

Integrated Building Information Modeling Using Off-the-shelf Software Components

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Using Revit, e-Specs and Microsoft Project for Integrated BIM

Integrated Building Information Modeling Using Off-the-shelf Software Components: Using Revit, e-Specs and Microsoft Project for Integrated BIM

Benjamin Frick

This paper examines how a piece of software, Autodesk Revit Architecture 2011, can be used to create an integrated information model for any project using BIM (Building Information Modeling) technology. With the help of e-SPECS for Revit, specifications can be written with a simple add-on to a Revit interface. This leads to great possibilities and proves further that BIM software, in this case, Revit Architecture, is capable of more than just 3D modeling and producing project documents. This could change the way architects do specifications and cost estimating. For the purposes of this research, a demo project was used to show how any project can be updated with cost and assembly code data and produce cost and specification information. Another component Revit has to offer is its ability to create schedules. After creating a schedule (walls, doors, windows etc.), it is simple to add or subtract information. Once finished, these schedules produced can easily be tied in with Microsoft Excel to create a more attractive looking table. You can also add or edit information that Revit wouldn't allow you to do (construction phasing, cost per square foot, etc.). To take it a step further, Microsoft Project can be introduced to formulate project/construction management information (Gantt charts, calendars, network diagrams, task forms, timelines, etc.). This could be broken down by phases of construction and give the Architecture firm and contractor the ability to calculate cost more effectively as a project moves from phase to phase. From there on, it's up to the firm on where they want to take the next step, there are no limits to the capabilities of BIM technology.

INTRODUCTION AND BACKGROUND

The following programs are off-the-shelf components used for the Integrated BIM model:

BIM & Revit:

Before BIM (Building Information Modeling), Architects predominantly used AutoCAD which is a 2D based drafting program. Revit has not only allowed for its users to see their projects in a 3D setting but edit the buildings components and store this information in the model itself.

Another issue AutoCAD has that Revit has fixed is its ability to change details in one set of drawings and instantly the edited details are changed in its corresponding views. For instance, if you changed a windows location in a wall by 2', Revit then changes that window in every elevation, floor plan or any other corresponding view by 2'. In AutoCAD you would have to manually change every document that corresponded to that window. So, if you missed a set of drawings with that change, that mistake could be made during the construction phase of the design. Overall, this concept of BIM software provides a building to be built virtually, prior to building it physically, in order to work out problems, and simulate and analyze potential impacts.

e-SPECS for Revit:

e-SPECS for Revit combines with Revit's parametric database, instantly updating your project specifications to the requirements of the building model. If a wall, door, window or any other building object is inserted into your Revit model, e-SPECS instantly updates your project manual with the appropriate specifications. Then, with the use of the e-SPECS program itself you can easily add project notes, update sections and turn on or off certain specs to use.

RSMeans Assemblies Cost Data 2010:

This tool provides assembly and component costs organized in a Uniforamt II numbering system (the same system used in Revit Architecture 2011). With its accompanying reference data you can quickly estimate a building's square foot cost and easily compare and price alternatives.

This book can also be used for its reference tables, cost indexes, square foot costs, reference aids, and estimating forms.

Microsoft Project 2010:

This program uses enhanced collaboration and reporting, built on SharePoint2010. It is used to reduce cost and drive efficiency through unified project and portfolio management. As you get familiar with the interface, your productivity is enhanced allowing you to use the scalable and connected platforms. It can become a very powerful tool for both the construction industry and project management. Microsoft Project even provides a commercial construction template downloadable from their main website that covers every phase for a three-story commercial office building of 76,000 square feet.

The initial research direction of designing an “integration of cost estimates in a Revit 3D model” quickly turned into “integrated Building Information Modeling using off-the-shelf software components” and what possibilities could come from this integration. Throughout the research, Revit Architecture, e-SPECS for Revit, RSMMeans and Microsoft Project were the programs used to test this theory of BIM integration and the results of the research were more than positive. Reading on, you will find information on BIM's history in the profession, information on cost estimation, the introduction to Microsoft Project and how the program e-SPECS can be used to implement specifications from a Revit Architecture BIM model.

BIM takes information that used to be stored in multiple files (AutoCAD drawings) and combines every aspect of the building design into one complex 3D information model. With the use of off-the-shelf software components, information from the BIM model can be formulated into Gantt charts, cost analysis data, etc. to provide a full range of options to a firm or client to better understand what fits best for their needs.

Cost estimation and the writing of specifications were once separate parts of the design process, but not anymore. Using Autodesk Revit Architecture and e-SPECS for Revit, both cost estimation and specifications information can be produced. With Revit's BIM (Building Information Modeling) technology, cost data can be placed in any of the building's components.

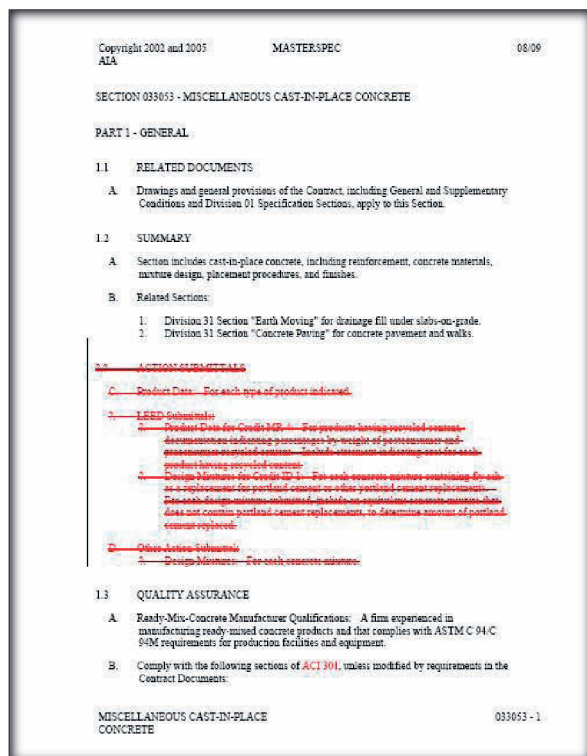
To insert information, simply click on any of your buildings components, and in your properties menu select "Edit Type". From there you can add the following information to the identity data: Keynote, Model, Manufacturer, Type Comments, URL, Description, Assembly Code, Type Mark, Fire Rating and Cost. You will see that "Assembly Description" is not editable in the identity data. This is because it is directly linked to the assembly code. Once you identify the assembly code, information will automatically be filled in with the assembly code's description you have chosen. The more accurate the selection the more accurate the description will be. For instance, if you want an exterior wall with wood studs and a stucco finish, you select: B – Shell > B20 – Exterior Enclosure > B2010 – Exterior Walls > B2010100 – Exterior Wall Construction > B2010180 – Wood Stud w/ Stucco.

This information can then be processed into a schedule and formatted to show information like: cost per square foot, count, name/description, assembly code, total cost information and more. These schedules are categorized by different component systems (i.e. walls, windows, doors, etc.). After creating a schedule, it is simple to add or subtract information. Once finished, these schedules produced can easily be tied in with Microsoft Excel to create a more attractive looking table. Further down, in the results section of this article you will see there is some information you will have to edit from Revit's scheduling to create a more cohesive schedule/table. You can also add or edit information that Revit wouldn't allow you to do (phasing, cost per square foot, etc.).

To take it a step further, Microsoft Project can be introduced to formulate project/construction management information (Gantt charts, calendars, network diagrams, task forms, timelines, etc. (need sample illustrations of these to be included)). This could be broken down by phases of construction and give the Architecture firm and contractor the ability to calculate cost more effectively as a project moves from phase to phase.

Specifications can be linked through Revit with the help of Unifomat assembly codes which are found through their component properties. Most of the cost information data used for this research report was found using RSMeans Assemblies Cost Data 2010 which links to the Unifomat code, making it easier to cross reference between the components in the design and the cost information provided by RSMeans. The assembly codes classify the components into different detailed categories.

Then with the program e-SPECS, you can process these codes to a specifications booklet which can then be edited using the programs provided editing software or your favorite word processing program. To transfer the specifications from Revit to e-SPECS, you use the provided add-on for Revit through the “Add-Ins” tab on your Revit interface. From there you can create reports, view sections and keynotes, download BPM (acronym needs to be expanded) content, edit the console settings and update your e-SPECS specs with any changes you make as you develop your project. The e-SPECS interface is easy to use and in a short matter of time your specifications booklet is complete and full of information from your Revit model. Of course, it helps to have background knowledge in specifications to understand some of the jargon used, but simple “how to” demo’s provided by the company clear up most of these issues. Below is an example of e-SPECS for Revit’s specification Section 033053 – Miscellaneous Cast-In-Place Concrete. This MASTERSPEC format shows how easy it is to edit the document; simply by clicking on a field to strikeout/highlight project information needed.



METHODS AND TECHNIQUES USED (METHODOLOGY)

Research started on August 27, 2010. The following is a list of procedures used (some by day, others by weeks at a time):

Friday, August 27, 2010

- Upgraded a studio design to a complex building with multiple materials.
- Familiarized self with online software programs for cost estimation.

Sunday, August 29, 2010

- Read Architecture Methods pg.'s 87-95.
- Watched/Reviewed an online demo of "E-Specs for Revit".
- Downloaded Revit 2011 and found a sample design to use with multiple components.
- Researched for other programs that might work with Revit 2011 or 2010 but only found 1 program that could only use the 2008 version of Revit (which can't be downloaded anymore).

Monday, August 30, 2010

- Researched Specifications (Masterformat and CSI).
- Wrote a description of the design problem and what steps need to be taken to solve this research problem over the semester.

Wednesday, September 8, 2010

- Introduced to the "sweets network" which is an online specification and CAD reference tool online.

Friday, September 10, 2010

- Watched an E-Specs demo video on how to use E-Specs with Revit 2011.
- Took notes on video.

Week of September 13-17, 2010

- Worked with the larger demo file on Revit 2011 only to figure out the demo was going to take too long to update with components and assembly codes and code descriptions.
- Started working with the small but complex demo provided by Revit 2011 and updated assembly codes and other basic information.
- E-Specs should be up and running soon.

Week of September 20-24, 2010

- E-Specs for Revit is installed on the computer, however the server downstairs in Klai hall has not been successfully installed because of complications with the programs manufacturer and firewalls.
- Finished working on assembly codes and getting cost information for the components in the demo Revit model.
- Learning about how to integrate cost into wall systems and how walls are calculated.

Week of September/October 27-1, 2010

- E-Specs is installed downstairs but now problems are occurring with the libraries needed for the program to work.
- Downloaded and watched a lecture on how to use Revit with E-Specs and took notes.
- Further developed the model and figuring out a cost formula for wall assembly cost.

Week of October 4-8, 2010

- Read up on Families in my "Mastering Revit Architecture 2008" handbook.
- Printed off "Valid Formula Syntax and Abbreviations" and "Conditional Statements in Formulas" to help formatting equations in schedules.

Week of October 11-15, 2010

- Continued to add cost information from RSMeans to components in the small project demo provided by Revit.

Week of October 18-22, 2010

- Finished adding component costs to entire model with RSMeans Assemblies Cost Data 2010.

Week of October 25-29, 2010

- Figured out how to format walls and other components to calculate cost per square foot.
- Created schedules in Revit and moved them to an Excel file.

Week of November 1-5, 2010

- Started writing the research report in the JAPR format for review.

RESULTS

What was found through this research study was that with the use of Revit and E-SPECS it is possible to produce cost estimation tables and a booklet of specifications. The research results found were designed to show the capabilities of the programs with a variety of components.

Some components were left out (electric, HVAC and plumbing) due to time constraints and very little experience with these systems.

Below (Figure 1.0 and 1.1) is an example of a schedule produced by Revit with a few modifications in the Excel document. One of the modifications was the square foot cost data (shown in the yellow outlined boxes). Revit will allow you to calculate square foot cost, but not through selected type: Currency, instead it only recognizes the formula $\text{area} * \text{cost}$ as selected type: Area. So all that needed to be changed once you export the file to excel from Revit is changing the SF (square foot) to a dollar sign (\$). Apparently this is a common problem with Revit users in that doing a calculated value formula of $\text{Area} * \text{Cost}$ produces not a currency, but an area outcome. Another way to eliminate this problem was found by editing the formatting in Revit to set the Unit Suffix to "None". This just gives you the numbers and may eliminate extra editing in Microsoft Excel.

Modify Schedule/Quantities

Properties

Schedule: Wall Sche Edit Type

Phase New Constr...

Other

Fields Edit...

Filter Edit...

Sorting/Grou... Edit...

Formatting Edit...

Appearance Edit...

Properties help Apply

Revit Demo Small House.rvt - Proje...

Level 2

Legends

Schedules/Quantities

Area Schedule (Gross Buildir

Door Schedule

Furniture Schedule

Multi-Category Material Tak

Room Schedule

Wall Schedule

Window Schedule

Sheets (all)

Families

Groups

Wall Schedule							
Assembly C	Area	Assembly Description	Width	Count	Cost	Cost Per Sq. Ft.	
A2020110	261 SF	Basement Walls - CIP	1' - 0"	1	\$155.50	40524 SF	8" wall height, pumpe
A2020110	313 SF	Basement Walls - CIP	1' - 0"	1	\$155.50	48747 SF	8" wall height, pumpe
B2010100	36 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	723 SF	
B2010100	37 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	751 SF	
B2010100	46 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	924 SF	
B2010100	51 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	1026 SF	
B2010100	56 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	1124 SF	
B2010100	57 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	1150 SF	
B2010100	118 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	2360 SF	
B2010100	150 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	3009 SF	
B2010100	205 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	4111 SF	
B2010100	256 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	5135 SF	
B2010100	702 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	14071 SF	
B2010180	16 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	135 SF	
B2010180	32 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	277 SF	
B2010180	88 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	759 SF	
B2010180	134 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	1147 SF	
B2010180	233 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	1999 SF	
B2010180	273 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	2347 SF	
B2010180	641 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	5506 SF	
B2020200	89 SF	Curtain Walls		1			Cost is measured by
B2020200	105 SF	Curtain Walls		1			Cost is measured by
B2020200	280 SF	Curtain Walls		1			Cost is measured by
C1010100	1 SF	Fixed Partitions	0' - 2"	1	\$20.09	24 SF	Glass Railing
C1010100	1 SF	Fixed Partitions	0' - 2"	1	\$20.09	29 SF	Glass Railing
C1010100	24 SF	Fixed Partitions	0' - 2"	1	\$20.09	480 SF	Glass Railing
C1010100	35 SF	Fixed Partitions	0' - 2"	1	\$20.09	700 SF	Glass Railing
C1010100	50 SF	Fixed Partitions	0' - 2"	1	\$20.09	1007 SF	Glass Railing

(Figure 1.0) this figure shows how Revit produced Cost Per Sq. Ft. data in SF instead of a currency.

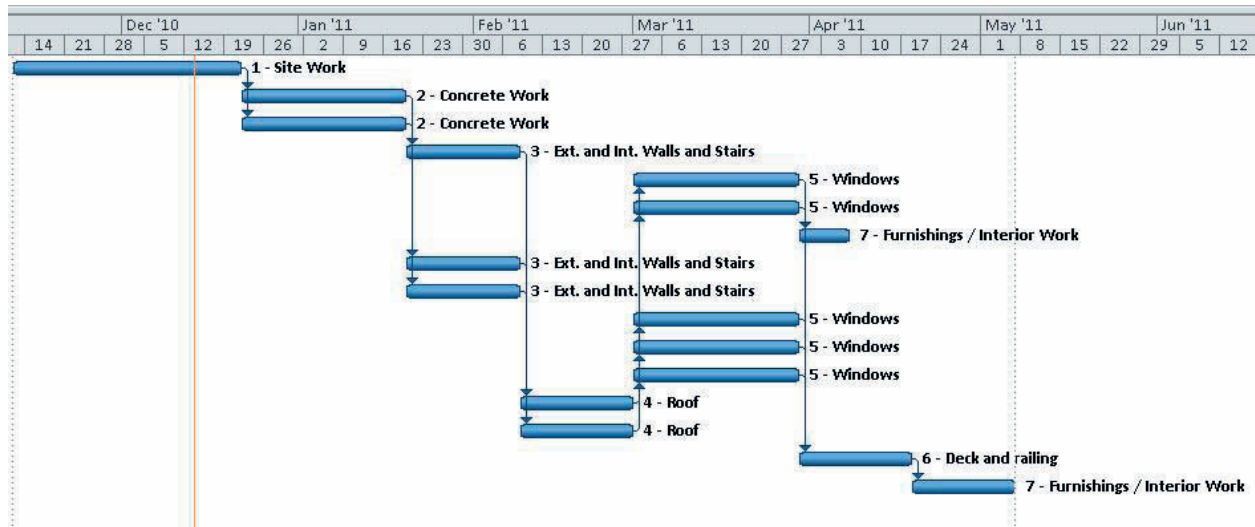
Wall Schedule							
Assembly Code	Area	Assembly Description	Width	Count	Cost Per Sq. Ft.	Cost	Description
A2020110	261 SF	Basement Walls - CIP	1' - 0"	1	\$155.50	\$ 40,524.00	8" wall height, pumped, 12" wall thickness
A2020110	313 SF		1' - 0"	1	\$155.50	\$ 48,747.00	
B2010100	36 SF	Exterior Wall Construction	0' - 8"	1	\$20.05	\$ 723.00	CIP concrete, reinforced, 8" thick, plain finish, 3000 PSI
B2010100	37 SF		0' - 8"	1	\$20.05	\$ 751.00	
B2010100	46 SF		0' - 8"	1	\$20.05	\$ 924.00	
B2010100	51 SF		0' - 8"	1	\$20.05	\$ 1,026.00	
B2010100	56 SF		0' - 8"	1	\$20.05	\$ 1,124.00	
B2010100	57 SF		0' - 8"	1	\$20.05	\$ 1,150.00	
B2010100	118 SF		0' - 8"	1	\$20.05	\$ 2,360.00	
B2010100	150 SF		0' - 8"	1	\$20.05	\$ 3,009.00	
B2010100	205 SF		0' - 8"	1	\$20.05	\$ 4,111.00	
B2010100	256 SF		0' - 8"	1	\$20.05	\$ 5,135.00	
B2010100	702 SF		0' - 8"	1	\$20.05	\$ 14,071.00	
B2010180	16 SF	Ext. Wall - Wood Stud w/ Siding & Shingles	0' - 7"	1	\$8.59	\$ 135.00	2"x6" studs, 16" O.C., insul. Wall, w/ 5/8" text. 8" alluminum siding
B2010180	32 SF		0' - 7"	1	\$8.59	\$ 277.00	
B2010180	88 SF		0' - 7"	1	\$8.59	\$ 759.00	
B2010180	134 SF		0' - 7"	1	\$8.59	\$ 1,147.00	
B2010180	233 SF		0' - 7"	1	\$8.59	\$ 1,999.00	
B2010180	273 SF		0' - 7"	1	\$8.59	\$ 2,347.00	
B2010180	641 SF		0' - 7"	1	\$8.59	\$ 5,506.00	
B2020200	394 SF	Curtain Walls Glazing			\$20.40	\$ 8,037.00	Alum flush tube frame, for 1/4" glass, 1-3/4"x4", 5'x6' opng, no
B2020210	474.13 SF				\$37.65	\$ 17,850.99	
C1010100	1 SF	Fixed Partitions	0' - 2"	1	\$20.09	\$ 24.00	Glass Railing - http://www.glassrail.com/pages/Glassrail.htm
C1010100	1 SF		0' - 2"	1	\$20.09	\$ 29.00	
C1010100	24 SF		0' - 2"	1	\$20.09	\$ 480.00	
C1010100	35 SF		0' - 2"	1	\$20.09	\$ 700.00	
C1010100	50 SF		0' - 2"	1	\$20.09	\$ 1,007.00	
C1010140	17 SF	Partitions - Drywall w/ Wood Stud	0' - 4 1/2"	1	\$4.06	\$ 67.00	5/8" FR drywall, no base layer, 2x4 @ 16" O.C., opp. Face same, 0 ins.
C1010140	19 SF		0' - 4 1/2"	1	\$4.06	\$ 77.00	
C1010140	23 SF		0' - 4 1/2"	1	\$4.06	\$ 93.00	
C1010140	23 SF		0' - 4 1/2"	1	\$4.06	\$ 93.00	
C1010140	26 SF		0' - 4 1/2"	1	\$4.06	\$ 106.00	
C1010140	28 SF		0' - 4 1/2"	1	\$4.06	\$ 113.00	
C1010140	30 SF		0' - 4 1/2"	1	\$4.06	\$ 123.00	
C1010140	33 SF		0' - 4 1/2"	1	\$4.06	\$ 133.00	
C1010140	34 SF		0' - 4 1/2"	1	\$4.06	\$ 139.00	
C1010140	41 SF		0' - 4 1/2"	1	\$4.06	\$ 167.00	
C1010140	42 SF		0' - 4 1/2"	1	\$4.06	\$ 172.00	
C1010140	44 SF		0' - 4 1/2"	1	\$4.06	\$ 179.00	
C1010140	44 SF		0' - 4 1/2"	1	\$4.06	\$ 180.00	
C1010140	57 SF		0' - 4 1/2"	1	\$4.06	\$ 232.00	
C1010140	76 SF		0' - 4 1/2"	1	\$4.06	\$ 309.00	
C1010140	92 SF		0' - 4 1/2"	1	\$4.06	\$ 373.00	
C1010140	130 SF		0' - 4 1/2"	1	\$4.06	\$ 527.00	
C1010140	134 SF		0' - 4 1/2"	1	\$4.06	\$ 543.00	
C1010140	164 SF		0' - 4 1/2"	1	\$4.06	\$ 664.00	
C1010140	200 SF		0' - 4 1/2"	1	\$4.06	\$ 814.00	
C1010145	129 SF	Partitions - Drywall w/ Metal Stud	0' - 6 1/2"	1	\$1.63	\$ 211.00	Metal stud, 16" O.C., including track, non load bearing, 25 page,
C1010145	150 SF		0' - 6 1/2"	1	\$1.63	\$ 244.00	
Grand total: 51						\$ 169,511.99	

(Figure 1.1) This figure shows how changes were made to calculate SF data to currency in Excel.

There were issues and complications with phasing in Revit. It was possible to edit each component and insert data for phasing in each component, but when it came to producing these results and phase numbers in a schedule, there was no found solution. Different formulas were attempted and “adding a parameter” or creating a “calculated value” didn’t seem to do the trick. So instead of spending valuable time on troubleshooting the program itself (knowing there wasn’t going to be an easy solution), it was decided to move on and manually place the phasing information in Excel. After doing this, the information from Excel was taken into Microsoft Project and formulated into a Gantt chart (Figure 1.2 and 1.3).

Task Name	Duration	Start	Finish	Predecessors	Phase
Site Work	28 days	Fri 11/12/10	Tue 12/21/10		1 - Site Work
Basement Walls - CIP	21 days	Wed 12/22/10	Wed 1/19/11	1	2 - Concrete Work
Exterior Wall Construction	21 days	Wed 12/22/10	Wed 1/19/11	1	2 - Concrete Work
Ext. Wall - Wood Stud w/ Siding & Shingles	14 days	Thu 1/20/11	Tue 2/8/11	2,3	3 - Ext. and Int. Walls and Stairs
Curtain Walls Glazing	21 days	Tue 3/1/11	Tue 3/29/11	13,14	5 - Windows
Tubular Aluminum Framing	21 days	Tue 3/1/11	Tue 3/29/11	13,14	5 - Windows
Fixed Partitions - Interior Glass railing	7 days	Wed 3/30/11	Thu 4/7/11	5,6	7 - Furnishings / Interior Work
Partitions - Drywall w/ Wood Stud	14 days	Thu 1/20/11	Tue 2/8/11	2,3	3 - Ext. and Int. Walls and Stairs
Partitions - Drywall w/ Metal Stud	14 days	Thu 1/20/11	Tue 2/8/11	2,3	3 - Ext. and Int. Walls and Stairs
Interior Doors - Wood	21 days	Tue 3/1/11	Tue 3/29/11	13,14	5 - Windows
Exterior Glazed Doors - Wood	21 days	Tue 3/1/11	Tue 3/29/11	13,14	5 - Windows
Windows - Wood	21 days	Tue 3/1/11	Tue 3/29/11	13,14	5 - Windows
Roofing - Preformed Metal	14 days	Wed 2/9/11	Mon 2/28/11	8,4,9	4 - Roof
Deck - Metal	14 days	Wed 2/9/11	Mon 2/28/11	4,8,9	4 - Roof
Exterior Decks and Railings	14 days	Wed 3/30/11	Mon 4/18/11	5,6,10,11,12	6 - Deck and railing
Interior Furnishings / Interior Work	14 days	Tue 4/19/11	Fri 5/6/11	15	7 - Furnishings / Interior Work

(Figure 1.2) Phase information put into Microsoft Project.



(Figure 1.3) Gantt chart produced by Microsoft Project from information in Figure 1.2

CONCLUSION AND PROJECTION INTO THE FUTURE

Overall, the information found in this research was possible from past education and helpful online tutorials. A more accurate cost estimation and detailed specifications booklet could have been produced with more experience in specifications and cost estimation. However, if both outside experience and known information about these programs were combined, projects could be estimated and specified to a very high degree of detail. Not to mention, if phasing was fixed in Revit to show up in scheduling, construction/project management would be able to use this information straight from the BIM model instead of having to create their own separate documents.

The future of Integrated BIM has endless possibilities; however, to better understand where Integrated BIM is today, the following example may clear up some of those possibilities in dimensional format:

2D – Something with 2 dimensions (hand drawn architectural drawings)

3D – Something seen in 3 dimensions; width, length and height (a computer or physical model)

4D – Adding the aspect of “Time” to a project (phasing/sequencing – Microsoft Project)

5D – Adding the aspect of “Cost” to a project (cost estimating – Revit Architecture)

6D – Adding the aspect of “Specifications” to a project (e-SPECS for Revit)

Together, these dimensions create a more complex integration of BIM than what was possible before. Who knows, maybe the Integration of BIM will reach 10D or even 20D in the future which will take the profession of Architecture to a whole new level of design.

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AUTOBIOGRAPHICAL SKETCH

Benjamin Frick is currently a graduate student at North Dakota State University in Fargo, North Dakota. His research focuses on using Revit and e-Specs for Revit to produce cost estimation and specifications.