THE PENNSYLVANIA STATE UNIVERSITY –
DEPARTMENT OF ARCHITECTURAL ENGINEERING

AE Fifth Year Senior Thesis

Final Report

Sami Boulos – Construction Management

April 9, 2008

Faculty Consultant : Dr. Riley

The Carl J. & Ruth Shapiro Cardiovascular Center at the Brigham & Women's Hospital in Boston MA

BRIGHAM AND WOMEN'S HOSPITAL
A Teaching Affiliate of Harvard Medical School

Carl J. & Ruth Shapiro Cardiovascular Center

Architectural and Site Features:

State of the Art equipment for Operating Rooms and in -patient care units

Connection to existing Brigham & Women's Hospital via Steel and Glass Connection Bridge spanning Francis Street.

Vast lobby area on the East Side, complete with glass fasçade, indoor plant life, and escalators to the upper lobby levels.

Mechanical:

4th floor of building serves as natural ventilation entrance, with louvers along all four sides

19 Air Handlers providing a total of 640,300 CFM

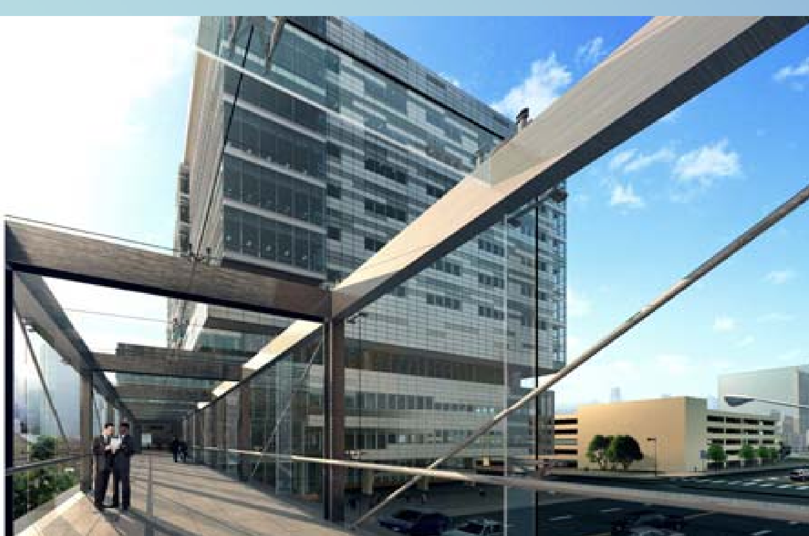
(3) 800-ton Cooling Towers provide 4800 GPM each

Structural:

Steel Frame Construction with Glass and Aluminum Curtain Wall system

Curtain Wall has unique connection to steel frame

6" concrete Slab-On-Grade



Project Team:

Owner - Partners Healthcare System

CM - William A. Berry & Son, Inc.

Architects - Cannon Design and Chan Kreiger & Associates

Plumbing/ FP - RW Sullivan Inc.

Mechanical/ Electrical - BR+A, Bard Rao and Athanas

Structural - McNamara/Salvia Inc.

Civil - Vanesse Hangen Brustlin Inc.

Vital Building Statistics:

Size - 450,000 SF

Height - 10 stories above grade, 13 total

Construction - Start October 2005

Complete April 2008

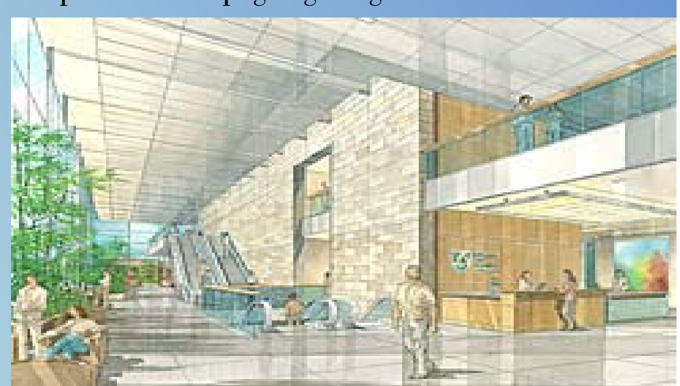
Delivery Method - CM @ Risk

Electrical:

Switchgear provides for 480/277V and 208/120V systems

Diesel Generators provide emergency power

Unique and complex lighting schemes illustrated by 3 separate multi-page lighting schedules.



BERRY

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http://www.engr.psu.edu/ae/thesis/portfolios/2008/seb307/

PARTNERS HEALTHCARE

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Executive Summary

Over the course of the 5^{th} year Senior Thesis project, the information gained through Technical Reports, the issues analyses, and the discussions with the project team and industry professionals illustrated the complexities that accompany a building project. The following report introduces Partners Healthcare System, the owner of the Brigham & Women's Hospital in Boston MA, and their latest construction endeavor. The project offered a unique experience to examine the application of 3D modeling to MEP coordination, an aspect of one of the central themes discussed at this year's PACE (Partnership for Achieving Construction Excellence) Roundtable. Students received information regarding critical construction issues in a discussion format with industry members. These critical issues can help students gain an interest and comprehension for the complexities inherent in construction practices, and also to recognize how those same issues can be applied to their own thesis projects. The issues from this year, other than BIM, were Prefabrication, and Workforce Relations. Since it related in some way to this project and for the personal interest to the process, Building Information Modeling and its growing use in the industry today was chosen as a depth topic.

The 3D modeling aspect of BIM acts as the focal point of the research for this thesis, but two technical analysis areas that connect to BIM in some way encompass the reminder of my thesis proposal. Research into the acoustical complications caused by Rooftop Mechanical equipment above the VIP patient rooms on the 10^{th} floor of the new building design of the new Carl J. and Ruth Shapiro Cardiovascular Center is followed by an architectural and mechanical study of the building envelope system.

The construction industry is ever-growing, now much faster than ever before. The BIM initiative continues to garner support as the technology maintains constant growth and constructive criticism, all the while the software behind BIM continues applications in the classrooms for younger generations as well. For the Carl J. and Ruth Shapiro Cardiovascular Center, only the 3D modeling aspect of BIM found use for the MEP coordination of the project. Some project members found the tool not as useful as a pencil and paper for solving coordination problems, demonstrating one of a plethora of obstacles preventing all members of the construction industry from fully embracing the BIM tools.

From this report, please discover the advantages and disadvantages of BIM, especially pertaining to the 3D modeling aspect. Note that the terms BIM and 3D Modeling are not the same and this will also be reflected in the depth analysis below. The last two sections of the report try to make the connection between two construction issues raised during the project and if a 3D model or BIM could have helped their resolution better or worse than the actual problem solving choices.

Credits/ Acknowledgements

I would first like to thank my family for their continued support through my academic career. My father, born in Lebanon, came to this country speaking little English but with a desire to gain the greatest education he possibly could. He spent most of his time studying engineering or working to survive in this country. My mother, born here in Michigan, took 6 years to finally figure out what she wanted to do with her life, discovered teaching was her passion, and has been my favorite teacher since I was little. It was them who have given me the grit and determination to get my work done, but also the notion that a combination of school and extracurricular activities is a necessity for a balanced and memorable college experience. Without my dad, I never would have gone to Architectural Engineering, and without my mom, I never would have pursued music and the Blue Band, as well as all my other extracurricular activities at Penn State.

The faculty & Staff of Penn State, specifically all of the professors in the Department of Architectural Engineering:

- Dr. David Riley
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William A. Berry & Son Inc. and Partners Healthcare System for permitting me to use the Carl J. & Ruth Shapiro Cardiovascular Center at Brigham & Women's Hospital for my thesis, and a special thank you to:

- Charlie Connor
- Michael Willet
- Scott Amaral
- Edwin Kudwoli
- Jason Giampa

Introduction/Project Background

The Carl J. and Ruth Shapiro Cardiovascular Center is a 10-story addition to the Brigham & Women's Hospital located on 70 Francis Street in Boston Massachusetts. Its location in the heart of medical research campuses in a major metropolis deems the site extremely congested, providing no lay down area for materials during construction of this project. A remarkable undertaking for a project team and owner given the limited space to work in downtown Boston the building will afford the hospital 134 new patient-care rooms and give the hospital state-of-the-art Operating Rooms and Imaging technology. The facility will also contain a mixed-use first and second level, containing coffee shops and newspaper stands amidst a lobby area with full height glass façade and plant gardens throughout the lobby. Lastly, the building strives to achieve a LEED Silver rating while also introducing "green" design components of sustainability to a healthcare facility.

The existing Brigham & Women's Hospital in Boston MA

The primary project team members are the owner, Partners Healthcare System, the construction manager is William A. Berry & Son, Inc., and the architecture firms of Cannon Design and Chan Krieger & Associates designed the facility.

Partners Healthcare is a non-profit healthcare corporation that owns a number of in and out-patient facilities throughout the North and South Shores of Massachusetts. Their primary reason for building the Carl J. & Ruth Shapiro Cardiovascular Center at The Brigham & Women's Hospital in Boston is for the increased need for patient care. This is a mission critical facility because it will give the hospital 134 new patient beds. There is a direct correspondence for pro forma business, so this facility will allow for the immediate aid of more emergency patients. It is also part of the long-term expansion of the several research hospitals located at the Longwood medical campus. The new cardiovascular center incorporates state-of-the-art imaging systems and Operating Rooms, but offers care in other areas than just cardiovascular. With the new patient rooms and space for offices, the building can accommodate more patients in the event of a critical catastrophe with a wide variety of injuries and emergency care necessities.

Site & General Architecture

The initial concept of the building was a "flash-cube", used on the early cameras of the 1960s. Essentially a glass cube itself, a steel superstructure frame resting on concrete piles and concrete foundation walls gives way to the building's exterior consisting of glass and aluminum panels arranged in a random pattern to form the curtainwall system. The building connects to the existing hospital via several underground bridge connectors and one above grade, which is steel frame with glass curtainwall as well.

Local conditions of the site again attribute to not only a congested project site, but also heighten the necessity for the project team to diligently monitor all major steps in the construction process because of the neighboring structures, particularly the existing hospital that is still operational at the time of construction. The hospital serves as a research facility for many students but also provides quality healthcare for the citizens of not only Boston or Massachusetts, but people from around the country and abroad as well. The ability for the hospital to meet the increasing demands for patients as well as the goals of the hospital to maintain a high level of research and development and implement state-of-the-art technology advancements intensified the need for this project's construction.

In Boston, the preferred method of construction for the high-rise buildings is steel frame with lightweight concrete slabs, due to the seismic issues. The floor deck concrete must be machine-troweled in order to achieve the appropriate tolerances for hospitals. Both of these conditions were satisfied on this project. In terms of interesting site conditions, the construction team was required to connect the new structure to the existing hospital in 3 places: the bridge connection above Francis Street, as well as the connection through Francis Street of the hospital to two of the sublevels of the new project. Francis Street was also relocated and moved slightly, all while maintaining 100% traffic. The neighbors of this area put a lot of restrictions on construction efforts, such as work hours and site layout. The relationship between Partners and its neighbors at Longwood is so critical to the continued growth and strides in the advancement of healthcare technology and research that it is important for both sides to see the gains for all parties involved. Because the entire area consists of active medical campuses, the noise cannot go beyond a specific level, the hours of construction are regulated, but the main goal is quality, which can never be sacrificed.

Parking for construction workers was available through the use of the adjacent parking decks near the site. Space on the site itself was extremely tight, with no available lay down areas for materials and no loading dock to the building. In terms of the existing site, 6 homes were relocated before construction began by Brigham & Women's Hospital. The bearing capacity of the soil is 8 tons per square foot, or 16 kilo pounds per square foot (ksf). The building foundation did move below the water table, making the water prevention a crucial step during its construction. The total waste costs, including the dumpsters and recycling costs, was difficult to determine due to fluctuating costs for trucking, however an allowance of $470,000 was made.

Depth Topic

Background/Inspiration:

Each year, PACE, the Partnership for Achieving Construction Excellence, holds two seminars that partner industry professionals with AE faculty and students. The fall 2007 PACE Roundtable introduced prominent problems or successes of the industry to the students with real-world experience interwoven via the members and faculty who attended the event. The spring's PACE Seminar will update the students and industry members with details of the progress that industry-led actions have made to address and correct those topics discussed at the Roundtable. This year's critical industry issues discussed were Prefabrication, BIM, and Workforce Relations.

Prefabrication of construction materials and elements discussions commenced the PACE Roundtable this past October. Panelists discussed several sides of the issue: owner/consumer perspective, manufacturer perspective, contractor perspective and academia perspective. Some common arguments against prefab were that it leads to lesser quality products and also does not allow quick changes in design. The arguments supporting prefabrication involved the waste on site being less and that some building systems can be installed faster with prefabrication. Other discussion topics included the idea of the phrase "prefab" leading to the idea of a lower quality product, particularly in Europe where "offsite production" has been a staple in construction. The third industry issue discussed at the PACE Roundtable was arguably the most important and dealt with the workforce relations problems, particularly those involving illegal immigration, union relations, and also the shortage of experienced tradesmen and labor shortages. The growing trend shows that experienced tradesmen whose children join the workforce only serve temporarily as they search for "a better job". The other growing problem that decreases the workforce is the raging immigration fight. Politicians on both sides of the argument are hurting the ability for experienced tradesmen to stay in the construction industry. One statistic that really resounded was the fact that 60% of the workforce is Latino/Hispanic and that of those, one-third are illegal immigrants!

Building Information Modeling, or BIM, was the second major topic at the Roundtable, and again panelists discussed the positives and negatives of BIM. The general feeling towards BIM was that it presented a good step for the industry in clash detection and also sequencing of trades on a project. Also, there would be less waste of paper to print every RFI and also all the revised drawings, and also there would be less of a delay in schedules because the problems would be addressed at the beginning of the project before construction commences. The dissentious comments against BIM were that the software was only accessible for some trades, and that not all trades bought into the idea of BIM. This is true, but more because BIM is a relatively new advancement in the construction industry; according to the panelists, five years ago BIM did not even exist.

The PACE Roundtable brought up some very interesting topics to research and apply to the thesis projects; for this thesis BIM seemed the most relevant to this project because of some BIM efforts (MEP Coordination) on this project. Also, through the five years of study at Penn State, the department's

curriculum has changed dramatically. However, their advancements in software and research benefit younger students, and the older members of the department suffer. 3-D and 4-D modeling practices often must be learned by the students on their own in my class, while the students just a year younger were taught those and many more of the software capabilities the AE department has in their classes. Similarly many of the trades in the construction industry are behind in the development and adoption of the new state-of-the-art computer programs that could greatly help the construction process. With more trades adopting 3-D programs and utilizing them allows more construction issues to be addressed and corrected before their construction begins, allowing more schedule savings and earlier delivery of the projects. This is the issue I would like to pursue through my research.

Problem Statement:

BIM project capabilities are readily available for all trades in the industry, and are also gaining support and implementation at a staggering rate, but there is still some opposition in the industry caused by the generation gap and experienced workers who do not need to use the model to visualize in 3D.

Goal of the research:

I chose to research this topic first and foremost because I see it as the way projects will be built in the future. Since I have had little experience with the tools incorporated in the BIM model, I wanted to examine the depth of the BIM models being used in the industry today. Also, I wanted to gauge the response of the industry to this project delivery tool, and learn the general opinions they have about BIM. Another goal is to find out the deterrents of adopting BIM tools and the problems with those tools, specifically related to **3D modeling**, and relating those general topics to my specific project. The audience of my research is the construction industry as a whole, but logically the best results would be to discuss the topic with those members who use BIM extensively as well as those who know little about it. The benefit of this study serves to better educate myself about BIM as a tool and to reflect on its true advantages and disadvantages to any building project in the industry by focusing on this project as an example. Lastly, it is my hope that by capturing the opinions and ideas of several different members of a project team, the concept behind BIM of working collaboratively on all aspects of a project from initial conception to finished product will be realized and will encourage further development and adoption of the tool of BIM on future projects.

Depth Study:

The research began with a review of articles in periodicals (ENR, the Architectural Record) and other published works pertaining to BIM. The concept of BIM is a model for a building project, but the common misconception is that BIM equals a 3D model; however BIM is so much more than that. Each article discussed a different aspect of BIM, but the general opinions of the research uncovered very similar opinions. The BIM tools developed over recent years and their installation into the common practices of many construction companies proves that the industry has responded to them positively. In an article by Joann Gonchar for the Engineering News Record (ENR), she gives a definition for BIM as "the model is a compilation of integrated and dynamic data that describes the functional and physical aspects of a building and its components" (Gonchar, 84). This explains to many how complex the BIM model, and she goes on to explain that not only does the model provide normal 2D plans, elevations, and sections, but also "could include information such as the dimensions and characteristics of beams, the fire rating of partitions, or warranties for mechanical equipment" (Gonchar, 84). The last point in this article referred to the BIM model after completion of the project. The suggestion of turning over the model to the facility's maintenance staff in order to be used for maintenance purposes throughout the lifetime of the building sounds terrific, although the question of operability comes to mind. So this new way of modeling a project encompasses so much more than the design and layout of a project, but also will provide information such as how long a wall could last in a fire and if that meets the building code. Other articles discussed similar attributes of this integrated model and how comprehensive it can become.

Apart from the initial research about what BIM is and represents, some of the literature conferred the application of this complex model. In ENR's November 13, 2006 article "Federal Agencies Look for Speedy BIM Implementation" Bruce Buckley talked about the U.S. General Services Administration (GSA) released a preliminary federal BIM requirements for all new and major modernization projects. This push by GSA will accelerate the adoption of BIM tools for most companies in the industry. By increasing the demand for BIM projects and tools, it is inevitable that they will become standard practice for projects within the next 10-20 years.

From the articles picked and researched, it seemed that all facets of design and construction fully adopted and integrated BIM, however there exist several reasons that companies give to justify their opposition or slow adoption of BIM. Some of these include:

- Contractual agreements/disagreements pertaining to the ownership of the BIM model
- Difficulty in coordinating a construction model with some subcontractors stuck in bidding problems
- Argument over having a single BIM Model or multiple models for multiple trades
- Who makes the model(s)
- Technology compatibility issues (one model in AutoCAD, one in REVIT)
- Costs

One sector of building construction that sees the greatest potential and benefit from a BIM project is the Mechanical/Electrical/Plumbing trades (MEPs). These trades often must work in the same spaces at the same time and are usually rushed to complete their tasks. This often causes clashes and could provide a prospective delays if problems arise. The use of a 3D model illustrating their equipment and materials being installed illustrates many of these clashes before the trades begin their work on the project. Also, the MEP trades can utilize the model in another way: design. In Nadine Post's article:

> For MEPs using sophisticated software for analysis of natural and artificial lighting, solar loading, energy modeling, heat load studies, sustainability studies and more, the ability to import an accurate architectural and structural database … provide the owner and architect with accurate alternatives during the important early conceptual stage of design."This is one of the most common ways that BIM technologies like the 3D model are helping projects, by showing these clashes that could inhibit the schedule for weeks, prior to the work being done (Post, 28)

So by having all of the major trades on board in the conceptual design phase of construction benefits the project as a whole, particularly for the owner who can utilize this advanced design and consider the alternatives much more scrupulously.

Besides the several articles of research done on this topic, in order to gauge the knowledge and use of BIM tools on this project, a survey of members of the Construction Manager for this building, William A. Berry & Son, Inc. (Berry for short), illustrate their opinions about BIM, both from the perspective of this project and the others being delivered by this company. The survey showed that efforts are being made by Berry to incorporate more BIM tools into their projects. Most recently, they are preparing to use Vico 5D Presenter with a fully integrated BIM endeavor on a large project for MIT. They have 1-2 staff dedicated to their imaging software updates and drawings. Berry has worked on a couple other projects using Autodesk Revit and AutoCAD 3D as well, both for the MEP coordination phases and some Architecture and Structural Steel design as well. The results from Berry unilaterally supported the BIM tools, particularly the 3D models, and also stated they would prefer working with more projects as they got more familiar with using the BIM software. Although some of the staff were not on the project team for the Carl J. & Ruth Shapiro project, their input nonetheless allowed for certain conclusions to be drawn in regards to some questions pertaining to the project: Was BIM a possibility for this project? Would it have helped or hindered the project? The answers to that will come later, and a copy of the survey questionnaire is located in the appendix in the back of this report (p. 22).

Apart from the survey sent to the Berry staff, I also sent an abbreviated survey out via the AE Construction Mentors forum in the hopes of gathering similar responses. A project manager from Balfour Beatty divulged that their company has recently begun using Revit since their architects are using that same program. Also, the structural engineers working with Balfour Beatty have also begun employing Revit, but the majority of structural engineers still use Microstation and AutoCAD MEP. Another question posed was in regards to their own internal analysis of projects they have completed using some or all aspects of BIM, to which the response was that they do not have an appropriate metric

as of this date to evaluate the successes or failures of BIM technologies. Another response on the forum came from Foreman Group, with similar responses pertaining to internal evaluations and also that their architecture firm uses Revit. However, they also stated that their CM company "has acquired Innovaya as the bridge software for BIM estimating, scheduling, and clash detection", illustrating yet another avenue of technology in place to help construct projects with BIM.

Advantages/Disadvantages:

Through the research of articles and testimonials, several advantages and disadvantages of this "construction tool of the future" have been discovered and already alluded to through this section. The table below gives a summary of the most common found through the research for this report:

Advantages	Disadvantages
Early clash detection for MEP trades	High initial cost and training
Better, simpler visualization of ideas	One model or several models, and if several, can they work together?
Increase quality of work through entire team having better knowledge of the project	Contractual obligations unclear; who provides the model?
Compatibility of Technologies	Compatibility of Technologies
When done correctly, BIM can elicit a higher quality building faster and at a lower cost	Ownership of BIM model after project completion; to the owner, architect, or facility maintenance?
	Generational Gap – the experienced team members do not need a 3D model to visualize the 2D drawings, they already think in 3D.
	No metrics exist to evaluate success or failure of BIM, nor to assess the cost savings of BIM

From analyzing these advantages or disadvantages, further insight into 3D modeling allowed for the thought of using it more on this specific project; would that have helped or hindered the project?

Project Specific:

After discussions with the project team and through the survey, the use of 3D modeling for MEP coordination was a necessity on this project. It helped to detect any clashes between those trades prior to their work beginning and alternative measures were generated for their sequence of work. It provided them with a great tool, and the benefits of using the 3D model were countless. Both time and money were saved by using the clash detection and to execute a properly sequenced and coordinated MEP trade's work for this project. The real difficulty came in trying to get the project tradesmen excited about the 3D model. Those individuals who have project experience of 30 years or greater who can visualize the clashes without the aid of a 3D model. That was a major obstacle, the fact that 3D modeling is useful for the less experienced personnel, illustrating another major obstacle in general for BIM to be fully integrated into the industry.

The one area of discussion about BIM and 3D modeling got onto the subject of the shortcomings of BIM. The 3D model is a wonderful visual aid, but could more be incorporated into the model. The short answer for a general BIM is yes, however for this project, there was a desire to have more information in the model. The desired information would be the ability to select a wall, or float the mouse over a wall and be able to know the properties of that wall's material, what type of paint is on it, the thickness, metal or wood studs, etc. During a 3D walkthrough of the corridor, or an office, or a patient room, the ability to select a light fixture and have a product data sheet pop up with all of the fixture's critical data. These improvements sound unlikely, but are in fact possible today and are being incorporated into future BIM software models.

Cost, Schedule, and Quality Implications:

It is certainly difficult to estimate the total cost of implementing BIM technology for a company, but some ways of estimating the cost include:

- Software costs
- Employee costs to run the software
- From a CM perspective, by incorporating BIM as a service to the owner, this could increase the total fee of the project or be another service provided by the company

Schedule delays or acceleration could be estimated by the productivity of the BIM model and staff. Because the model provides clash detection, this is a time and cost savings for the project. Depending on the severity of the clash, it could be hours or days that the model saves on the total construction time. On the other hand, the interface between project team and the BIM model could perhaps slow the process down initially because they are not experts at manipulating the model.

The only results from having BIM on a project are positive. BIM can predict clashes, saving time and money. Because of this, there will also be less RFIs and less time spent clarifying some questions answered by the 3D visualization capabilities of the model.

Conclusion/Recommendation:

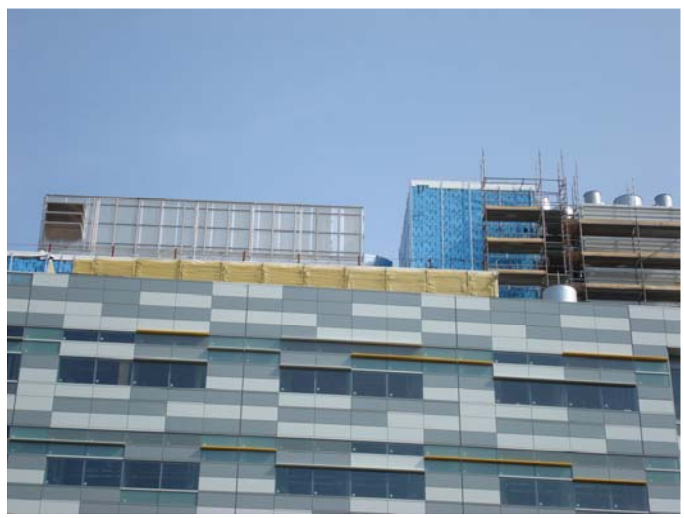
From the analysis of the articles originally researched, to the discussion with project team members and industry professionals in general, and including the answers to survey questions on the AE Construction Mentors forum and the Berry survey, the use of 3D modeling for the Carl J. & Ruth Shapiro Cardiovascular Center at Brigham & Women's hospital in Boston was a great tool for MEP Coordination. The BIM process in the industry will continue to gain support through new technologies and a larger volume of use on more projects over time. With the advent of the Federal government requiring aspects of BIM for their projects and with the newer generations having more experience with these tools, the BIM process is the way of the future.

Technical Breadth Analysis

The Carl J. & Ruth Shapiro Cardiovascular Center is going to be the premier healthcare facility in Boston, with state-of-the-art Operating Rooms, Imaging systems, and the ability to address a multitude of patients while still being a central research campus for medical students in Boston. The level of quality and accuracy in project task completion is critical to the hospital, but the project was not without problems. Apart from trying to implement further Building Information Modeling into the project tasks, the following are the Analysis topics to be researched and presented in April of 2008.

Through the course of researching each technical analysis topic, each incorporates components of other disciplines of Architectural Engineering. These breadth studies are taken from Structural, Mechanical, or Lighting/Electrical options studies, and are interwoven into the analysis subjects listed in this proposal. During the course of the year and the study of this project, several problems during the project have been fascinating to study and discuss. From the work done in the Technical Reports last semester, those several issues have been narrowed down to the following Breadth Study topics:

VIP Room Acoustical Quality Breadth Study: This analysis focuses on the sound quality of the VIP patient rooms on the 10th floor of the building. The mechanical system equipment on the roof sits just above these rooms, causing sound pollution and potential vibrations. These rooms service the patients of higher social status, and considerable money and labor has been spent on sound and vibrations dampening in order to provide and maintain the luxurious atmosphere in those spaces.



Air Handling Units on the roof above VIP Rooms

Problem Statement: The acoustical insulation of the VIP rooms adequate to attenuate the 4 majors sources of noise, the mechanical equipment above these rooms (on the roof).

As an acoustical breadth, I would like to analyze those vibrations and sound issues and perhaps find an alternative solution that still meets the high vibration and sound transmission control, but for a cheaper price and less labor. In order to accomplish this task, in-depth research and the following steps must be taken:

1. Begin by gathering information about the mechanical equipment and also the installed acoustical attenuation equipment, i.e. ceiling tiles, carpet, etc.

2. Once the research has been done, examine the data on the AHUs and other roof equipment, such as its vibration and sound properties, i.e. how much sound in decibels is transmitted or how much of a vibration is caused when the power level of the generator is at a certain level?
3. From these inquiries, a proper solution will be made, comparing it against the project solution. Re-sizing the equipment would be a vast undertaking considering the size of the hospital, however by making an assumption about increasing or decreasing the acoustical insulation might prove useful in suppressing the noise in the VIP room. One room will be used as a model in the Trane Acoustical Program (TAP), and will be run with the current materials and equipment along with the solution.
4. Based on the results, and accounting for cost, schedule time, and other considerations, conclusions and recommendations will be made.

Since Acoustics has been a strong consideration for this project, as well as the idea of a VIP hospital room has been intriguing for me, this analysis helps to strengthen my acoustical appreciation on construction projects and better understand the necessity for acoustical analysis. Another strong aid from this segment is the ability to apply creative thinking and solution design into other facets of a construction project. The ability to think of these critical construction issues will allow me to manage a project more smoothly, with knowledge of potential labor considerations necessary to allow the project to succeed. Lastly it will reinforce my desire to consider the client's needs at all times on a project and help find the best solution to fit his or her requirements.

Results:

As per the above steps, a discussion with the project manager began the research into this issue. He provided the name Cavanaugh & Tocci Associates, Inc., who served as the acoustician on the project. The mechanical engineer was BR+A, Bard, Rao, and Athanas, who believed that the acoustical systems suggested by the acoustician would be more than sufficient to prevent the noises from the rooftop units reaching into the VIP patient rooms. When discussing the system with Cavanaugh & Tocci, the conversation led to the discovery that in a hospital project or any healthcare facility, insulating the ductwork from those mechanical systems with any fibrous insulation is prohibited. This fact caused a very elaborate acoustical design to maintain a quiet and comfortable sound level in the VIP rooms. Their determination for the system installed began with the determination of acceptable MEP background noises from the ASHRAE guide. Next, they considered the airflow velocities maximums in the ductwork provided by BR+A. In using the TAP program, they could discover also if fan noise and/or regenerated sound would be problems to consider as well.

A very simple calculation was done using the TAP program just to determine the level of noise that could be caused by the 4 major sources on the roof without insulation: Fan/ Air Handling Unit, Emergency Generator, Cooling Tower, and Compressor/Chiller. Below are the results from TAP of an estimated total of noise generated by these sources:

TAP Noise calculation results

THE TRANE ACOUSTICS PROGRAM

Project Name: 70 Francis St
Location: Boston MA
Building Owner: Partners Healthcare System
Project Number:
Comments: Estimate of Sound Sources entering VIP Rooms

Path Table View -- Path1:

LINE ELEMENT	63	125	250	500	1k	2k	4k	COMMENTS
			Octave Band Data					
Indoor (Regression)	-4	-4	-3	-5	-6	-7	-9	
CVHE Chiller	73	74	73	72	74	72	69	
Cooling Tower	105	105	102	99	96	93	89	
Air Cmpressr	102	102	101	104	107	107	105	
Elec Generator	107	108	108	108	106	104	101	
SUM	110	111	110	110	110	109	106	
RATINGS	NC >65			RC 110(H)		115 dBA		

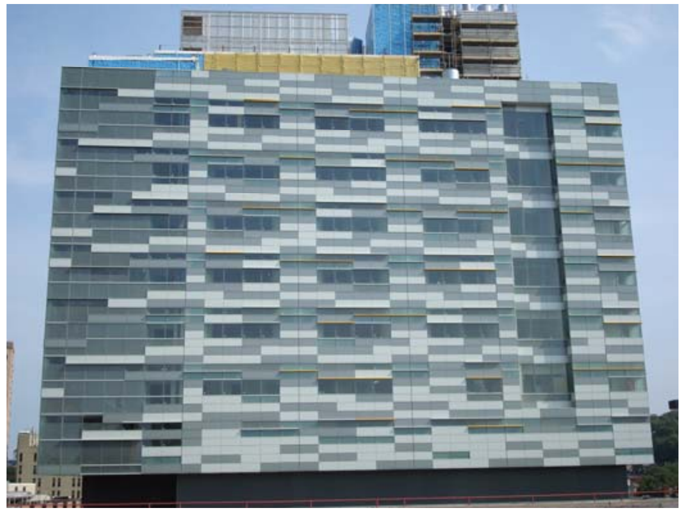
HIGH PROBABILITY OF NOISE-INDUCED VIBRATION

Conclusion/Recommendation:

After further discussion with Cavanaugh and Tocci, it was reasonable that their design was necessary for the prevention of the noise generated above, especially considering that the greatest source of sound attenuation comes from the insulation in the ductwork, but since that was not possible on this project, their solution made sense. Initially I believed that the acoustical system was too much and that excess money was being spent to over-dampen sound in that space. However, upon further review and a brief crash course using TAP, my recommendation is that the system should be installed the way it is.

Depth Research connection: Speaking with the acoustician on the project gave me some really fascinating insight into the world of acoustics. So many variables and sources to consider, as well as realizing that at the time of analysis the room may not be fully occupied, which alters the results as well. However, software such as TAP is created by Trane, a mechanical equipment manufacturer, so all of the necessary data is in one program. A marriage of TAP into a BIM model would be a great source of information to add into the model for several reasons. The ductwork sizes and criteria are already in the BIM model, and by incorporating that data into TAP all at one time, the model could generate acoustical data real-time for the project. This benefit could greatly increase the accuracy of making spaces comfortable acoustically, saving time in the schedule and long-term costs on the project (a large initial cost for the software would be offset by the savings in schedule and by designing it right the first time). If a 3D model was generated to serve for acoustical testing, marrying the TAP Program with a 3D Revit model and being able to calculate the Acoustical Quality of the VIP rooms, only that model would have been valuable for this project.

Curtainwall Study:



View of existing curtainwall pattern

The curtain wall system for the building has been designed and redesigned quite a few times during this project. The entire building envelope consists of 3 different methods of construction adopted for different heights of the building, i.e. the fourth floor is entirely louvers in order to achieve the outdoor air intake for the building, and the curtain wall on the lower three levels implements a different system than those floors above level 4. The patient floors 6-10 combine panels of various glass colors and types as well as different-colored aluminum panels in order to create the random aesthetic pattern desired by the architect. **Problem Statement: The curtain wall system on the patient levels 6-10 required too many panels and unique materials with the end result (a truly random pattern) not being achieved.**

The curtain wall is a major component to the building envelope and the total aesthetic effect of the building, and is extremely important to construct accurately. I have several goals in mind to accomplish in this analysis. The first is to gain a better understanding and more knowledge about the various systems used for curtain wall construction. Second, I hope to establish a more uniform type of curtain wall system in order to save both time and money on the project. Lastly, in continuing the theme of BIM, I would like to see if the tools of Building Information Modeling would have been a help in seeing connection issues and other curtain wall issues beforehand on the project. Listed below are some steps necessary to accomplish this:

1. Begin by gathering information about the present solution and research those curtain wall systems, including the R-values and other thermal properties and the costs associated with each. This can be done by accessing the submittal information from the Construction Manager and then researching these materials via Internet sources, periodicals, speaking with the contractor (with permission of course) and manufacturer's guides.
2. Next, a discussion with the project manager and contractor specializing in curtain wall systems will lead to answers for questions regarding products and materials used in the construction of the curtainwall, and issues that must be considered when designing a curtain wall system. Lastly, some opinion questions in regards to BIM and their experience will be given in the hopes of discovering clues to help adopt better implementation of BIM for a curtainwall system.
3. From these inquiries, a potential solution will be proposed, compared against the current project solution. They will be weighed with cost savings, time saving, and other considerations as well. The report will be presented to a proper authority on the subject and then the results will be summarized for presentation in April to the AE Jury.

The expected outcome of this research will be a comparison of the curtain wall systems used on the Carl J. and Ruth Shapiro project, and a potential uniform curtain wall solution. Also, there is a hope for sound recommendations with regards to BIM implementation into the curtainwall phase of construction projects. Also, an outcome of this analysis will benefit me when discussing curtain wall systems in the future while in the industry. Since it has never been a strong concentration for me before, I hope to gain invaluable knowledge of the concepts, the materials involved in the design and construction of curtain walls, and their applications to buildings.

Results:

Upon discussion with the curtainwall contractor, Karas Glass, several key points were discovered. The first was that the contractor did not divulge cost data for the system, so an effective cost analysis could not be completed; however an estimation of cost reduction was determined. Also, in terms of saving time in the actual installation of the system, it was discovered that regardless of the material of each panel, the amount of time to install was the same for any material.

When speaking with both the curtainwall contractor and the project manager, the re-design by the architect called for more types of glass panels to be introduced to the curtainwall, from 9-12 types up to 43 different arrangements of the curtainwall frames. The initial suspicion was that this change involved more than an aesthetic consideration, perhaps a structural application for resistance of lateral loads in the building, i.e. wind loads. However this was not the case, and the call for more varying types of glass derived from the architect's desire to incorporate a more random appearance of the curtainwall. Upon review of the mock-up of the curtainwall and also looking at the building's exterior from afar, the distinction of those several types of glass is difficult. Note the mock-ups above and try to decipher 43 different shadings or tints of glass and aluminum in the photo of the complete building elevation at the beginning of this section.

Based on further discussion with the Curtainwall contractor, a proposal of going back to the original design using only the 9-12 glass types would be a sufficient alternative to the constructed curtainwall. From this proposal, some serious questions were considered, including a modification of the percentage of glass being used in the design and the thermal implications from that.

Using the Trane Trace program, a simple model of the building envelope was developed, with the assumption of one room representing one floor in the building. With the quantities of glass from the existing design, about 40% glass, the program calculated a cooling total of 1,616 tons and a heating total of 12.1 million BTU/hr. The results are shown below in Calculation 1. By modifying the type of glass from double paned ¼" coated glass to a triple paned ¼" coated glass (results in Calculation 2 figure below), 2 important calculation variables changed, the U-factor of the glass and the shading coefficient of the glass. These affect the amount of sunlight entering the space. These fluctuations will change the amount of heating and/or cooling the mechanical system needs to provide for that space. See the difference in the heating and cooling totals, both figures going down. This decrease will allow for a decrease in the amount of money spent to heat and cool a space, as well as decrease the energy consumption of the building.

Calculation 1

SYSTEM SUMMARY
DESIGN CAPACITY QUANTITIES
By PSUAE

		COOLING				HEATING						
System Description	System Type	Main System Capacity ton	Auxiliary System Capacity ton	Optional Vent Capacity ton	Cooling Totals ton	Main System Capacity Btu/h	Auxiliary System Capacity Btu/h	Preheat Capacity Btu/h	Reheat Capacity Btu/h	Humidification Capacity Btu/h	Optional Vent Capacity Btu/h	Heating Totals Btu/h
System - 001	Variable Volume Reheat (30% Min Fl	1,616	0	0	1,616	-6,393,735	0	-5,700,760	-2,370,023	0	0	-12,094,494
Totals		1,616	0	0	1,616	-6,393,735	0	-5,700,760	-2,370,023	0	0	-12,094,494

* The building peaked at hour 16 month 7 with a capacity of 1,616 tons.

Calculation 2

SYSTEM SUMMARY
DESIGN CAPACITY QUANTITIES
By PSUAE

		COOLING				HEATING						
System Description	System Type	Main System Capacity ton	Auxiliary System Capacity ton	Optional Vent Capacity ton	Cooling Totals ton	Main System Capacity Btu/h	Auxiliary System Capacity Btu/h	Preheat Capacity Btu/h	Reheat Capacity Btu/h	Humidification Capacity Btu/h	Optional Vent Capacity Btu/h	Heating Totals Btu/h
System - 001	Variable Volume Reheat (30% Min Fl	1,589	0	0	1,589	-6,147,509	0	-5,693,265	-2,320,221	0	0	-11,840,774
Totals		1,589	0	0	1,589	-6,147,509	0	-5,693,265	-2,320,221	0	0	-11,840,774

* The building peaked at hour 16 month 7 with a capacity of 1,589 tons.

Because the triple paned, ¼" coated glass yields a shading coefficient that is very low, it is essentially unattainable and also more expensive per panel. Therefore, using the values of the most common panels of glass used in the curtainwall system (Calculation 3), the following results were tabulated

Calculation 3

SYSTEM SUMMARY
DESIGN CAPACITY QUANTITIES
By PSUAE

		COOLING				HEATING						
System Description	System Type	Main System Capacity ton	Auxiliary System Capacity ton	Optional Vent Capacity ton	Cooling Totals ton	Main System Capacity Btu/h	Auxiliary System Capacity Btu/h	Preheat Capacity Btu/h	Reheat Capacity Btu/h	Humidification Capacity Btu/h	Optional Vent Capacity Btu/h	Heating Totals Btu/h
System - 001	Variable Volume Reheat (30% Min Fl	1,605	0	0	1,605	-6,374,979	0	-5,697,720	-2,349,575	0	0	-12,072,699
Totals		1,605	0	0	1,605	-6,374,979	0	-5,697,720	-2,349,575	0	0	-12,072,699

* The building peaked at hour 16 month 7 with a capacity of 1,605 tons.

So by inputting the proper glazing, the total cooling capacity is 1,605 tons, and the heating total is 12.07 million Btu/hr. This is still assuming the 40% glass in the curtainwall. However, another alternative would be to modify the glass percentage. 2 trials were run, using 35% and 55% glass in the system. Below are the results (Calculation 4 is for 55% glass, Calculation 5 for 35% glass), which yielded an increase in the heating and cooling loads for the increased glass curtainwall, while the decreased percentage of glass yielded a lower heating and cooling load on the mechanical system:

Calculation 4

SYSTEM SUMMARY
DESIGN CAPACITY QUANTITIES
By PSUAE

		COOLING				HEATING						
System Description	System Type	Main System Capacity ton	Auxiliary System Capacity ton	Optional Vent Capacity ton	Cooling Totals ton	Main System Capacity Btu/h	Auxiliary System Capacity Btu/h	Preheat Capacity Btu/h	Reheat Capacity Btu/h	Humidification Capacity Btu/h	Optional Vent Capacity Btu/h	Heating Totals Btu/h
System - 001	Variable Volume Reheat (30% Min Fl	1,687	0	0	1,687	-6,984,067	0	-5,718,896	-2,498,976	0	0	-12,702,962
Totals		1,687	0	0	1,687	-6,984,067	0	-5,718,896	-2,498,976	0	0	-12,702,962

* The building peaked at hour 16 month 7 with a capacity of 1,687 tons.

Calculation 5

SYSTEM SUMMARY
DESIGN CAPACITY QUANTITIES
By PSUAE

		COOLING				HEATING						
System Description	System Type	Main System Capacity ton	Auxiliary System Capacity ton	Optional Vent Capacity ton	Cooling Totals ton	Main System Capacity Btu/h	Auxiliary System Capacity Btu/h	Preheat Capacity Btu/h	Reheat Capacity Btu/h	Humidification Capacity Btu/h	Optional Vent Capacity Btu/h	Heating Totals Btu/h
System - 001	Variable Volume Reheat (30% Min Fl	1,578	0	0	1,578	-6,172,071	0	-5,690,077	-2,299,636	0	0	-11,862,148
Totals		1,578	0	0	1,578	-6,172,071	0	-5,690,077	-2,299,636	0	0	-11,862,148

* The building peaked at hour 16 month 7 with a capacity of 1,578 tons.

To summarize the results of the existing curtainwall system with the re-design, the table below lists the pros (+) and cons (-) listed for both as well as the calculation results as a pro or a con.

Existing Design	Alternative Design
- High cost for various glass types	+ Standardized system with less glass types, less cost
+ More random pattern, theoretically	- Less of a random design aesthetic, theoretically
40% glass creates approx. 1,605 cooling tons	+ 35% glass = 1,578 cooling tons, - 55% = 1,687 tons

Conclusion:

The alternative design accounts for the estimated cost of materials, the installation time, and the value of the system both aesthetically and considering the mechanical system ramifications. By incorporating more varying degrees of glass into the system, the existing system costs more than the alternative design. For both systems, the installation time remains the same regardless of the material or glass type. The aesthetic value of the system is not changed either, given that the existing design and the alternative would "look the same" despite the many more types of glass in the existing. An estimated $2 million would be saved if the alternative design using 35% glass is installed, but that figure would be less given the cost of increasing the aluminum. Yet, the overall value would increase due to the lower cost of running the mechanical system. Lastly, the aesthetic value is diminished by increasing the aluminum and may strain relations with the architect or designer.

Recommendation:

Factoring in all of the pros and cons from above, it is recommended that the alternative design be chosen. This determination was difficult to select when considering the architect placed a lot of time and effort in the aesthetic of the building. However, when considering the owner and the money being spent on this project, to field a change of $2 million to the original design is difficult, and for the change to only offer aesthetic value and not structural or other enhancements, the existing design offers little more than cost to the project.

Depth Research connection: Could a 3D model have helped solve this problem prior to the construction of the curtainwall system? No, in fact the 3D model would have been so complex that it *could* distinguish between the 43 different colors and shadings attributed to the curtainwall change by the architect. Therefore, the model would have given justification to the change, clearly failing in its use to provide clash detection. By using the 3D model, the curtainwall system rendered image would be just as the architect wanted, but the constructed curtainwall would look much different, proven by the photos and the testimony of the construction team today.

Appendix A – Survey to Berry

3-D Modeling Survey to the Construction Industry

SECTION 1

What kind of company do you work for?

____Owner
____Architect
____Construction Manager
____General Contractor
____Trade Contractor
____Supplier
____Manufacturer
____Other: ____

Have you participated in a design or construction project using 3-D Modeling?

____Yes. Please proceed to SECTION 2 (pg.2)
____No. Please proceed to SECTION 3 (pg. 4)

SECTION 2

1. How many projects have you participated in using 3D modeling?
   ____1-2
   ____3-4
   ____5 or more

2. Could you please give a brief description of those projects, i.e. location, type, size, and explain what aspect of the project used 3D modeling?

3. What software was being used for the 3-D modeling?
   ____AutoCAD 3D
   ____AutoDesk Revit
   ____AutoDesk VIZ
   ____Other: ____

4. In your company, how many employees are dedicated to the creation and/or maintenance of 3D models for projects?
   ____1-2
   ____3-4
   ____5 or more

5. Please indicate the phase or aspect of the project where 3D modeling was used:
   ____MEP Coordination
   ____SuperStructure Sequencing
   ____Entire Project (full integration)
   ____Other ______________________

   If Other, please describe below:

6. When the project was completed, did your company complete an evaluation of the 3D modeling tool to determine its overall effectiveness?
   ____Yes
   ____No
   If yes, please explain the results.

7. In your opinion, what are the advantages/disadvantages of 3D modeling?

8. Please provide your personal experience/ opinion about 3D modeling, i.e. is it worth the investment to use for construction projects?

9. Would you recommend the company continue to build projects using the 3D modeling tool?
   ____Yes
   ____No
   If yes, please provide explanation.

SECTION 3

Recently there has been a push for Building Information Modeling (BIM), a full-integration of multiple resources into a 3D and 4D model of the project to help coordinate and sequence a construction project. These resources include materials data, accurate 3D models, using that same 3D model broken down into segments to illustrate the sequence of the construction phases over time, and much more. These tools help the entire project team to better visualize the construction of the building.

Would your company be interested in the use of 3D modeling as a tool on a project?

____Yes
____No
If yes, has the company begun to do this already?

If no, please provide explanation.

Do you feel that you have adequate knowledge of design and construction methods using 3D modeling?

____Yes
____No
Please provide explanation.

What reasons do you feel have prevented or are hindering the growth of 3D modeling in the industry?

Appendix B – Sota Glass Product Data Sheets

ORDER CONFIRMATION

DATE: May 3, 2006 3:24 PM CDT
Project: 70 Francis Street
PO#: 36304-776

Viracon Order #: S2-459527
Rev #: 01

Sold To: Karas & Karas Glass Co
Attention: Armand Brunelle
455 Dorchester Ave
South Boston, MA 02127
USA
Phone: (617) 268-8800
Fax: (617) 464-1867

Ship To: Sota Glazing
Attention: Jack Eggenberger
443 Railside Drive
Brampton, ON L7A 1E1
CA
Phone: (905) 846-3177

Special Instructions:
- Call Jack at Sota 48 hours before delivery at 905-846-3177
- 3 1/2" bottom cleats
- DDU Brampton
- End caps needed whenever possible
- Call Armand at Karas 48 hours before delivery at 617-464-1834 or cell #617-212-5326

Incoterm 2000: DDU Pre-glazing Facility, Brampton, ON CA
Freight Term: Prepaid

Transport Mode: Best Way

Glass Type: G-1

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.
- Offset units will have Beveled-Standard fill.

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
1	103	59 7/16 x 23 9/16	G1-1	10.0	10.0	1,030.0	[redacted] /sq. ft.	[redacted]
2	34	58 25/32 x 23 9/16	G1-2	10.0	10.0	340.0	[redacted] /sq. ft.	[redacted]
3	4	69 19/32 x 23 9/16	G1-CR	11.7	10.0	46.8	[redacted] /sq. ft.	[redacted]
4	4	59 7/16 x 23 3/8	G1-E-4	10.0	10.0	40.0	[redacted] /sq. ft.	[redacted]
5	4	58 25/32 x 23 3/8	G1-E-3	10.0	10.0	40.0	[redacted] /sq. ft.	[redacted]
6	4	65 7/8 x 23 9/16	G1-CL-2	11.0	10.0	44.0	[redacted] /sq. ft.	[redacted]
7	312	59 7/16 x 49 1/8	2G1-1	20.8	10.0	6,489.6	[redacted] /sq. ft.	[redacted]
8	63	58 25/32 x 49 1/8	2G1-2	20.8	10.0	1,310.4	[redacted] /sq. ft.	[redacted]
9	10	65 7/16 x 32 1/8	2G1-3	15.6	10.0	156.0	[redacted] /sq. ft.	[redacted]
10	10	64 25/32 x 32 1/8	2G1-4	15.6	10.0	156.0	[redacted] /sq. ft.	[redacted]
11	5	Ext: 50 1/8 x 32 1/8 Int: 50 1/2 x 32 1/8 3/8" Interior to the Right	2G1-C	12.3	10.0	61.5	[redacted] /sq. ft.	[redacted]
12	6	71 1/32 x 49 1/8	2G1-CL	25.0	10.0	150.0	[redacted] /sq. ft.	[redacted]

ORDER CONFIRMATION

DATE: May 3, 2006 3:24 PM CDT
Project: 70 Francis Street
PO#: 36304-776

Viracon Order #: S2-459527
Rev #: 01

Glass Type: G-1 Continued

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
13	5	65 3/16 x 32 1/8	2G1-CL-1	15.6	10.0	78.0	[redacted] /sq. ft.	[redacted]
14	5	65 3/16 x 32 1/8	2G1-CR	15.6	10.0	78.0	[redacted] /sq. ft.	[redacted]
15	6	70 1/2 x 49 1/8	2G1-CR-1	25.0	10.0	150.0	[redacted] /sq. ft.	[redacted]
16	6	59 7/16 x 100 1/4	4G1-3	42.5	10.0	255.0	[redacted] /sq. ft.	[redacted]
17	6	58 1/8 x 100 1/4	4G1	42.5	10.0	255.0	[redacted] /sq. ft.	[redacted]
18	12	65 7/16 x 100 1/4	4G1-1	46.8	10.0	561.6	[redacted] /sq. ft.	[redacted]
19	12	64 25/32 x 100 1/4	4G1-2	46.8	10.0	561.6	[redacted] /sq. ft.	[redacted]
20	6	Ext: 50 1/8 x 100 1/4 Int: 50 1/2 x 100 1/4 3/8" Interior to the Right	4G1-C-3	36.8	10.0	220.8	[redacted] /sq. ft.	[redacted]
21	6	Ext: 33 7/8 x 100 1/4 Int: 34 1/4 x 100 1/4 3/8" Interior to the Left	4G1-C-1	25.5	10.0	153.0	[redacted] /sq. ft.	[redacted]
22	6	Ext: 65 7/8 x 100 1/4 Int: 66 1/4 x 100 1/4 3/8" Interior to the Right	4G1-C-2	48.2	10.0	289.2	[redacted] /sq. ft.	[redacted]
23	12	65 7/16 x 23 3/8	G1-E-1	11.0	10.0	132.0	[redacted] /sq. ft.	[redacted]
24	12	64 25/32 x 23 3/8	G1-E-2	11.0	10.0	132.0	[redacted] /sq. ft.	[redacted]
25	6	Ext: 50 1/8 x 23 3/8 Int: 50 1/2 x 23 3/8 3/8" Interior to the Right	G1-E-C	8.7	10.0	60.0	[redacted] /sq. ft.	[redacted]
26	6	65 3/16 x 23 3/8	G1-E-CL	11.0	10.0	66.0	[redacted] /sq. ft.	[redacted]
27	6	65 3/16 x 23 3/8	G1-E-CR	11.0	10.0	66.0	[redacted] /sq. ft.	[redacted]
28	6	Ext: 59 13/32 x 100 1/4 Int: 59 25/32 x 100 1/4 3/8" Interior to the Left	4G1-CL-2	42.5	10.0	255.0	[redacted] /sq. ft.	[redacted]
29	6	65 3/16 x 100 1/4	4G1-CL-3	46.8	10.0	280.8	[redacted] /sq. ft.	[redacted]
30	6	Ext: 59 13/32 x 100 1/4 Int: 59 25/32 x 100 1/4 3/8" Interior to the Right	4G1-CR-2	42.5	10.0	255.0	[redacted] /sq. ft.	[redacted]
31	6	57 1/4 x 100 1/4	4G1-CL-1	41.1	10.0	246.6	[redacted] /sq. ft.	[redacted]
32	6	57 1/4 x 100 1/4	4G1-CR-1	41.1	10.0	246.6	[redacted] /sq. ft.	[redacted]
33	6	65 3/16 x 100 1/4	4G1-CR-3	46.8	10.0	280.8	[redacted] /sq. ft.	[redacted]
34	2	58 5/32 x 23 9/16	G1-CR-2	10.0	10.0	20.0	[redacted] /sq. ft.	[redacted]
35	2	70 1/2 x 23 9/16	G1-CR-1	12.0	10.0	24.0	[redacted] /sq. ft.	[redacted]
36	1	71 1/32 x 23 9/16	G1-CL	12.0	10.0	12.0	[redacted] /sq. ft.	[redacted]
37	1	Ext: 59 13/32 x 23 9/16 Int: 59 25/32 x 23 9/16 3/8" Interior to the Left	G1-CL-1	10.0	10.0	10.0	[redacted] /sq. ft.	[redacted]
38	1	57 3/16 x 49 1/8	2G1-CR-2	20.1	10.0	20.1	[redacted] /sq. ft.	[redacted]
	714	**Total for Glass Type G-1**						

ORDER CONFIRMATION

DATE: May 3, 2006 3:24 PM CDT
Project: 70 Francis Street
PO#: 36304-776

Viracon Order #: S2-459527
Rev #: 01

Glass Type: G-2 Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
Silkscreen: screen 5023, V1086 SIM SANDBLAST #2
Orientation: No Orientation Required
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
39	45	59 7/16 x 49 1/8	2G2-1	20.8	10.0	936.0	[redacted] /sq. ft.	[redacted]
40	35	58 25/32 x 49 1/8	2G2-2	20.8	10.0	728.0	[redacted] /sq. ft.	[redacted]
41	38	59 7/16 x 48 15/16	2G2-E-1	20.8	10.0	790.4	[redacted] /sq. ft.	[redacted]
42	12	58 25/32 x 48 15/16	2G2-E-2	20.8	10.0	249.6	[redacted] /sq. ft.	[redacted]
43	3	65 23/32 x 48 15/16	2G2-E-CL	22.9	10.0	68.7	[redacted] /sq. ft.	[redacted]
44	3	74 3/8 x 48 15/16	2G2-E-CR	26.4	10.0	79.2	[redacted] /sq. ft.	[redacted]
45	12	59 7/16 x 74 11/16	3G2-1	31.7	10.0	380.4	[redacted] /sq. ft.	[redacted]
46	9	58 25/32 x 74 11/16	3G2-2	31.7	10.0	285.3	[redacted] /sq. ft.	[redacted]
47	5	69 19/32 x 74 11/16	3G2-CR	36.9	10.0	184.5	[redacted] /sq. ft.	[redacted]
48	2	74 3/8 x 74 11/16	3G2-CR-1	40.1	10.0	80.2	[redacted] /sq. ft.	[redacted]
49	2	65 23/32 x 74 11/16	3G2-CL-1	34.8	10.0	69.6	[redacted] /sq. ft.	[redacted]
50	5	65 7/8 x 74 11/16	3G2-CL	34.8	10.0	174.0	[redacted] /sq. ft.	[redacted]
51	16	58 25/32 x 23 9/16	G2	10.0	10.0	160.0	[redacted] /sq. ft.	[redacted]
52	19	59 7/16 x 23 9/16	G2-1	10.0	10.0	190.0	[redacted] /sq. ft.	[redacted]
53	3	69 19/32 x 23 9/16	G2-CR	11.7	10.0	35.1	[redacted] /sq. ft.	[redacted]
54	3	65 7/8 x 23 9/16	G2-CL	11.0	10.0	33.0	[redacted] /sq. ft.	[redacted]
55	6	69 19/32 x 49 1/8	2G2-CR	24.3	10.0	145.8	[redacted] /sq. ft.	[redacted]
56	6	65 7/8 x 49 1/8	2G2-CL	22.9	10.0	137.4	[redacted] /sq. ft.	[redacted]
57	5	65 23/32 x 23 9/16	G2-CL-1	11.0	10.0	55.0	[redacted] /sq. ft.	[redacted]
58	7	59 7/16 x 23 3/8	G2-E-1	10.0	10.0	70.0	[redacted] /sq. ft.	[redacted]
59	9	58 25/32 x 23 3/8	G2-E-2	10.0	10.0	90.0	[redacted] /sq. ft.	[redacted]
60	2	69 19/32 x 23 3/8	G2-E-CR	11.7	10.0	23.4	[redacted] /sq. ft.	[redacted]
61	5	74 3/8 x 23 9/16	G2-CR-1	12.7	10.0	63.5	[redacted] /sq. ft.	[redacted]
62	2	65 7/8 x 23 3/8	G2-E-CL	11.0	10.0	22.0	[redacted] /sq. ft.	[redacted]
63	4	74 3/8 x 49 1/8	2G2-CR-1	26.4	10.0	105.6	[redacted] /sq. ft.	[redacted]
64	4	65 23/32 x 49 1/8	2G2-CL-1	22.9	10.0	91.6	[redacted] /sq. ft.	[redacted]
65	1	69 19/32 x 48 15/16	2G2-E-CR-1	24.3	10.0	24.3	[redacted] /sq. ft.	[redacted]
66	1	65 7/8 x 48 15/16	2G2-E-CL-1	22.9	10.0	22.9	[redacted] /sq. ft.	[redacted]
	264	**Total for Glass Type G-2**						

ORDER CONFIRMATION

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Viracon Order #: S2-459527
Rev #: 01

Glass Type: G-2 Partial Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
Silkscreen: screen 5023, V1086 SIM SANDBLAST #2
Orientation: See Sketch Attached for silkscreen orientation.
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.
- Offset units will have Beveled-Standard fill.

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
67	10	59 7/16 x 49 1/8 Drawing Number 63670-sketch1 Rev. 0	2G12-1	20.8	10.0	208.0	[redacted] /sq. ft.	[redacted]
68	9	58 25/32 x 74 11/16 Drawing Number 63670-sketch6 Rev. 0	3G122	31.7	10.0	285.3	[redacted] /sq. ft.	[redacted]
69	6	65 23/32 x 74 11/16 Drawing Number 63670-sketch6 Rev. 0	3G122-CL-1	34.8	10.0	208.8	[redacted] /sq. ft.	[redacted]
70	6	74 3/8 x 74 11/16 Drawing Number 63670-sketch6 Rev. 0	3G122-CR	40.1	10.0	240.6	[redacted] /sq. ft.	[redacted]
71	6	Ext: 26 7/8 x 100 1/4 Int: 27 1/4 x 100 1/4 3/8" Interior to the Right Drawing Number 63670-sketch7 Rev. 0	4G1121-CL	19.8	10.0	118.8	[redacted] /sq. ft.	[redacted]
72	6	Ext: 26 7/8 x 100 1/4 Int: 27 1/4 x 100 1/4 3/8" Interior to the Left Drawing Number 63670-sketch7 Rev. 0	4G1121-CR	19.8	10.0	118.8	[redacted] /sq. ft.	[redacted]
73	5	58 25/32 x 49 1/8 Drawing Number 63670-sketch1 Rev. 0	2G12-2	20.8	10.0	104.0	[redacted] /sq. ft.	[redacted]
74	2	65 7/8 x 49 1/8 Drawing Number 63670-sketch1 Rev. 0	2G12-CL	22.9	10.0	45.8	[redacted] /sq. ft.	[redacted]
75	2	69 19/32 x 49 1/8 Drawing Number 63670-sketch1 Rev. 0	2G12-CR	24.3	10.0	48.6	[redacted] /sq. ft.	[redacted]
76	1	65 23/32 x 49 1/8 Drawing Number 63670-sketch1 Rev. 0	2G12-CL-1	22.9	10.0	22.9	[redacted] /sq. ft.	[redacted]
77	1	74 3/8 x 49 1/8 Drawing Number 63670-sketch1 Rev. 0	2G12-CR-1	26.4	10.0	26.4	[redacted] /sq. ft.	[redacted]
78	1	69 19/32 x 74 11/16 Drawing Number 63670-sketch6 Rev. 0	3G122-CR-1	36.9	10.0	36.9	[redacted] /sq. ft.	[redacted]
79	1	65 7/8 x 74 11/16 Drawing Number 63670-sketch6 Rev. 0	3G122-CL	34.8	10.0	34.8	[redacted] /sq. ft.	[redacted]

ORDER CONFIRMATION

DATE: May 3, 2006 3:24 PM CDT
Project: 70 Francis Street
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Glass Type: G-2 Partial Continued

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
	56	**Total for Glass Type G-2 Partial**						

Glass Type: G-3 Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
Silkscreen: screen 5066, V1086 SIM SANDBLAST #2
Orientation: See Sketch Attached for silkscreen orientation.
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.
- Offset units will have Beveled-Standard fill.

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
80	281	59 7/16 x 23 9/16 Drawing Number 63670-5066 Rev. 0	G3-1	10.0	10.0	2,810.0	[redacted] /sq. ft.	[redacted]
81	39	58 25/32 x 23 9/16 Drawing Number 63670-5066 Rev. 0	G3-2	10.0	10.0	390.0	[redacted] /sq. ft.	[redacted]
82	5	70 1/2 x 23 9/16 Drawing Number 63670-5066 Rev. 0	G3-CR-1	12.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
83	60	59 7/16 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-1	10.0	10.0	600.0	[redacted] /sq. ft.	[redacted]
84	23	58 25/32 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-2	10.0	10.0	230.0	[redacted] /sq. ft.	[redacted]
85	20	59 7/16 x 49 1/8 Drawing Number 63670-5066 Rev. 0	2G3-1	20.8	10.0	416.0	[redacted] /sq. ft.	[redacted]
86	18	58 25/32 x 49 1/8 Drawing Number 63670-5066 Rev. 0	2G3-2	20.8	10.0	374.4	[redacted] /sq. ft.	[redacted]
87	9	59 7/16 x 32 1/8 Drawing Number 63670-5066 Rev. 0	2G3-3	14.2	10.0	127.8	[redacted] /sq. ft.	[redacted]
88	8	58 25/32 x 32 1/8 Drawing Number 63670-5066 Rev. 0	2G3-4	14.2	10.0	113.6	[redacted] /sq. ft.	[redacted]
89	5	Ext: 59 13/32 x 49 1/8 Int: 59 25/32 x 49 1/8 3/8" Interior to the Left Drawing Number 63670-5066 Rev. 0	2G3-CL-1	20.8	10.0	104.0	[redacted] /sq. ft.	[redacted]

ORDER CONFIRMATION

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Glass Type: G-3 Continued

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
90	6	58 5/32 x 49 1/8 Drawing Number 63670-5066 Rev. 0	2G3-CR-1	20.8	10.0	124.8	[redacted] /sq. ft.	[redacted]
91	3	58 5/32 x 32 1/8 Drawing Number 63670-5066 Rev. 0	2G3-CR-2	14.2	10.0	42.6	[redacted] /sq. ft.	[redacted]
92	5	71 1/32 x 23 9/16 Drawing Number 63670-5066 Rev. 0	G3-CL	12.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
93	6	58 1/8 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-3	10.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
94	6	Ext: 33 7/8 x 23 3/8 Int: 34 1/4 x 23 3/8 3/8" Interior to the Left Drawing Number 63670-5066 Rev. 0	G3-E-C-1	6.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
95	6	Ext: 65 7/8 x 23 3/8 Int: 66 1/4 x 23 3/8 3/8" Interior to the Right Drawing Number 63670-5066 Rev. 0	G3-E-C-2	11.3	10.0	67.8	[redacted] /sq. ft.	[redacted]
96	6	Ext: 59 13/32 x 23 3/8 Int: 59 25/32 x 23 3/8 3/8" Interior to the Left Drawing Number 63670-5066 Rev. 0	G3-E-CL	10.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
97	5	Ext: 59 13/32 x 23 3/8 Int: 59 25/32 x 23 3/8 3/8" Interior to the Left Drawing Number 63670-5066 Rev. 0	G3-E-CL-1	10.0	10.0	50.0	[redacted] /sq. ft.	[redacted]
98	6	57 1/4 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-CL-2	9.7	10.0	60.0	[redacted] /sq. ft.	[redacted]
99	6	57 1/4 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-CR-1	9.7	10.0	60.0	[redacted] /sq. ft.	[redacted]
100	6	Ext: 59 13/32 x 23 3/8 Int: 59 25/32 x 23 3/8 3/8" Interior to the Right Drawing Number 63670-5066 Rev. 0	G3-E-CR	10.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
101	6	58 5/32 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-CR-2	10.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
102	2	58 5/32 x 23 9/16 Drawing Number 63670-5066 Rev. 0	G3-CR	10.0	10.0	20.0	[redacted] /sq. ft.	[redacted]
103	1	Ext: 59 13/32 x 23 9/16 Int: 59 25/32 x 23 9/16 3/8" Interior to the Left Drawing Number 63670-5066 Rev. 0	G3-CL-1	10.0	10.0	10.0	[redacted] /sq. ft.	[redacted]
104	1	70 1/2 x 23 3/8 Drawing Number 63670-5066 Rev. 0	G3-E-CR-3	12.0	10.0	12.0	[redacted] /sq. ft.	[redacted]
105	1	59 25/32 x 32 1/8 Drawing Number 63670-5066 Rev. 0	2G3-CL-2	14.2	10.0	14.2	[redacted] /sq. ft.	[redacted]
	540	**Total for Glass Type G-3**						

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Glass Type: G-3 Partial Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
Silkscreen: screen 5066, V1086 SIM SANDBLAST #2
Orientation: See Sketch Attached for silkscreen orientation.
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.
- Offset units will have Beveled-Standard fill.

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
106	28	59 7/16 x 49 1/8 Drawing Number 63670-sketch3 Rev. 0	2G13-1	20.8	10.0	582.4	[redacted] /sq. ft.	[redacted]
107	15	58 25/32 x 49 1/8 Drawing Number 63670-sketch3 Rev. 0	2G13-2	20.8	10.0	312.0	[redacted] /sq. ft.	[redacted]
108	2	Ext: 59 13/32 x 49 1/8 Int: 59 25/32 x 49 1/8 3/8" Interior to the Left Drawing Number 63670-sketch3 Rev. 0	2G13-CL	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]
109	2	58 5/32 x 49 1/8 Drawing Number 63670-sketch3 Rev. 0	2G13-CR	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]
	47	**Total for Glass Type G-3 Partial**						

Glass Type: G-4 Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened
Silkscreen: screen 3058, V1086 SIM SANDBLAST #3
Orientation: No Orientation Required

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.
- Offset units will have Beveled-Standard fill.

ORDER CONFIRMATION

DATE: May 3, 2006 3:24 PM CDT
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Viracon Order #: S2-459527
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Glass Type: G-4 Continued

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
110	188	59 7/16 x 23 9/16	G4-1	10.0	10.0	1,880.0	[redacted] /sq. ft.	[redacted]
111	340	58 25/32 x 23 9/16	G4-2	10.0	10.0	3,400.0	[redacted] /sq. ft.	[redacted]
112	3	70 1/2 x 23 9/16	G4-CR-1	12.0	10.0	36.0	[redacted] /sq. ft.	[redacted]
113	6	59 7/16 x 23 3/8	G4-CE-1	10.0	10.0	60.0	[redacted] /sq. ft.	[redacted]
114	12	57 27/32 x 23 9/16	G4-CL	9.7	10.0	120.0	[redacted] /sq. ft.	[redacted]
115	8	Ext: 58 3/4 x 23 9/16 Int: 59 1/8 x 23 9/16 3/8" Interior to the Left	G4-CL-2	10.0	10.0	80.0	[redacted] /sq. ft.	[redacted]
116	12	57 3/16 x 23 9/16	G4-CR-2	9.7	10.0	120.0	[redacted] /sq. ft.	[redacted]
117	8	58 25/32 x 23 3/8	G4-E-2	10.0	10.0	80.0	[redacted] /sq. ft.	[redacted]
118	32	59 7/16 x 23 3/8	G4-E-1	10.0	10.0	320.0	[redacted] /sq. ft.	[redacted]
119	2	58 25/32 x 32 1/8	2G4-2	14.2	10.0	28.4	[redacted] /sq. ft.	[redacted]
120	4	59 7/16 x 32 1/8	2G4-3	14.2	10.0	56.8	[redacted] /sq. ft.	[redacted]
121	1	Ext: 59 13/32 x 32 1/8 Int: 59 25/32 x 32 1/8 3/8" Interior to the Left	2G4-CL	14.2	10.0	14.2	[redacted] /sq. ft.	[redacted]
122	1	Ext: 59 13/32 x 23 3/8 Int: 59 25/32 x 23 3/8 3/8" Interior to the Left	G4-E-CL	10.0	10.0	10.0	[redacted] /sq. ft.	[redacted]
123	1	71 1/32 x 23 9/16	G4-CL-1	12.0	10.0	12.0	[redacted] /sq. ft.	[redacted]
124	1	71 1/32 x 23 3/8	G4-E-CL-1	12.0	10.0	12.0	[redacted] /sq. ft.	[redacted]
125	1	59 7/16 x 49 1/8	2G4-1	20.8	10.0	20.8	[redacted] /sq. ft.	[redacted]
127	1	69 3/16 x 49 1/8	2G4-CL-1	24.3	10.0	24.3	[redacted] /sq. ft.	[redacted]
	621	**Total for Glass Type G-4**						

Glass Type: G-4 Partial Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened
Silkscreen: screen 3058, V1086 SIM SANDBLAST #3
Orientation: See Sketch Attached for silkscreen orientation.

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.

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Glass Type: G-4 Partial Continued

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
126	1	58 25/32 x 49 1/8 Drawing Number 63670-sketch5 Rev. 0	2G14	20.8	10.0	20.8	[redacted] /sq. ft.	[redacted]
	1	**Total for Glass Type G-4 Partial**						

Glass Type: G-3/4 Silkscreen

1" (0.99" avg.) VE1-2M Insulating Glass HS/HS

1/4" Clear, heat strengthened
VE-2M #2, edge deletion
Silkscreen: screen 5066, V1086 SIM SANDBLAST #2
Orientation: See Sketch Attached for silkscreen orientation.
1/2" airspace - stainless steel
Sightline: 13/16", Dow 982 silicone (Gray)
1/4" Clear, heat strengthened
Silkscreen: screen 3058, V1086 SIM SANDBLAST #3
Orientation: See Sketch Attached for silkscreen orientation.

Glazing method: 2 sided vertical - structural

Comments:
- High Volume Qualification: 1300 sq. ft.
- Offset units will have Beveled-Standard fill.

Line	Qty	Dimensions In Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
128	20	59 7/16 x 49 1/8 Drawing Number 63670-sketch2 Rev. 0	2G34-1	20.8	10.0	416.0	[redacted] /sq. ft.	[redacted]
129	13	58 25/32 x 49 1/8 Drawing Number 63670-sketch2 Rev. 0	2G34-2	20.8	10.0	270.4	[redacted] /sq. ft.	[redacted]
130	1	65 1/4 x 49 1/8 Drawing Number 63670-sketch2 Rev. 0	2G34-CR-2	22.9	10.0	22.9	[redacted] /sq. ft.	[redacted]
131	12	59 7/16 x 32 1/8 Drawing Number 63670-sketch8 Rev. 0	2G34-3	14.2	10.0	170.4	[redacted] /sq. ft.	[redacted]
132	6	58 25/32 x 32 1/8 Drawing Number 63670-sketch8 Rev. 0	2G34-4	14.2	10.0	85.2	[redacted] /sq. ft.	[redacted]
133	3	Ext: 59 13/32 x 32 1/8 Int: 59 25/32 x 32 1/8 3/8" Interior to the Left Drawing Number 63670-sketch8 Rev. 0	2G34-CL-2	14.2	10.0	42.6	[redacted] /sq. ft.	[redacted]
134	2	58 5/32 x 49 1/8 Drawing Number 63670-sketch2 Rev. 0	2G34-CR-1	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]
135	2	59 7/16 x 49 1/8 Drawing Number 63670-sketch4 Rev. 0	2G43-1	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]

ORDER CONFIRMATION

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Project: 70 Francis Street
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Viracon Order #: S2-459527
Rev #: 01

Glass Type: G-3/4 Continued

Line	Qty	Dimensions in Inches B x L x R x T	Tag	Area Each	Area Min	Area Total	Price (USD)	Extended Price
136	2	58 25/32 x 49 1/8 Drawing Number 63670-sketch4 Rev. 0	2G43-2	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]
137	2	Ext: 59 13/32 x 49 1/8 Int: 59 25/32 x 49 1/8 3/8" Interior to the Left Drawing Number 63670-sketch4 Rev. 0	2G43-CL	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]
138	1	59 7/16 x 32 1/8 Drawing Number 63670-sketch9 Rev. 0	2G43-3	14.2	10.0	14.2	[redacted] /sq. ft.	[redacted]
139	4	58 25/32 x 32 1/8 Drawing Number 63670-sketch9 Rev. 0	2G43-4	14.2	10.0	56.8	[redacted] /sq. ft.	[redacted]
140	2	58 5/32 x 32 1/8 Drawing Number 63670-sketch9 Rev. 0	2G43-CR	14.2	10.0	28.4	[redacted] /sq. ft.	[redacted]
141	2	Ext: 59 13/32 x 49 1/8 Int: 59 25/32 x 49 1/8 3/8" Interior to the Left Drawing Number 63670-sketch2 Rev. 0	2G43-CL-1	20.8	10.0	41.6	[redacted] /sq. ft.	[redacted]
	72	**Total for Glass Type G-3/4**						

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