DOES IT MEASURE UP?
DOCUMENTING THE MECHANICAL SYSTEMS OF FL2

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INTRODUCTION

I would like to propose an analogy...when you think of buildings and people, you probably do not think they have much in common. Well, I see things a little differently. Buildings are like people and in more ways than one. If a building were to be compared to a human body, quite a few similarities would become apparent. I see buildings and people as having quite a lot of similar parts, parts that perform similar functions. Just like a human body, a building is made up of several complex parts. These parts are not always understood or even visible, except through evolved inspection. Take for example the cladding of a building, it is similar to the skin on a human body. Cladding and skin act in similar ways, they provide protection from the elements and help regulate internal temperatures. Look at the walls and structure of a building, they are like the muscles and bones of a human body. The walls and structure of a building provide support against the attraction of gravity, just like the muscles and bones of a human body. Think about the mechanical equipment of a building, it is like the organs of a human body. The mechanical equipment of a building allows a building to function properly, just like the internal organs of a body. Finally, imagine the control system of a building and the brain of a human body. The control system of a building dictates the functions of the mechanical systems of that building, just like the brain controls the functions of the internal organs of a body.
# BUILDINGS ARE LIKE PEOPLE

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>BUILDINGS</th>
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<tr>
<td>SKIN</td>
<td>CLADDING</td>
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<tr>
<td>A person has skin that protects that person from the elements and helps to regulate internal temperatures. A building has skin, it is called cladding.</td>
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<td>BONES</td>
<td>STRUCTURE</td>
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<td>A person has bones that hold that person up against the forces of nature...forces such as gravity, wind, and motion. A building has bones, they are called structure and walls.</td>
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<td>INTERNAL ORGANS</td>
<td>MECHANICAL SYSTEMS</td>
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<td>A person has internal organs that perform necessary functions. A building has internal organs, they are called mechanical equipment.</td>
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<td>VEINS &amp; TUBES</td>
<td>PIPES &amp; DUCTS</td>
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<td>A person has veins and tubes that transport nutrients and wastes throughout the body. A building has veins and tubes, they are called pipes and ducts.</td>
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BRAIN CONTROL SYSTEMS

A person has a brain that controls all of the bodies functions. A building has a brain, it is called a control system.

Although there are quite a few similarities that can be seen to exist between a building and the human body, there are a few important discrepancies. People can think and speak, buildings cannot. Most people are put together according to the same plan, buildings are not. If a person feels sick they have the option to go seek help from a professional. If a building is not working properly then a professional must come to it. Since every building is arranged differently it is important for each building to be documented accurately and to be kept up to date as to changes. This paper is intended to describe this documentation process, focusing on why it is done, how it is done, and how it could be done more efficiently.

BUILDINGS ARE NOT LIKE PEOPLE

| PEOPLE                | BUILDINGS
<table>
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<tr>
<td>THINK &amp; VERBALIZE</td>
<td>CANNOT</td>
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People can think and verbalize, buildings cannot. If a person feels sick, that person can ask for help, a building cannot.

MOVE CANNOT

A person can move, a building cannot. If a person needs to go to the doctor, they can, a building cannot. A building has to rely on a professional to come to it.
SAME PLAN       ALWAYS       DIFFERENT

Most people have the same parts and are put together according to the same basic plan, buildings are not. Doctors know how a person is put together and they are able to help them. Buildings have all different plans and the person helping the building has only the plans of the building to go by.

Since every building is arranged differently it is imperative that the documentation of the systems of a building be up to date and accurate. Now, maybe it is not clear why this is so important. Imagine for a moment that you are working on your computer one morning and all of a sudden water starts flowing down from the ceiling all over you and your computer. This is something you never anticipated so you are thrown off for a while. Upon regaining your senses you call maintenance for help. The speed at which maintenance is able to rectify this problem is critical...your computer, all of your books and papers, and your office is in danger of getting damaged. Maintenance knows that the problem is a broken pipe and they know that they have to shut off a valve but what they do not know is where exactly that valve is. They think it is somewhere above the ceiling in your office but they are not sure where. They have to waste precious time removing ceiling tiles to find it while you stand by watching all your things get ruined thinking to yourself...what just happened?

That example is an extreme and there are examples to every extent. There are, however, some specific reasons that the documentation of a building should be up to date and accurate.
IMPORTANCE OF ACCURATE DOCUMENTATION

A basic reason for accurate documentation is to know what is there. There are a lot of different things going on in a building and all of these things have to be documented. As you can see, the list is quite extensive.

KNOW WHAT IS THERE

Control Systems
Heating, Ventilating, and Air Conditioning Systems
Domestic Hot and Cold Water Systems
  Sewage Systems
Fire Protection Systems
  Electrical Systems
  Lighting Systems
  Security Systems
  Telephone Systems
  Computer Systems
  Structural Systems

The users of the building need to have the information about what is in their building.
Other than just having a general knowledge of what is in the building, there are also practical reasons for having accurate documentation. It sure does make things a lot easier if up to date documents are available.

**CURRENT & ACCURATE DRAWINGS**

**MAINTENANCE**

Maintenance...As in the example I gave earlier, in order for the maintenance people to perform their tasks with ease and speed they need to know where everything is.

**REMODELS**

Remodels...it is important to have accurate drawings for the architects to work from so they know what is there and how much room it occupies so they can design around it.

**SAFETY**

Safety...all of the safety systems of a building need to be constantly checked and updated—it is most important that the documentation of these systems is current and accurate. In order to understand how and why the process of documentation occurs, it is important to understand what happens prior to documentation. As I said before, even though most people never experience the technical aspects of these systems first hand, most people are still dependant on them. There are, however, people who deal with these systems on a daily basis. The question is...who designs, installs, and maintains these systems?
WHO DESIGNS & Installs THESE SYSTEMS?

ARCHITECTS

Design the Space

First I will start with who designs the systems. Although it works differently in every office there are certain people who are capable of designing these systems. Architects are responsible for a great deal of design consideration. They have a program they have to follow as well as a budget. Architects have to work with what they have and come up with the best solution. They have to take into account all sorts of limitations. They take everything into consideration nd they create a design that meets all of the requirements taking into account all the limitations. One of the things that they do is design for the areas that the mechanical systems will be housed. They are aware of how much are is necessary for these systems according to how big the building is and what its function will be.

MECHANICAL ENGINEERS

Design the System

The next person who is responsible for the designing of mechanical systems is a mechanical engineer. These people are educated in how to design the actual systems. Mostly they decide how big they have to be according to the function they are responsible to perform.. They also have to decide how to squeeze all of the systems into the are allotted. What they design is generally what is known as a schematic design. That means that what they design is not necessarily they way it has to be arranged. It is a preliminary design, a suggestion.
CONTRACTORS

Install

This brings us to who installs these systems and it also brings us to the point where things start to become fuddled. Contractors are responsible for installing these systems. They have to work with what the architect and mechanical engineer had dictated before them. These people are the ones who have to take what they have to work with and make it right to the best of their ability. They take what they were given and they do what they have been taught to do. Some of the time they have to make changes to the schematic design in order to make it all work together. There are usually several contractors, remember, there are a lot of systems to deal with. All of these people have to work together to fit all this stuff in the space provided.

WHAT DOES THIS MEAN?

What all of this means is there are a lot of people responsible for this process, getting these systems in the building. All of these people are professionals and they have all been trained in their particular fields. There is a order of operations, Architects design a space big enough, engineers design a system big enough, and the contractors make it all go together. The point is that sometimes things turn out differently than originally drawn.
WHO MAINTAINS THESE SYSTEMS?

USER
First we have the users of the building. Sometimes the users of a building have to do some of the maintenance work of a building, depending on how complex the building is. In smaller buildings there is a greater likelihood that there would not be a maintenance crew to fix things, if the task was too complicated, a professional would be called in to help.

MAINTENANCE
Next, there are the maintenance people. If the building was big enough, it might warrant a maintenance crew. These people are responsible for monitoring and repairing the systems in the building.

PROFESSIONALS
Finally, there are the professionals. Sometimes there are problems that the maintenance crew is unable to handle so professionals are called in.
Hopefully, at this point, it is clear just how necessary accurate and current documentation of all these systems is to all the people concerned. You may be saying to yourselves...aha, but I don't have to be concerned, I just work here. Well, believer it or not, you are dependent on these systems to a large extent just to do your jobs. I would like to read an excerpt from a book called Heating, Ventilating, and Air Conditioning-Analysis and Design by McQuiston and Parker...

"A comfortable and healthful environment is now considered a necessity, and many modern processes and products would not exist without precise control of environmental conditions. Therefore almost all homes, offices, and industrial structures are now designed with a means of controlling the indoor environment throughout the year. Maintenance of warm surroundings had always been considered necessary during the cold months. However, in our modern society the maintenance of a cool environment during the warm months proves to be just as important for the utilization of human resources and productivity."

Now that it has been made clear who is responsible for the design, installation, and maintenance of these systems I am now able to describe the next process, the process of documentation.
THE DOCUMENTATION PROCESS

SCHEMATIC DRAWINGS

As I have said before, there are drawings that were created by the architects and engineers but these drawings are schematic. This means that these drawings are able to be changed in order to suit the needs of the contractors.

AS BUILT DRAWINGS

What has to be done sometime after the installation of these systems is known as creating a set of as built drawings. This means that the systems have to be checked over, measured, and any discrepancies between the schematic and the actual have to be noted.

METHODS OF CREATING AS-BUILTS

There are a few ways in which as-built documents can be created. All of these procedures have their ups and downs. I will briefly describe each and I will go into a little more detail about the method that I was practicing here this summer.

First we have what is known as a clerk of the works.
CLERK OF THE WORKS

The position called clerk of the works is held by a draftsperson who is on sight. This person is in charge of documenting and keeping track of paper work. Paper work can include change orders, creating as-builts, and daily reports of weather, who is on sight, work in progress, and problems. The advantages to having a clerk of the works do the as built documentation are that he or she is there at the time that the discrepancies occur, they are also capable of documenting the changes properly. Another advantage is that things do not get lost in the shuffle. A disadvantage would be that the budget will not always allow for a clerk of the works to be hired.

CONTRACTORS RESPONSIBLE

Another option, which happens to be the most common, would be for the contractors to provide a set of as-builts. They have a set of drawings that they keep on sight and do red lines on. A red line drawing is a drawing that has had corrections made to it, these corrections are drawn over the original drawing. These red lined drawings are then sent to the architect after the construction process is over in order for them to be documented on AutoCAD. The advantages to this system are that if the contractors are on top of things they can accomplish a lot by just writing down what they change. A disadvantage would be that things could get lost in the shuffle because the contractors may not be so concerned with doing the red lines promptly and accurately. It would also be nice if the contractors could be responsible for having the changes documented in AutoCAD.
FULL TIME DOCUMENTER

This happens to be the category that I fall under and I would like to explain this option a little more in depth for you so you can get a feel for how it is done. I was hired for the summer to work on the documentation process. The advantages of this system, at least as far as I can see, are personal advantages to the part time person. What I mean, is I have gained a lot of insight into how this process works and it has started me thinking of ways that it could be made simpler. I think this system could be more efficient if the process was started soon after construction. Rather than just tell you what I did this summer, I would like to show you some slides of the methods I used to document some of the systems here in FL2.

PART TIME DOCUMENTER

This happens to be the category that I fall under. I was hired for the summer to work on the documentation process. My job entailed measuring and documenting the mechanical systems and the walls in the basement of FL2. I noted discrepancies and made the appropriate changes to the documentation. Although this endeavor has not yet been completed, there are plans to complete this work someday. As I have tried to make it clear through this paper, the accurate and up to date documentation of the systems in all buildings is an important and sometimes urgent necessity.
ACKNOWLEDGMENTS

There are several people who I would like to thank for all they have done for me this summer. I would also like to say that I have gained so much insight in the last ten weeks, I will forever be grateful for this opportunity. I will never forget NCAR and boulder.

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Michael George- These were my advisor for the summer and they helped me out in
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I want to thank the english crew we had to advise us on our papers and presentations, they were a big help to me.

And finally I would like to thank the following groups of people for making my job here and enjoyable experience-

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