Davis Centre Atrium Doors - A Case Study

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ABSTRACT
The presented work is a case study of the doors at the William G. Davis Computer Research Centre, University of Waterloo as a part of our Advanced topics in Software Engineering : Requirements Engineering course project. This study dwells upon the idea of changing requirements over time and how requirements engineering is an evolutionary process. This work discusses the process of evolution of the Davis Centre doors and how the requirements changed, with the help of a timeline, detailing the reasons for those requirement changes over a period of time and how were these changes dealt with. In addition, our work discusses the possibilities of a better design for the Davis Centre and the doors which can deal with the major problems of maintaining an optimum temperature inside the Davis Centre Atrium during the winters, regulating traffic through the Davis Centre doors, and ensuring people safety more efficiently. We aim to discuss the problems from the perspective of different people working at the Davis Centre Library, Media Doc and Tim Hortons Express.

General Terms
Software Engineering, Requirement Engineering, Requirement Gathering

Keywords
Requirement Engineering, Davis Centre

1. INTRODUCTION
According to Fred Brooks, "The hardest single part of building a software system is deciding precisely what to build. No other part of the work so cripples the resulting system if it is done wrong. No other part is more difficult to rectify later"[1]

Specifying requirements however is a tedious task since what the client wants is only a fraction of what he really expects. This can be best explained using the famous iceberg example where the requirements specified by the client is only the tip of the iceberg and a good portion of it remains hidden from the view, which could be due to several reasons, ranging from lack of knowledge to unrealistic expectations. In fact, most projects often fail due to incorrect or incomplete requirements specification.

In 1996, Ariane 5 Flight 501, a rocket that took 10 years and $7 billion to build, exploded within a minute of its launch. The reason for its failure was one line of code in the SRI (Inertial Reference System) that converted the horizontal velocity of the rocket in a 16-bit format, which the engineers decided to reuse from Ariane 4. Further investigation revealed that Ariane 5 was able to achieve five times more velocity and acceleration than Ariane 4, which the system could not handle. The aftermath of the incident was that the engineers did not build Ariane 5 in accordance with its requirements and the SRI was retained for commonality reasons and that it was not required at all.

It is important to do Requirements Engineering in the earlier stages of project development since Requirements Engineering is hard and costs a lot more to fix in the later stages. There are several industry methods like the traditional Waterfall Model which allows for requirements to be specified in the initial stages. However, this method does not account for requirements change that might creep up during the course of the development. Thus, a more realistic life cycle model to follow is the Spiral Model proposed by Barry Boehm in 1988 which allows the user to follow the waterfall model in each 360 degree sweep of the spiral. This model accounts for requirements change since the requirements are developed incrementally.

The rest of the case study is organized as follows: in section 2 we provide a brief history of the William G. Davis Computer Research Centre and explain the architecture of the building. We motivate the study in section 3 followed by a detailed time line of events in section 4. Finally, we discuss the issues, solutions, and future work in section 5 before we conclude in section 6. In section 7, we acknowledge the help of our Professor and all the people who took the time to help us in the completion of this study. Section 8 mentions the sources and we cite the references in section 9.

2. BACKGROUND

Figure 1: The original doors on the east side of Davis Centre.

Figure 2: The original doors on the west side of Davis Centre.

The William G. Davis Computer Research Centre, popularly known as the Davis Centre was built in 1988. It was inaugurated on 10th November 1988 by David Peterson, the Premier of Ontario at that time and was named after William Grenville "Bill" Davis, the former premier of Ontario. The building was initially named Math 2 , but became popular as the Davis Centre. The Davis Centre was designed by the same architect who designed the famous Eaton Centre in Toronto, Eberhard Zeidler. The building is intended to look like a motherboard of a computer system from an aerial view, though some people believe that the Davis Centre resembles Centre Georges Pompidou in Paris, France from the outside, while from inside it looks like a prison. This resemblance can be seen in figure 3 and figure 4

The Davis Centre has two lecture halls, a food court and a library that contains books from many disciplines such as Engineering, Mathematics, Science and Computer Science. The upper floors of Davis Centre house several offices for the David R. Cheriton School of Computer Science. On the main and the lower floors of Davis Centre is the Davis Centre Library. Figure 1 and figure 2 display the original doors on both the sides of the building when it was constructed in 1988.

3. MOTIVATION

As the offices of the David R. Cheriton School of Computer Science are located on the upper floors of the Davis Centre, the building is most frequently used by Computer Science Undergraduate and Graduate students, and Professors. Many other lectures of different disciplines are also held in Davis Centre. The doors at the Davis Centre present a very interesting history of their evolution since the building was constructed. This evolution is a great example of how requirements of a building could change over time and how these changes are dealt with. All these factors about the Davis Centre motivated us to conduct the case study. The final findings of this case study were intriguing and thought provoking. The case study also helped us to better understand the concepts of Requirement Engineering and how it plays a significant role in the development of any project.

4. TIME LINE

The doors at the Davis Centre have evolved through the last two decades. Hence, the case study is presented here in the form of a time line that comprises of many milestones in terms of years of major requirement changes that led to the changes in the doors for the Davis Centre atrium. The time line goes through the year 1988 in which the Davis Centre was built, to 2015 as shown in figure 5, highlighting the major events in each year of the time line.

4.1 1988

The Davis Centres construction was complete by 1988. The building had manual swinging doors on both the sides when it was constructed, with an automatic push operator on one side of the doors. Figure 1 displays the manual doors that were installed in the beginning. The structure of Davis Centre in the year 1990 can be seen in the figure 6. These manual swinging doors were relatively narrow and have been known to raise many safety concerns. The automatic push operators led to many accidents. One of them was when a woman

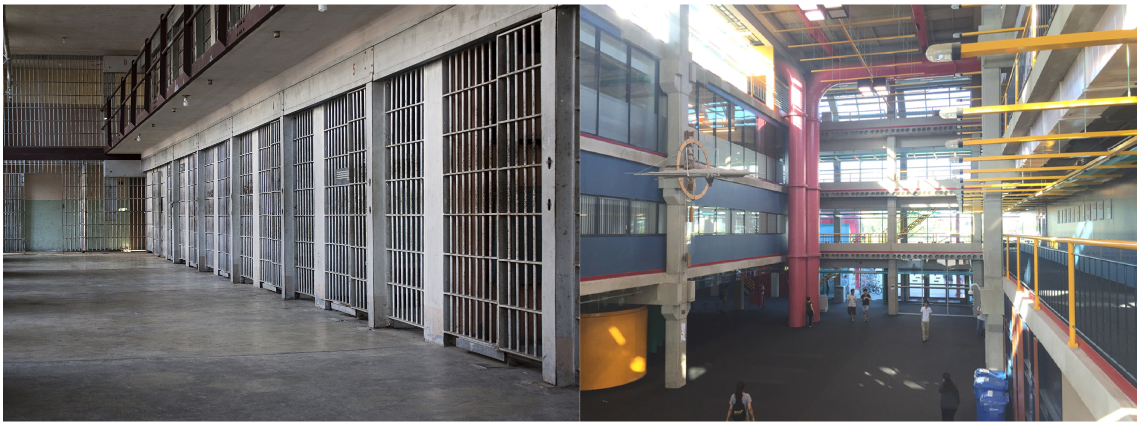

Figure 4: Resemblance of a prison-cell with the interior of Davis Centre.

Figure 3: Centre George Pompidou,Paris,France.

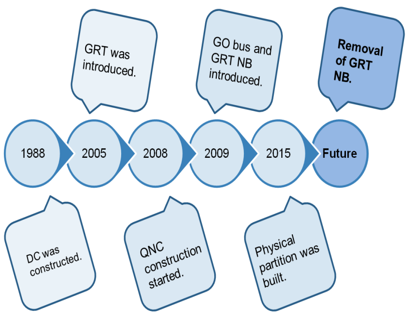

Figure 5: The time line followed in the case study.

Figure 6: The above diagram displays the structure of the Davis Centre in 1990.

with a stroller got caught in the doors when she used the automatic push operator and could not reach the door to open it. Another incident was when an elderly woman on a wheelchair got caught in the doors too.

4.2 2005

The year 2005 saw the construction of the Grand River Transit bus stops on the east side of the ring road, that is in front of the Davis Centre. This led to an increase in the number of people that entered Davis Centre on a daily basis as they were frequent users of the Grand River Transit bus stops.

4.3 2008

The Mike and Ophelia Lazaridis Quantum-Nano Centres construction started in the year 2008. Figure 7 displays this magnificent building. The Quantum-Nano Centre is one of the most recent buildings at University of Waterloo with the highest scientific control of vibration, humidity, electromagnetic radiation and temperature. During the construction process of this building, the vehicles carrying the construction material obstructed the traffic. In order to resolve this issue and ensure smooth traffic flow, the Grand River transit bus stops that were in front of the Quantum-Nano Centre were moved to the eastern ring road, that is,in front of the Davis Centre. As a result, the number of people entering

Figure 7: The Mike and Ophelia Lazardis Quantum Nano Centre.

the Davis Centre for their lecture and offices or to just go through the building to reach any other buildings of the campus, increased dramatically.

4.4 2009

In 2009, GO bus stops were introduced as seen in figure 8. This led to a dramatic increase in the amount of traffic that entered the Davis Centre as the GO bus is a prime service used by students for intercity travel. This amount of traffic became too large for the manual swinging doors to handle. Hence, to accommodate the increasing traffic in the Davis Centre, the manual doors were replaced by automatic sliding doors. These doors work in pairs and initially opened with a minimal but noticeable time gap. The people at Plant Operations mentioned that timing these pair of doors was a difficult task. These automatic sliding doors have a safety feature that in case of an emergency, such as a power failure, hitting the edge of the doors can slide them off their tracks and the doors will stay open until they are reset back to their position. Since the timing was initially staggered, students would accidentally hit these doors with their backpacks and move them off their tracks or there would be students who would ride their bikes through the doors and hit them out of their tracks. This would keep the doors open all the time and would affect the temperature settings inside the atrium. In order to avoid these situations, the doors are now timed to open at the same time. There is no external source of heat near the automated doors as well, so there are air curtains installed just above these doors. It was not possible to install these air curtains in the Davis Centre atrium as it was difficult to decide the optimum height at which to install these air curtains due to the geometry of the building.

4.5 2013

The Tim Hortons Express was started in October 2013, to reduce the number of people that line up at the Tim Hortons in the food court inside the Davis Centre. The Tim Hortons Express is a self-service station that provides a faster access to students to the Tim Hortons beverages and other food items so as to avoid long queues. This express service is located in a very close proximity to the automated doors as seen in figure 9

4.6 2015

Figure 9: Tim Hortons Express.

Figure 10: The only source of heat in the Davis Centre atrium.

The dramatic increase in the amount of the traffic during the past few years led to the automated doors staying open most of the times. The west winds would enter the building and strip it off of its heat. The heating system for the Davis Centre was maxed out but the atrium still remained very cold. The only source of heat for the atrium are the silver grills as shown in figure 10 and they were not sufficient to keep the atrium warm enough for the people working at the Media Doc and the Tim Hortons Express. They had difficulties at their working place due to the cold and west winds entering the atrium. Also, when the students would open the library door to enter the Davis Centre Library, a gush of really cold wind would enter the library. These cold winds also made it difficult for the people to work at the Media Doc.

In order to obstruct these strong western winds, physical barriers were constructed during late winters in 2015 in front of the automated sliding doors. As a part of this case study, we conducted interviews with the people working inside the library, at the Media Doc and at the Tim Hortons Express. It can be concluded from these interviews that the barriers helped the people working at the Tim Hortons Express significantly and some what helped the people working at the Media Doc. The Media Doc needs to keep their doors open all the time in order for students to know that they are open hence, they required a heater to be placed inside the Media doc to help with the heat. The Tim Hortons Express had

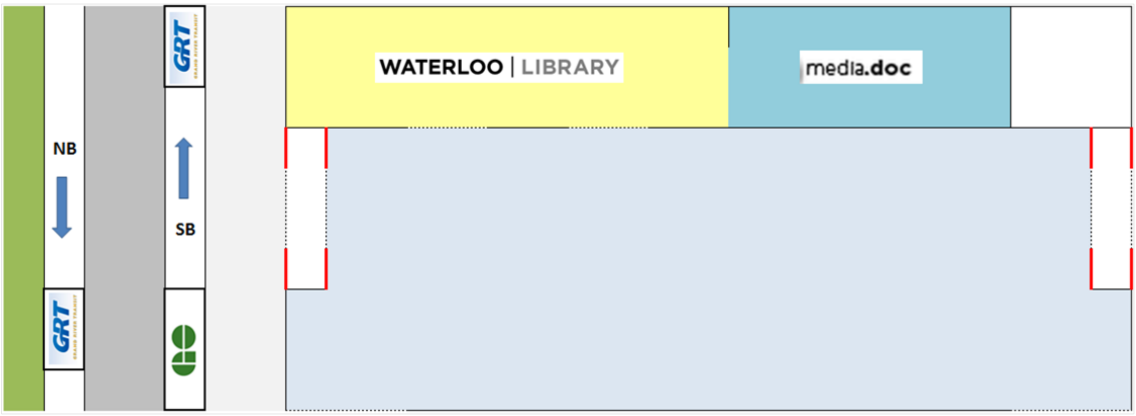

Figure 8: The above diagram displays the structure of the Davis Centre in 2009.

Figure 11: The Davis Centre Library.

to install heaters as well since it is an open space.

4.7 Future

In this section, we present the steps that might be taken in the future to deal with the requirements that changed over the last 27 years. It was seen in the entire case study, that volume of the traffic is huge and plays a major role in the evolution of the doors of the Davis Centre. A preventive measure to reduce this huge amount of traffic entering Davis Centre is the removal of the Grand River Transit bus stop on the east side of the ring road in front of Davis Centre and hence there will be no more northbound buses. As fewer buses will stop in front of Davis Centre after the removal of this stop, the number of people entering the Davis Centre through the automated doors is expected to reduce significantly. This removal of Grand River Transit stop is also a measure to ensure pedestrian safety. Many students have been seen crossing the road to get to the other side for the bus stops with lesser care and traffic awareness, so it would be an effective way to reduce any accidents that may take place. All the pedestrians willing to go to the other side of the road will be channeled with the help of a barrier that will extend towards the plaza. The sidewalk on the eastern side of the ring road is also expected to be removed.

Also if the physical barriers constructed to obstruct the wind flow do not work as anticipated, new doors will be constructed at a right angle to the physical barriers as shown in figure 14.

5. DISCUSSION

In this section, we present a discussion of the various scenarios mentioned in the time line above and attempt to understand how the requirements changed and what was done to deal with the changed requirements.

5.1 1988-2005

Since the William G. Davis Computer Research Centre or the Davis Centre was built in 1988, not many significant structural changes were made to the building for several years that followed. The manual doors which were a part of the initial construction were relatively narrow at the time, allowing not more than one person to pass at a time. During this time safety was a major concern since there were a few incidents including an elderly lady and a woman with a stroller getting stuck in the door because the assisted door shut with a lot of force very quickly. However, events like these did not prompt a quick fix and were passed off as isolated events. We believe that these incidents should not have been ignored and the expansion of the doors should have taken place sooner, ensuring the safety of its passersby. This was one of the very first changes in the requirements for the Davis Centre doors and that they needed to be expanded.

5.2 2005-2008

However, with the passing of time, the amount of traffic increased, especially when in 2005, the Grand River Transit decided to introduce bus stops to Davis Centre on the west side of the ring road which brought in a significantly high amount of traffic to the Davis Centre. This led to several problems for both the Davis Centre and the people alike. The high amount of traffic that the Grand River Transit brought in to the Davis Centre led to long queues at the door since the narrow doors could only let one person pass at a time. This problem became worse during the winters as people would get stuck in the cold for a long time. We think that this should have been a major requirements change point at which to consider the expansion of the Davis Centre doors including a safety feature for several reasons.

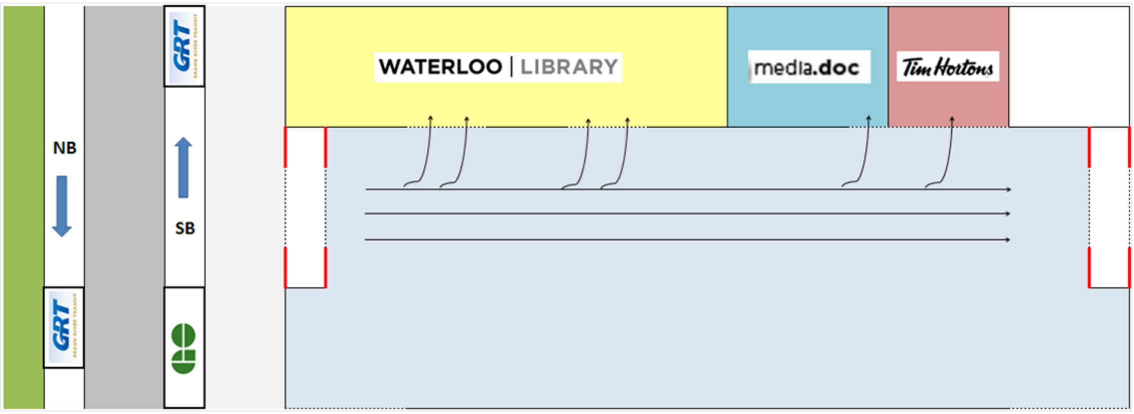

Figure 12: The above diagram displays the structure of Davis Centre in the year 2015.

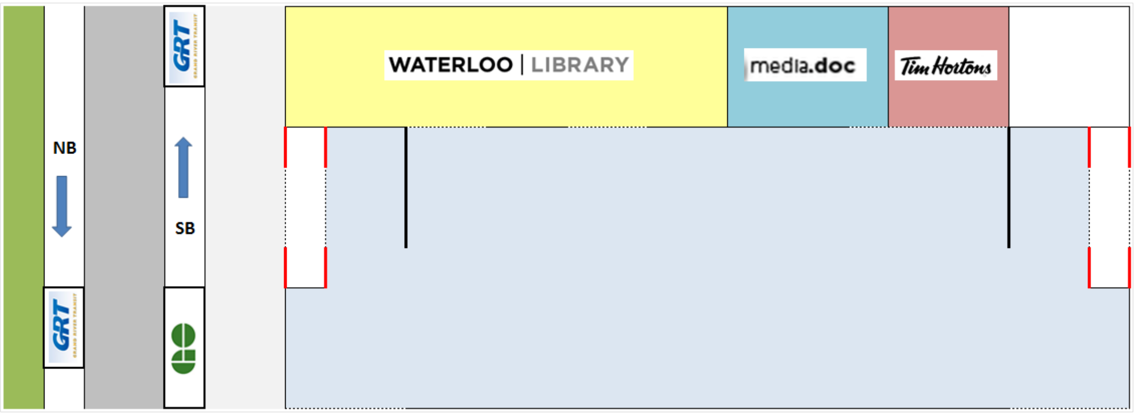

Figure 13: The above diagram displays the structure of the Davis Centre after the physical barriers were constructed in early 2015.

For one, it would allow more people to pass through the doors at a time thus handling the traffic better. Two, wider doors with a safety feature would stop any more incidents to happen.

5.3 2008-2014

The next major requirement change came about in 2008 when the construction of the Mike and Ophelia Lazaridis Quantum-Nano Centre, popularly called the Quantum-Nano Centre, caused the Grand River Transit bus stops to move from the Quantum-Nano Centre to Davis Centre. This resulted in a dramatic increase in the amount of traffic passing through the Davis Centre doors. It was during this time between 2008-2009 that the authorities finally decided to make the shift from the narrow manual doors to a wider set of automatic sliding doors. We believe this was a good move and that the switch from the manual to the automatic sliding doors should have been done sooner. The wider automatic sliding doors were successful for the most part. However, this resulted in another problem which had not been anticipated earlier. The high traffic passing through the Davis Centre doors caused the doors on both sides of the building to remain open most of the time which allowed for the west winds to create a wind tunnel scooping all the heat out of the Davis Centre atrium making it unbearably cold for the people in the atrium. So, it turns out that the automated sliding doors did help in incorporating the increasing traffic in the Davis Centre but led to the atrium being cold. However, since Canada is a very cold country, this problem could have been anticipated earlier and right measures could have been taken before hand.

Figure 15: The Media Doc.

5.4 2014-2015

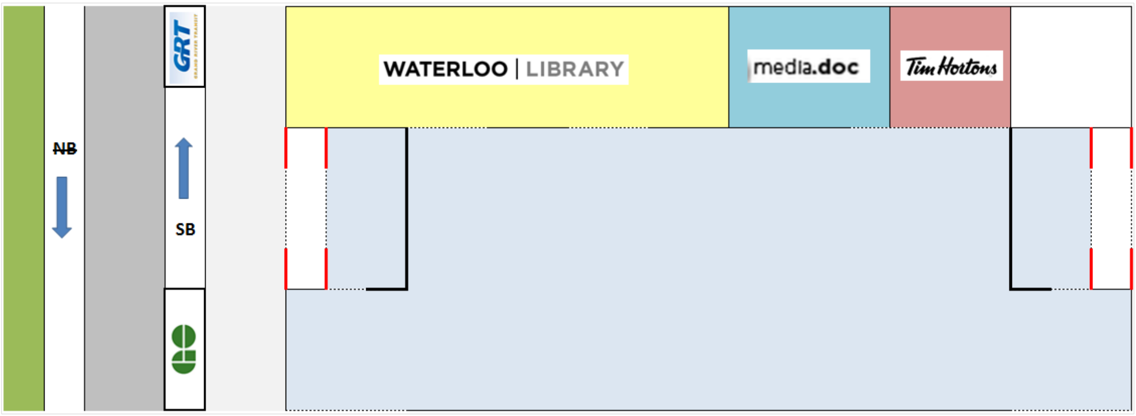

Figure 14: The above diagram displays the structure of anticipated changes to the Davis Centre in the future.

It was only recently in early 2015 that the physical barriers were set up to break the flow of the west winds to deal with the wind tunnel and the temperature problems. This has largely been successful but since this has not been tested for a whole winter season yet, there is some conjecture about its effectiveness as described by people working at different locations in the Davis Centre. The people working at the Davis Centre library said that the physical barriers did not bring about any change in the temperature inside the library. The lady working at Media Doc said that the physical barriers did help keep the office warm but still needed to install more heaters inside the office. The people working at Tim Hortons Express claimed that the barriers helped them a lot since there is no other door at Tim Hortons Express and it is in the direct path of the west winds. The people at Plant Operations said that the barriers were "more of an experiment than science" so it remains to be seen how effective the physical barriers turn out to be.

5.5 Heating System Breakdown

Recently, in early 2015, 20 per cent of the heating system pipelines needed replacement. It was believed that the automated doors and the cold they brought inside the Davis Centre broke the heating system but that was not the case. The heating pipelines of the Davis Centre are designed in accordance with the structure of the building and they act as natural pockets of sediment collect. They need to be flushed on regular basis to get rid of the debris. These heating pipes use hot water to keep the building warm during the winters. To keep the water from freezing a chemical called Glycol is used. The debris in the pipelines led to corrosion and the Glycol system broke down. Hence, the pipelines for the heating system needed replacement and this entire process was unrelated to the automated sliding doors as opposed to the earlier belief that the cold broke down the heating system of the building.

6. CONCLUSIONS

This case study suggests that, like in every other project, be it in the construction domain or a software development domain, the requirements tend to change and one has to be able to address these requirements efficiently. Davis Centre is an excellent example for this study since it has seen a lot of changes since it finished its construction in 1988 and the engineers have been able to accommodate these changes efficiently.

It was also seen that new requirements come up with time, or requirements creep. When the bus stops were moved and new bus stops were introduced in front of the Davis Centre, the manual doors were unable to handle the amount of traffic that entered inside the building. Hence, the requirement of the building changed and a switch had to be made from manual swinging doors to automatic doors. The automatic doors handled the increasing traffic well, but this led to some heating problems in the atrium. As the doors worked in pairs and opened at the same time, and a huge amount of people entered the building, the doors remained opened almost all the time. This led to the atrium being cold in the winters. This was again a requirement creep and the heaters in the atrium had to be maxed out to deal with this change. The physical barriers that were constructed recently to obstruct the west winds and their effects in the atrium are also an example of how requirements creep and it becomes important to deal with them.

The evolution of the Davis Centre atrium doors conforms with the notion that requirement change is a continuous process and is inevitable. The requirements for any project, be it the construction of a building or development of a software can change at any time and a good project plan should be able to accommodate these changes with every step of the development process.

7. ACKNOWLEDGMENTS

We would like to thank Professor Daniel M. Berry for providing us with an opportunity to conduct this interesting case study. We would also like to thank the people at Plant Operations, the Davis Centre Library, Media Doc and Tim Hortons Express for providing us with all the information and taking out the time to answer our questions regarding the history of the building and the heating system problems, and for their kind cooperation.

8. SOURCES

All the information provided above was collected by conducting interviews with people working at the Plant Operations at University of Waterloo, the Davis Centre Library, Media Doc and the Tim Horton Express at the Davis Centre.

9. REFERENCES

[1] Brooks, F. P. No silver bullet. April, 1987.