Architectural Engineering 2012 Senior Thesis

Technical Assignment 3

Reston Station Phase 1 Garage | Reston, VA

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Executive Summary

Technical Assignment 3 focuses on the challenges related to value engineering and schedule acceleration that the Reston Station Phase 1 Garage project team are facing. An evaluation of the implementation of LEED efforts and a review of some topics discussed at this year's PACE Roundtable are also included in the report. Finally, some possible issues are highlighted as they relate to the successful completion of the garage.

Even though the Phase 1 Garage project is not seeking formal LEED certification, the design and construction of the project shows clear effort in adhering to some sustainable practices. Specifications for the project cite 12 different LEED credits from the 2009 edition of the program as benchmarks for incorporating sustainability awareness. The project has not accumulated enough points to qualify for LEED certification but if the building owner was willing to dedicate more funds and effort to the cause of sustainability they could theoretically accumulate enough points to gain a silver rating.

The schedule for the Phase 1 Garage project is significantly delayed due to design and resource allocation. The garage foundations had to be redesigned after future intentions were finalized for the above ground commercial and residential structures creating a domino effect through the design process of the entire concrete structure. The additional future threat to the schedule is the document approval and response procedures. With two additional reviewing parties, the entire process is subject to work flow complexities that will also result in delays.

Value engineering efforts are still in the review process as of November 2012 and they prove to be a challenge for the owner of the project due to conflicting goals of both low cost and high quality. Comstock Partners is trying to save costs any way possible but does not want to sacrifice high quality finishes for their savings. The proposed value engineering solutions can be broken down into two main categories known by the project team as "scalpel" and "patch" solutions. The patch items involve replacing items with less expensive alternatives while the scalpel options delete high end items altogether.

This year's Partnership for Achieving Construction Excellence (PACE) roundtable highlighted a few key topics that could be a great benefit to the Reston project. Two sessions in particular discussed the benefits of collaboration and integration on construction projects. Conversations in these groups revolved around questions like what environments best foster integrated processes and how can the level of collaboration be measured in these project teams?

The final section of this technical report reviews several key issues to consider with the Reston Station Phase 1 project. Design team collaboration is needed in order to minimize further delay to the construction schedule. Finish trades must be properly sequenced in the remaining areas of the garage in order to make up the accumulated negative float in the project schedule. The value engineering actions for the plaza level must be finalized in the near future to continue work and protect the owner's interests. Finally, mechanical systems that are currently being installed will likely be removed in the early stages of the next phase of construction due to design team conflicts. These are the issues that will likely be revisited in the proposal portion of this capstone project for areas of in depth analysis.

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Sustainability and LEED Evaluation

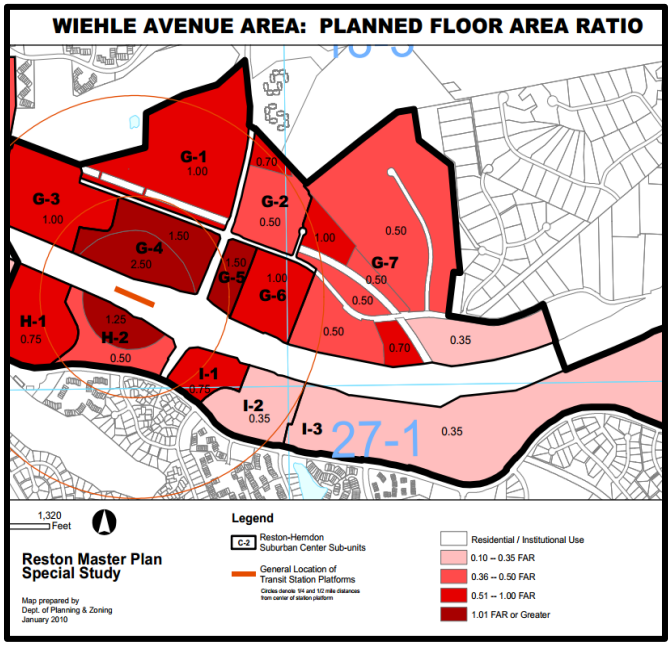
The owners of the Reston Station Garage decided not to pursue LEED certification due to the added costs and practicality. Even though certification is not formally being sought, the project specifications list 12 credits from the LEED 2009 rating system that are mandatory for the construction of the garage. In addition to these credits, there are several features in the design of the garage that would entitle the project to additional LEED points. A full project checklist of the planned, unplanned, and unsought points and credit opportunities are available in Appendix A.

The project was done this way, without formal certification, so that if the above grade structures are all LEED certified in the future, Comstock Partners will be able to claim that the entire development was built with sustainability in mind. Due to the nature of the underground concrete structure there are certain points that are not obtainable and this is also a major factor in the decision to be green certified. Comstock, like many other owners, are aware that only some credits make sense for their facility and aren't willing to make certain efforts simply for the formal recognition.

Sustainable Sites

For the US Green Building Council (USGBC), the concept of Sustainable Sites incorporates site selection, community connectivity, and environmental consciousness to reduce the overall burden that a new building project puts on its surrounding environment. The Sustainable Site Credits that are required by the specifications of the garage are: Site Selection, Development Density, Public Transportation Access, and Fuel Efficient Vehicles (credits 1, 2, 4.1 and 4.3). Additional Sustainable Site credits that the Phase 1 Garage qualify for but are not specifically required to complete are: Bicycle Storage, Parking Capacity, and Maximize Open Space (credits 4.2, 4.4, and 5.2).

Figure 1: Reston Master Plan FAR Values



The Development Density credit that the Phase 1 Garage qualifies for requires that the site be "previously developed and be in a community with a minimum density of 60,000 square feet per acre net" (LEED 2009 for New Construction and Major Renovations). The requirement for 60,000 square feet of development per acre is equivalent to a Floor Area Ratio (FAR) of 1.38. The Reston Master Plan designates the area around the Reston Station development to be a FAR value of 2.5, well above the 1.38 minimum; this can be seen in sub unit G-4 in Figure 1. The site was also previously developed as a parking lot for commuters to use the public transit bus

system; therefore, Reston Station Phase 1 Garage can redeem this 5 point credit.

Even though project specifications only require the Alternative Transportation credits 4.1 and 4.3, Reston Station actually qualifies for all 4 credits in this section. Public transportation access (credit 4.1) has options for proximity to rail stations, bus stops, and rideshares all of which are integrated parts of the Garage project. Bicycle Storage (credit 4.2) is achieved with the 150 bicycle spaces provided on the G2 level of the garage along with a male and female changing room. The Fuel Efficient Vehicles and Parking Capacity (credit 4.3) requirements were met by reserving a certain portion of spaces for highly efficient vehicles and high occupancy vehicles.

The only credits that are unachievable for the Sustainable Site category are Brownfield Redevelopment and the Protect or Restore Habitat credits. Brownfield redevelopment is simply not possible on this project because the original site is not considered a brownfield. The protection or restoration of the surrounding habitat is also not possible because several roadways will be developed in the near future around the site. The Sustainable Sites category is the most beneficial for the garage project overall as it contributes almost two-thirds of the reportable points from the 2009 LEED rating scale for the Phase 1 Garage Project.

Materials & Resources

The USGBC incorporates the materials and resources section of the rating system as a way to encourage recycling materials, using sustainable materials, and reduce waste destined for landfill. The only credits that are possible to achieve on the project are also the only ones required by the project specifications. These are the Construction Waste Management, Recycled Content, and Regional Materials credits. The construction waste was diverted from landfill and into recycling plants at a small added cost to the general conditions of the project. The recycled content requirement is almost entirely covered by the use of fly ash in the concrete mix designs which minimizes the amount of cement needed in concrete batches. Finally, since concrete is mixed on site in two batch plants, all aggregates and admixtures are transported by relatively local facilities (within 500 miles).

There are a significant amount of credits that cannot be attained by this project due to the fact that Reston Station Phase 1 Garage is new construction. The other requirements of the materials and resources category include building reuse of walls, floors, roofs, and non-structural elements. There is also a credit available for using materials from the old structures of a renovation project. In addition to these, there are credits available to using certified wood and rapidly renewable materials both of which are not used on the phase 1 garage project.

Indoor Environmental Quality

Indoor Environmental Quality refers to the indoor air quality of the building and the overall level of habitability. In some ways since the garage is a transient space where occupants are not meant to spend any appreciable amount of time inside at once, the project is disadvantaged when it comes to indoor environment quality. Two credits were required by the project specifications for low emitting adhesives and paint coatings. Due to the underground

nature of the project and the limited circulation of air during construction the project team hired an industrial hygienist to monitor certain air quality parameters and installed temporary fans and humidification equipment as necessary. These efforts qualified the project for the IAQ management plan credits for both during construction and prior to occupancy.

Due to the large system of air intake and exhaust fans credits like outdoor air delivery monitoring and increased ventilation would require only limited additional efforts. The credits that the project is unable to achieve are largely missed because of a lacking of day lighting and thermal control. While the underground spaces are properly ventilated, the conditioning of such a large space is limited to a few localized units. Also, due to the underground nature of the structure natural daylight is unable to reach a vast majority of the floor area.

Other Categories

The LEED categories not mentioned or required by the project specifications are Water Efficiency, Energy and Atmosphere, Innovation and Design Process, and Regional Priority Credits. The Water Efficiency category is particularly challenging for the Phase 1 Garage Project because there are no inherent points from the projects original design. The water use reduction credit is the only possible water savings can come from fixture selection of the toilets, urinals, and faucets in the bathroom facilities of the garage. Certain credits are unachievable in the water efficiency category because of design decisions like irrigation for the planters in the plaza area.

In terms of Energy and Atmosphere, Reston Station Phase 1 Garage takes advantage of enhanced commissioning through a 3rd party independent commissioning agent. The project also saves approximately 20% in energy requirements due to the utilization of LED lights in many areas of the garage instead of fluorescent fixtures. Many of the alternative energy opportunities cannot be achieved due to the limitations of the garage being underground and only a fraction of a large development project.

The final two categories of the LEED 2009 for New Construction and Major Renovation project checklist are for Innovations and Design Process and Regional Priority Credits. The Innovation and Design Process category is essentially a petition system for getting credits for unofficial sustainable efforts. There is also one point for having a LEED accredited professional on the project team. The General Contractor does not have a team member with their certification at this time but these may be the easy points the project could use to achieve a LEED certified minimum level of points. Regional Priority credits are decided by local chapters of USGBC and can be applied for and approved through those local organizations.

Summary of LEED Evaluation

Upon tabulation of all the sustainable efforts on the Reston Station Garage project, several interesting results appeared. A summary of the point totals for each category and overall can be seen in figure 2. In this checklist, a number value in the "Y" column indicates that the requirements for this credit are complete or in progress and only need formal documentation and approval to be granted to the project. A number in the "?" column indicates that this credit is

possible for the project with added resources assigned to its pursuit. This could range from small modifications in design to an additional investment towards professional services provided by others. An entry in the "N" column indicates that this credit is either unattainable due to project conditions or it is simply not in the interest of the owner to make the level of investment needed to incorporate that piece of sustainability into the project.

By totaling the categories and credits the result is a hypothetical total of 38 points by counting only credits with fulfilled requirements or is in progress towards completion. The minimum number of credits for LEED certification is 40, which may explain why Comstock in not seeking LEED certification. Only being 2 points shy however, could easily be remedied with a staff assignment to include a LEED AP on the project team or submission for an Innovation in Design credit. If all of the possible credits were attempted, a total of 63 points would be attainable making the garage a LEED Gold rated building.

Figure 2: Summary of LEED Points

Point Category Summary				
Y	?	N	LEED Category	Possible Points
19	5	2	Sustainable Sites	26
0	4	6	Water Efficiency	10
7	3	25	Energy and Atmosphere	35
6	0	8	Materials and Resources	14
6	3	6	Indoor Environmental Quality	15
0	6	0	Innovation and Design Process	6
0	4	0	Regional Priority Credits	4
38	**25**	**47**	**Total**	**110**

Schedule Acceleration Scenarios

Critical Path Analysis

Due to the octant zoning of the construction sequence and the continued delays, a somewhat unique consequence has emerged of having two concurrent critical paths. These paths run through the east and west sides of the garage culminating in issues with waterproofing and finish activities. Many of the delays are a result from foundation redesigns early on in the project when the owners decided on the final schematic designs of the above grade buildings.

On the west side, the concrete progress is at a -21 day float as of early November 2013. This will translate to delays in the following critical path activities which are hot fluid waterproofing, paver installation, and bus vault elevators. This effects the rest of the schedule because unless multiple crews are brought in, finish trades must first complete construction in the west side before moving to the east.

On the East side of the project, an even longer lag of -25 days is being experienced in the concrete construction progress. The East side of the project is in some ways more critical to the project because inspections and substantial completion activities are dependent on the completion of the construction tasks being done in these areas. The east side critical path from concrete forward continues through the removal of reshores from levels G5 to G1, the installation of exhaust fans, and final closeout.

To compound the issue, a peripheral project consisting of roadwork adjacent to the garage has been significantly delayed due to failed coordination with utility companies and slowed utility relocations. The current lag in the schedule for this project is -48 days. Some of this delay is a result of one earthwork crew being available during times when two or more concurrent activities were scheduled. The site will have accessibility issues if the roadwork cannot continue and the overall development won't be able to open at the scheduled time if this work isn't complete.

Schedule Risks

The greatest risk to the schedule is continued lag in design. The schedule delay on the design of the garage began early in construction when the owner made a final decision about the size of the above ground buildings for future development on the site. To a certain degree the entire design of the garage had to be re-examined starting with the size of the foundation footings. This was essential to ensuring building loads are properly accounted for but it set design up for schedule failure at some point when construction trades ultimately caught up to design progress.

A second concern for the schedule is the added scrutiny from a separate set of architects and engineers who are working on the above ground apartment and hotel. Hickok Cole and Structura have been selected to design the hotel and apartment buildings that use the top floors of the garage for private parking and lobby space. The hotel and apartment buildings will be built above garage octants A, C, and E and so all submittals and RFIs in these areas must now be

reviewed by this second architect and structural engineer. While their approval is not required by contract in order to build the garage space, the two firms are included in the submittal and RFI review process which causes a delay is document processing. Typically, if these non-garage design firms had concerns, they forwarded comments to the garage architect (Davis, Carter, and Scott) and then DCS makes appropriate changes or edits to the formal documents. This has already slowed progress for the approval of several façade areas and has the potential to create serious logistical headaches with design approvals on an already delayed project. The document review process for octants A, C, and E is outlined in figure 3.

Figure 3: Typical Process of an RFI or Submittal in Octants A, C, and E

Acceleration Options

As with any construction project the two main options for schedule acceleration are working smarter or harder. The project team prefers to work "smarter" by adjusting trade sequence and optimizing work team productivity. Working "harder" involves overtime which means higher costs for the project. The project team is trying to avoid this solution but at least some overtime construction might be necessary in order to deliver the garage project to the owner in time for the date of substantial completion.

Several strategies have been developed to try to approach the schedule acceleration in a smart manner. The most promising of these is grouping several finish and MEP trades together in the schedule that would not previously have shared the same space. The floors were divided into 6 zones as opposed to their original 2 zones (east and west) to take better advantage of spaces immediately after postshores are removed. A completion schedule was also developed to better hone in on exactly when and how trades need to progress to meet the date of substantial completion. Holding subcontractors to this more detailed and refined schedule should encourage the acceleration of the trades.

The last resort solution for the delays on the Reston Station Garage Project is to extend working hours for subcontractors. This is a last ditch effort for acceleration due to the added costs of overtime for the work force. Garage progress should be able to catch up to the original schedule by utilizing only 10 hour workdays and Saturday work if extended work hours are required at all.

Value Engineering Efforts

The value engineering efforts on the Reston Station Project can be broken down into two categories. The first known by the project team as "patch" solutions replace certain materials and systems with more cost effective solutions. A more severe tactic to save costs involves complete deletion of products and systems from the building which is known by the team as "scalpel" solutions. As of early November 2012 there are a total of $1.7 million worth of value engineering options on the table, most of which occur on the plaza level do to the lack of flexibility in the materials used within the underground garage space and the just-in-time design progress.

The process is very challenging to Comstock, the private sector owner, because they are expecting both a good quality product as well as a cost that does not exceed their original budget. The owner's goals in this situation are conflicting and a balance needs to be found in order to reduce rising costs and delays in the design.

"Patch" Value Engineering

The "patch" option for the value engineering effort is the process of altering a product or design detail to create a lower cost solution. There are currently 7 of these options being considered with a possible savings of approximately $500,000. Many of these solutions are relatively minor and result in modest savings.

The solution with the greatest benefit is replacing all the stainless steel ornamental metals to painted galvanized steel. These changes occur at the stair railings, headache bars, bike racks, bollards, and cable rails. A net savings of over $250,000 is gained from this change which is half of the possible "patch" solution value in just one change. The negative side to this alternative is the significant effect that a change like this would have on the aesthetic appearance of these metals.

Other solutions for cost savings on the plaza level focus on finish items like pavers and bollards. There are two separate cost saving solutions for the pavers including changing the color and size of the paver units. The solution to saving costs on the bollards is to change all the lighted bollards to being just standard steel bollards. These changes are pretty straightforward and not devastating to the design on the plaza but their cost benefits are relatively low compared to other VE options. A full list of possible "patch" solutions is available in figure 4.

Figure 4: Summary of Patch Solutions

Patch Value Engineering Solutions		
Current Design	**VE Alternative Option**	**Approximate Cost Savings**
Lighted Bollards	Steel Bollards	$ 5,000.00
Single Post Cable Rails	Side Mounted Cable Rails	$ 20,000.00
Origional Structural Soil	Alternate Mixture of 20% Stalite, 30% Sand, 30% Compost, 20% Topsoil	$ 20,000.00
6"x12" Paver size	4"x8" paver size	$ 18,000.00
Paver Color: Super Black	Paver Color: Charcoal	$ 15,000.00
Cubic Stone Stairs	Cladding	$ 90,000.00
Stainless Steel on Plaza	Galvanized Steel on Plaza	$ 270,000.00

"Scalpel" Value Engineering

Scalpel value engineering options refer to the practice of completely deleting a product or system from the project. This is a particularly challenging concept to the owner team because even though big savings can be realized through this practice, the overall quality of the project is sacrificed at a much higher level. An example of this value engineering option is the proposition to delete the entire irrigation system and depend on maintenance personnel to hand water plaza vegetation. This option alone saves the project almost $90,000 but doesn't factor in the continued operation costs required without an automated system. Altogether, the "scalpel" options could result in a net savings of $1.2 Million. This is an attractive option for the owner due to the large savings that can be realized, but the owner is still not willing to make drastic concessions for the savings.

The most financially beneficial deletions are found in the lighting fixture redesign packages. There are 3 separate options developed by the project team ranging from approximately $150,000 to $400,000 in savings. The common base solution for the lighting redesign options is to delete lighting fixtures embedded in the pavers. The more advanced solutions extend alternate products to other plaza fixtures.

Some of the deletion options sacrifice more than just appearance. Two of the possible scalpel solutions include deleting 50% of the plaza bicycle racks and 20% of the plantings. This extends the concessions from just looks to sustainability features. These changes could impact LEED efforts as well as diminish the environmental appeal of the plaza level. This may not be a concern for the owner because they do not wish to certify the garage space as a LEED building at this time. A full list of the possible deletion options for the value engineering efforts is available in figure 5.

Figure 5: Summary of Scalpel Solutions

Scalpel Value Engineering Solutions	
Deleted System or Project	**Estimated Savings**
Detectable Pavers	$ 120,000.00
Lights in Handrails	$ 20,000.00
Lighting Option #1	$ 130,000.00
Lighting Option #2	$ 350,000.00
Lighting Option #3	$ 400,000.00
Platypus Tree Anchoring System	$ 5,000.00
20% Overall Planting Quantity	$ 20,000.00
Stone Stairs and Curbs	$ 200,000.00
Irrigation System	$ 100,000.00
50% of Bike Racks	$ 20,000.00

Critical Industry Issues

The Partnership for Achieving Construction Excellence (PACE) holds a conference every year in early November to discuss current industry issues and contemplate how to best address the present industry environment. The 2012 roundtable conference highlighted the three major themes of supply chain, delivery of services, and operations & maintenance. The delivery of services topic is of particular significance to the Reston Station Phase 1 Garage project because the topics covered in these conversations revolved around integration and collaboration for building project teams.

Efficient Use of Integrated Design

This meeting session focused on the questions what is an integrated process and what does one look like on a construction project? The group concluded that at it's core, collaboration and integration can only be achieved when there is a shared purpose for all the individual members. The breakout group went on to discuss some of the barriers to integration on a project and how certain aspects of an integrated process can be implanted regardless of the project delivery method.

An effective mission has three parts: a function, being, and motivation. The structure of these three things in a typical sentence reads like this: "To (function) in a way that (being) so that (motivation)". Developing a mission statement as a team and all team members agreeing to its content creates a common goal and motivation to work together and get to the finish line of any given task. An example of a mission statement for a student's thesis might read something like the following:

> *"To develop a senior capstone project in a way that effectively investigates and critically analyzes several aspects of a construction project so that the knowledge gained fully prepares the student for the professional workplace and a lifelong learning experience."*

On a building project this statement will be much more team oriented and focused on the goals of constructing a successful building project. Each project team with a shared mission will be much more capable of an integrated construction process.

As the industry has shown through its resistance to the Integrated Project Delivery (IPD) method there are many barriers to the implementation of integrated processes when it comes to building design and construction. The biggest road blocks to integration come from a risk management and trust standpoint. There is a significant likelihood on every construction project for things to go wrong. When things do go wrong, many design, construction, and inspections companies are eager to point the figure and any one of the other team members to place blame. The current industry standard of contract management has developed precedence for risk sharing where the contractor generally take a majority of the risk after design is 100% approved. While determining risk ownership is not always straight forward in the traditional system, a new integrated way of sharing risk has not been tried enough to establish steadfast rules and this scares away many participants from possibly taking more risk than they can afford. There were,

however, many key suggestions from the roundtable group in developing a collaborative environment regardless of contract type.

The most important conclusion that the team reached in the investigation of ways to implement integration on a project is that the methods used are completely dependent on the individual project. That being said, techniques like establishing work flow clarity, close proximity, and good information exchange procedures can go a long way to encouraging an integrated environment. Another beneficial practice is for team members to teach other their craft. By allowing others to see how an individual's job is done it allows them to interact with them in a way that best enables that individual to complete their job at a high level of quality.

Measuring Effective Collaboration

The second breakout session in the Delivery of Services topic investigated how collaboration can be measured on a project and what sort of metrics could be used to do this. Discussion began with a summary of the root goals of any project which were to do the project "cheaper, faster, and better". The rest of the time was spent considering how are these things achieved and how one knows when the goals of cheaper, faster, and better has been realized.

Several conclusions were reached in considering the best ways to foster collaboration on a project team. The first and most beneficial contributor to collaboration is leadership by the owner. When the owner leads the efforts to integrate the project team, the chances of successful collaboration increase tremendously. Another method to encouraging collaboration is co-location. A specific note was made in the break out session that co-location does not necessarily ensure collaboration due to the attitudes of individuals and the dynamic of the shared physical environment. The final key ingredient to get collaboration to work on a project is to find the proper timing for teaming. Bringing team members together at the right time is crucial to the success of collaborative efforts. While the "earlier the better" is generally true project leaders must evaluate the stages of development to ensure each team member is being brought on when they are best utilized.

A significant portion of the breakout session was spent determining what specific metrics can be used to measure the amount of collaboration on a project. The first example was presented by Brian Franz who is involved with research of the South Halls Renovation Project at Penn State University. Brian noted that for the South Halls Project, RFI and submittal turnaround time was the chosen method for determining the quality of collaboration. A short RFI turnaround time indicates that the contractor and architect of a project have already communicated about the question and the RFI document is more of a formality to record the exchange of information. The goal of this project was a RFI turnaround time of only 3 days and a submittal review period of a week. This comes with it certain implications of performing to the tests and not the tested behaviors but overall the team was reasonably successful and was able to reveal certain issues with their current process. Other possible metrics that were brought up by participants include the quantity of "good" subcontractors, and enhanced profit margin, quantity of warranty calls after project completion, number of punch list items, and the number of

submittal revisions, to name a few. By utilizing some of these metrics and establishing them as project goals, projects like Reston Station could being to develop collaboration on their teams without a formal IPD contract.

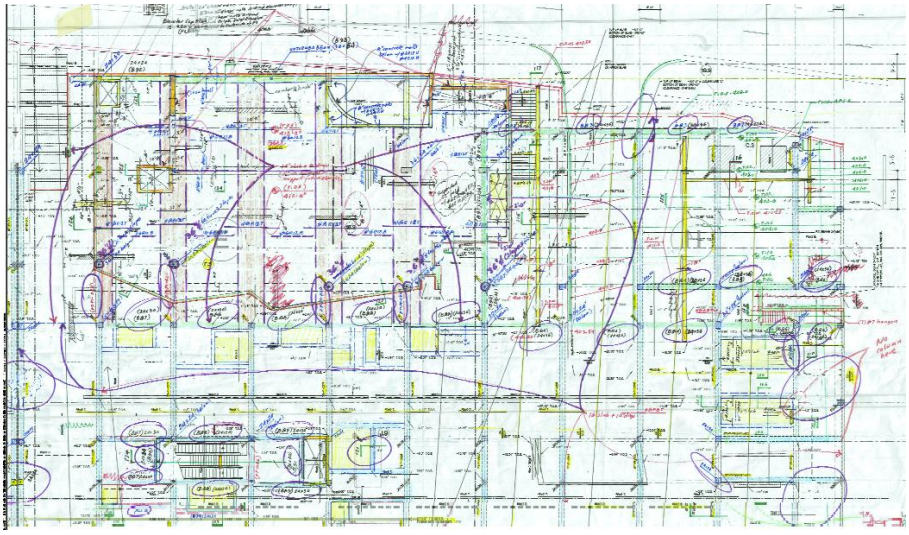
Possible Problem Analysis Options

Design Team Collaboration

Additional design team's review of submittals and RFIs has the potential to create a systematic schedule delay. While the architect and engineer are not required to formally approve shop drawings and respond to RFIs their input is very valuable to future collaboration with the general contractor and their review is a necessary step in the documentation process. Several issues have already arisen from the approval of G2 and G1 level façade materials.

Aside from submittal and RFI review, many drawing coordination issues have also been identified between the 4 design firms sharing design aspects of the G2 through P2 levels. The most frequent issue between different drawings of the same area is the location of floor penetrations for mechanical work. Other issues such as conflicting column shapes, beams locations, and floor elevations also appear throughout updated versions of drawings. The problem is caused by urgency to get drawings to the field as quickly as possible with very little quality control of their content. Even the structural and architectural drawings from the original A/E team on the garage have a significant number of conflicts between them. Figure 6 shows a marked up structural drawing with notes indicating information that is not the same on the architectural drawing of the same area.

Figure 6: Markups on a Structural Drawing



Finish Trade Sequencing

If the project is to be ready for turnover by the date of substantial completion, efficient trade work is a necessity. While the concrete progress is hindered by design, most finish trades are only dependent on the architect's approval of submittals. Crews will need to share areas and strategically take advantage of post shore removals. Smart sequencing will be able to make up the current 25 day lag and hopefully avoid the need for overtime work hours.

Owner Concerns with Value Engineering at Plaza Level

The private entity of the owner team, Comstock, is facing a serious dilemma between saving money and building a high quality garage project. Concerns are focused at the plaza level because it is the architectural highlight for both the end users of the above ground buildings and the general public going to the train in the morning. The cuts offered by Davis amount to a total of over $1 million in savings but Comstock cannot live with many of the aesthetic sacrifices they would need to make. If decisions are not made soon, the process could further delay the schedule and leave the owner with a project that does not meet their expectation in quality, cost, or delivery time.

Mechanical Pipe and Equipment Coordination

Due to the unique relationships between owner, designer, and contractor on this project, it is likely that significant changes will occur to mechanical system designs between the garage and apartment construction. If proper coordination is not done, pipes will likely need to be removed and relocated in the newly finished garage to accommodate the above buildings' needs. Other complications could be present for electrical distribution as well as plumbing locations and sizing. This leads to a higher cost in the next phase of construction and possible core drilling through concrete slabs which is known to be a very costly way of achieving what would be virtually free with proper up front planning.

APPENDIX A

Detailed LEED Scorecard

LEED 2009 for New Construction and Major Renovations

Project Checklist

Reston Station Phase 1 Garage

Y	?	N	d/C				Notes:
19	5	2		**Sustainable Sites**		26	
Y			C	Prereq 1	Construction Activity Pollution Prevention		
1			d	Credit 1	Site Selection	1	Previously developed site, not prime farmland or wetland
5			d	Credit 2	Development Density and Community Connectivity	5	FAR = 2.5 which is greater than required 1.38 OK
		1	d	Credit 3	Brownfield Redevelopment	1	Not a Brownfield Site
6			d	Credit 4.1	Alternative Transportation—Public Transportation Access	6	Bus, Train, and Rideshare integrated
1			d	Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1	150 spaces = 5% garage capacity
3			d	Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3	spaces reserved for fuel efficient cars
2			d	Credit 4.4	Alternative Transportation—Parking Capacity	2	High Ocupancy Vehicle spaces provided
		1	C	Credit 5.1	Site Development—Protect or Restore Habitat	1	additional work onsite doesn't allow for restoration
1			d	Credit 5.2	Site Development—Maximize Open Space	1	plaza qualifies for more than 50% of open site space
	1		d	Credit 6.1	Stormwater Design—Quantity Control	1	
	1		d	Credit 6.2	Stormwater Design—Quality Control	1	
	1		C	Credit 7.1	Heat Island Effect—Non-roof	1	
	1		d	Credit 7.2	Heat Island Effect—Roof	1	
	1		d	Credit 8	Light Pollution Reduction	1	
0	4	6		**Water Efficiency**		10	
Y	?	N					Notes:
Y			d	Prereq 1	Water Use Reduction—20% Reduction		
		4	d	Credit 1	Water Efficient Landscaping	2 to 4	Plaza planters utilize irrigation
					Reduce by 50%	2	
					No Potable Water Use or Irrigation	4	
		2	d	Credit 2	Innovative Wastewater Technologies	2	not a priority
	4		d	Credit 3	Water Use Reduction	2 to 4	some fixtures could be utilized
					Reduce by 30%	2	
					Reduce by 35%	3	
					Reduce by 40%	4	
7	3	25		**Energy and Atmosphere**		35	
Y	?	N					Notes:
Y			C	Prereq 1	Fundamental Commissioning of Building Energy Systems		
Y			d	Prereq 2	Minimum Energy Performance		
Y			d	Prereq 3	Fundamental Refrigerant Management		
5		14	d	Credit 1	Optimize Energy Performance	1 to 19	not a priority
					Improve by 12% for New Buildings or 8% for Existing Building Renovations	1	
					Improve by 14% for New Buildings or 10% for Existing Building Renovations	2	
					Improve by 16% for New Buildings or 12% for Existing Building Renovations	3	
					Improve by 18% for New Buildings or 14% for Existing Building Renovations	4	
				x	Improve by 20% for New Buildings or 16% for Existing Building Renovations	5	
					Improve by 22% for New Buildings or 18% for Existing Building Renovations	6	
					Improve by 24% for New Buildings or 20% for Existing Building Renovations	7	
					Improve by 26% for New Buildings or 22% for Existing Building Renovations	8	
					Improve by 28% for New Buildings or 24% for Existing Building Renovations	9	
					Improve by 30% for New Buildings or 26% for Existing Building Renovations	10	
					Improve by 32% for New Buildings or 28% for Existing Building Renovations	11	
					Improve by 34% for New Buildings or 30% for Existing Building Renovations	12	
					Improve by 36% for New Buildings or 32% for Existing Building Renovations	13	
					Improve by 38% for New Buildings or 34% for Existing Building Renovations	14	
					Improve by 40% for New Buildings or 36% for Existing Building Renovations	15	
					Improve by 42% for New Buildings or 38% for Existing Building Renovations	16	
					Improve by 44% for New Buildings or 40% for Existing Building Renovations	17	
					Improve by 46% for New Buildings or 42% for Existing Building Renovations	18	
					Improve by 48%+ for New Buildings or 44%+ for Existing Building Renovations	19	
		7	d	Credit 2	On-Site Renewable Energy	1 to 7	not a priority
					1% Renewable Energy	1	
					3% Renewable Energy	2	
					5% Renewable Energy	3	
					7% Renewable Energy	4	
					9% Renewable Energy	5	
					11% Renewable Energy	6	
					13% Renewable Energy	7	
2			C	Credit 3	Enhanced Commissioning	2	commissioning services being performed by a 3rd party
		2	d	Credit 4	Enhanced Refrigerant Management	2	not a priority
	3		C	Credit 5	Measurement and Verification	3	could be an option
		2	C	Credit 6	Green Power	2	not a priority

Y	?	N						
6	0	8			**Materials and Resources**		**14**	
Y	?	N						Notes:
Y			d	Prereq 1	Storage and Collection of Recyclables			
		3	c	Credit 11	Building Reuse—Maintain Existing Walls, Floors, and Roof		1 to 3	new construction
						Reuse 55%	1	
						Reuse 75%	2	
						Reuse 95%	3	
		1	c	Credit 12	Building Reuse—Maintain 50% of Interior Non-Structural Elements		1	new construction
2			c	Credit 2	Construction Waste Management		1 to 2	required by specs
						50% Recycled or Salvaged	1	
						x 75% Recycled or Salvaged	2	
		2	c	Credit 3	Materials Reuse		1 to 2	new construction
						Reuse 5%	1	
						Reuse 10%	2	
2			c	Credit 4	Recycled Content		1 to 2	Fly ash in concrete mix design
						10% of Content	1	
						x 20% of Content	2	
2			c	Credit 5	Regional Materials		1 to 2	Local quarries and on site batch plants
						10% of Materials	1	
						x 20% of Materials	2	
		1	c	Credit 6	Rapidly Renewable Materials		1	no repidly renewable products utilized
		1	c	Credit 7	Certified Wood		1	no wood products required on project
6	3	6			**Indoor Environmental Quality**		**15**	
Y	?	N						Notes:
Y			d	Prereq 1	Minimum Indoor Air Quality Performance			
Y			d	Prereq 2	Environmental Tobacco Smoke (ETS) Control			
	1		d	Credit 1	Outdoor Air Delivery Monitoring		1	
	1		d	Credit 2	Increased Ventilation		1	
1			c	Credit 3.1	Construction IAQ Management Plan—During Construction		1	Industrial Hygentist utilized by project team
1			c	Credit 3.2	Construction IAQ Management Plan—Before Occupancy		1	Industrial Hygentist utilized by project team
1			c	Credit 4.1	Low-Emitting Materials—Adhesives and Sealants		1	Required by Specs
1			c	Credit 4.2	Low-Emitting Materials—Paints and Coatings		1	Required by Specs
	1		c	Credit 4.3	Low-Emitting Materials—Flooring Systems		1	
		1	c	Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products		1	
1			d	Credit 5	Indoor Chemical and Pollutant Source Control		1	
1			d	Credit 6.1	Controllability of Systems—Lighting		1	Occupancy Sensors
		1	d	Credit 6.2	Controllability of Systems—Thermal Comfort		1	
		1	d	Credit 7.1	Thermal Comfort—Design		1	
		1	d	Credit 7.2	Thermal Comfort—Verification		1	
		1	d	Credit 8.1	Daylight and Views—Daylight		1	
		1	d	Credit 8.2	Daylight and Views—Views		1	
0	6	0			**Innovation and Design Process**		**6**	
Y	?	N						Notes:
	1		d / c	Credit 11	Innovation in Design: Specific Title		1	
	1		d / c	Credit 12	Innovation in Design: Specific Title		1	
	1		d / c	Credit 13	Innovation in Design: Specific Title		1	
	1		d / c	Credit 14	Innovation in Design: Specific Title		1	
	1		d / c	Credit 15	Innovation in Design: Specific Title		1	
	1		d / c	Credit 2	LEED Accredited Professional		1	No LEED AP on GC Team
0	4	0			**Regional Priority Credits**		**4**	
Y	?	N						Notes:
	1		d / c	Credit 11	Regional Priority: Specific Credit		1	
	1		d / c	Credit 12	Regional Priority: Specific Credit		1	
	1		d / c	Credit 13	Regional Priority: Specific Credit		1	
	1		d / c	Credit 14	Regional Priority: Specific Credit		1	
38	25	47			**Total**		**110**	

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

APPENDIX B

PACE Conference Worksheet

Student Name Jon Fisher

Session #1

Topic: Efficient Use of Integrated Design

Research Ideas:

(1) Incorporating integration regardless of contract type
- → Shared mission statement
- → Barriers to integration
- → integration regardless of delivery method

(2) benefits of integration
- → Brian Franz case studies

Session #2

Topic: Measuring Effective Collaboration

Research Ideas:

(1) What metrics measure collaboration?
- RFIs
- profit margins

(2) Concurrent Engineering
- → designing above ground and below ground simultaneously

Industry Panel: Differentiation in a Down Economy

Research Ideas:

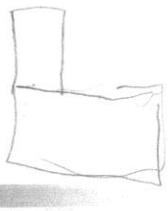
(1) Not Applicable to PACE 2012

(2)

Student Form *Pg. 1*

→ MEP coordination

* start from scratch
- design assist



Industry Member Discussion

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic?

Utilizing integration and IPD

→ design assist contractors

→ concurrent design

→ system coordination between garage and upper building

Suggested Resources:

What industry contacts are needed? Is the information available?

→ post doc researching concurrent design

→ South Halls pilot program
— OPP (Penn State)

→ Brian Franz

Student Form

Pg. 2