Revised Thesis Proposal

February 7, 2014

Silverado Senior Living
Brookfield, WI

SILVERADO
AT HOME • SENIOR LIVING • HOSPICE

BUILDERS Hunzinger SINCE 1907

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EXECUTIVE SUMMARY

This proposal outlines potential opportunities to accelerate the schedule, reduce costs, or increase building performance and quality for Silverado Senior Living. Silverado is an approximately 45,000 SF assisted living facility located in Brookfield, WI. Technical information was researched during the fall 2013 semester and used to determine multiple analyses that could benefit the owner. These evaluations will be performed over the course of the spring 2014 semester and are listed below:

Analysis 1: Re-sequencing of the Project Schedule

Hunzinger poured the slab on grade during the winter months in order to reach the firm September 2013 deadline. This resulted in higher costs associated with that process as well as longer pouring durations. Re-sequencing the project schedule could avoid these costs by postponing slab placement until March, but would require the remaining work to be completed more quickly. In order to make up lost time, multiple solutions are needed in addition to working overtime or increasing crew sizes. Analysis 3 and 4 explores these possibilities. Ultimately this evaluation will determine if the savings from the advantages of pouring the concrete in March are worth pursuing.

Analysis 2: Installation of Rooftop Solar Panels

Silverado utilizes wood trusses to support the roofing system, and because of the large amount of open rooftop area, this analysis will focus on the installation of solar panels. The deadline for substantial completion is strict, so a schedule will be developed that will account for this work without missing the intended completion date. This study will account for any cost and schedule impacts on other trades as well as the solar PV system's contribution to a potential LEED certification.

Analysis 3: Schedule Acceleration through SIPS

The facility contains 50 sleeping units which are broken up into three different layouts. Because of the repetitive design of these rooms, SIPS could significantly reduce the time needed for the MEP rough-in for the sleeping units. This evaluation will determine the magnitude of time saved by implementing this method and costs associated with the reduction in schedule.

Analysis 4: Prefabrication of the Interior Wood Panels (Critical Industry Issue)

The interior wall panels are already shop fabricated, so this study will explore incorporating the in-wall plumbing rough-in into the fabrication process. The relatively open site can provide a location to assemble these components, and could ultimately decrease installation time. This analysis will determine the savings associated with the reduction in schedule versus the additional costs required to fabricate the panels.

TABLE OF CONTENTS

Building Introduction

Silverado Senior Living, shown in Figure 1, is a high-end assisted living facility located in Brookfield, WI, next to several single family homes located to the East and West, and a church to the South. With a focus on memory care, this roughly 45,000 square foot building will ultimately house up to 90 residents in 50 separate sleeping units. Total cost for this one story project totaled about $10 million, and construction began in September of 2012 and was completed one year later in September 2013. Hunzinger Construction Co. was general contractor for this facility, and the delivery method was Design-Bid-Build.

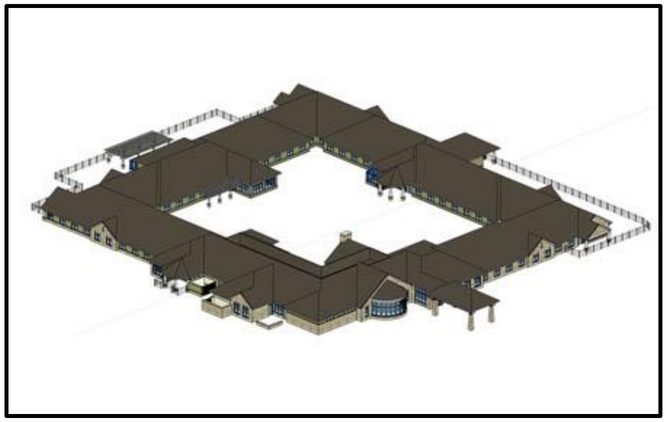


Figure 1 : Silverado Senior Living ***Courtesy of Hunzinger**

The owner of the project, Silverado, owns and operates 31 facilities nationwide, and has established themselves as a premier industry leader in at home, hospice, and memory care for seniors. For this facility, Silverado utilizes a “Back-of-House” layout that separates the employee areas from the spaces inhabited by the residents. It also boasts features such as an enclosed courtyard with a gazebo, walking paths, a solarium, two bistros, and a great room that contributes to their esteemed reputation in senior care. Silverado implements a philosophy called “normalization” into their treatment plan for the residents in addition to traditional methods. This approach focuses on treating patients as they were prior to diagnosis, which can provide them with a renewed sense of purpose. Part of this principle includes techniques such as pet therapy and giving residents jobs around the facility. In order to successfully implement this paradigm, spaces for activities, pleasant eating areas, and high quality interior finishes help residents to live a relatively normal life.

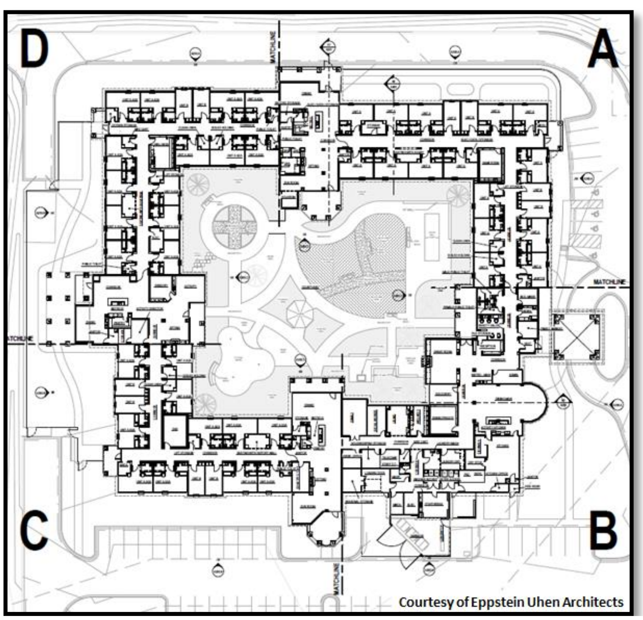


Figure 2 : Overall Floor Plan ***Courtesy of Hunzinger**

The facility is broken into four quadrants which surround an enclosed central courtyard. The main entrance is on the East side of the building and is marked by a canopy so patients can be dropped off and protected from potentially harsh weather conditions. The kitchen, mechanical rooms, and employee areas are located in the Southeast corner of the building in quadrant B. The other three quadrants contain 50 sleeping units which house up to 90 residents. Interior amenities such as the great room, bistros, and activity rooms are located throughout the building.

Analysis 1: Re-sequencing of the Project Schedule

Project Identification

Because of the strict September 2013 deadline stemming from the owner's financial constraints, Hunzinger began construction with the civil and sitework from September of 2012 and completion in mid-November. This meant that unless work was halted from December to early March, the foundations and slab on grade had to be erected using cold weather procedures. Especially in Wisconsin, harsh winter temperatures mean significantly increased installation costs and activity durations because of additional manpower, equipment, and facilities needed to pour concrete in below freezing conditions. Also, erection of the exterior and interior wall panels could not begin until half the SOG was poured. The added risk associated with winter weather pouring increases the chance of an error that could delay any subsequent activities.

Figure 3 – Placement of the SOG ***Courtesy of Hunzinger**

Background Research

In order to mitigate the additional risks and avoid extra expenses from cold weather pouring, the schedule could be re-sequenced so the SOG is poured during normal conditions. Hunzinger self-performed all concrete work and allotted $175,000 for "winter conditions" in addition to the estimated $67,147/month for general conditions costs.

The SOG was originally scheduled to be poured from Jan 9, 2013 to March 1, 2013, which totaled 40 working days in a harsh environment. With consistently cold temperatures, the chance for human error, equipment malfunction, or injury that could result in delays or other penalties is increased. ACI 306 defines cold weather as when the average daily temperature is less than 40^{o}F for three consecutive days, and does not exceed 50^{o}F for more than half of any 24 hour period. To allow for placement of concrete during "cold weather", all snow or ice must be removed so the subgrade can thaw to the proper temperature. Portable heaters will warm up the space inside the temporary enclosure so the ambient air temperature is conducive to pouring and curing of the individual section of the SOG. Then after the concrete is placed, then slab still needs to be protected until it reaches the proper strength. For Silverado, this process included two enclosures, concrete buggies, glycol hoses, a vapor retarder, an accelerating admixture, and heaters to create and maintain proper pouring conditions. Hunzinger rarely pours the slab during the winter, so quality control was a concern because this was not a normal practice.

If the slab was rescheduled to be poured during the spring, then the additional costs and risks could avoided; however, all subsequent trades would be pushed back and would need to make up the lost time with additional crews on-site or over time. Pouring the slab would begin approximately mid-March when the weather falls under normal placement conditions. As a result, work would be postponed roughly three months to accommodate for this modification. Normal pouring conditions would mean quicker and higher quality placement, so this delay could be significantly less than the original three months allotted for this process.

Potential Solutions

- Start pouring the SOG in March to avoid additional expenses and risks associated with cold weather pouring. Using various schedule acceleration techniques the September 2013 substantial completion deadline could still be met.
- Postponing installation of the slab of grade was cost effective, but the schedule acceleration techniques do not save enough time to meet the September deadline.
- Re-sequencing is not feasible for this project to because of the strict deadline and inadequate time for the remaining trades to finish their work. The shortened schedule could result in a lower quality product because of added pressure for trades to complete their work in a shorter amount of time.

Methodology

- Evaluate schedule and cost implications for the sitework completed prior to erecting the foundations.
- Consult with the project team and other industry professionals to find the best solution.
- Continue researching the process of cold weather concreting and alternatives to placing the SOG in winter.
- Examine related case studies with similar circumstances to help determine typical durations for concrete work.
- Calculate durations for normal placement conditions and the related personnel, crew size, material, labor, and equipment expenses.
- Explore means of accelerating pouring the SOG.
- Evaluate impacts on other trades relative to the overall schedule as well as any constructability issues.
- Create a site plan that details the process and illustrates the pouring sequence under normal conditions.
- Perform a cost-benefit analysis that compares the expenses associated with the original placement plan during winter versus installing the slab in the spring.

Expected Outcome

Although three months is a significant amount of time to postpone construction operations, pouring the concrete during normal conditions will ultimately reduce the project cost and avoid additional risks. Three months was allotted for pouring during the winter using two heated enclosures at a time; so the duration and cost can be reduced because placing concrete under normal conditions is faster and less expensive. Hunzinger budgeted $175,000 to account for winter conditions, and general conditions expenses were estimated to be roughly $67,147/month, which means there are potential savings by avoiding the winter months and decreasing the overall project duration. Because of the time lost by postponing the installation date, it is likely that Hunzinger and potentially other trades will need to work additional shifts and weekends in order to make the September 2013 deadline. This will increase the cost traditionally associated to pouring a slab, but these expenses should not outweigh the savings and reduction in the overall project schedule.

Analysis 2: Installation of Rooftop Solar Panels

Problem Identification

Silverado incorporates multiple high-end products through the facility, but the owner did not want to pursue more expensive materials solely because they would increase the overall energy efficiency of the building. For example, premier items such as low flow plumbing fixtures, marble counter tops, LED light fixtures, and exhaust equipment were included because of the high quality interior spaces that are standard for all Silverado facilities. Silverado Senior Living could also take advantage of the spacious rooftop area to install solar panels. Installation of these modules would initially raise costs, but after enough time, the power generated from these devices would eventually pay for themselves. Since the panels would only be placed on South-facing sections of the roof, the photovoltaic cells would almost be invisible because the street leading to the facility is to the west and surrounded by trees. In addition, these panels could contribute to a LEED certification that the project was already on the verge of earning. The challenge with installing the rooftop panels would be integrating the work into the schedule without causing significant delays.

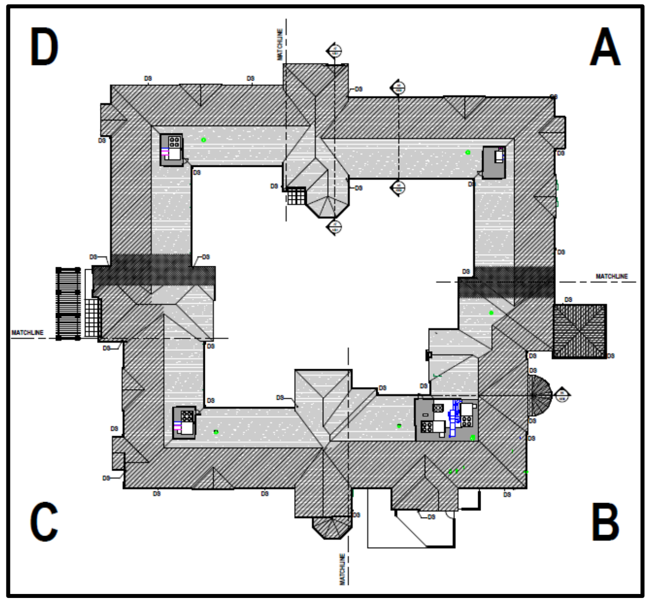


Figure 4 – Overall Roof Plan *Courtesy of Hunzinger

Background Research

The focus of this analysis will explore the cost, quality, LEED contributions, safety issues, and schedule implications of adding the panels to the current design. First, the panels need to be oriented properly to maximize exposure to sunlight. Silverado's layout is a rectangle with roughly equal sides, so this study will determine which southern facing locations are the most cost effective based on their orientation and potential obstructions. A solar study will estimate how much sunlight the panels could potentially absorb during each season, and from those results, the cost savings can be quantified based on product specifications and local utility rates.

In addition to providing a renewable energy source, the panels will also need to be installed quickly to avoid missing the September 2013 substantial completion deadline. This process will affect multiple trades, in particular the asphalt roofing, rough carpentry, mechanical, plumbing, electrical, and other subcontractors who would be working beneath them. To avoid interfering with other work being done, the schedule will need to be re-sequenced to include the installation or the panels, as well as tying them into the current electrical system. Because the installation requires workers to be on the roof, safety is a concern for those tradesmen as well as others who may be working in the spaces below. Silverado is one story tall and contains an attic that is open except for a small catwalk. Uncluttered space in the attic is conducive to hiding equipment and other distribution components from view. Also, because there is excess space in the attic, that will help the installers to avoid clashing with other subcontractors during installation.

Since the panels will located on the roof, there may be design changes that will affect the quantity of asphalt shingles. This potentially could result in material, labor, and equipment savings because decreased surface area that normally would require asphalt shingles. Rooftop solar panels are notorious for causing leaks, so there will be emphasis on quality control to prevent unwanted moisture from seeping into the attic during installation and the life span of the building.

Potential Solutions

- The re-sequenced schedule is able to accommodate the additional work, and the cost benefit analysis shows long term cost savings within a reasonable amount of time. The panels satisfy enough LEED criteria to earn a LEED certification.
- The project still meets the deadline in September, but the extra material expenses, overtime, lack of sunlight, and potential repairs needed for leaks does not make this a profitable endeavor.
- The panels provide enough power to be cost effective within a reasonable amount of time, but the added work, coordination efforts with the other trades, safety issues, and tying the panels into the original electrical system is too complex and slow of a process to complete the project on time. Such a delay would cost the owner more money due to financial constraints, as well as lost revenue from not moving the residents into the facility on time.

Methodology

- Perform cost-benefit analysis comparing the added material, labor, and equipment expenses with the long term savings from reduced utility costs.
- Re-sequence the schedule to account for the installation process. This may require subcontractors to work additional shifts or weekends to ensure the September deadline is met. Enclosing the building will be a significant milestone that may need may need to be altered.
- Interview suppliers as well as related trades to determine how the panels would affect their type of work.
- Determine the appropriate crew personnel, size, and equipment needed on-site to install the panels.

- Find accurate product data and specifications for the solar panels. This will include material costs, installation durations, operational expenses, energy absorption properties, necessary supporting equipment, recommended means of distribution, unit weights, optimal placement location, and other data that could impact project cost, schedule, or performance.
- Redesign the electrical system to tie the panels to the current design and determine the effect on cost, schedule, and quality (Electrical Breadth Located in Appendix A). This includes sizing the conduit and wiring from the solar panels to the main panel boards, and if needed, additional distribution equipment.
- Outline the estimating, submittal, procurement, and installation processes in a manner that is easy to comprehend.
- Calculate the increase in load from the panels on the roof trusses (Structural Breadth Located in Appendix A). From these calculations, the trusses will be redesigned, if needed, to support the extra weight.

Expected Outcome

If the change in aesthetic appearance is acceptable to the owner, then these panels should pay for themselves in the long run. Implementing the system into the current electrical system will initially be more expensive, but analyzing the solar gains and associated savings will show when the owner can expect to see positive returns. Also, since this work is primarily located on the roof, integrating the installation of the panels should be an attainable goal because the installation will occur either in a separate quadrant, or above other trades if there is no conflict with safety regulations.

By providing their own source of renewable power and consequently reducing utility costs, Silverado should be able to earn a LEED certification without chasing points and unnecessarily raising costs. Also, the roof trusses and shear walls may need to be redesigned if the load is excessive, but many buildings typically can support solar panels without major modifications to the structural system.

Analysis 3: Schedule Acceleration through SIPS

Problem Identification

Silverado will ultimately house up to 90 residents in 50 sleeping units which are located in quadrants A, C, and D. These units consist of three different layouts, which also vary slightly depending on whether they facing the interior courtyard or exterior façade. With the strict deadline and potentially shortened schedule due to pouring the slab in March as opposed to January, this process provides a good opportunity to make up lost time.

Background Research

Short Interval Production Schedule (SIPS) is a means of analyzing on specific operation down to each basic step. Durations, which can be down to the minutes, are assigned to each activity and communicated to the corresponding trades. SIPS function similar to an assembly line, with one trade following the other in a fluent and efficient manner. Although typically used for larger scale buildings with repetitive layouts, this strategy could be productive for Silverado because the sleeping units have similar designs.

Implementing SIPS on any project requires early collaboration between all parties in order to develop the most efficient sequence of operations. This requires the project team, subcontractors, material suppliers, safety officers, and anyone who plays a role in the process to be brought onboard as soon as possible so the schedule can adjusted to maximize efficiency. Because multiple trades will be working in a confined space, safety issues are a concern. For example, the mechanical and plumbing contractors may not be familiar with standard safety practices for electrical work. Minimizing the number of different subs in a single space will be critical to maintaining an efficient pace without and injury or other incidents.

In Silverado's case, the mechanical, electrical, plumbing, and fire protection wall and ceiling rough-ins (only ceiling for Plumbing) are scheduled to begin March 6, 2013 and finish on July 17, 2013. This totals a duration of 77 work days not including weekends. Because that duration includes all interior spaces not just the sleeping units, the number is likely to be significantly reduced because most of the MEP intensive areas are located in quadrant B which does not contain any residences. Even with reduced duration for those activities, there is ample room to accelerate the schedule if needed.

Potential Solutions

- If implemented properly, SIPS could significantly reduce the time needed for the interior MEP rough-in. Considering that pouring the slab will potentially be pushed back until March, any means of accelerating a given process needs to be explored. Although it will take more coordination early on, the reduction in schedule will be accompanied by some cost savings from the general conditions.
- If the process is not thoroughly communicated to each party involved, then delays could arise when trades begin to overlap. SIPS may still reduce the schedule, but because Silverado is not the same scale that SIPS is usually implemented on, time lost due to the learning curve and other delays, did not have a chance to be recovered. This would result in postponing the following trades and require additional means of accelerating the schedule in order to meet the September deadline.
- SIPS is not implemented properly but did increase productivity due to relatively small size of Silverado. This process should not be utilized on this project because there is no schedule, cost, or quality benefit to the project.

Methodology

- Divide each process into individual activities and determine appropriate durations.
- Sequence the detailed schedule using the calculated durations and break up each activity by trade and personnel.
- Maximize productivity for each crew based on man power, trade, typical task durations, and amount of work to be completed.
- Research past projects that implemented SIPS, especially ones similar to Silverado. Interview personnel on those projects if possible.
- Determine if the overall project schedule needs to be re-sequenced. If needed, then consider the impact on other trades not directly involved in SIPS and look for other areas to reduce the schedule. Determine if working additional shifts or weekends is needed to accelerate the schedule.
- Perform a cost-benefit analysis to conclude if the reduction in overall schedule justifies the expenses associated with implementing SIPS. Determine if Silverado is large enough to utilize SIPS.

Expected Outcome

Implementing SIPS has significant potential to reduce the time required for ceiling and wall MEP rough-in. If prepared properly and communicated to each trade, then the process should run fluently enough to make up some lost time. Because Silverado is a relatively small building to practice SIPS, time lost from the learning curve needs to minimized or eliminated altogether. This construction method will only be effective if each trade learns to work together to expedite the process. Combining this process with the prefabricated wall panels, re-sequencing of the overall schedule, and possibly working overtime, Silverado could be completed by the September deadline even if the slab on grade was poured three months later. In turn, savings from winter conditions expenses and general conditions would compensate for any additional expenses stemming from SIPS.

Analysis 4: Prefabrication of the Interior Wood Wall Panels (Critical Industry Issue)

Problem Identification

The superstructure of Silverado is composed of shop fabricated, wood shear walls as well as a roof truss system. These are assembled, delivered to the site, and set into location with a 160 ton crane. With a relatively open jobsite, there is potential to accelerate the schedule by adding the plumbing rough-in to the fabrication of the interior structural panels. With added coordination during the schematic and design phases, Hunzinger could take advantage of the open space to assemble these on site.

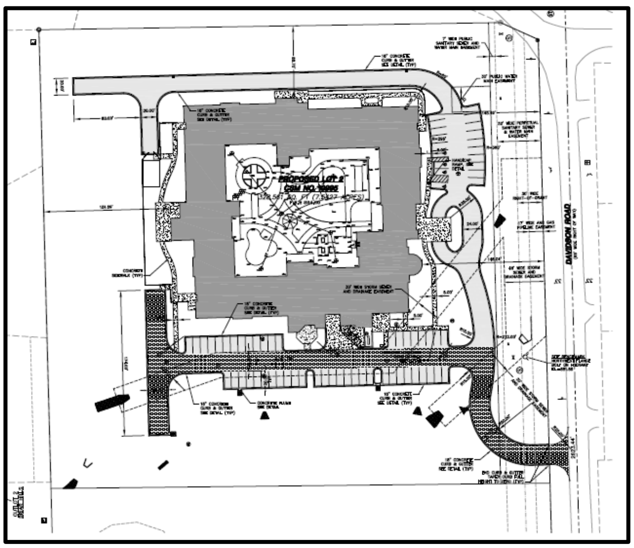


Figure 5 – Project Site *Courtesy of Hunzinger

Background Research

Prefabrication has become an increasingly popular means of reducing installation time on a variety of different types of projects. By collaborating with the involved trades early in the preconstruction phase, the project team can work with the subcontractors to design components that are preassembled on or offsite, and then are ready to be installed once they arrive at the jobsite. This process typically raises initial costs stemming from providing a location for fabrication, transportation expenses, larger hoisting equipment, additional safety measures, and a more time intensive design procedure. Because of these added expenses, this method is frequently used on larger projects with short and strict deadlines for substantial completion.

The plumbing rough-in and insulation phase for Silverado is scheduled to take 35 work days from March 26 to July 19. With earlier involvement of the structural and plumbing engineers and corresponding subcontractors, the total duration could be shortened if the plumbing rough-in located in the interior wall panels was assembled prior to erecting the walls. A location on the west side of the property could be allocated for this process, which would provide a more controlled atmosphere for the tradesman to construct each panel. This increases the overall quality of the components because assembly takes place in a controlled environment as opposed to working around and protecting existing work. Because the work is done in a separate location, safety risks are minimized by avoiding other construction operations taking place on the job site.

Silverado has a firm September deadline, and if pouring the slab is postponed until March to avoid cold weather placement conditions, then prefabricating the interior structural panels could be a means of making up time. An important factor of making this process a success is determining how long the assembly process of each panel takes. This will help determine how the onsite fabrication will need to begin. Because this will occur during the winter months, a temporary enclosure will be needed to protect the components as they are built. The panels will arrive on site with the rough carpentry already completed and ready for the plumber to do begin his rough-in work, so it is important that an accurate estimate of an average panel assembly is calculated. If carried out properly, then once each panel is completed, it can be installed shortly thereafter, which then frees up space inside the enclosure to assemble the next component.

Quality control is critical in this process because the plumbing rough-in will need to align with any under slab or above ceiling piping. Because the plumbing will already be roughed before the panels are set, the in-wall components may obstruct the nailing process. Installation locations will need to be verified so they do not interfere with setting the panels in place.

Potential Solutions

- Prefabrication of the interior wall panels is cost effective and results in the desired reduction in installation time.
- Expenses are higher than anticipated due to unforeseen issues and ends up over budget. Installation time is decreased enough to meet the September deadline, but the additional cost up front is too high to be considered a “cost effective” solution.
- Prefabrication is too costly and will not produce the desired reduction in installation time. Issues with quality cause delays and require additional funds to remedy installation errors.

Methodology

- Determine when the involved parties need to be brought onboard to properly design, procure, assemble, and eventually install the interior structural panels.
- Calculate assembly and installation time requirements based on productivity rates provided by industry professionals.
- Create a project schedule that implements prefabrication of the wall panels and determine if overtime will be needed.
- Assign an onsite location for assembly and determine the proper size needed to create a fluent assembly process. Also, determine additional expenses to procure, construct, maintain, dismantle, and haul off site once finished.
- Analyze case studies that implement prefabricated components and are a similar type of building.

- Consult with structural and plumbing professionals to discuss the feasibility of prefabrication the structural panels with the in-wall rough-in. Obtain realistic assembly times for the plumber to complete the rough-in for an average panel.
- Obtain installation durations and costs for the original plumbing rough-in and panel installation process to use in performing a cost-benefit analysis of the two methods.
- Research means of protecting existing work as well as potential impacts on other trades work. In particular, examine how the plumbing rough-in affects installation of the other engineering systems within the panels.

Expected Outcome

Onsite prefabrication of the wall panels will initially raise costs because of the additional coordination efforts and assembly costs associated with the process, but should accelerate the project schedule. Because of the potentially postponed date for pouring the slab on grade, the savings and decreased risk of avoiding cold weather placement conditions will prove sufficient enough to justify prefabrication of the panels. If this is not the case, this analysis will show what issues need to be resolved in order for the project to be successful.

Analysis Weight Matrix

Analysis Weight Matrix					
Description	**Critical Issue Research**	**Value Engineering**	**Constructability Review**	**Schedule Acceleration**	**Total**
Re-sequencing of the Project Schedule	0%	10%	5%	10%	25%
Installation of Rooftop Solar Panels	0%	15%	15%	0%	30%
Schedule Acceleration through SIPS	0%	0%	10%	10%	20%
Prefabrication of Interior Structural Panels	15%	0%	5%	5%	25%
Total	15%	25%	35%	25%	100%

Table 1 – Analysis Weight Matrix

Conclusions

Once each technical analysis has been completed, the feasibility, quality, safety, cost, schedule, and adherence to the owner's needs will be determined for each area. The primary objective is to avoid the additional expenses associated with cold weather placement of concrete, and each of these topics directly or indirectly have an effect on that outcome. Re-sequencing the project schedule postpones installation of the slab until March, so the new schedule will need to make up for that time. Installing solar panels will not accelerate the schedule, but since most of that work will take place on the roof, most other activities should not be negatively impacted. This analysis will determine potential modifications to the trusses because of the increased rooftop load, as well as the contribution to a LEED certification and potential savings from the power generated from them. Schedule acceleration through SIPS for the 50 sleeping units is one of the means of revising a portion of schedule. Because the work involves the ceiling and wall rough-in of the MEP systems, this analysis is influenced by both the installation of the solar modules as well as prefabrication of the interior wall panels. The critical industry research issue for this project will explore the benefits of onsite prefabrication of the interior wood wall panels with the in-wall plumbing rough-in. Each of the three analyses, which can be implemented in conjunction with each other, has the potential to either generate savings or accelerate the schedule as needed in order to meet the September 2013 deadline for substantial completion.

Appendix A

Breadth Topics

Structural Breadth

This breadth will focus on the design and performance implications of installing rooftop solar panels. Because of the increased load on the roof trusses and loadbearing shear walls, calculations are needed to determine if the original structural design is capable of handling the added weight. If this evaluation shows that the roof trusses are inadequate, then stronger trusses and potentially wall panels must be utilized. The costs and schedule implications will vary based on how much larger or stronger the structural members need to be. The goal of this breadth will ultimately determine the impact the solar panels have on cost, schedule, quality, and constructability of modifying the original design.

Deliverables:

- Analysis of current structural system and load bearing capacity of the roof trusses
- Structural analysis based on additional load from the solar panels and potential modifications needed to support the extra weight
- If changes are needed, a cost analysis to between the old and new systems will be performed
- Based the results, a conclusion will be made on if the installing solar panels is cost effective from a structural perspective

Electrical Breadth

This breadth will explore what efforts are needed in order to synchronize the solar panels with the current electrical system. Additional equipment will be needed in order to recirculate the generated power back into the building and distribute it back into the utility grid. This also may require resizing of current electrical equipment in order to accommodate the additional load. Because Silverado will then supply a portion of their own power to run the facility, utility costs will be lower. Eventually, the panels should pay for themselves, and this breadth will quantify those savings and provide a timeframe for when the owner can expect to break even. Silverado is also already close to earning a LEED certification, so this evaluation will also conclude what contribution can be expected by installing rooftop solar panels.

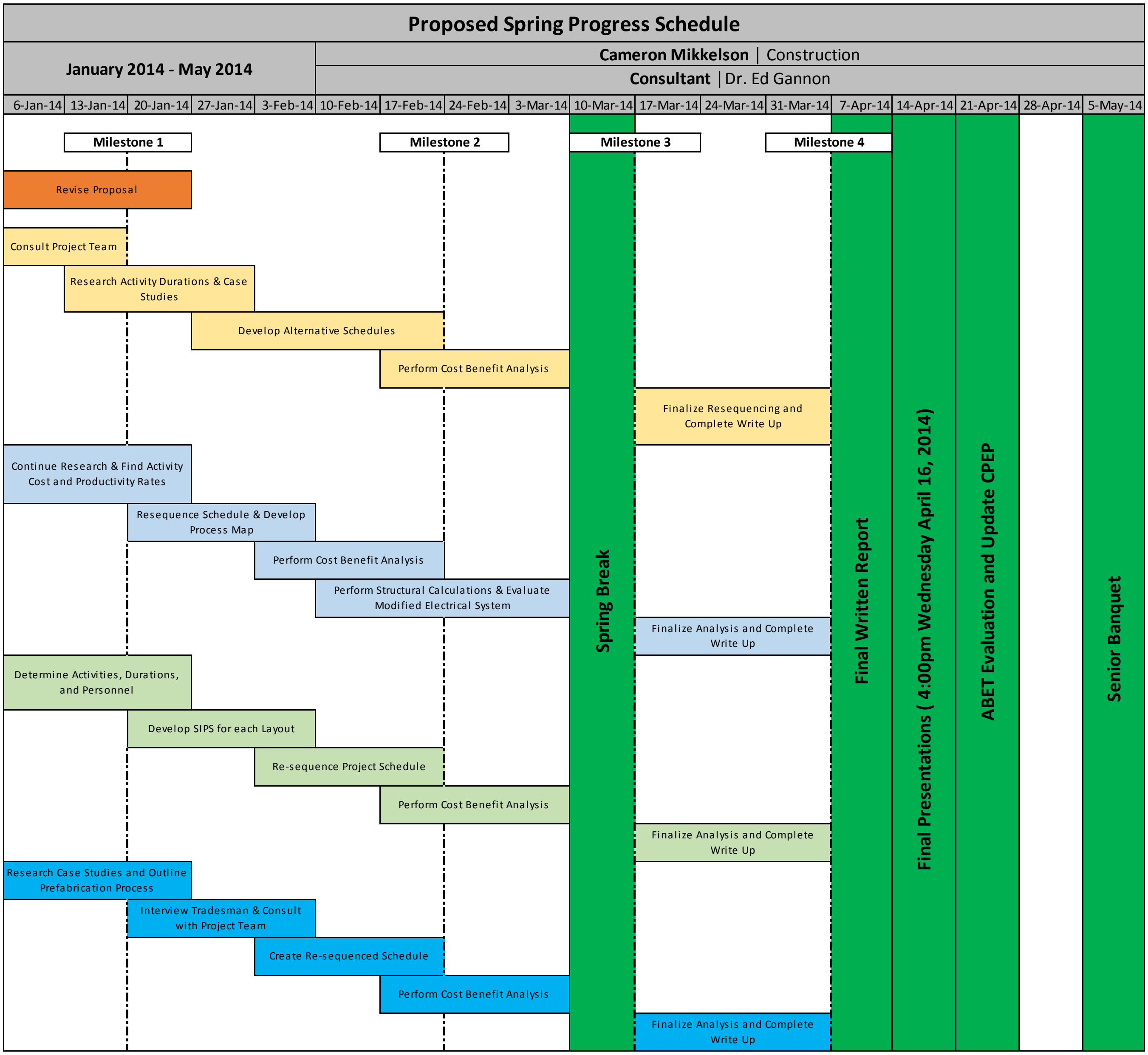
Deliverables:

- Solar panel locations and sizing of conduit and wiring needed for the system
- Expected payback period for the solar panels based on solar and shading analyses

- LEED analysis for Silverado and potential points earned from the solar power generated
- Cost analysis to determine the energy savings versus costs from utilizing solar panels
- Conclusion on if the panels are a worthwhile endeavor based cost of the system, performance, schedule impacts, and LEED contributions

Appendix B

Thesis Progress Schedule



Analysis Key	
(yellow)	Re-sequencing of Project Schedule
(grey-blue)	Installation of Solar Panels, Structural, Electrical Breadths
(light green)	Sleeping Unit SIPS
(blue)	Prefabrication of Interior Structural Panels

Milestones	
1	Preliminary Research 90% Complete. Begin Re-Sequencing of Project Schedule.
2	Performing Cost Benefit Analyses and Selecting Final Solutions.
3	Analysis 95% Complete. Ready to Begin Final Write-Up.
4	Write-Up Complete. Prepare and Practice Presentation