**Spatial Planning:**

The purpose of this research is to analyze the usefulness of animating the space planning process by creating generic masses that would allow someone with little software experience to create a 4D spatial plan. On WestEnd**25** the typical spatial trade conflicts were expected and merely tolerated. This paper's process goal will be to allow a general contractor to have an easy medium that spatial planning can be completed and trade interference can be avoided. The idea behind this analysis is that designers will be more likely to use designing software based on parametric data which can quickly produce three dimensional representations of their designs. According to a poll by the American Institute of Architects shows that 10% of architectural firms that have purchased Building Information Modeling, BIM, and software are using it for billable work[4]. It is expected that the amount of architecture firm will only increase. With the use of such software becoming common place, contractors will be faced with an ability to use a tool to help with project planning. Designers who use such software will be able to share versions with different parties of the project team with a copy of the building. One potential use of this software for a contractor will be for spatial planning. This analysis looks at using Revit Architecture (Revit), a database modeling program, and NavisWorks, a multipurpose planning program in order to plan the flow of trades through a building floor plan. The main criteria that will be used to determine the success will be ease of the process and the time to complete.

**Workflow:**

The workflow shown in Figure SP2, starts with the assumption of a complete architectural model and project schedule. The architectural model can be copied as a contractor version so that a contractor may edit the model data in terms of inserting blocks, as discussed above. To insert the block the contractor needs to go to the desired floor plan in the model and load the block library into the project. From this stage the contractor can begin inserting the specific trade blocks in their desired location. NavisWorks lists the blocks in the sequential order in which they were entered into Revit. This is important because the step of linking the blocks to the schedule can be facilitated by logically placing the block in the order that they will be tied to schedule activities. Figure SP1 shows a potential layout of the imported schedule and model object.

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[4] Goldberg, H. Edward, AIA. How Are Architects Using Digital Design Tools? *Cadalyst.* June 1, 2007.
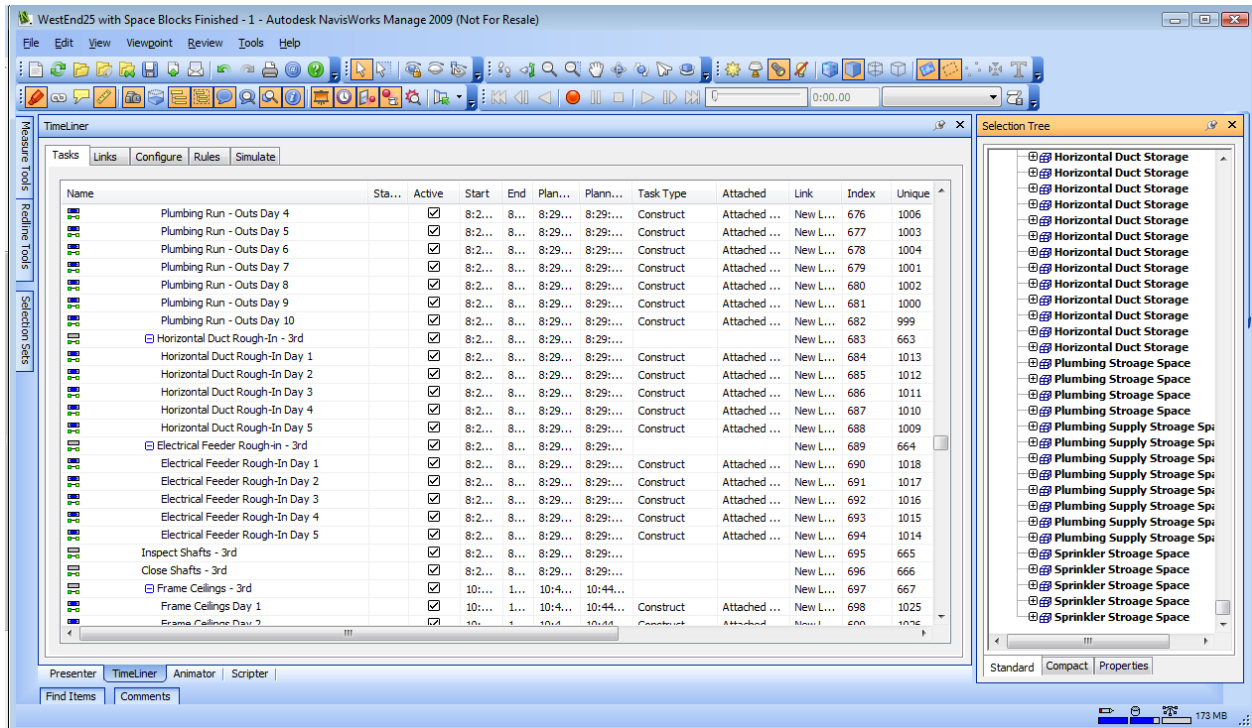
Figure SP1: NavisWorks Schedule – Object Interface

The project schedule should show the specific activities and durations of the work space that are being modeled in Revit.  Once all the blocks are inserted the floor plan can be exported to NavisWorks.  In NavisWorks the project schedule can be imported.  Linking the activities in the schedule to the objects creates a 4D representation of the trade flow on a floor.  This flow should be evaluated for major clashes or out of sequenced work.
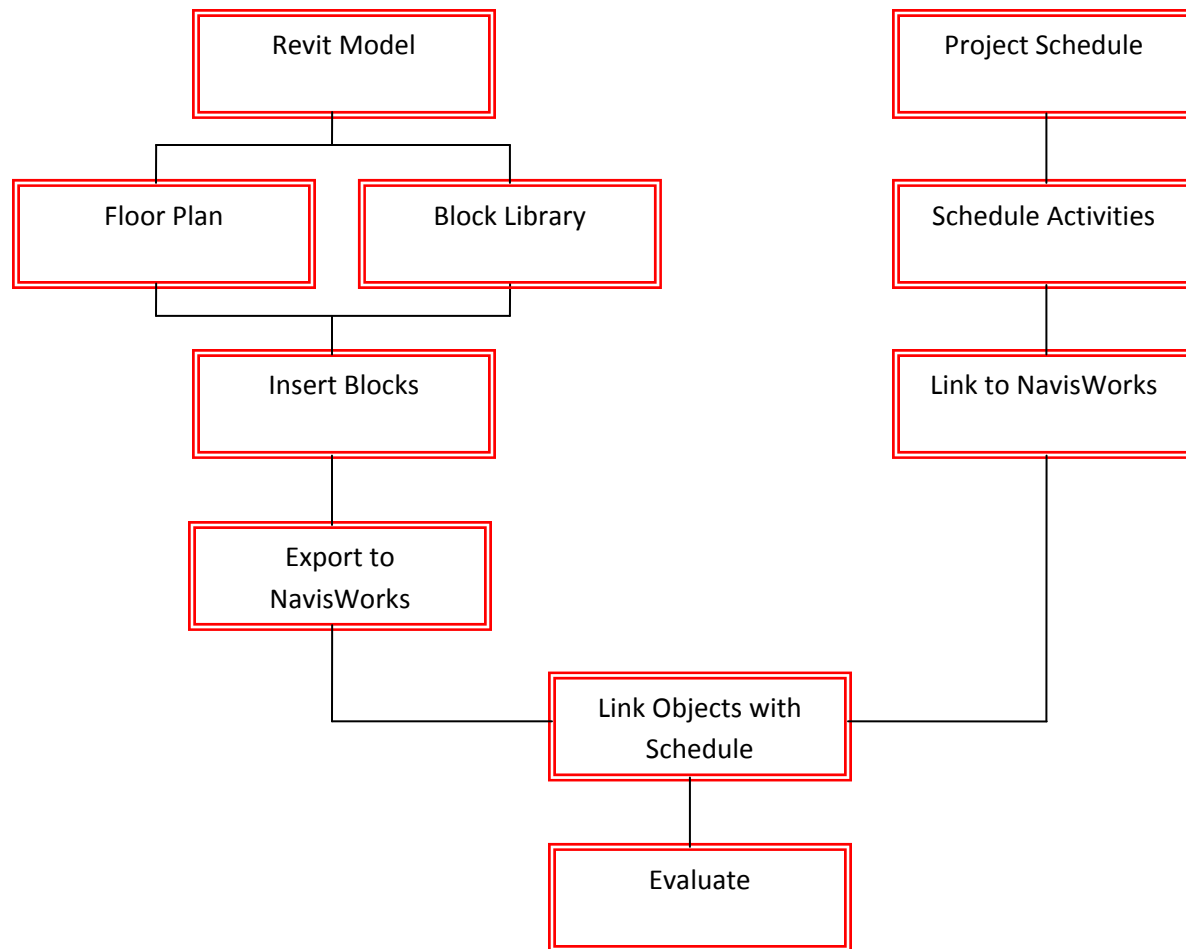
```
┌─────────────────┐                          ┌─────────────────┐
│   Revit Model   │                          │ Project Schedule│
└─────────────────┘                          └─────────────────┘
        │                                             │
   ┌────┴────┐                                        │
┌──────────┐ ┌──────────────┐              ┌───────────────────┐
│Floor Plan│ │ Block Library│              │Schedule Activities│
└──────────┘ └──────────────┘              └───────────────────┘
   └────┬────┘                                        │
┌─────────────────┐                          ┌─────────────────┐
│  Insert Blocks  │                          │ Link to NavisWorks│
└─────────────────┘                          └─────────────────┘
        │                                             │
┌─────────────────┐                                   │
│    Export to    │                                   │
│    NavisWorks   │                                   │
└─────────────────┘                                   │
        │         ┌─────────────────┐                 │
        └─────────│ Link Objects with│────────────────┘
                  │    Schedule     │
                  └─────────────────┘
                          │
                  ┌─────────────────┐
                  │    Evaluate     │
                  └─────────────────┘
```

Figure SP2: Animated Spatial Planning Workflow

**Blocks:**

The creation of space blocks is an important step in the planning process. The time taken to determine the size and create the shapes of the space blocks have not been considered as part of the planning process.  This is because once they are created they can be reused for multiple projects.  In the workflow above this is called a Block Library to highlight the preexisting choices of blocks that can be picked from.  The size of these block are based on typical medium sized floor planes.  Blocks were created for work space, storage space, and equipment space for each building system.  An advantage of the multiple blocks is that they only need to be created once and then can be inserted into any project numerous times.
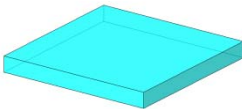
**Specific vs. Generic:**

The blocks that have been created for the Block Library are considered specific blocks.  They have been created with a particular trade in mind.  Specific blocks allow easier assigning of schedule activities in the planning program.  The downside to this is that similar proportioned blocks must be
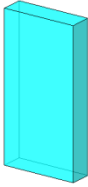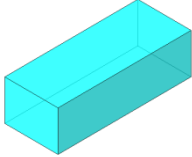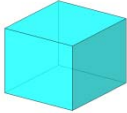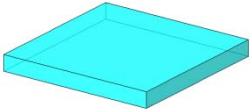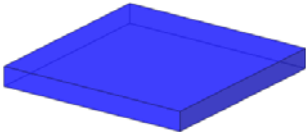
inserted at relatively same locations on the floor plan and Revit does not accept overlapping blocks well. The benefit of generic blocks is that they only need to inserted once into Revit and then can be tied to a specific trade in the schedule with relative ease in NavisWorks.  This concept works well for wall spaces that will have multiple trades working at different times.  Therefore, instead of inserting the same space five times for five different trades, it only needs to be inserted once and multiple trades can be associated to that space at different times in the planning program.   Furthermore, it is important to note that the blocks should be inserted into Revit as the spaces would be used in real life.  NavisWorks maintains the knowledge of the order the blocks were inserted and lists the blocks in that order. Therefore, an organized insertion method makes tying blocks to the schedule much easier.  Table SP1 below highlights important aspects of generic and specific block types.

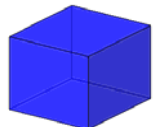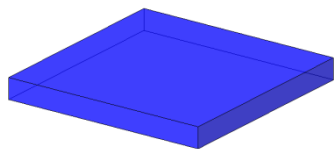| Blocks | Software | User |
|--------|----------|------|
| Generic | Allows multiple selection of same space for multiple trades | Best to put in order to be tied to schedule |
| Specific | Color characteristics are lost in the export to NavisWorks | Cannot put more than one block in one location in Revit |
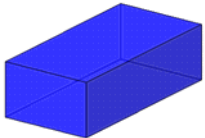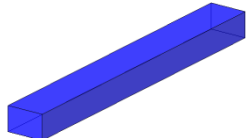
Table SP1: Block Type Shortcomings
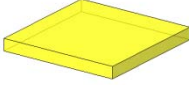
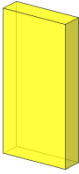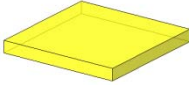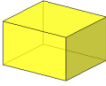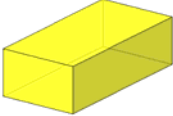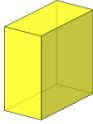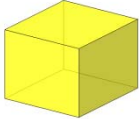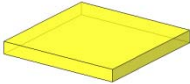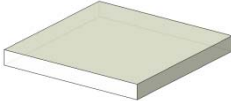The summary of the Block Library can be found in the Table SP2 below:

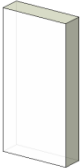| Trade Activity | Properties |
|----------------|------------|
| Mechanical | |
| Mechanical Ceiling:  | Description of Properties: <br><br> Size- <br> Width: 20' <br> Height: 2' <br> Depth: 20' |

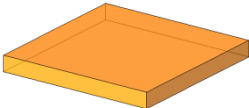| Mechanical Wall: | Description of Properties: |
|---|---|
| | Size-<br>Width: 2', 3', 5', 10'<br>Height: 10'<br>Depth: 1' 6" |
| Mechanical Duct Storage Space: | Description of Properties:<br><br>Size-<br>Width: 4'<br>Height: 3'6"<br>Depth: 10' |
| Mechanical Finishes Storage Space: | Description of Properties:<br><br>Size-<br>Width: 4'6"<br>Height:<br>Depth:<br><br>Number per Story- |
| Mechanical Finishes Work Space: | Description of Properties:<br><br>Size-<br>Width: 20'<br>Height: 2'<br>Depth: 20' |
| Plumbing | |
| Plumbing Ceiling: | Description of Properties:<br><br>Size-<br>Width: 20'<br>Height: 2'<br>Depth: 20' |

| | |
|---|---|
| Plumbing Wall: | Description of Properties: |
| | Size- |
| | Width: 2', 3', 5', 10' |
| | Height: 10' |
| | Depth: 1' 6" |
| Plumbing Storage Space: | Description of Properties: |
| | Size- |
| | Width: 4'6" |
| | Height: 3' |
| | Depth: 10' |
| Plumbing Work Space: | Description of Properties: |
| | Size- |
| | Width: 3' |
| | Height: 2' |
| | Depth: 25' |
| Plumbing Finishes Storage Space: | Description of Properties: |
| | Size- |
| | Width: 4'6" |
| | Height: 3' 8" |
| | Depth: 5' |
| Plumbing Finishes Work Space: | Description of Properties: |
| | Size- |
| | Width: 20' |
| | Height: 2' |
| | Depth: 20' |
| | Number per Story- |

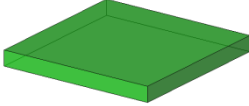| | |
|---|---|
| **Electrical** | |
| Electrical Ceiling Work Space: | Description of Properties:<br><br>Size-<br>Width: 20'<br>Height: 2'<br>Depth: 20' |
| Electrical Wall Work Space: | Description of Properties:<br><br>Size-<br>Width: 2', 3', 5', 10'<br>Height: 10'<br>Depth: 1' 6" |
| Electrical Roughin Room Space: | Description of Properties:<br><br>Size-<br>Width: 20'<br>Height: 2'<br>Depth: 20' |
| Electrical Roughin Skid Storage: | Description of Properties:<br><br>Size-<br>Width: 5'<br>Height: 3'<br>Depth: 4' 6" |
| Electrical Roughin Storage Space: | Description of Properties:<br><br>Size-<br>Width: 5'<br>Height: 3'<br>Depth: 10' |

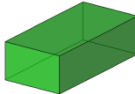| Electrical Work Space: | Description of Properties: |
|---|---|
|  | Size-<br>Width: 5'<br>Height: 10'<br>Depth: 10' |
| Electrical  Finishes Storage Space: | Description of Properties:<br><br>Size-<br>Width: 4'6"<br>Height: 3' 8"<br>Depth: 5' |
| Electrical  Finishes Work Space: | Description of Properties:<br><br>Size-<br>Width: 20'<br>Height: 2'<br>Depth: 20' |
| **Drywall** | |
| Drywall Ceiling Work Space: | Description of Properties:<br><br>Size-<br>Width: 20'<br>Height: 2'<br>Depth: 20' |
| Drywall Wall Work Space: | Description of Properties:<br><br>Size-<br>Width: 2', 3', 5', 10'<br>Height: 10'<br>Depth: 1' 6" |

| Drywall Storage Space: | Description of Properties: |
|---|---|
| | Size-<br>Width: 4'<br>Height: 3'<br>Depth: 8' |
| **Floor** | |
| Finish Floor Work Space: | Description of Properties: |
| | Size-<br>Width: 20'<br>Height: 10'<br>Depth: 20' |
| **Paint** | |
| Paint Wall Work Space: | Description of Properties: |
| | Size-<br>Width: 2', 3', 5', 10'<br>Height: 10'<br>Depth: 1' 6" |
| Paint Ceiling Work Space: | Description of Properties: |
| | Size-<br>Width: 20'<br>Height: 2<br>Depth: 20' |
| Paint Storage: | Description of Properties: |
| | Size-<br>Width: 5'<br>Height: 3'<br>Depth: 4' 6" |

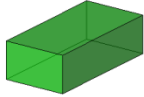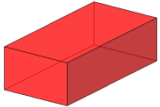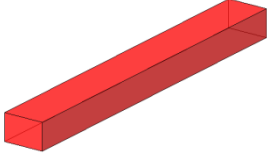| Partitions | |
|---|---|
| Interior Partitions Work Space: | Description of Properties: <br><br> Size- <br> Width: 2', 3', 5', 10' <br> Height: 10' <br> Depth: 1' 6" |
| Frame Walls Work Space: | Description of Properties: <br><br> Size- <br> Width: 2', 3', 5', 10' <br> Height: 10' <br> Depth: 1' 6" |
| Frame Corridor Ceiling Work Space: | Description of Properties: <br><br> Size- <br> Width: 4' <br> Height: 2' <br> Depth: 10' |
| Frame Room Ceiling Work Space: | Description of Properties: <br><br> Size- <br> Width: 20' <br> Height: 2' <br> Depth: 20' |
| Frame Storage: | Description of Properties: <br><br> Size- <br> Width: 5' <br> Height: 3' <br> Depth: 10' |

| Interior Partitions Storage: | Description of Properties: |
|---|---|
|  | Size- <br> Width: 5' <br> Height: 3' <br> Depth: 10' |
| **Sprinkler** | |
| Sprinkler Storage Space: <br>  | Description of Properties: <br><br> Size- <br> Width: 5' <br> Height: 3' <br> Depth: 10' |
| Sprinkler Work Space: <br>  | Description of Properties: <br><br> Size- <br> Width: 3' <br> Height: 2' <br> Depth: 25' |
| **Equipment** | |
| Standard Equipment Space: <br>  | Description of Properties: <br><br> Size- <br> Width: 4' 6" <br> Height: 3' 8" <br> Depth: 5' |
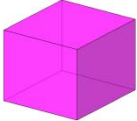
Table SP2: Block Types and Descriptions

**Results:**

It was intended with a general knowledge of how the trades will move through the floor a superintendent or project manager could spend relatively little time, at most two hours, to insert the pre-made blocks and tie them to a schedule. The contractor would not need to create their own blocks because once generic space blocks are made they can be used from on project to another. However, the inserting of blocks took more time than what was expected, approximately six and a half hours.

Furthermore, in the export to NavisWorks the visual properties, which were intended to show the different trades work, were lost and every block was the same color as shown in Figure SP3. This made the selection of the blocks tedious and the simulation meaningless. The tying of schedule activities to blocks took four hours.
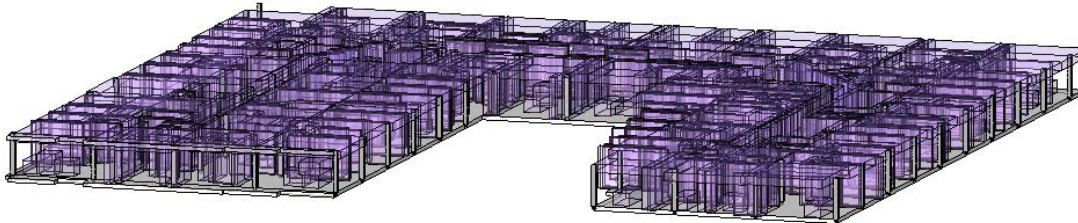


Figure SP 3:  Conjested blocks in NavisWorks

**Lesson Learned:**

By working through the process described above several issues were found that made this planning method not worth the time investment.  From these problems lessons have been learned and potential different methods have been theorized.  There were problems with the sizes associated with the blocks.  The large ceiling spaces were created to cover the size of the typical rooms.  But this either caused an overlap of similar blocks or voids in the planning.  Contrastingly, the wall blocks were created with the foresight that there needs to be a way to adjust for non-uniform wall lengths. Therefore, wall lengths of ten, five, three and two feet were created.  However, the main factor that inserting blocks took so much more time than expected was from inserting the detailed wall blocks.  To accurately model the wall work spaces several different sized block had to be used.  Also, because this is a residential building there are multiple partitions all of which were modeled.  If this was a core and shell building it can be expected that this would be less of a problem.

A better method can be theorized from these results.  If it is possible to alter the wall structure to include workspace then entire walls can be selected in NavisWorks and the inserting of wall work spaces in Revit does not need to be completed.  The downside to this is this method is that walls may need to be separated to create reasonable workable lengths.  Also, this may not be a feasible option if the Revit model will also be used for material estimates.  Also, a better method for ceiling and floor work spaces can be to use room walls as boundaries and extrude masses to create work spaces.  This requires more experience with Revit but can be quickly learned.

**Spatial Planning Conclusion:**

With the ever increasing use of BIM software to design buildings there will be opportunities for contractors to also implement the software to handle their responsibilities.  This analysis looked at the use of BIM software to complete a 4D spatial plan of trades.  This process should not take a long period of time to complete and should be a simple workflow, in order for those with little computer experience but a lot of industry experience to complete.  The suggested workflow took too long for the planning and therefore should not be implemented.  Further problems include a loss of trade color differentiation.  Research into the best practices and methods is extremely important to find for when BIM software is part of standard industry practice.

**LEED:**

Leadership in Energy and Environmental Design or LEED is a rating system based on criteria to quantify green building design measures.  LEED criteria focus on five important areas of building design and its effects on human and environmental wellbeing.  These areas include site characteristics, water consumption, energy use, material selection, and interior environment.  Certification levels are based on points and increase with a range of points from Certified, to Silver, to Gold, and to Platinum.  Platinum is the highest rating that can be obtained.  The purpose of this analysis is to understand the thoughts of industry members about owner involvement in LEED to determine where owners fall short and where they are being successful.   To obtain the view of industry professional a questionnaire was sent asking for responses based on their professional experiences working on actual projects.  Respondents included owners, contractors, LEED consultants, and designers.

**LEED Research:**

The goal of this research is to provide a useful tool to educate owners on practices that are key to sustainability success.  In discussion with industry professionals at the *2008 PACE Roundtable Breakout Session: LEED Evolution* there was a consensus that owners were either too late in deciding to go LEED or not willing to commit to obtain certification.  The best way to attain owner involvement on projects is to educate them and assure their understanding of what commitments will need to be made.  The following report includes analysis of the LEED credit system highlighting important aspects for owners while tying in research gathered from industry professionals including owners, architects and contractors.  The participants brought forth valuable information that owners wanting to develop a sustainable building should know.  This research acknowledges that all owners should desire being sustainable, but that certification is not necessary to be sustainable.  Nevertheless, the focus of this research has been on the LEED Criteria point system.