IPRO 305

ILLINOIS INSTITUTE OF TECHNOLOGY

Building a Wireless Infrastructure to Support Maritime Applications

Spring 2007 - Final Report

Team Members: Jack Calzaretta
Brian Chung
Daniel Czuchra
Joe Dietz
Ike Emelogu
James Hendrickson
Brian Kim
Jason Tenenbaum
Talha Yousuf

Advisors: Prof. Cindy Hood
Dennis Hood

Sponsor: Air2Access™ www.Air2Access.com

April 27, 2007

Table of Contents

Introduction

Air2Access, a provider of maritime internet connectivity solutions for recreational boaters, is looking to expand their offerings to provide service for commercial and government institutions. The goal of the project is to improve boat and barge traffic flows, security and emergency response along the river, and will serve as the foundation for Air2Access's future commercial offerings platform. This IPRO team has focused on both the wireless network infrastructure design and the initial set of maritime applications. The infrastructure effort will be used to understand what it takes to deploy and operate a large scale broadband wireless maritime network. The maritime applications effort will be used to understand some of the circumstances where broadband wireless maritime network would be desired by local property owners, governmental regulators, and other river traffickers.

Background

Air2Access, LLC (A2A) is a start-up provider of maritime communication systems and solutions. They provide ubiquitous network connectivity and maritime applications along coastal and inland waterways. A2A's offerings include a range of consumer and commercial wireless network services and a suite of software applications aimed at improving industry efficiency and security. The company is headquartered at IIT's University Technology Park in the IIT Tower. A2A has been an active recruiter of IIT students on the Main Campus.

A2A is planning to build a wireless broadband network infrastructure along a local river to help build its maritime solutions offering. This infrastructure effort will be used to understand what it takes to deploy

and operate a large scale broadband wireless maritime network. A2A plans to partner with industry leaders to undertake an intensive test of wireless technology, applications and its business case in the maritime environment.

The goal of the project is to improve boat and barge traffic flows, security and emergency response along the river, and will serve as the foundation for A2A's future commercial offerings platform. This IPRO team will focus on both the wireless network infrastructure design and the initial set of maritime applications.

Objectives

The objective of IPRO 305 was to build a wireless broadband network infrastructure along the Calumet River in Chicago to help Air2Access, an IIT University Technology Park Company, expand its maritime solutions offerings. We did this by becoming familiar with cutting edge wireless broadband network technologies and the different vendors that offer and use this technology. We will also examine the pilot site and work with the appropriate Agencies to determine any natural, man-made or legal restrictions that we must abide by. To effectively complete our task in a timely manner, our team has divided into two sub-teams. The application team will focus on business applications and how to build them from off-the-shelf and custom built software. The infrastructure team will focus on technologies to support the necessary applications and will focus on the site itself, along with the required hardware deployment.

Methodology

The problem presented to our team was to create an efficient wireless broadband network for use of maritime applications along the Calumet River. To solve this problem, our team divided into two (2) sub-teams, an infrastructure team and an application team. This allows each team to focus on a specific set of requirements that were obtained from the sponsor.

Application Team

The aim of the application team is to research and identify potential vendors and clients for our sponsor, as well as, to define a set of business and technical requirements. To do these tasks, the team will conduct preliminary research, then interviews with relevant stakeholders in conjunction with the sponsor.

Infrastructure Team

The aim of the infrastructure team is to define wireless technologies set, as well as, the technical and network architecture. The team will also need to determine building and permitting requirements related to the construction of a radio tower. To do these tasks, the team will conduct site surveys to determine

Assignments

The individual task assignments and roles have remained largely the same the same, any changes

A. Team Leader

James Hendrickson

Sub-Teams

1. Application Team:

Jason Tenenbaum (Leader)

Brian Chung

Ike Emelogu

TalhaYousuf

2. Infrastructure Team:

Joe Dietz

Daniel Czuchra

Brian Kim

Jack Calzaretta

B. Sub-Teams' Responsibilities

Application Team:

- The application team focused on how maritime customers will use the broadband wireless access and applications. Using A2A's RiverWatch application suite as the initial platform, we will help in defining A2A's waterside perimeter protection offering for riverside and port facilities and vessels. We will create a list of perceived business and technical requirements for potential maritime customers. We will meet and work with public and private stakeholders to better define the needs and requirements. We will survey the landscape of existing applications and meet with vendors to review and assess capabilities. We will develop recommendations on a set of applications to be developed and vendors with which to partner.

Infrastructure Team:

- The infrastructure team will focus on the building and operation of a wireless network in maritime conditions. We will be working with the latest wireless technologies, including Mobile Wi-Max, 802.11 a/b/g, and 4.9Ghz Public Safety, as well as looking at creative and alternative power sources to operate our hardware. We will review GPS & satellite data and imagery and make design recommendations. We will assist in the design and network engineering of

individual site locations, tower placement, and design configurations including high capacity links, mesh networks and stand alone access points. We will also assist in site surveys, field testing and pre-implementation and test planning.

C. Sub-Teams Individual Responsibilities

Application Team:

- Jason Tenenbaum: Coordinating emergency response communications during a combined land and river chemical fire
- Brian Chung: Avoiding collisions between commercial & recreational traffic
- Ike Emelogu: Securing a ship docked at a riverside terminal facility
- Talha Yousuf: Visually Tracking Hazardous Cargo

Infrastructure Team:

- Joe Dietz: Building Logistics
- Daniel Czuchra: Bandwidth Requirements
- Brian Kim: Network Design
- Jack Calzaretta: Radio Deployment

E. Assign Meeting Roles

- Minute Maker: James Hendrickson
- Agenda Maker: James Hendrickson
- Time Keeper: James Hendrickson

F. Other Roles

- Define Paper Layout: James Hendrickson
- Define PowerPoint Layout: Jason Tenenbaum
- Presentation Boards: Joe Dietz

Obstacles

As we began the project, IPRO 305 encountered barriers and obstacles that slowed us down and raised certain questions of dealing with identified barriers. It initially took longer than expected for all the team members to gain a full understanding of the project. This kept the project from progressing according to the original plan. This was addressed by the individual team members through a great deal of effort in research and work to get the project back on schedule.

Another obstacle that IPRO 305 encountered during the semester is the punctuality of members for scheduled meetings. This was addressed numerous times throughout the semester but an effective solution was never found.

One obstacle that was brought to the attention of the team is the inability to construct a tower on one of the sites due to environmental reasons. The building logistics lead worked with the local alderman and the sponsor to establish an alternative and ultimately found out the problem was not as big of an issue as originally thought.

Results

Application Team

The application team successfully determined and provided solutions for four use case scenarios. The team worked with Bill Shipley from Air2Access to finalize a set of scenarios that would be both appealing for Air2Access to offer and useful for stakeholders along the Calumet River. The use case scenarios were identified to be:

1. Visually tracking hazardous cargo
2. Coordinating emergency response communications during a combined land and river chemical fire
3. Securing a ship docked at a riverside terminal facility
4. Avoiding collisions between commercial & recreational traffic

These scenarios relate to maritime security and safety needs. Research into the maritime industry revealed that there is a market for improvements to maritime security, and these scenarios reflect this market opportunity. The description, requirements, key data flow, target customers and partners, value proposition, and core offerings are detailed below for each scenario.

Visually Tracking Hazardous Cargo

A vessel loaded with hazardous cargo enters the river and must be continually monitored as it travels along the river to ensure safety of the cargo and surrounding area. A hazardous spill in the river could cause unparalleled economic and environmental damage. We sought to determine how the Coast Guard can effectively continuously monitor the vessel.

Functional requirements for a solution include:

- Ability to capture the live video of the vessel along the river
- Ability to zoom in and out the view from the control center
- Lightning or any other weather condition should not affect the video quality
- The streaming of video should not interfere the bandwidth of other tasks
- Ability to store data and play when needed, with all the information required
- System should be able to take night time videos

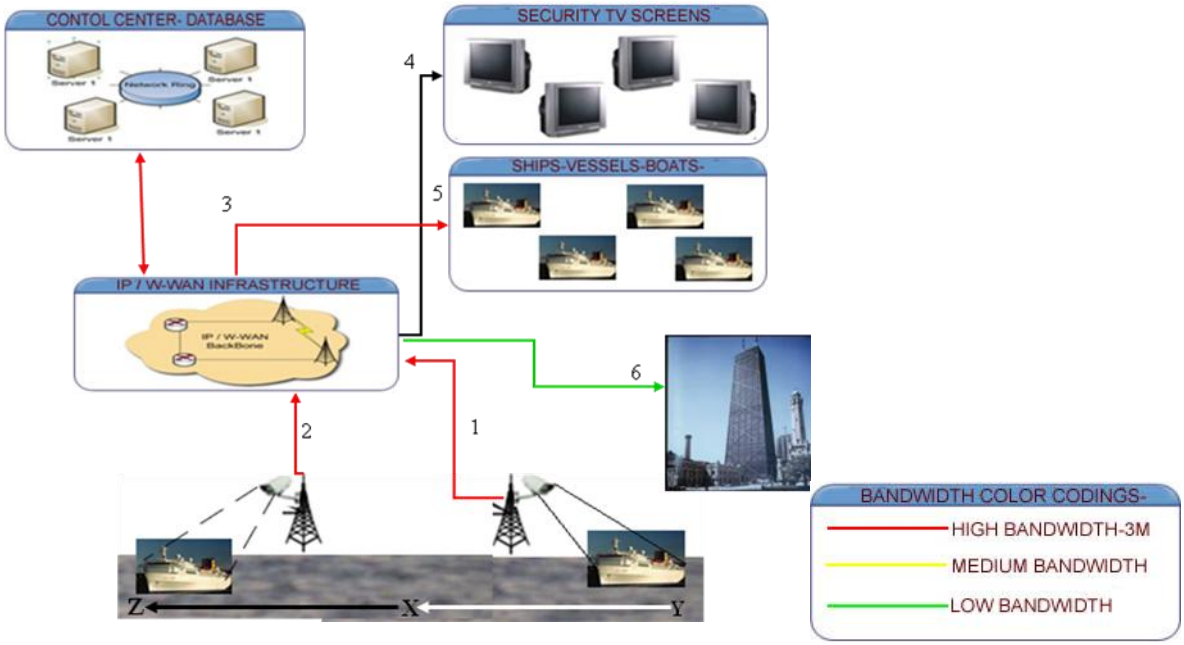
Technical requirements were determined to be:

- Resolution of 800 x 600px or better
- 802.11a/b/g WAN (wide area network)
- Should automatically transfer the video to the next camera

- A zipped/compact video to be stored in the database, for future purposes
- User friendly software to manage the video surveillance system

Furthermore, maritime security requirements (Title 33) require continuous tracking vessels with hazardous cargo along the river.

Utilizing the wireless infrastructure, Air2Access can provide live streaming video of the vessel along the river using 4 pan tilt zoom (PTZ) cameras spaced approximately 1 mile apart. Given this range, the smallest viewable object with the cameras recommended by the Infrastructure Team is approximately 2 square feet. The figure below shows the key data flow involved with this solution.



At (1) the PTZ 1 camera is used to track the vessel from point Y to point X with streaming video. At (2) PTZ 2 camera tracks the vessel from X to Z. At (3) Video transmits to the servers via the wireless infrastructure to a control center, where the video is monitored and/or recorded. At (4) the control center sends the digital video to various facilities and companies. Typically, only one camera will require bandwidth at a time, however during any periods of hand-off and in the uncommon occurrence of more than one hazardous vessel in the river at the same time, the system can support both cameras recording active video.

This solution should be offered to the United States Coast Guard, given their interest in ensuring the safety of vessels on the waterways. Potential strategic partners include camera vendors, camera video analytic vendors, and monitoring system vendors.

Tracking hazardous cargo prevents and illegal/misuse activities on the river and would help emergency services respond without delay in the case of an accident.

Coordinating emergency response communications during a combined land and river chemical fire

A barge full of a flammable liquid is unloading its cargo when a valve erupts, spilling the liquid into the water and then igniting. The financial losses, damage to the environment, and possible loss of lives that could result from poor emergency response could prove devastating to the surroundings of the accident site. We sought to determine how emergency first-responders and the property owner coordinate emergency response effectively.

Functional requirements for a solution include:

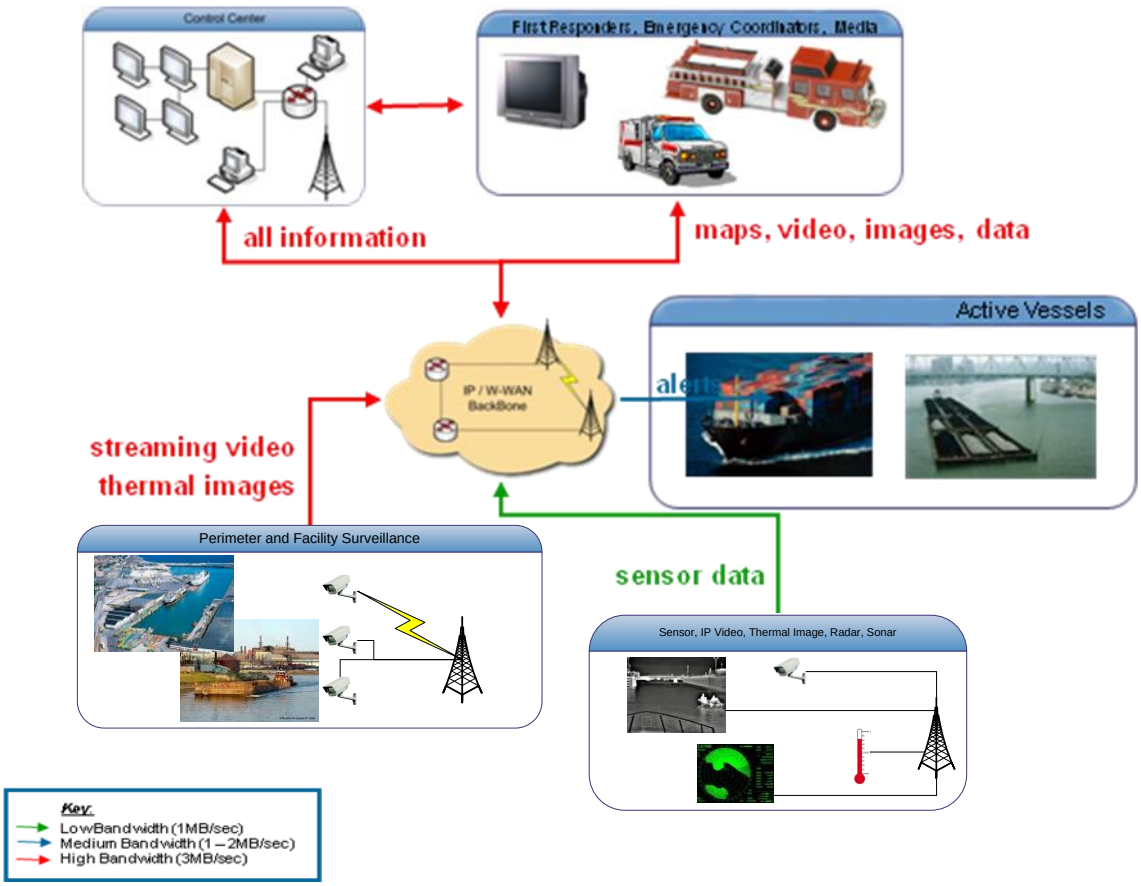
- Need to gather specific information in regard to the vessel of interest, including crew, cargo, passenger, and location.
- Must establish exact incidence location.
- Should be able to assess waterway traffic and make appropriate considerations.
- Should determine information on location and intensity of fire.
- Must communicate information within area of interest, along river, and to appropriate emergency response agencies.
- Should be able collect information on weather and forecasting conditions (and real-time conditions).

Technical requirements were determined to be:

- Must have network infrastructure to send/receive information to/from emergency response organizations.
- Must have 4.9GHz public safety radios and ability to use public safety network
- Should use marine VHF and/or UHF radio communication
- Should use application for or access to information regarding traffic flow
- Must use surveillance to establish incident location and monitor area(s) of concern
- Should collect infrared images to determine location and intensity of fire
- Should collect real-time water and weather conditions

Additionally, the 4.9 GHz Public Safety radio services must not be made available to the public.

Utilizing the wireless infrastructure, Air2Access can provide 4.9 Public Safety radio access to the Coast Guard as well as the Chicago Fire and Police Department. Live video surveillance in place, as well as any infrared cameras will allow emergency responders to have instant access to real-time fire conditions. The wireless network also allows for a common network that responders and the property owner can share data on. Furthermore, water sensors could be deployed into the water to determine the water conditions, saturation levels, etc. The figure below shows the key data flow involved with this solution.



In this scenario, a fire breaks along riverside on the land and water. First-responders are notified and requested to scene. Live surveillance video and IR images are transmitted to first-responders to analyze. News and alerts are sent to active vessels. Maps and other needed data are sent to first-responders, and all information is sent to an on-site control room for to relay out if necessary.

This solution should be offered to the United States Coast Guard, the Chicago Police Department, and the Chicago Fire Department. Any emergency unit or official first-responder should be granted access to the network. Proxim may prove to be a worthwhile strategic partner since they currently offer a 4.9 GHz public radio system. Air2Access and the Coast Guard could pair up to install video cameras at local businesses such as Morton Salt, Walsh Construction, and ACME Steel that can be utilized by first-responders in the case of an emergency.

Having appropriate resources in place for emergency response for a fire or disaster will help minimize financial losses and property damage, and could potentially save lives.

Securing a ship docked at a riverside terminal facility

A malicious intruder sneaks onto a vessel docked along a harbor, hoping to gain access to valuable cargo. We sought to determine how the facility owners can secure their vessels and quickly alert authorities, while also giving helpful data about the intrusion?

Functional requirements for a solution include:

- Access/Surveillance system must have armed and unarmed states
- When armed, must offer continuous surveillance till it is unarmed.
- Doors/Gates must work with intrusion detection system, via sensors, access control or other applicable technology.
- Must collect visual data about intrusion
- Must function in conjunction with surrounding landside surveillance systems (cameras, etc)

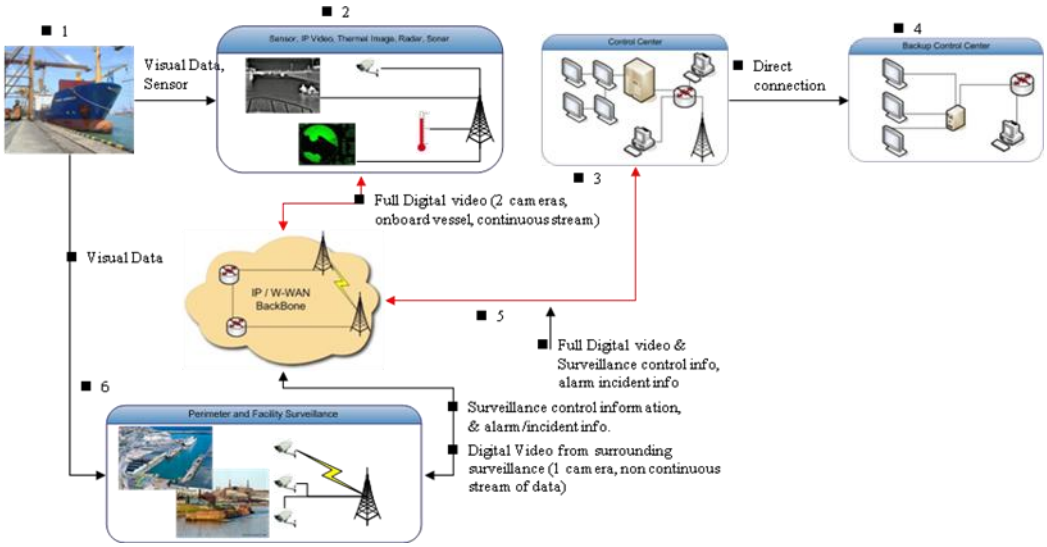
Technical requirements were determined to be:

- Electronic sensors on doors/gates, or/and virtual fencing implementation for restricted areas.
- Access/arming system, activated via access card, and IP ready.
- Onboard, IP ready PTZ digital video cameras
- W-WAN infrastructure that supports Point to Multipoint connections, for incoming & outgoing vessels
- PC based systems, management servers & DVR's.

Safety requirements include:

- Fulfill Maritime security requirements on safety measures for restricted areas
- Provide unobtrusive monitoring of vessel activities
- Recorded data must be accessible to maritime authorities

The solution to this scenario is an access control and surveillance system that Air2Access can provide to companies to improve their security. It would be composed of PTZ cameras at the facility, as well as a PTZ camera mounted on the vessel. Access cards can be implemented to provide an access barrier, and other extra options include virtual fencing sensors, etc that can act as triggers. Once a trigger is activated, whether by video or virtual fence, or whatever, notification is sent to the proper parties. The data flow of this solution is shown in the figure below.



As (1), an intruder enters a restricted area/boat, disrupting the sensor/visual perimeter. (2) Cameras access sensors pick up the data and share it via the wireless network. The control center then (3) receives breach information. The incident is recorded (4) and the control center sends alert via the wireless network to surrounding cameras, security on ship, and facility (5). At (6) the facility receives incident alert.

These services would be offered to the Coast Guard, Chicago Fire Dept, US Steel, Inland Steel, Nidera Inc, Metal Management, etc. Potential partners include Aventura Technologies, Ionas & Edge Responder. The service would prove valuable to a company because it can potentially reduce the loss of capital stolen goods, deter thieves, and reduce the need for third party security.

<u>Avoiding collisions between commercial & recreational traffic</u>

A commercial vessel and a recreational boater both approach a sharp bend with low visibility from opposite directions. We sought to determine what system can be set in place to help ensure the small recreational boat does not collide with the large vessel.

Functional requirements for a solution include:

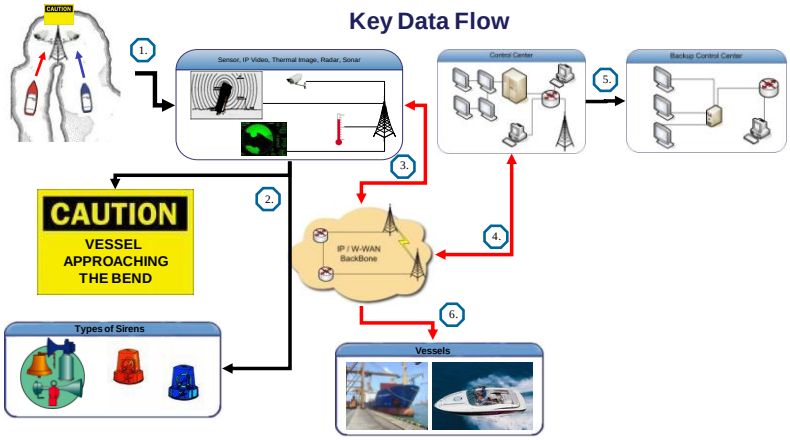
- PTZ cameras scanning vessels while in motion
- Visual signals established at a height where it can be viewed at a certain distance
- Provides ample time to maneuver vessel out of high risk areas

Technical requirements were determined to be:

- Activating output signals when vessel motion is detected

- Output visual and audio signals function in sync with each other
- Output signals reacting accordingly to the order of vessels detected

Additionally, regulating the traffic between high risk areas ensures better safety. The solution uses PTZ cameras mounted on either side of a junction or bed, an audio warning system (i.e. bullhorn), and a visual warning sign to indicate oncoming traffic. The combination of a video and audio warnings provide a unique way to capture the attention, especially of the recreational boater. The figure below illustrates the data flow.



(1) As the video sensors detect incoming vessels, the (2) sensors will trigger visual signs/signals. (3) The cameras, access sensors pick up data and share via the wireless network. (4) The alert tower receives detection and the (5) data is recorded. (6) The control tower sends an alert to surrounding ships through warning signals.

This solution would be offered by Air2 Access to the US Coast Guard as part of their role in ensuring the safety of ships and vessels on the water. Potential partners include EZWatchPro, Aventura Technologies, and marine communication vendors.

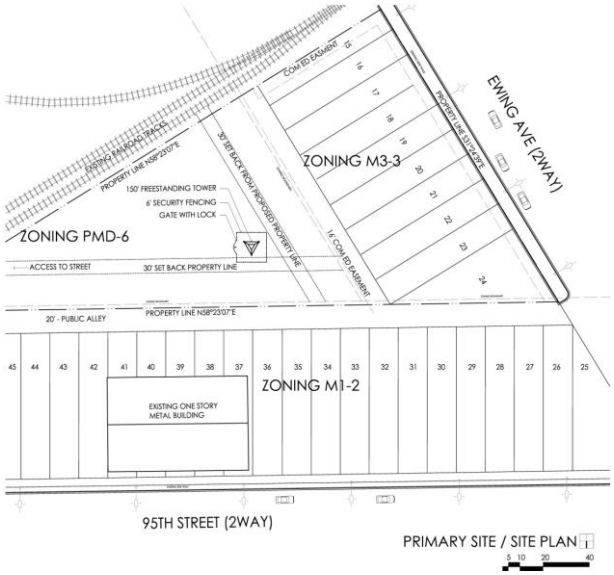
Utilizing a collision avoidance system will not only increase safe travelling, but it will also prevent property and vessel damage.

Infrastructure Team

The Infrastructure team conducted extensive research on the two sites, tower placement, radio types, camera types, and bandwidth demands needed to support the system proposed by the Application team.

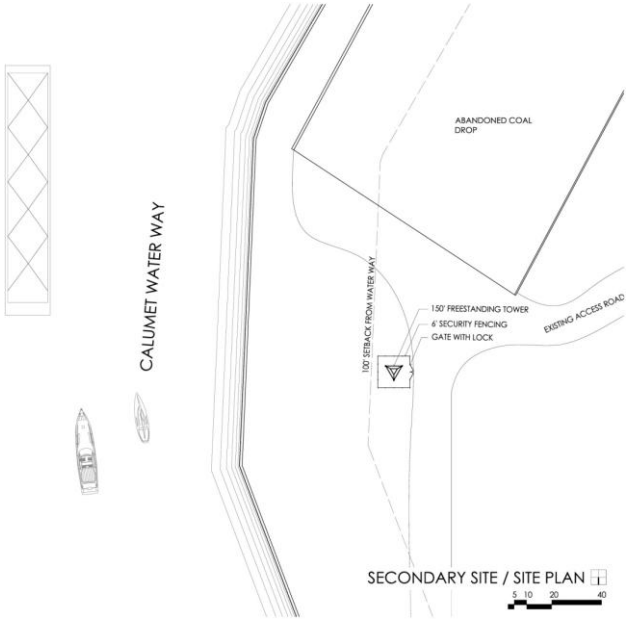
The first site, located at 3434 East 95th Street (Crowleys Boat Yard). The position of the tower at this site is proposed to be placed on the eastern portion of the property. In accordance with the 2007 Chicago Zoning Ordnance, the set backs that are imposed on this site are 30' from the property line.

Placing the tower at this location will give the tower a clear line of sight to the second tower over/around the Chicago Skyway Bridge. The recommended placement of this tower provides the ability to mount PTZ cameras that can monitor the river entry from Lake Michigan as well as the turning basin just north of the site. This tower placement option also prevents future zoning problems from arising if the site owner decides to sell off some or all of the plots found directly east and south of the proposed location.

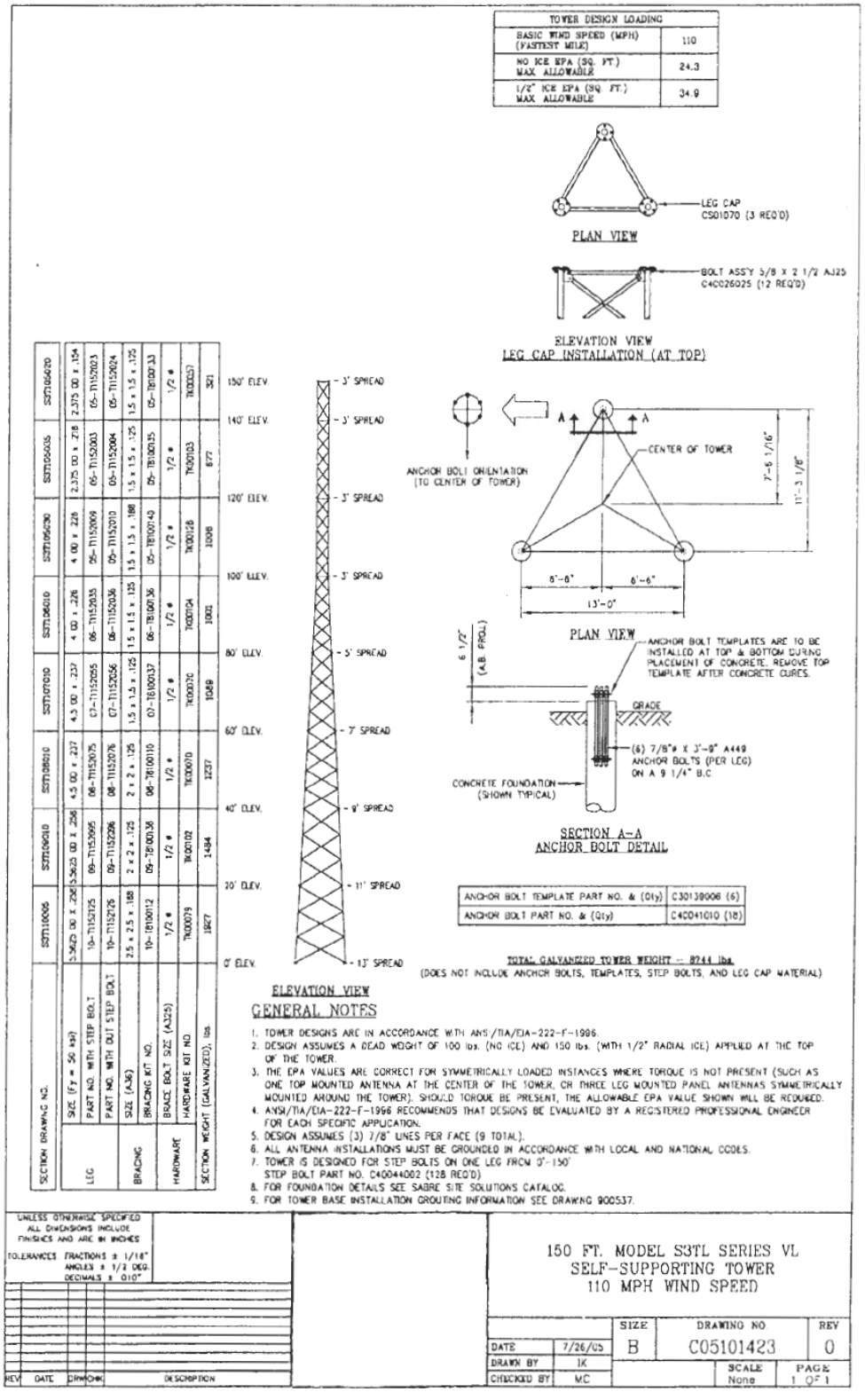


The second site, located at 11300 South Burley Ave. (formerly known as US Steel). The position of the tower at this site is proposed to be placed on the western portion of the property, as close to the river as possible. In accordance with the 2007 Chicago Zoning Ordnance, the set backs that are imposed on this site are 100' from the river edge.

Placing the tower at this location will provide a clear line of sight between the two towers. The recommended placement of this tower is along a curve and across from a turning basin. These surroundings make this an ideal location to place PTZ cameras and collision avoidance systems.



In addition to selecting two ideal site locations, the team also received a tower construction recommendation from Antenna Systems & Solutions headquartered in Schaumburg, IL. The prototype tower is designed to be 150’ tall and able to safely withstand all typical Chicago weather conditions, including up to 110 mph winds. Basic design features of the tower include a freestanding tower with a base of 13’ and tapers to 3’ at the top of the tower, maintaining complience with the 2007 Chicago Zoning and Building Ordnances. An engineering cut of the tower can be seen below.

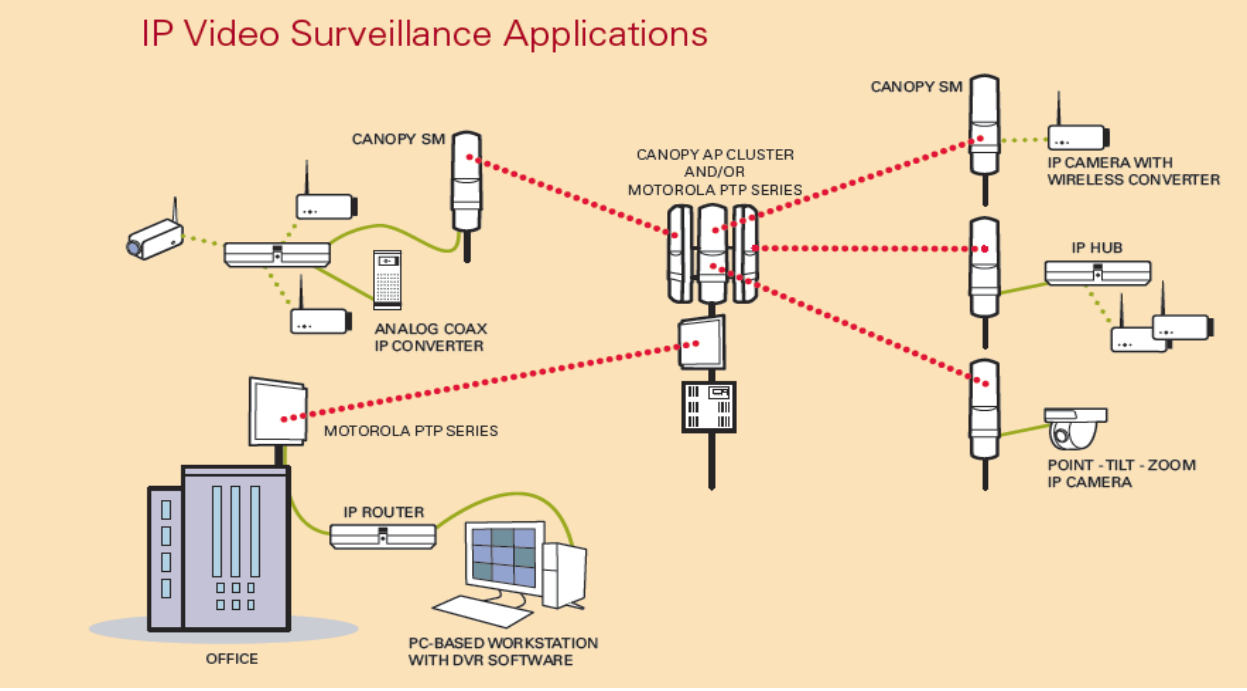


The team's research into wireless hardware options led to focusing on products from the Proxim and Motorola companies. To meet the demands of the potential stakeholders, both point-to-point and point-to-multipoint radios would be needed.

Motorola Option

PTP-100 PTP-400

The Motorola option, for our needs, would require the use of PTP-100 point-to-multipoint access points. The Motorola PTP-100 has a data rate of up to 14 Mbps *(2.4, 5.1, 5.4 and 5.8 GHz),* a range of up to 35 miles with a clear line of sight, and both DES and AES Encryption. This system would also require the use of PTP-400 point-to-point backhaul radios. The Motorola PTP-400 has data rates of up to 43 Mbps *(5.8 and 5.4 GHz)* and up to 35 Mbps for Public Safety 4.9 GHz. The range of the PTP-400 is up to 6 miles for non-line of sight, up to 25 miles for partial/obstructed line of sight, and up to 124 miles with a clear line of sight.



Proxim Option

Tsunami MP .11 5054

Tsunami GX-200

The Proxim option, for our needs, would require the use of Tsunami MP .11 5054 point-to-multipoint access points. The Proxim Tsunami MP .11 5054 has a data rate of up to 54 Mpbs full duplex *(5.24-5.35Ghz,15 channels),* a range of 1-10 Miles depending on the type and size of antenna used and can support up to 250 subscribers at one time. This system would also require the use of Tsunami GX-200 point-to-point backhaul radios. The Proxim GX-200 has data rates of up to 200 Mbps Aggregate and 100 Mbps Full Duplex *(*5.724-5.84Ghz*).* The range of this radio is up to 32 km with a clear line of sight.

The cameras we recommend for use in the system is the Axis Communications 223D. All cameras will display a frames per second (FPS) rate of 30, approximately what the human eye sees. The PTZ cameras at the tower locations will not be constantly streaming video, but be event triggered by the security sensors. Thus, the cameras take up a combined total of 2.2 Mb/s. If both are left fully streaming at 30 frames per second, they will consume up to 11.4 Mb/s and with all four constantly streaming they will use 22.8 Mb/s. The functionality of this camera model matches the needs identified in the use case scenarios. These cameras are shown below.

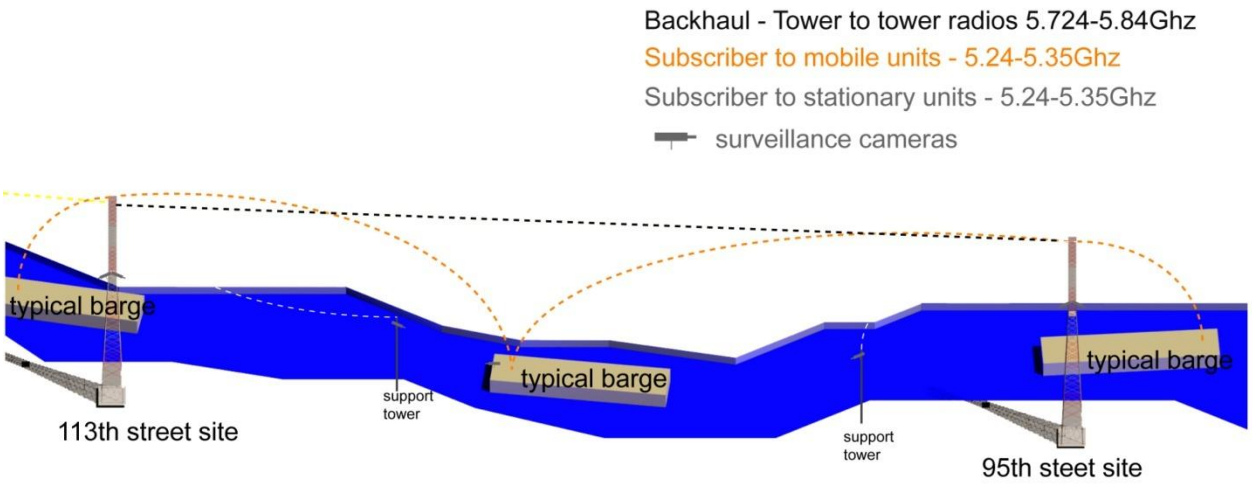
AXIS COMMUNICATIONS

The last two cameras that will make up the surveillance system for the site are Cohu made thermal PTZ cameras. These are specifically designed to survive harsh environments and track thermal profiles at long distances. The 5960 series will best suit our needs for a thermal solution but they do offer more integrated camera options. The 6980 series will integrate an IP encoder, but will be released as of summer 2007. Both models will use 200mm lenses and take up individually 8 Mb/s; or 16Mb/s for our thermal camera system. These cameras meet the needs identified for thermal imaging in each of the use cases that require infrared cameras. Both the 596D and 696D/80.

The bandwidth demands for all of these different radios and cameras will rely upon a dedicated fiber optic backhaul. Fiber is needed for our heavy bandwidth needs due to it's scalability and reliability in providing services to our customers. The fiber optic connectivity will be provided by the Comcast Corporation; Comcast is the best option because they offer more competitive pricing than AT&T and Novacon, and the scalability of their services can meet our backhaul needs up to 1 Gb/s which will allow our network to grow in the future without having to worry about service disruptions.

Recommendations

Total system recommendations is to use two towers, one located at the 95th street site (Crowley's Yacht Yard) and the other located at the 113th street site (the former U.S. Steel site). The system also calls for four (4) point, tilt, zoom (PTZ) cameras and two (2) thermal/infrared imaging cameras to be attached to these two primary towers. Support towers could be added as needed to provide additional video coverage in key areas



References

CIBER's Harbor Management and Security System. CIBER, Inc., 2006.

Frittelli, John F. Port and Maritime Security:. Library of Congress. Congressional Research Service, 2005.

Frittelli, John. Terminal Operators and Their Role in U.S. Port. Dept. of Homeland Security. 2006.

O'rourke, Ronald. Homeland Security: Coast Guard Operations. Dept. of Homeland Security. 2005.

Security Annual 2006. New York: Lehman Brothers, 2006.

"US CODE--TITLE 33--NAVIGATION ANDNAVIGABLE WATERS." 20 Apr. 2007 <http://www.access.gpo.gov/uscode/title33/title33.html>.

www.motorola.com

www.proxim.com

www.axis.com

www.cohu-cameras.com

Acknowledgements

John A. Pope Chicago City Alderman

Marilyn Engwall Project Manager, Department of Planning and Development

Ryan Woody Antenna Systems & Solutions, Inc.

James Patla Senior Firmware Engineer, Motorola

Simon Beemsterboer Site Owner

Dan Bochnovice Site Owner

Bill Shipley CEO – Air2Access

Udayan Das Graduate Assistant

Cindy and Dennis Hood Faculty Advisors