



**WPI**

The University of  
Science and Technology.  
And Life..

*Plant Services*

**An Integrated Building Management System for the WPI Campus**

*An Interactive Qualifying Project Report submitted to the Faculty of  
WORCESTER POLYTECHNIC INSTITUTE  
in partial fulfillment of the requirements for the Degree of Bachelor of Science*

**Sponsoring Agency:**

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# 1 Introduction

There is so much information that must be processed in the management of a building that it is often difficult to stay on top of everything. Building managers all over the world run into the same problems. These problems include energy conservation, building maintenance and organizing all of the building information. To solve these existing problems there are many organizations of building owners that hold annual conferences and meetings that deal specifically with building management issues. One of the most recognized organizations is the Building Owners and Management Association (BOMA). This foundation encourages research, offers training and education, and sponsors different programs like BOMA Energy Efficiency Program (BEEP). BOMA International represents nearly 100 American affiliates as well as 9 overseas affiliates. BOMA's membership in North America alone represents more than 9 billion square feet of commercial properties and facilities. More than 80% of the members of BOMA have an annual operating budget of over \$1 million<sup>1</sup>.

The same building management issues concern college campuses throughout the country. This applies to the 43 buildings on the WPI campus. College campuses contain many different types of buildings including residence halls, laboratories, dining halls, libraries, gymnasiums and others. Many of these buildings are only occupied during the day. Colleges and universities take different approaches in the management of their buildings, including having a department within the school to manage the buildings or having a specific individual in charge of the management of a specific building. Safety is the number one priority in the management of collegiate campuses. Montana State University actually has a department within the school devoted to this purpose, called The Safety and Risk Management Department.<sup>2</sup>

The Plant Services department at WPI is solely responsible for the management of the buildings on campus. Their mission is to provide a safe, clean, properly maintained environment for the WPI community. There are multitudes of safety and fire suppression

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<sup>1</sup> [www.boma.org](http://www.boma.org)

<sup>2</sup> <http://www.montana.edu/wwwsrn/>

systems in all of the buildings on campus. A host of inspections take place throughout the year to insure that these systems are in place and operating correctly, and that the buildings are safe in general according to city, state and federal regulations. In particular, a building inspection takes place annually and insurance inspections take place periodically. For residence halls only, a code compliance team which consists of a building, fire, and health inspector inspects these particular buildings. The Plant Services department hopes to utilize technology in the form of an integrated information system to assist in the management of the buildings on campus.

However, this information is difficult to organize and process. The fact that much of the information about the buildings on campus is either fragmented and/or available in a variety of different mediums can make the information hard to find and could cost the school valuable time and money. It can also complicate the job of the building inspectors. Having this information available in an easy to access form would not only help inspectors of the buildings, but assist the building managers as well. In order for an integrated information system to be created, both the physical information about the buildings as well as input from Plant Services itself and the inspectors of the buildings must be considered. Previous projects began the process of collecting data and mapping the buildings and safety systems within the buildings. At this point it is necessary to verify the pertinence of the information collected with regards to the needs of the inspectors and managers of the buildings.

In order to validate the work previously done, this project will determine the needs and requirements of the building inspectors and managers. The goal of this project is to create an integrated computer information system for the Plant Services Department at WPI to help make decisions related to the safety and efficient operation of the buildings on the WPI campus based on the needs previously determined. This information would be available to all people who access the WPI buildings and who need any specific information on the buildings. Once a plan for this integrated information system has been produced, the building information that has been previously collected will be analyzed for pertinence in terms of the system.

## **2 Background**

### **2.1 Building Management**

Building management is more commonly referred to as facility management. This is due to most of the information and literature on the subject existing for the purpose of commercial and industrial facilities. The same principals involved in commercial and industrial facilities management can be applied to the management of all buildings however. In terms of the actual management organization, there is no ideal group. In the best case scenario, the management organization is tailored to the buildings and facilities that that organization is in charge of. It is important for clear lines of authority to be developed within the organization and all responsibilities and tasks assigned to the individual members.

Energy efficiency is the most important issue that most building owners are concerned about. Energy Star is a program that promotes energy conservation and awards those who score the highest on energy performance by decreasing building operating costs by 20 to 30 percent<sup>3</sup>. Washington Mutual is a national financial company that owns more than 2600 properties and in the last year they made a commitment to reduce energy consumption by 10 percent<sup>4</sup>. They achieved this goal by strategic planning including many changes starting from new lighting to larger mechanical retrofits.<sup>5</sup>

### **2.2 Campus Building Management**

On every college campus throughout the world, there is a department within the school that is responsible for the management and maintenance of the facilities on campus. These management departments have different responsibilities at different institutions, but their general purpose is the same and their priority is always safety.

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<sup>3</sup> Brodsky, Stuart *Energy Star Tools for Building Performance Planning & Management* [www.betterbricks.com](http://www.betterbricks.com) [article online] Retrieved November 14<sup>th</sup> 2005.

Miller, Brian *A Bold Commitment by Washington Mutual in Planning & Management* [www.betterbricks.com](http://www.betterbricks.com) [article online] Retrieved November 14<sup>th</sup> 2005.

<sup>5</sup> Ibid. Brodsky, Stuart.

Many colleges like Arizona State University (ASU), Carleton College, University of Wisconsin (UW) etc. have a department called the Facilities Management and Planning, which is responsible for managing the college's financial resources to provide and maintain a welcoming, safe, and attractive environment for all students and faculty. Some colleges divide campus building management into different departments such as Property Services Safety Management, Energy Management, and Maintenance Management; each department with a specific manager in charge. The figure below shows the Facilities Building at Carleton College.



Figure 1 Facilities Building- Carleton College<sup>6</sup>

## 2.2.1 Building Management at WPI

This aerial photograph of the campus is presented to illustrate the complexity of managing the entire WPI campus. (See Figure 2)

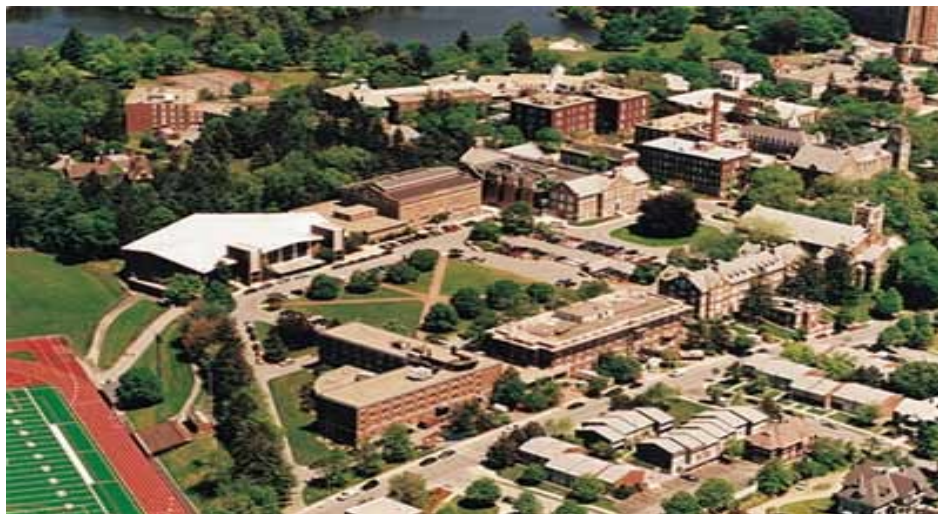


Figure 2 WPI Campus<sup>7</sup>

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<sup>6</sup> Carleton College, Facilities planning & Management <http://apps.carleton.edu/campus/facilities/> Retrieved October 2<sup>nd</sup>, 2005.

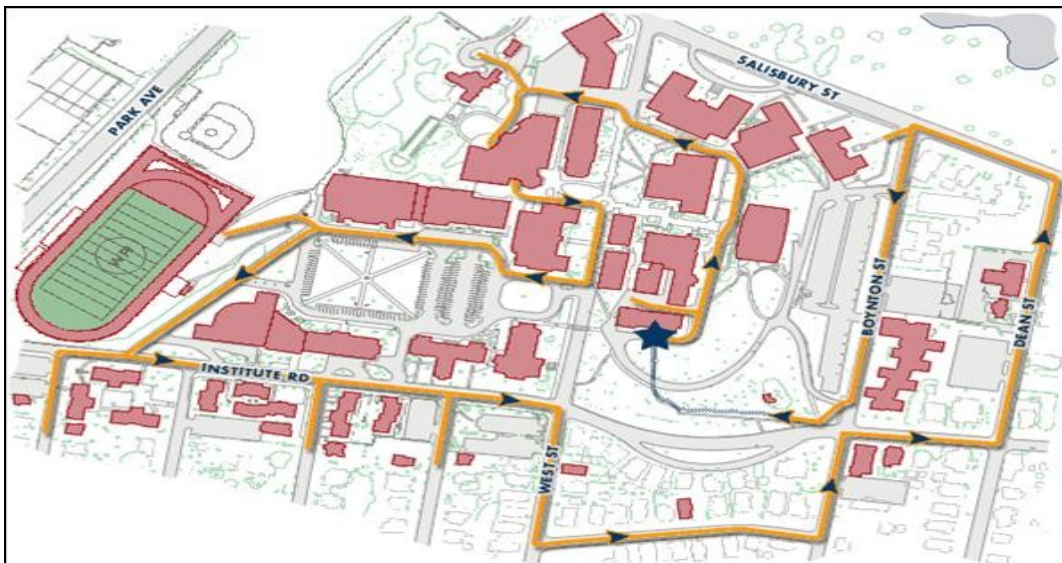
<sup>7</sup> Worcester Polytechnic Institute [www.gradprofiles.com](http://www.gradprofiles.com) Retrieved October 2<sup>nd</sup>, 2005.



Plants Services is responsible for building management at WPI. Plant Services is divided into other departments which include: Building Projects and Renovations, Trades Maintenance and Repairs, Ground Services, Custodial Services, Rental Properties, and Environmental and Occupational Safety Offices (EOS). Each department has distinctive tasks and a specific manager in charge. Trades Maintenance and Repairs mission is to sustain and renovate all the buildings owned by WPI and provide services in carpentry, electrical, plumbing, HVAC, and Service Desk. Ground Services keep clean and proper outdoor surroundings on all properties owned by WPI. Custodial Services are responsible for maintaining a clean and healthy environment.

Building Projects and Renovations is responsible for the competition of new buildings and other projects on WPI. Each project proposed by the Plant Services has to be confirmed by the Vice President, President's Cabinet, and the Board of Trustees. These projects are then categorized depending on cost and yearly budget: less than 10,000, between 10,000 and 50,000, over 50,000, and over 250,000<sup>8</sup>.

The figure below shows an aerial photograph of all the buildings on WPI campus. All WPI buildings total 1,560,172 sq. ft. WPI Buildings Value reaches \$168,783,000 plus a total content value of \$77,162,000 gives a total insurance value of \$245,945,000<sup>9</sup>.



**Figure 3** Aerial Photograph of WPI Buildings<sup>10</sup>

<sup>8</sup> Plant Services. Project Management Protocols [www.wpi.edu](http://www.wpi.edu) Retrieved December 1st, 2005.

<sup>9</sup> Cove, Danielle. Treasury Office. WPI Safety Committee 2005-2006.

<sup>10</sup> Worcester Polytechnic Institute. E-Buildings @ City Lab [www.wpi.edu](http://www.wpi.edu)

## **2.3 Building Safety Management**

Safety is the primary concern in all buildings especially in collegiate campus buildings. Many organizations are devoted to reduce accidents and provide a safer environment for all. Occupational Safety and Health Administrations (OSHA) is committed to improve safety in workplaces by offering training and education through enforcement of their strong standards. (OSHA)

This administration has more than 2,220 employees and 1,100 inspectors and it is worth \$468.1 million<sup>11</sup>. OSHA insures safety based on three tactics: strong enforcement of codes, encouragement of education, and cooperative programs. This has shown to be extremely effective because since its beginning in 1971 it has reduced work-related injuries and fatalities by 40% up to 60%<sup>12</sup>.

Universities are key to the progress and success of a country hence the US government is willing to spend over \$15 billion on their research<sup>13</sup>. Often these universities are affected by natural disasters that could cost them millions of dollars; for instance University of California, Berkeley, Stanford University, California State University, University of Miami, Syracuse University etc, have all been damaged repeatedly by earthquakes, hurricanes, and flooding<sup>14</sup>. The Federal Emergency Management Agency (FEMA) and University of California have organized a national program called Disaster Resistant Universities Initiative to assist universities in case of emergencies. This program assists universities in their loss reduction efforts by providing guidelines for a strategic risk management plan. University of California, Berkeley even created a program in 1997 Seismic Action Plan for Facilities Enhancement and Renewal Program (SAFER program) with \$1 billion budget dedicated to seismic safety on campus buildings<sup>15</sup>.

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<sup>11</sup> US Department of Labor. Occupational Safety & Health Administration- OSHA facts [www.osha.gov](http://www.osha.gov) Retrieved December 3rd, 2005.

<sup>12</sup> OSHA

<sup>13</sup> Comerio, Mary. The Economic Benefits of a Disaster Resistant University. [www-laep.ced.berkeley.edu](http://www-laep.ced.berkeley.edu) Retrieved December 5th, 2005.

<sup>14</sup> Ibid. Comerio, Mary.

<sup>15</sup> Ibid. Comerio, Mary.

International Code Council (ICC) is another nonprofit organization whose mission is to “Provide the highest quality codes, standards, products, and services for all concerned with the safety and performance of the built environment”<sup>16</sup>(ICC). This organization was found in 1994<sup>17</sup> and it is committed to protect our communities by creating safer buildings. ICC has also created International Code Council Foundation (ICCF) which promotes the improvement of buildings and homes through use of technology and ICC codes. ICCF has developed codes to provide a complete building safety system to minimize property damage and loss of life<sup>18</sup>.

## **2.4 Building Inspections**

Building inspectors are grouped into different categories depending on their area of specialization including electrical inspectors, elevator inspectors, mechanical inspectors, plumbing inspectors, and public work inspectors. Building Inspectors are responsible to study the building’s structural quality, and also inspect the safety of buildings, by focusing more on fire safety. An inspector’s job involves discovering and identifying an existing problem, gathering information, inspecting the quality and material of the product, and reporting all findings and conclusions. They are needed for inspection before, during, and after the construction of a building. They also check for permit and report any violations in compliance with the ICC codes<sup>19</sup>.

A typical BOMA Building Inspection Form<sup>20</sup> checks for level of maintenance and grades each part of the building by using a rubric from 1 to 4 (1=poor to 4=excellent). The inspection focuses more on the safety, functionality and operation, physical appeal, and cleanliness. The inspection form is divided into the following:

<i>Entrance/Main Lobby</i>	<i>Security/Life Safety</i>	<i>Management Office</i>
<i>Elevators</i>	<i>Multi-tenant Corridors</i>	<i>Restrooms</i>
<i>Stairwells</i>	<i>Typical Tenant Suite</i>	<i>Central plant/Engineering Office</i>
<i>Service Areas</i>	<i>Roof</i>	<i>Parking Facilities</i>
<i>Grounds</i>	<i>Loading Deck Areas</i>	<i>Tenant Amenities</i>

<sup>16</sup> International Code Council [www.iccsafe.org](http://www.iccsafe.org) Retrieved November 30th, 2005.

<sup>17</sup> Ibid.

<sup>18</sup> International Code Council Foundation [www.icc-foundation.org](http://www.icc-foundation.org) Retrieved November 30th, 2005.

<sup>19</sup> US Department of Labor. Bureau of Labor Statistics. Construction and Building Inspectors [www.bls.gov](http://www.bls.gov) [database online]. Retrieved December 5th, 2005.

<sup>20</sup> BOMA Building Inspection Form (2004-2005) [www.bomaseattle.org](http://www.bomaseattle.org) Retrieved December 3<sup>rd</sup>, 2005.

## 2.4.1 Safety and Inspections at WPI



Figure 4 Safety Divisions

The Environmental and Occupational Safety (EOS) Office is responsible for protecting and keeping a safe and secure working environment at WPI. Figure 4 shows the divisions of EOS into four main departments: Biological Safety, Laboratory Safety, Occupational Safety, and Radiation Safety<sup>21</sup>. Each department has its own safety guidelines and strict regulations, for instance: WPI hazardous waste storage area is inspected weekly to insure safety from hazardous materials. Fire safety regulations for residence halls are also posted online. With all the cautions there still have been fire occurrences on WPI residence buildings. Fire safety regulations should be followed strictly by all to prevent these incidents. WPI campus is inspected annually.

## 2.5 Building Management Information Systems

An ideal building management information system would be a complex and multifunctional system capable of collecting, saving, and processing data. We are interested in systems whose primary functions are to store, compile, display and analyze the desired information. In addition to these qualities this data management system should also be easily accessed by building managers, inspectors, and all building maintainers. Information Systems using constantly evolving technology have revolutionized the way we work by simplifying data collection and data organization. Some examples of information systems that we have come across so far include: GIS, EIS, Winoscular Systems etc.

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<sup>21</sup> Ibid.

Winocular System “Innovations in Paperless Automation”<sup>22</sup> is a Document Imaging System designed to organize all different documents into a categorized and systemized database. This system is easy to use and also time saving. It consists of many applications such as: “City Records Management, Accounts Payable Document Management, and Accounts Receivable Document Management”<sup>23</sup> etc.

Geographic Information Systems (GIS) is a very successful system that uses high technology to examine and study geographic data. GIS uses three distinct ways to apply geographic information: database (Database View), processing (Model View), and visualization (Map View)<sup>24</sup>. GIS is used as a problem solving tool to analyze and interpret data.

### **2.5.1 Building Information Systems at WPI**

An information system is needed to organize all the buildings’ information at WPI. Various information systems have been used in the past including GIS. GIS has been widely used on different projects on WPI such as “GIS Development in Costa Rica”, or for parking management in “Applications of GIS to a Parking Study in Newton”<sup>25</sup> etc.

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<sup>22</sup> Winocular Systems [www.winocular.com](http://www.winocular.com) [database online] Retrieved December 3<sup>rd</sup>, 2005.

<sup>23</sup> Ibid.

<sup>24</sup> The Guide to Geographic Information System. What is GIS? [www.gis.com](http://www.gis.com) Retrieved Decemer 3<sup>rd</sup>, 2005.

<sup>25</sup> Kligman, Ricardo *Applications of GIS to a Parking Study in Newton* [www.wpi.edu](http://www.wpi.edu) Retrieved December 10<sup>th</sup> 2005.

### 3 Methodology

The goal of this project is to create an integrated computer information system, based on building information and requirements for such a system gathered from building inspectors, for the Plant Services Department at WPI. This system will help Plant Services make decisions related to the safety and efficient operation of the buildings on the WPI campus. Through research on building safety and management, building inspections, and information systems, followed by analysis of this research, this goal should be accomplished by the end of the 2005/2006 WPI academic year.

To determine the requirements and needs of the various individuals and companies who manage and maintain the buildings on the WPI campus

To design and validate a prototype of a building maintenance system

To analyze the suitability of the existing data with respect to the requirements of the aforementioned building maintenance system by the managers and maintainers of the buildings

To validate and integrate the existing knowledge base about WPI buildings to suit the requirements of the building information system

The spatial extent of this project includes the main WPI campus bordered by Boynton and Salisbury Streets, Institute Road and Park Avenue, as well as any outlying buildings that are owned by WPI. A map of this area can be seen at <http://www.wpi.edu/About/Visitors/Images/walkingmap.pdf>.

This project began in September of 2005 and ended in May of 2006.

The buildings on the WPI campus consist of any structure owned by WPI in which faculty, students, or staff occupy and conduct business in for an extended period of time on a daily basis. This would exclude storage sheds or anything of the like which are used sporadically.

The rest of this chapter illustrates the methodology of the project. It will begin by showing how the resources and information were gathered for the project, then proceed into the thought process behind the analysis of that information. It will then proceed into the process of creating the mock-up system and end with the analyzing of previous building information gathering methodologies.

### **3.1 Determining Requirements for Building Information System**

#### **3.1.1 Identifying managers and maintainers of buildings with emphasis on personal and fire safety**

We identified the following managers and maintainers of the buildings by interviewing John Miller, the director of the Plant Services Department. He identified the insurance inspector (Joe Sanford), the building inspector (Paul DiBenedetto), a Captain at the Worcester Fire Department (William Metterville), WPI's Manager of Environmental Safety (Dave Messier) and Chris Salter (Plant Services) as these managers and maintainers. In addition, the directors of the physical plant at The College of The Holy Cross were interviewed in order to gain a different perspective on facilities management. It was determined that Mr. Sanford was no longer the insurance inspector for WPI, so Diane Gould, a property specialist for WPI was interviewed as a replacement. See Appendix C. We will also be interviewing Jon Miller for his input on the requirements for the system. In order to conduct these interviews, it was necessary to create a questionnaire to use during the interviews.

The questionnaire was created as a general questionnaire to be used for all of the various managers and maintainers of the building. This questionnaire is possibly the most important part of our project, as all the information to be used in the design of the prototype would be derived from the answers provided by the managers and maintainers of the buildings.

In order to be sure that the questions in the questionnaire both provided the necessary results and retrieved the appropriate information, it was important to field test the questions using an outside and impartial source. To test these questions we used the former WPI insurance inspector, Steve Petrolati. Mr. Petrolati has been inspecting buildings for over 20 years, which were exactly the credentials needed for testing our questions, and his familiarity with the WPI campus was an added bonus. The questions were tested simply by mock interviewing Mr. Petrolati. Notes of the interview were taken, and later transcribed into a document and added to this report as an appendix. All interview transcriptions can be found in Appendix D. If Mr. Petrolati had raised serious concerns about the questions themselves, it would have been necessary to rework the

questionnaire and then retest the questions. This was not the case, although Mr. Petrolati did suggest adding some questions, which became part the questionnaire.

The interviews of the managers and maintainers of the buildings were conducted in much the same manner as the testing of the questions for these interviews. Notes were taken during these interviews, and their answers to the questionnaire recorded. For some of the people interviewed, the test questions did not completely suit them, such as the directors of the physical plant at Holy Cross, so the transcripts of the interviews take a different form. These changes are noted before each transcript. After all of the interviews, the information that was collected from the interviews was inserted into the Table 1, which was used to determine what information should be included in the system. This was simply done by quantifying each request for a particular system feature, and the features with the highest totals were determined to be the most important to the managers and maintainers of the buildings.

### ***3.2 Designing a Prototype Building Information System***

As stated above, the information that will be included in the information will be determined from the interviews and the subsequent data matrix. Once this has been done, the actual design of the information system will begin. The form of the system has not been decided yet. It would be easier to access it from a portable CD, or computerize it in a hand held device or a more sophisticated device as the technology progresses in the future, but for now it will be web based. The managers and maintainers of the buildings can easily examine the system, and give feedback on its form and content. We have decided to plan the mock up system using Power Point for our convenience. Map Info is also a good option, although it is more complicated and not as easy to access from different computers. The system will have a similar look to a typical GIS system, with a map of the campus, and tabular pages for each manager or maintainer of the buildings. It will be categorized into different departments such as: fire department, building inspectors, plant services, and insurance inspectors. Each tabular page of the program would contain a list of the different information available for that manager or maintainer, so for example if the building inspector selected “fire extinguishers” all of the buildings with fire extinguishers would become highlighted, and the building inspector could select



an individual building and see a map of the building and the fire extinguisher locations within that building, as well as information pertaining to each individual fire extinguisher.

We are concentrating on one particular building right now, and once we have a mock up system for that building, the same idea will be applied to the rest of the buildings. We have chosen to use Goddard Hall as a first example because we have more available information on it than the other buildings. Once this skeleton of the system has been created, the managers and maintainers of the buildings will be asked to check the system and give their input on what might be improved or eliminated. Any suggestions by the managers or maintainers will then be applied to the system.

### ***3.3 Analyzing Existing Building Data***

At this point it will be necessary to validate the information collected on the buildings by previous projects. The existing building data will be compared to the information required by the managers and maintainers of the buildings. Any existing information that is required will be included in the system. We do not foresee any of the information that has been collected being deemed unusable in the information system, but the check is necessary. From our interviews so far we determined that the users were interested in the floor plans, and locations of the fire extinguishers, exit signs, hazardous materials etc, but they were not interested in the 3-D maps from the past projects. The available collected data from past projects is useful; however it is not enough.

The existing building data was determined to be pertinent to the system prototype almost entirely. The work that has been done to collect information on and map the locations of fire extinguishers, emergency light and exit signs, as well as hazardous materials storage were all deemed important by several building managers and maintainers. The existing building data was compared to Table 1 to determine the relevance and importance of said data to the building information system prototype.

### ***3.4 Validating and Integrating Existing Information***

Once the system has been created, we will be creating data forms for further projects to use in the collection of data for the system, and if time permits, collecting some of that data ourselves. The existing information that has been determined to be required will be integrated into the system.

## 4 Results and Analysis

From the interviews that were conducted we created a PowerPoint presentation mock-up of the information system, which is available on the project website. The people interviewed were individuals that we felt either had direct involvement with the management of the buildings at WPI or would be able to provide some insight into building management and in addition provide sound advice for the information system. These individuals are listed in Appendix C. Transcripts of the interviews are available in Appendix D.

### Inspection Process:

Inspection Date →	Instruments →	Violations →	Work Orders →	Reschedule Inspection Date →
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Based on the interview we formulated the steps during an inspection process. Usually there is a 24 hour notification before an inspection. A building inspector is interested in the building permit, certificate of occupancy, and whether the job is being done in compliance with the codes. Throughout the procedure the inspector consults with different code books such as 780 CMR dealing with residential codes, Zoning Code, and 521 CMR dealing with Handicap issues. These codes specify the absolute minimum requirement.

The form used during the inspection consists of a thorough check up on excavation, footing-right size and space inspection, foundation- if the wall is up at right elevation/ wood construction/ water sealed, rough frame, fireplace- size, containment of fire, material-wood frame/or steel frame, and sealed vertical penetration. The inspector checks for insulation, energy, ceiling, walls, piping, and air condition using code 68 from CMR. Finally multiple inspections are conducted including electric, gas, fire, plumbing, and health. The inspector looks for what kind of building is being constructed and why, if things are getting done right and on time, and whether everyone has signed all the right inspection forms. Building inspectors are also interested in the history of the building, and the structure of the building to make sure nothing is loose, if bricks are ok, if there are any recent repairs, or previous repetitious violations. In schools and dormitories

annual inspections are performed and one of the most common violations is blocked stairwells and doors. Safety is always the priority of the inspectors. If something is not right, work orders are assigned for repairs and corrections. Afterwards a follow up inspection is carried out to validate a new certificate.

Steve Petrolati, who is the former WPI insurance inspector, was the individual we interviewed to test our interview questions, but he also provided information that was used in development of the system mock-up. As the insurance inspector, it was Mr. Petrolati's job to inspect all of the safety devices in the buildings, which is a very extensive list. In terms of what Mr. Petrolati said would be good additions to the system, most of them were related to fire protection and fire safety. These included egress pathways, pull boxes, stop devices, sprinklers, emergency lights, kitchen stove hoods and extinguishing devices, fuel shutoffs, first hydrant location, and the fire department for each building. In addition, Mr. Petrolati said during his inspections that he checks that all exits and exit signs are clear, that there are spare sprinkler heads in the right locations, and that the trash is properly and safely stored.

The building inspectors were far less specific with their information. They did mention that they would like to have means of egress, emergency lights and the emergency power test log to be included in the information system. They building inspectors were also looking to make sure that the exits and exit signs are clear as well as that the fire doors are unblocked. Paul DiBenedetto stressed that when going through his inspection process, something barely meeting the code is not always adequate in his eyes, and at his discretion he can insist on improvements in a particular building feature.

Chris Salter was interested in a combination of CAD, MAXIMO, and text format that layers important data, providing the inspectors with quick and accurate information. Maximo is the program used by Plant Services to manage the work orders for the entire campus. Mr. Salter was not interested in 3-Dimensional Revit drawings as long as the location and the floor plans were clearly displayed. According to him this electrical document should contain a general building description, picture of the building, history of the building, the different departments, energy standpoint, heating source, as well as the card access points on campus.

Captain Metterville not only had some distinct safety features that he wanted to see present on the information system, but also some simple numbering and labeling for the buildings themselves which would match the numbers and labels in the buildings themselves. In particular, Mr. Metterville wanted the rooms, hallways, doors, stairwells and elevators numbered and/or labeled with corresponding labels on the floor plans in the information system. Captain Metterville was also interested in seeing fire extinguishers, sprinklers, first hydrant locations, electrical shutoffs, fire alarm panels, compressed gas storage locations and heating plant locations included in the building information system.

After going through the interview process, there was very noticeable overlap in the elements of the information system that each individual requested. These overlapped system elements were grouped into a common safety features list in the system mock-up. These common features included egress paths, fire extinguishers, pull boxes, sprinklers, emergency lights, fuel and electrical shutoffs, first hydrant locations, the building fire department plans and the fire alarm panel locations. This overlap is illustrated in Table 1. There is a column for each person or group interviewed and a row for each information system features that at least one interviewee expressed interest in. There is also a column summing the total amount that each feature had interest expressed in it. The overlap is represented by the features with a two or more in that column.

All of this information would be nice to have in such a building information system, but only if it contributes to the overall goal of Plant Services and the inspectors of the buildings on the WPI campus, which is the overall safety of the students, faculty and staff. As can be seen in Table 1, the vast majority of the features that the managers and maintainers of the buildings would like to see in the building information system are safety devices or features that contribute to safety on the WPI campus.

With that understood, it can be said that such an information system would not only hopefully contribute to the speed, accuracy, and effectiveness of the inspections of buildings on campus, but also increase overall campus safety. If all the system accomplishes is increase the speed with which faulty fire extinguishers are replaced, then the system would be worth it already. However, if implemented, this system has the potential to improve all aspects of safety on the WPI campus.

		Insurance	Building	Fire Dept.	WPI Health	Property	Plant
		Inspector	Inspector		& Safety	Specialist	Services
<b>Features</b>							
<b>Map</b>	<b>Sum</b>						
Room Labeling	1			1			
Stairway Labeling	1			1			
Building Photographs	1					1	
Elevator Labeling	1			1			
Means of Egress	2	1	1				
Fire Lanes	1			1			
Identify Egress Pathways	1				1		
<b>Physical</b>	0						
Door Labeling	1			1			
Fire Extinguishers	2			1			1
Pull Boxes	2	1					1
Stop Devices	2	1					1
Sprinklers	3	1		1			1
Emergency Lights	2	1	1				
Occupant Load Sign*	1	1					
Hydraulic Design Plaque	1	1					
Hood Vent Filters(K)	1	1					
Hood Ducts(K)	1	1					
Extinguishing System(K)	1	1					
Fuel Shut-Offs	2	1			1		
First Hydrant Location	2	1		1			
Electrical Shutoffs	2			1	1		
Fire Alarm Panel	2			1			1
Building FD Plan	2	1		1			
Compressed Gas Storage	1			1			
Backflow Preventers	1						1
Heating Plant(Boiler)	1			1			
Emergency Eyewash	1				1		
Electrical/Gas Meters	1						1
Emergency Phones	1				1		
Emergency Power Test Log	1		1				
<b>Pre-Inspection</b>	0						
Exits Clear	2	1	1				
Building Snapshot	2					1	1
Exit Signs Clear	2	1	1				
Trash Stored Safely	1	1					
Spare Sprinkler Heads	1	1					
Improper Storage	1			1			
Fire Doors Unblocked	1		1				
<b>Building Maintenance</b>	0						
Work Orders(Maximo)	2				1		1

Inspection Fixes	2				1		1
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Table 1

**INSPECTION CALENDAR**

An inspection calendar informing the Plant Services of the next inspection date would be very helpful in preparing for the inspection. This is a simple figure showing what it could look like. The month of the inspection date would be highlighted and the computer/device would be programmed so that a week before the inspection a pop up window would show. This window will notify the user when, where and who would be coming and also it would provide links to the list of previous inspections, past problems and violations, and a blank inspection form.

**The highlighted months signify a scheduled inspection date.**

**MARCH**


JANUARY	FEBRUARY	<b>MARCH</b>
APRIL	MAY	JUNE
JULY	AUGUST	SEPTEMBER
OCTOBER	<b>NOVEMBER</b>	DECEMBER

Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	<b>31</b>				


**Click on the highlighted date to get more information on the inspection date.**

Reminder: Inspection Scheduled

March



**Who:** Fire Department  
**Where:** Goddard Hall  
**When:** Time 2:30 pm



List of Previous Inspection Forms

Past Problems and Violations

Blank Inspection Form

## **5 Recommendations and Comments**

The content of such an information system would need to be maintained and updated regularly in order to be effective. The purpose of this program is to incorporate different functions into a single database system so that the most current, organized, and accurate information is distributed simultaneously to all users. The form of the program is still up in the air. Some interviewees suggested that it should be in a portable disc that way it is easier to access from different locations. Some thought it would be easier if the initial program was web based although in the future a hand held device would be more helpful. Whatever form the final version of this information system takes, it should be readily accessible and easy to use.

Holy Cross Physical Plant director Scott Merrell introduced us to FAMIS. FAMIS is a facilities management information system used at Holy Cross. FAMIS is a complex database system that combines multiple tasks and functions; however it is a very expensive product, too complicated, and only a few people at Holy Cross were trained to use it. In order for a building information system to be effective at WPI, such a situation would have to be avoided. There would need to be several individuals who were capable of updating the system in order to prevent the possibility that one person is responsible for the entire system.

In addition to improving safety on the WPI campus, the system must also help WPI stay current and accurate for the state and city regulations. This means improving inspections. Not only the initial inspections, but the speed at which violations are corrected and can be inspected again.

The feedback from the inspectors was positive. They agreed that this program would be very helpful in the future. They were happy with the results and all the contents of the mock up system. We included most of the information that they were interested to see; however, there is still some information missing and there is room for improvement.



Dave Messier mentioned that navigation could be better laid out; also we should include the room location of chemical fume hoods. The best time for them to use this program is before the inspection.

In theory, it would be possible for a system such as the one discussed here to change the way many things are done at WPI for the better. It could provide a way for professors to report problems in offices and classrooms promptly, and Plant Services would be aware of the problem immediately, resulting in the problem being fixed quickly. It is our recommendation that if the building information system is constructed at WPI, it needs to be kept in mind that simplicity, ease of use, and overall usefulness for the managers and maintainers of the buildings be the number one priorities.

## Appendix A

Bryan, John L. Fire Suppression and Detection Systems. Beverly Hills, CA: Glencoe Press, 1974.

This book gives in depth information on fire suppression systems, including fire extinguishers. This provides a solid background for writing about the fire suppression systems present in the buildings on campus.

Chasse, Denise Marie. The Design and Implementation of a Flexible, Maintainable Handheld Application. Worcester Polytechnic Institute: Thesis

This thesis provides an idea for creating a handheld system to be used for this project. It even goes as far as identifying a piece of hardware that might be useful in the applications of this project.

Coan, Steven D. Massachusetts Fire Incident Reporting System 2003 Annual Report.  
<http://www.mass.gov/dfs/osfm/firedata/mfirs/2003annualreport.pdf>

This report gives a wealth of information about fires in the state. The information is broken down into building categories, including dormitories, and includes charts and graphs. This is useful because it gives hard facts about fires in the state as well as what helped to prevent them from causing harm or escalating.

Committee on Risk Appraisal in the Development of Facilities Design  
Criteria, Building Research Board, Commission on Engineering and Technical  
Systems, National Research Council. Uses of risk analysis to achieve  
balanced safety in building design and operations Bruce D. McDowell,  
Andrew C. Lemer, editors Washington, D.C. National Academy Press, 1991.

The topics covered in this book include Building Protection, Risk assessment and Building failures.

Curl, Robert S. Building Owner's and Manager's Guide: Optimizing Facility Performance. Lilburn, GA: Upper Saddle River, NJ The Fairmont Press, 1999.

This online book provides excellent information about all the aspects of managing a building. Everything is covered, from air pollution to energy saving techniques. It also provides information regarding different groups and organizations such as BOMA.

Department of Building and inspections, Winocular Systems  
<http://www.winocular.com> (2005).

This website has developed a program called Winocular software that offers a summary on building and inspection records management and “data organization methodology”.

International Code Council, International Building Code. Country Club Hills, IL:  
2002

This book covers the generally accepted international building codes and includes everything from use and occupancy to fire protection systems as well as energy efficiency.

International Conference of Building Officials, Uniform Building Code  
California ,1976 Fourth Edition.

This book contains valuable information on the codes for building constructions related to public safety. It has an overview of all the general requirements and regulations based on types of construction and occupancies.

Safety Management Periodical, Waterford, CT : National Foremen's Institute,

This periodical has different articles on safety issues, accident preventions, and the cost for safety servicing and maintenance.

Samelson, Nancy. Levitt, Raymond. Construction Safety Management. New York, NY: John Wiley & Sons, Inc. 2<sup>nd</sup> Edition, 1993.

This book is based on the research conducted at Stanford University on safety management methods. Some chapters of the book are useful because they explore different issues and topics related to “the benefits of safe jobs, building a culture of zero accidents, managing staff support for safety, planning for high project performance. “

Ruskin, Arnold. Estes, W. Eugene. What Every Engineer Should Know About Project Management. Marcel Dekker Inc., New York, 1982.

This book contains valuable information on successful approaches to a project. It provides information on all aspects that engineers should consider and know about project management.

Town of Worcester, MA, Official Worcester Building Laws: Building Ordinances and Regulations Relating to Building and Zoning. 1965

These are the official guidelines for all the buildings in Worcester. They are what building and code inspectors have to follow which makes this book very useful.

United States Environmental Protection Agency, EPA Facilities Manual. 2003

This is the manual for compliance to the EPA's codes. This manual covers architectural, engineering and planning guidelines and facility safety, health and environmental management.

## Appendix B

- 1) What one particular aspect or task of your inspection/duties causes you the most trouble, in terms of time or work load?
- 2) What would make this aspect or task easier for you to accomplish?
- 3) Beyond what you are collecting, is there anything else that you are looking for?
- 4) If you received information about the buildings when you arrived, what kind of information would make it easier to do your job?
- 5) Would you find it useful to have this information on the web, either to review beforehand or to bring with you?
- 6) If there was an integrated computer information system available for you to use during your inspection, what form would it be in? (Handheld, terminal, etc.)
- 7) Specifically, what information would it contain?
- 8) Do you have a manual and/or forms that you use during your inspections?
- 9) Do you feel that these forms are satisfactory?
- 10) Here is a list of the information we have so far (mapped locations of safety devices, along with integrated information about the devices, i.e. extinguisher size and date of last inspection). What other information could be included?

## Appendix C

### **Managers and Maintainers of Buildings**

<b>Name:</b>	<b>Title:</b>
Steve Petrolati	Insurance Inspector
John Morowski & Paul DiBenedetto	WPI Building Inspector
William Metterville	Capt. Worcester FD
Dave Messier	WPI Manager of Environmental Health and Safety
Jon Miller	WPI Director of Plant Services
John Cannon	Holy Cross Physical Plant
Chris Salter	Plant Services
Diane Gould	Property Specialist

Appendix D  
**Interview Transcripts**

11/28/2005

Interviewee: *Steve Petrolati*

Interviewer: *Andrew Mills*

Description: *Test Interview*

**Notes** – This interview was conducted in order to further develop the interview questions that will be used during the interviews of the managers and maintainers of the buildings on the WPI campus. The following numbered responses represent Mr. Petrolati's answers to the respective questions listed in Appendix B.

- 1) *What one particular aspect or task of your inspection/duties causes you the most trouble, in terms of time or work load?* When the client is not prepared, it causes me problems. In some cases the client's representative will not have the right keys, in which case I have to wait until I can get access to certain areas, which costs me time. I like to send out an itinerary of my inspection 2-4 weeks in advance. Also, when I am not aware of what types of building systems updates have occurred, that causes me problems, whether it is an update to the electrical systems, HVAC systems, roof, etc.
- 2) *What would make this aspect or task easier for you to accomplish?* Having the information about the updates well in advance would eliminate this problem.
- 3) *Beyond what you are collecting, is there anything else that you are looking for?* The list of things I am looking for is extensive. In terms of fire protection, I am looking to make sure the sprinklers and pull boxes are in working order, as well as the guidelines for the maintenance, testing, and inspection of the sprinkler system. I am also looking for sprinkler system design information, such as the hydraulic force, which is different for every building. Fire extinguishers are not that important to my inspection, nor are the in-building fire hoses, which generally lead to vandalism. In residence halls, I am looking to make sure the trash receptacles are in a separate room, not out in the hallways, whether or not there are decorations blocking exit signs, etc. I am also looking to make sure the doors are self closing and that there is fire safety information on the inside of those doors. I am also looking to make sure there are adequate means of egress, such as that all the doors open and that there are emergency evacuation plans posted. In terms of buildings with assembly places, I am looking for occupant load signage, emergency lighting, whether there is a crowd management plan and personnel to conduct the management, and means of egress. Other things I am looking at are the standard operating procedure of the local fire department, as in whether they bring their own hoses or not. I am also looking for stop devices on the pull boxes to minimize false alarms, which tend to have a "boy who cried wolf" effect. I am also looking at how the building was constructed, as in its age, whether there is asbestos or lead, etc. If there is a loss, I will obviously look at that as well.
- 4) *Interviewer Note: Some of the information provided in the answer to this question should be considered part of the answer for the third question. The*



*information that regard question 3 is preceded by “I am looking..” If you received information about the buildings when you arrived, what kind of information would make it easier to do your job?* I would like to receive the square footage of the building and its age as well as the history of the structure in terms of losses. Things I am looking for in terms of the sprinkler systems is the hydraulic design info plaque, whether there are spare sprinkler heads and a wrench next to the riser, and that the pressure gauges are routinely checked and replaced every five years. I’m also making sure the exterior control valve has some form of tamper protection, and when the last 2” main drain test occurred, which checks that the water coming in from the street is adequate. In terms of industrial kitchens, I am looking to make sure the filters in the hood vents are changed every 7-14 days and that the ducts are cleaned twice a year. I am also looking at the cooking equipments extinguishing systems and making sure it is serviced twice a year and is using the proper extinguishing agent as well as making sure there is a automatic fuel shutoff if the system is tripped. In terms of laboratories. I want to be sure that there is a main shutoff for the Bunsen burner gas, that the chemicals are stored by keeping the compatibles separated, not alphabetically, and that there is an inventory system for the chemicals. I also look at how the combustibles are carried from room to room. It is preferable that they are on a cart or in a secondary bag as opposed to just carried by hand. I want to make sure that everyone knows what to do in case of a fire and that the eyewash and shower are tested regularly.

- 5) *Would you find it useful to have this information on the web, either to review beforehand or to bring with you?* I would most like people to be prepared for my visit. Anything about safety, risk management, and building layouts.
- 6) *If there was an integrated computer information system available for you to use during your inspection, what form would it be in?* It would just be a checklist. It would be good to have an inspection form.
- 7) *Specifically, what information would it contain?* Type of occupancy, loss history, and type of controls in place, risk management policies and how the exposures and controls are assessed would be what I would like to see in the system.
- 8) *Do you have a manual and/or forms that you use during your inspection?* We use electronic forms and a loss control manual. They are more of just a starting point though. It takes years to know what to look for as an inspector.
- 9) *Do you feel that these forms are satisfactory?* The forms are alright at the beginning, but as you gain more experience it becomes less and less useful.
- 10) *Here is a list of the information we have so far (mapped locations of safety devices, along with integrated information about the devices, i.e. extinguisher size and date of last inspection). What other information could be included?* It could include the main sprinkler control valve, the sprinkler heads, the area of refuge which is a location in a building where people with physical limitations can go to if they can’t get out of the building, and the fire department would know where the location is to rescue them. It would also include whether or not the fire department continuously update their fire plan, including checking on the key box (the box with all of the keys to the building doors,) the main control valve and

their communications between firefighters. I also want to make sure that the FD is familiar with the first hydrant location and the means of egress.

**Additional Information:** I am also looking at egress distances and that there are gates preventing people from passing exits in stairwells and other places when they are trying to get out if the building is over 5 stories tall.

**Suggested Questions:**

- 1) How do you prepare for a visit? Do you do a prep?
- 2) What types of losses or causes have you experienced in your career?
- 3) What type of good technology related to this project is already in place?

1/30/2006

Interviewee: *Captain William Metterville*

Interviewer: *Andrew Mills, Sibora Halilaj*

Description: *Interview*

**Notes** – This interview was conducted at the Worcester Fire Department offices on Grove St in Worcester. In this particular interview several of the answers to the prepared questions covered multiple questions. What follows is a general summary of the interview, not a question by question breakdown.

Captain Metterville's main concern was the actual maps of the buildings. The example that he presented was the new emergency ward at UMass Medical. The hospital presented the captain with a floor plan for each level of the new ward for him to review. The captain made notes on these plans so that the hospital could make the appropriate changes in their fire plans. Captain Metterville brought up the idea of a fire command center. In larger buildings, such as a hospital, this might actually be an entire room. In a smaller setting, the fire command center could consist of nothing more than the fire alarm panel and a book or binder containing the Building Fire Department Plan.

It is this fire department plan that we spoke the most about with Captain Metterville. On the floor plans he would want to see all stairwells, hallways, doors and rooms numbered. In addition, he would want to see the actual doors in the buildings labeled with their corresponding plan numbers on both sides. In addition, the fire alarm panel should say what type of alarm was triggered and where it was triggered.

In terms of what he would like to see in the information system, the captain mentioned fire alarms, sprinklers, hydrants, fire lanes, and the fire department connection (FDC).

Other things that the captain would be looking for when he came to the buildings were how recently the fire extinguisher and sprinkler inspections took place as well as whether there was improper storage in the elevator and electrical rooms,

that the exits were lit and unblocked and whether the fire doors were wedged open or not.

2/10/2006

Interviewees: *John Morowski, Paul DiBenedetto*

Interviewer: *Andrew Mills, Sibora Halilaj*

Description: *Interview*

**Notes** – Mr. Morowski provided most of the material covered in this transcript. The bulk of the interview covered buildings that were either under construction or undergoing renovations, and thus not extremely important in terms of this particular project. Any information that was deemed extraneous has been omitted from this transcript. As with the interview with Captain Metterville, the interview did not consist of direct answers to the prepared questions, so what follows is a summary of the interview.

As with Mr. Petrolati, Mr. Morowski felt that the biggest problem encountered during his inspections was actually getting the inspection started in the first place. All too often he has trouble getting into the building, or the owners are unprepared for the inspection. Mr. Morowski would like to be notified who he will be meeting with ahead of time. He would also like the owner to notify whoever will be meeting Mr. Morowski what the inspection is about.

The building inspectors for the city of Worcester follow The Code of Massachusetts Regulations 780CMR. All of the inspections conducted by the city inspectors are validated and governed by this code. However, this code only sets the bare minimum in terms of specifications. Many times if the inspector sees the bare minimum in a building he will ask that the owner increase whichever specification was the bare minimum.

The remainder of the conversation with Mr. Morowski and Mr. DiBenetto consisted of regulations for building construction, and consisted of everything from footing design to certificate of occupancy.

2/12/2006

Interviewee: *Dave Messier*

Interviewer: *Andrew Mills, Sibora Halilaj*

Description: *Interview*

**Notes** – None

- 1) *What one particular aspect or task of your inspection/duties causes you the most trouble, in terms of time or work load?* It is very time consuming to escort the building inspector around when he does his inspections. This has to be done for the initial inspection, where the inspector points out things that need fixing, but then the inspector has to return to recheck those fixes. Also, the certificates of occupancy expire every March or April, which causes all the inspections to pile up at once.
- 2) *What would make this aspect or task easier for you to accomplish?* There is no real fix for that problem. Someone has to escort the inspector around.
- 3) *Beyond what you are collecting, is there anything else that you are looking for?* I check the emergency elevator phones. I also generate work orders for Plant Services and outside contractors. The repair log is done in Maximo by Chris Salter.
- 4) *If you received information about the buildings when you arrived, what kind of information would make it easier to do your job?* Not Applicable.
- 5) *Would you find it useful to have this information on the web, either to review beforehand or to bring with you?* Yes.
- 6) *If there was an integrated computer information system available for you to use during your inspection, what form would it be in?* It would simply be a local program and might look similar to CAD drawings.
- 7) *Specifically, what information would it contain?* I would like to see emergency eyewash and shower locations as well as utilities shutoffs, such as gas shutoffs.
- 8) *N/A*
- 9) *N/A*

**10)** *Here is a list of the information we have so far (mapped locations of safety devices, along with integrated information about the devices, i.e. extinguisher size and date of last inspection). What other information could be included?*

It would be good to see the campus emergency phone locations on the map, which would require a map of the entire campus, not just the buildings.

2/14/2006

Interviewee: *Scott Merrill, John Cannon*

Interviewer: *Andrew Mills, Sibora Halilaj*

Description: *Interview*

**Notes** – Mr. Merrill and Mr. Cannon are directors of the Physical Plant at the College of the Holy Cross. As they are not inspectors of any sort, some of the interview questions were not applicable. What follows is a general summary of the interview.

The one thing that is giving us the most trouble right now is the HVAC in several of the buildings on campus. Something that would help a lot with that is an energy management system, which would include temperature trackers, but that is not feasible at this point.

We have a computer program that we use for the entire campus called FAMIS. FAMIS does everything from work orders to carpeting. FAMIS tracks the work orders right down to number of work orders per room. It also consists of floor by floor maps with locations of handicapped paths, eyewashes, hoods, equipment, utilities and where they run, card access points, etc. Eventually we would like to be able to use FAMIS for preventative maintenance. However, the program is almost too complicated, and it is not always beneficial to spend the time entering information such as the carpeting and paint for every room. FAMIS is structured in a broad to specific manner, as in you start with a map, and then proceed to a building, then to a floor, then to a room, and lastly to who uses the room and for what.

FAMIS can also be used to do studies, such as color coding rooms by the number of work orders that allows for problem areas to be addressed.



2/15/2006

Interviewee: *Chris Salter*

Interviewer: *Andrew Mills, Sibora Halilaj*

Description: *Interview*

**Notes** – Again, since Mr. Salter is not an inspector, what follows is a general summary of the interview.

We already have CAD drawings for most of the buildings on campus, with different layers for different features. The goal of this information system you are designing should be to provide inspectors with quick and accurate information. The fire extinguishers are already contracted out, as well as the battery units for the emergency lights.

I would like to see back flow preventers included as a layer in the CAD drawings. Also, although this isn't a top priority, I would like to see the fire alarm systems included as well. At some point, it would also be good to include any pieces of mechanical equipment that are present in the buildings.

This system would be best used if it helps WPI stay current and accurate regarding any city or state codes. Also, the three dimensional aspect is not necessary; it is the location of the feature that is important.

It would be great to include a building synopsis, which could provide the name of the building, the date it was built, the materials it is made from, and any renovations that have taken place. It would be incredibly helpful to include the card access points as well and finally lay the whole system out. Integration with MAXIMO would be excellent as well.

Finally, in order for this system to actually work, it will need to be updated regularly, as it will have no value if it is not.

2/28/2006

Interviewee: *Kolleen Rahilly, Diane Gould*

Interviewer: *Andrew Mills, Sibora Halilaj*

Description: *Interview*

**Notes** – Ms. Rahilly and Ms. Gould are the new WPI insurance and property specialists. This interview was more a conversation than an interview, so a general summary was necessary.

It would be great for this system to provide a building snapshot. Also, any fire alarms and sprinklers could be included. Building photographs would also be a good addition.

It would be nice if the program was in disk fashion and could be easily updated. It may be tough to make the system immediately helpful to inspectors. The system should also include any building renovations. Also, a history of the buildings losses, and that doesn't mean a dollar amount, but perhaps just a list of the incidents that have occurred in the building would be good. Including near misses in that list would allow for loss control recommendations to be made, and how the school responds to those recommendations would result in lower insurance rates possibly.

Having this system available to all of the departments at the school would allow for all of the departments to be on the same page on building and budget issues as well.