Taking Full Advantage of BIM and Mobile Technologies: A $225 Million Renewable Energy Plant Design-Build Project

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SAIC is providing engineering, procurement and construction (EPC) on a $225 million design-build project to create a renewal energy plant in Plainfield, Connecticut. This case study will showcase how we took full advantage of a large number of technologies such as Autodesk® Revit® software, the AutoCAD® Revit® family of suites, and Intergraph® CadWorx® in the office to come up with a state-of-the-art complex industrial design. Next, we pushed the envelope by deploying a complete virtual design and construction (VDC) and mobile technology environment in the field to manage the tight construction schedule. Join members of the Building Information Modeling (BIM) technology team to discuss the workflow of managing Revit® software models and imports and exports of the industrial models and to find out what software (including apps) enabled us to use BIM in the field on our most prestigious and critical design-build project in the organization.

LEARNING OBJECTIVES
At the end of this class, you will be able to:
- Manage workflow for various intelligent models
- Take BIM to the construction site
- Support a true design-build BIM project in the office and in the field
- Put together proper documentation to support the process

ABOUT THE SPEAKERS

Brett Goodchild is the BIM Applications Manager for SAIC Energy, Environment & Infrastructure, LLC. His role spans a unique range of responsibilities from training and support to implementing new, more streamlined workflows and researching new technologies in both hardware and software for design and build solutions. His focus and experience has been with architecture, structures, MEP, ACS, and interiors and is heavily involved in technology planning and development, standards development training and technical support. During his career, Brett has taught the use of Autodesk® applications at several colleges and was a consultant with a Gold PSP Autodesk reseller.

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Joseph Joseph attended the Lebanese American University where he studied Architecture. In 1997, he came to the United States to complete his studies in Architecture as well as complete a two-year degree program specializing in CAD/Technology Management. Joseph has over 16 years of direct industry exposure from Job Captain/Project Architect to Managing Director of Information/CAD/BIM Technologies. He has served as a strategic and tactical partner to many architectural/engineering organizations (50–3000 employees) spearheading CAD/BIM planning, deployment, implementation, and training strategies. In addition, he has taught/supported multiple Autodesk® products at the higher education level. Joseph Joseph joined SAIC early in 2010 as the company’s Managing Director overseeing all BIM/CAD Technologies aspects and focusing on revamping the firms BIM/CAD initiatives from the ground-up, including strategizing, standards, and implementation of BIM in a true design/build environment.

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CASE STUDY INTRODUCTION

PROJECT OVERVIEW

Plainfield Renewable Energy (PRE) project, a $225 million biomass facility in Plainfield, Connecticut financed by Science Applications International Corporation (SAIC) along with Carlyle Energy Mezzanine Opportunities Group and sponsored by Enova Energy Group, has received two awards from Energy Risk and Project Finance. The Plainfield Renewable Energy project won the Deals of the Year award from Energy Risk and the North American Mezzanine Deal of the Year 2011 award from Project Finance.

SAIC is engaged as the engineering, procurement, and construction (EPC) contractor under a fixed-price, date-certain contract for the project, which is being developed by Enova Energy Group. As part of its financing arrangements, SAIC is deferring its fees under the EPC contract to construct the biomass facility. The Plainfield Renewable Energy project will generate 37.5 megawatts (net) of clean energy to power the equivalent of 37,000 homes. The project will consume wood readily available from various sources such as construction and demolition (C&D) debris, recycled wood pallets, and land clearing materials using a unique, proven, and low-risk gasification process.

The Plainfield Renewable Energy project is the only C&D waste-to-power facility to receive renewable energy credits in southern New England. The National Resources Defense Council has endorsed the project and now points to it as the model of good, clean use of waste resources. Additionally, the project will create significant employment opportunities in the region during construction and on a permanent basis for all components of facility operations and maintenance.

"This project is great news for Plainfield, the region, and the state. It will create 400 jobs, bring more than $800,000 per year of tax revenues to the town, and increase the supply of electricity to the region. It represents exactly the type of renewable energy projects that the state should attract,"
~ Town of Plainfield First Selectman Paul Sweet.

The Project’s Strategic Value to SAIC - PRE is a very important ground breaking project for SAIC. It is the largest EPC we have done to date and is the largest equity investment we have ever made, at the same time, is also one of the largest projects that SAIC Constructors has performed.

Success on this project is vital to SAIC for many reasons, with a very large one being the qualification of federal grant monies under Section 16.03 of the American Recovery and Reinvestment Act of 2009 (ARRA). The federal funding accounts for roughly 30% of the project’s funding and if we miss the functional deadline we lose our grant.

All of the risk is not without reward, however. The completion of Plainfield Renewable Energy will open future opportunities on the east coast, become the flagship project for future energy projects as well as potential capital return in three areas.

- Money through EPC
- Return on equity investment
- Money through development fee

Challenges - From the beginning, the Plainfield Renewable Energy project presented a number of challenges that had to be overcome in order to deliver a successful and functional project in the end. Some of these challenges are presented in the form of legalities while others are purely site logistical problems and other yet are due to the involvement of more than 40 contractors and vendors spanning four continents.
PROJECT OVERVIEW - CONTINUED

**Legal** - For starters, the project had a number of permits in place very early in the process. Having these permits in place meant that we have an agreement with the State of Connecticut that we will not make changes to the project that would require a modification to any of the permits. An example of this is we had to adjust the overall height of the building and had to prove to the State the alteration was negligible and would not require permit changes.

The citing and permits mean that we have project milestones for design and there are initiatives that are essentially cast in stone. Meeting these milestones qualifies us to be put into a cue for the regional authority for putting power back into the regional area. If one of the milestones is missed we will lose our position in the cue which would have an impact on the project schedule that significantly raise the risk of missing the project delivery deadline and lose the qualification for the grant money.

**Site Logistics** - The site itself has posed some challenges on this project. Due to the location of the building, we had to make a decision regarding what source was going to be used for cooling water. Typically water in this area would be well water however, the plant would consume far too much water from the community, drive up cost and the supply could not meet the demand. Add to that, well water in that region is typically three times the cost in other regions of the nation. This meant we had to find an alternate solution for cooling water.

The solution was to use river water from the nearby Quinebaug River. This involves purchasing a one acre site about 2.5 miles away from the main building and routing more than 13,000 feet of piping back to the plant. The impact of this choice was the owner had to purchase additional conservation wetland to offset the project’s footprint.

**Communication between Different Countries** - A big challenge we face is the fact that there are over forty vendors spread over four continents. Considering the schedule and all the risks involved on this project, there is no option for a communications breakdown between any of the contractors, the design team and the job site. This has posed many hurdles that range from language barriers, technological differences and varying time zones.

A prime example of these obstacles is the building’s generator. The turbine design was awarded to a company in Poland and was the driving force of the modeling efforts for the space and equipment. That company designed the turbine in Poland but had the gearbox designed and built by their office in Germany. The manufacturing of the turbine was awarded to a company in Brazil whose manufacturing facility for this type of generator was in India where it faces an 18,000km (11,184mile) journey to the port where it will ship to Connecticut.

This single building element required four different nations to communicate in a fashion that would not hold up production or manufacturing. A task that is not easy to achieve when you have to span eleven different time zones. Having these types of trials between our contractors and us leaves very little room for error given that a small mistake in communication, or lost and neglected information could ultimate result in the project losing its budget and funding.
**Bridging Advanced Technologies During Design**

There is a challenge that technology forces us to face. How do we bring teams together when technology forces us to work in silos? The problem this presents is a separation of data communication and flow of information in an area where multiple design teams should be heavily integrated with each other. Plainfield Renewable Energy was no exception to this.

PRE is broken into two parts, building design and industrial design; with the later of the two being the main driving force behind the project’s design. In a scenario like this there cannot be a separation of disciplines; rather they must interact with each other in the form of a unified team. Both teams must be able to access and interact with each and every design model in order to achieve a true integrated project delivery.

The solution to this problem becomes how to structure a project where technology forces team separation in a manner that brings all the design teams together, ultimately bridging the gap between them and making technology work for people not people working for technology.

**BIM Technologies Integration**

Technologies integration is how all the disciplines will work collaboratively and not make decisions in a silo. For Plainfield Energy to successfully bridge the gap, we had to examine the process and understand what applications will be utilized for what building functions. This can be complex to discover given that PRE is both facilities and industrial. Fortunately at SAIC, a good amount of the industrial design is in house and we can assess both the building and process side from our experience.

Once we knew what design & engineering applications will be used, we can then begin to structure how the entire project will be laid out and how to bring everyone together. The list below is some of the aspects were considered for determining the project’s integration.

- What disciplines are involved?
- What design applications will be used?
- What are the file formats?
- What + how many models will there be needed?
- File formats for linking?
- Worksets + Layer structuring?
Involved Disciplines - It’s important to know what disciplines will be involved in the project from the beginning because this will help formulate many things including scope and who you will need to interface with. On the building side of PRE we had Architectural and Structural internal to SAIC with MEP getting subbed out. On the industrial side we have process equipment and piping for specific systems designed internal to SAIC while the complicated gasifier and turbine processes were designed by vendors. All of the supporting process electrical and the conveyor system for the fuel were subbed out.

Design Applications & File Formats - Once we knew who was involved we could then find out what design applications they were going to use. For the building, the architectural and structural would use Autodesk Revit while the building’s MEP system would be done in AutoCAD.

For the industrial portion, we had strongly considered putting it into Revit for better integration, but decided to move forward with CadWorx, which is extensively used by our industrial team at SAIC. Also, the supporting industrial electrical would be done in Revit along with the conveyor system.

At this point we know what applications we will be interfacing with and can then determine what file formats each application uses and is capable of importing or exporting to. This is important to know because it helps us understand what technology roadblocks we may have to address before moving any further. Not all applications are capable of exporting to Revit friendly format, and the quicker we find that out, the quicker we can find a file translation solution.

Model Setup - In its current state, the Plainfield project consists of nearly 32 separate model files that make up roughly 2.5gigs of information. Because of the thorough diligence we took during the integration phase we were able to successfully account for the file size and structure the models in a manner that today, we can open a file across the WAN in less than 4 minutes.

Now that we have uncovered what applications will be used we can now begin setting up the project. We examined the scope and determined the best approach for breaking up the project into individual model files that will minimize wait time for opening and linking and allow for a seamless workflow between all the files. Below is a list of the criteria we consider for model breakouts.
BIM TECHNOLOGIES INTEGRATION – CONTINUED

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Based off of this list, the end result on Plainfield was a series of models that created a model workflow that is easy to follow and understand. For the building models, we broke out the structural and architectural discipline into a single model for each building on site. Each model file respectively housed schedules, details and sheets. The AutoCAD portion of the building models had a separate file for each discipline.

For the industrial side of PRE, we could not break out the models based on the building. We determined that such a breakout would not benefit a more downstream purpose on the construction site. It could possibly limit how they could isolate the different systems and potentially cause more work. We decided that creating a separate model for each system would give us the most control of managing the information in both design and construction phases.

Model Linking – After the model setup was established we needed to determine the best method of bringing the technologies together. Given the complexity of the project, with the amount of equipment and process piping, it is extremely important that all the model files can link together interchangeably. However, with the models setup we can estimate the impact that certain file types will have on each other. Even though programs might share an extension, it might not always be the best choice.

In the case of PRE, both the building and industrial sides were using programs capable of authoring and linking DWG and we could easily manage the burden these files would have on each other so it was determined that was going to be the common format implemented for linking all model files together.

Model Breakdown – With the models in place and know what file format will be used for exchanging information, the models themselves need structuring to account for the file interoperability. Again, gauging that the file sizes would get substantially large and that there were roughly 32 files, this kind of impact has to be accounted for.

In Revit, SAIC as a standard practice sets up a workset for each linked model in the project which allows us to do several things.

- Close out the workset to reduce the amount of loaded geometry in the building models
- Visually isolate any system by filtering the view for it.
BIM TECHNOLOGIES INTEGRATION - CONTINUED

For example, the Revit model for the conveyor system is a roughly 80mb is file size. That is not large in the world of Revit but it contains complex geometry, content that was created in a CAE based program and brought into Revit. Having that level of modeling complexity in a linked model can have significant performance impacts. End-users may experience slow file open times and sporadic model navigations and if they are experiencing those, there is a good chance the model export to DWG will take an extremely long time. Having a workset just for these types of models allows the end-user to mitigate the impact they have by unloading the data from the project in the form of a closed workset.

When linking in DWG based models, we took all the files and xref’ed them into empty blank files. Those base files, as well call them, are the files that get linked into the Revit building models. This approach adds some extra padding to account for the larger file size. It will however, still allow layers to display in Revit and it will show them in the object styles dialog. This means that even though the file is an external reference in AutoCAD, the layers can still be controlled for visibility in Revit.

We also have to account for exporting to DWG from Revit. We don’t want to provide our subs with DWG that are bloated with model information that is not relevant to their needs. We account for this with the use of custom export views that use view templates. View templates are just that, visual templates that can be applied to Revit views that control the graphic display of the views. They control line weights, element visibility, graphic overrides and many more aspects. The view templates ensure that the export only shows the model geometry and annotative components they need to see. Having the view templates in place allow us to export to DWG to meet very specific needs, whether it’s exporting a plan that shows only an enlarged plan of the turbine housing or a 3D model of the gasifier framing. We can simply apply the template and export the view in minutes.

In the CadWorx environment, we have to account for importing the 3D Revit generated DWG files. We manage this by setting up a layering structure that mimic the worksets from Revit. There are layers in place for all the Revit exports that allow the design team to quickly isolate specific part of the building or freeze a layer to reduce the impact a large xref’ed file may have.

In order to provide the Revit teams with the information they require, we created layer filters that can quickly be applied so when a Revit user has a need for a CAD background the CadWorx team can apply the necessary filters and send the file off.

Having worksets, view templates, layers and filters in place has not only reduced the turnaround time for getting background but it has also help eliminate issues that arise when layers or elements have to be turned on or off for exporting. With these types of checks in place, end-users do not have to worry as much about information getting left off a view and having inaccurate prints.
BIM TECHNOLOGIES EXCHANGE

Once the project was setup in a well-structured manner, we could accurately determine a good method for exchanging the models. For Plainfield Renewable Energy we determined that Microsoft SharePoint was going to be the central repository for model exchanges.

We chose SharePoint for a few reasons. It has been around for a long time and can be integrated into many things, for example there are many iPad apps that boast SharePoint integration. Since it has been around there are many companies that use it and employees who can work with it.

In order to avoid the pitfall of working in a vacuum, we need to be exchanging models on a regular basis. We established a model upload frequency that required a weekly upload. Though not real-time or right-time, sharing models on a weekly basis, that were pre-cleaned and prepped allowed us ample time to coordinate with the new modifications and still progress the models and stay ahead of the schedule.

BIM TECHNOLOGIES COLLABORATION

That last part of bridging the gap is having everything well-coordinated. Linking models together has been very beneficial for visual coordination and the utilization of Revit coordination tools, like clash detection and coordination review, are extremely useful and important but there is no guarantee that those tools are being employed by the end-users on a regular basis. These tools are not a replacement for basic engineering principals. We still need to coordinate our models.

For the design aspect of Plainfield, we implemented the use of Autodesk NavisWorks Manage for coordination. We found that the set of coordination tools in NavisWorks greatly enhanced not only how our coordination meetings ran, but the quality of them. The clash detection tool in NavisWorks has been and continues to be vital to the project. With the ability to specify tolerances for clash, and isolate each unique system in problematic areas we can quickly identify spatial problems and discover solutions.

For coordinating effort to be efficient, we asked each design team to export their files to the NWC format on a bi-weekly schedule. This saved time and resources by not having one person responsible for generating all the NWC files and set a timeline on how often a thorough coordination review would take place.

EXPANDING MODEL CAPABILITIES

Because we structured the project very early on, we could focus on a few areas that we identified as potential bottlenecks. Through the project setup, we were able to gauge the model impact on two areas that have historically proven to be pain points.
EXPANDING MODEL CAPABILITIES - CONTINUED

The bid turn around on the Plainfield Biomass Renewable Energy project was very quick. We had very little time to review bids and were not afforded the luxury of trusting the contractors comprehension of the scope, especially that there were many assumptions made on the design regarding the amount of steel, equipment design and instrumentation involved in the processes.

We needed to gauge how to use the models during the design phase to minimize the turnaround time on bid reviews and get contractors under contract as quickly as possible. The whole idea was to not impede on the construction process due to waiting to get 3rd parties under contract and having to build the job around contractors.

Leveraging BIM Technology for Value Engineering - For the amount of process equipment and piping, there is a lot of supporting steel of the areas we identified as a bottleneck in the process was steel bid packages. We knew we would receive multiple bids that would break down tonnage for various steel types differently. What we ended up with was 5 bid packages that broke out rolled steel, built-up steel, wide flange members, tube steel miscellaneous steel shapes and joints each in a different fashion.

- Moment frame East-West, Braced frame North-South - Rolled steel sections with a fixed base
  Tonnage = 460
- Moment frame East-West, Braced frame North-South – Shallow Rolled steel sections with a fixed base
  Tonnage = 930
- Moment frame East-West, Braced frame North-South - Deeper built up steel members with a pinned base
  Tonnage = 709

The cost of the fixed bases vs. the pinned bases had to be considered in the total for the price options. Fixed bases are more expensive, so the tonnage alone was not directly compared. Estimating ran the pricing numbers with input from some fabricators for rolled vs. built up pricing. The rolled sections are some of the largest that are made at the mills and are not readily available always, so delivery schedule was looked at also.

- Braced frame East-West at end walls with a horizontal bracing diaphragm, Braced frame North-South
  Using rolled steel sections with a pinned base
  Tonnage = 500

This option was not selected due to the tonnage being higher and also the coordination of penetrations and the horizontal diaphragm members could have led to a problem since many things were still unknown.

Leveraging BIM Technology for Cost Verification - Given the complexity of the process piping and the amount of fitting and instruments involved (900 instruments and over 1200 valve) and having very little room for error on the project, we needed to extract as much from the piping models as possible. Early in the design process we established a set of modeling requirements that would allow us to do full material take off from the Intergraph® CadWorx® models with the objective of not having to perform any manual quantity take off from the models.

We required that all piping and equipment contractors modeled to a Level of Development 500, which was to include all fittings, valves and instrumentation for every large bore run of pipe. To showcase what our requirements were, we completed several material takeoffs that demonstrated the level of modeling needed along with the amount of information required to successfully extract quantities.

- Specification file
- Quantity
- Length
- Alpha size
- Long description
- Line number
EXPANDING MODEL CAPABILITIES - CONTINUED

Once the contractors understood what the needs were they took over populating the takeoffs and posted them to the project Microsoft® SharePoint site® for our estimators to reference. Having this process in place completely eliminated manual takeoffs of any type form taking place the equipment piping models. A spreadsheet was put into place that would check for updates and compare our takeoffs to theirs and became a huge time saving process.

Leveraging BIM Technology for Fabrication – Another area we wanted to expand on leveraging model capabilities to save on time and budget was the use of a digital model for fabrication. Given the complexity and level we were modeling the process piping models for material takeoff, the next logical step for us was to get those very models into the fabricator’s hands.

We sent the pipe contractors our files in the DWG format that they were able to use for the generation of ISO’s. From our models they were able to create ISO’s and modify them to accurately reflect pipe cut lengths, determine weld numbers, spool numbers and ultimately created their own bill of material.

Having a well-developed model to begin with allowed the pipe contractor a very quick method to generate fabrication sheets, or cut sheets. Because we required that all piping models have all the fittings modeled, the fabricator didn’t have to make assumptions on their bill of materials. Aided by the accurately modeled pipe, in a very short time a bill of material was generated that showed the pipe diameter, the quantity, the end-to-end length (cut length) and what make up fittings were required.
ADVANCED TECHNOLOGY ON THE CONSTRUCTION SITE

The efficiency and effectiveness of the construction process strongly depends on the quality in the flow of information. We set out to advance the flow of data communication between designers, subs and vendors, and the site to enhance a process that historically had the project teams working in a silo with iterations of drawings and ultimately making decisions in a vacuum. By bringing the latest technologies to the construction site we have enabled the project teams to streamline the process and make collaborative decisions in a real-time environment.

IMPLEMENTING VDC

To advance the flow of communication between the project teams and the site, we had to understand what some of the deficiencies in process where. Having a better understanding of areas that are potential bottlenecks for the flow of information allowed us to create a VDC solution that fit the needs of the Plainfield Renewable Energy project.

One area that we found to be problematic was the job site not having access to the BIM models. Without access to the models, the field cannot take full advantage of powerful coordination and visual tools that a VDC workflow offers. Rather than leaving the construction site in the dark, SAIC brought virtual coordination and advanced visualization to the field and in doing so increased and helped streamline the flow of information to and from the field.

VDC Coordination - SAIC took a unique approach to handling onsite coordination. The idea was to empower the key individuals at the construction site, allowing them host coordination meetings where they have access to the latest BIM models. After testing multiple applications, SAIC delivered an interactive and user friendly coordination tool with the implementation of Autodesk® BIM 360 Glue®. We chose this application for its feature set and after very positive feedback about how user friendly it was.

- Cloud Based Collaboration
- Clash Detection
- View Manipulation
- Documentation / Markup abilities

The project team using it found it very easy to navigate the complex models and create views. This program has allowed anyone on site to very quickly isolate problematic areas and virtually navigate the space to make better decisions based on more current information.

Autodesk® BIM 360 Glue® is based on the Autodesk® 360 Cloud environment which allows our superintendent, project engineers, subs and vendors to navigate the Plainfield models without having to
IMPLEMENTING VDC - CONTINUED

maintain expensive hardware. Because the application is cloud based the PRE teams can navigate over 2.5gigs of model files from any location and can do so with no performance loss. What they end up with is model navigation inside of an environment that allows them to isolate the many complex process systems for examination, cut live sections on the fly, create and save views for reference and upload images and documents from any computer on site or on a tablet.

The end result of implementing Autodesk® BIM 360 Glue® are coordination meetings on site that involve all teams interacting with the project in a manner that has increased the level of data communication. Coordination meetings have become very interactive with cutting sections and views on the fly, creating clash reports for various systems in the meetings and creating comments and markups that are stored in the cloud and sent to the necessary individuals for comment. All of this has not only significantly streamlined flow of data but it has greatly enhanced the quality and frequency of communication for the project.

Immersive Technology – Real Time Rendering - Coordination applications can be intimidating to the general staff, owners or individuals who are less technically inclined. Many of them have in-depth feature sets, multiple pallets and toolbars and a complicated interface with graphics that appear very technical. To encourage further interaction with the data without the intimidation that may come from such applications we implemented immersive technology in the construction trailer. We want anyone to be able to navigate the building in a user friendly manner that showcases the project within a real time, immersive environment. After looking at several options we settled on Lumion® by Act-3D®.

Lumion® is a real-time 3D visualization tool that allows an end-user full navigation of a building and its site in an immersive, 3D environment. This application provides the end-user the ability to submerge them into the project’s environment and the end result is that the individual interacting with the model really sees the design come to life in real-time. This application provides real-time rendering of ambient and daylight, shadows, window and particles using High Dynamic Range (HDR) rendering.
IMPLEMENTING VDC - CONTINUED

On Plainfield, we took this a step further with the development of a utility that allows full navigation of the project’s environment by simply using a Microsoft® Xbox® controller. What this has really brought to the job site is a very quick and easy way for the owner or team members to visualize what the end result is going to be and has given them the ability to traverse their project and provide feedback without having to learn complicated software and commands.

Touch Screen Technology - Instead of using traditional plasmas or white boards, we wanted to establish a digital environment that would invite the construction site, in a less intimidating way, to interact with the flow of information. The large touch screen acts as a digital kiosk to access the most current models, drawings and documentation and everything necessary from design through ground breaking.

SAIC also developed a Construction Information Portal (CIP) based on Windows 8 technology that allows access to project information. Coupled with the touchscreen, the CIP creates an interactive access point allowing any member of the project team, including contractors, an interactive source to access the most current information.

WIRELESS TECHNOLOGY

Because of the importance of information flow, IPD and time being of the essence, we decided to equip the job site with mobile devices. There are x amount of drawing packages and we didn’t want people to grab their drawings, forms and any other necessary documentation and walk around a 26.5-acre site. Instead, we wanted them to have access to all the models, drawings and forms and document throughout the job site. We wanted key individuals to have the capacity to look at a detail, capture images from the site and upload it back to the design team and streamline the flow of information.

Wireless Communication on the Job Site - In order to expand the project team’s capabilities to the field, we had to design and install wireless communication throughout the job site. Having a wireless connection on the job site gives the project teams the ability to take their role out to the field without putting a hold on the documentation process, risking overlooking information.
Wireless Technology - Continued

SAIC decided to install wireless mesh access point throughout the job site to provide a constant source of connectivity. This allows the team to maintain a constant connection to all necessary project data stored on Microsoft® SharePoint® or access the current models in Autodesk® BIM 360 Glue®. The Project Engineer can go to the source of an RFI and access the latest drawing to compare what is happening in the field. Having these types of abilities has allowed for a greater, more streamlined flow of information and has allowed for the project to remain on schedule.

SAIC chose the Cisco Aironet 1552 E as the wireless mesh access points of choice and had a radio site survey of the job site to determine the best locations of the wireless access points to achieve optimum line of sight and the best possible signal strength.

Challenges - A system like this is not without limitations and restrictions and if not systematically approached, could prove problematic. Below are just some of the challenges we had to face and overcome before we could put a wireless solution into place.

- These access points are regulated by the FFC and may require permitting
- Maybe required to contact municipalities to install in highly dense urban areas
- As construction advances, the building, cranes and equipment will interrupt the signal by causing interference in the access points Fresnel Zone
  - Fresnel Zone - The area around the visual line-of-sight that radio waves spread out into after they leave the antenna. This area must be clear or else signal strength will weaken.
- Uneven and rugged terrain makes it difficult to locate each access point at consistent heights while meeting height requirements/restrictions of the access points.
- The wireless access points can be affected by inclement weather
- Connection limitations on number of connected devices

Mobile Technology

Putting mobile technology in the field is much more than giving field staff mobility on the site. It’s about improving the flow of relevant information between site and office. During the construction process there is so much information that the site must convey back to the design teams. Whether it’s for making appropriate model adjustments to reflect as-build conditions or a request for information, mobile devices can expedite the process and improve the quality of information.

Key Roles – In order to be successful, we had to put the technology into the right hands, the hands of people who are impacted the most by breaks in communications and workflows. We examined each job role and function and developed a short list of people on the site who would both use and benefit the most from mobile technology.

- Superintendent
- Project Engineers
- Safety Coordinator
- Schedulers
- Project Managers
MOBILE TECHNOLOGY - CONTINUED

By empowering key individuals with mobile technology, SAIC set out to enhance current data workflow, allowing them to stay in the field and communicate with the trailer and/or the design teams seamlessly. Mobile technology has allowed project management to stay in the field to better document and convey both design and construction needs, allowed them to walk the site without carrying large cumbersome rolls of drawings, a camera, pen and paper or scrambling to find media to take notes on.

After much consideration, SAIC decided upon iPad as the mobile device to implement. This decision was largely based on a few factors.

- **User Friendliness** - The iPad was found to be easier for technology savvy and those much less technical to navigate and perform basic functions and had a lower learning curve. Perhaps due in part to its more restrictive nature, the iPad tested as less prone to hardware and software incompatibilities and operating system and app problems.

- **Higher Screen Resolution** - The iPad has a screen resolution of 2048 x 1536 which is higher than some other mainstream tablets.

- **Rear Facing Camera** - The iPad has a 5mp rear facing camera, as do some other tablets, but it also has a backside illuminated sensor which helps for taking pictures on site where there may not be good lighting. It also supports a video resolution of 1080p.

- **Amount of Apps available** - The iPad also has access to the largest inventory of apps and since the app store is a controlled environment, most app purchased will be of a very high quality.

MOBILE DEVICE MANAGEMENT (MDM)

Mobile devices cannot simply be deployed and forgotten about, left to the end-users to manage the devices. There are a number of challenges associated with the implementation of such technology in the field and the challenges must be managed.

**Security Risk** - One of the larger risks that SAIC put focus to was eliminating the potential security risks that may arise should an iPad be lost or stolen.

To counter and manage these potential security risks, SAIC employed a Mobile Device Manager, AirWatch®. The AirWatch® program allows a Mobile Device Administrator to track all deployed iPads via GPS (if enabled) so if an iPad is lost or stolen, it can located. This program also allows for remote wiping of the device, essentially resetting the iPad back to its original factory settings.

**Mobile Profiles** – Another aspect of mobile technology that needs managing is app purchases and to aid us with the support of apps we created MD Profiles that allow the management of both public and purchased apps. We didn’t want to restrict end-users to only using SAIC approved apps rather we wanted to encourage them to fully use the iPads for both personal and work reasons. Our hope was that this would help make end-users more comfortable with the devices as well as encourage their use without feeling controlled by “corporate.” However, there are a number of apps that we would purchase under the Apple® Volume Purchase Program (VPP) and would push to end-users without having them pay for it. For this, we made an SAIC app catalog and by using AirWatch® MDM, we can push out the installs to anyone who needs them.

There is a challenge that we had to face early on in the process though, and that is how the licensing of apps applies to the device. The apps are licensed under a gifting policy, which means the license is owned by the Apple® ID that installs the app on the device. We had to decide if it would be acceptable for end-users to own apps that were purchased by SAIC under the VPP or if each device would function under multiple Apple® ID’s. To avoid complicating the device management, we chose to allow each install to take place under each end-user’s Apple® ID.
MOBILE APPS

Before purchasing any mobile apps, we needed to understand the main areas of PRE that could be significantly impacted and improved with the utilization of apps. We worked with the field teams to better understand their needs and wants and then set out to build an app library that could be useful to them. App R&D can be costly and timely and was not something we wanted to impose on our field teams. To ensure only useful and quality apps would be used, we broke app field usage into three phases:

- Diligence
- R&D
- Field Test

For the diligence phase, we needed to figure out how to group the apps into useful categories of focus. To solve this, we worked closely with our field team to figure out the areas that could be impacted the most by useful apps and came up with the following categories.

- Coordination
- Schedule
- Management
- Budget

For research and development, we began downloading multiple apps and put them through many tests. Given the amount of apps that are available and wanting to guarantee only useful and quality apps would be used, we put each potential app through a series of test to make sure that they would meet the needs of our end-users.

We looked at a few categories and based our purchases on the following:

- Usability
- Compatibility with existing software versions (Primavera and P6 Team Member)
- Cost
- Integration into the project (import/export)

Usability – This was to see how user friendly the app was. We wanted highly functional apps but at the same time not so complicated that they wouldn’t be used.

Compatibility – This was to see how well the app would work with any associated software. For example, if the app has a desktop version would they be compatible with previous version?

Integration – This was to see if the app’s generated data could be useful outside of the app, in downstream applications.

Cost – We last considered cost. We didn’t want the price of an app to cloud our judgment of its overall usefulness. If we determined that if an app met our criteria, the price should be the least important aspect. If it was determined to be too expensive, we could look into other competing apps for an alternative.
MOBILE APPS - CONTINUED

During the R&D phase we broke each app down into more in-depth categories for preparation for field testing to better convey, gauge and ultimately understand where each app would be the most effective.

For the field testing phase, we pushed installs of the selected apps to end-users in the field based on each individual’s needs and let them use them on a daily basis. Feedback from the field came almost immediate and the results of the test are the apps listed in the table below.

<table>
<thead>
<tr>
<th>PLAINFIELD BIOMASS RENEWABLE ENERGY</th>
<th>MOBILE APPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>APP</strong></td>
<td><strong>FUNCTION</strong></td>
</tr>
<tr>
<td>Autodesk® BIM 360 Glue®*</td>
<td>Cloud Based Collaboration Solution</td>
</tr>
<tr>
<td>Autodesk® AutoCAD WS®*</td>
<td>Cloud Base DWG Editor Solution</td>
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<tr>
<td>Autodesk® 360 Mobile®*</td>
<td>Cloud Based Model Viewing Solution</td>
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<tr>
<td>Cisco® WebEx®*</td>
<td>Mobile Web Meeting Solution</td>
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<tr>
<td>Readdle® PrinterPro®</td>
<td>Mobile Printing Solution</td>
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<tr>
<td>Skype Communications®</td>
<td>Skype VMWare®*</td>
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<tr>
<td>Ramki® NoteShelf®</td>
<td>Mobile Documentation Solution</td>
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<tr>
<td>SouthLabs® SharePlus®</td>
<td>Mobile Microsoft SharePoint Access Solution</td>
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<tr>
<td>Readdle® PDFExpert®</td>
<td>Mobile PDF Documentation Solution</td>
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<tr>
<td>That'sMyStapler® ChemSafety®*</td>
<td>Mobile Access to ICSC Solution</td>
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<tr>
<td>Illum Software® ListPro</td>
<td>Mobile Punch List Solution</td>
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<tr>
<td>Caramba App Development® EasyMeasure®*</td>
<td>Mobile Measuring Solution</td>
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<tr>
<td>WebMD®*</td>
<td>Mobile Medical Advice Solution</td>
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<tr>
<td>WageWorks® EzReceipts®*</td>
<td>Mobile Medical Insurance Solution</td>
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<tr>
<td>IAM Web Services® CountDown®</td>
<td>Mobile Schedule Timer Solution</td>
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<tr>
<td>TheWeatherChannel®*</td>
<td>Mobile Weather Solution</td>
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<tr>
<td>Aviation Data Systems® MyRadar®*</td>
<td>Mobile Weather Solution</td>
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<tr>
<td>FourthFrame Technologies® SGProject®</td>
<td>Mobile Schedule Solution</td>
</tr>
<tr>
<td>Irfan Farooq® CalculatorPro®</td>
<td>Mobile Calculator Solution</td>
</tr>
<tr>
<td>QuickOffice® QuickOfficePro®</td>
<td>Mobile Documentation Solution</td>
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</tbody>
</table>

*Denotes Free Apps
BIM COORDINATION IN THE OFFICE AND THE FIELD

With so much information getting exchanged from so many different locations, project coordination is vital in order to keep the job on schedule and not put the budget at risk. From the onset of the project, we invested in a very strong support system with capabilities to provide technical support, model management and data management from design through construction. We understood that the complexity of the project, logistics and the fast track schedule would combine into a perfect storm that if not properly managed from the beginning we would surely sink.

LOGISTICS MANAGEMENT

One of the biggest challenges we face on the Plainfield Renewable Energy project is the fact that there are over forty vendors and contractors spread out across four continents and they all need the most up-to-date information at all times. The story of the Biomass Plant’s turbine is a prime example of some of the logistical challenges we face daily on this project.

The types of challenges that are presented by the logistics are not only technical but also cultural and involve different ideas and methods of accomplishing similar tasks all the way down to breaking the language and time barriers that arise from spanning multiple continents.

As mentioned in the beginning, the generator involved four nations and spanned eleven time zones. Logistical challenges are amplified when trying to get information to one location where it is early afternoon from another location where it is very early morning the next day. Because of these types of challenges, we had to manage logistics from the beginning.

Model Coordination - Simply having models from each vendor or contractor linked into the design models is not enough to guarantee that the models are well coordinated. Elements will get hidden, layers turned off and the links themselves may not get reloaded on a regular basis. In order to limit the amount of redesign due to costly and time consuming change orders in the field that could arise from uncoordinated models, we ensured that all models were not only well-coordinated, but that all the different design teams were essentially on the same metaphorical page. We wanted to expand on the coordination allowed by integrating models from the multiple designs.
LOGISTICS MANAGEMENT – CONTINUED

applications by having a single source, master model that could be used for much more in-depth coordination. For model coordination during the design period, we chose to implement Autodesk NavisWorks® as a solution. We felt that unique toolsets offered by Autodesk® NavisWorks Manage® gave us the greatest amount of control for model coordination.

In using Autodesk® NavisWorks Manage®, we established a strict timeline for all contractors and vendor to upload their models to the projects Microsoft® SharePoint® site. To save time, each team posting to the site was required to generate their own NWC files that would be compiled into the master Autodesk® NavisWorks® model. This simply allowed for downloading the individual NWC files and compiling them and saved a lot of time over having the NWC export task assigned to a single user.

Once the master model was updated, detailed clash detection reports were ran, complicated areas like small bore piping locations were examined and an overview of the design was assessed. When the model was ready, all the design teams were brought together to discuss the design’s current state.

For coordination during the construction phase we chose Autodesk BIM 360 Glue. After initial feedback regarding using NavisWorks Manage on the job site we needed to find a coordination application that was a bit more “user friendly” for the site team to work with.

The addition of BIM 360 Glue has greatly impacted the quality of onsite coordination meetings. The application allows for very quick model navigation in a cloud environment. This allows us to view a master coordination file with all disciplines and trades visible and still navigate the building with ease. Each system can quickly be isolated for viewing or compared with other building systems for spatial coordination.

Because of the ease of use and the built in functionality that BIM 360 Glue offers, we found our Project Engineers frequently asking for model updates multiple times a week, more during intense periods of construction. With more frequent model uploads out engineers on site have vastly improved the quality and the level of communication between the site, the subs and the design teams.
LOGISTICS MANAGEMENT – CONTINUED

Documentation Coordination - Similar to the models, sharing documents between the office and the field when so many different people are involved from so many locations can be complicated. Due to the schedule of the project, we could not afford any time lost on waiting for drawing comments to be turned around; we could not wait long periods for RFI responses. We had to implement solutions that would not impact the flow of information from the field to the office, but a solution that could also point out areas that would cause a delay in schedule or have potential cost.

To control the flow of information on the Plainfield Biomass Renewable Energy project we chose to implement both Oracle® Primavera Contract Manager® and Microsoft® SharePoint®.

Microsoft® SharePoint® was chosen to act as the central repository for all models and documentation as it relates to the project. Each design team, contractor and vendor was given access to the site and a directory to store their information. The project site was setup with automatic notifications when information was uploaded by a vendor or contractor, removing the need to monitor the site for new or updated files. With all designers, contractors, vendors and project managers working off the same project site, allowing for right time document sharing, the flow of information was not impeded by having to mail drawing sets, or email documents and wait for responses. We found that in many cases, drawings were turned around with comments in less than 24 hours! At one point, over 650 drawings were issued, commented on and turned back in less than 1.5 weeks!

Oracle® Contract Manager® was chosen on this job to act as a source to streamline field communications, facilitate project team collaboration and to track and manage the project budget. Prior to an implementation of a project management application, there was much time lost waiting for responses to RFIs, budget and schedule issues due to vendors and contractors not completing work on time. With the implementation of Contract Manager® we are able to document what contractors are holding up work. We are able to reduce the turnaround time for waiting for information request.

Using Contract Manager’s role based functionality; external users to SAIC were given access to the central repository of project documentation so they could view, modify and update the necessary information. Expanding on the application’s issue tracking features external teams could generate RFI’s and post them and internal SAIC team members would be notified and we could greatly reduce turnaround time and the amount of people getting involved. This allowed them the ability to collect information they needed, take pictures and fill in forms that they need and then pass them seamlessly to our project controls team for almost immediate response. By implementing Contract Manager® and allowing contractors access, we were able to reduce the RFI turnaround time from typically ten days to less than 24 hours!

Schedule Coordination - It was not only important to coordinate the models as they were, it was equally important to coordinate the construction schedule as well. The scheduler on site needed to verify, in some cases almost hourly, that the project was on time. Risking the loss of grant monies that account for nearly 30% of the jobs capital is something that simply cannot happen. From early in the scope the project had to be tracked and managed to ensure that we did not fall behind schedule.

The schedule on PRE was a “hand to mouth” schedule, it was very fast tracked. There were instances of our design team finishing a design and the drawings or models were immediately sent out for procurement, fabrication or straight into development.
LOGISTICS MANAGEMENT – CONTINUED

To manage the schedule, we used Oracle® Primavera and integrated the schedule into NavisWorks. The schedule in NavisWorks allowed for our schedule team on site to visually convey to contractors what needed to be done, what was behind and what was coming down the pipeline. During contractor meetings our schedule team would display the schedule and the model on the touch screen monitor and walk through the schedule.

We also found ourselves with another challenge due to the fast paced schedule. In order to stay ahead of the schedule we had to procure equipment and material ahead of time so we would not be left waiting on the site and risk delays. This meant that we had many pieces of equipment arriving on site long before it was scheduled for construction which caused some site management problems. We couldn’t afford time wasted on moving equipment and materials around the site again and again.

To aid against this, we again leaned on Autodesk NavisWorks with the integrated P6 schedule. This allowed us to visualize where equipment and materials were on site and compare them against the future schedule and plan the site accordingly. For example, much of the equipment and materials were randomly placed in the location of the fuel barn. With the visual aid provided by NavisWorks, we were able to plan the site and clear space when it came time to pour the footings so there would be no conflict between equipment and work.

Project Coordination - With construction underway, more vendors and contractors are getting involved with the project. The flow of information increases almost daily and with that comes the need for a better coordinated project, more integrated design and construction teams and stronger communication. Having project teams in so many different locations, including 5 states just for SAIC, and more than 4 different nations involved, scheduling coordination meetings can be very difficult. We established a timeline for biweekly coordination meetings that would bring the entire project team together and allow everyone to see the master model, address interferences and thoroughly examine more complex or problematic areas of the buildings.

The coordination meetings have allowed us to have get design input from all contractors and vendors on the project. If there are problems involving the scope of work from a contractor outside of the US, they will be included in the meetings, which means adjusting the time frame and working at unusual hours. It is not uncommon to have a team on the job site at 3am to have a coordination meeting with a team in Germany.

Previous coordination meetings had issues with document and model versioning. We found many ties there were a few contractors who did not have the latest version. To counter this we established a frequency for model uploads that require updated models from all contractors and vendors be uploaded on a biweekly basis. This allows us time to prepare for the meetings by running clash detection, cut building sections, save preset views and create agendas. Having all this material ready before the meeting begins allows us to control the direction and dialog of the meetings and therefore keeping them productive. With each model upload we found ourselves spending a lot of time tracking down all the changes that were made. This quickly became problematic as we found ourselves spending more time looking for modifications that prepping for coordination.
LOGISTICS MANAGEMENT – CONTINUED

To limit this, we created a spreadsheet that tracks changes. When a model is uploaded to SharePoint, each one is required to fill out the spreadsheet with information pertaining that the changes made.

- What areas were changed?
- What sheets were updated?
- What model information was added/removed?

Model Performance - With so many models getting linked together it was inevitable that there would be model performance degradation. In some cases our models have over 20 active links at one time. We have established file maintenance processes, best practices for linking, worksets allowing control over the amount of loaded data at one time and regardless of all this we still suffer from bad performance.

File open times across the WAN at peak hours of operations can take over an hour if proper opening procedures are not followed. Synchronization times can get in excess of 30 minutes and model reloads can become very cumbersome.

Version Control – Though lessened by the upload schedule and change tracking spreadsheet and regularly scheduled project team coordination meetings, we suffer from version control. There are so many documents and models being exchanged and modified by so many different people it has been a challenge to assure that everything is current.

There have been coordination meetings where the presenter on Autodesk BIM 360 Glue was showing the master model and was told that he did not have the most current electrical model. And then found out that the electrical contractor did not have the most current process controls model. We often find ourselves falling into the situation of one hand not being aware of what the other hand is doing.

PROJECT SUPPORT TEAM

To be successful with managing all aspects of the job, we established a strong support structure that could aid in many of the tasks involved with all the data that was coming from multiple continents at different times, we established a support structure early on that would be able stay ahead of the design schedule. The design and technology support team is composed of Revit® Power Users, BIM Job Captains, CAD Specialists, and the Corporate BIM team consisting of the Application Programmers, the BIM Applications Manager and the BIM/CAD Technologies Director.

This team serves the project in multiple roles that allows data to flow between multiple design teams making multiple models in multiple formats merge seamlessly with one another and a number of other functions. This support team was assigned at the beginning of the project and will stay on through construction in order to aid in the collaborative efforts between the design teams, vendors and contractors. We help ensure that all parties have the most current documents and models, model coordination and aid in integrating the models with the schedule and maintain the stream of information.

<table>
<thead>
<tr>
<th>DESIGN + TECHNOLOGY SUPPORT FUNCTIONS</th>
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<tbody>
<tr>
<td>Model Efforts</td>
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<tr>
<td>Model Management</td>
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<tr>
<td>Workflow + Process Management</td>
</tr>
<tr>
<td>Research + Development</td>
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</tbody>
</table>
PROPER DOCUMENTATION

Projects like Plainfield can be overwhelming for many. The combination of a fast tracked schedule, new technologies and new workflows can be daunting even to the most experienced team members.

To help relieve some of the anxiety that such projects can present, our team has put into place many documents and videos that end-users can access whenever they need. There are many components that can be documented, acting as reference guides that end users can use to see how the project is structured or what modeling procedures to follow or what is the support team and who to talk to get information needed to complete the task at hand.

Process Documents – These are documents that we generate to showcase to end-users, project management and subs how processes take place. There are a large of process documents that we have and spread many topics, each unique in its own. These documents are important because they graphically represent topics that are very difficult to explain and typically follow a flow chart in look and feel. On Plainfield, we used process documents to show our teams many different aspects of BIM including:

- BIM Project Workflow – Breaks down what applications will be used and how they will communicate
- BIM Application Process Map – Shows the many process that take place on a BIM project

Procedure Documents – These are documents that are generated to act as an extended support resource for end-users. Typically, these documents focus on a single topic and are in place for reference for task execution and are can be graphic or text rich, or both depending on the complexity of the task. Often times, if created for a support problem and the resolution needs to be largely distributed these will get generated in videos. On Plainfield, we used these documents when tasks were deemed to be confusing or if there were a lot of repetitive support issue and we needed to mass support a problem.

- iPad Support – These were videos put together that covered general support issues
- DWG | RVT Interoperability – Showed each design team how to plan for exporting/importing models

Best Practices – These are series of compiled educational documents that are put into place that direct end-users on proper methods for executing tasks in their respective applications. These are reference documents that can be used to reduce the amount of overhead support on a project by educating the end-users on how to properly execute tasks, perform file maintenance or properly sync a file.
**CONCLUSION**

Why is this important? Understanding the core problem of technology forcing many design teams to work in a silo and how it can lead to decisions being made in a vacuum, is a problem that has to be addressed at a project’s onset. It is vital to understand what this problem does not apply to just the design aspect of a building but also to construction where can be amplified by the very nature of the job site.

- Tight schedules
- Logistical challenges
- Intimidation by the “unknown BIM factor” causing a push back on implementation

Finally, it is critical to understand that this issue can be countered very early on in a project’s concept by structuring a well-planned and well documented project workflow that involves proper technology use, training and constant communication and collaboration. It is also key to have well-structured support system needs to be in place very early on and remain on through commissioning that is capable of supporting all aspects of BIM and VDC. With a well-planned project, teams will no longer work in a silo but work in a collaborative space that will ultimately enhance the flow of data and result in real-time decisions that help keep a project on time and on schedule.