in the "mock proposal section".

6.3.2 Incentives

After this informational session, the companies may need to be given additional incentives. It will cost the companies a substantial amount of money to relocate their antennas and will most likely a source of adversity. To compensate for this, a possible incentive for the *Settore Sicurezza del Territorio* to offer is a tax break. Because Venice is dense and much of it has historical significance, there is minimal room for new structures, or additions to buildings. As a result, taxes and rent within Venice are extremely high. If the *Settore Sicurezza del Territorio* offers the companies a tax break, they are increasing the companies' annual profits dramatically. Hopefully, this will persuade them to consider either moving their antennas, and/or placing future antennas in the bell towers.

6.3.3 Regulations

As a final approach, the government could utilize and impose new regulations. Notably, the government can not make new laws that would make the companies move their present antennas nor can they make laws to require companies to use bell towers for new antenna locations. Beforehand, we described the two new regulations on antenna placement that Venice recently established. As found in our analysis there are five existing antennas not within new regulations, and there may be more as we did not have enough information to check them all. These five antennas are grand-fathered in, meaning they do not have to comply with any new regulations imposed by the *Comune*. Presently the cellular market is switching over from their current systems of transmission (such as TACS, GSM and DCS) to a system known as UMTS that will allow a wide variety of options to consumers. Venice has released five bids, and at the moment four of those have been given to TIM, Omnitel, WIND and Blu, while the last is still unknown. This means that the current providers may want to upgrade all of their antennas. As the companies do this they are altering the structures that are supporting the antennas, introducing the possibility of having to be updated to new regulations. If this takes place then at least five of the established antennas will need to be moved.

6.3.4 Cornering the Market

A completely different option for the *Comune* to consider is cornering the antenna market in Venice. With this new system (UMTS) coming into the market, they could buy their own antennas, and install them into the bell towers with the help of a company like Ericsson for technical details. As the companies make the switch over, the *Comune* could offer their antennas for rent. To make their locations enticing to the companies they could offer low rent, or a type of tax break as stated before.

6.4 Approaching the Curia

Once it has been established that the companies decided to either move their present antennas and/or put new antennas in bell towers, permission for installation must be obtained. To do this, the *Settore Sicurezza del Territorio* would need to contact the owners (recorded in our bell tower catalog). Out of the seventy-seven feasible bell towers, seven are owned by the government, one is privately owned, and the Curia owns the remainders. Therefore the seven owned by the government do not need approval and can already be considered as possible antenna locations. We recommend that the *Settore Sicurezza del Territorio* approach both the private owner and the Curia in a similar manner to which they approached the companies: educate them, and then show benefits as well as provide incentives. Again, they should state why bell towers improve upon antenna's effects on health and aesthetics. However, with the exception of possibly stating that antenna performance would stay the same or improve, it is not important to discuss the technical aspects with either the Curia or private owners, unless this knowledge is desired.

6.4.1 Educate

The *Settore Sicurezza del Territorio* should be more in depth on their health descriptions, and less technical with the Curia and private owners than they were with the companies. They should take the time to fully explain the health concerns involved followed by why the bell towers are the best location for antennas in Venice as far as health is concerned. Finally, the new regulations should be explained as the final motivation to relocate the antennas.

Concerning the aesthetics, the *Comune* can use the same information as they used for the companies. However, the Curia and the private owners will be extremely reluctant to install an antenna on their towers for reasons of aesthetics and structural stability. To lessen their worries, the *Settore Sicurezza del Territorio* can have Ericsson install a *moc* antenna. A *moc* antenna is a fake antenna installation for the purpose of allowing the property owner to make a judgment on antenna installation. From this they would find that the antenna is attached to the inside of the belfry, with no drilling through the shaft, and is therefore barely visible from the outside and poses minute structural strain on the towers.

6.4.2 Incentives

There are actually several implied incentives as far as the church is concerned. The major incentive is the money they will receive as rent from the cellular provider. However, the church is a non-profit organization and if the antenna was placed in their bell towers they will become a profitable organization. For profitable organizations the municipal government imposes a tax on property otherwise known as *Imposta Comunale sugli Immobili* (ICI), which the churches would be forced to pay. Our suggestion would be for the churches to sign an agreement with the municipal government, exempting them from the tax. However, certain conditions would apply. The money will either have go to restoration and up-keep of the church and bell tower, or to their charity of choice. Another hidden incentive for the church is that they are doing their part to keep their parishioners healthy, as well as to improve on the aesthetics of their community.

In terms of a private owner, the major incentive would also be the rent from the companies. However, they will be taxed on the new property value created by the addition of the antenna. For this dilemma we thought of two suggestions. First, the municipal government could either lower their ICI tax significantly, or exempt the owner from having the added tax altogether. The second suggestion would be for the company to pay the tax for the owner as part of their rent fee. Other then a profit, the private owner can also benefit from the health aspect where the antennas would now be farther away from their family and friends. Finally, they would also be benefiting their community by hiding the antennas and restoring the aesthetics of their city.

6.5 Summary

In conclusion, we have provided research, functional databases, catalogs, maps, graphs, charts and other tools to fully support the *Settore Sicurezza del Territorio's* quest to move present antennas or put future antennas in bell towers. We have recommended various approaches to important parties involved, utilizing components of health, aesthetics and law by means of three tools: education, incentive, and regulation. Hopefully, these suggestions will serve at minimum as a basis for further pursuit on this topic. With these tools they can take our recommendations or use their own plan to fulfill the goal, concealing cellular antennas within the beauty of bell towers.

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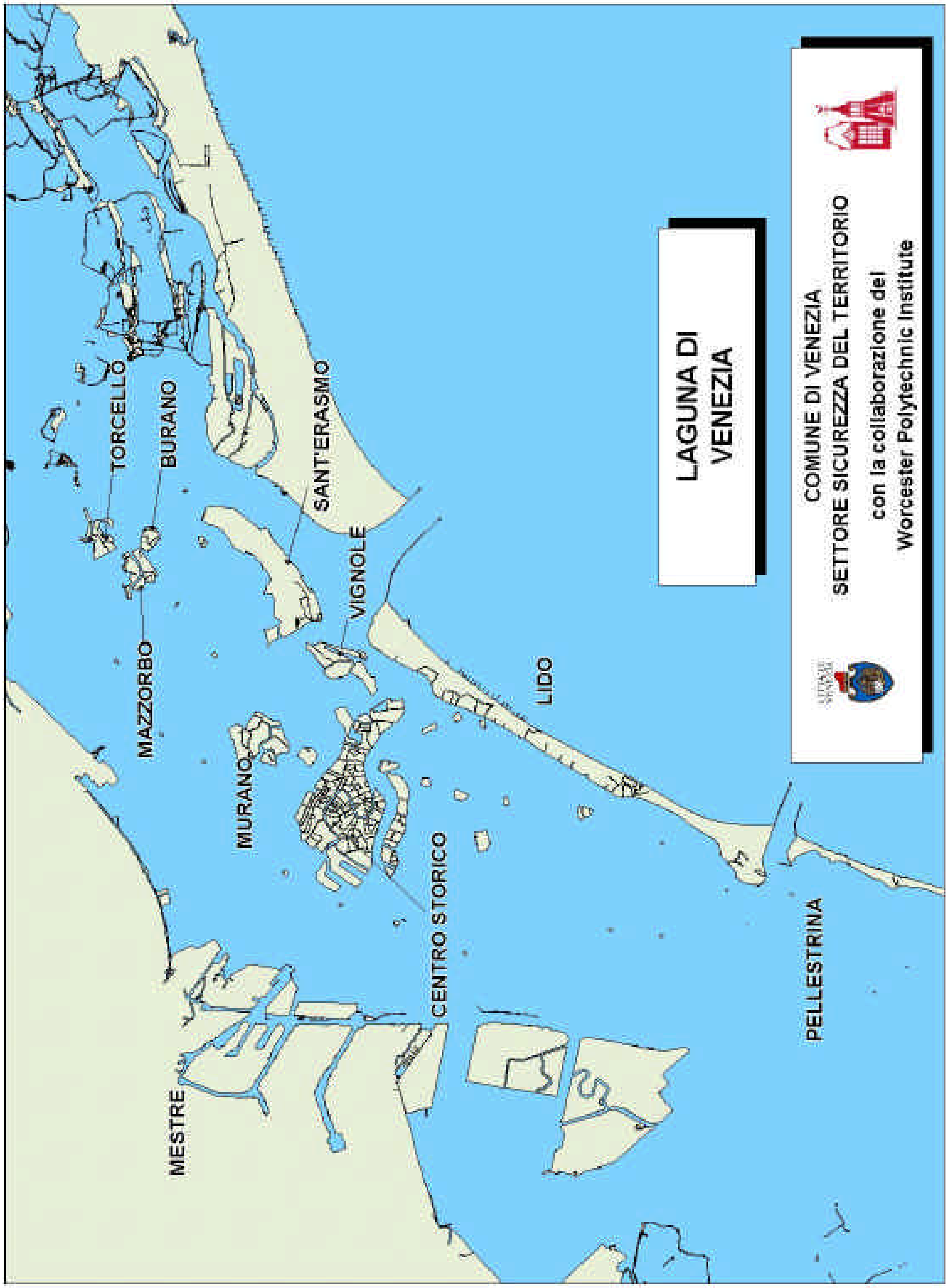
Chapter 8 Appendices

8.1 Appendix A: Maps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Worcester Polytechnic Institute
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PELLESTRINA
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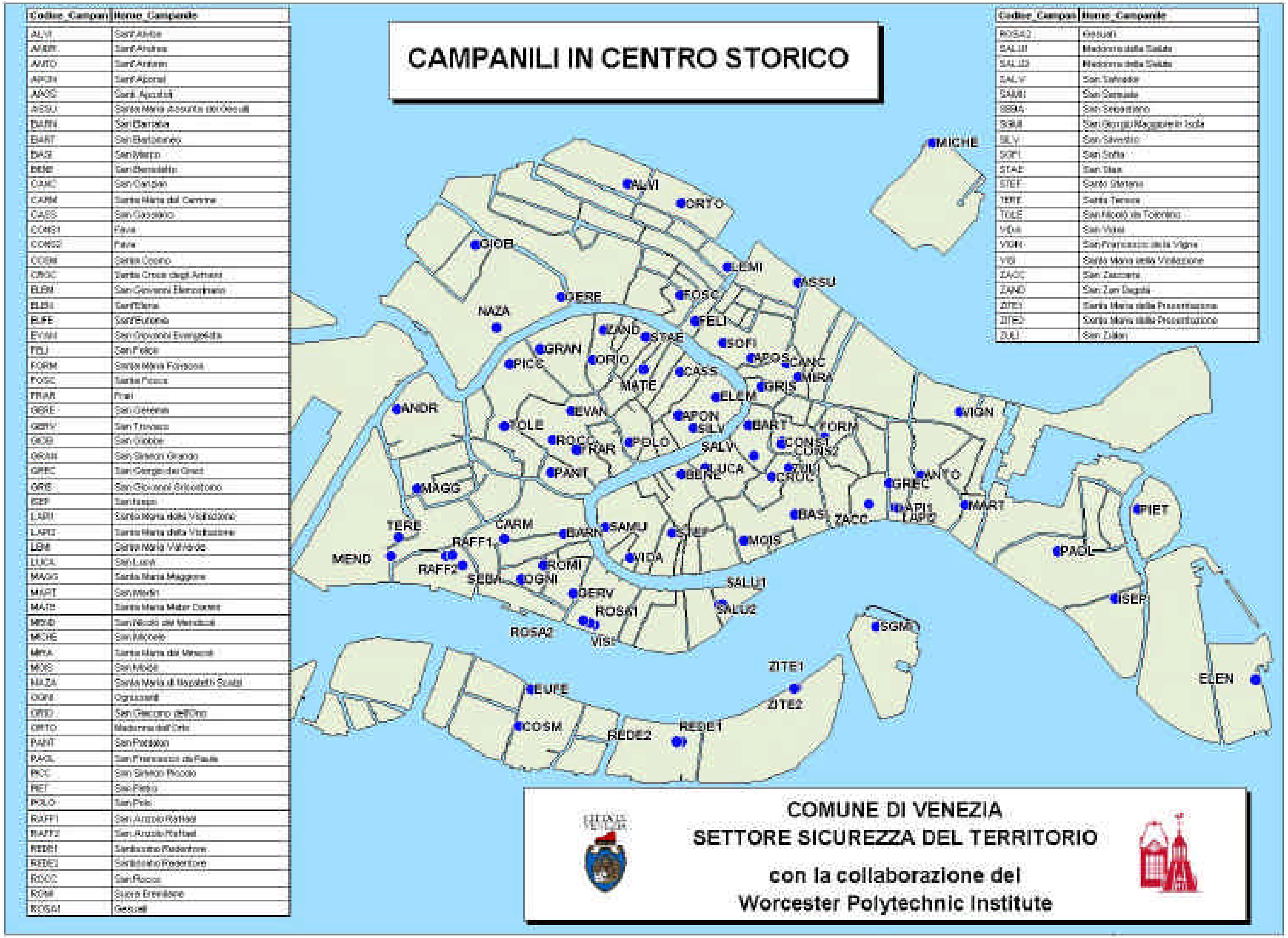

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ANDR	Sant'Andrea
ANTO	Sant'Antonin
APON	Sant'Aponal
APOS	Santi Apostoli
ASSU	Santa Maria Assunta dei Gesuiti
BARN	San Barnaba
BART	San Bartolomeo
BASI	San Marco
BENE	San Benedetto
CANC	San Canciano
CARM	Santa Maria del Carmine
CASS	San Cassiano
CONS1	Fava
CONS2	Fava
COSM	Santi Cosmo
CROC	Santa Croce degli Armeni
ELEM	San Giovanni Elemosinario
ELEN	Sant'Elena
EUFE	Sant'Eufemia
EVAN	San Giovanni Evangelista
FELI	San Felice
FORM	Santa Maria Formosa
FOSC	Santa Fosca
FRAR	Frari
GERE	San Geremia
GERV	San Trovaso
GIOB	San Giobbe
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GREC	San Giorgio dei Greci
GRIS	San Giovanni Grisostomo
ISEP	San Isepo
LAPI1	Santa Maria della Visitazione
LAPI2	Santa Maria della Visitazione
LEMI	Santa Maria Valverde
LUCA	San Luca
MAGG	Santa Maria Maggiore
MART	San Martin
MATE	Santa Maria Mater Domini
MEND	San Nicolò dei Mendicoli
MICHE	San Michele
MIRA	Santa Maria dei Miracoli
MOIS	San Moisè
NAZA	Santa Maria di Nazareth Scalzi
OGNI	Ognissanti
ORIO	San Giacomo dell'Orio
ORTO	Madonna dell'Orto
PANT	San Pantalon
PAOL	San Francesco da Paola
PICC	San Simeon Piccolo
PIET	San Pietro
POLO	San Polo
RAFF1	San Arcangelo Raffael
RAFF2	San Arcangelo Raffael
REDE1	Santissimo Redentore
REDE2	Santissimo Redentore
ROCC	San Rocco
ROMI	Suore Eremitane
ROSA1	Gesuati

Codice_Campan	Nome_Campanile
ROSA2	Gesuati
SALU1	Madonna della Salute
SALU2	Madonna della Salute
SALV	San Salvador
SAMU	San Samuele
SEBA	San Sebastiano
SGMA	San Giorgio Maggiore in Isola
SILV	San Silvestro
SOFI	San Sofia
STAE	San Stae
STEF	Santo Stefano
TERE	Santa Teresa
TOLE	San Nicolò da Tolentino
VIDA	San Vidal
VIGN	San Francesco della Vigna
VISI	Santa Maria della Visitazione
ZACC	San Zaccaria
ZAND	San Zan Degolà
ZITE1	Santa Maria della Presentazione
ZITE2	Santa Maria della Presentazione
ZULI	San Zulian


STAZIONI RADIO-BASE
IN CENTRO STORICO
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con la collaborazione del
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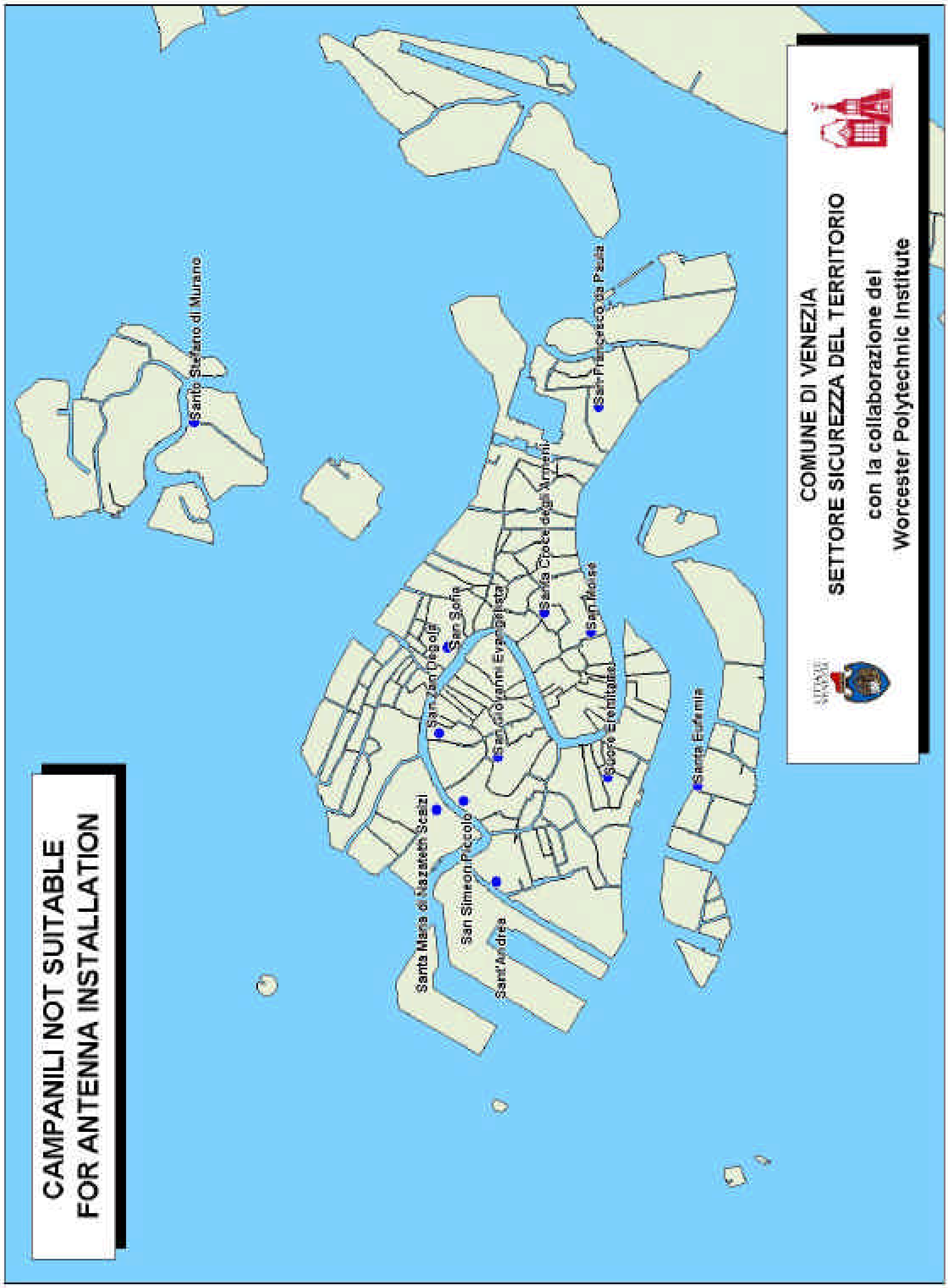
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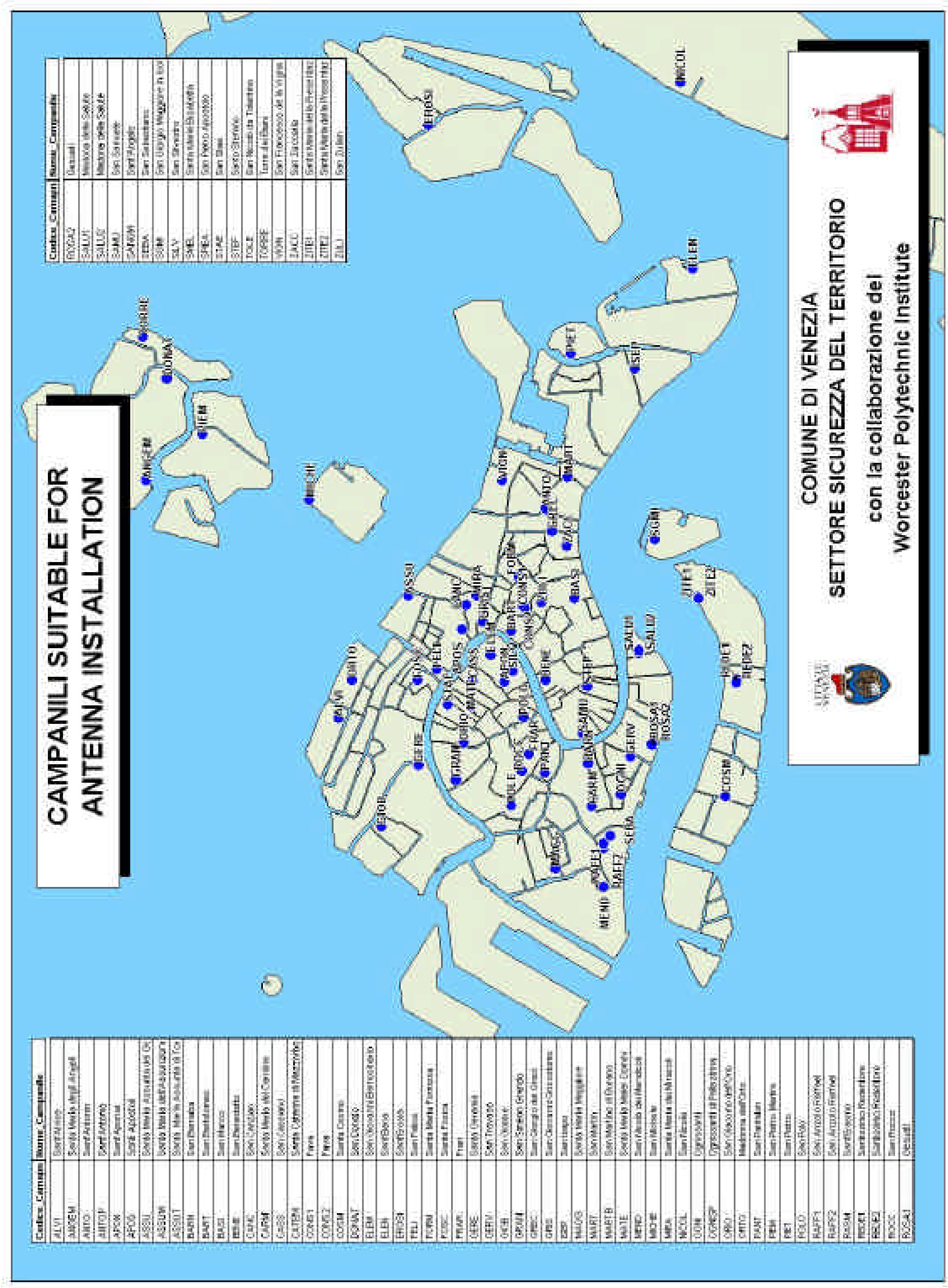
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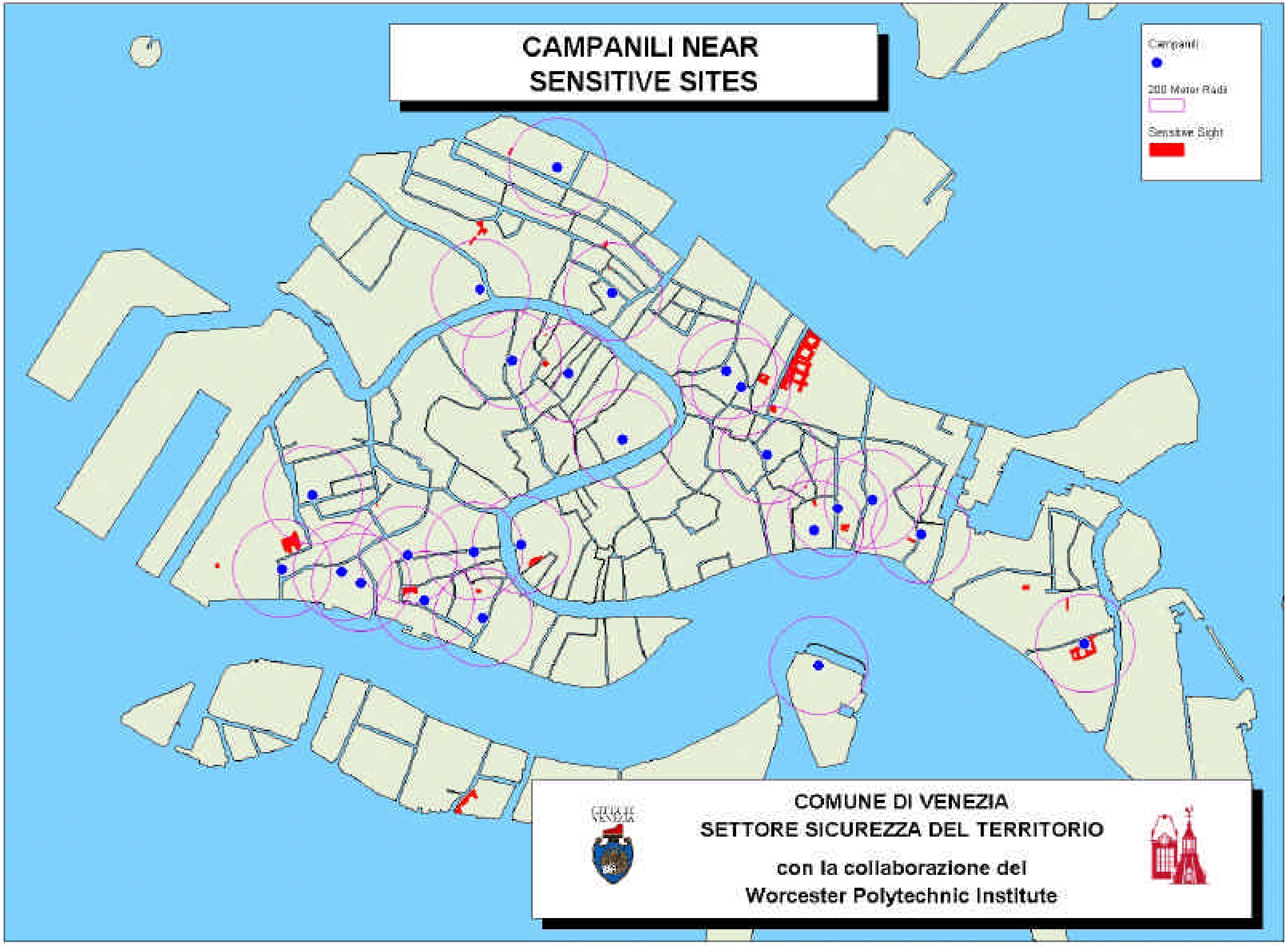
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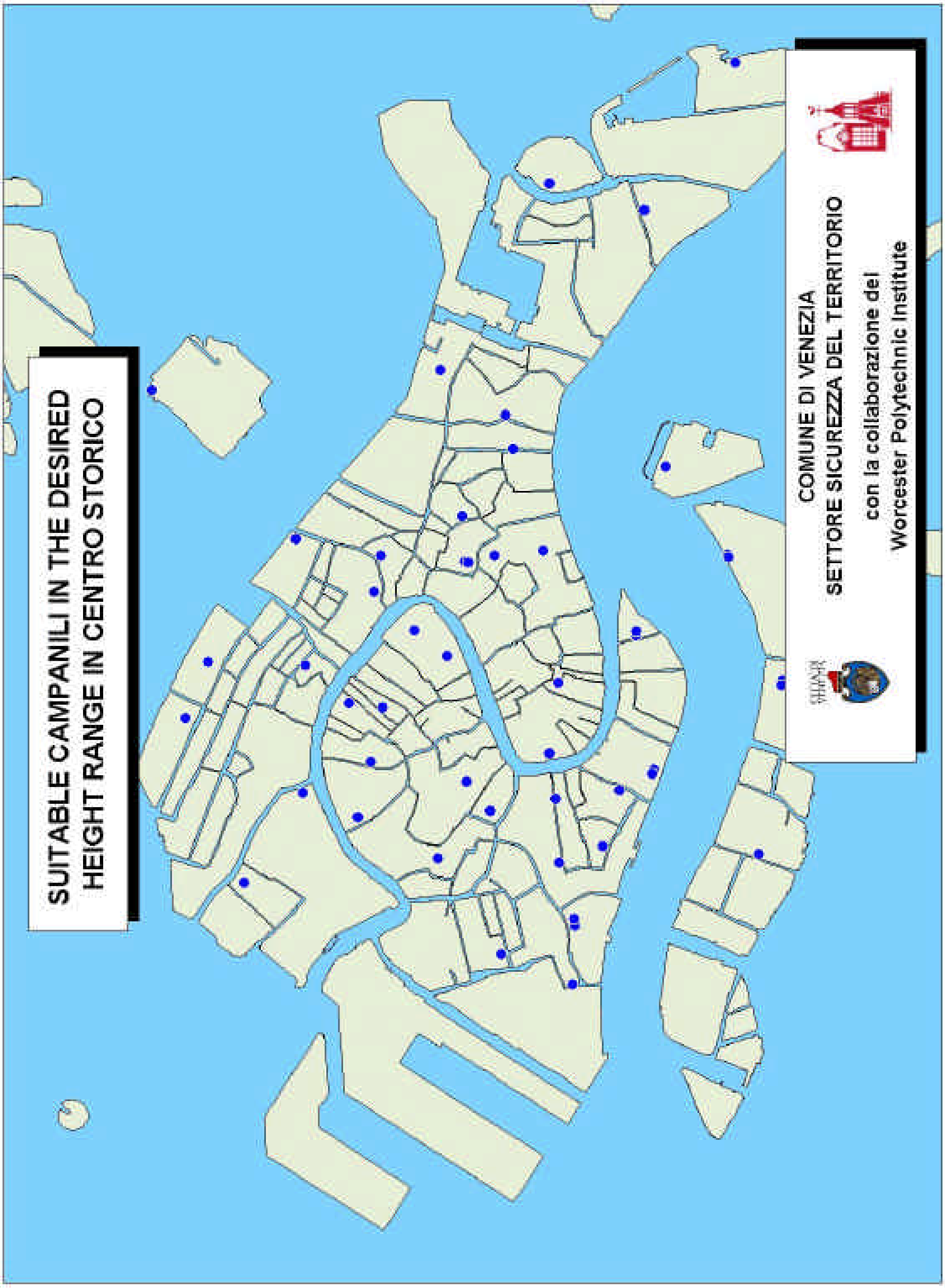
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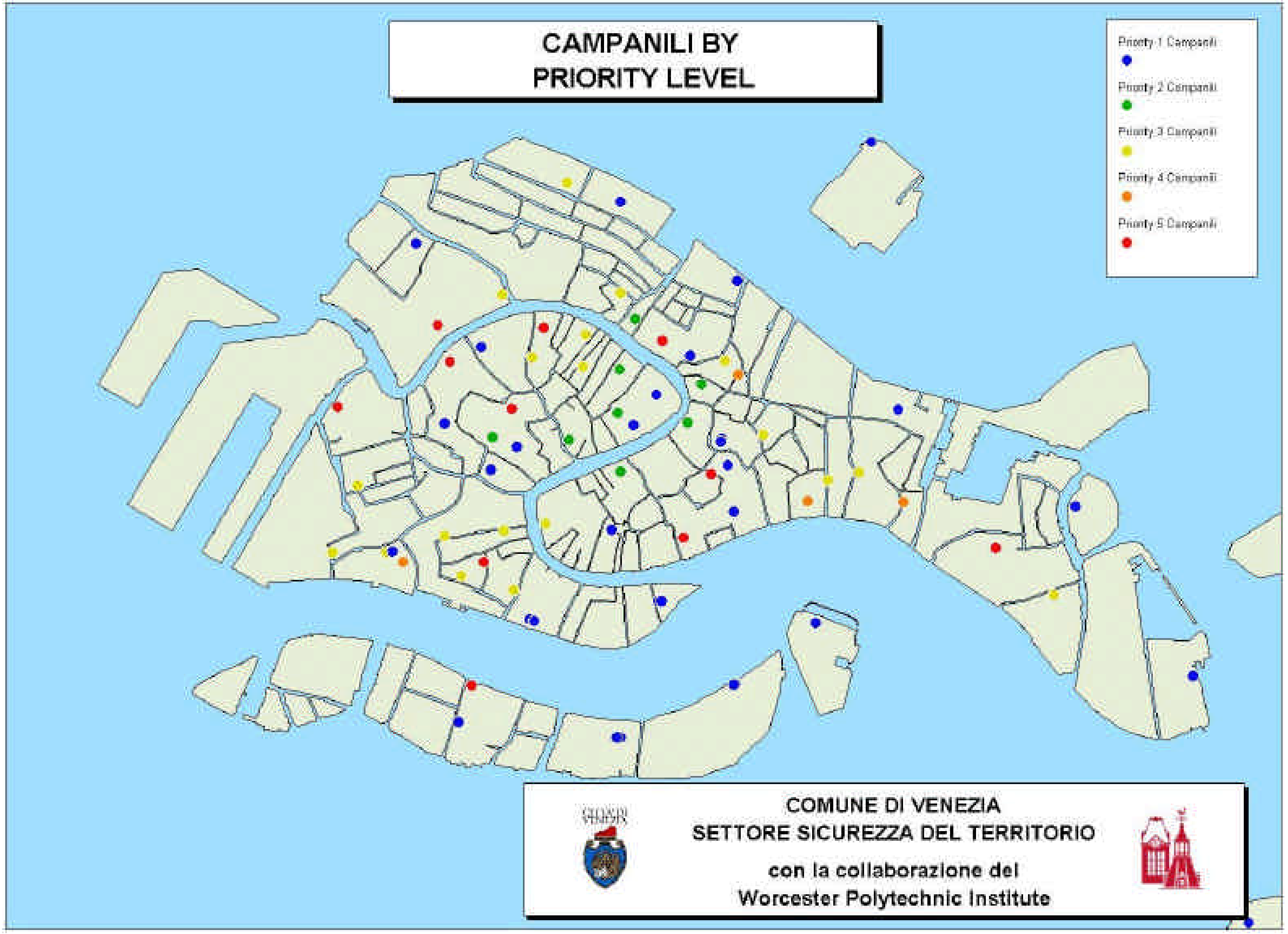
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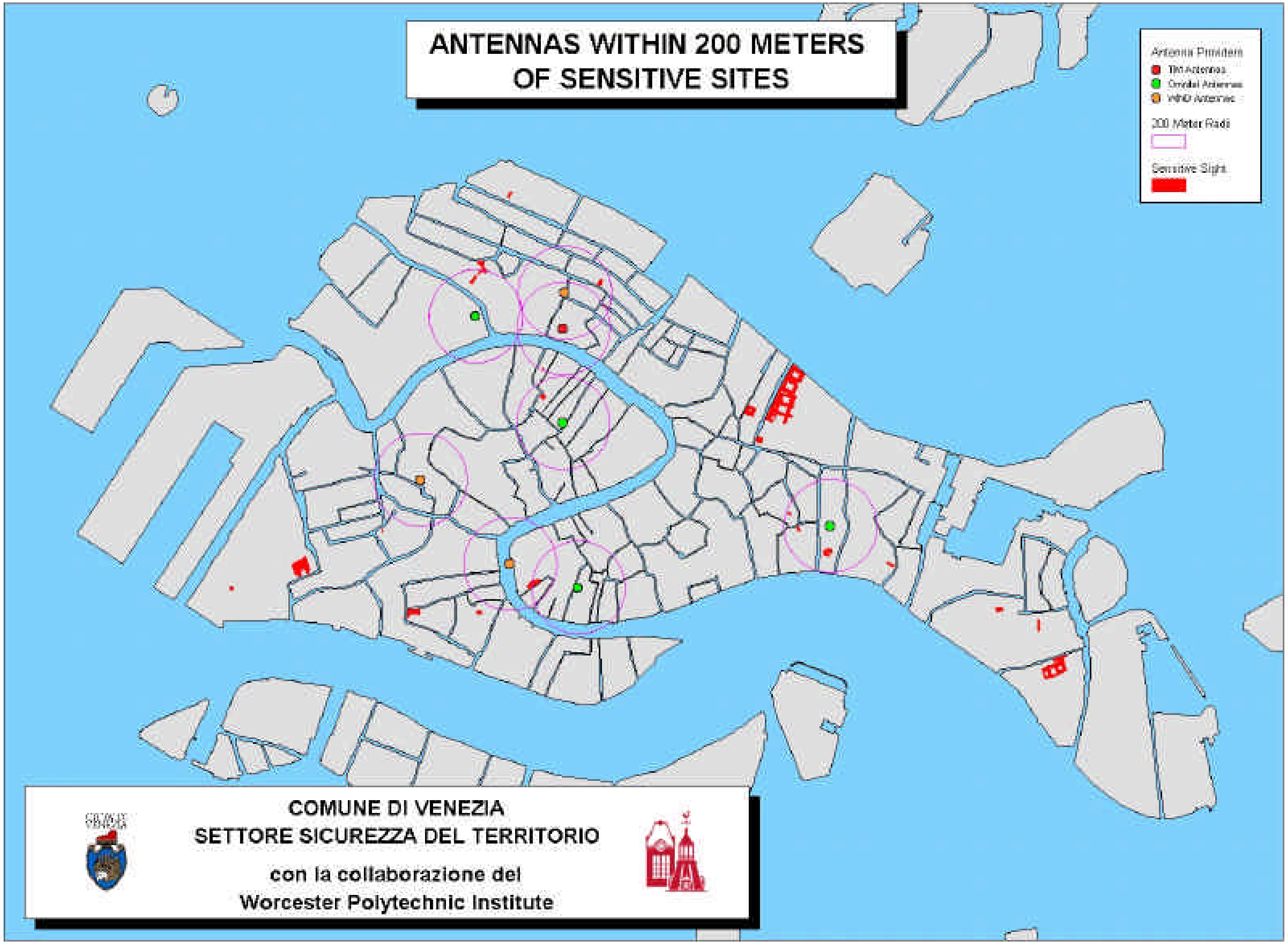
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con la collaborazione del
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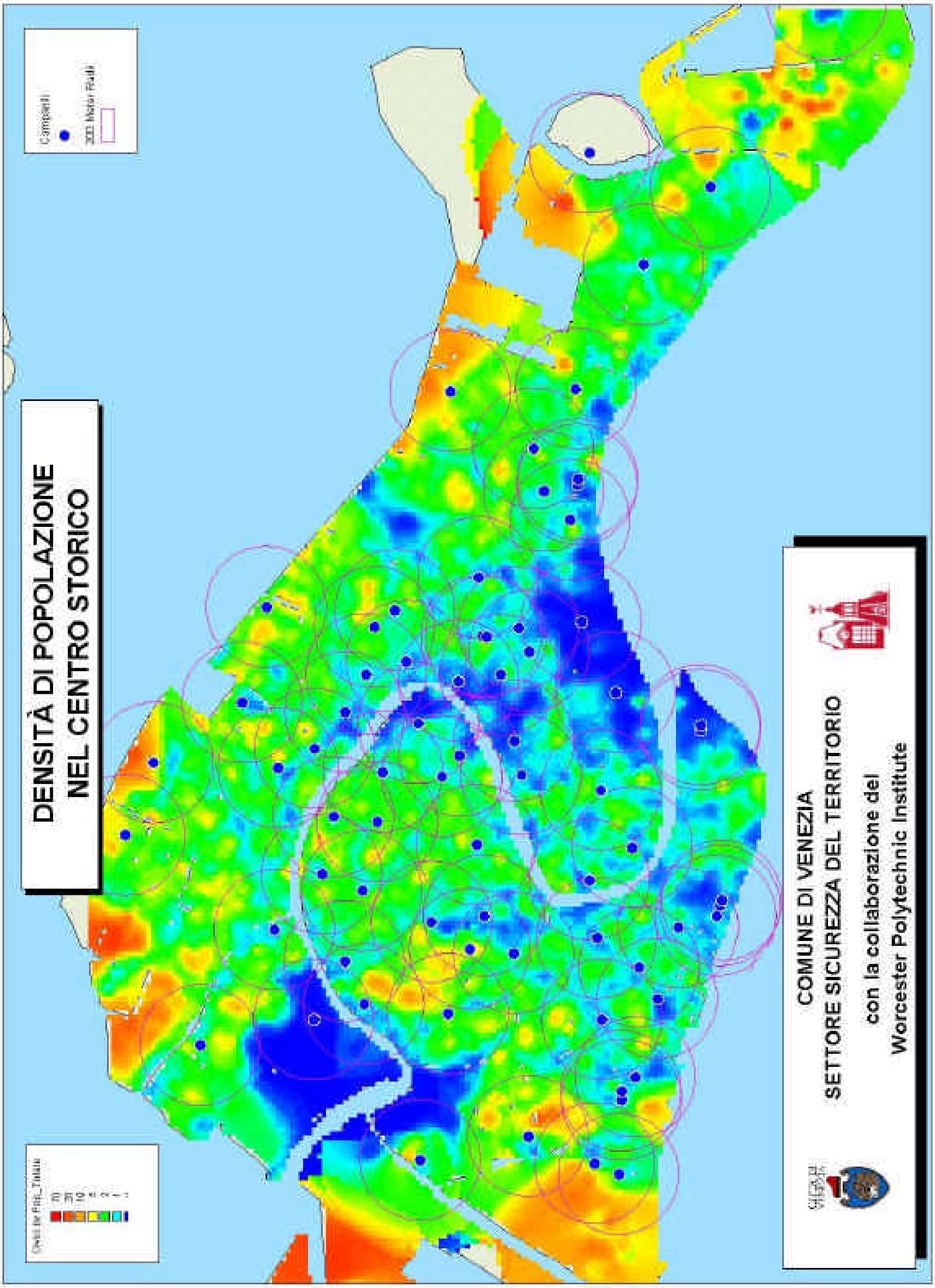
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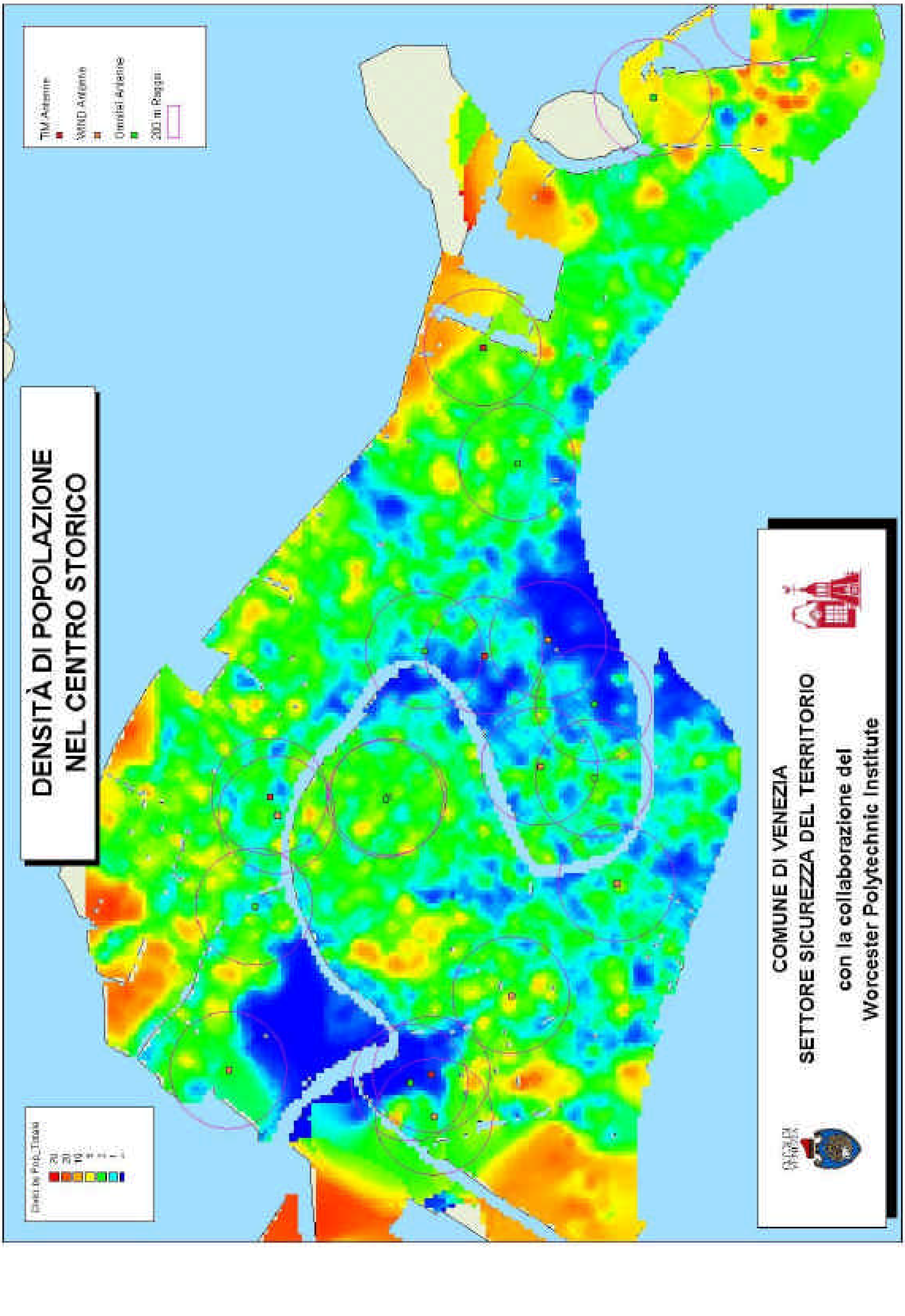
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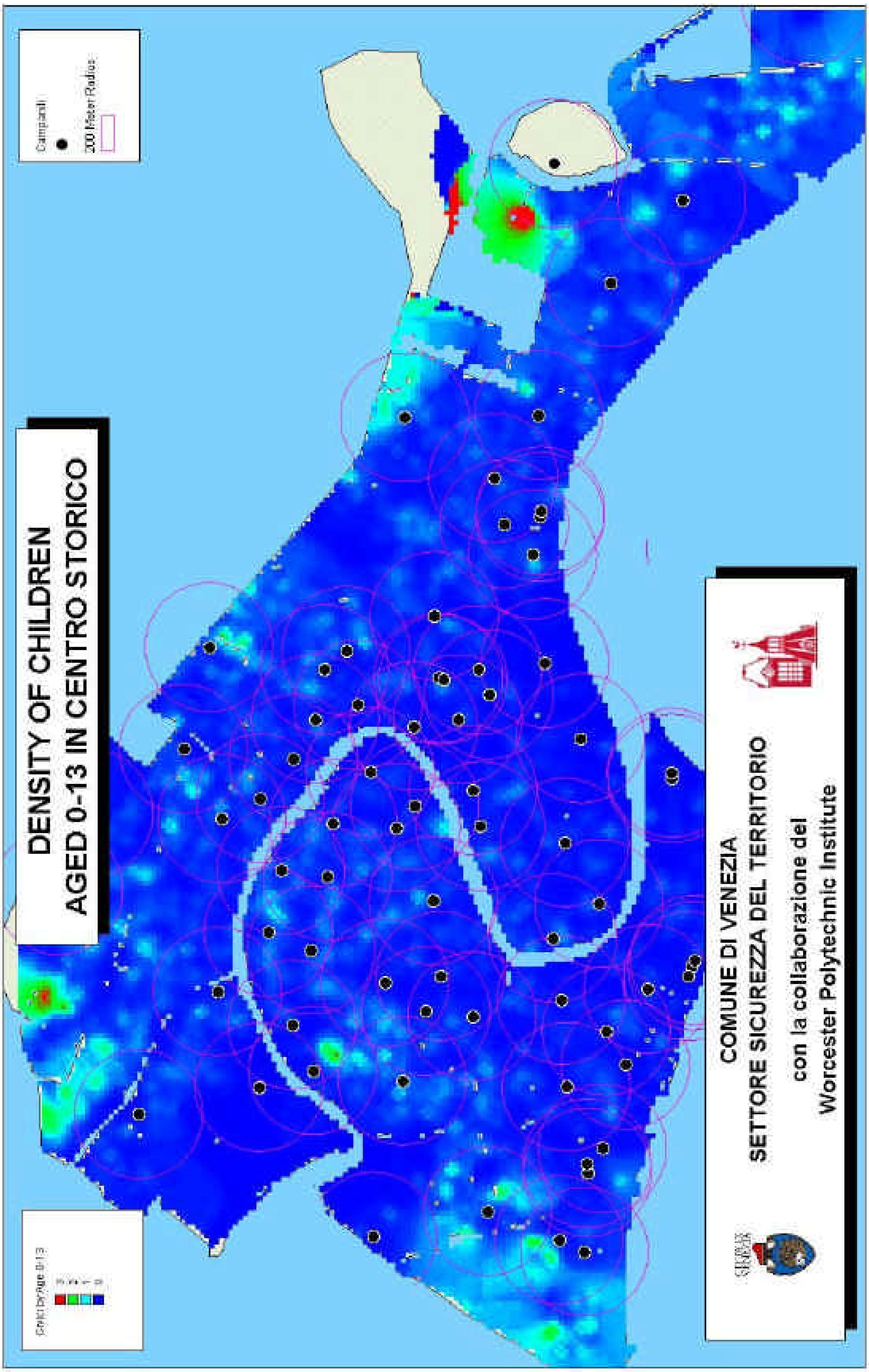
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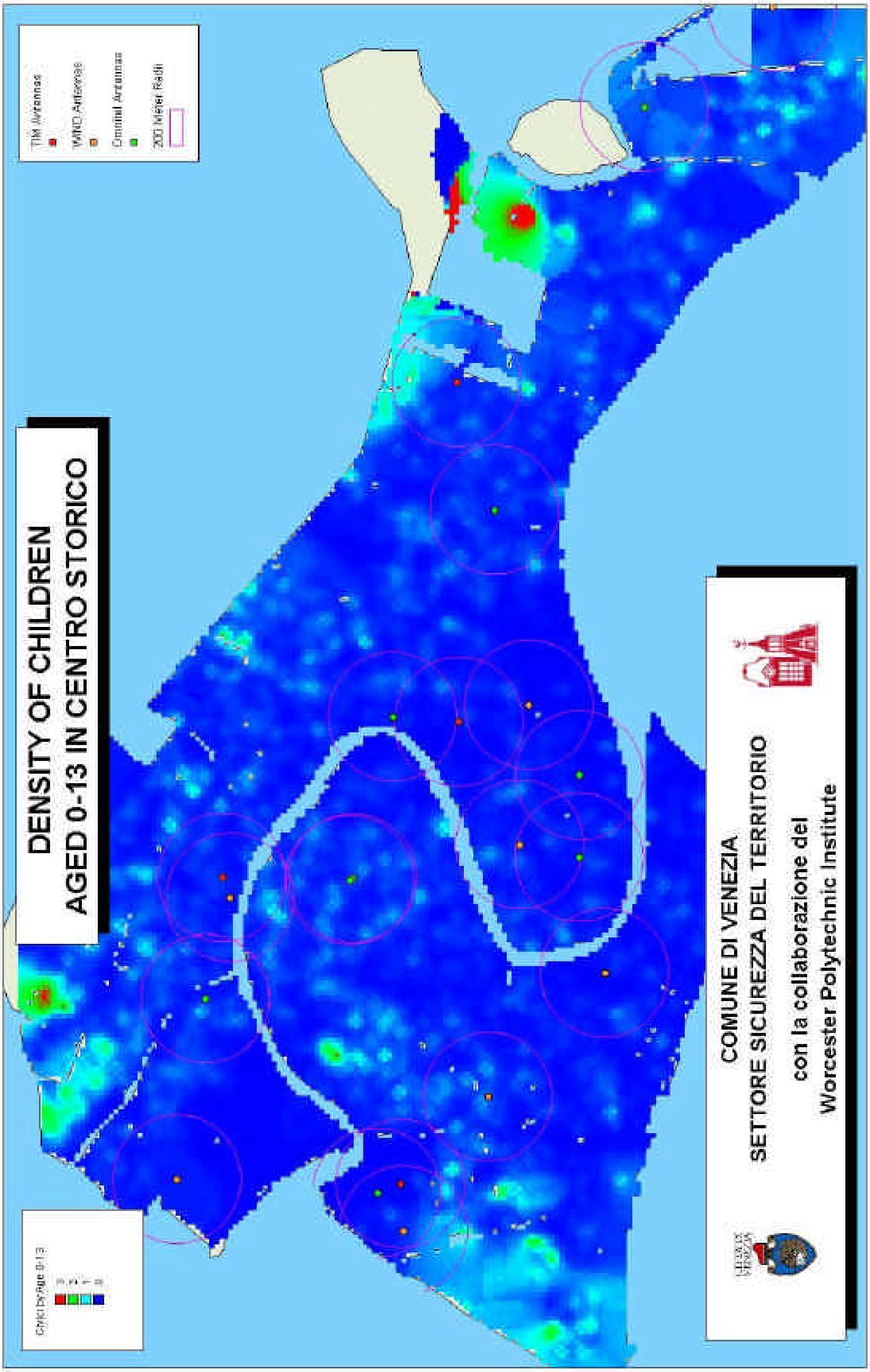
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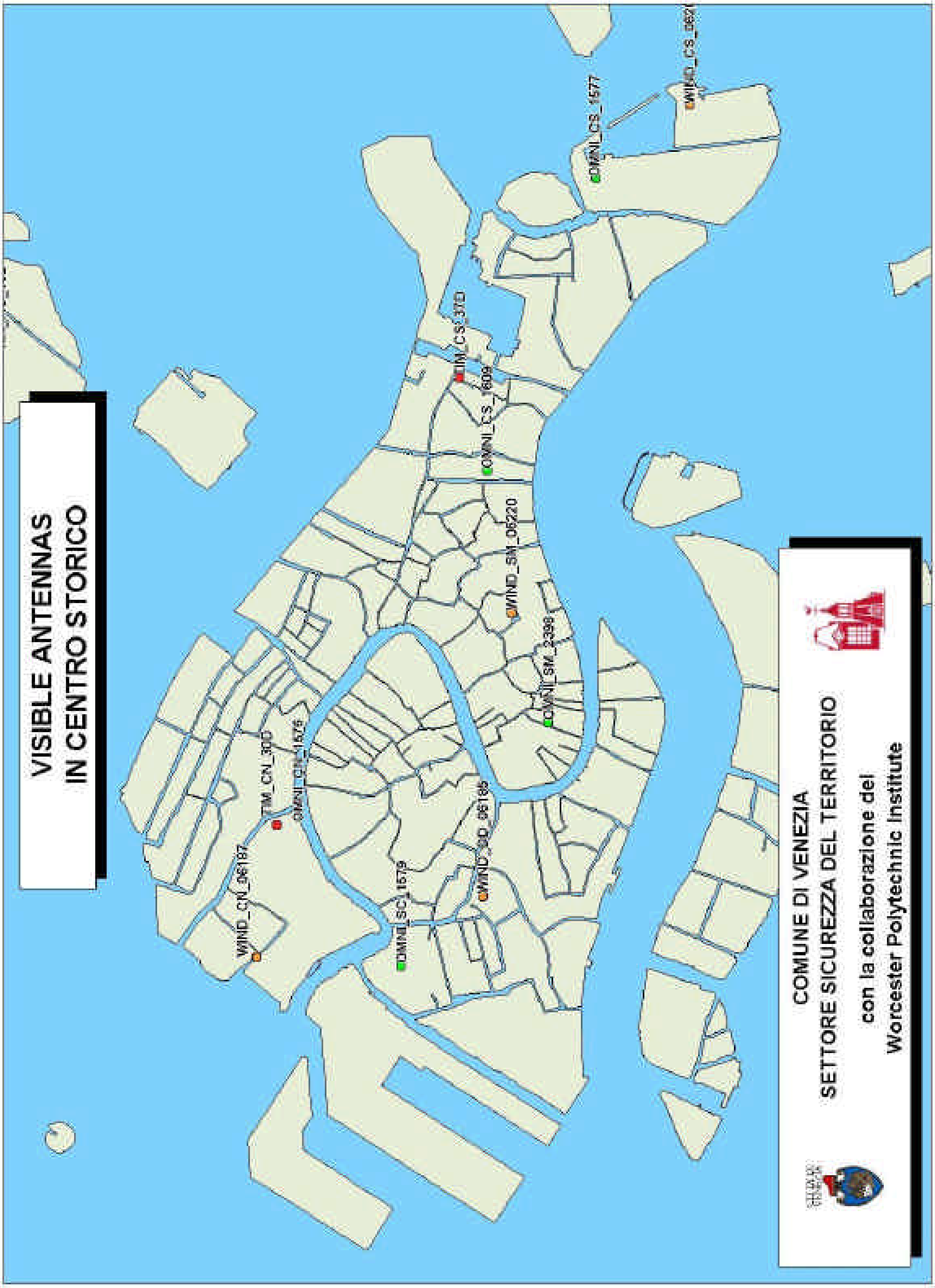
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COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
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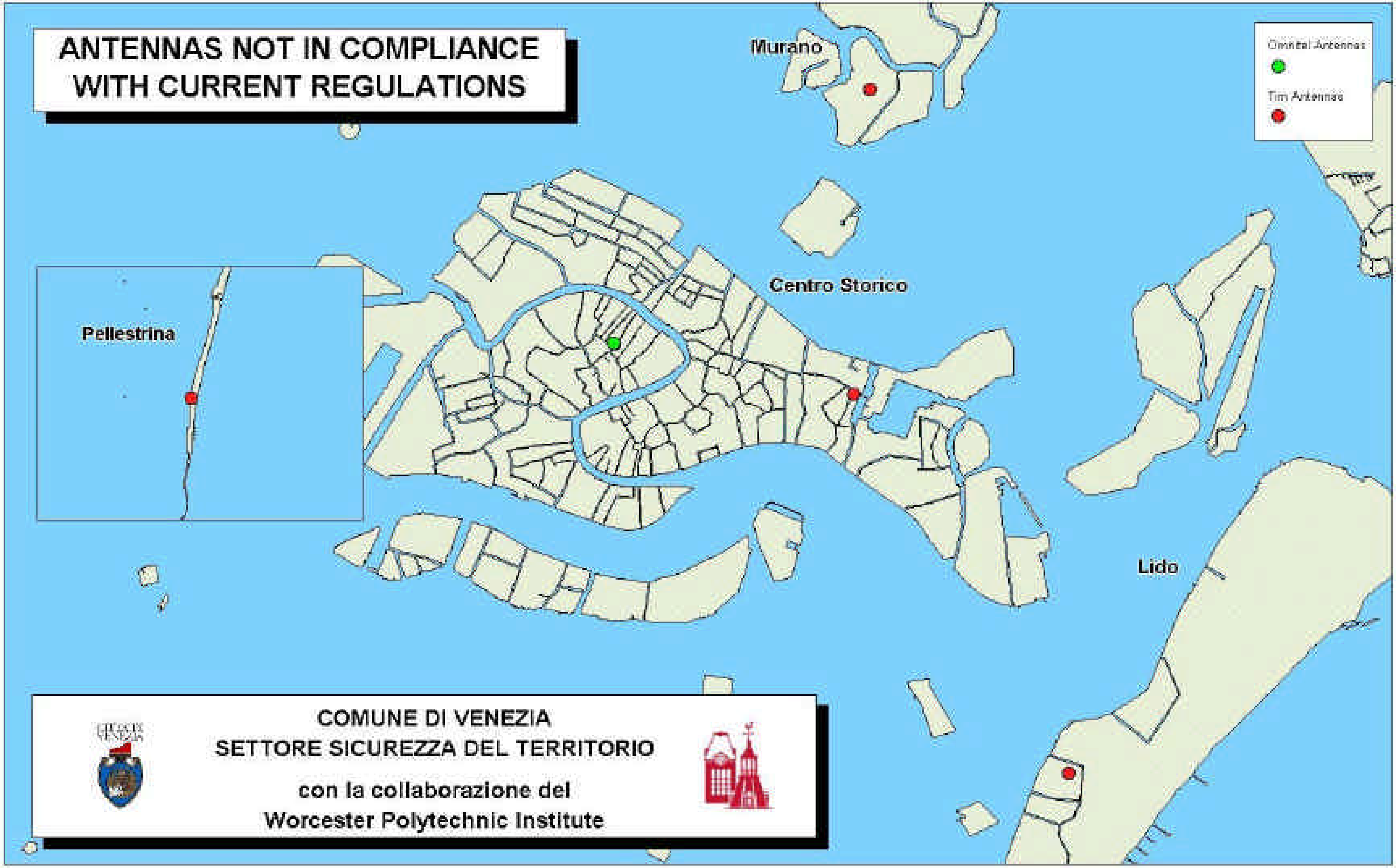
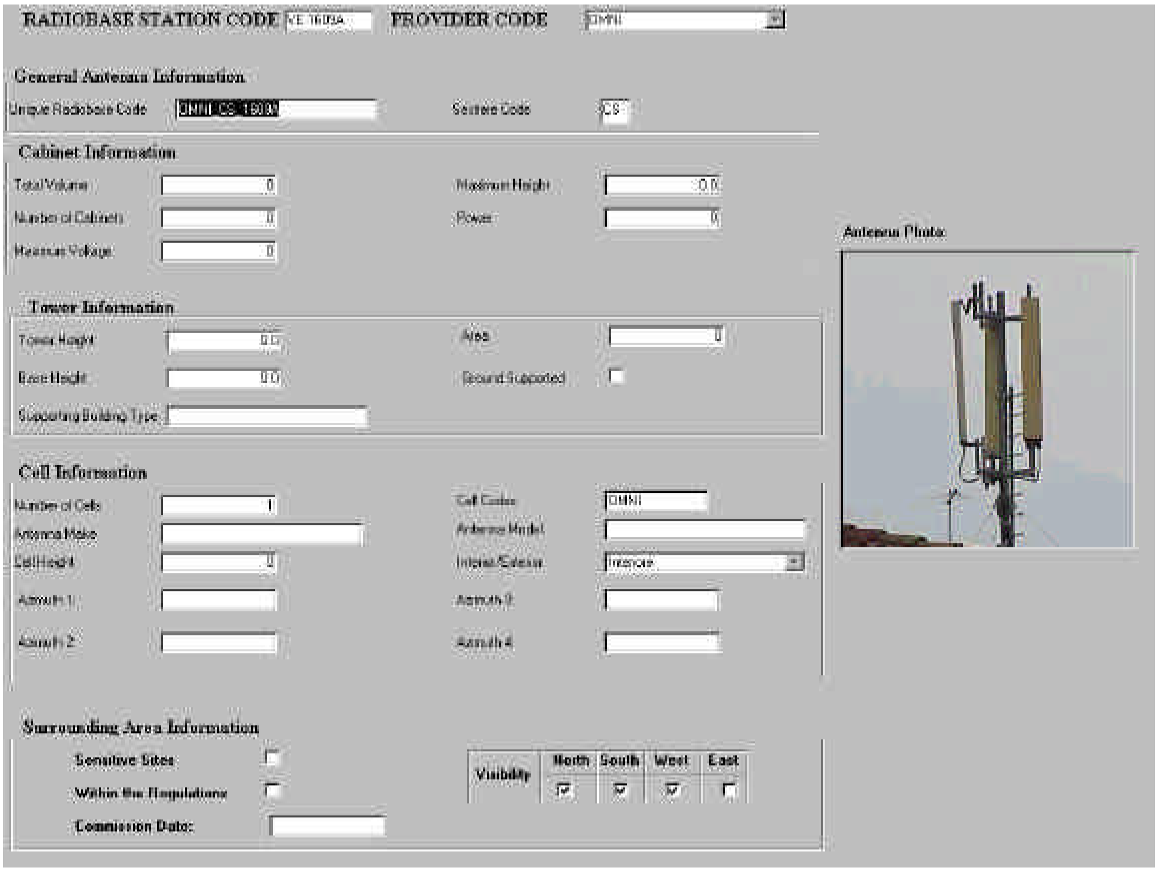

ANTENNAS NOT IN COMPLIANCE
WITH CURRENT REGULATIONS
Murano
Omnitel Antennas
Tim Antennas
Centro Storico
Pellestrina
Lido
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute

8.2 Appendix B: English Antenna Database



RADIOBASE STATION CODE VE 1609A PROVIDER CODE OMNI

General Antenna Information

Unique Radiobase Code OMNI_CS_1609A

Sectore Code CS

Cabinet Information

Total Volume 0

Number of Cabinets 0

Maximum Voltage 0

Maximum Height 0.0

Power 0

Tower Information

Tower Height 0.0

Base Height 0.0

Supporting Building Type

Area 0

Ground Supported

Cell Information

Number of Cells 1

Antenna Make

Cell Height 0

Azimuth 1

Azimuth 2

Cell Codes OMNI

Antenna Model

Interior/Exterior Interiore

Azimuth 3

Azimuth 4

Antenna Photo:

Surrounding Area Information

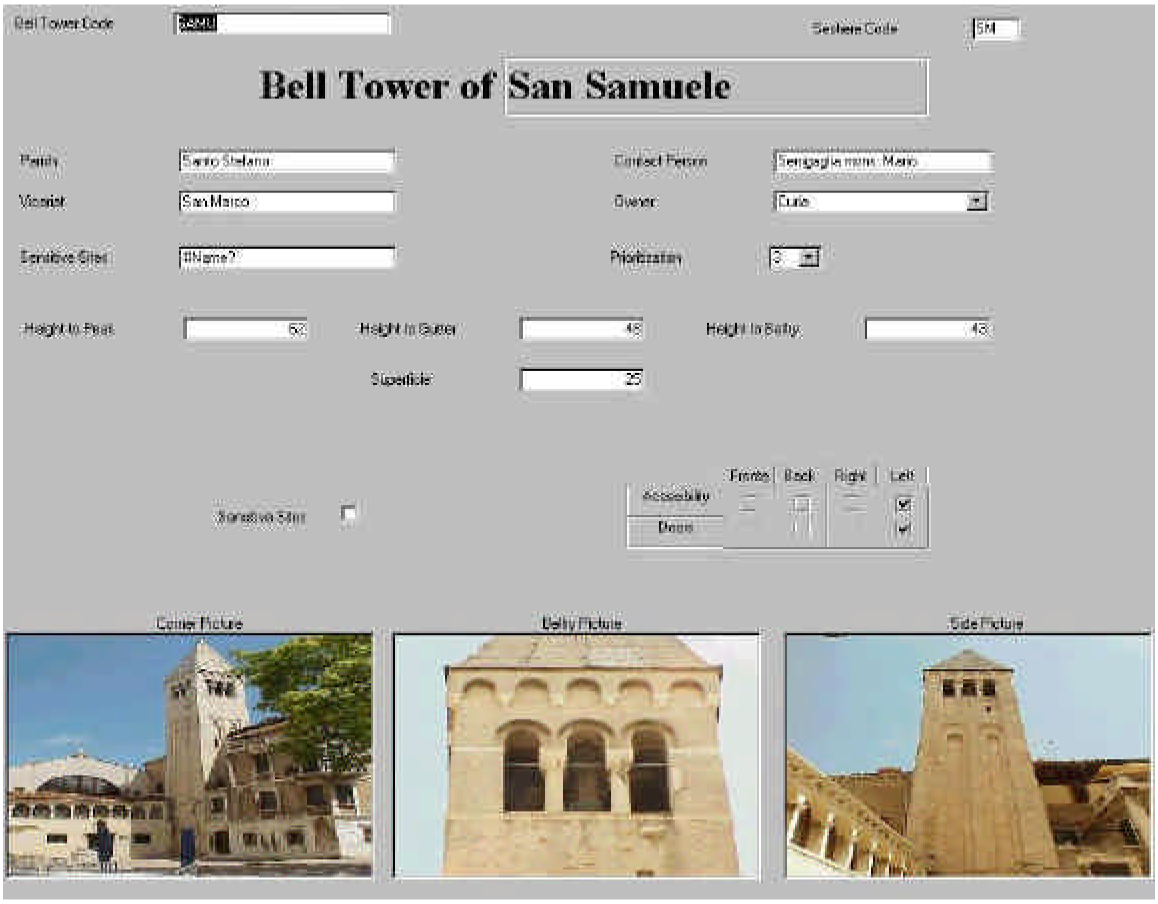
Sensitive Sites

Within the Regulations

Commission Date:

Visibility	North	South	West	East
	☑	☑	☑	☐

8.3 Appendix C: English Bell Tower Database



8.4 Appendix D: Before and After Pictures of Antennas

OMNI_BU_1610 Before

OMNI_BU_1610 After

OMNI_CN_1576 Before

OMNI_CN_1576 After

OMNI_CS_1577 Before

OMNI_CS_1577 After

TIM_LD_14D Before

TIM_LD_14D After

TIM_MU_16D Before

TIM_MU_16D After

TIM_PL_24D Before

TIM_PL_24D After

TIM_SM_01D Before

TIM_SM_01D After

WIND_CS_018D Before

WIND_CS_018D After


WIND_DD_002D Before


WIND_DD_002D After


WIND_LD_020D Before


WIND_LD_020D After


WIND_LD_022D Before


WIND_LD_022D After


WIND_LD_040D Before


WIND_LD_040D After

8.5 Appendix E: Ericsson Simultion

This simulation shows the current coverage of ten antennas on buildings and three antennas in privately owned bell towers. Areas of high coverage are in red while regions of low coverage are in yellow. This is the actual coverage of Venice today using real antenna locations.

In the second part of the simulation there are ten antennas on buildings and ten antennas in bell towers. As you can see, the amount of red, (high coverage areas), has increased. The antennas on the previous page are used and seven hypothetical antennas were added to produce this model.

This diagram shows the path of radiation from the antenna and is based on a 20 V/m electromagnetic field. Also, it shows that this field would be above the rooftops surrounding the bell tower.

8.6 Appendix F: Mock Antenna Proposal

SCHEDA DEL SITO

- DATI GENERALI -

ZONA DI COPERATURA: *Sestiere di San Marco*

INDIRIZZO DEL SITO: *San Giorgio dei Greci, San Marco*

TIPOLOGIA DEL SITO: *Edificio di campanile*

COORDINATE GPS: *LAT.:* ***N 45.43°*** *LON.:* ***E 12.34°***

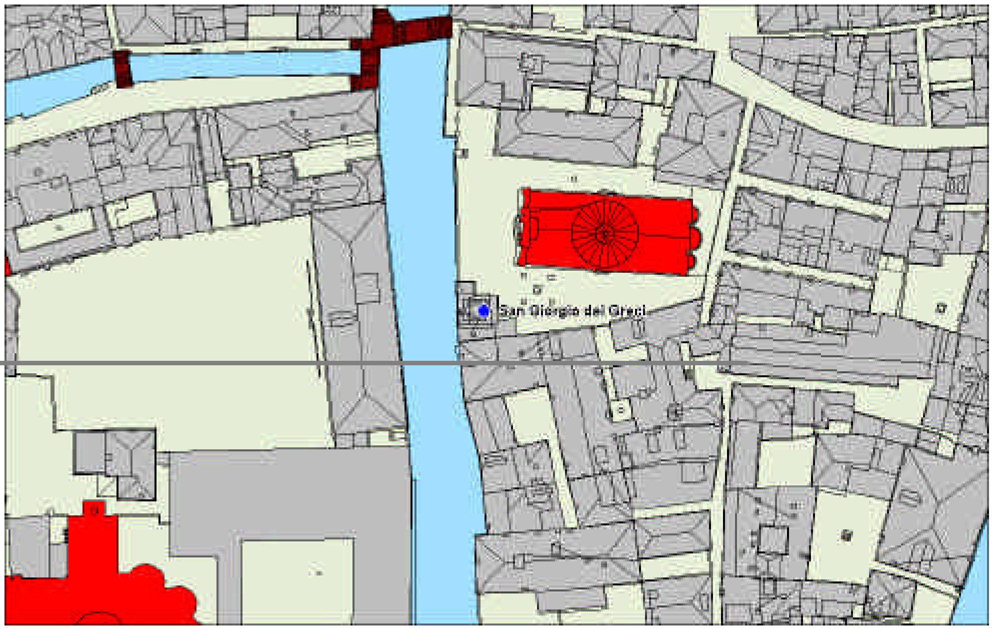
- INSTALLAZIONE -

ANTENNE: *Sulla coperatura*

APPARATI: *Da definire con la proprietà*

NOTE:

- STRADARIO -



SCHEDA DEL SITO

Facciata Nord

Foto dal C.llo drio agli incurabili

- OSTACOLI -

N°	TIPO	ALT.	DIST.
1)			
2)			
3)			
4)			

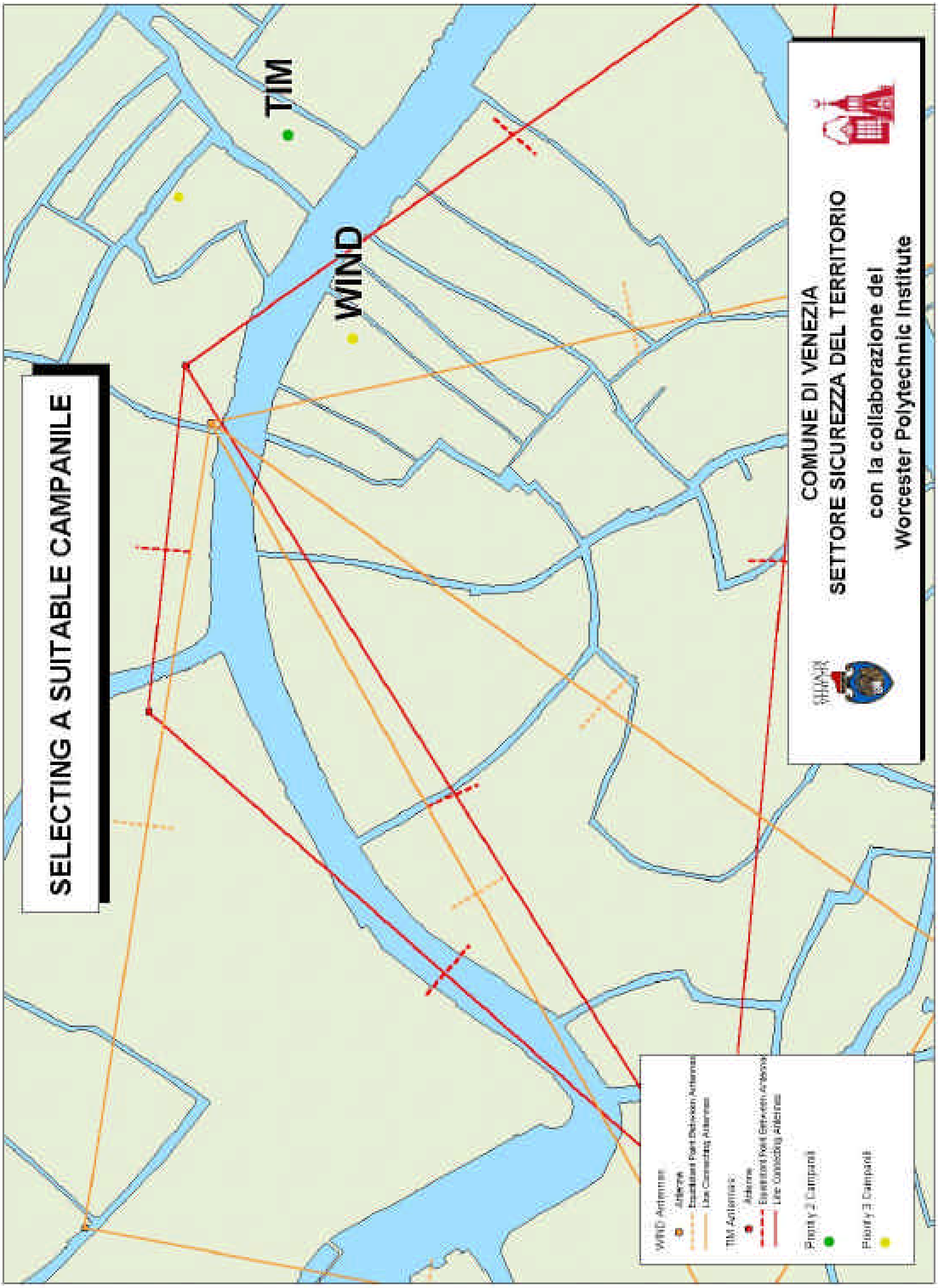
SCHEDA DEL SITO

FOTOPIANO Scala 1:1000

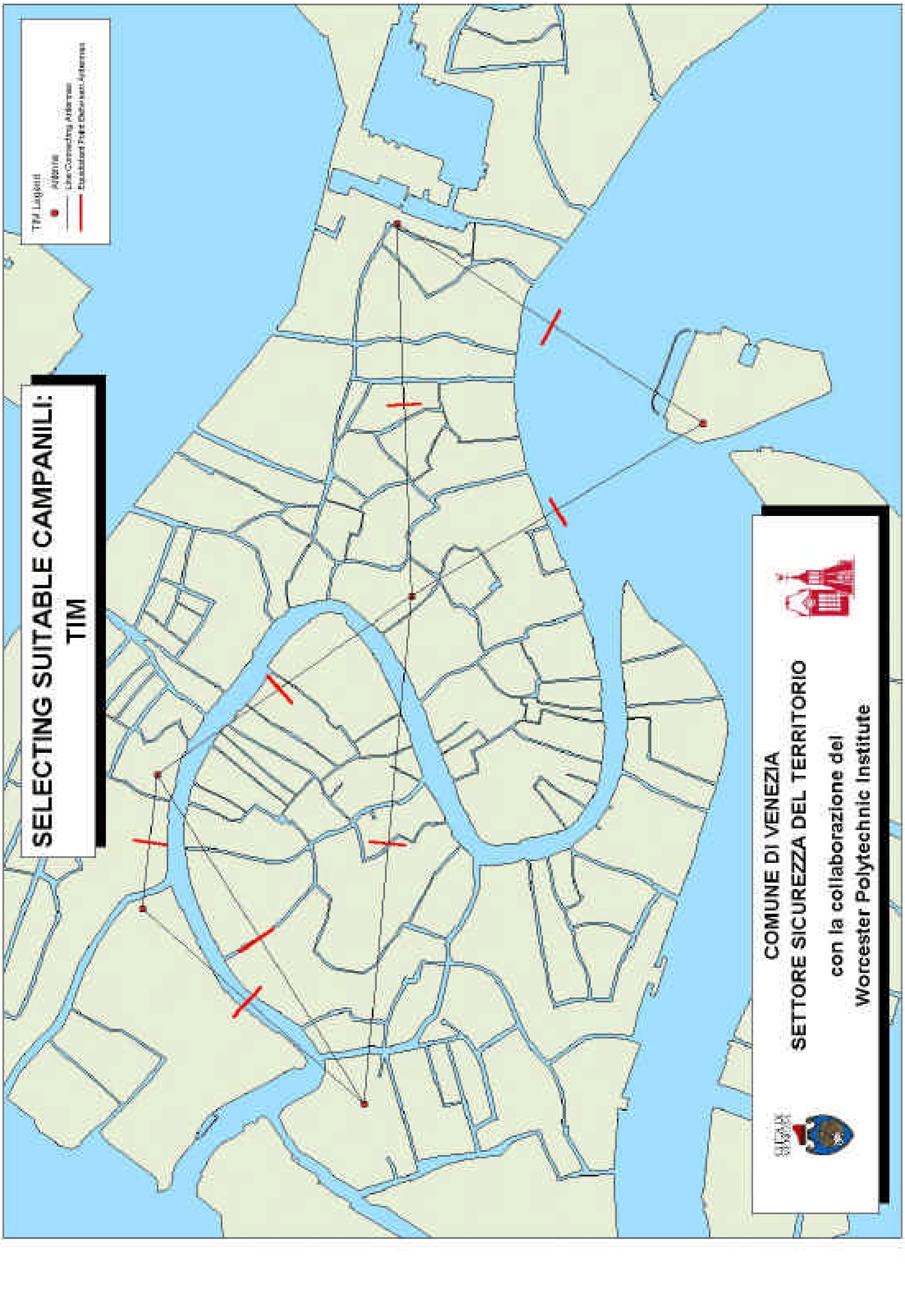
NOT AVAILABLE: AN AERIAL PHOTO

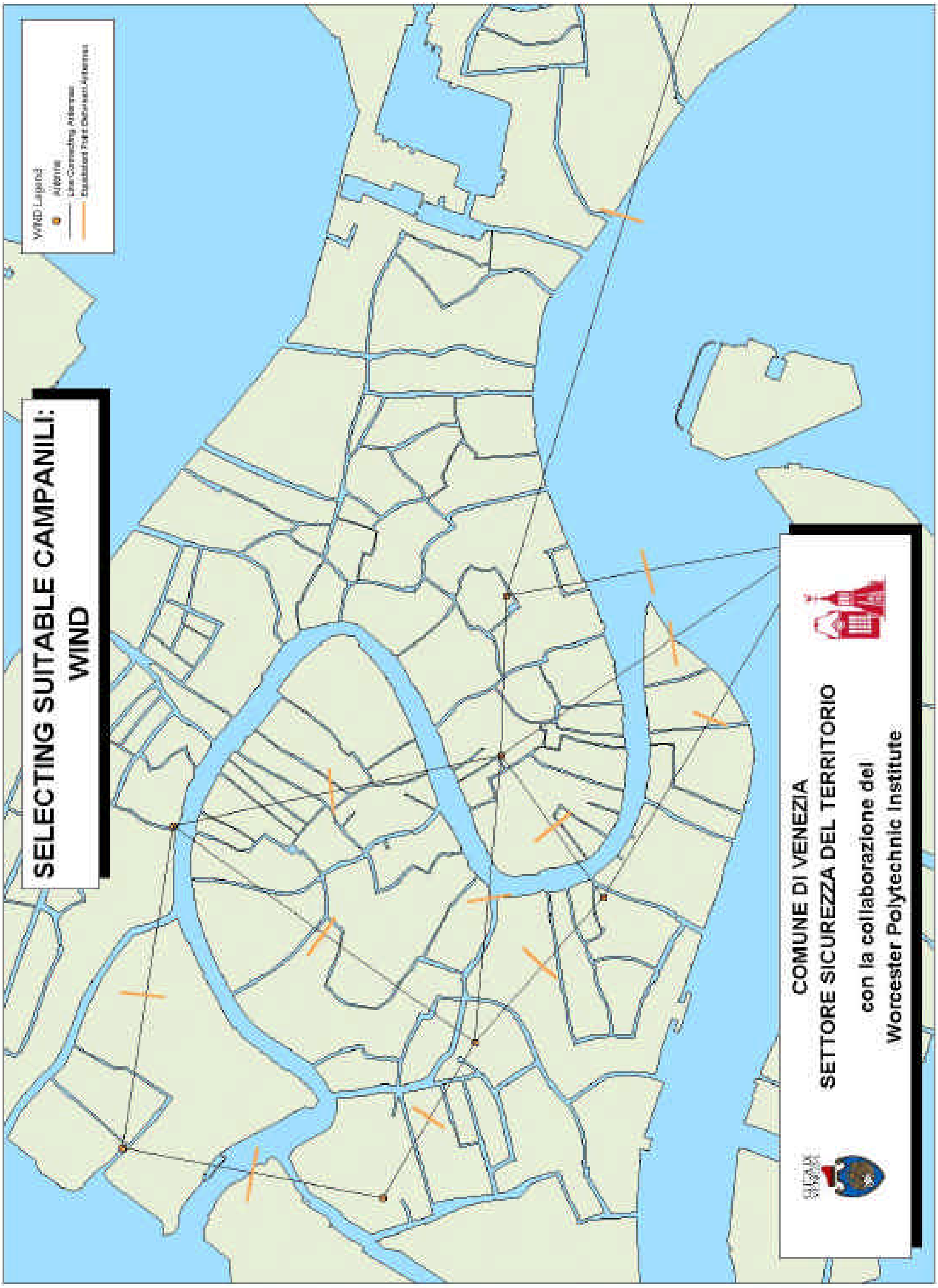
PLANIMETRIA Scala 1:25

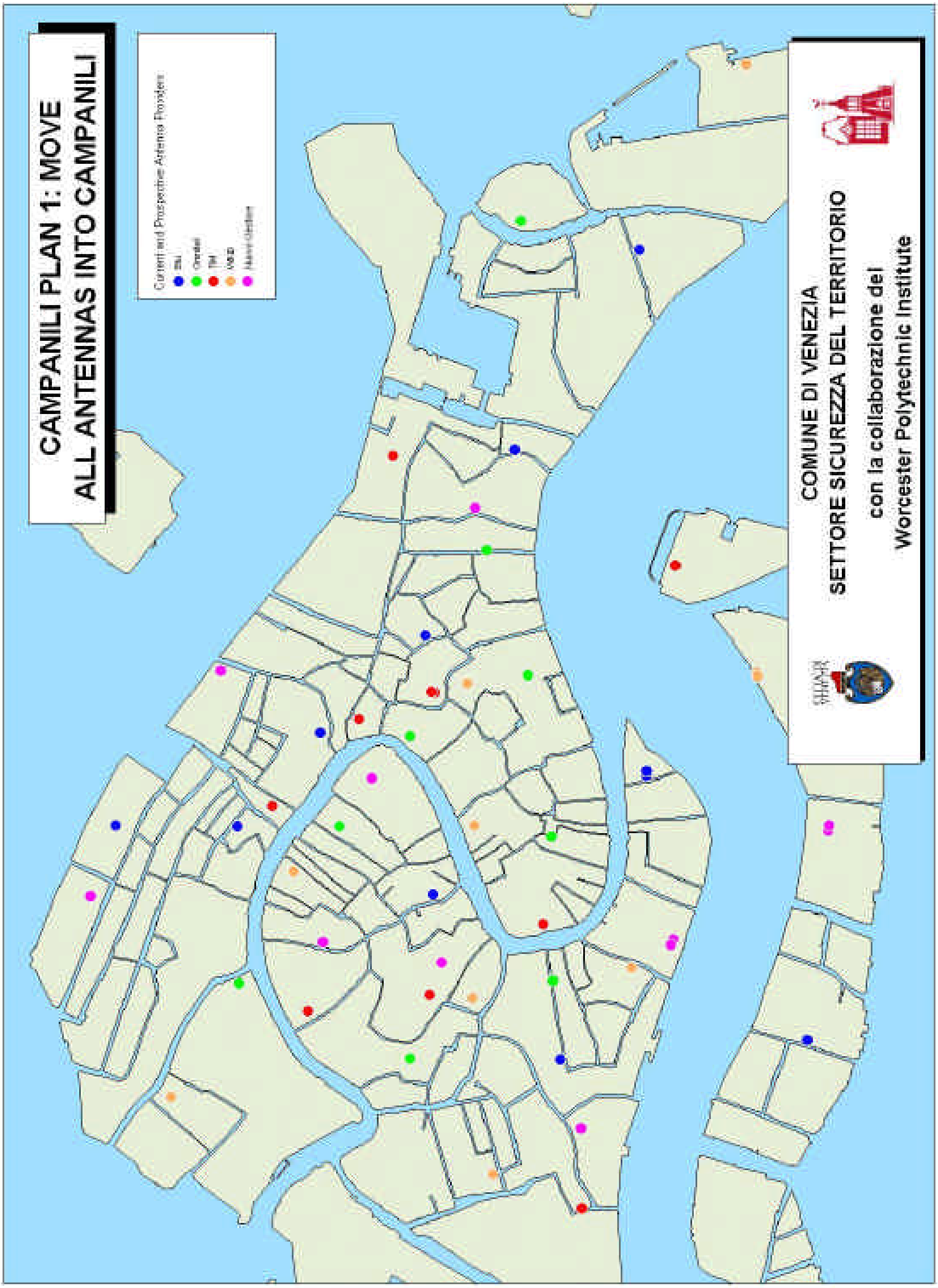
8.7 Appendix G: Campanili Plans

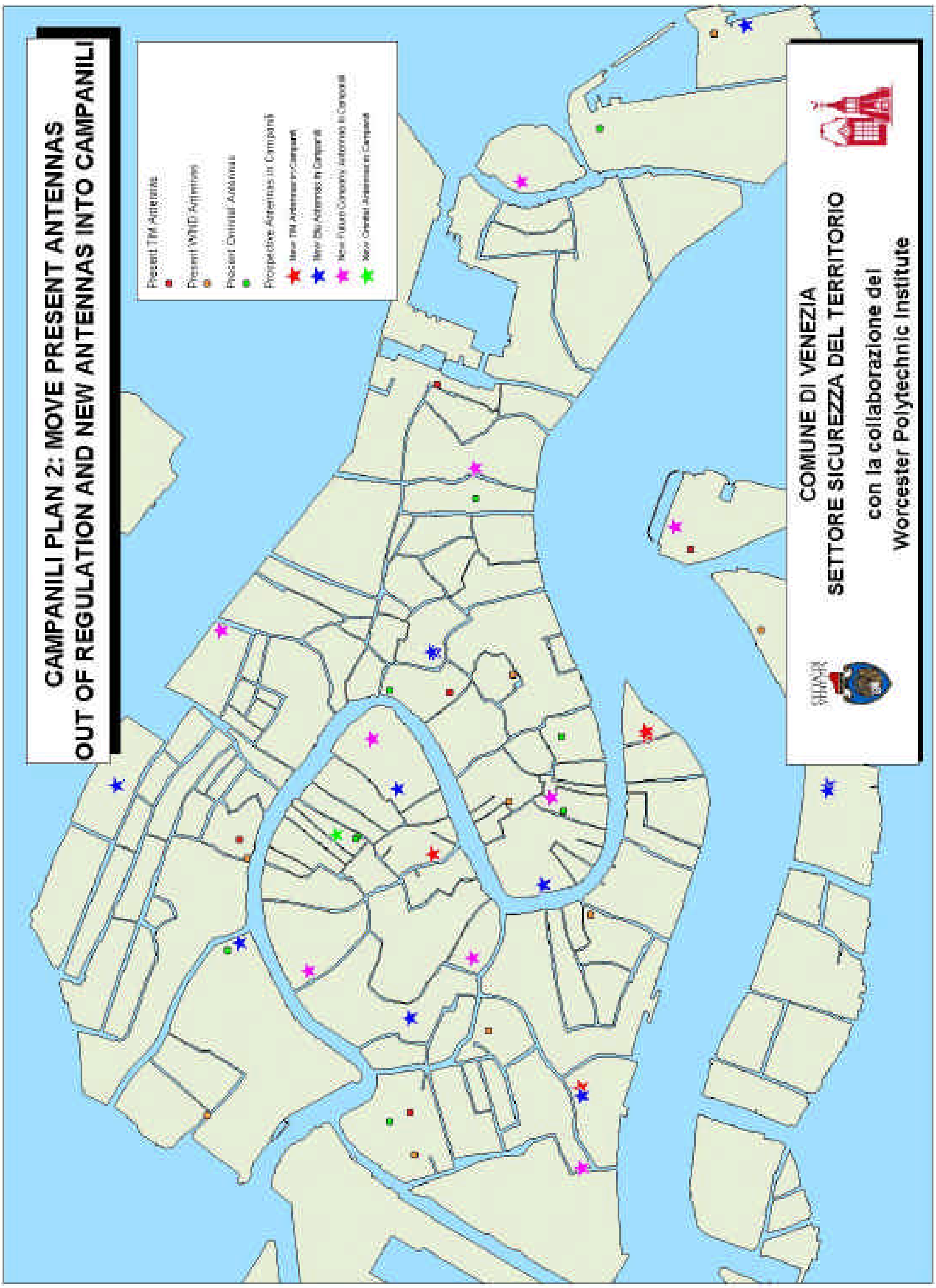

SELECTING A SUITABLE CAMPANILE
TIM
WIND
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute
WIND Antennas
TIM Antennas
Priority 2 Campanili
Priority 3 Campanili


SELECTING SUITABLE CAMPANILI:
OMNITEL
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute


SELECTING SUITABLE CAMPANILI:
TIM
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute


SELECTING SUITABLE CAMPANILI:
WIND
WIND Legend
Antenna
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute


CAMPANILI PLAN 1: MOVE
ALL ANTENNAS INTO CAMPANILI
Current and Prospective Antenna Providers
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute


CAMPANILI PLAN 2: MOVE PRESENT ANTENNAS
OUT OF REGULATION AND NEW ANTENNAS INTO CAMPANILI
Present TIM Antennas
Present WIND Antennas
Present Omnitel Antennas
Prospective Antennas in Campanili
New TIM Antennas in Campanili
New Blu Antennas in Campanili
New Omnitel Antennas in Campanili
COMUNE DI VENEZIA
SETTORE SICUREZZA DEL TERRITORIO
con la collaborazione del
Worcester Polytechnic Institute

8.8 *Appendix H: Charts and Tables*

Discarded Bell Towers

Bell Tower Name	**Code**	**Sestiere**	**Reason**
San Marcuola	MARC	Cannaregio	Not a bell tower
San Marziale	MARZ	Cannaregio	Not a bell tower
San Zaninovo	NOVO	Castello	Not a bell tower
Santa Caterina	RINA	Cannaregio	Not a bell tower
San Lio	SLIO	Castello	Not a bell tower
Santissima Trinita	TRIN	Giudecca	Does not exist
San Boldo	BOLD	San Polo	No belfry
Suore Mantellate	MANT	Castello	No belfry
Santa Margherita	MARG	Dorsudoro	No belfry
Santa Maria della Visitazione	LAPI1/LAPI2	Castello	Not visible
Santa Maria Valverde	LEMI	Cannaregio	Not visible
San Luca	LUCA	San Marco	Not visible
San Salvador	SALV	San Marco	Not visible
Santa Teresa	TERE	Dorsudoro	Not visible
San Vidal	VIDA	San Marco	Not visible
Santa Maria della Visitazione	VISI	Dorsudoro	Not visible
San Lazzaro dei Mendicanti	IMEN	Castello	Not visible

Visibility Information

Gestore	Site ID	Site Name	Visibility
Wind	VE001D	Piazzale Roma	Not Visible
Wind	VE002D	Enel Rio Novo	2
Wind	VE004D	Enel S.Giobbe	4
Wind	VE006D	Casino'-VE	Not Visible
Wind	VE010D	Zitelle	Not Visible
Wind	VE018D	S.Elena	4
Wind	VE020D	Lido Casino'	3
Wind	VE022D	Lido Negroponte	2
Wind	VE037G	Campo S.Luca	1
Wind	VE040D	Lido Alberoni	1
Omnitel	VE 1610	Burano- Venezia	4
Omnitel	VE 1576	Venezia	4
Omnitel	VE 1579	Venezia	Not Visible
Omnitel	VE 1580	Venezia	3
Omnitel	VE 1608	Venezia	Not Visible
Omnitel	VE 1575	Venezia	Not Visible
Omnitel	VE 1577	Venezia	4
Omnitel	VE 1578	Venezia	Not Visible
Omnitel	VE 1588	Murano	1
Omnitel	VE 1609	Venezia	2
Omnitel	VE 2398	Venezia	2
Tim	VE14D	Venezia-Lido	4
Tim	VE16D	Murano- Venezia	4
Tim (microcella indoor)	VE83D	Venezia	Not Visible
Tim	VE30D	Venezia	4
Tim	VE39D	Lido-Alberoni-Ve	4
Tim	VE01D	Venezia	Not Visible
Tim	VE24D	Pellestrina-Lido-Ve	4
Tim	VE36D	Lido-Venezia	3
Tim	VE37D	Venezia	4
Tim (Impianti indoor)	VE43D	Venezia	Not Visible

8.9 Appendix I: Glossary

Advanced Mobile Phone Service (AMPS) - System put into place in North America in 1978 coining the term "cell" describing their initial antenna configuration which was similar to the structure of a cell in a honeycomb.
***Agenzia Regionale per la Prevenzione e Protezione Ambievae del Veneto* (ARPAV)**- Governmental agency supervising different communities in all of Veneto, they approach environmental issues.
Analog Signals - A signal using AMPS technology
Antennas - Signal propagating equipment
As Low as Reasonably Achievable (ALARA) - ALARA is a principle that states that through arbitration the companies must demonstrate that the use of too low of a frequency is out of the question due to detriment in service
As Low As Technically Achievable (ALATA) - This principle states that comparnies are to strive to offer a design in the lowest radiation as possible with the technology offered in the market.
Bandwidth - The amount of space available on a channel
Baroque- Architectural style that used detail and decoration to a great extent
Base (*Base*)- On self standing bell towers, the part which is in contact with the ground
Base Transmission System - This is the equipment that manipulates and processes the signals to be emmited by the antenna
Belfry (*Cella Campanaria*)- Location of bells in a bell tower, usually containing windows for sound propagation
Bell tower (*Campanile*)- Structures associated with churches, house bells used to announce religious festivities
Byzantine- Architectural style from the eighth to the twelfth century, tall structures with low roofs and large window openings
Cell- Antenna hexagonal configuration when the system was first introduced in the shape of a cell on a honely comb
Cellular telephones- Telephones which work on a "cell" basis and are within the realm of mobile communications
Centro Storico- Cluster of main islands in Venice
Channel - Frequency in which a conversation is held on.
Code Division Multiple Access (CDMA) - A code based digital format for sending signals
Comune- Community
Cross talk- Occurs when two signals are too close to one another, hearing other conversations
Digital Signals - A signal using CDMA or TDMA technology
Diocese- Fundamental unit of organization in the Catholic Church
Directional antennas - Antennas capable of propagating signals to an exact location or region
European Union (EU)- Organization formded to consolidate the countries of Europe in an economic, political, and social union. The members are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, England.
Federal Communications Commission- Organization created ub 1934 in the United States to regulate all aspects dealing with communications
Frequency - Frequency is the inverse of the period of the signal
Full duplex- allows simultaneous communication, the transmit and receive channel are at two different frequencies
Genotoxicity studies - Research done on radiation capable to break chemical bonds such as those in DNA

Gothic- Architectural style popular during the fourteenth and fifteenth centuries, characterisized by its bright colors and light

Group System for Mobile Communications (GSM) - Initially called Groupe Speciale Mobili, is Europe's fully digital system developped in the mid- 1980's to resolve the compatibility issues around most of Eorupe.

Gutter- Location on a building which is the point where it falls straight down, this is for collection of water

Improved Mobile Telephone System (IMTS) - Improved system based on the MTs introduced by Bell Labs in 1964

Infrared Rays - Rays at frequencies between 10^{12} and 10^{14}. They are partly in the ionizing radiation part of the electromagnetic spectrum.

International Commission on Non-ionizing Radiation Protection (ICNIRP) – International organization that monitors and researches ionizing and non-ionizing radiation

Ionizing radiation- Radiation made of frequencies greater than 10^{15} and can break bonds.

Jasc Software Paint Shop Pro - This program is a photo editor which is used to alter and manipulate graphics, photos in particular, with a wide variety of effects and tools. It is a very useful tool when editing imperfections in picture or when special effects are wanted to modify the picture.

Mannerism- Architectural style considered a modification of Gothic, supplemented by a variety of columns.

MapInfo- This software package is a map development tool that allows the user not only to create maps but also to manipulate them. The way this is accomplished is because the objects on the layers are linked to different table with desired data fields. Maps can be combined and superimposed according to the users needs. Analysis of data is also possible through thematic maps, in other words maps which categorize objects by a unifying theme. Also graphical representation of information is possible thanks to the tables mentioned before

Microsoft Excel - Microsoft Excel is a spreadsheet and table software package which helps the user compile gathered data in an easy to read and manipulate spreadsheet. The tables can be represented in carious graphical ways such as bar graphs, pie charts, scatter plots, etc. for a clearer view of the desired data.

Microsoft Visual Basic 6.0 - This is a windows runing programming tool focused on developing windows-based programs. This is a very powerful tool because it can be linked to a number of programs, including Microsoft Access, Map X, and other software packages

Microtesla: Comes from the unit tesla which describes electromagnetic fields. This number in the range of 10^{-6}

Microwaves - Waves at frequencies between 10^{7} and 10^{9}. Within the non-ionizing range.

Mircrosoft Access - This software package is very powerful. It serves two main purposes: data gathering and organization, and data manipulation. This tool can combine data from several tables to create queries, forms, and reports with data gathered. The data can be linked to different databases and organized with logic operations and meeting desired criteria

Mobile communications- Any means of artificial communications which are not physically constrained within an area

Mobile Telephone System (MTS) - First mobile radio telephone service (1946) This service ran in the simplex system.

Neo-classicism- New-classic style, known for its simple architecture

Omni-directional antennas - Antennas capable of propagating signals 360 degrees

Optical tape measure- Device which measures distances by focusing two lenses with a rotating dial that gives the result.

Pacemakers- Device that maintains cardiac rhythm

PCS band - This is a band of frequencies higher than GSM opened for public use in view of the high demand in the US.

Principle of Caution - This principle states that human well-being supercedes all other principles in order to prevent possible problems

Principle of Justification- The principle of justification states that if it is found, through arbitration that a lab worker or an individual has to be exposed to radiation greater than the stipulated amount then minimal amounts may be used.

Principle of Minimization- The principle of minimization states that people in a laboratory and the general public must be exposed to the minimal amount of electromagnetic radiation.

Principle of Optimization- The principle of optimization states that in planning the placement of the antennas and setting their frequencies, companies may modify their frequencies within the range in order to optimize the service.

Pythagorean Theorem- States that if two of three sides in a right triangle are known then the third can be found by setting the square of the hypotenuse equal to the sum of the squares of the sides.

Radio waves - Waves at frequencies between 10^5 and 10^8. Within the non-ionizing region of the electromagnetic spectrum.

Renaissance- Architectural style which emphasized proportion and humanism

Residential- Area where mainly inhabitated by humans

Romanesque- Architectural style of the seventh century that empahasized on large structures and little decoration

***Settore Sicurezza del Territorio* (Sector of Territorial Safety)**- Ecology Department of Venice, organization regulating and protecting environmental issues facing at the *comune* di Venezia

Shaft (*sfiatatoio*)- Actual body of the bell tower, composed of intermediate and ringing chamber

Simplex radio systems- System where only one person could speak at a time with out overlapping voices

Spire- Area above the belfry including the roof and additions

Time Division Multiple Access (TDMA) -A time based digital format

Time stamps - Binary code attached to a digital signal based on the time at which that signal was sampled

Ultraviolet rays - Rays at frequencies between 10^{15} and 10^{17}. They are partly in the ionizing radiation part of the electromagnetic spectrum.

Venice- (for the purpose of this project only) Isole Laguna, Lido, Pellestrina, and *Centro Storico*

Visible light - Rays with a frequency of about 10^{15} hz in the electromagnetic spectrum

Chapter 9 Annotated Bibliography

9.1 Cellular Technology

1. Farley, Tom, Cellular Defined. http://www.privateline.com/PCS/history.htm 27 Mar. 2000

This web site takes an in depth look into the technology that accompanies cellular communications. It is split up into different sections according to history, types of frequencies, and types of standards. Much of the discussion is dedicated to digital transmissions and how this aspect of cellular works.

2. Johnston, William, "Europe's Future Mobile Telephony System" IEEE Spectrum. October 1998

William Johnston of the British Telecommunications Laboratories submitted this article to the IEEE Spectrum. In this article he specifically talks about where Europe's mobile telecommunications system is going and the state at which it is at today. A lot about GSM, or the Group System for Mobile Communications is said and he goes on to talk about the third generation digital system Europe is looking into and developing.

3. Telestructures, Inc. http://www.telestructures.com/products/unipole/applications.htm 13 April 2000

This web site is the home of the company Telestructures, Inc. At this site it gives a good idea of what a typical cellular tower would look like. They also manufacture alternatives to traditional cellular towers in the forms of flagpoles and light posts.

4. "Industry Associations" The Cell Site http://www.cordero2.com/links 3 April 2000

This site gives the web addresses for Industry associations affiliated with cellular technology. The groups listed include the Personal Communications Industry Association, the Cellular Telecommunications Industry Association, GSM World, and the US Federal Communications Commission.

5. WIND, "SITE REQUIREMENTS"

This document served as a reference on our background on the antenna section describing the requirements which WIND looks for when searching for a location in terms of their necessities.

9.2 Health Concerns

6. Moulder, J. E.Cellular Phone Antennas and Human Health. 16 Mar. 2000. FAQ Sheet.
http://www/mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html 22 Mar. 2000

This FAQ addresses the question of whether or not base station antennas for cellular phones, PCS phones, and other types of portable transceivers pose a risk to human health. He uses his own research as well as that of respected colleagues and other nations to help address the issue. He also introduces the many different regulations there are for the topic around the world.

7. Cell Phone Radiation – Telecommunications. 5 Sept. 1999. About.com. “Cell Phone Radiation” http://telecomindustry.about.com/industry/telecomindustry/library/weekly/aa053099.htm? 21 Mar. 2000

This is an extremely useful website done by Brian McIntosh of About.com. It gives leads to many other websites and sources covering information on cellular radiation and health hazards.

8. Lai, Henry. “Neurological Effects of Radiofrequency EMFacts Consultancy. 16 Sept. 1997. Electromagnetic Radiation Relating to Wireless Communication Technology”
http://www.tassie.net.au/emfacts/henrylai2.html 27 Mar. 2000

This website offers the paper presented by Henry Lai of the Department of Engineering at the University of Washington to the IBC-UK Conference. It explores the possible health effects of RF radiation produced by cellular phones.

9. EMF Shielding Devices for Cell Phones. Home Page. <http://www.lessemf.com/cellphon.html>. 10 April. 2000.

This site offered a variety of different devices for the average consumer to purchase in order to protect himself or herself from cellular radiation. It gives background information and prices.

10. Martin, Susan Lorde. Communications Tower Sitings: The Telecommunications Act of 1996 and The Battle For Community Control.
<http://www.law.berkeley.edu/journals/btlj/articles/12_2/Martin/html/text.html>.

This website displayed an article that gave us a depiction of how communities feel about antennas in their neighborhood. It surveys why residents do not want antennas in their neighborhood and hints at how the telecommunications companies feel as well. It goes over the Telecommunications Act of 1996 as well.

11. Moulder, J. E., *et al*. "Cell Phones and Cancer: What Is the Evidence for a Connection?" Radiation Research 151 (1999) : 513-531.

This was an excellent review done on various experiments that have studied the effects of cellular radiation. He gives a brief background on radiation, and the physics and technology of cellular phones, followed by a survey of experiments done on radiation in the discipline of epidemiology. He pulls together the evidence well, stating in the end that no real conclusions have been made.

12. National Institute of Health Fact Sheet: What We Know About Radiation. http://www.nih.gov/health/chip/od/radiation/ 28 Mar. 2000.

This website offers the average person background information on radiation. It explores basic definitions, as well as everyday exposure, and its pros and cons.

13. WDIV – Cell Phone Dangers. Home Page. http://www.wdiv.com/cellphone.html 27 Mar. 2000.

Being a website of News Channel 4, these insights on cellular phone radiation came from an actual news script that was broadcast. It investigates the health concerns of cellular phone radiation and explores the precautions that can be taken.

14. Vecchio, Paolo. "Campi Elettromagnetici Ad Alta Frenquenza: Problemi Sanitari e Percezione Dei Rischi". 86, n.4: 4/99:33-46

This article describes the health hazards possibly correlated with EMF radiation. Though we had extensive research on physical pathologies this article brought into the light possible psychosomatic illnesses caused by the presence of the bell towers in the vicinity of residential areas. In overall this was a very useful document specific to this subject.

9.3 Legislation

15. Giunta Comunale, "Installazione Impianti Radiobase Per Telefonia Mobile. Applicazione Del 'Principio Di Giustificazione'"

This article had some interesting information regarding the liberalization of telecommunications. It also points out to the role of the government in this matter. Nevertheless, the information is too general and ambiguous and thus was not been quoted.

16. Assessorato all' Ambiente, "Parere in Ordine all Applicazione del *Principio di Minimizzazione* delle Esposizioni ai Campi Electromagnetici in Area Urbana", *Comune di Venezia*, 1/7/2000 prot n. 17

This document has been very useful. It provided a clear understanding of the principles behind the existing laws. Some of the principles discussed is the one of justificiation, minimization, hygienic surveillance, and others. It also gives place to a broader view of the subject and forces to incorporate the different components that should be analyzed when discussing the topic area.

17. "Normativa Radiobase", Regione del Veneto, Giunta Regionale

It was useful to see this as a source of what the legislation has done. It was not quoted given the degree of specialization. Yet it provided an appropriate framework of what parameters are out there.

18. Deliberazione della Giunta, "Tutela Igienico-Sanitaria della Popolazione dall Esposizione a Radiazioni non Ionizzanti Generate da Impianti per Teleradiocomunicazioni", Regione del Veneto, 12/29/1998

As in the instance before, the legislation provides an appropriate reference to understand the perception of society in regards to a certain area. It also presents the role of the government and the areas of concern that it might have as a public regulator.

19. Giunta Regionale, "Tutela Igienico-Sanitaria della Popolazione dall Esposizione a Radiazioni non Ionizzanti Generate da Impianti per Teleradiocomunicazioni", Regione del Veneto, 03/19/1999

Once again here the legislative component and information provided are very useful. They provide the necessary framework to develop business, analyze the constraints, and also provide with some information on what is possible in the future.

20. Zorzi, Michele Prof., "Considerazioni sull'Inquinamento Elettromagnetico Causato da Stazioni Radio Base nei Sistemi di Telefonia Cellulare", Dipartimento di Ingegneria, Universita di Ferrara, Ferrara, Italy

This document was particularly useful and clear. It was not quoted but it became a very good reference. It is provides technical information to better analyze things and at the same time a very complete description of the different systems available. Some of the areas discussed are cellular and micro cellular.

21. "Decreti, Delibere e Ordinanze Ministeriali", Ministero dell' Ambiente, 09/10/1998

As discussed before this document is very important for overall reference, but are not quoted since they are very specific. In addition, this document provides with useful information on how to define the different sources of electricity and how to measure them.

22. Lorde Martin, Susan, "Communications Tower Sitings: The Telecommunications Act of 1996 and the Battle for Community Control", www.law.berkeley.edu/journals, 04/07/2000

This document presents an interesting outlook on the Telecommunication Act of 1996. It is important to understand the implications of the deregulatory environment and the pro-competitive effects in the industry. It also presents some case studies that better exemplify the issues at hand and the different ways that these can be appropriate. It would seem though that there was some degree of bias in the document.

23. "Scheda Informativa sulle Stazioni Radio Base", ARPAV

This is a useful reference to identify what type of information is requested and what it is that is consider comparative reference. Yet it did not particularly pertain to the scope of the paper to be quoted in the paper itself.

24. Omnitel Pronto Italia S.p.A., "Progetto di Infrastrutture per Stazione Radiobase per l'Espletamento del Servizio Pubblico Radiomobile di Comunicazione con il Sistema in Tecnica Numerica Denominato GSM, da Realizzarsi in Calle dei Greci No. 3419", *Comune di Venezia*, 04/23/1998

This has been a useful reference for planning purposes. It also provides with some visual basis of what can be expected or how to represent some of the information graphically. It is appropriate for a plan presentation. It was not included in the paper as a quoted reference.

25. "Autorizzazione", *Comune di Venezia*, 09/16/1998

This reference was not very legible and thus its usefulness was very limited.

26. Demarest Yant, Richard, "Federal Law Restricts Local Land Use Regulation of Wireless Telecommunications Facilities", www.seyfarth.com/practice/business/articles, 04/07/2000

This document presents a useful and interesting analysis of the legal scenario. It provides with a practical way of how the federal restricts local land use and how it regulates the wireless telecommunications facilities. The format of the paper is good since it provides some useful definitions and presents the different restrictions imposed by the government at a local and federal law. For the former there is support presented with cases.

27. "Proposal for a Council Recommendation", Commission of the European Communities, Brussels, Com (98)

This proposal has proven to be very informative. It presents a broader perspective since it addresses the European Union. Thus, it provides a wider framework of the European perspective on the subject area which will also permeate the national initiatives in the future in one way or another. It also discusses important issues such as public health, safety, environment impact assessment, and research. The proposed recommendations are a very good for reference.

9.4 Bell Tower History

28. A Method for the Evaluation of Venetian Bells and Bell Towers, 1994 by Morillo and Rosas

This was an Interactive Qualifying Project (IQP) which determined the necessary parameters of bells and bell towers to be researched when gathering useful data on the structures. It focuses on the structure of the bell towers and their historical significance. This IQP gives crucial information to our project. When contemplating whether or not to place antennas within or outside a bell tower it is necessary to know the structure of the bell towers. Also, it is important to understand and recognize their significance to the Venetians. Most of the background information for the structure and history of bell tower architecture came from this IQP.

29. Computerized Catalog of Venetian Bells and Bell Towers, by Carlson, Prince and Roosa

This was an Interactive Qualifying Project (IQP) that focuses on prioritizing the bell towers of Venice. Many of the bell towers need restoration and based on their analysis they attempted to establish a system to

prioritize the bell towers based on their need for repairs. This IQP was used to reinforce information taken from another IQP, A Method for the Evaluation of Venetian Bells and Bell Towers.

30. Venice, KNOPF Guide, 1993

This text does not provide detailed information on Venetian bell towers, but it gives key points. It supplies multiple pictures of the various architectural styles depicted in the bell towers and gives a broad summary of Venetian history in all aspects. This is useful because it is a quick reference to use when beginning to research a topic.

9.5 Church Background

31. Patriarcato di Venezia, "Annuario Diocesano 1999" 15 Mar. 2000

The "Annuario Diocesano" is basically the phone directory for the Patriarcato of Venice, where phone numbers and other contact information for every parish, and office related with the Curia can be found. This booklet was very useful in providing us with both information for our database on the bell towers as well as reference for the section in the background pertaining the church organization specific to Venice.

32. "Roman Catholic Church" Home Page, www.fwkc.com?encyclopedia/low/articles/r/r02200/034f.html

This document was very useful in explaining the church's organization. It was very clear and concise highlighting the positions in the church hierarchy and the responsibility of the people occupying these positions..