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Increasing Efficiency in the Construction Industry and  
Construction Management Classrooms Using Computer Software

BY

Tina T. Bien

**UNDERGRADUATE THESIS**

Submitted in partial fulfillment of the requirement for obtaining

**UNDERGRADUATE DEPARTMENTAL HONORS**

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Charleston, Illinois

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12 DEC 2017

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12 DEC. 2017

Date

DEPARTMENT CHAIR \_\_\_\_\_

Increasing Efficiency in the Construction Industry and  
Construction Management Classrooms  
Using Computer Software

Tina Bien

For

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Eastern Illinois University

December 2017

## **ABSTRACT**

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The purpose of this research is to identify the best computer software programs that are the most effective within the construction industry. Companies are gradually shifting from manual practices to various software and technologies to optimize business and communication efficiency. With the plethora of software available, the industry does not fully understand which software are the most effective for addressing the challenges of the industry. As the industry is struggling with integrating these software into their company structure, more money is being spent to tackle the challenges that face the construction industry today. Companies that do not integrate construction technology to further their efficiency will be left behind. Industry productivity reports show that the construction industry has lost productivity since the 1950's while other industrial sectors have increased their productivity using modern technology. (Crumrie, 2017). Most construction companies work through their management processes manually, instead of utilizing available software programs like Procore, Bluebeam, ASTA Powerproject, and ProEst. These programs are designed to increase efficiency and productivity. In this paper, data is collected and analyzed from Fortune 500 companies, such as Lithko Contracting LLC, Bulley & Andrews, Hensel Phelps, NECA, Walsh and others, and their representatives, regarding their technology usage. The data is taken from company Vice Presidents, Project Managers, Supervisors, and Project Engineers. Application software for various construction management practices are examined and evaluated for their production efficiency impact and relative cost.

**Keywords:**

Integrations: Bringing together sub-systems into one system to deliver an overarching functionality

Optimization: Methodology of making use of a resource

Efficiency: Organization, accomplishing something with little waste

Streamline: Efficient, smooth, seamlessly

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# Increasing Efficiency in the Construction Industry and Construction Management Classrooms Using Computer Software

## 1.0 INTRODUCTION

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Population growth and deteriorating infrastructure within the United States paints a bright future for the construction industry. The demand for construction is at an all-time high.

“Construction is already one of the largest industry sectors, accounting for more than 11 percent of global GDP and expected to grow to 13.2 percent by 2020” (Leeds, 2016). With all this growth, the construction industry finds difficulty in meeting the current production demands. The challenges lie in productivity, profitability, performance, labor, and sustainability (Leeds, 2016). These challenges hold the industry back from growing at a faster rate. Companies that do not address such challenges will become obsolete or non-competitive. In order for the construction industry to prosper, they must choose to incorporate software to make their processes (cost estimating, scheduling, take-off, and project management) more efficient.

Poor productivity can be realized in the following ways: by waiting for materials and equipment, traveling costs, labor inefficiency, and improper planning. Think of finite element analysis. It is a computerized method of predicting how something reacts to forces in the real world. A good defining word for this is: simulation. With the technology available in the industry now, companies will be able to predict and plan more effectively. This is where software for project management, 3D, 4D, and 5D modeling, cost estimating, and scheduling can work together to create more efficient processes in the construction realm. Often, a limiting

factor for many companies is that they find themselves trapped between shrinking profit margins and stagnant productivity; unable to generate the profit necessary to invest in critical technology (Leeds, 2016).

As building design complexity increases, more devotion is required to streamline the process – but construction companies struggle to keep up. This is why the software that will be introduced in this research will help streamline takeoff, estimating, and scheduling. These processes are the backbone of this industry. As a result, software has been developed to handle the bidding, design, takeoff, and scheduling processes. These software applications have been reported to make construction management processes more productive, profitable, on-time, and on-budget.

With the recommendation of these software, Construction Management industry partners and classrooms will be able to meet the demands of the current construction industry demands. “A countrywide survey conducted by the Associated General Contractors of America (AGC) in 2013 found that 53 percent said they were unable to hire construction professionals such as supervisors, estimators and engineers.” (Pillai, 2015). The data collected by AGC shows that there is a shortage of skilled labor, which emphasizes the importance of assimilating these software into the curriculum in classrooms of Construction Management.

Currently, the Construction Management (CMG) classrooms at Eastern Illinois University are using excel for estimating, and MS Project for scheduling. The industry is already moving away from Excel as it is limited to one user at a time and introduces a lot of human error into the equation. It does not allow for team collaboration, and enforces manual data input.

The 5<sup>th</sup> Annual Construction Technology Report stated that 48% of users used MS Project (JBKnowledge, 2016). MS Project lacks in presentation. When the most efficient software is incorporated into the CMG curriculum, students will be able to work collaboratively with their teams, anytime, anywhere as well as be better prepared to address the challenges of the industry.

## 1.2 PROBLEM

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As mentioned earlier, population growth and deteriorating infrastructure within the United States creates a high demand for the construction industry. But the “Construction productivity has been flat for decades, according to McKinsey research. In manufacturing, by contrast, productivity has nearly doubled over the same period, and continuous improvement has been the norm” (McKinsey, 2015). Refer to figure 1.2.1 for an overview of productivity improvement over time in the manufacturing and construction industry. There is such a high demand for construction, but the productivity level is a lot lower than expected. Raj Manohar S Pillai, a lead analyst with Beroe Inc., and specialist in tracking various trends and dynamics of the global construction industry states:

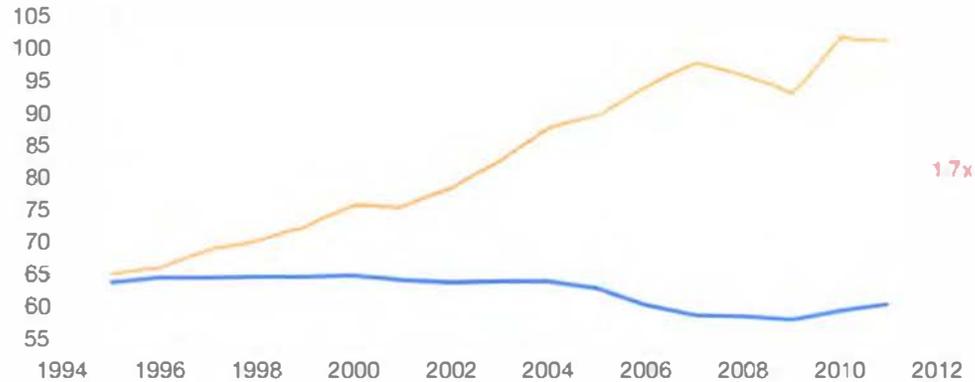
*“Until 2010, the U.S. construction market was made up of two generations: the traditionalists and baby boomers. Since 2012-2013, the workforce has split into four generations: traditionalists, baby boomers, generation X and millennials. This present labor diversification is a challenge because of stark differences in work ethic, attitude, outlook and behavior. The traditionalists and baby boomers are the industry's major source of experience and skills, but this situation is changing with time.”*

-Raj Manohar S Pillai

**Overview of productivity improvement over time**

Productivity (value added per worker), real, \$ 2005

\$ thousand per worker



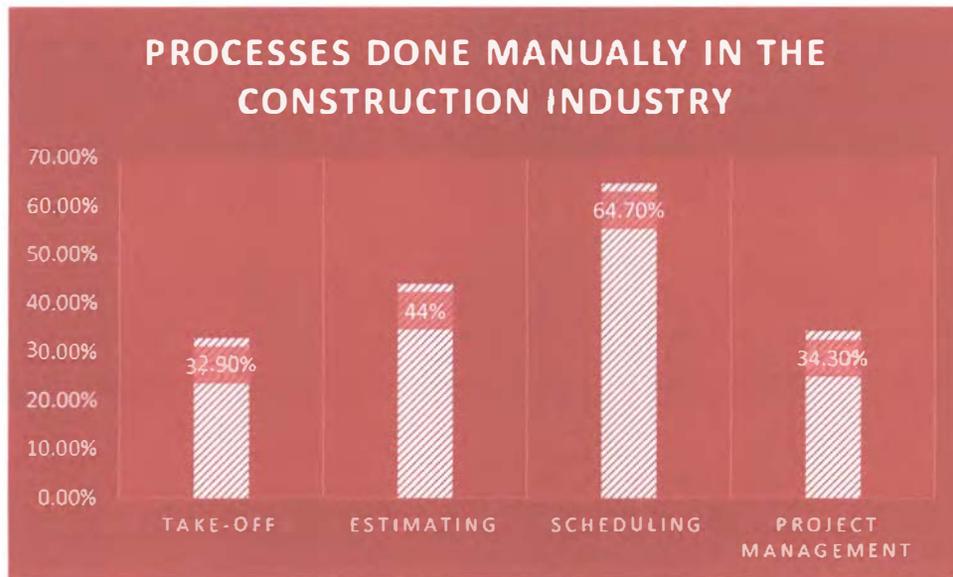
Source: Expert interviews; IHS Global Insight (Belgium, France, Germany, Italy, Spain, United Kingdom, United States); World Input-Output Database

McKinsey & Company

*Figure 1.2.1 – Overview of Productivity Improvement over Time (McKinsey, 2015)*

The construction industry needs an upgrade to their current system in order to keep up with the complex demands of the industry. Bulley & Andrews, an industrial partner of the Construction Management program at Eastern Illinois University, show strong embracement of the technologies used in the industry. In a brief interview with Frank Floss, Senior Project Superintendent at Bulley & Andrews, he expresses their company's usage of field technologies like BIM 360 Glue and 360 cameras for project documentation (Floss, 2017). While they are advancing in field technologies, he states that they use Bluebeam's quantity take-off capabilities for take-offs. From there, they use an excel sheet to put together their budget. Their master schedules are typically made in MS Project, while their 3-week schedules are made in Excel (Floss, 2017). This shows that they need an upgrade in their software arsenal. There is a great

number of companies in the industry still performing takeoff, estimating, scheduling, and project management manually (Fig. 1.2.2).



*Figure 1.2.2 – Processes Done Manually in the Construction Industry (Data from JBKnowledge, 2016)*

Pillai was correct when he said that the “traditionalists and baby boomers are the industry's major source of experience and skills, but this situation is changing with time” (Pillai, 2015). The construction industry needs a technological shift in their work and they look to students to help with the shift. Currently, the curriculum for construction management at Eastern Illinois University teaches students a lot of practical skills, but struggle when it comes to technological skills. Students are introduced to the basics of the Microsoft Office 365 suite, instead of emphasizing on software that teaches the importance and value of collaboration and communication. Computer-aided design (CAD) is another software that is taught to students, but

the construction industry is already shifting away from this technology. Students are in need of exposure to software that will refine their understanding of the various processes in construction.

### **1.3 PURPOSE**

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The purpose of this study is to address the problem of productivity, profitability, performance, labor, and sustainability, and how computer software can further make takeoff, estimating, and scheduling processes more efficient to accommodate the demands of the construction industry.

### **1.4 METHOD**

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The methodology for this report began with gathering personal interviews with industry partners, attending webinars, and viewing company technology reports. Personal interviews were conducted with industry partners; Lithko Contracting LLC, Bulley & Andrews, LLC, Hensel Phelps, Walsh, NECA, Walsh, and their representatives, regarding their technology usage. The technology usage data is taken from company Vice Presidents, Project Managers, Supervisors, and Project Engineers. The interviews ask companies what technology they are currently using for takeoff, estimating, scheduling and project management processes. Webinars hosted by Assemble and Engineering News-Record are used in data collection because they are hosted by big companies like iSqft and Bentley to further explore what the companies themselves are using today, they allow for access to the most current publish construction productivity research data. The 5<sup>th</sup> Annual Construction Technology Report is also used, as it shows where the industry is

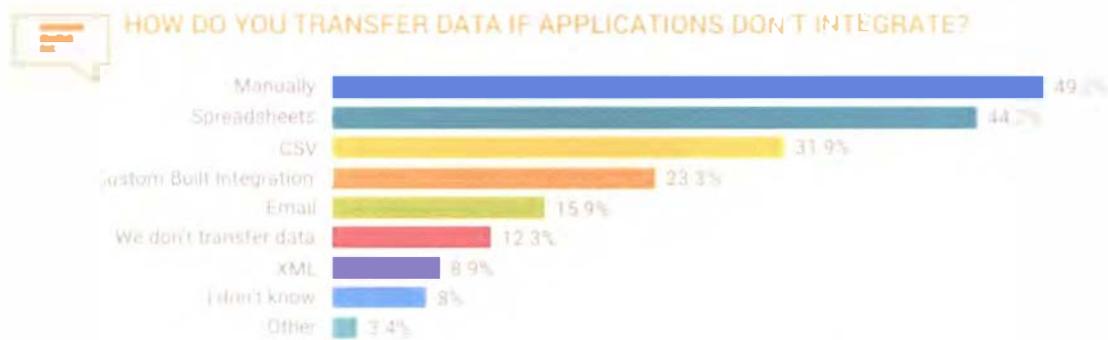
currently at, as a whole. The data extracted from this report is used to measure where the industry partners are in regard to the findings of the technology report. The data collected from companies are the names of software that they are using for each stage in the construction process; take-off, estimating, scheduling, and project management. From there, companies elaborate on how they use it. That data is recorded and analyzed. The data is analyzed by identifying what software they are using, and how effective it is in addressing the challenges of the industry. From there, after analysis of the data collected, software will be reviewed and recommended for the industry and construction management classrooms. The software will make processes more productive, profitable, on-time, on-budget, as well as reduce energy consumption and pollution. With the recommendation of these software, industry partners and classrooms for Construction Management will be able to meet the demands of the construction industry. Furthermore, it will help construction management classrooms by shaping the curriculum and providing students with a more technological approach to construction processes. The technology will allow students to work with software that is beginning to emerge in the industry and will further prepare them for the positions within the construction industry.

## **2.0 PROJECT MANAGEMENT, PROCORE & INTEGRATIONS**

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Increased collaboration, process enhancement, accuracy of information in real-time, elimination of redundant processes, ease of use, content viewing, and project management are the basic needs of the industry (Grayson, 2012). JBKnowledge (2016) reports that “Interoperability and system integration is a huge challenge in our (*construction*) industry. 99% of the time we have to interface with an owner’s legacy system (generally an Access or similar).

Integrating an in-house solution with an off-the-shelf system is always a painful process.” When software applications do not integrate, users are forced to manually input the data into other applications. The software integration process can cause frustration with new software and can in the short term reduce company productivity. According to survey data from JBKnowledge (2016), a majority of the construction companies indicate that they are still manually inputting data and manually communicating information to project stakeholders (Fig. 2.1).

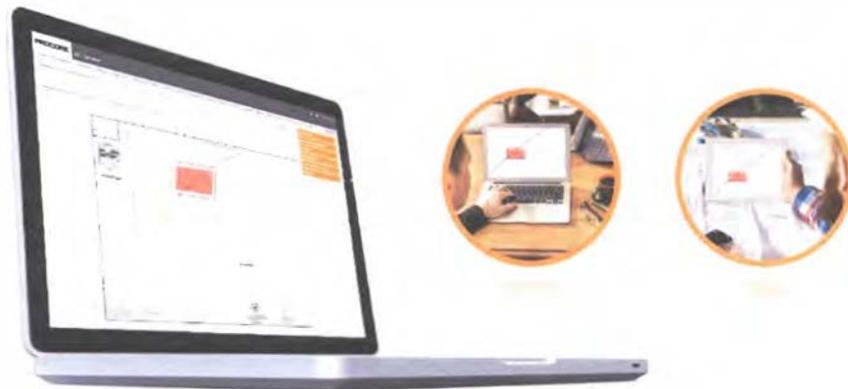


*Figure 2.1 –Graphical Data on Data Transference (JBKnowledge, 2016)*

One software integration application that was examined is called Procore. Procore is the #1 most widely used construction management integration software in the industry. Bulley & Andrews is a client of Procore among many others according to the Engineering News-Record top 400 (Procore, n.d.). It is a cloud-based application made for construction. With its many integrations, Procore is able to increase project efficiency and accountability by streamlining and mobilizing project communications and documentation (Procore, 2017). The Procore software can manage, store, access, and share information from one central encrypted cloud-based data source that's guarded by Procore's gold standard security protocols. With AES-256-bit encryption,

continuous data backups, granular permission levels, and automatic user tracking, your information is kept out of harm agents all day, every day so you can mitigate risks—even in your sleep (Procore, 2017). AES-256 bit encryption is among the top ciphers. The 256 bit is protected at a level that is equivalent to what the government would use. Granular permission levels in Procore is the ability to assign permission levels. It is an upper level of control.

Procore makes project management mobile, enabling collaboration anytime, anywhere. “Teams can access all the information needed with real time updates and tracking. Procore helps teams stay in sync, even when they are not together. This means more teamwork, less rework, and even better project margins.” (Procore, 2017) There is a project directory within Procore that allows team members to find contacts, similar to that of emails.



*Figure 2.2 – Procore’s Ease of Collaboration from Office to Field (Procore, 2017)*

Documents have unlimited storage in the cloud. The cloud acts as a virtual filing cabinet where teams in real time can have access to drawings and documents (Fig. 2.2). Documents and photos can be updated and uploaded from the field and office in real time. Procore is a drawing-centric

application which puts submittals, RFIs, punch lists, photos and more, into the current drawing set (Procore, 2017).

Project management is the overarching purpose of Procore. The document management process is simplified in Procore's user-friendly interface. Bid documents can be uploaded in any format, including plans, specs, PDFs, and file types from other construction software applications such as CAD applications or spreadsheets. After being uploaded to Procore, all documents are sent out to bidders as download links to accommodate the likelihood that other users may not have the software or viewing capabilities. Because Procore is cloud-based, there are no limitations on file size either.

Procore has a document management integration with Bluebeam Studio Prime. This particular integration "creates a studio session in Procore for each of your submittals and sends submittal documents from Procore to the Studio Session" (Procore, 2017) Procore can also integrate project scheduling. Currently, there are integrations for Asta Powerproject, Primavera P6 and MS Project. Teams will be able to view and get updates from the schedule. This is beneficial to further strengthening field communications.

### Schedule Week View (04/26/15 - 05/02/15)



*Figure 2.2 – Week View of Schedule in Procore (Procore, 2015)*

Integrations allow for seamless collaboration. ProEst is an estimating integration that allows teams to produce professional proposals with ease, and perform digital takeoffs quickly. “Our ProEst Cloud platform handles all aspects of the estimating & sales cycle for a construction company. After an estimate is awarded, it is automatically populated into Procore for project management” (Procore, 2017). With the Asta Powerproject integration, users can view tasks in a Gantt chart as well as receive progress updates in the field. Procore automatically distributes weekly look-ahead schedules, sends out weekly resource schedules, and gives project team members the opportunity to request schedule changes through the system (Procore, 2017). The Primavera P6 and MS Project integrations work similarly.

### **3.0 WHY THE INDUSTRY IS MOVING AWAY FROM EXCEL**

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Jeff Gerardi, with ProEst, poses a question that many Construction estimating professionals ponder: “To Excel or not to Excel?” (Gerardi, 2014). Excel is easy to use and easy to learn, it is a simple interface that is flexible because it can be used for many purposes such as Request for Information (RFIs) and tracking. But how well Excel executes those items is a different story. Excel information is often manually transferred into another application. The construction industry is currently trying to overcome the challenge of being more efficient, and to be more efficient, the tasks at hand should not be tedious. This is where software integration comes into play, because it will speed up the tedious process as well as allow team collaboration to become a reality. With integration, teams will be able to distinguish between current and older versions of the estimate. The estimates will then integrate into the overall project in real time.

With such connectivity, equational errors will be found with ease. It is very easy for someone to change equations in Excel in a very minor way and cause errors that are much larger. These changes are very hard to detect within Excel.

Data control is very difficult when there are multiple versions at hand. Ron Antevy, President of e-Builder, inc., states that his team were given a spreadsheet and when the data was imported, they “discovered a \$500,000 error due to a ‘broken formula’ in the spreadsheet used to manage the job” (Antevy, 2014). Excel was mainly made to deal with data in one place, and the fact that we use it to store data collaboratively – can get messy.

The next question is – how can bigger projects be managed with Excel? That is where it becomes more difficult to keep track of information. Bigger projects mean bigger equations, so how could a company avoid those formula errors in Excel? Truth is, it would take a lot of time. Getting the numbers right can make all the difference between winning a bid and losing one (Gerardi, 2014). Excel welcomes a lot of human error. Software that can integrate will offer better insight by automatically calculating everything. Not only that, everything is customizable by the user, meaning they can group the data by cost, material, labor, etc. Another great feature of most estimating software in comparison to Excel is that they have an integrated cost database which will deliver the most accurate and current estimate.

Excel is part of a Microsoft suite. The origins of the system itself can indicate the foundations they are built on. What is meant by this is that Microsoft was initially made to present data and information. Excel’s focus is not on construction and the estimating process. There is a lot of software out there that have a specific focus on construction, and this

specialization makes the construction manager more productive. Their construction manager can easily adapt the specialty application to ensure the accuracy of data as well as address the challenges of the industry.

The industry is continually shifting technologically to tackle the challenges faced. In order to compete in such a demanding market, companies are adapting technology to streamline their processes intelligently in order to win projects and increase their overall profitability. Those that do not take the step ahead, will be left behind as the market continues to develop more complex and demanding projects.

## **4.0 COST ESTIMATING WITH PROEST**

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ProEst is a sleek, powerful, user-friendly and cloud-based construction estimating and takeoff solution. A cloud-based cost estimating platform helps tackle the problem of downloads and compatibility of software and systems. With ProEst, information can be access from anywhere, which means that project collaboration is easy. ProEst allows teams to create estimates, perform digital takeoffs, and store project drawings. With its user-friendly interface the learning curve is lowered, which in turn allows for users to create detailed estimates quickly and with swift and ease. In a trial with students in the Construction Management classrooms, ProEst only required 3-4 hours of dedicated time with a ProEst trainer. From there on out, it is a very simple and easy to understand program.

Often times with Excel, many versions of files are downloaded onto the system, and it can get messy. ProEst stores all estimates in one single location, which allows users to quickly

find estimates in seconds because they integrated the search bar into their design. Excel formatting for cost estimates can sometimes change based on the version of Excel currently installed. The features are user-friendly and most items like markup items are automatically calculated, which removes human error from the equation.

ProEst also specializes in digital takeoffs (Fig. 4.1). The cost can be automatically calculated from the takeoff, saving teams' time. The flexibility to perform takeoffs on-screen eliminates manual take-offs as they are time-consuming and tedious. Companies like Hensel Phelps express that with the usage of digital take-offs, they can have virtually paperless projects (Meyers, 2017). Most estimators are saving an average of 75% of their time by using estimating software (Barlow, 2017).

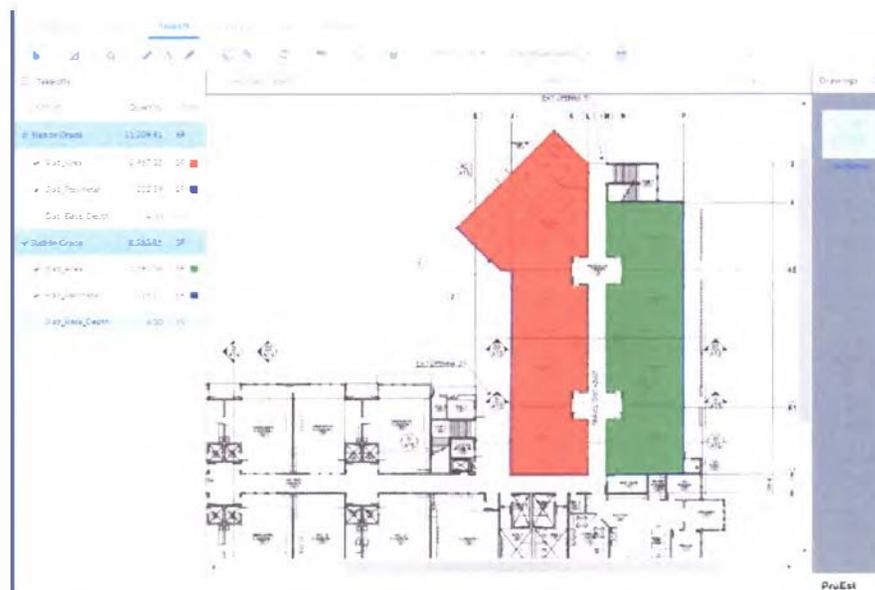


Figure 4.1 – Digital Take-Off in ProEst (Procore, 2017)

ProEst has a reporting feature where it allows users to generate high quality reports and summaries as well as material lists. Professional reports can be created quickly because the database has many report templates to choose from. This can be very useful when creating bids and proposals, especially when in a hurry. The reports available include: estimate cost types, estimate summary, estimate totals, accounting totals, estimate summary totals, material list, equipment costs, estimate unit costs, estimate unit totals, labor costs, test proposal, takeoff, estimate assessment, estimate comparison, estimate product usage, estimate profitability, estimate success, estimate workload, and databases.

ProEst is integrated with an extensive cost database library from RSMeans with the latest information. The database covers general requirements, existing conditions, all the way down to electrical power generation. You are able to view the item code, description, unit, and unit cost. You can also view the assemblies for each section. Teams will have the most up to date information when using ProEst because their team tracks labor and material cost changes.

Remember earlier when Excel was discussed to be an inferior program? ProEst tackles challenges that Excel faces. ProEst can accurately analyze and calculate the cost of projects of any size. And on terms of technical support, ProEst has got it covered. In the cloud-based service, users have short videos that remind users how to perform certain tasks. Not only that, there is also a support section where technical support issues can be submitted. ProEst is built on user feedback in the construction industry.

The industry is shifting and beginning to adapt Building Information Modelling (BIM). In an interview with Carol Hagen, with ProEst, she expresses where she sees the future in construction application software heading.

*“It’s already evolved to the point where you can have 6D capabilities, meaning the building models can be rendered in virtual 3D and also have dimensions of how much time it will take (4D) and the cost (5D) built in. 6D BIM also includes product information on all the components of a building linked to the virtual 3D model.”*

*-Carol Hagen, Computer Software Specialist and Social Media Consultant*

ProEst has already taken BIM into consideration and are currently developing a BIM integration where the model can be included while building the estimate. The assemblies will be highlighted in the model which will aid with further visualization of the project. The model will also be included in the reports and summaries, as they will allow for clients to see the cost breakdown visually.

In summary, ProEst is highly recommended for use because there is no special training required. It has a very simply and user-friendly interface that allows for less questions to be asked. ProEst has the ability to streamline workflow by developing detailed project estimates including material, labor, subcontract, equipment and administrative costs. They work to eliminate manual double entry that can result in costly errors. With the ability to measure blueprints and perform digital takeoffs onscreen on a cloud-based platform, teams can work efficiently from anywhere. There has also always been an issue with generating reports for

clients, and ProEst has that capability. Reports are generated with existing data for the estimate and can be created in a matter of minutes.

## **5.0 COST ESTIMATING WITH HEAVYBID**

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HeavyBid is part of the HCSS product family which includes project management, dispatching and scheduling, safety management, fleet management, and electronic logging services. It is an industry-leading estimating and bidding software. It is used by more than 50,000 estimators and is in Engineering News-Record's (ENR) Top 50 Heavy Civil Contractors. This software is highly recommended for use only with the HCSS product suite, as it will integrate seamlessly. Many key features of HeavyBid would include detailed estimate entry, ability to copy previous bid items/activities, and subs and materials quote system. Teams will be able to build the structure of their estimate on the fly, from previous estimates, or from a list of standardized activities of work. There is a library of estimates that allows for quick population of data for the estimates (Fig. 5.1).

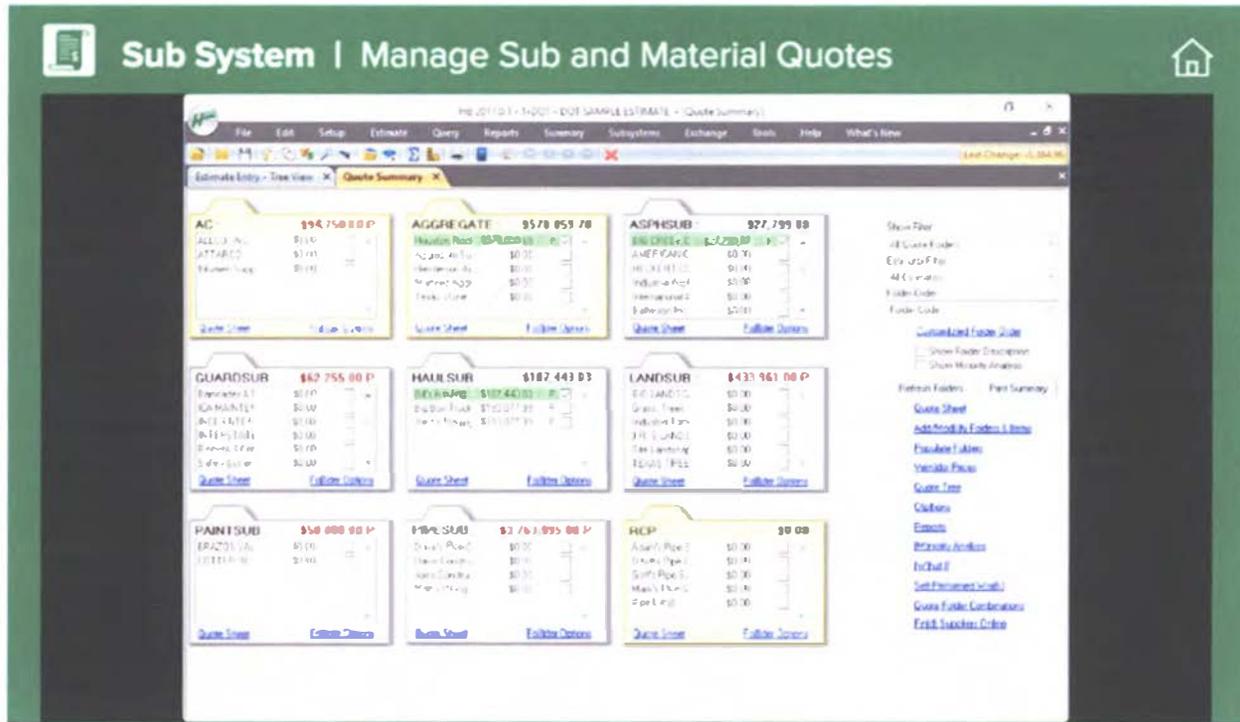


Figure 5.1 – Subs and Materials Quotes Management (GetApp, 2017)

Nic Buhler, an Estimator from Webber Construction expresses that the most useful feature of HeavyBid would have to be the quote system. The quote system makes it easier to analyze the different subs and be able to capture all of their escalation, all of their mobilizations, and terms and conditions suppliers put into their quotes. It makes it easier to input into the system to analyze everything apples to apples and decide what will be the most cost effective out of the mix. Last-minute quotes, discounts, and adjustments are quick, and the estimate will automatically be updated when changes are made. HeavyBid’s key features like being able to automatically identify the most advantageous quote expedites the estimating process for users (Table 5.2).

<b>Key Features of HeavyBid</b>	
Manage Subcontractors and Supplier Quotes	Flexible Labor and Equipment Cost Methods and Cost Types
Automatically Identify the Most Advantageous Quote	Copy From Previous Estimate or Master Template
Handle Unit Price, Lump Sum, Design-Build, and Joint-Venture Bids	Manage DBEs and Minority Requirements
Mark Items for Review	Eliminate Spreadsheet Management and Broken Formulas
Manage Spreads and Indirect Costs	Flexible Work Breakdown Structure
Perform Automatic Pricing Calculations	Access Historical Estimating and Performance Data
Import Bid Forms and RFPs Directly from DOT Websites	Track Edits with Audit Trails
Run Reports and Create Key Indicators to Analyze Bids Against Benchmarks	Integrate with RSMeans for Average Industry Costs

*Table 5.2 – Key Features of HeavyBid (HCSS, 2017)*

## 6.0 DIGITAL TAKEOFF WITH BLUEBEAM REVU

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Bluebeam Revu is a “digital workflow and collaboration solution trusted by over 1 million AEC professionals worldwide” (Bluebeam, 2017). Revu’s core functionality allows teams to import and convert an unlimited number of documents and drawings into high quality PDFs. With its markup capabilities, clear communication can be achieved. Speaking of

communication, Bluebeam Studio allows teams to work with partners anywhere in the world, live. With smart technology sweeping the nation, Bluebeam took this idea and came up with smart documents by streamlining the maintenance of large drawing sets. With Bluebeam's success time and again with their clients, they are able to evolve with the industry. There are more than 4 billion Bluebeam Studio transactions since 2010 and more than 1 million Bluebeam Revu users worldwide (Bluebeam, 2017).

There are some basic features that make Bluebeam more efficient for users. Document tab preview allows users to preview pages that they hover over as well as hyperlinks. Users are also able to make use of running multiple sessions of Revu. PDF files can be dragged from one session to another by simply dragging and dropping. PDF files can also be dragged out creating another window, so that multiple screens can be viewed. There is a small feature called sync view that can synchronize both screens so that when zoomed in or out, both screens will mirror the movement. There is also an extensive list of PDF markup tools; text, notes, highlighters, lines, clouds, callouts, stamps, arcs, curves, and images (Fig. 6.1).



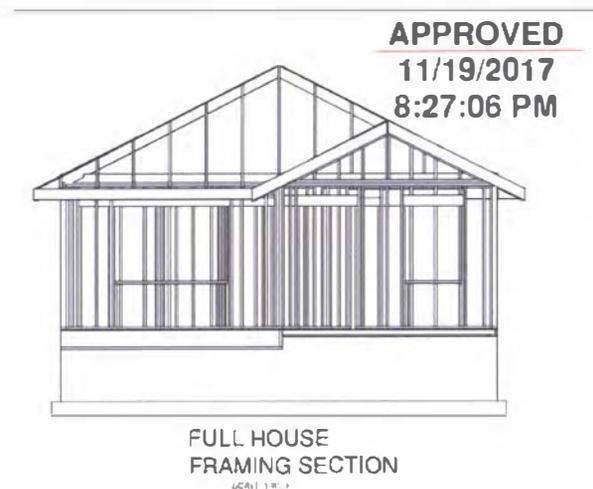
Figure 6.1 – Markup toolbar & highlighting of important information (Bien, 2017)

Bluebeam Revu allows for PDFs to be created from MS Office, AutoCAD, Revit, Solidworks, Navisworks, a scanner, and images. There is a plug-in for the software that instantly creates PDFs. Then, there are PDF packages to organize the PDF files. Still-shots can be created from 3D, 4D models. The models can then be rotated and viewed from all angles.



Figure 6.2 – PDF file created from Revit model (Bluebeam 2017)

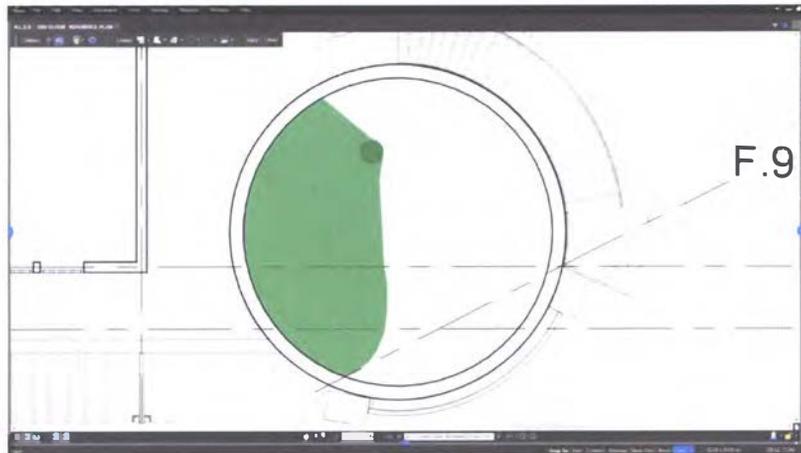
In Revit, there is a plug-in for creating a 3D PDF. Once imported into Bluebeam, the model can be rotated (Fig. 6.2). Markups can also be added. This is a great feature because it can help teams better communicate on the project. PDF stamps are available for use. There is also a stamp editor in the software that allows for high customization (Fig. 6.3). Once saved, the stamp will be available for use. Dates and times are automatically populated by Bluebeam once the stamp is used.



*Figure 6.3 – Stamp edited to display time and date (Bien, 2017)*

With PDF editing, not only can files be added to a file set, but Bluebeam also allows for users to edit the text of the PDF while still maintaining high quality.

Dynamic fill is another feature that makes performing takeoffs more efficient (Fig. 6.4). It allows users to make large selections. Selections are made using the fill tool.



*Figure 6.4 – Dynamic Fill Markup Tool (Bluebeam, 2017)*

There is also a boundary tool that can create barriers for shapes that are not closed, that way the dynamic fill can proceed to fill the area without spilling over the boundary. The boundary tool can fix a fill that has spilled out of bounds. Dynamic tool overall is an extremely helpful tool for performing takeoffs, defining spaces, and measurements and elements quicker than ever imagined.

Bluebeam Stapler binds multiple files into a multi-page PDF document, and vice versa. This works on Microsoft Office documents, windows files, images, etc. Reviewing changes in Bluebeam can be done through a feature called the overlay tool, which puts a new layer over an old layer, so that way, the changes can be seen (Fig. 6.5). It is very similar to mirroring or using a light table.

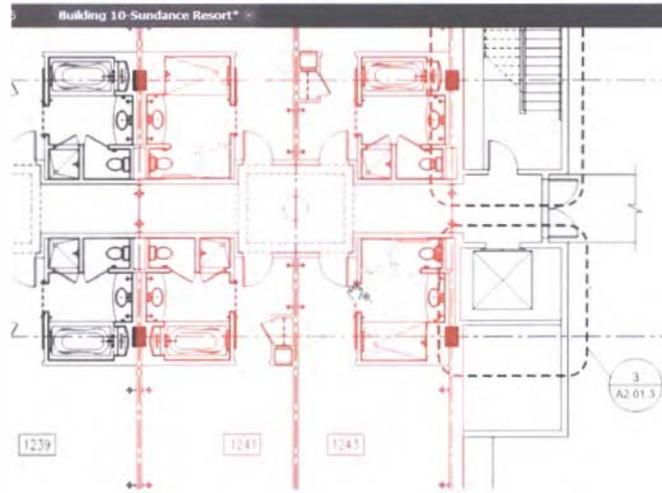


Figure 6.5 – Overlay Tool (Bluebeam, 2017)

Bluebeam also allows users to make measurements off PDFs. There is a built-in worksheet to calculate costs. Length, area, perimeter, diameter, angle, radius, and volume can be measured.

Legends for takeoffs are like legends found on maps (Fig. 6.6). They give viewers an immediate understanding of the markups on the page.

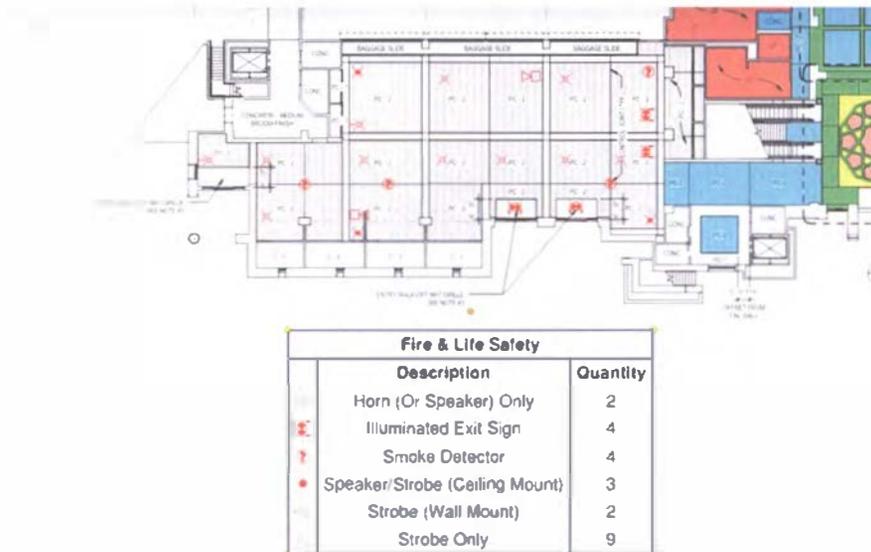


Figure 6.6 – Legend of Fire & Life Safety Items (Bluebeam, 2017)

In the Architecture, Engineering, & Construction (AEC) realm, there are submittals, time sheets, safety forms, RFIs, etc. Digital form fields can be added in Revu eXtreme. It will auto-detect form fields. By clicking on forms and auto-create, the software will analyze the document and create forms accordingly. OCR+ is an optimal character recognition feature that recognizes text and make it searchable and selectable. This will help navigate and search through PDF documents faster. Bluebeam also makes keeping complex file sets up to date with ease. A feature called batch slip sheet automatically matches revisions with their corresponding current sheets. It carries over markups, hyperlinks, spaces, and bookmarks. Superseded sheets are also stamped (Fig. 6.7).



*Figure 6.7 - Superseded Stamp on Revised Sheet (Bluebeam, 2017)*

Bluebeam Studio is a cloud-based collaboration solution allows users to work digitally and concurrently with the project team. It also allows you to securely manage projects anywhere,

anytime. It replicates a conference room environment. It allows multiple users to work on the same document.

With Optical Character Recognition (OCR) and Batch Link technology, Bluebeam scans PDFs and creates links throughout the document. Batch hyperlinking links everything to its corresponding information. This makes navigation throughout the PDFs a lot more efficient, and beats manually flipping through a set of blueprints and trying to find corresponding notes and drawings.

Other efficient Bluebeam features includes the count tool, hyperlinking, batch markup, and summaries. The count tool makes counting items faster, as well as putting the data in the markup summary. The items counted can be merged into a category, or split to further facilitate organization. Not only can teams use this but clients can also join without having Bluebeam installed. The feature is called Bluebeam Vu. They are able to access all the features of that session. Users are able to follow what someone is marking up in real time. Attendees can view, but cannot alter another person's work. Bluebeam conveniently tracks all markup activity that links back to the session PDFs.

There are many integrations within Bluebeam, such as Revit, Navisworks Manage and Sketchup Pro (Fig. 6.8). The Revit integration includes a plug-in in Revit. Users have the option of exporting rooms to spaces. Once exported to Bluebeam, it will automatically detect and create rooms. Refer to Figure 2.6 the left bar in the figure are individual rooms that have been detected. When hovering over the rooms in that bar, the rooms will be highlighted in the PDF.



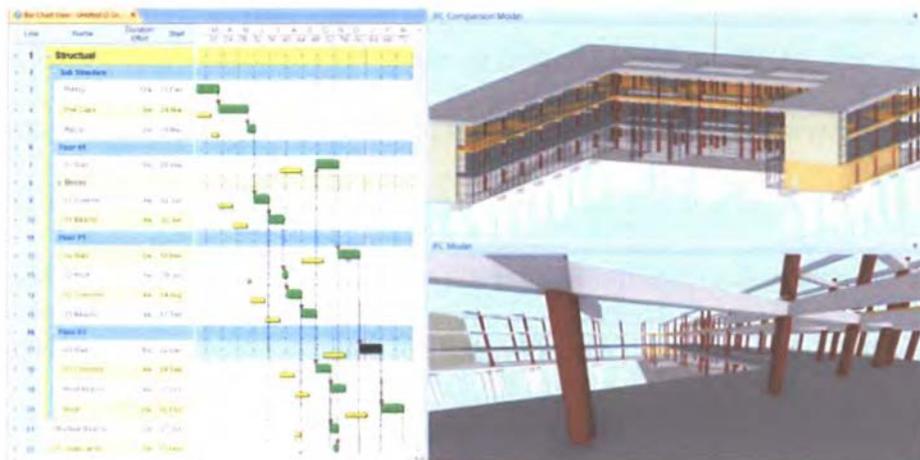
Bluebeam Revu is highly recommended for use because they evolve with the industry. There are five processes throughout a project lifecycle; design review, quantity takeoff, submittal review, punch process, and project handover. With regard to design review, Bluebeam Revu speeds up design reviews by allowing teams to use OCR technology to search throughout documents as well as markup and collaborate on the same documents in real time. For quantity takeoff, there is a suite of measurement tools that allow teams to capture project scope and produce a higher quality bid that will give teams the competitive edge (Bluebeam 2017). Submittal reviews are simple with Bluebeam Revu, because there are powerful markup and editing tools that seamlessly integrate into document management systems to keep projects smooth. Bluebeam Revu helps teams achieve a 90% completion rate on first back check by assigning responsibilities, connecting issues on the jobsite directly to plans, and tracking punch items (Bluebeam 2017). Finally, with the project handover, the dynamic document creation tools enable users to deliver smart operation and maintenance manuals that creates an ease of access to critical project information digitally.

## **7.0 SCHEDULING SOFTWARE: ASTA POWERPROJECT OVER PRIMAVERA P6**

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Oracle Primavera P6 gives unparalleled control, monitoring, and insight to planners, project managers, schedulers, employers, stakeholders, and any others who are involved in a given project (Collins, 2016). It is used to help schedule activities and tasks. The top benefits are risk reduction, ease of use, optimized resources, enhanced visibility, forecasting of project

activities, tracking, enhanced communication, and improved collaboration. P6 reduces risk by identifying and mitigating risks in the course of planning, managing, and completing a project (Collins, 2016). The software can be very complex, but it can scan and determine if any problems exist after information has been inputted. The advantages that P6 brings to the table is undeniably brilliant, but the costs outweigh the benefits. This is where Asta Powerproject comes in. “Asta Powerproject is one of the world’s leading project management software solutions for construction. Used by over 100,000 construction professionals throughout the world, it has been the project scheduling standard for UK and European firms for the last 25 years. Specifically designed for construction it combines easy-to-use functionality with powerful feature-rich capability (Elecsoft, 2017). Not only that, Asta has taken on a BIM integration as it allows presenting and progress monitoring in 3D (Elecsoft, 2017).



*Figure 7.1 – 4D Planning in Asta Powerproject (Asta Powerproject, 2016)*

Many companies have chosen Asta Powerproject as their scheduling solution. Refer to Figure 7.1 for companies currently using Asta Powerproject. 4D planning helps identify problems that may not be visible through traditional schedules like MS Project. The project can

also be seen at different stages and how it is built. Asta even synchronizes the model with the Gantt chart, so users can see the impact of their amends.



Figure 7.2 – Who uses Asta Powerproject? (Encore Group, 2016)

Project Managers are making the switch from P6 to Asta because Asta is easier to use, more intuitive, has a shorter learning curve, lower cost of ownership, and complies with customer needs making Asta's client database ever-growing (Fig. 7.2)(Encore, 2016). The learning curve is shorter because it only takes a day or two of training to be able to start creating robust schedules. Users are able to draw tasks directly on the Gantt chart. Often times, it is mastering the software that takes up the most time, but with Asta's simplicity, schedulers can focus on the project. When comparing the cost of seats for Asta, it is \$1575 compared to P6's \$2095. Asta also has a concurrent license that costs \$2095. Asta is also very flexible as it can open and save schedules in P6, MS Project, etc. P6 lacks features that Asta has, such as: monthly net cash flow, drag and drop functionality, multiple activities per line, users can easily draw relationships and even include lag time, unlimited undo and redo, user defined formulas in spreadsheet columns.

Asta Powerproject comes pre-loaded with templates and common layouts, including BIM. It also makes reporting easy because it generates sleek prints of what the user is currently seeing on their screen (Fig. 7.3). Asta also allows for users to view project schedules and resource histograms on the same page (Fig. 7.4).

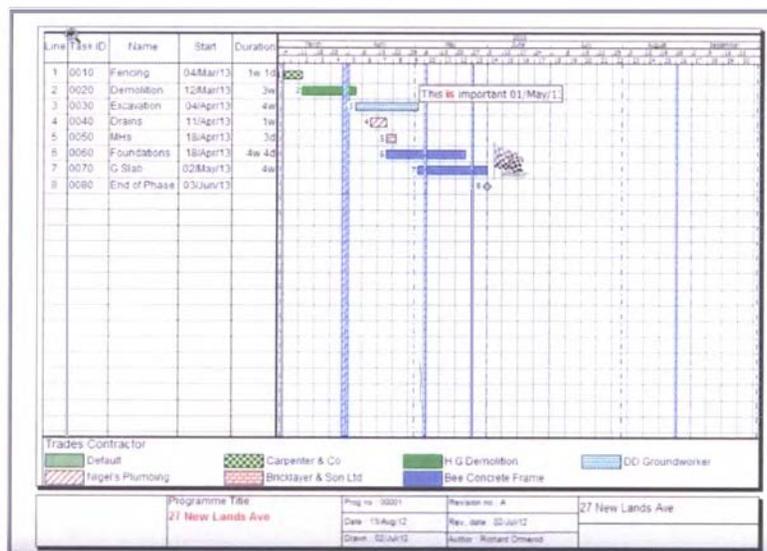
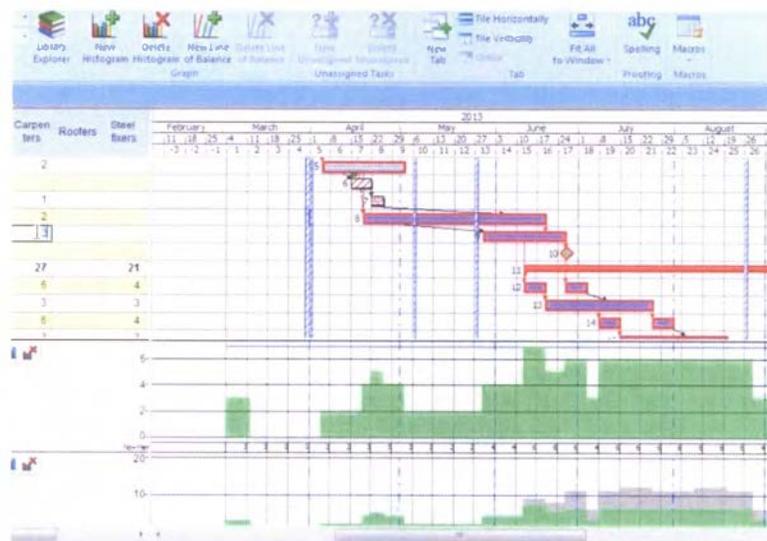


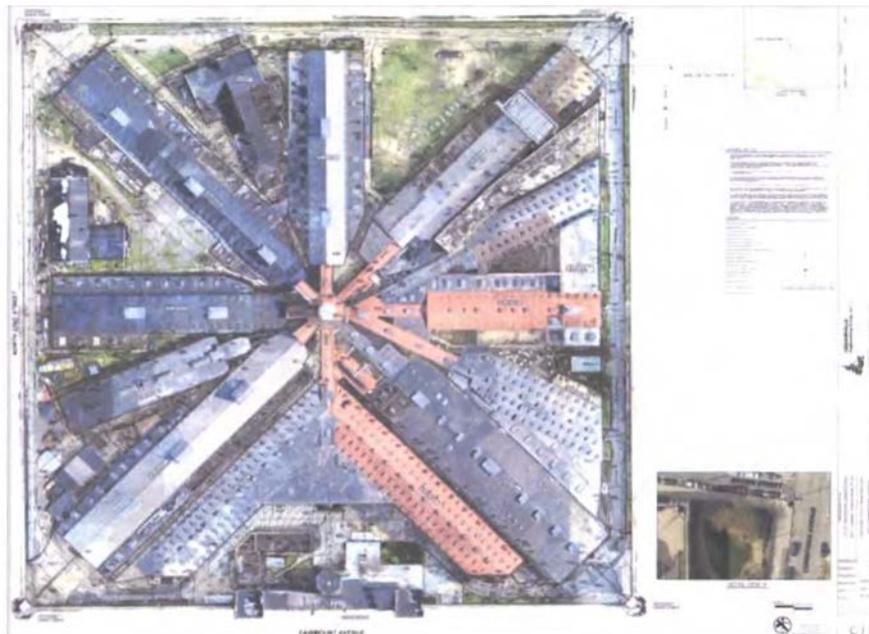
Figure 7.3 – Sample Print Preview of Schedule (Encore Group, 2016)



*Figure 7.4 – Schedules and Resource Histograms within Asta Powerproject (Encore Group,  
2016)*

## 8.0 OTHER TECHNOLOGIES USED BY THE CONSTRUCTION INDUSTRY

The construction industry is slowly incorporating new technology, but there are many reasons as to why adaptation is in slow-gear: lack of IT staff, budget, employee hesitancy, lack of IT experience, management hesitancy, and maturity of technology (Bentley, 2017). Some emerging technologies are laser scanning, field communications, augmented and virtual reality, and drones. A brief overview of laser scanning is that it scans the existing conditions in 3D using either a handheld camera or laser scanner. Figure 8.1 shows the product of a laser scan.



*Figure 8.1 – Laser Scan with Bentley (Bentley, 2017)*

There are however, challenges to adopting such technology; acquisition methods, understanding precision and accuracy, costs in start-up and equipment, and with drones—there are regulations governing the use of drones. Augmented and virtual reality in the construction industry is growing. “Virtual reality takes 3D modeling to new heights by giving designers the opportunity to work with vivid and lifelike structures, instead of the age-old scaled mock-up models. Professionals are employing drones and laser scanners to gather information about a project site, which they’re then using to create VR models” (GenieBelt, 2017). One way of using augmented reality would be to “replace laser tripod scanners in mapping project sites and create templates for VR models in real time. The goal of this impending merger is to make scanning and rendering so smooth and effortless that construction crews can do it daily, establishing a tight feedback loop around quality control” (GenieBelt, 2017). McCarthy, a 152-year-old construction company uses VR technology and is constantly upgrading it. “In 2012, McCarthy built its own Building Information Modeling (BIM) Cave, which uses projection technology and 3D glasses to allow multiple users to see what a hospital room or office space will look like” (Gaudiosi, 2015). Mike Oster, Vice President at McCarthy states that “We’re at a point where we can fly a drone around, laser scan an area, upload that model into a VR headset, and walk through the model using a virtual immersion tool.”

## 9.0 RESULTS

Upon reviewing information from various companies, Figure 9.1 shows the data collected from each company.

<b>Companies:</b>	<b>Take-Off</b>	<b>Estimating</b>	<b>Scheduling</b>	<b>Project Management</b>
<b>Lithko Contracting, LLC</b>	None indicated	Excel	None indicated	None indicated
<b>Bulley &amp; Andrews, LLC</b>	Bluebeam	Bluebeam & Excel	MS Project & Excel	Procore
<b>Hensel Phelps</b>	Bluebeam	None indicated	Asta Powerproject	None indicated
<b>The Walsh Group</b>	Bluebeam & On-Screen Take-off	HCSS & Bluebeam	P6 & MS Project	None indicated

*Figure 9.1 – Company Data of Technology Usage (Bien, 2017)*

Figure 9.2 shows the pros and cons between Excel and ProEst. It shows that ProEst is a more robust software that covers the needs of the construction industry.

Excel vs. ProEst	
Control issues	Cloud-based
More human error is introduced	User-Friendly Interface
Not a database	Ability to perform quick digital takeoffs from set of blueprints
Not specifically made for construction	Can integrate seamlessly into Procore
Files are saved onto computer, sharing requires manual delivery	Generates professional reports quick
Broken or incorrect formulas can throw the estimate off	Has a RSMeans database with current figures
Reports and formatting take time	Affordable, almost half the price of its competitors
Hard to track errors in formulas	Enables team collaboration anywhere, anytime

*Figure 9.2 – Excel vs. ProEst (Bien, 2017)*

Figure 9.3 covers the pros and cons for MS Project and Asta Powerproject. The data shows that Asta builds on where the industry is heading. It incorporates BIM and continually improves using the needs of the construction industry.

<b>MS Project vs. Asta Powerproject</b>	
Integrates with MS Suite and Procore	Easy to use
Custom reports are difficult to make	Can integrate with other software
Time-consuming	Generates professional reports
Manual data input	BIM Add-on
Steep learning curve	4D Planning enables for problems to be detected easier
Focus is not construction	Cost-effective in comparison to its competitors
Does not enable collaboration	Shorter learning curve
Stored locally	Construction specific training courses

*Figure 9.3 – MS Project vs. Asta Powerproject (Bien, 2017)*

Figure 9.4 covers the pros and cons between Procore and face to face collaboration. Procore goes beyond groups meeting up and working individually, then combining the work afterwards. Procore shows promise in team development and collaboration according to the data.

<b>Procore vs. Face to Face Collaboration</b>	
Cloud-based, users can work anywhere, anytime	Lack of control of project
Daily log of submittals	No log of activities
Enables collaboration	Local storage – files can get lost
Unlimited storage	Manual
Great document management tool	Lack of communication

*Figure 9.4 – Procore vs. Face to Face Collaboration (Bien, 2017)*

## 10.0 RECOMMENDATIONS

The construction industry challenges of productivity, profitability, performance, labor, and sustainability can be mitigated. It will, however, take adaptation of the emerging technologies in the industry. The concluding recommendation for the companies in the construction industry are as follows (10.1):

<b><u>Recommendations for the Construction Industry</u></b>	
<b>Take-off</b>	Bluebeam
<b>Estimating</b>	ProEst
<b>Scheduling</b>	Asta PowerProject
<b>Project Management</b>	Procore

*Figure 10.1 – Recommendations for the Construction Industry (Bien, 2017)*

Bluebeam will help expedite the take-off process for projects big and small. Tools like OCR and batch link help prevent users from ever having to sift through blueprints manually. Bluebeam also counts items and figures square footage. ProEst will allow users to generate quality and professional reports for their clients. It also keeps all documents in one central location with an RSMeans database to give users the most up-to-date information. Asta Powerproject has a shorter learning curve as well as the functionality to generate quality reports like ProEst. It is cheaper than its competitors and is made specifically for the construction industry. Procore will be able to combine all of the software into its cloud database and allow for users to collaboratively work from anywhere, anytime. These applications get the job done and at a fraction of the cost.

For the construction management classrooms, the recommendations will be for specific courses in the curriculum (Fig. 10.2)

<b><u>Recommendations for the Construction Management Classrooms</u></b>	
Computers for Applied Engineering & Technology	Introductions to the Cloud and how to collaboratively work on it. Some options would include A360 and/or Google Drive
Architectural Drafting & Blueprint Reading	Bluebeam capabilities
Construction Cost Estimating	Bluebeam & ProEst
Construction Project Management	General introductions to: Asta PowerProject, Procore, Bluebeam, ProEst, Sketchup
Safety for Engineering and Technology Professionals	Procore – daily log, inspections, detailed observations
Virtual Design	Bluebeam, ProEst, Asta Powerproject, Procore & Revit
Surveying & Site Planning	Procore – detailed observations (field notes), and material tracking

*Figure 10.2 – Recommendations for the Construction Management Classrooms*

The recommendation for Computers for Applied Engineering & Technology is to continue introductions to the Microsoft Office 365 Suite. Then, students should work on the cloud and learn how to collaboratively work with others. This provides students with a tool that will last through the years. For Architectural Drafting & Blueprint Reading, it is recommended that this class use every capability of Bluebeam, as it will help them greatly maneuver blueprints

digitally rather than sit and sift through printed blueprints page by page. Students should learn how to use the count, dynamic fill, batch link, OCR, and other tools in the arsenal. For the Construction Cost Estimating course, students should receive more exposure to Bluebeam and an intimate introduction to ProEst. They should be able to create detailed reports and present the data effectively. Construction Project Management is a senior level course and therefore should cover at minimum, the introductions to Asta Powerproject, Bluebeam, ProEst, and Sketchup. More emphasis should be placed on Procore, as it is a project management solution. The Safety class should use Procore's quality & safety features that include daily logs, inspections, and detailed observations. Virtual design should include Bluebeam, ProEst, Asta Powerproject, Procore, and Revit. Sketchup is good for quick sketches but Revit is more advanced and can integrate with Autodesk software as well as the recommended software. Revit shows that students can understand technical information. Lastly, Surveying & Site Planning should make use of Procore's material tracking and observations. Procore is available on mobile devices, which makes it compatible with surveying and taking field notes. Another optional technology integration would be laser scanning. Drones have the capability to aid in laser scanning. From there, students will be able to see the grading of the land. These recommendations will further massage the software into their memory and better prepare students for the work ahead.

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