Panel Stacking and Worker Assignment Problems in Residential Construction Using Prefabricated Panels: A Lean Approach

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Dissertation submitted to the Faculty of
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Industrial and Systems Engineering

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May 14, 2010
Blacksburg, Virginia

Keywords: residential panel stacking, worker assignment, construction plan

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Abstract

A current trend in residential construction is the use of prefabricated wall panels. It is important to carefully establish how panels will be stacked, because an optimal sequence will improve productivity and reduce the possibility of worker injury. Mathematical models and heuristics are proposed for solving the panel stacking problem without consideration of interference. Dissertation work includes a mathematical model of the corresponding panel stacking problems in which the goal is to minimize total weighted panel move distance concurrent with certain construction assumptions. The heuristic method was provided to establish how each panel would be stacked and gave the drop-off location of each stack. The heuristic method was found to be able to reduce the total weighted panel move distance and ensure connectivity was always maintained, meanwhile, interference could also be avoided. In terms of solution speed, the heuristic method can solve real size problems in less than one second. Solutions to such problems can increase productivity.

Three improvements to the only known existing panel stacking algorithm with consideration of interference were proposed. The computational results indicate the proposed algorithm performed better than existing algorithm in all experimental cases. Improvement on panel move distance ranged from 1.35-47.93%, and improvement on interfering panels ranged from 20-100%. The proposed algorithm can solve non-rectangular cases (not possible with existing algorithm) and was compared with an experienced panel designer and commercial software. When compared to the proposed algorithm, total weighted panel move distance increased 0.10-85.52% and 0.77-136.23%, respectively, for the panel designer and software. While connectivity was 100% for all cases with the proposed algorithm (the algorithm ensures connectivity is always maintained), it ranged from 69.56-86.95% and 73.33-90.91%, however, for the panel designer and software respectively. Finally, the proposed algorithm can solve the interfering panels in the last stack: this cannot be done with the existing algorithm.

Because prefabricated wall panels are typically large and cumbersome to work with, there is a significant probability of worker injury. It is important to carefully establish how each panel will be handled by workers. This is typically the responsibility of field construction foreman, but such personnel are often ill-equipped to make such decisions. An alternative, proactive approach is to establish how each panel will be handled in advance, such that overall ergonomic consequences can be properly considered. This dissertation presents mathematical models of the corresponding construction task scheduling and worker assignment problems, where the goal is to minimize total project completion time (subject to worker quantity constraints) and assign tasks to workers as evenly as possible. The solution of such problems can help residential construction managers better plan construction by establishing the ergonomic impact associated with a given construction plan. A heuristic was also developed to solve large problems by balancing workload between workers. The heuristic was found to be able to provide near-optimal solutions, and can solve large problems in less than one second.

ACKNOWLEDGEMENTS

First, I would like to gratefully and sincerely thank my advisor, Dr. John P. Shewchuk, for his continuous support in the Ph.D. program. He taught me how to ask questions and express my ideas. He showed me different ways to approach a research problem and the need to be persistent to accomplish any goal. Not only did he give me substantial and relevant advice, guidance and encouragement, but also taught me what a great professor should be.

Besides my advisor, I would also like to thank my committee members, Dr. Douglas R. Bish, Prof. Thomas H. Mills, and Dr. Maury A. Nussbaum, for their constructive advice and efforts in my dissertation research. Their encouragement and constant guidance means a lot to me.

Thanks to my friends at Virginia Tech, Lingrui Liao, Min Chen, Chengbin Zhu, Lixin Wang, Liming Yao, and Billy Wang. Thanks to Dr. Lynn Ehrke for proofreading my dissertation. I cannot list everyone here but I want to thank you for all your help and friendship.

Last, but not least, I thank my parents, Jian Guo, and Min Luo, for giving me life in the first place, for educating me with your hearts, for unconditional support and encouragement to pursue my interests, for reminding me that my research should always be useful and serve good purposes for all humankind. I would also thank my wife, Sisi Ji, for her love and care, without which this dissertation would not have been possible.

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Chapter 1 Introduction

1.1 Motivation

A current trend in residential construction is the use of prefabricated wall panels (O'Brien et al., 2000). Panelized wall construction presents significant opportunities to improve housing quality, safety, and affordability. Prefabricated wall systems are becoming a popular element of building construction (Louis, 1999). It has many benefits (Lindow et al., 2003) which include: reduced on-site construction time, reduced labor costs, increased product consistency, and decreased noise pollution for the indoor environment.

Lean manufacturing has become a popular topic in recent years because it is a method of manufacturing using less of everything compared to mass production. Lean has been proved powerful in the manufacturing industry. Residential construction can also be viewed as a manufacturing industry, if we consider the house as the final merchandise. Therefore, if we can apply the lean philosophy to the building construction, less waste and less human effort will be required in the whole construction process. Actually lean thinking principles have been applied to identify and reduce the non-value added activities and improve performance in residential construction (Sharma et al., 2006). Lean construction research has also shown that managing work flow effectively and maintaining labor flow on site can improve construction labor performance (Watkins et al., 2009).

The key of lean is to reduce all kinds of waste. The first thing needed is to identify where waste exists in the construction process. After viewing several construction field video tapes and interviewing some construction workers, it was established that prefabricated panels were usually shipped to the construction site via trucks and unloaded in several stacks. The usual objective of this process is to minimize the number of trips. This results in two problems. The first problem is that the panel stacking order is not in the order the construction workers need. A typical scene in the video tapes showed that workers kept moving the top panels of a stack to somewhere else until they got to the panel they wanted. A field study of mechanical installation work has shown that over 50% of the total time observed on construction sites is non-value-adding time in the categories of interruption, disturbance, communication and preparation (Vedder et al., 2005). The second problem is that in some cases, the panel drop off location is not predetermined. If the drop off location was not pre-arranged, it often required workers to walk a long way to get the panels.

The disadvantage of the above scene is obvious. There is too much wasted motion and time, as well as the possibility of damaging parts during the process of workers seeking the "right" panel. From the ergonomic point of view, it is not safe as well. Due to the unneeded work efforts and unorganized workplace, the ergonomic impact on workers therefore increases the possibility of their injury.

Under this circumstance, we propose an effective lean approach which will reduce wasted motion and time, improve work efficiency, and maximize worker safety. During the construction process each panel must join to one or more of the panels already in place, excluding the first panel. To minimize the workload and the possibility of worker injury, we should sequence those panels within a stack, in the order they are going to be used, so that the next available panel is the next needed panel. Once a panel is taken from a stack, it will be moved to its location and put in place. Meanwhile, minimization of total number of stacks (total shipments) reduces the shipping costs. As many panels per layer as possible as noted in Figure 1.1. Traps, such as situations that prevent workers from accessing a panel due to its location, must be avoided.

Figure 1.1 Stack example

The approach will assign panels to stacks and provide the order they are going to be stacked. The drop-off location of each stack will also be provided under the goal of minimizing total panel move distance. Computational experiments are conducted to establish performance.

1.2 Problem Statement

The panel stacking problem may be formulated as follows. There is a set of N (which is given) prefabricated wall panels (panel parameters are defined as Figure 1.2) which are going to be shipped to the construction site and divided into S (unknown) stacks.

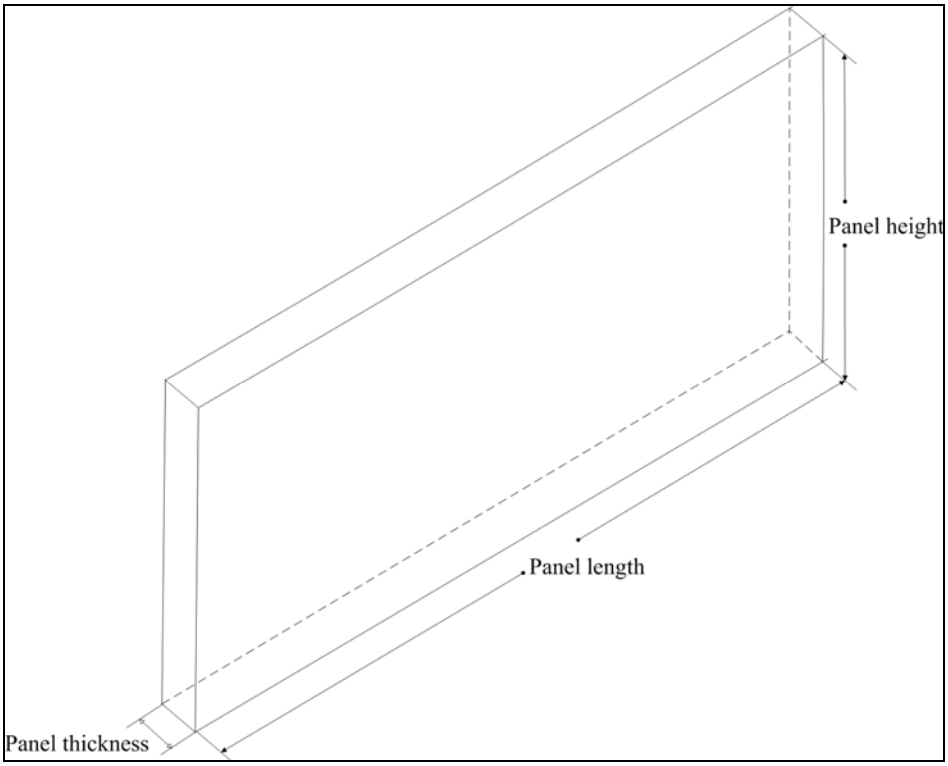


Figure 1.2 Panel parameters

Based on transportation limits, ergonomic considerations and other considerations, the maximum of stack length and stack height (defined as Figure 1.3) will be specified.

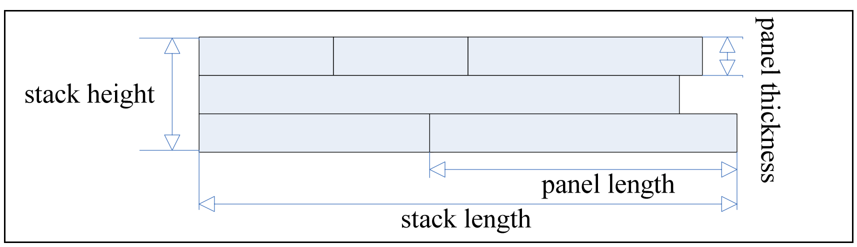


Figure 1.3 Stack parameters

When trucks arrive at the construction site, usually for easy access of trucks, an edge (dropping edge) will be chosen along which the trucks should unload stacks. Also, one or more possible dropping edges (refer to Figure 1.4) are given. In the Figure 1.4, the outside rectangle refers to the building plan, and the bottom edge is the dropping edge we choose. All stacks will be dropped on the chosen dropping edge (if there are multiple possible dropping edges, we will choose one).

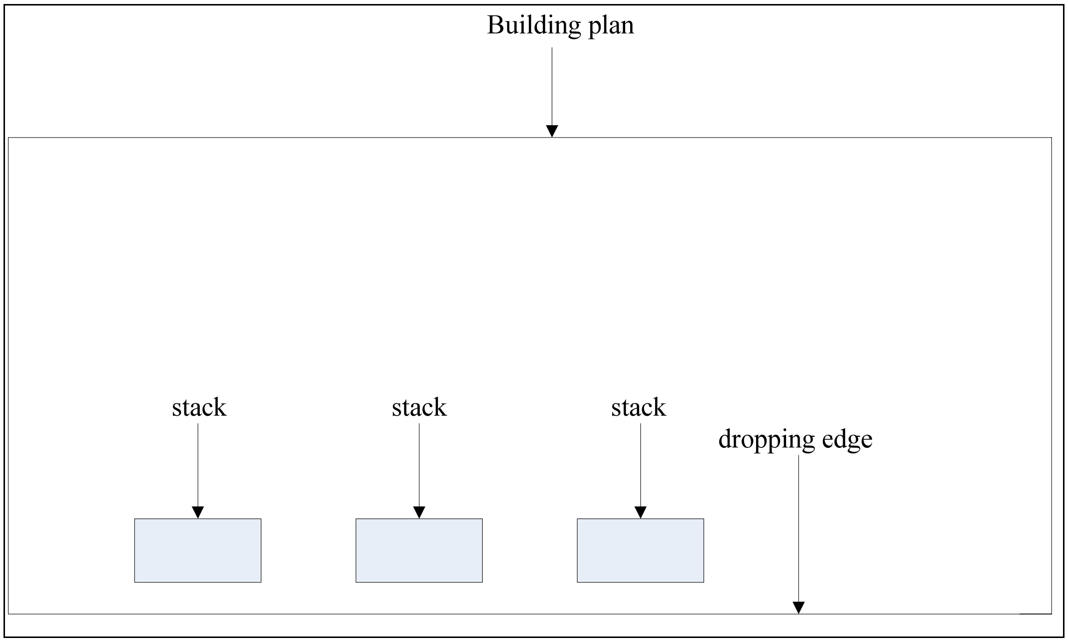


Figure 1.4 Dropping edge

Panels are placed with the bottom plate parallel to the dropping edge (Figure 1.5). It has two ways to place the panel just like (a) and (b) in Figure 1.5, and when you turn the panel over it will have two additional ways to place the panel like (c) and (d) in Figure 1.5. So when stacking a panel, there are total four possible orientations which will be specified in the solution. Just like Figure 1.5, the rectangle indicates a panel and we use the little circle to indicate different orientations. These are established per Shewchuk (2008).

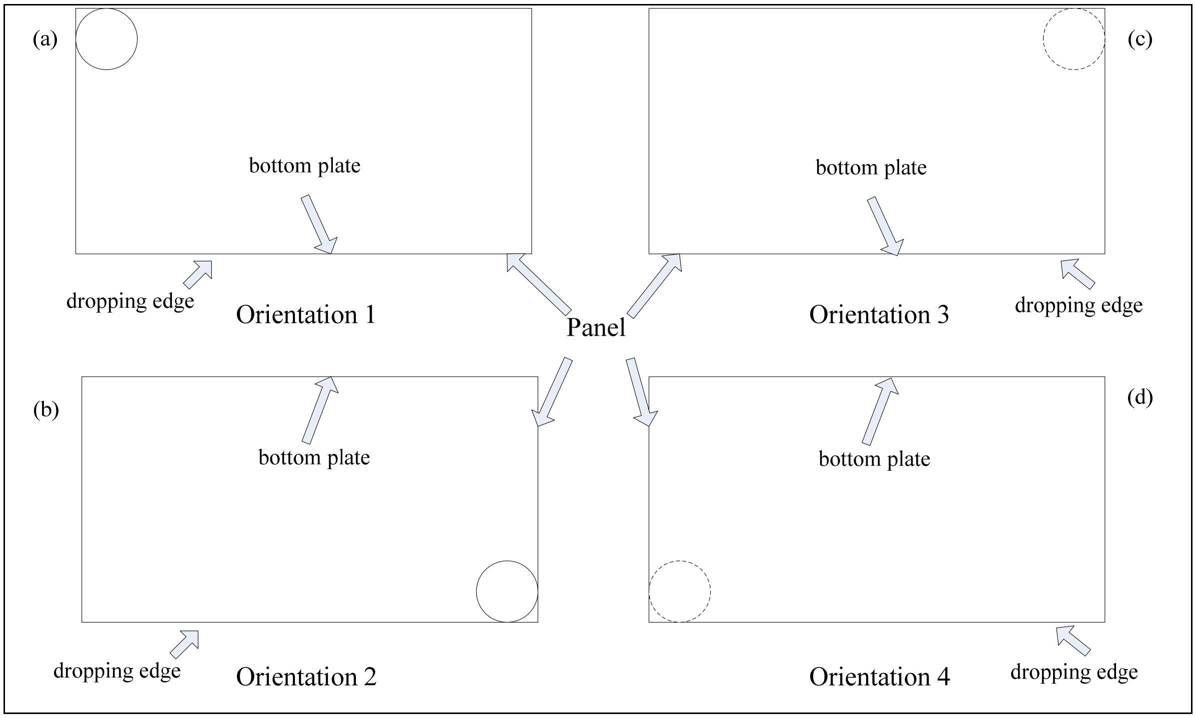


Figure 1.5 Panel stacking orientations

We have the following assumptions:

- All panels have the same height.
- Stacks always have the long edge parallel to the chosen dropping edge (Figure 1.5).
- Temporary bracing used on the construction site is not considered.
- Workers have the ability to choose an appropriate way to carry and move a panel, i.e., the workers will carry panels vertically when space is not enough for carrying them horizontally, since carrying panels horizontally will need more space.
- Blocks will be used to keep panels parallel to each other (Figure 1.6).
- Stacks are delivered to the dropping edge separately which means the second stack will not be delivered to the dropping edge until the first stack is fully completed.

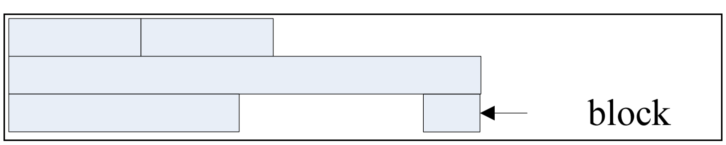


Figure 1.6 Use of Block

Since the number of stacks is positively associated with the shipping costs, one objective is to minimize the number of stacks. The other objective is to minimize the total weighted panel move distance weighted by panel length. This will also reduce workers' workload and construction project completion time

The problem is thus to determine how to assign panels to each stack, the location of each panel in a stack, the stacking orientation of each panel, as well as the drop-off location of each stack to minimize total weighted panel move distance and the number of stacks under the following constraints:

- To improve the work efficiency, during the construction process each panel must join to one or more of the panels already in place if possible, excluding the first panel.
- To reduce the wasted motion and minimize the possibility of worker injury, panels should be stacked in the order they are going to be used. It means once a panel is taken from a stack, it will be moved to its location and put in place.
- Transportation physical constraints on stack length and stack height.
- Interference constraints to avoid the following interference situations (Figure 1.7) when move clearance (which will provide enough room for workers to walk around stack and unload the panels) is considered:

  (a) the interference between stacks and finished panels (due to the overlapping of stacks and panels, they cannot be installed).

  (b) panels left in a stack cannot be moved to their destinations since they are blocked by other finished panels.

  (c) the interference from finished panels encountered by workers while moving panels to final location, i.e., when carrying panels, workers cannot access the final location since they are blocked by some finished panels.

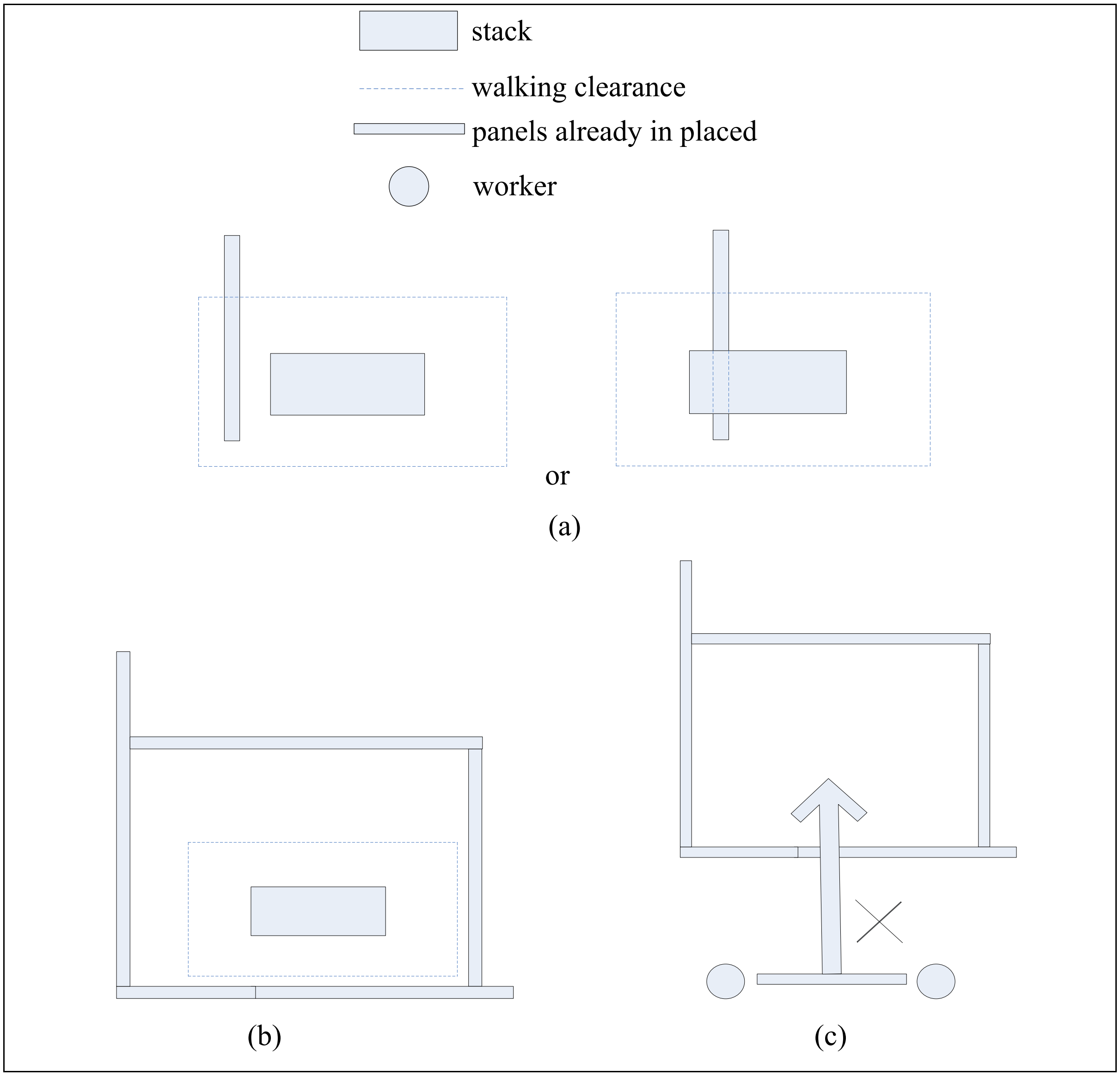


Figure 1.7 Interference situations: (a), (b) and (c)

1.3 Research Objective

This dissertation research primarily focused on two areas. The first area is on the panel stacking problem. The second is on the worker assignment problem. Overall, objectives of the research were to develop algorithms which will solve the panel stacking and worker assignment problem and provide a solution which includes:

- The number of stacks.
- Which panel goes to which stack and the location of each panel in a stack.
- Orientation of each panel.
- Which dropping edge will be chosen among all possible dropping edges.
- The location of each stack.
- How to handle the interfering panels in the last stack.
- Worker assignment.

Chapter 2 Literature Review

The use of panelized construction increased dramatically during the past several years (Table 2.1 & Figure 2.1). It accounted for only 5.2% of the linear feet of light-frame frame walls in residential construction in 1991 (Annual Builder Practices Survey, 2000). The number increased to 47% in 2006 and continues to increase. Among the industrialized housing segments, the panelized manufacturers posted the greatest increase, estimated at 8% for 2006. Panelizer's production continued to exceed that of production builders from 2004 (Automated Builder, 2007).

Table 2.1 Estimated housing productions by industry segments 1996-2006 (in thousands)

Year	1996	1997	1998	1999	2000	2001
panelizers	740	762	793	801	841	877
production builders	696	698	792	889	960	984
modular	112	124	140	163	148	166
Year	2002	2003	2004	2005	2006	% change
panelizers	989	1081	1254	1377	1483	+8%
production builders	1082	1118	1241	1293	1354	+5%
modular	181	198	206	212	187	-12%

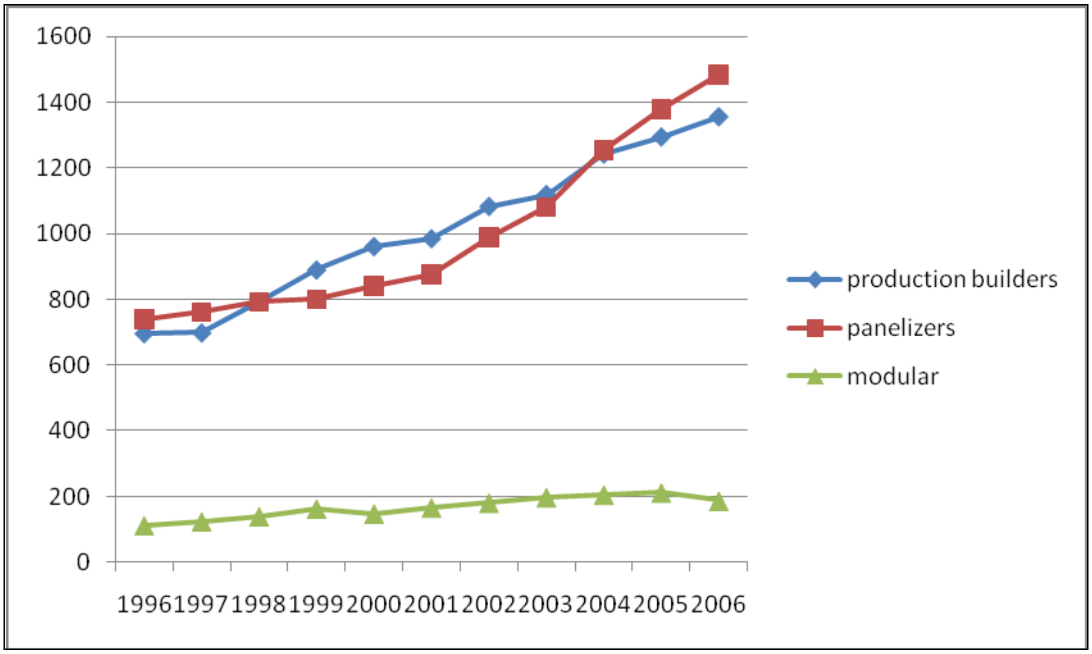


Figure 2.1 Estimated housing productions by industry segments 1996-2006 (in thousands)

Many sources of literature referred to construction project scheduling, but few of them addressed the panel stacking problem. The only known work is Shewchuk (2008). Only a few related previous works were found.

Zhang et al. (2005) proposed to replace the traditional management approach with residential construction site operation by using a management philosophy that has as its sole and unifying objective: the elimination of process waste. However, they did not address panel stacking. The waste considered was about the following aspects: 1) Missing or broken tools/equipment; 2) lack of sufficient information; 3) misstaged material; and 4) preceding work that has not been totally completed.

Jang, Lee & Choi (2007) proposed a floor-level construction material layout to minimize repositioning construction materials by the genetic algorithm. It was reported that material handling time is reduced. However, it only discussed the material layout problem, such as the crane location, but it did not address the panel stacking problem.

Hegazy et al. (1999) presented a genetic algorithm based model for site layout planning which placed facilities within a construction site. It "places the facilities", but actually did not stack the panels when they were delivered to construction site.

Beary & Abdelhamid (2005) developed a production planning model based on Lean Construction production planning concepts and Six Sigma methodology. It was reported that lean construction aimed at identifying and eliminating waste. But there is a need for continuous improvement in lean construction since there are no guidelines for implementation.

Choo et al. (1999) created a database program which implemented several lean construction techniques to help crew foremen allocate available equipment resources. However, the program did not address the panel stacking problem.

Hu (2005) presented a model based on geometric reasoning which reversed the disassembly process to produce a construction sequence. The model could generate a graph of precedence constraints. However, it did not explicitly specify how the panels should be stacked and which panel should come first. Instead, it was the responsibility of field construction crews to choose construction sequences, but such personnel are often ill-equipped to make such decisions.

Nguyen and Oloufa (2001) developed a building design framework in a solid modeling platform which generated complex building information. Nguyen (2005) proposed a framework that generated sequences of construction activities automatically. Since the framework was limited to the use of spatial information to establish construction sequences, other factors such as work spaces and panel stacking were not taken into consideration.

Chantawit et al. (2005) developed a 4DCAD-Safety application which uses scheduling information created by MS Project software to assist users in analyzing what, when, where and why safety measures are needed. Yet, this method separated safety planning with scheduling. Again, the panel stacking problem is not considered.

Constructing a building involves design tasks and construction tasks. Both practitioners and researchers have paid increasing attention to the control of the schedule of design work, because construction is commonly delayed by the lateness of design deliverables (Wang et al. 2006). However, the panel stacking problem is still not addressed.

For human resource planning in construction, most approaches allocate labor based on the assumption of a stable organizational structure for executing processes. Some researchers have forecasted human resource requirements based upon mass sampling surveys with statistical analysis (Cheng et al. 2006).

Discrete-event simulation has been used to assist construction engineers in analyzing and designing construction operation processes for years (Cheng et al. 2006). Similarly, discrete optimization techniques can be applied to generate construction schedules.

Gomar et al. (2002) investigated the mechanics of allocating a multiskilled workforce and developed a linear programming model to help optimize the multiskilled workforce assignment and allocation process in a construction project. Ahuja et al. (2004) mentioned further research should increase the use of various mathematical scheduling models such as linear programming. All of the above papers assumed panel stacking problem was solved.

In short, the automatic construction planning literature provides useful background, but no one, except Shewchuk (2008), focuses on the very first problem, which is the panel stacking problem. This research complements the previous researches by improving upon Shewchuk (2008) and hence helping workers further reduce wasted motion and total project completion time.

Chapter 3 Panel Stacking without Consideration of Interference

Abstract

More and more prefabricated wall panels are used in residential construction. Panels are manufactured in a factory and shipped to a construction site for workers to assemble. Current approaches usually aim at reducing the transportation cost and do not consider how construction workers will handle these panels after they are brought to construction site. From the observation of construction video tapes, this increases material handling workload, possibility of damaging panels, construction time, and risk of worker overload. This chapter proposes a lean approach to the panel stacking problem without consideration of interference, where panels are stacked in the exact construction sequence which means workers can work continuously to get a panel from stack and put it in place. Mathematical models and a heuristic are presented for solving the panel stacking problem. Computational experiments are conducted and results show the proposed heuristic can ensure a continuous flow and reduce total panel move distance without compromising panel transportation costs.

3.1 Introduction

More and more prefabricated wall panels are used in residential construction. In this case panels are manufactured in factory and then shipped to construction site for workers to assemble. This will bring some benefits like: reduced on-site construction time, reduced labor costs, increased product consistency, increased soundproofing, and decreased noise pollution for the indoor environment.

It is very important to determine how to transport the panels to construction site. Panels are usually arranged into stacks (Figure 1.1) and transported to construction site by trucks. Current approaches usually only aim at reducing the transportation cost and don't consider how construction workers will handle these panels after they are brought to construction site. Also the drop-off location of each stack is not pre-determined and stacks are typically dropped off at the most convenient location to drivers, even though that may increase panel move distance for workers. The construction sequence will be determined by construction foreman. If it is not the same sequence panels are arranged in stacks, workers will have to remove unwanted panels from top of a stack until they get to the one they need. This process not only increases material handling workload, but also may cause damaged panels. In other cases, some panels are carried to their final location and temporarily braced since they are not connected with any completed panels. This additional activity (bracing) is not required if each panel connects with at least one completed panels. Overall, current panel stacking approach will result in unnecessary material handling workload and increase the total construction time.

In this chapter, we propose a lean approach to panel stacking problem which will assign panels to stacks, provide the arrangement of panels within each stack, and establish drop-off location for each stack to minimize total panel move distance.

3.2 Research Approach and Methodology

Because there is a finite set of alternative panels and configurations, it allows us to model the panel stacking problem as discrete optimization problems. Then operations research (OR) techniques can be employed. Such techniques include both optimal methods (Mixed Integer Linear Program, which takes a long time to find optimal solution) and heuristics (rapid solution, but only a near optimal solution is expected).

The objective of both optimal methods and heuristics is minimizing total weighted panel move distance which will decrease the possibility of musculoskeletal injuries of workers since total material handling workload is minimized.

The overall approach is to use computer-based methods (optimal methods and heuristics) to generate panel stacking solutions. By construction assumptions, there are the following constraints:

i) Panels are erected in the order in which they are arranged in the stack. This ensures workers will always get the panel they want.
ii) Workers will always remove the top panel to its final location and get it erected directly.
iii) Except the first panel, each panel will connect with at least one completed panels. This will reduce unnecessary bracing activity.

3.3 Mathematical Model

We formulate the problem as a Mixed Integer Linear Program (MILP), using binary variables that establish the sequences of panels on each stack. Objective function is to minimize total weighted (weighted by panel length) material handling distance (x-direction only, since the y-location of stacks are fixed). Quantity of stacks is given. In practice, we will try from the smallest number which is calculated based on the smallest size panel (actually it is a lower bound on number of stacks needed). If the problem is infeasible, then increase the number until a feasible solution is reached.

Parameters

N	Total number of panels
$S_{\max}$	Maximum possible length, any stack layer
$H_{\max}$	Maximum height, any stack
L_i	Length of panel i
T_i	Thickness of panel i
q_i	x coordinate, final location of panel i
$L_{\min}$	The minimum possible panel length
$L_{\max}$	The maximum possible panel length
$T_{\min}$	The minimum panel thickness
$T_{\max}$	The maximum panel thickness
K	Number of stacks
M	Total length of the dropping edge
$K_{\min}$	Lower bound on number of stacks: $K_{\min} = \left\lceil N \Big/ \left(\left\lfloor \frac{L}{L_{\min}} \right\rfloor \cdot J_{\max} \right) \right\rceil$
$K_{\max}$	Upper bound on number of stacks: $K_{\max} = \left\lceil N \Big/ \left(\left\lfloor \frac{S_{\max}}{L_{\max}} \right\rfloor \cdot \left\lfloor \frac{H_{\max}}{T_{\max}} \right\rfloor \right) \right\rceil$
$J_{\max}$	Upper bound on number of layers per stack: $J_{\max} = \left\lfloor \frac{H_{\max}}{T_{\min}} \right\rfloor$

Sets

Panels	set of panels (1, 2, 3….., N)
Layers	set of layers (1, 2, 3……, $J_{\max}$)
Stacks	set of stacks (1, 2, 3….., K)

Maxstacks set of stacks (1, 2, 3….., $K_{\max}$)

P[i] set of panels that is connected to panel *i*

Variables

$X_{i,j,k}$ Binary variable. $X_{i,j,k}$ =1 if panel *i* is placed in layer *j* stack *k*, 0 otherwise

U_k *x* coordinate of stack *k*

$C_{j,k}$ Maximum panel thickness of layer *j* stack *k*

$F_{i,j,k}$ *x* coordinate of the stack to which panel *i* is assigned

$E_{i,j,k}$ Move distance for panel *i*, layer *j*, stack *k*

A mathematical model for the proposed approach, where the quantity of stacks *K* is given, is as follows:

$$\text{Minimize } \sum_{i=1}^{N}\sum_{j=1}^{J_{max}}\sum_{k=1}^{K} L_i E_{ijk} \tag{1}$$

subject to

$$E_{ijk} + F_{ijk} \geq x_{ijk} q_i \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{2}$$

$$E_{ijk} - F_{ijk} \geq -x_{ijk} q_i \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{3}$$

$$F_{ijk} \leq u_k + M\left(1 - x_{ijk}\right) \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{4}$$

$$-F_{ijk} \leq -u_k + M\left(1 - x_{ijk}\right) \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{5}$$

$$F_{ijk} \leq M x_{ijk} \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{6}$$

$$-F_{ijk} \leq M x_{ijk} \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{7}$$

$$\sum_{j=1}^{J_{max}}\sum_{k=1}^{K} x_{ijk} = 1 \quad \forall\ i \in Panels \tag{8}$$

$$\sum_{i=1}^{N} L_i x_{ijk} \leq S_{max} \quad \forall\ j \in Layers, k \in Stacks \tag{9}$$

$$\sum_{j=1}^{J_{max}} C_{jk} \leq H_{max} \quad \forall\ k \in Stacks \tag{10}$$

$$C_{jk} \geq T_i x_{ijk} \quad \forall\ i \in Panels, j \in Layers, k \in Stacks \tag{11}$$

$$x_{ijk} \leq \sum_{n \in P[i]} \sum_{m=1}^{j} x_{nmk} + \sum_{q=1}^{k-1} \sum_{m-1}^{J_{\max}} x_{nmq} \qquad \forall \; i \in Panels, j \in Layers, k \in Stacks \quad (12)$$

Where the objective function (1) minimizes total weighted material handling distance. Constraint (2) (3) are objective function absolute value forcing constraints. $E_{i,j,k}$ represents the absolute value of move distance in x direction only if $X_{i,j,k} = 1$, $E_{i,j,k}$ =0 if $X_{i,j,k} = 0$ by constraint (6). Constraint (4)-(7) are logical constraints which ensure $Y_{i,j,k}$ represents the x coordinate of stack to which panel i is assigned and make sure $Y_{i,j,k} = U_k$ only if $X_{i,j,k} = 1$, $Y_{i,j,k} = 0$ if $X_{i,j,k} = 0$. Constraint (8) forces each panel appears in exactly one layer of a stack. Constraint (9) forces total length of each layer of a stack does not exceed $S_{\max}$. Constraint (10) forces total height of each stack does not exceed $H_{\max}$. Constraint (11) calculates maximum panel thickness each layer of each stack and make it equal to C_{jk}. Constraint (12) ensures that panel connectivity is maintained.

The above model is a variation of the generalized assignment problem, which is NP-hard. Few papers have addressed this problem mathematically before. Although the models developed cannot solve large problems (it was found that the optimal solution can be found for a problem with up to17 panels, but needs more than 15 hours runtime), they provide insight into the problem structure. To solve the panel stacking problem quickly and easily in practice, a new algorithm for solving the problem was developed.

3.4 Heuristic

A practical problem cannot be solved optimally by the mathematical model because the size of the problem is too large for the MILP model to solve optimally. So a heuristic approach is required.

The following preliminary work is presented without the consideration interference constraints. To avoid traps, a global building direction should be specified, e.g., from north to south. We should specify the dropping edges first, along which the trucks should unload panels. Usually we choose the dropping edge for easy access of trucks. Then the building direction should be from the opposite edge to the dropping edge. For example, if the south edge of the structure is the dropping edge, the build direction is north-south. Also any panel should join to a panel already in place, except the first panel. The heuristic only can handle rectangular buliding plans.

After all the panels are assigned, the drop-off location for each stack is determined. Since the larger panels are more difficult for workers to handle, we multiply panel move distance by panel length. The problem then becomes a traditional weighted mini-sum location problem, with weight corresponding to panel length. An iterative algorithm can be used (Appendix A) to calculate drop-off locations for each stack. The objective is to minimize total weighted panel move distance. Let

I: Set of panels that already assigned to a stack.

A: Set of all panels.

C: Set of candidate panels for the next panel.

N: Total number of panels.

D_i: Distance from the center of panel i to the dropping edge.

B_i: Distance from the center of panel i to the left side of structure (building plan rotated until the dropping edge is at the bottom)

A_{ij}: A_{ij} =1 if panel i and j are adjacent, 0 otherwise.

L_i: Length of panel i.

H_i: Height of panel i.

S_{rem}: Length capacity remaining for the current layer.

H_{rem}: Height capacity remaining for the current layer

Using the above notation (and that established previously), the algorithm is shown in the flowchart of Figure 3.1.

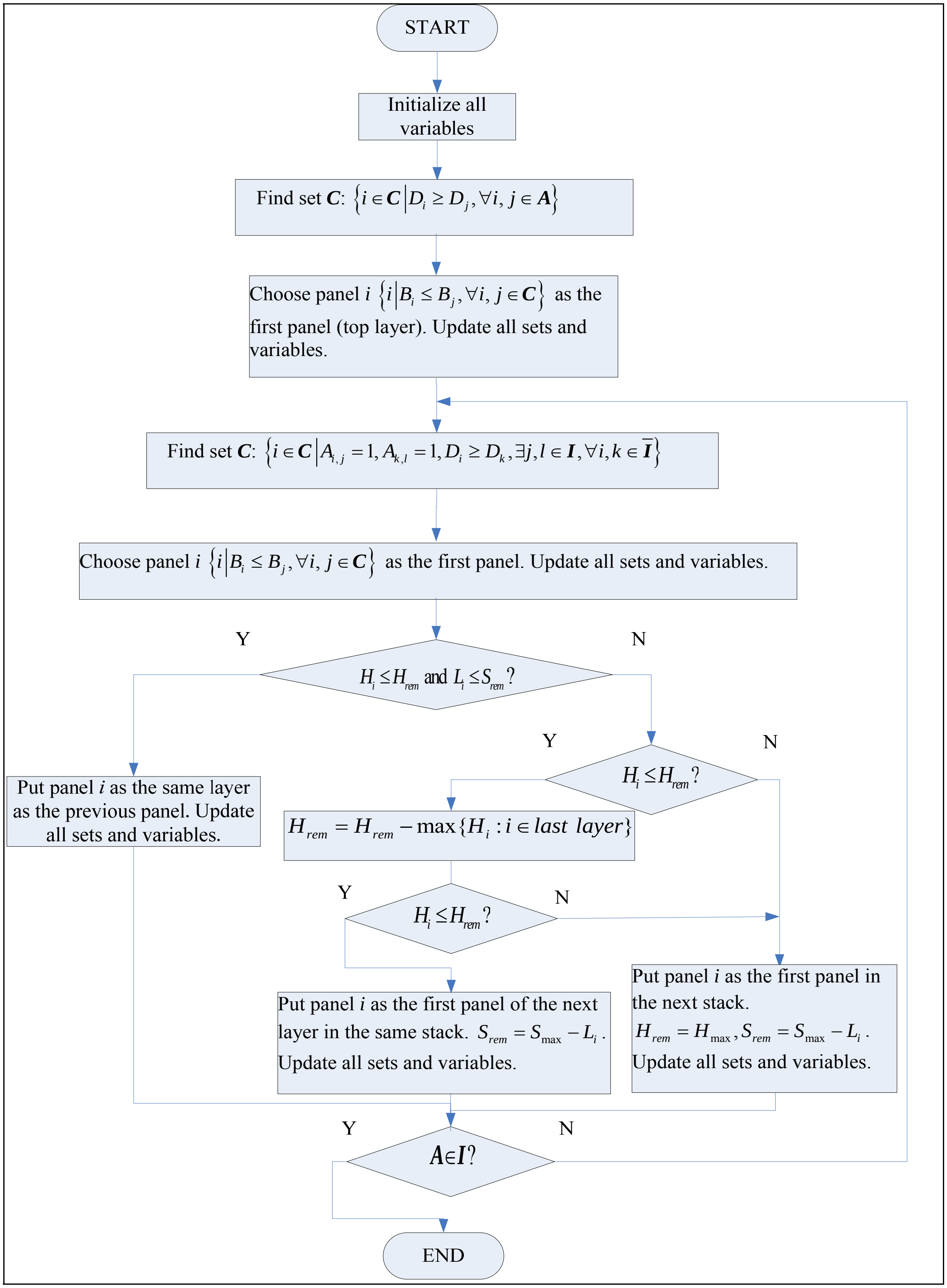


Figure 3.1 Algorithm Flow Chart

Note Figure 3.1 shows calculations for a single dropping edge only. But the algorithm can run for each accessible dropping edge (all the coordinates recalculated automatically) and the stacking solution having the minimum total weighted panel move distance selected.

3.5 Computational Experiments

3.5.1 Experimental Design

As outlined in Chapter 2, there is no published algorithm for panel stacking problem. The traditional emphasis in stacking is to minimize the quantity of stacks. The problem of minimizing the number of stacks is actually a two-staged fixed-orientation two-dimensional cutting stock problem. It is a variant of the constrained two-dimensional cutting stock problem (Hifi et al. 2006). If all the panels have the same thickness, then it is reduced to a one-dimensional cutting stock problem, for which several commercial software packages are available. Thus, all the experiments were assumed to have the same panel thickness, and a commercially-available business cutting stock software package (Astrokettle, 2009) was employed as the traditional approach to solve all the problems.

A set of computational experiments was performed to establish the performance of the proposed algorithm as compared to the traditional approach. Three sizes of residential home design were investigated: small (<1,000 sq.ft.), medium (1,000-2000 sq.ft.) and large (>2,000 sq.ft) which were based on the size of the house. For each scenario, 5 problems were randomly chosen from an online database (The Home Plan Group, 2009), giving fifteen problems with rectangular building plans. For each problem, the corresponding set of panels were found by 'breaking up' walls one-at-a-time into panels assuming a preferred panel length of 8 feet. These can all be found in Appendix B.

Each problem was solved using both the proposed algorithm and traditional approach. Solutions were compared in terms of (a) quantity of stacks (b) total weighted panel move distance, and (c) the percentage of panels for which connectivity is maintained (when panels are installed in the stacking order). On a construction site, it requires more activity (like additional bracing) to install a panel when it does not connect with any completed panels. Of the three criteria, (a) is the objective of traditional approach, but the traditional approach does not consider (b) and (c). Instead, our proposed algorithm tried to minimize (a) and (b) under the constraint (c) must be 100%.

3.5.2 Results

Experimental results are presented in Table 3.1. The proposed approach reduces the total weighted panel move distance in all cases, for which the improvement ranged from 18 - 68%. Connectivity was 100% for all cases with the proposed algorithm since it will always maintain connectivity. And using the traditional approach the connectivity ranged from 26 - 59%. Finally, the proposed approach resulted in the same quantity of stacks in all cases except one (Med-5). In terms of solution speed, the proposed algorithm will always provide a solution in less than one second.

Table 3.1 Computational results for Proposed Algorithm vs. Traditional Approach

		Traditional Approach				**Proposed Algorithm**			
Case	# of panels	# of stacks	Total move distance, ft	Total weighted move distance, ft.^{2}	Connectivity, %	# of stacks	Total move distance, ft	Total weighted move distance, ft.^{2}	Connectivity, %
Small-1	27	2	116	730	26	2	93	599	100
Small-2	26	2	143	960	34	2	109	708	100
Small-3	21	2	102	655	47	2	59	372	100
Small-4	25	2	177	1,119	56	2	109	641	100
Small-5	27	2	152	970	44	2	79	484	100
Med-1	35	3	259	1,632	57	3	168	1,037	100
Med-2	52	5	618	3,886	28	5	269	1,658	100
Med-3	27	2	111	697	41	2	62	375	100
Med-4	39	3	317	1,997	40	3	128	796	100
Med-5	43	3	329	2,075	39	4	155	974	100
Big-1	60	5	552	3,477	43	5	206	1,310	100
Big-2	47	4	351	2,208	49	4	136	800	100
Big-3	49	4	452	2,831	33	4	179	1,146	100
Big-4	52	4	473	2,979	42	4	346	2,211	100
Big-5	46	4	386	2,427	59	4	132	780	100

In order to show the difference between traditional approach and the proposed algorithm, please see an example (Small-1) in Figure 3.2 which shows the building structure.

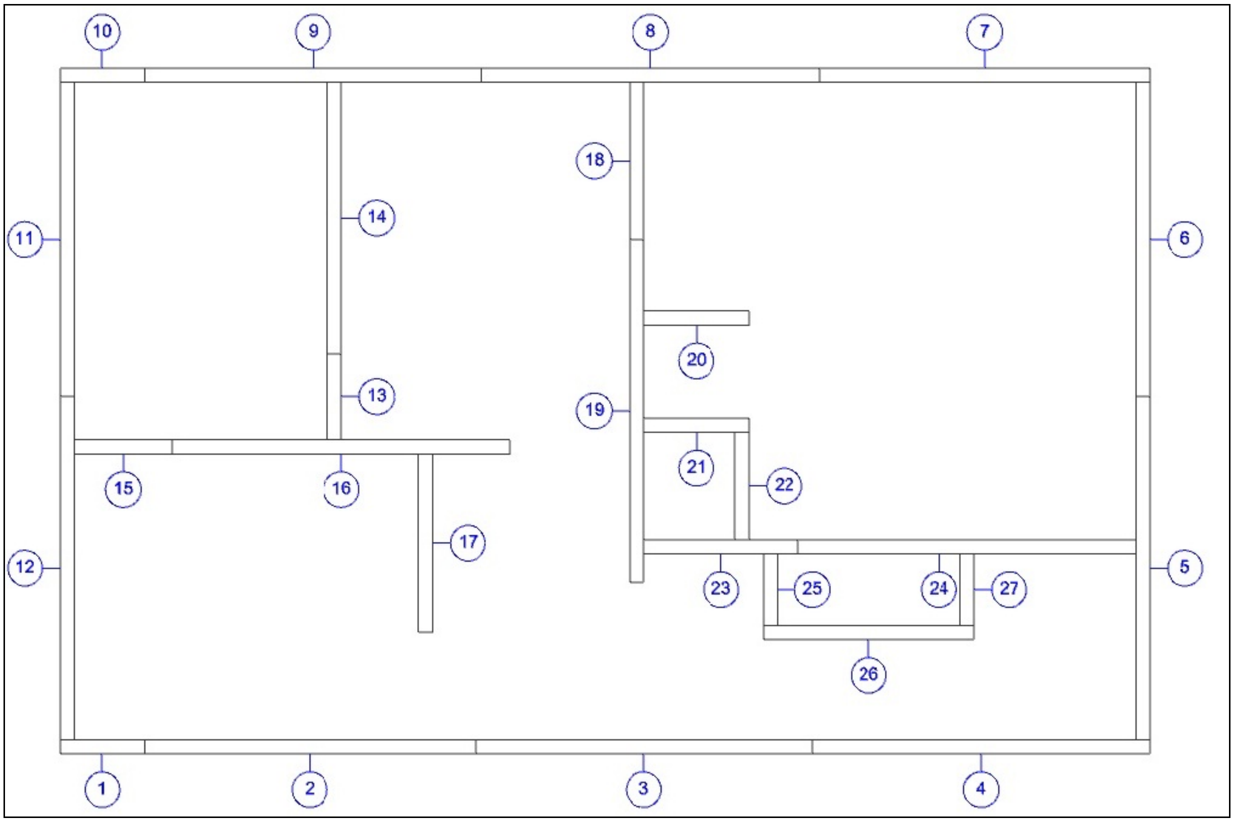


Figure 3.2 Building structure

The stacking solution using the traditional approach is shown in Table 3.2. From table 3.2 we can see that the solution contains two stacks.

Table 3.2 Stacking solution using the traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	2	14	17	15
2	1	156	2	2	26	
3	1	156	4	6	18	25
4	1	156	4	11	23	27
5	1	156	6	3	20	10
6	1	156	6	4	21	13
7	1	156	6	5	22	1
8	1	156	60	8		
9	1	156	60	9		
Stack 2						
1	1	156	60	12		
2	1	156	60	16		
3	1	156	60	19		
4	1	156	60	24		
5	1	156	62	7		

The stacking solution for the proposed algorithm is shown in Table 3.3. From table 3.3 we can see that the solution contains two stacks as well which is the same as the solution from traditional approach.

In order to show the impact on panel move distance and non-connecting panels by different stacking solutions, panelization plan is shown with the panels labeled by build sequence for each approach in Figure 3.3 & 3.4. From these figures, it can be seen the traditional approach results in excessive walking and more non-connecting panels. Also note that the traditional approach would result in interference during construction. Figure 3.4 shows top – down, left – right build direction, which leads to smoother construction.

Table 3.3 Stacking solution using the proposed approach

```
*** smallcase1.txt

** Dropping Edge (1=South, 2=West, 3=North,4=East)
1

** NStacks
2

** stack#     xloc   #layers    j   #panels  panels
     1         80.3       9      1      2       10  11
                                 2      3       12  1  15
                                 3      1       2
                                 4      1       9
                                 5      2       14  13
                                 6      2       16  17
                                 7      1       3
                                 8      2       8   18
                                 9      3       19  20  21
     2        223.3      6      1      4       22  23  25  26
                                 2      2       24  27
                                 3      1       4
                                 4      1       7
                                 5      1       6
                                 6      1       5
```

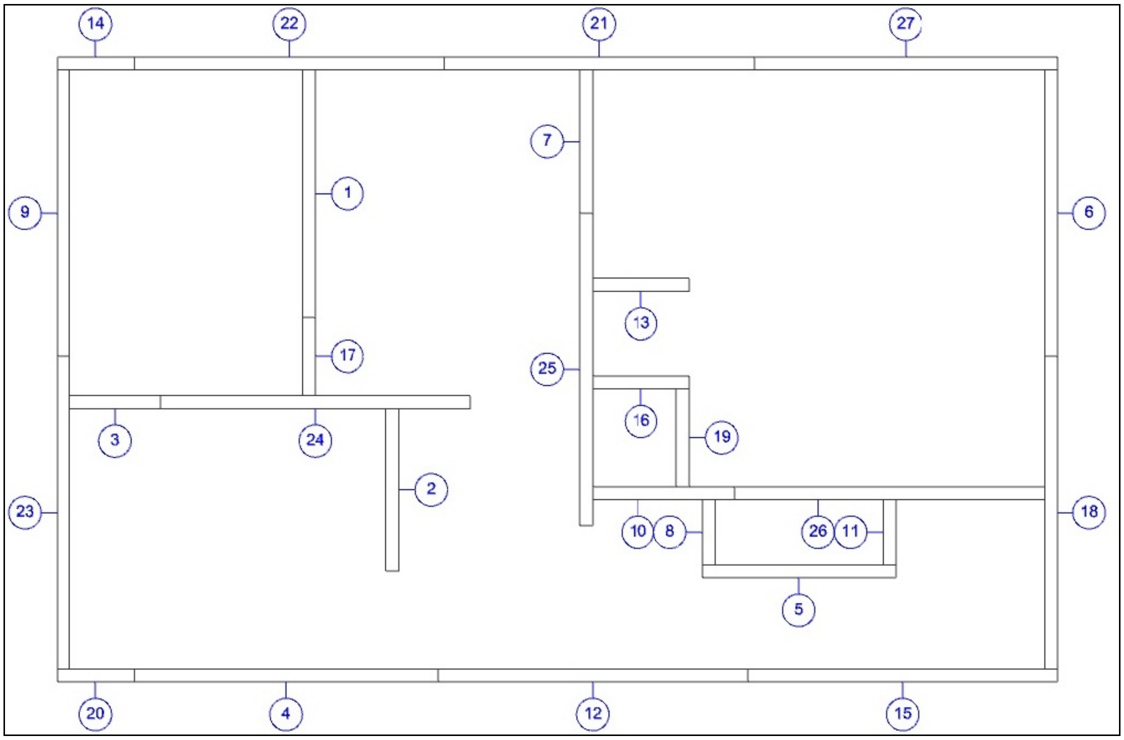


Figure 3.3 Solution of traditional approach (by build sequence)

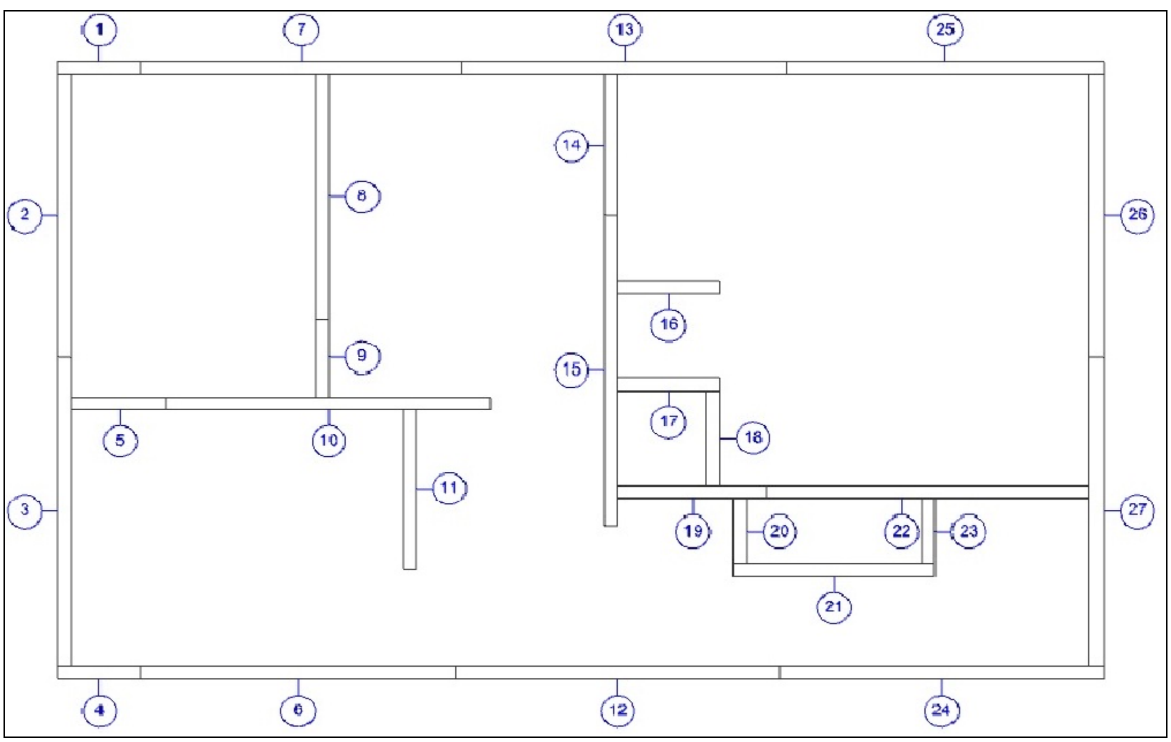


Figure 3.4 Solution of proposed approach (by build sequence)

3.5.3 Discussion of Results

The computational results indicate the proposed algorithm performed much better than traditional approach in 14 cases, because it provided much less total panel move distance and much better connectivity with the same quantity of stacks. Only in Medium case 5, the traditional approach provided one stack less, but much worse in total panel move distance and connectivity. The advantages of proposed algorithm against the tradition approach include much less total panel move distance (less workload) and better panel connectivity issue (increase working efficiency). It is not surprising that proposed algorithm will perform much better in panel move distance since it is also one of our objectives. Instead, the traditional approach has just one objective.

From these computational results, we can see the proposed research can reduce worker's workload by reducing the total weighted panel move distance and providing much better connectivity in working with panels.

Chapter 4 Panel Stacking with Consideration of Interference

Abstract

Chapter 3 mainly solved the panel stacking problem without the consideration of interference. But in practice, there may be several kinds of interference (Figure 1.7). Such issues are extremely difficult to model mathematically. From Chapter 2 we can know that Shewchuk (2008) is the only algorithm that solve panel stacking problem with consideration of interference. But it still has some limitations: (1) the zone width is not optimally calculated, (2) cannot solve non-rectangular cases, and (3) cannot solve the panels left in the last zone. This chapter proposes new algorithms which are based on Shewchuk (2008) and address the limitations (1) - (3) mentioned above.

4.1 Introduction

Chapter 3 discusses the panel stacking problem without consideration of interference constraints which means extra work (moving some panels to somewhere else) is needed to continue working. But in practice, in addition to the constraints considered in last chapter, we still have "interference constraints" to avoid any interference problems in the practical work. When put into practice, the walking clearance around a stack will be required to provide enough room for workers to walk around and unload the panels.

Some interference is hard to be incorporated to mathematical models since we do not know if such interference exists until we know which panel will be assigned to which stack.

Usually interference happens in the last stack since by that time the number of finished panels has increased. As a result, we should choose dropping edge carefully to minimize the interference occurring in the last stack.

The only known algorithm which tackles panel stacking problem is Shewchuk (2008). This work solves the panel stacking problem by splitting building plan into vertical zones which can provide a feasible solution without interference. Zone 1 only has one stack type which has the panels in area 1A and all the other zones have two stack types which have the panels in corresponding area (Figure 4.1). Since the building direction is from North to South and from West to East (in Figure 4.1), so the stack unloading sequence is 1A, 2A, 2B, 3A, 3B. Stack type

1A, 2A, and 3A are placed on the dropping edge, since we don't need tip a panel off the bottom of stack. Stack type 2B and 3B have an offset, due to the need to tip the horizontal finished panels on the dropping edge off the bottom of stack.

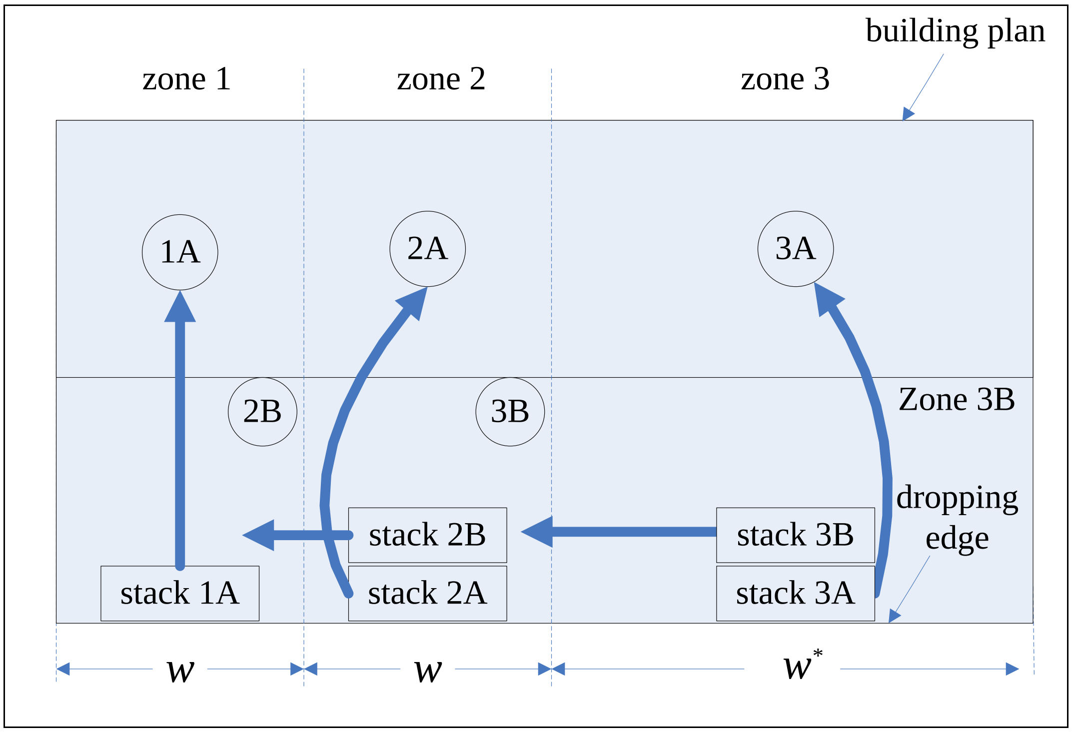


Figure 4.1 Panelized Wall Construction Process (Shewchuk, 2008)

However, this algorithm has the following limitations:

1) Zone width is determined by the maximum panel length which is not the best solution. All zones have the same width, w, which is determined by the maximum panel length except the last zone. Plus, the width of last zone, w^*, can be greater than w, i.e., $w \leq w^* < 2w$. All the above situations may increase the total weighted panel move distance.
2) The algorithm can only handle rectangular building plans.
3) The panels in zone 3B in Figure 4.1 are referred as interfering panels. The algorithm can handle at most only the last interfering panel in the stack.

The new proposed algorithm will be developed based on Shewchuk (2008) and address the shortcomings (1) — (3) mentioned above.

i. The new proposed algorithm will optimize the zone width and stack locations which will provide a solution with less total weighted panel move distance. A new iterated algorithm will be developed to solve the zone width problem.

ii. The new proposed algorithm will be able to handle both rectangular and non-rectangular building plans.

iii. The new proposed algorithm will determine how to handle the interfering panels in the last zone which is not addressed in Shewchuk (2008).

iv. The new proposed algorithm will check building direction of Left→Right and Right→Left and provide a better solution in terms of panel move distance, while Shewchuk (2008) will only check building direction of Left→Right.

Above all, the new proposed algorithm will provide a solution which includes:

- The number of stacks,
- Which panel goes to which stack and the location of each panel in a stack,
- Orientation of each panel,
- Which dropping edge will be chosen among all possible dropping edges,
- The location of each stack,
- How to handle the interfering panels in the last stack.

4.2 Improvement 1 — Minimize Zone Width

4.2.1 Algorithm

Shewchuk (2008) split the building plan into vertical zones which have the same zone width except possibly the last. Also each zone is divided vertically into a lower and an upper zone based on 'unload zone height'. Meanwhile stack clearance is calculated which ensures enough room for workers to work around stacks. Please refer to Shewchuk (2008) for additional details. In the algorithm, zone width and unload zone height are calculated for all zones based on the maximum panel length and stack length (see Figure 1.3). It is actually a relaxation, and the maximum panel width and stack length in the current zone should be used. In order to tighten the calculation, a new iterated algorithm was developed as follows and here are some notations:

Input Parameters

H = panel height, inch.

w_dia = worker diameter, inch.

L_{min} = minimum panel length (inch), all stacks

L_0 = maximum panel length (inch), all stacks

mc = move clearance, inch..

M = zone width multiplier ($M \geq 1$)

Variables

L_{max} = maximum panel length (inch), current stack

L_S = maximum stack length (inch), current stack

W = current zone width

W_{new} = current zone width from current iteration

H^* = unload zone height, current stack

1. Calculate initial value for unload zone height, H^*_{max}, for all zones

H^*_{max}= max{H_{min}, ($f_1(L) + D/2 + w\_dia/2$),($f_2(L) + L/2 + 2{\cdot}w\_dia$), ($f_3(L) + D^*/2$)}, Shewchuk (2008)

where $H_{min} = H + mc + H + w\_dia + mc$

$f_1(L) = \max\{D/2, Y_{r,min}\}$

$f_2(L) = \max\{L/2 + w\_dia, Y_{r,min}\}$

$f_3(L) = \max\{D^*/2, Y_{r,min}\}$

$Y_{r,min} = H + w\_dia/2$

$$D = \sqrt{L^2 + H^2}$$

$$D^* = \sqrt{(L + 2{\cdot}w\_dia)^2 + (H + 2{\cdot}w\_dia)^2}$$

and $L = L_0$

2. Calculate initial value for stack clearance, *sc* and minimum zone width, W_{min}

$sc = \max\{3, D - L_s, (D_{sum} - L_s)/2\}$, Shewchuk (2008)

where

$$D = \sqrt{L^2 + H^2}$$

$$D^* = \sqrt{(L + 2{\cdot}w\_dia)^2 + (H + 2{\cdot}w\_dia)^2}$$

$$D_{sum} = D^*/2 + D'/2$$

$$D' = \sqrt{(L + 2{\cdot}w\_dia)^2 + H^2}$$

and $L = L_{min}$

W_{min} = minimum zone width = $(sc + L_s + sc) * M$

Where $L_S = L_{min}$

3. **Initiate zone width for current zone**

   Each zone starts from zone width:

   $$W = W_{min}$$

   If current zone width exceeds building plan, it means current zone is the last zone, go to step 6.

   Otherwise, go to step 4.

4. **Update current zone width**

   If current zone width exceeds building plan, it means current zone is the last zone, go to step 6.

   Otherwise calculate and record panel set which include panels within current zone, update L_{max}, L_S correspondingly.

   Update sc and current zone width W_{new}.

   $$sc = \max\{3, D - L_s, (D_{sum} - L_s)/2\}$$, Shewchuk (2008)

   Where $D = \sqrt{L^2 + H^2}$

   $$D^* = \sqrt{(L + 2 \cdot w\_dia)^2 + (H + 2 \cdot w\_dia)^2}$$

   $$D_{sum} = D^*/2 + D'/2$$

   $$D' = \sqrt{(L + 2 \cdot w\_dia)^2 + H^2}$$

   and $L = L_{max}$

   $$W_{new} = (sc + L_s + sc) * M$$

   If $W_{new} = W$, then find current zone width W_{new}, go to step 5.

   If $W_{new} > W$, then set $W = W_{new}$, go to step 4.

   If $W_{new} < W$, then if panel set within current zone equals some previous panel set for current zone, we find current zone width W, go to step 5, otherwise go to step 4.

5. **Update unload zone height, *H**, for current zone**

   Update H^* using L_{max}.

   $$H^* = \max\{H_{min}, (f_1(L) + D/2 + w\_dia/2), (f_2(L) + L/2 + 2 \cdot w\_dia), (f_3(L) + D^*/2)\},$$

   Shewchuk (2008)

   where $H_{min} = H + mc + H + w\_dia + mc$

   $$f_1(L) = \max\{D/2, Y_{r,min}\}$$

$f_2(L) = \max\{L/2 + w\_dia, Y_{r,min}\}$

$f_3(L) = \max\{D^*/2, Y_{r,min}\}$

$Y_{r,min} = H + w\_dia/2$

and $L = L_{max}$

Since $H^* \leq H^*_{max}$, New panels may be introduced into current zone. Update L_{max}, L_S and W_{new} correspondingly.

If $W_{new} > W$, then set $H^* = H^*_{max}$.

If current zone is the last zone, then END.

Otherwise go to step 3.

6. Update zone width for last zone

Zone start from right side of the building plan, zone width increasing direction is from right to left. Let current zone width $W = W_{min}$**,** calculate and record panel set which include panels within current zone, update L_{max}, L_S correspondingly.

Update sc and current zone width W_{new}.

$sc = \max\{3, D - L_s, (D_{sum} - L_s)/2\}$, Shewchuk (2008)

Where $D = \sqrt{L^2 + H^2}$

$D^* = \sqrt{(L + 2 \cdot w\_dia)^2 + (H + 2 \cdot w\_dia)^2}$

$D_{sum} = D^*/2 + D'/2$

$D' = \sqrt{(L + 2 \cdot w\_dia)^2 + H^2}$

and $L = L_{max}$

$W_{new} = (sc + L_s + sc) * M$

If $W_{new} = W$, then find current zone width W_{new}, go to step 5.

If $W_{new} > W$, then set $W = W_{new}$, go to step 6.

If $W_{new} < W$, then if panel set within current zone equals some previous panel set for current zone, we find current zone width W, go to step 5, otherwise go to step 6.

The whole process is shown in Figure 4.2. And Figure 4.3 shows the difference between Shewchuk (2008) and the proposed algorithm. White zone in Figure 4.3 shows the "interfering zone" which contains the interfering panels. Obviously the proposed algorithm will have a smaller "interfering zone" which result in less interfering panels than Shewchuk (2008).

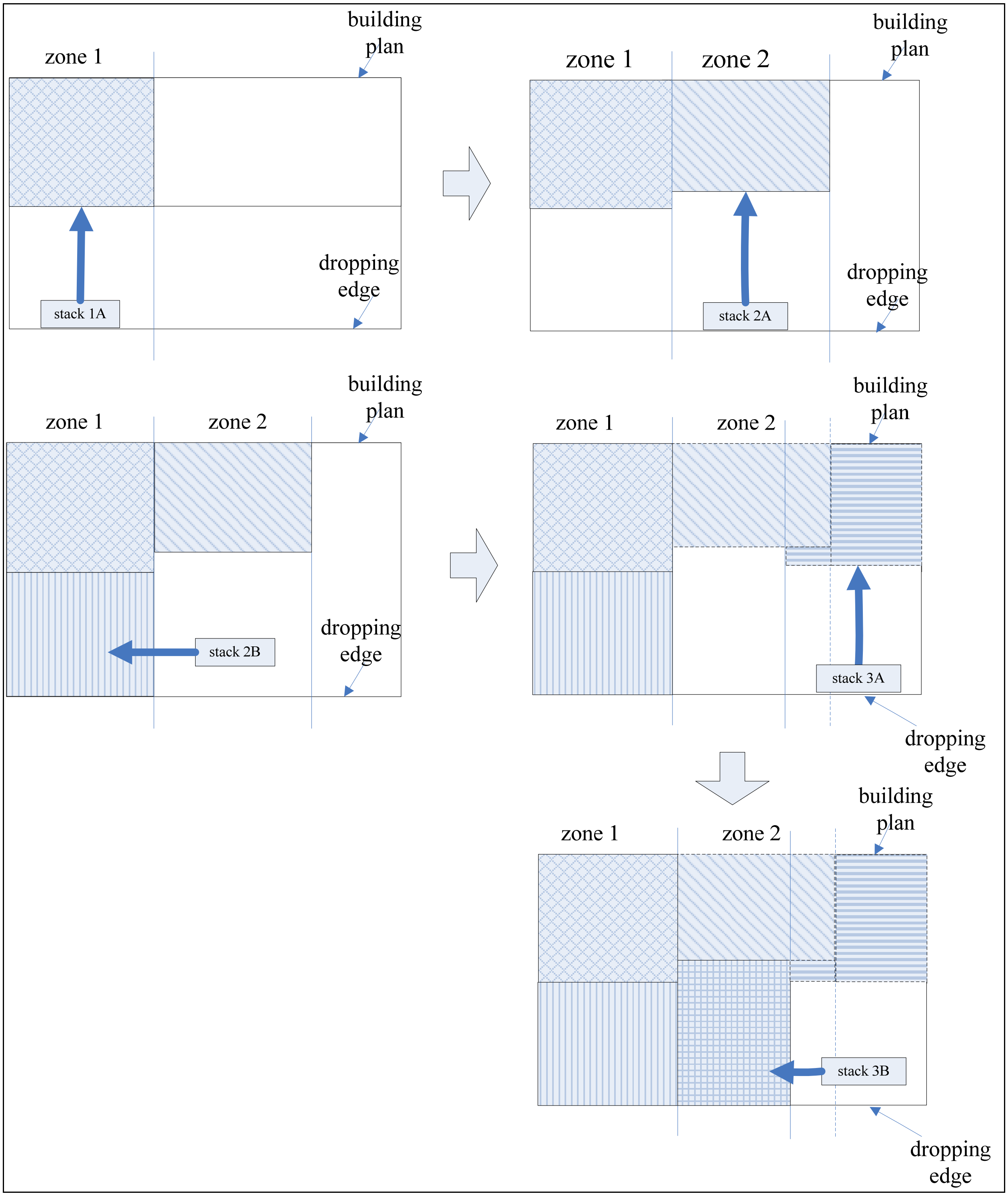


Figure 4.2 Process of the algorithm

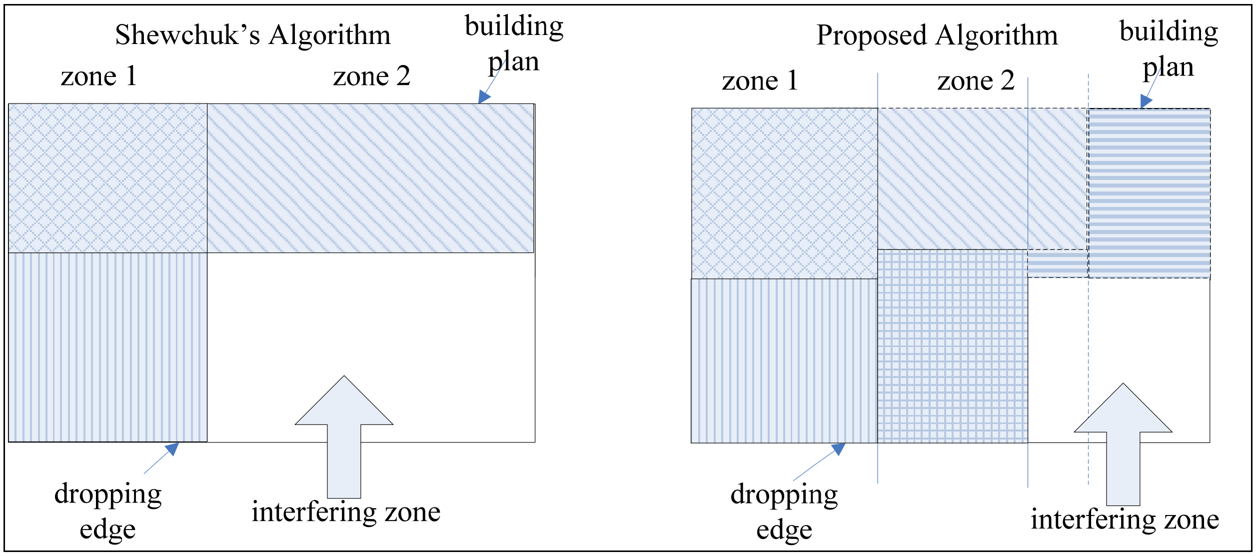


Figure 4.3 Last zone, Shewchuk (2008) vs. Proposed Algorithm

4.2.2 Experimental Design

A set of computational experiments was performed to establish the performance of both the proposed panel stacking algorithm and Shewchuk (2008). Three sizes of residential home design were investigated: small (<1500 sq.ft.), medium (1500-3000 sq.ft.) and large (>3000 sq.ft.) based on the size of the house. For each scenario, 5 problems were randomly chosen from an online database (The Home Plan Group, 2009), giving fifteen problems with rectangular building plans since Shewchuk (2008) can only solve rectangular building plans.

The computational experiments were performed for different panelization strategy. For each problem, the corresponding set of panels were found by 'breaking up' walls one-at-a-time into panels using different preferred panel length, 8 ft., 10 ft. & 12 ft., giving total 45 problems. These can all be found in Appendix C. From there it can be seen if the panelization would affect the performance of proposed algorithm.

Each problem was solved using both the proposed panel stacking algorithm and Shewchuk (2008). Solutions were compared in terms of (a) total weighted panel move distance and (b) the number of interfering panels left in the last zone.

4.2.3 Results

Experimental results are presented in Table 4.1. The table compares total weighted panel move distance and number of stacks of for both approaches. The cases are named in this format: S*a*-*b*. The first character S indicates the size of the problem (S: small cases, M: medium cases, and L: large cases). The number *a* indicates the case number and number *b* indicates the panelization parameter (1: preferred panel length is 8 ft., 2: preferred panel length is 10 ft., and 3: preferred panel length is 12 ft.). For example, case M3-2 would be medium case 3 with preferred panel length 10 ft.

In all cases, the proposed algorithm reduces both the total weighted panel move distance and the number of interfering panels. In terms of solution speed, the proposed algorithm solved each problem in less than one second.

Table 4.1 Computational results for Proposed Algorithm vs. Shewchuk (2008)

		Original Algorithm			Improved Algorithm				
Case	p[1]	s[2]	TWD[3], ft.[2]	ip[4]	s[2]	TWD[3], ft.[2]	ip[4]	IMP[5], %	IMP[6], %
S1-1	31	4	1,336	8	5	1,299	6	3	25
S2-1	37	3	1,804	12	5	1,614	7	11	42
S3-1	29	4	1,612	6	5	1,535	4	5	33
S4-1	31	2	1,930	7	3	1,301	2	33	71
S5-1	27	2	1,522	7	4	1,296	4	15	43
S1-2	28	4	1,386	9	5	1,349	7	3	22
S2-2	33	3	1,793	11	5	1,677	6	6	45
S3-2	23	4	1,672	5	6	1,588	3	5	40
S4-2	26	2	1,909	6	3	1,409	2	26	67
S5-2	23	2	1,506	6	3	1,307	4	13	33
S1-3	24	4	1,316	9	5	1,298	7	1	22
S2-3	28	3	1,796	10	5	1,609	6	10	40
S3-3	20	4	1,594	3	6	1,529	2	4	33
S4-3	24	2	1,894	5	3	1,499	4	21	20
S5-3	23	2	1,498	6	3	1,260	4	16	33
M1-1	57	5	2,681	6	6	2,385	3	11	50
M2-1	69	6	4,411	3	6	3,481	0	21	100
M3-1	67	5	3,855	7	5	3,705	6	4	14
M4-1	78	8	4,469	4	9	3,321	0	26	100
M5-1	62	6	3,227	4	6	2,722	0	16	100
M1-2	49	5	2,678	7	6	2,441	4	9	43
M2-2	57	6	4,297	1	6	3,295	0	23	100
M3-2	47	5	3,678	5	5	3,529	4	4	20
M4-2	65	7	4,675	3	8	3,469	0	26	100
M5-2	52	5	3,321	4	5	2,843	0	14	100
M1-3	43	5	2,532	5	6	2,354	3	7	40
M2-3	47	5	4,752	1	4	3,484	0	27	100
M3-3	44	5	3,687	5	5	3,539	4	4	20
M4-3	58	7	4,398	2	8	3,475	0	21	100
M5-3	46	5	3,340	2	5	2,924	0	12	100
L1-1	114	13	9,022	5	13	5,402	3	40	40
L2-1	111	12	6,072	5	12	4,936	0	19	100
L3-1	108	10	8,769	7	10	6,253	3	29	57
L4-1	114	13	8,750	5	13	4,556	0	48	100
L5-1	111	13	9,033	5	13	6,633	3	27	40
L1-2	93	11	7,926	4	11	5,703	3	28	25
L2-2	85	11	5,973	4	11	4,922	0	18	100
L3-2	94	9	7,531	6	9	6,138	3	18	50
L4-2	90	12	7,130	4	13	5,123	0	28	100
L5-2	91	10	8,413	2	10	6,694	1	20	50
L1-3	82	10	8,431	4	10	6,168	3	27	25
L2-3	74	10	6,096	4	10	5,134	0	16	100
L3-3	72	8	6,921	5	9	6,094	2	12	60
L4-3	80	12	8,561	3	12	6,350	0	26	100
L5-3	81	10	8,232	3	9	6,476	1	21	67

p[1]: number of panels
s[2]: number of stacks
TWD[3]: total weighted panel move distance
ip[4]: number of interfering panels
IMP[5]: improvement on move distance, and IMP[6]: improvement on interfering panels

In order to show the difference between the proposed algorithm and Shewchuk (2008), please see the case S3-1 in Figure 4.4 which shows the building plan. Table 4.2 and 4.3 show the solution from Shewchuk (2008) and the proposed algorithm, respectively. From the two tables, we can see the proposed algorithm will have one zone more than Shewchuk (2008), just like Figure 4.3, which result in less interfering panels. Also, the proposed algorithm has smaller zone width and less panel move distance (239,606 in.^{2} vs. 244,080 in.^{2}).

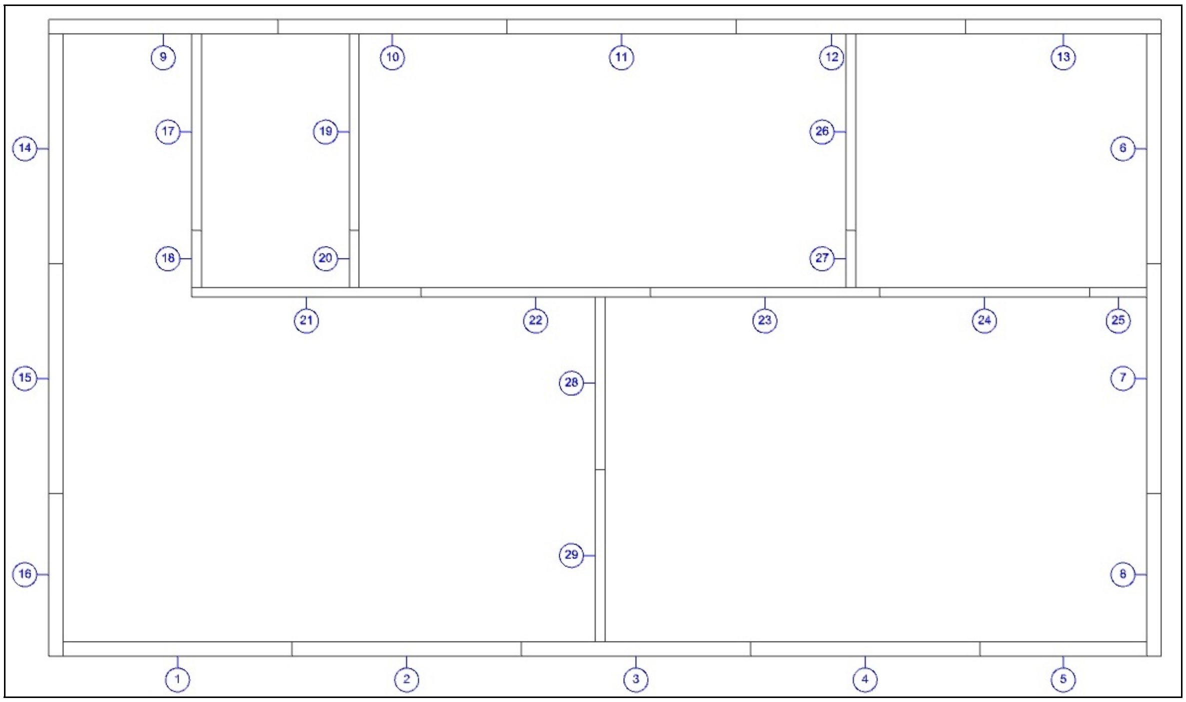


Figure 4.4 Building plan

Table 4.2 Solution from Shewchuk (2008)

```
** Stacking Plan
** File: example.stk

** Dropping Edge (1=North, 2=South, 3=East,4=West)
2

** # of zones
2

**zone    left edge X coordinate
 1           6.0
 2         228.0

** # of Stacks
4

** stack               flush
**  #   zone  type     edge      xloc     yloc   #layers  j  #panels   panels          orientation
   1     1     A    RIGHT    117.0    48.0      6      1     1          9               2
                                                       2     1         10               2
                                                       3     1         14               1
                                                       4     1         15               1
                                                       5     1         16               1
                                                       6     1          1               3
   2     2     A    RIGHT    344.0    48.0      6      1     1         11               2
                                                       2     1         12               2
                                                       3     1         13               2
                                                       4     1          6               2
                                                       5     1          7               2
                                                       6     1          8               2
   3     2     B     LEFT    344.0    90.0      5      1     1          2               3
                                                       2     1         17               1
                                                       3     3         19 18 20         1 1 1
                                                       4     1         21               3
                                                       5     2         26 27            1 1
   4     2     B     LEFT    344.0    90.0      7      1     1          3               3
                                                       2     1          4               3
                                                       3     1         22               3
                                                       4     1         23               3
                                                       5     2         24 25            3 3
                                                       6     2         28 29            1 1
                                                       7     1          5                 3

** # of interfering panels
6: 22 23 24 25 28 29

** weighted panel move distance
232151
```

Table 4.3 Solution from proposed algorithm

** Stacking Plan
** File: example.stk

** Dropping Edge (1=North, 2=South, 3=East,4=West)
2

** # of zones
3

**zone left edge X coordinate

zone	left edge X coordinate
1	6.0
2	210.0
3	258.0

** # of Stacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	102.0	48.0	6	1	1	9	2
							2	1	10	2
							3	1	14	1
							4	1	15	1
							5	1	16	1
							6	1	1	3
2	2	A	RIGHT	351.0	48.0	2	1	1	11	2
							2	1	12	2
3	2	B	LEFT	351.0	90.0	6	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	17	1
							5	3	19 18 20	1 1 1
							6	1	21	3
4	3	A	RIGHT	369.0	48.0	4	1	1	13	2
							2	1	6	2
							3	1	7	2
							4	1	8	2
5	3	B	LEFT	369.0	90.0	7	1	2	28 29	1 1
							2	1	26 27	1 1
							3	1	5	3
							4	1	25	3
							5	1	24	3
							6	1	23	3
							7	1	22	3

** # of interfering panels
4: 25 24 23 22

** weighted panel move distance
220970

4.2.4 Discussion of Results

Improvement was found in all cases. Improvement on panel move distance ranged from 1.35-47.93%, and improvement on interfering panels ranged from 20-100%. The computational results indicate the proposed panel stacking algorithm performed better than Shewchuk (2008) in all cases, because it provided less total weighted panel move distance and interfering panels. It is not surprising that proposed algorithm will perform better in panel move distance since zone width is optimized for each zone and from Figure 4.3 it can be seen the proposed algorithm will have less interfering panels than Shewchuk (2008).

A summary is presented in Table 4.4. From the summary we can see that the proposed algorithm can provide more improvement on panel move distance in large cases than small cases. It is not surprising since the larger the problem, more zones it will have which results in more improvement. In terms of the improvement on interfering panels, the proposed algorithm can provide a slight more improvement in medium and large cases than small cases, it maybe because there are more interfering panels in the last zone for medium and large cases. Regarding the panelization strategy, we can see from the summary that the proposed algorithm can provide more improvement if the preferred panel length 8 ft. is selected. When 8 ft. is selected as the preferred panel length, it will result in more panels and smaller average panel length which will possibly result in smaller zone width, and as a result, it will possibly result in more improvement on both improvements on panel move distance and interfering panels. From these computational results, we can see the proposed algorithm performs better in larger cases with the preferred panel length 8 ft.

Table 4.4 Summary for the computational results

Case	Average improvement on panel move distance, %	Average improvement on interfering panels, %
Small - panelization 8ft	13.11	42.86
Small - panelization 10ft	10.72	41.53
Small - panelization 12ft	10.53	29.78
Medium - panelization 8ft	15.47	72.86
Medium - panelization 10ft	15.29	72.57
Medium - panelization 12ft	14.23	72.00
Large - panelization 8ft	32.41	67.43
Large - panelization 10ft	22.54	65.00
Large - panelization 12ft	20.34	70.33

4.3 Improvement 2 — Solve for non-rectangular cases

4.3.1 Algorithm

When the building plan is non-rectangular, which Shewchuk (2008) could not solve, the idea of the proposed algorithm is similar to Shewchuk (2008). First, zone width and unload zone height will be calculated based on the algorithm described in chapter 4.2. Then each zone will be examined: if the zone is rectangular, it will be the same as Shewchuk (2008), otherwise, it will provide different solutions based on the shape of the zone and unload zone height.

The follows will show how the proposed algorithm perform for each situations (first zone-type a, second zone-type a, second zone-type b, etc.)

1. <u>First Zone (stack type a)</u>

1.1 When the width of first zone is calculated like Figure 4.5 and $H_1^* + offset < H_0 - L_{max}$,

Where L_{max} = maximum panel length (inch), current stack

H_0 = maximum distance from the top edge of the building plan to the dropping edge

Stack 1a in the location as Figure 4.5 indicates. Calculate x coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{W_1}{2}$$

Calculate *y* coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold} + offset$$

If $H_1^* + offset \geq H_0 - L_{max}$ and $H_{1low}^* + offset < H_0$, we put stack 1a in the location as Figure 4.6 indicates.

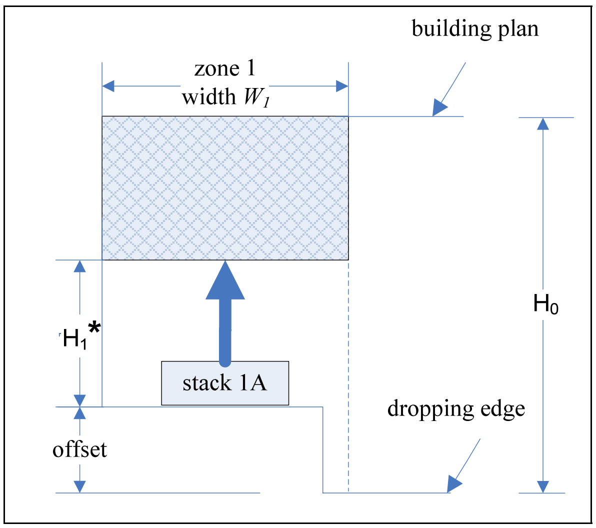


Figure 4.5 Non-rectangular, Zone 1, case a

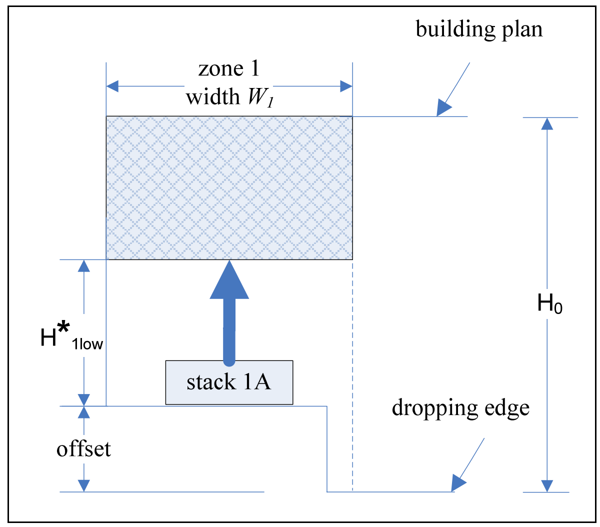


Figure 4.6 Non-rectangular, Zone 1, case b

Where H_{1low}^* = unload zone height calculated based on lift activity L3 and L4 (Shewchuk et al., 2009, Figure 4.7). L3 and L4 are two lift activities which will be used when the space is limited, they are illustrated in Figure 4.7.

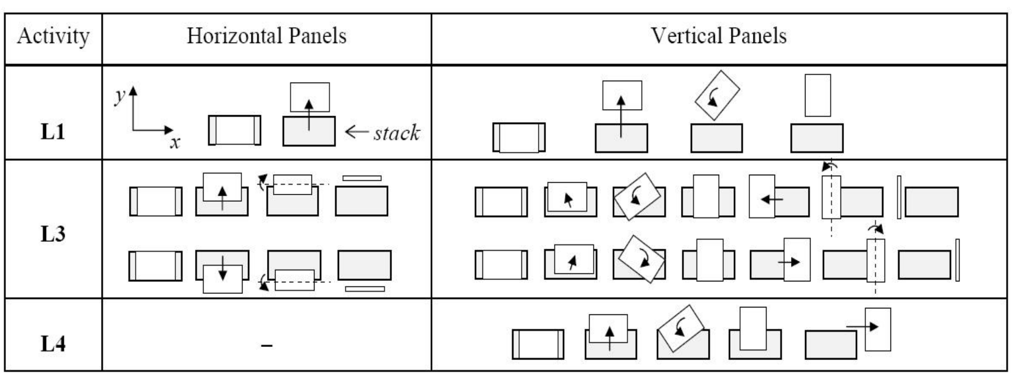


Figure 4.7 Lift activity (Shewchuk et al., 2009)

Calculate x coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{W_1}{2}$$

Calculate y coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold} + offset$$

If $H^*_{1low} + offset \geq H_0$, we put stack 1a in the location as Figure 4.8 indicates.

Calculate x coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{W_1}{2} + W_0$$

Calculate y coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold}$$

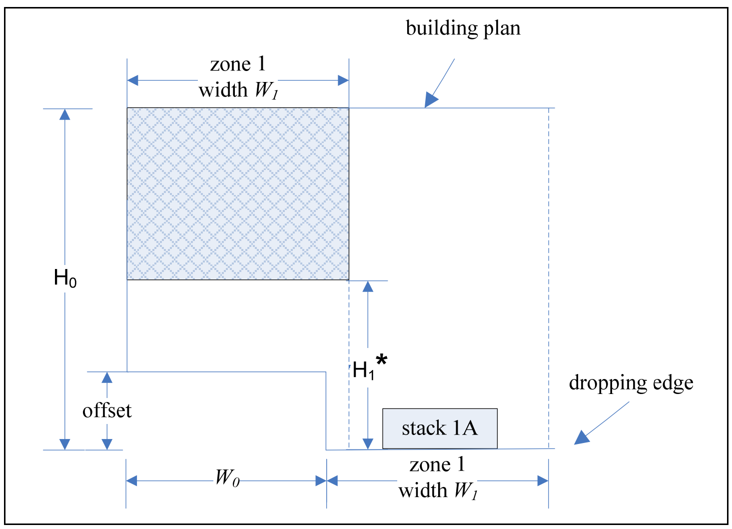


Figure 4.8 Non-rectangular, Zone 1, case c

1.2 When the width of first zone is calculated like Figure 4.9 and $H^*_1 + offset < H_0 - L_{\max}$

Stack 1a in the location as Figure 4.9 indicates. Calculate x coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{W_1}{2}$$

Calculate y coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold} + offset$$

If $H^*_1 + offset \geq H_0 - L_{max}$ and $H^*_{1low} + offset < H_0$, stack 1a in the location as Figure 4.10 indicates.

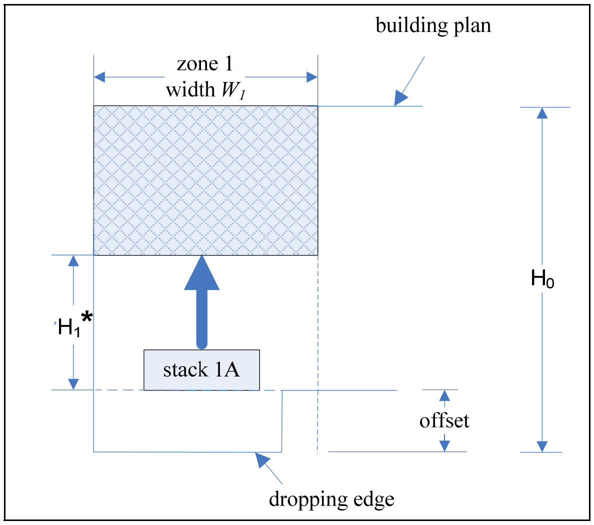


Figure 4.9 Non-rectangular, Zone 1, case d

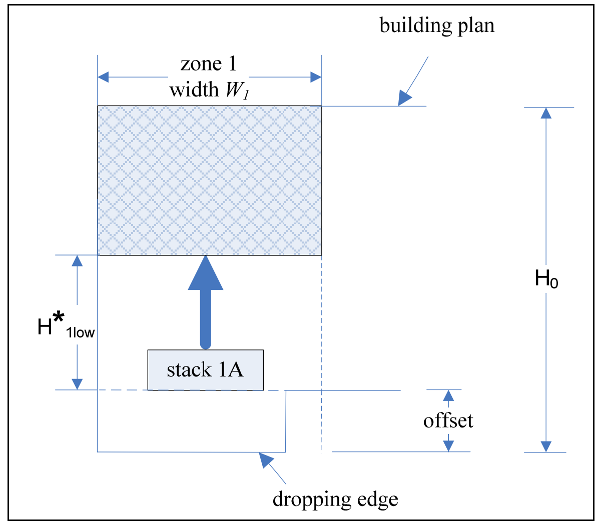


Figure 4.10 Non-rectangular, Zone 1, case e

Calculate *x* coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{W_1}{2}$$

Calculate *y* coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold} + offset$$

If $H^*_{1low} + offset \geq H_0$, stack 1a in the location as Figure 4.11 indicates.

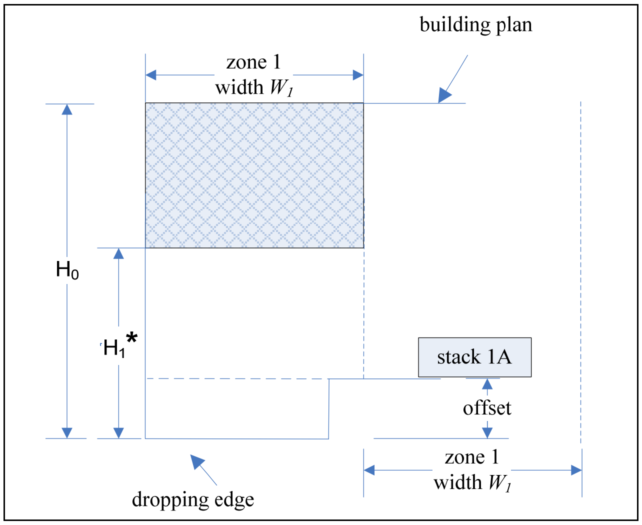
Calculate *x* coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{3}{2} W_1$$

Calculate *y* coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold} + offset$$

Situation like Figure 4.12 is similar to situation 1.2.



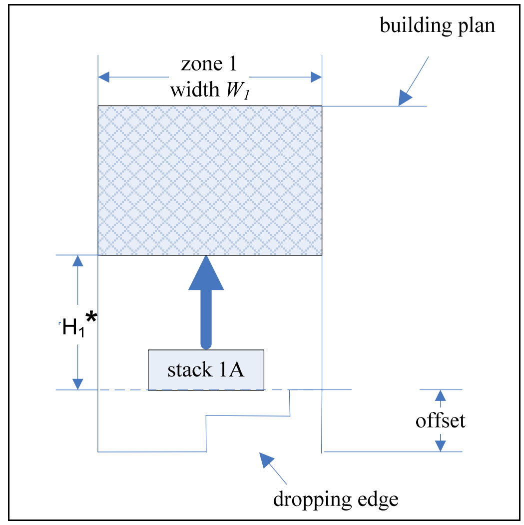


Figure 4.11 Non-rectangular, Zone 1, case f **Figure 4.12 Non-rectangular, Zone 1, case g**

1.3 When the width of first zone is calculated like Figure 4.13:

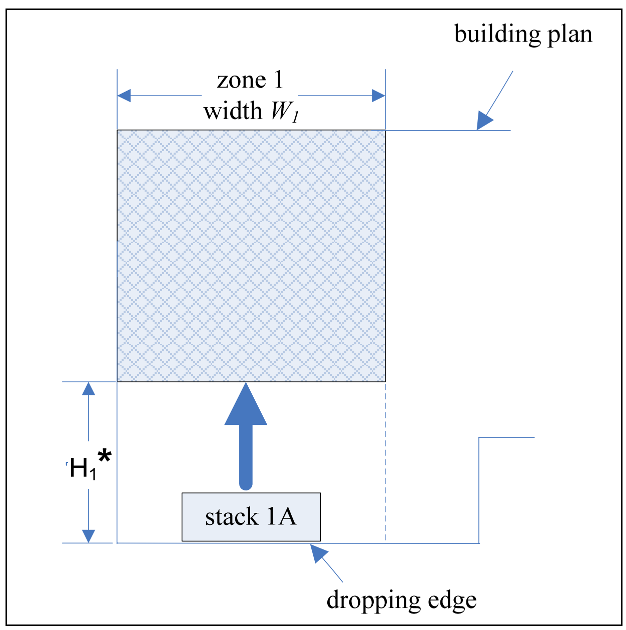


Figure 4.13 Non-rectangular, Zone 1, case h

Stack 1a in the location as Figure 4.13 indicates. Calculate *x* coordinate $Xstack_{1a}$:

$$Xstack_{1a} = \frac{W_1}{2}$$

Calculate *y* coordinate of stack 1a $Ystack_{1aold}$ following Shewchuk (2008). Then now

$$Ystack_{1anew} = Ystack_{1aold}$$

2. <u>Zone i > 1 (except last zone), stack type a</u>

2.1 When the width of zone i is calculated like Figure 4.14 and $H_i^* + offset < H_0 - L_{\max}$,

Stack ia in the location as Figure 4.14 indicates. Calculate x coordinate $Xstack_{ia}$:

$$Xstack_{ia} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

Calculate y coordinate of stack ia $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold} + offset$$

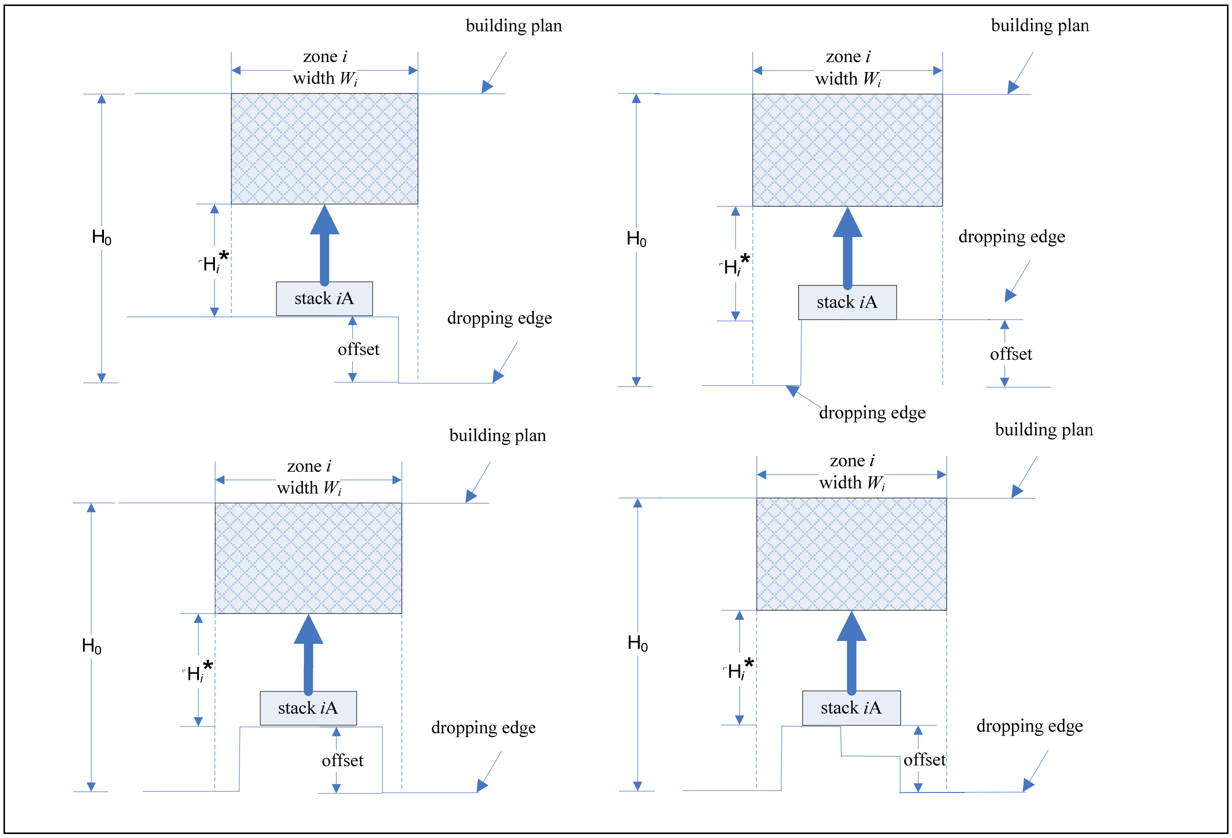


Figure 4.14 Non-rectangular, Zone i-type A-case a

If $H_i^* + offset \geq H_0 - L_{max}$ and $H_{ilow}^* + offset < H_0$, stack ia in the location as Figure 4.15 indicates. Calculate x coordinate $Xstack_{ia}$:

$$Xstack_{ia} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

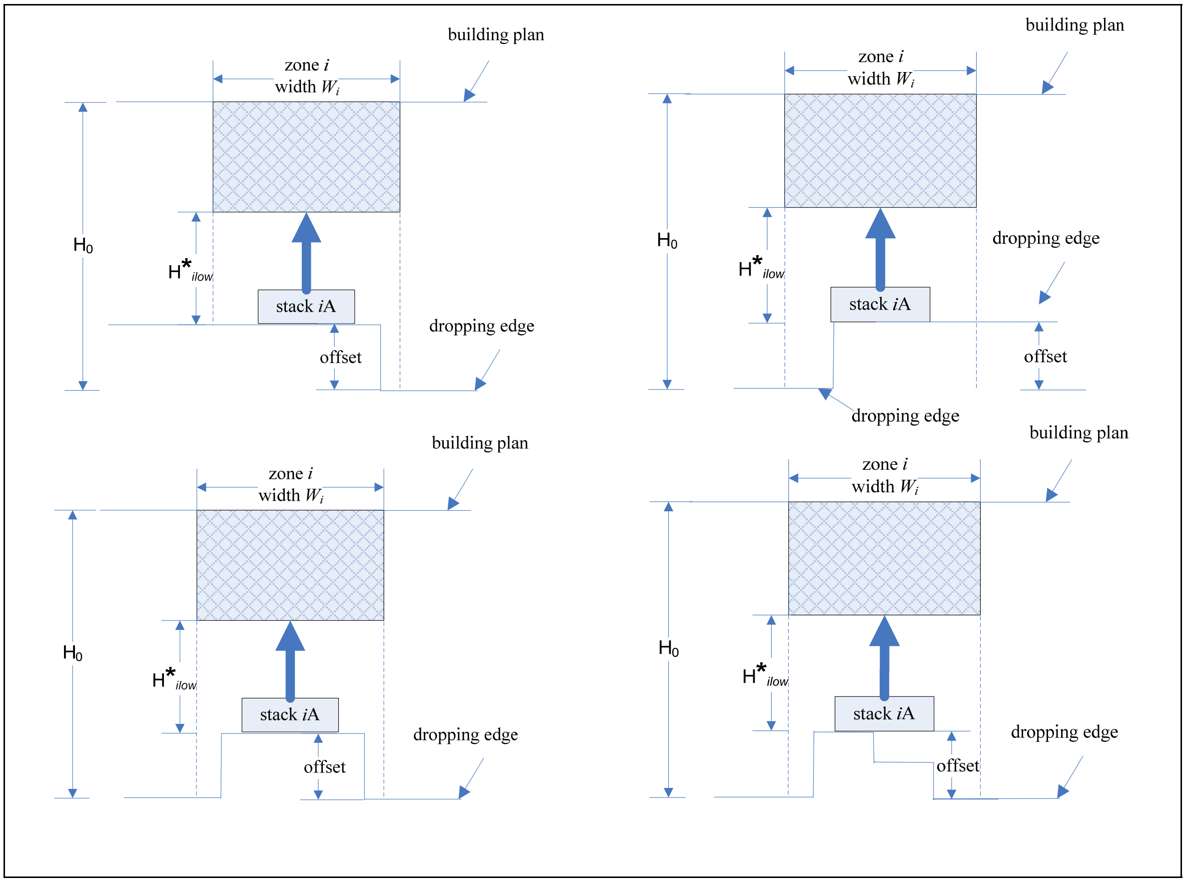


Figure 4.15 Non-rectangular, Zone *i*-type A-case b

Calculate *y* coordinate of stack *ia* $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold} + offset$$

If $H^*_{ilow} + offset \geq H_0$, stack *ia* in the location as Figure 4.16 indicates.

Calculate *x* coordinate $Xstack_{ia}$:

$$Xstack_{ia} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2} + W_0$$

Calculate *y* coordinate of stack *ia* $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold}$$

If a location like Figure 4.16 could not be found, stack *ia* in the location as Figure 4.17 indicates. Calculate *x* coordinate $Xstack_{ia}$:

$$Xstack_{ia} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

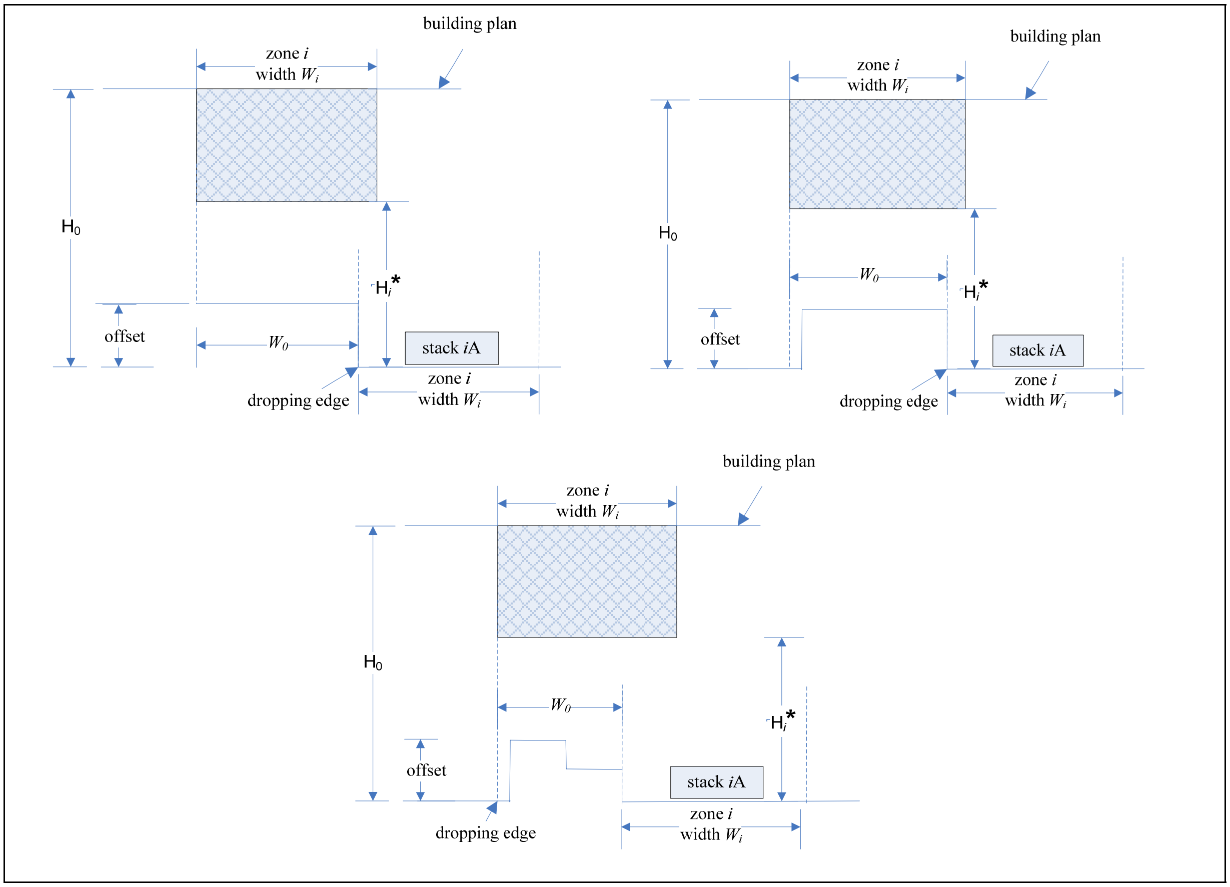


Figure 4.16 Non-rectangular, Zone *i*-type A- case c

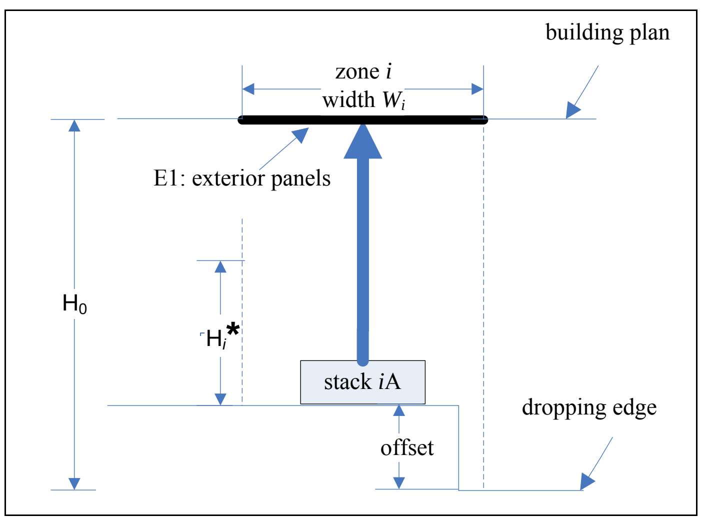


Figure 4.17 Non-rectangular, Zone *i*-type A-case d

Calculate y coordinate of stack ia $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold} + \text{offset}$$

In this situation, stack ia will only contain the exterior panels E1.

Situation like Figure 4.18 is similar to situation 2.1

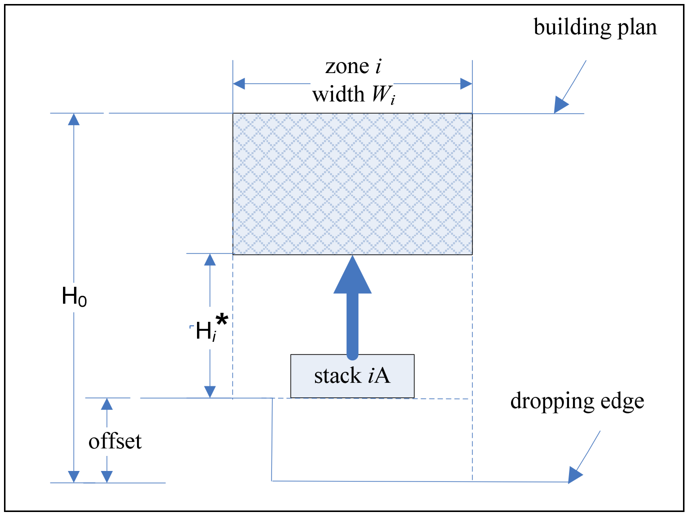


Figure 4.18 Non-rectangular, Zone *i*-type A-case e

2.2 When the width of zone i is calculated like Figure 4.19:

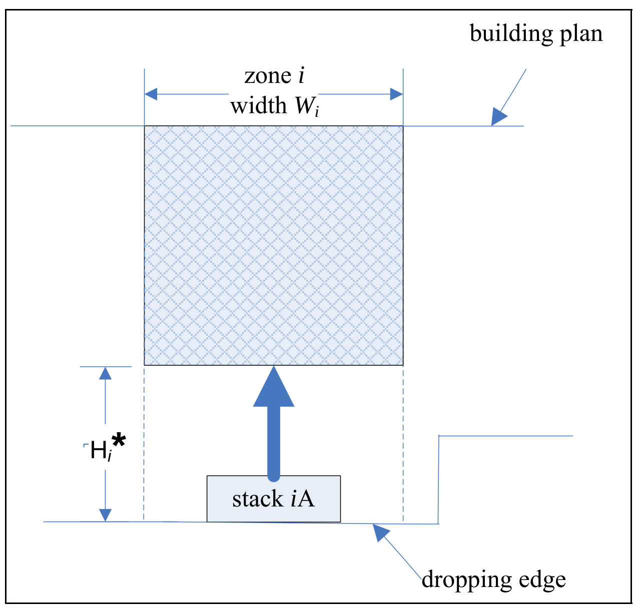


Figure 4.19 Non-rectangular, Zone *i*-type A-case f

Stack ia in the location as Figure 4.19 indicates. Calculate x coordinate $Xstack_{ia}$:

$$Xstack_{ia} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

Calculate *y* coordinate of stack *ia* $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold}$$

3. <u>Zone *i* > 1 (except last zone), stack type b</u>

3.1 When the width of zone *i* is calculated like Figure 4.20:

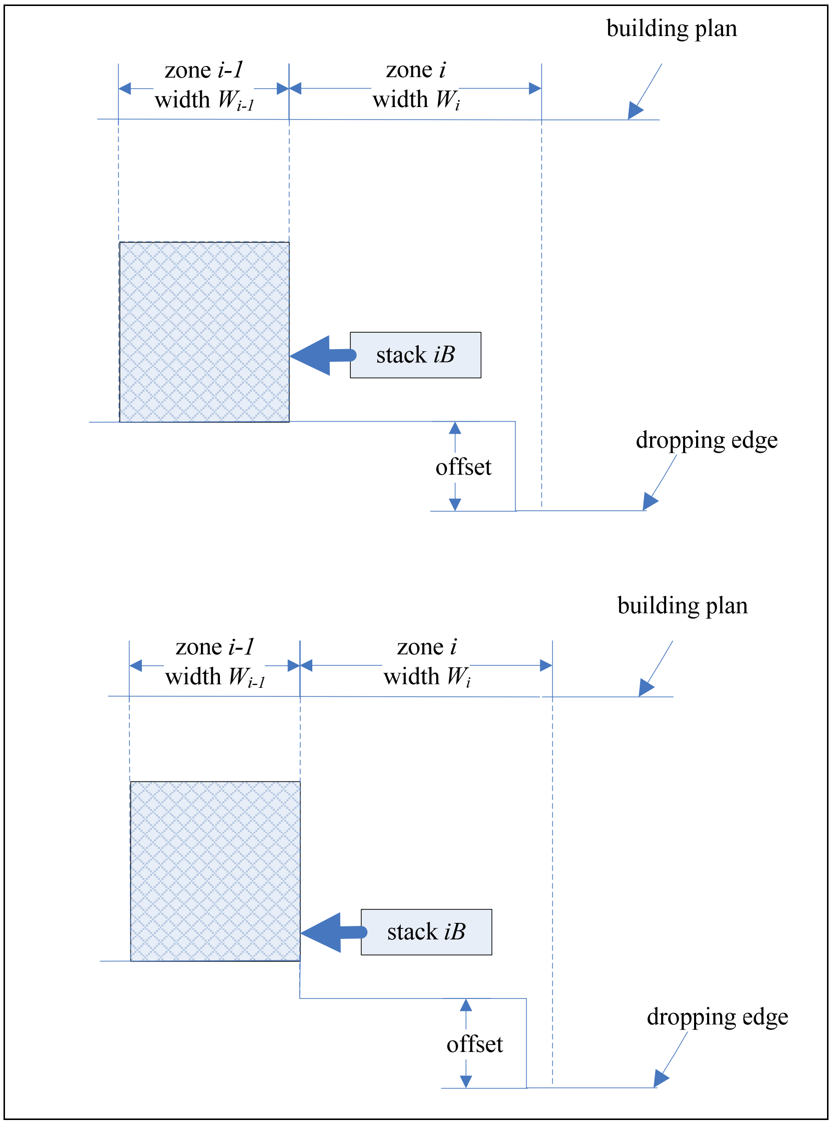


Figure 4.20 Non-rectangular, Zone *i*-type B-case a

Stack *i*b in the location as Figure 4.20 indicates. Calculate *x* coordinate $Xstack_{ib}$:

$$Xstack_{ib} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

Calculate y coordinate of stack ib $Ystack_{ibold}$ following Shewchuk (2008). Then now

$$Ystack_{ibnew} = Ystack_{ibold} + offset$$

3.2 When the width of zone i is calculated like Figure 4.21:

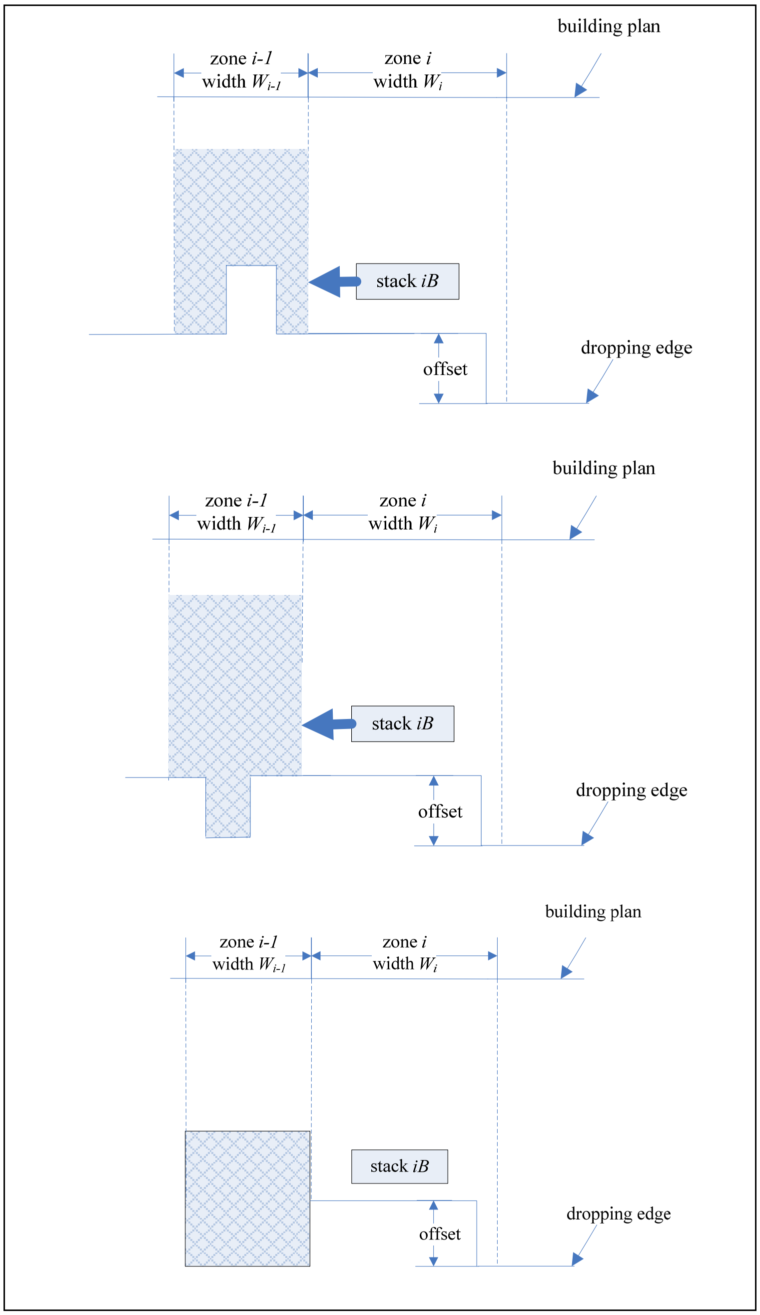


Figure 4.21 Non-rectangular, Zone *i*-type B-case b

Stack ib in the location as Figure 4.21 indicates. Calculate x coordinate $Xstack_{ib}$:

$$Xstack_{ib} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

Calculate *y* coordinate of stack *i*b $Ystack_{ibold}$ following Shewchuk (2008). Then now

$$Ystack_{ibnew} = Ystack_{ibold} + offset$$

3.3 When the width of zone *i* is calculated like Figure 4.22:

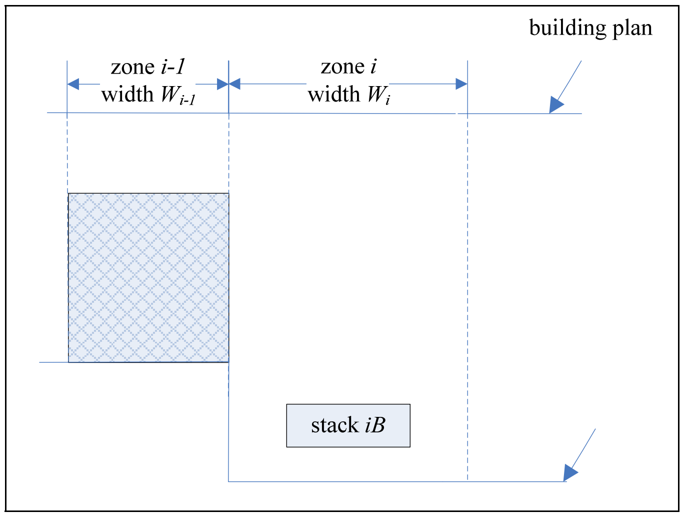


Figure 4.22 Non-rectangular, Zone *i*-type B-case c

Stack *i*b in the location as Figure 4.22 indicates. Calculate *x* coordinate $Xstack_{ib}$:

$$Xstack_{ib} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

Calculate *y* coordinate of stack *i*b $Ystack_{ibold}$ following Shewchuk (2008). Then now

$$Ystack_{ibnew} = Ystack_{ibold}$$

3.4 When the width of zone *i* is calculated like Figure 4.23:

Stack *i*b in the location as Figure 4.23 indicates. Calculate *x* coordinate $Xstack_{ib}$:

$$Xstack_{ib} = \sum_{j=1}^{i-1} W_j + \frac{W_i}{2}$$

Calculate *y* coordinate of stack *i*b $Ystack_{ibold}$ following Shewchuk (2008). Then now

$$Ystack_{ibnew} = Ystack_{ibold}$$

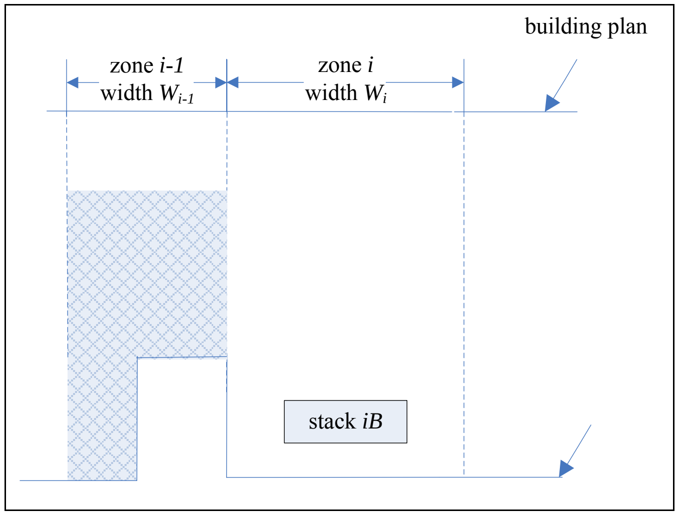


Figure 4.23 Non-rectangular, Zone *i*-type B-case d

4. Zone *i* > 1 (last zone), stack type a

4.1 When the width of first zone is calculated like Figure 4.24 and $H_i^* + offset < H_0 - L_{\max}$,

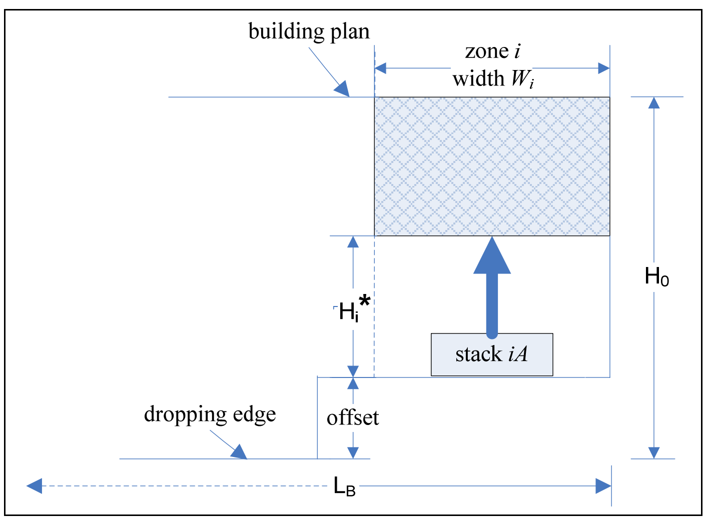


Figure 4.24 Non-rectangular, Last Zone-type A-case a

Stack *i*a in the location as Figure 4.24 indicates. Calculate *x* coordinate $Xstack_{ia}$:

$$Xstack_{ia} = L_B - \frac{W_i}{2}$$

Where L_B is the total building length.

Calculate *y* coordinate of stack *i*b $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold} + offset$$

If $H_i^* + offset \geq H_0 - L_{max}$ and $H_{ilow}^* + offset < H_0$, we put stack *i*a in the location as Figure 4.25 indicates.

Calculate *x* coordinate $Xstack_{ia}$:

$$Xstack_{ia} = L_B - \frac{W_i}{2}$$

Calculate *y* coordinate of stack *i*b $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold} + offset$$

If $H_{ilow}^* + offset \geq H_0$, we still put stack *i*a in the location as Figure 4.25 indicates. But stack *i*a will only contain those exterior panels like shown in Figure 4.26.

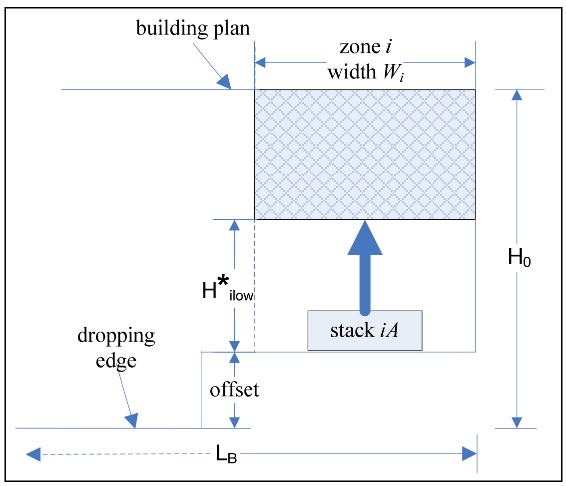


Figure 4.25 Non-rectangular, Last Zone-type A-case b

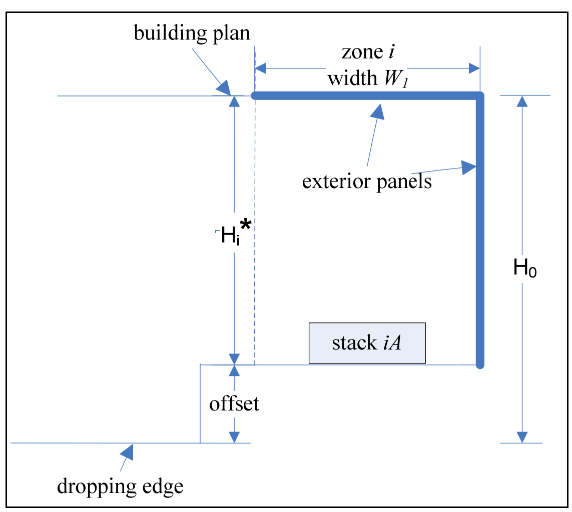


Figure 4.26 Non-rectangular, Last Zone-type A-case c

4.2 When the width of first zone is calculated like Figure 4.27,

Stack *i*a in the location as Figure 4.27 indicates. Calculate *x* coordinate $Xstack_{ia}$:

$$Xstack_{ia} = L_B - \frac{W_i}{2}$$

Where L_B is the total building length.

Calculate *y* coordinate of stack *i*b $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ianew} = Ystack_{iaold}$$

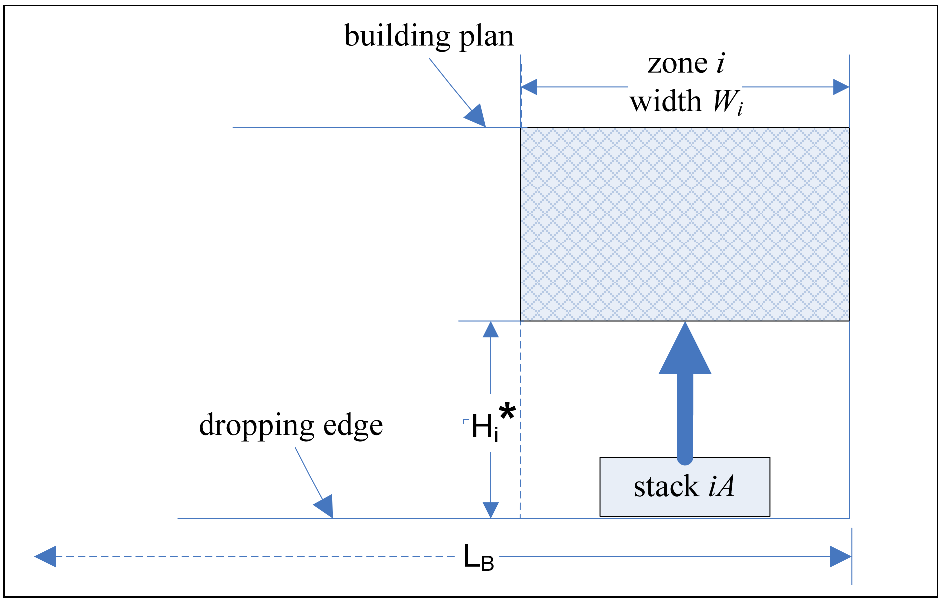


Figure 4.27 Non-rectangular, Last Zone-type A-case d

5. <u>Last Zone, stack type b</u>

It will be discussed in section 4.4.1.

4.3.2 Experimental Design

A set of computational experiments was performed to establish the performance of the proposed panel stacking algorithm, as compared with commercial software and an experienced panel designer. For commercial software we chose IntelliBuild 2.4.8.4, which was developed by Truswal Systems and Intelligent Building Systems and widely used in the industry. We also chose a panel designer, who has 8 years experience in generating panel stacking plan, to solve all the problems manually. Three sizes of residential home design were investigated: small (<1500 sq.ft.), medium (1500-3000 sq.ft.) and large (>3000 sq.ft.) based on the size of the house.

For each scenario, 5 problems were randomly chosen from an online database (The Home Plan Group, 2009), giving fifteen problems with non-rectangular building plans.

The computational experiments were performed using different panelization strategy. For each problem, the corresponding sets of panels were found by 'breaking up' walls one-at-a-time into panels using different preferred panel length: 8 ft., 10 ft. & 12 ft., giving total 45 problems. These can all be found in Appendix D. From there we can see if the panelization would affect the performance of the proposed algorithm.

Each problem was solved using the proposed panel stacking algorithm, IntelliBuild, and the panel designer. Solutions were compared in terms of (a) total weighted panel move distance and (b) the percentage of panels for which connectivity is maintained (when panels are installed in the order they appear in the stack). Since solutions from IntelliBuild and the panel designer did not provide stack drop-off locations, we assumed the best case possible and used an iterative algorithm (Appendix A) to calculate stack drop-off locations to minimize total weighted panel move distance. Note that as interference was not checked here, problems can occur when panels are unloaded from their stacks. By contrast, the proposed approach guarantees no such interference will occur when panels are unloaded.

4.3.3 Results

Experimental results are presented in Table 4.5. The table compares total weighted panel move distance and connectivity for all approaches. The cases are named in this format: S*a*-*b*. The first character S indicates the size of the problem (S: small cases, M: medium cases, and L: large cases). The number *a* indicates the case number and number *b* indicates the panelization parameter (1: preferred panel length is 8 ft., 2: preferred panel length is 10 ft., and 3: preferred panel length is 12 ft.). For example, case M3-2 would be medium case 3 with preferred panel length 10 ft. In terms of solution speed, the proposed algorithm solved each problem in less than one second.

Table 4.5 Computational results for Proposed Algorithm vs. IntelliBuild vs. Panel Designer

Case	p[1]	Panel Designer			IntelliBuild			Proposed Algorithm				
		s[2]	TWD[3], ft.[2]	C[4], %	s[2]	TWD[3],ft.[2]	C[4], %	s[2]	TWD[3], ft.[2]	C[4], %	INC[5], %	INC[6], %
S1-1	28	3	1,967	82	3	1,910	89	5	1,548	100	27	23
S2-1	27	3	1,353	81	3	1,504	89	3	1,308	100	3	15
S3-1	30	4	1,478	80	3	1,814	73	5	1,311	100	13	38
S4-1	31	4	1,480	80	3	1,920	84	3	1,313	100	13	46
S5-1	36	4	1,642	72	4	1,657	86	3	1,629	100	1	2
S1-2	23	3	1,999	87	3	1,915	87	5	1,602	100	25	20
S2-2	23	3	1,346	74	3	1,430	89	3	1,319	100	2	8
S3-2	27	3	1,652	74	3	1,825	81	5	1,361	100	21	34
S4-2	25	3	1,699	80	3	1,910	84	3	1,422	100	20	34
S5-2	33	4	1,470	73	4	1,731	79	3	1,467	100	0	18
S1-3	20	3	1,948	80	3	1,996	85	5	1,543	100	26	29
S2-3	23	3	1,398	70	3	1,414	89	3	1,272	100	10	11
S3-3	24	3	1,643	71	3	1,647	75	5	1,310	100	25	26
S4-3	24	3	1,568	79	3	1,884	83	3	1,513	100	4	25
S5-3	30	3	1,459	77	3	1,732	83	3	1,457	100	0	19
M1-1	66	6	2,588	70	5	2,242	83	5	2,225	100	16	1
M2-1	61	7	3,212	80	5	3,432	87	6	2,747	100	17	25
M3-1	56	7	2,962	84	5	3,137	88	6	2,407	100	23	30
M4-1	77	9	4,452	83	6	7,917	91	9	3,351	100	33	136
M5-1	68	8	2,482	79	6	4,512	87	6	2,551	100	-3	77
M1-2	46	5	2,800	78	5	2,690	85	5	2,450	100	14	10
M2-2	51	6	3,845	84	5	4,431	84	5	2,869	100	34	54
M3-2	49	6	2,431	84	5	3,268	86	6	2,427	100	0	35
M4-2	64	8	5,533	78	6	6,890	89	8	3,501	100	58	97
M5-2	59	7	2,667	83	5	4,502	86	6	2,631	100	1	71
M1-3	43	5	2,382	74	5	3,263	88	5	2,376	100	0	37
M2-3	45	6	4,027	76	5	4,804	84	5	2,951	100	36	63
M3-3	43	6	2,399	81	5	3,615	86	6	2,376	100	1	52
M4-3	57	8	5,230	81	5	6,427	89	8	3,506	100	49	83
M5-3	47	6	3,307	79	5	5,405	87	4	3,258	100	1	66
L1-1	107	11	6,157	82	8	6,459	86	9	6,102	100	1	6
L2-1	112	13	8,529	83	9	10,438	86	11	4,597	100	86	127
L3-1	113	13	6,696	81	9	9,567	87	13	5,451	100	23	76
L4-1	110	12	10,543	83	9	13,019	87	13	6,693	100	58	95
L5-1	110	12	7,252	82	8	8,280	87	12	4,981	100	46	66
L1-2	90	11	6,452	79	8	7,033	86	9	6,194	100	4	14
L2-2	91	10	8,014	84	8	11,230	89	10	5,169	100	55	117
L3-2	93	11	6,291	81	8	10,222	89	11	5,755	100	9	78
L4-2	87	10	11,077	80	8	15,468	87	12	6,755	100	64	129
L5-2	84	10	8,162	77	8	7,703	88	11	4,967	100	64	55
L1-3	71	9	6,260	77	7	6,855	87	9	6,149	100	2	11
L2-3	82	9	8,928	78	7	12,620	88	9	6,408	100	39	97
L3-3	81	9	8,025	81	7	11,079	86	10	6,224	100	29	78
L4-3	74	10	10,788	77	7	14,759	88	12	6,535	100	65	126
L5-3	73	10	6,496	79	7	11,423	82	10	5,181	100	25	121

p[1]: number of panels
s[2]: number of stacks
TWD[3]: total weighted panel move distance
C[4]: connectivity
INC[5]: increase on the TWD[1] by panel designer, and INC[6]: increase on the TWD[1] by IntelliBuild

In order to show the difference between the panel designer, IntelliBuild, and the proposed algorithm, please see the case S4-1 in Figure 4.28 which shows the building plan. Figure 4.29, 4.30 and 4.31 show the solution from panel designer (4 stacks), IntelliBuild (3 stacks), and the proposed algorithm (3 stacks), respectively. Panel designer mainly makes the stacking efficiently and stable (no block will be used).

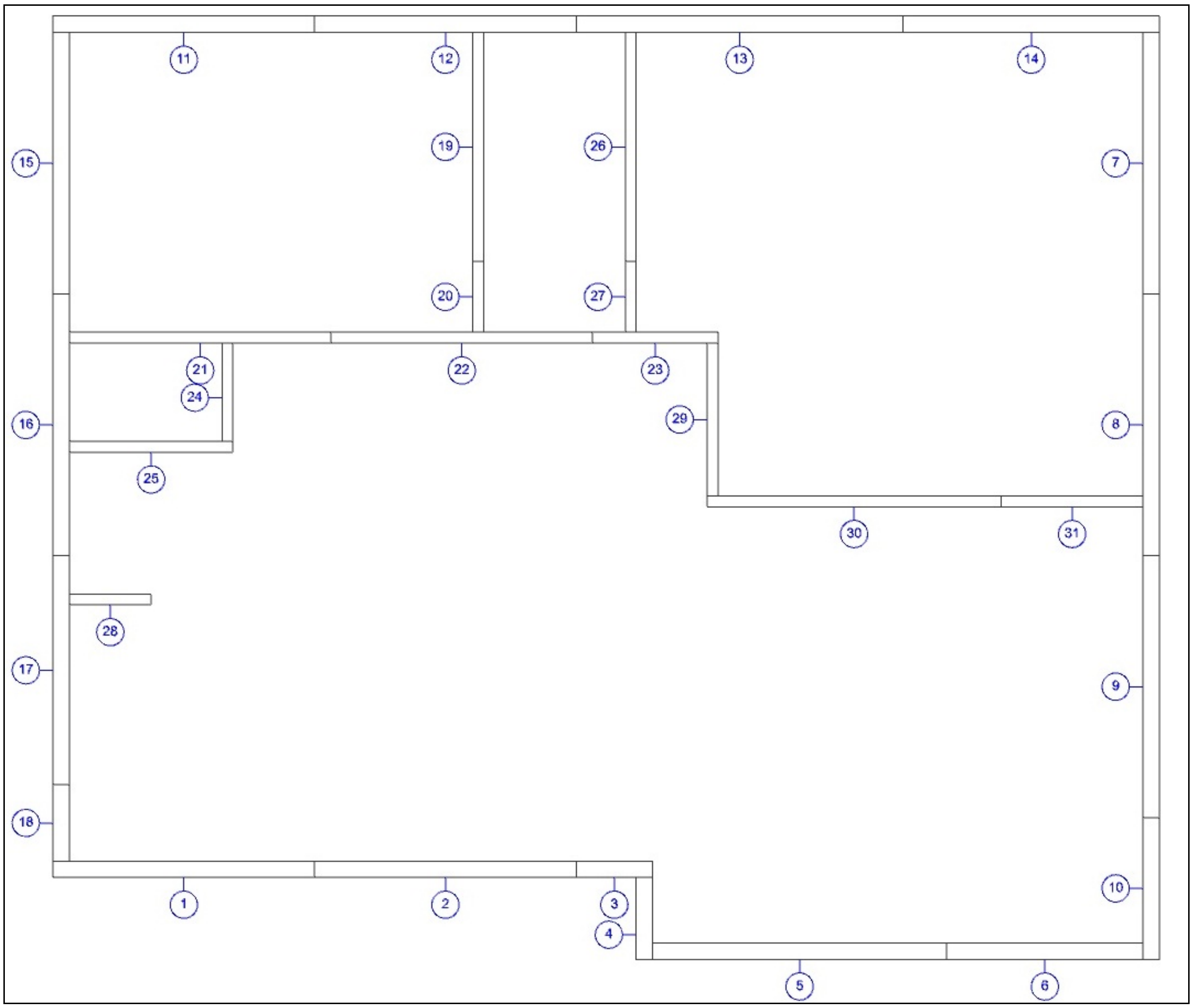


Figure 4.28 Building plan

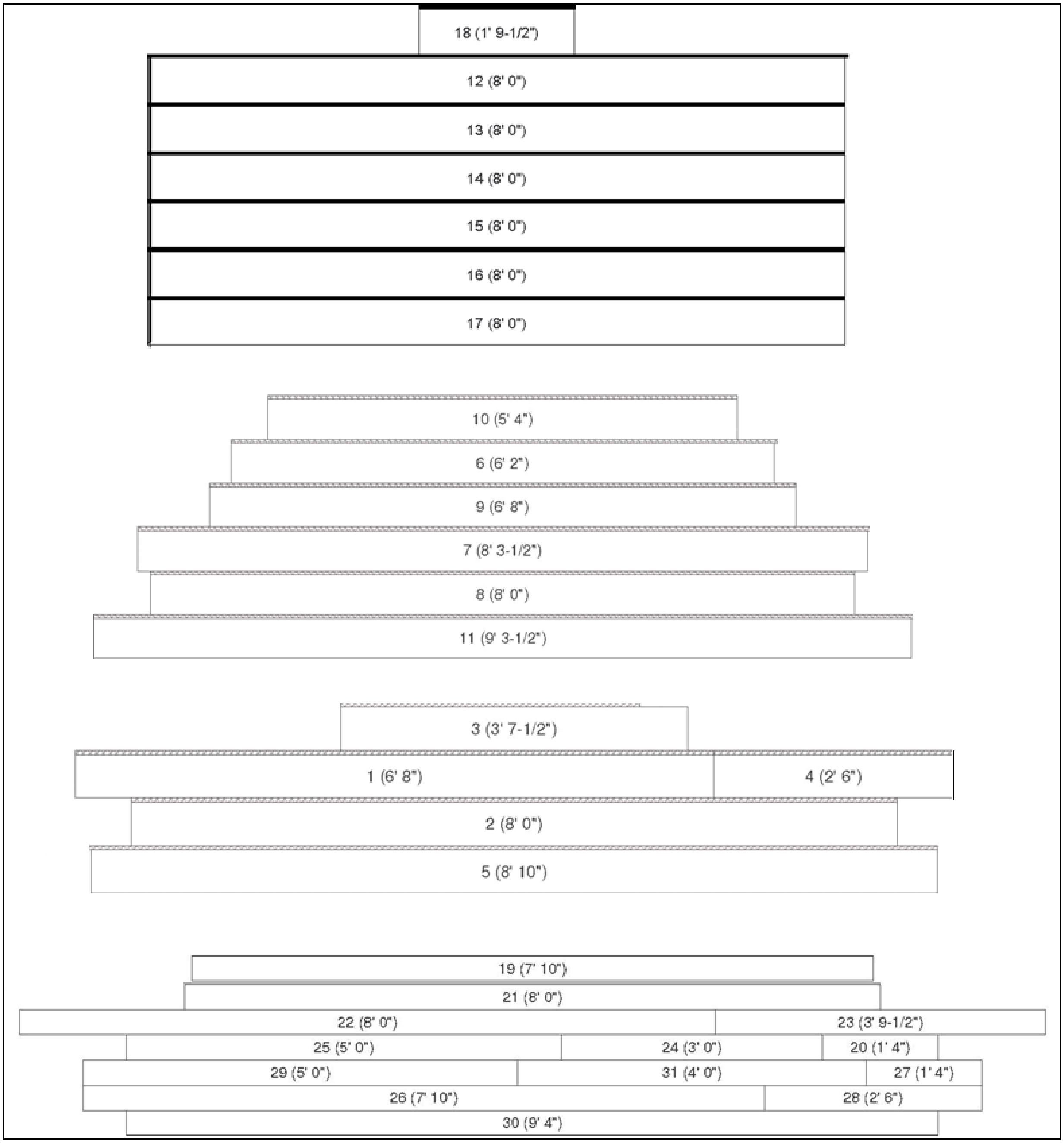


Figure 4.29 Stacking Solution from Panel designer

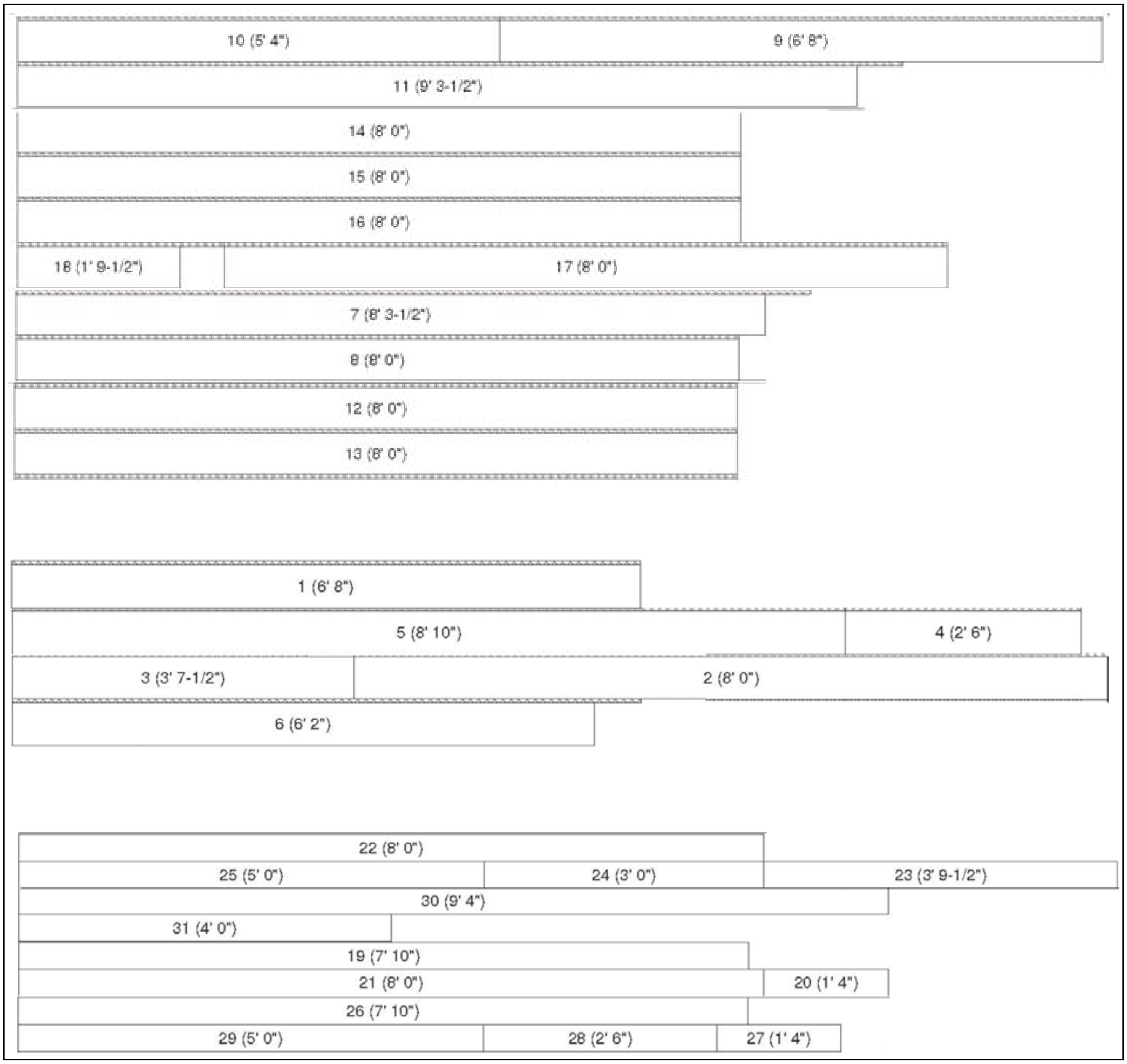


Figure 4.30 Stacking solution from IntelliBuild

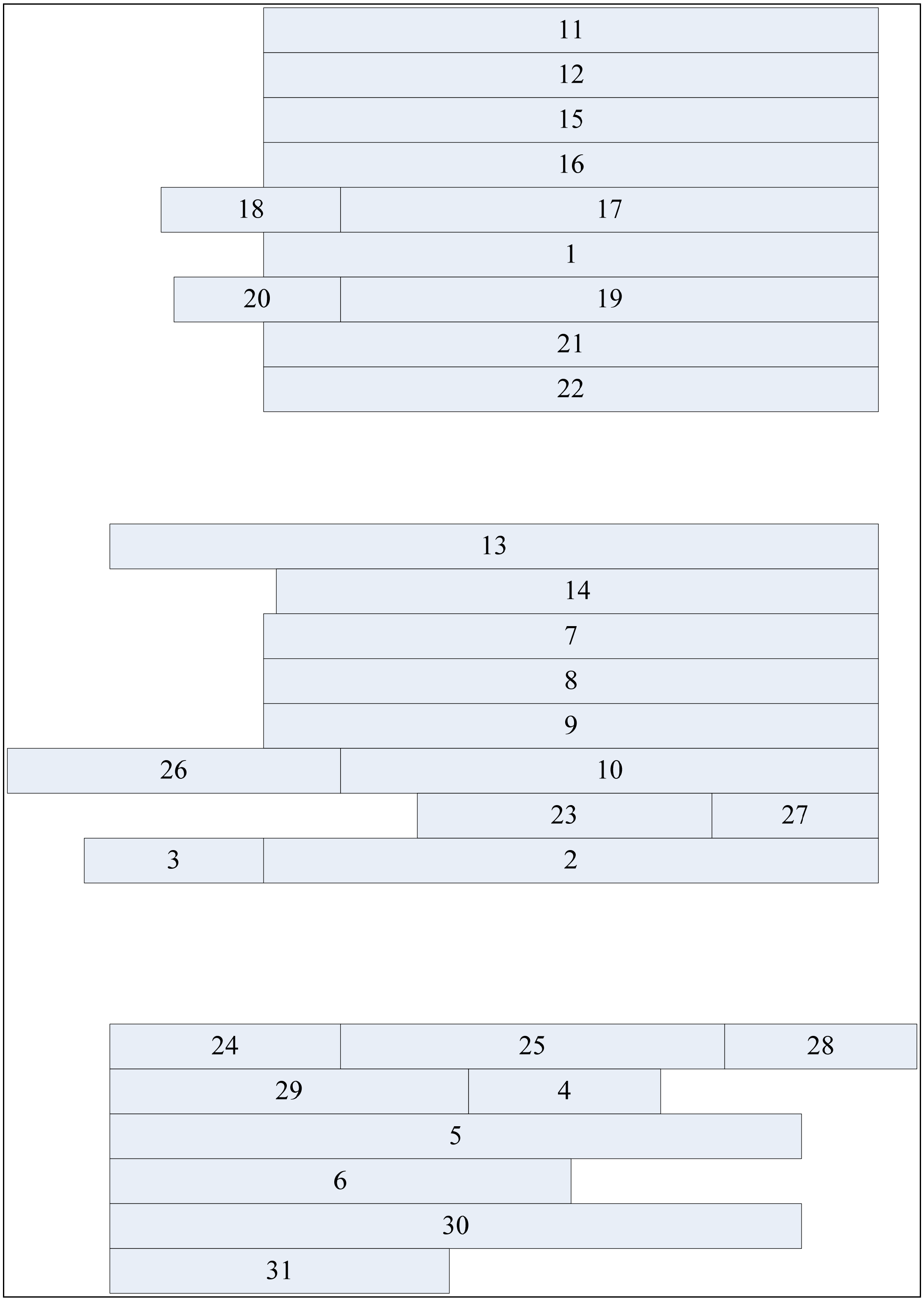


Figure 4.31 Stacking solution from the proposed algorithm

In order to show the impact on panel move distance and non-connecting panels by different stacking solutions, we show the panelization plan with the panels labeled by build sequence for each approach in Figure 4.32，4.33 and 4.34. From these figures, we can see the panel designer and IntelliBuild results in more non-connecting panels.

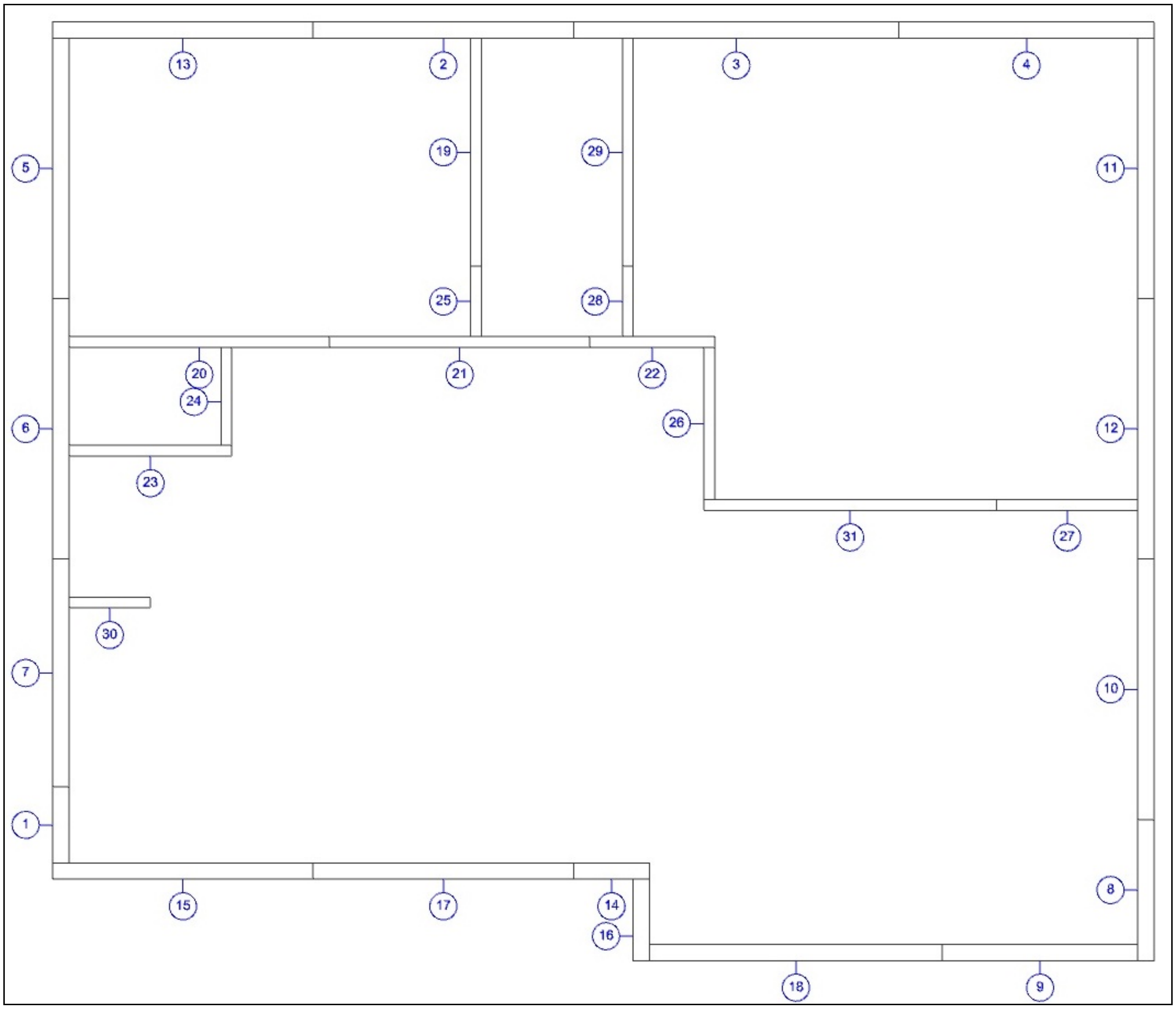


Figure 4.32 Solution of Panel designer (by build sequence)

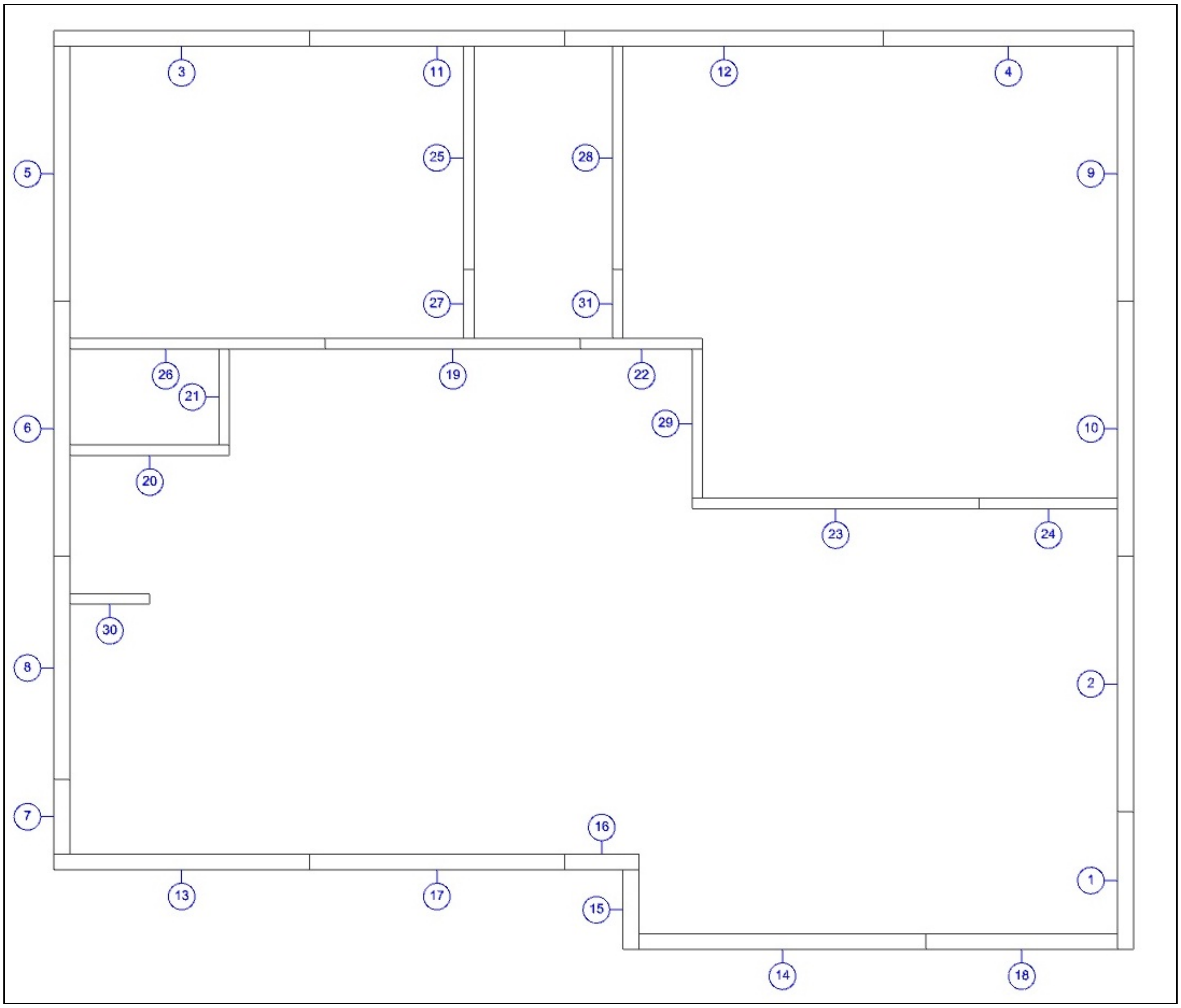


Figure 4.33 Solution of IntelliBuild (by build sequence)

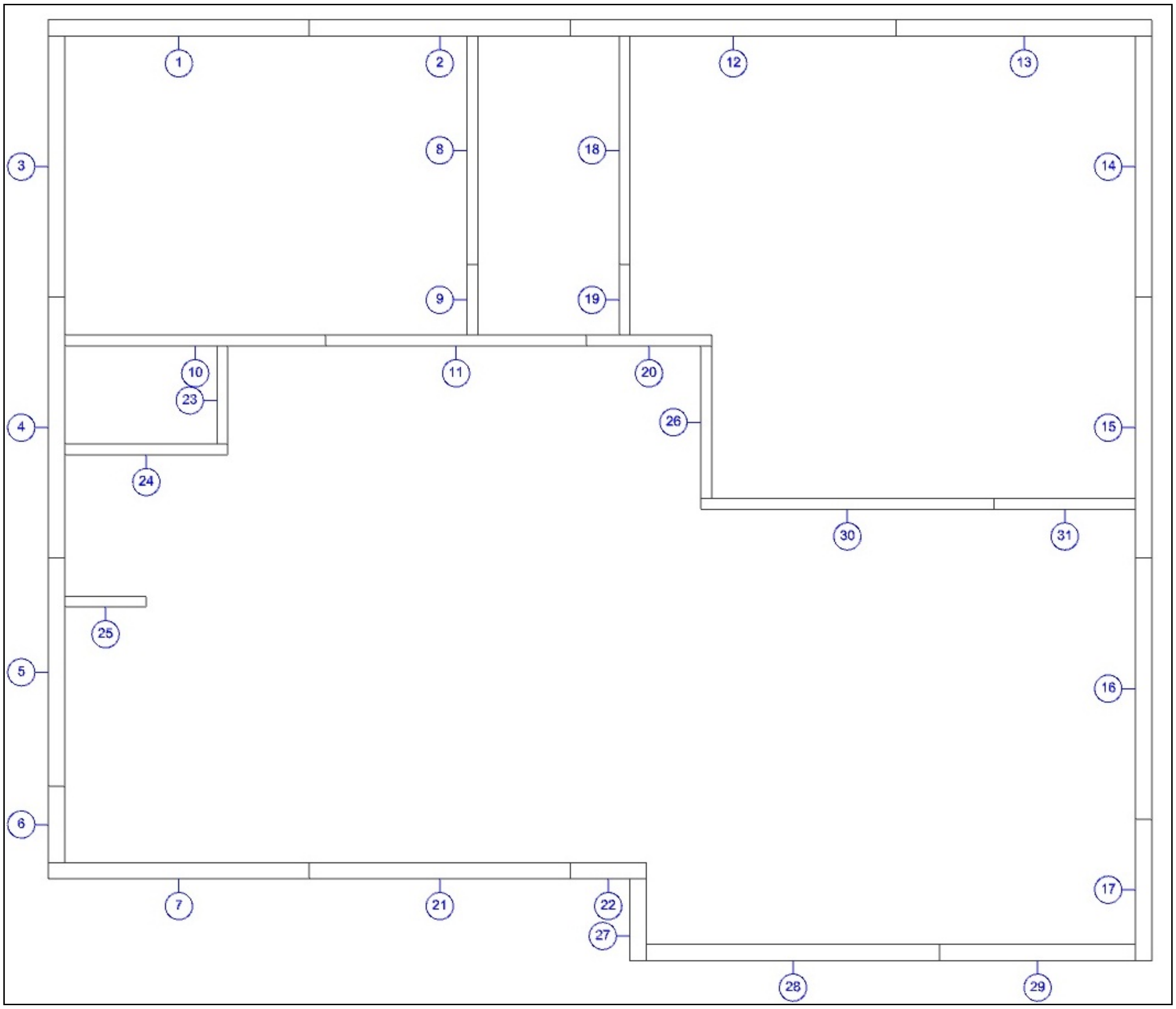


Figure 4.34 Solution of the proposed algorithm (by build sequence)

4.3.4 Discussion of Results

There were improvements in all cases except one for panel move distance, M5-1: panel designer (357,366) vs. proposed algorithm (367,284) with 2 less stack. When compared to the proposed algorithm, total weighted panel move distance increased 0.10-85.52% and 0.77-136.23%, respectively, for the panel designer and IntelliBuild. While connectivity was 100% for all cases with the proposed algorithm (the algorithm ensures connectivity is always maintained), it ranged from 69.56-86.95% and 73.33-90.91%, however, for the panel designer and IntelliBuild respectively. Finally, it is seen that typically IntelliBuild resulted in the least quantity of stacks, panel designer and the proposed approach resulted in the same quantity of stacks for medium and large cases.

The computational results indicate the proposed panel stacking algorithm can decrease the amount of material handling workers must perform in erecting panelized structures. Additionally, it will always guarantee connectivity and reduce the amount of additional work required when panels are installed in the given stack order (as indicated by the connectivity values). Plus it can avoid interference problems which was not addressed in Panel designer or commercial software.

A summary is presented in Table 4.6. From the summary it can be seen that the proposed algorithm can provide more improvement on panel move distance in large cases than small cases. It is not surprising since large cases will have more panels, shorter average panel length, and more zones. IntelliBuild tends to have more material handling work since it typically results in least quantity of stacks.

In terms of the panelization strategy, the effect was mixed. When compared to panel designer in large cases, the proposed algorithm can provide more improvement if the preferred panel length 8 ft. is selected. The possible reason could be that it would result in more panels and shorter average panel length. While for small and medium cases, the computational results indicated 10 ft. preferred panel length can provide more improvement. From the value of panel move distance, we can see that 8 ft. preferred panel length would result in better solutions, but the panel designer provided relatively worse solutions for 10 ft. preferred panel length which resulted in better improvement. So it can be concluded that the proposed algorithm performs better in larger cases with the preferred panel length 8 ft. selected.

Table 4.6 Summary for the computational results

Case	Average increase on panel move distance by panel designer, %	Average increase on panel move distance by IntelliBuild, %
Small - panelization 8ft	11	25
Small - panelization 10ft	14	23
Small - panelization 12ft	13	22
Medium - panelization 8ft	17	54
Medium - panelization 10ft	22	53
Medium - panelization 12ft	18	60
Large - panelization 8ft	42	74
Large - panelization 10ft	39	79
Large - panelization 12ft	32	87

4.4 Improvement 3 — Solve for interfering panels

The third improvement is that the proposed algorithm specifies how to handle the interfering panels in the last zone. First, following building direction, install any panels directly (lifting, moving, and erecting, etc.) as long as there is no interference. Then for those panels which do have interference, a place is found to put them and then install them directly.

The algorithm is as follows:

4.4.1 Algorithm

<u>Last Zone (stack type b)</u>

1.1 When the width of last zone is calculated like Figure 4.35:

Stack 1a in the location as Figure 4.36 indicates.

Step 1: Install the exterior panels along edge E1;

Step 2: Install some panels directly as long as it does not have any interference.

After step 2 is completed, we define 2 corners (C1& C2) as Figure 4.36.

Step 3: The panels left are interfering panels. If an interference situation is not detected as Figure 4.37, we lean these panels against the corner C1 as Figure 4.38. Then install the interfering panels. Otherwise, go to step 4.

Step 4: Check corner C2. If no similar interference like step 3 exists, these panels are leaned against the corner C2, then install these panels. Otherwise, go to step 5.

Step 5: Install panel *a* and *b*, then lean other panels against the corner C1. Install the interfering panels.

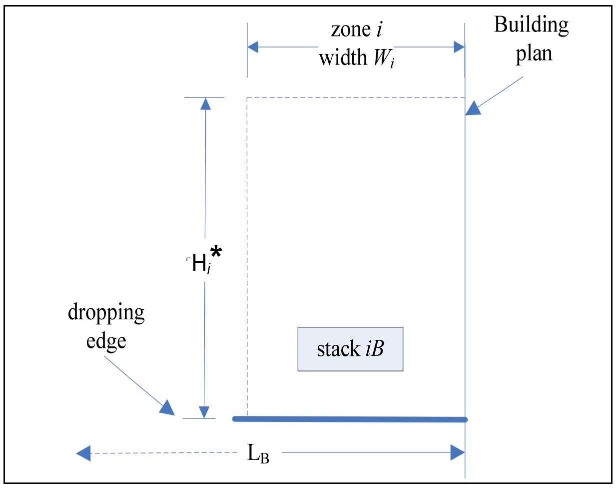


Figure 4.35 Last zone, type B-case a

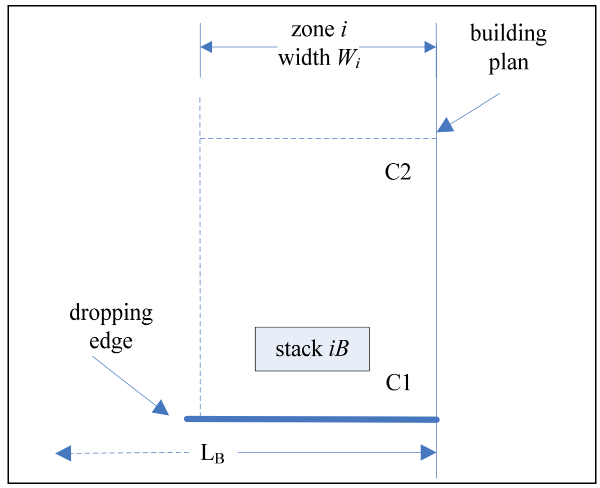


Figure 4.36 Last zone, type B-case b

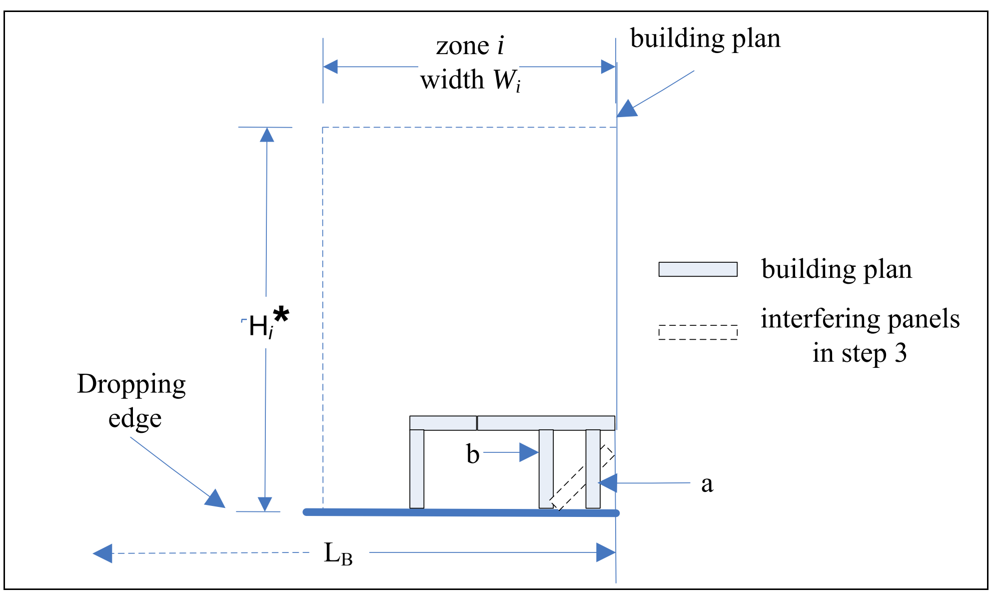


Figure 4.37 Last zone, type B-case c

The benefits putting the interfering panels like Figure 4.38 include:

a) Avoid the interference situation shown in Figure 4.39 since $l_1 < l_2$.

b) The rule is simple as all the interference panels will be handled in the same way.

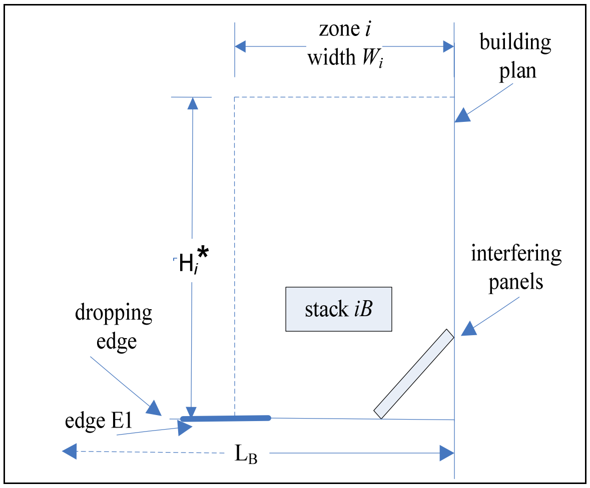


Figure 4.38 Last zone, type B-case d

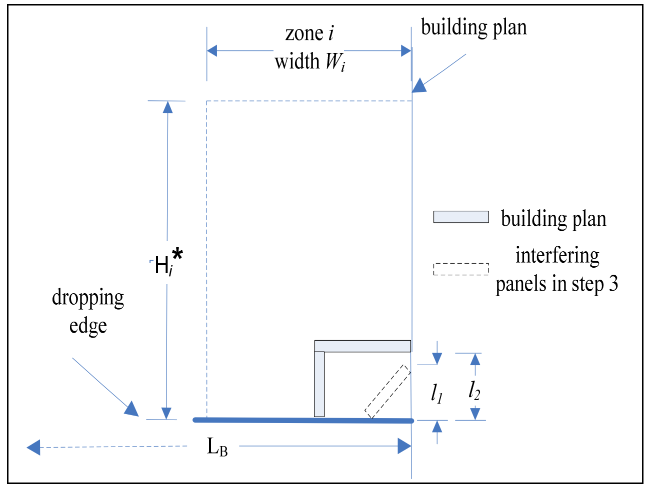


Figure 4.39 Last zone, type B-case e

Calculate *x* coordinate $Xstack_{ib}$:

$$Xstack_{ib} = L_B - \frac{W_i}{2}$$

Calculate *y* coordinate of stack *ia* $Ystack_{iaold}$ following Shewchuk (2008). Then now

$$Ystack_{ibnew} = Ystack_{ibold} + L_s * \sqrt{2}/2$$

Where L_B is the total building length,

L_S is the maximum interfering panel length.

1.2 When the width of zone *i* is calculated like Figure 4.40:

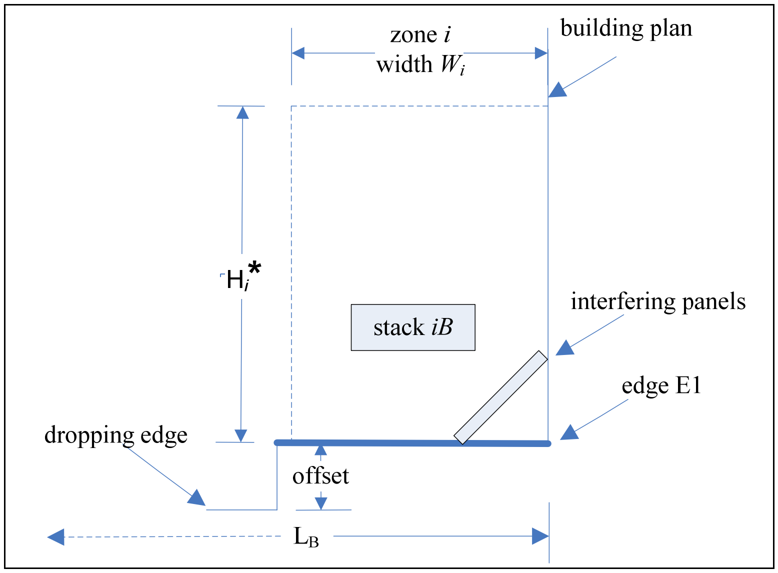


Figure 4.40 Last zone, type B-case f

Situation 1.2 is similar to situation 1.1 except

$$Ystack_{ianew} = Ystack_{iaold} + \text{offset} + L_s * \sqrt{2}/2$$

1.3 When the width of zone *i* is calculated like Figure 4.41:

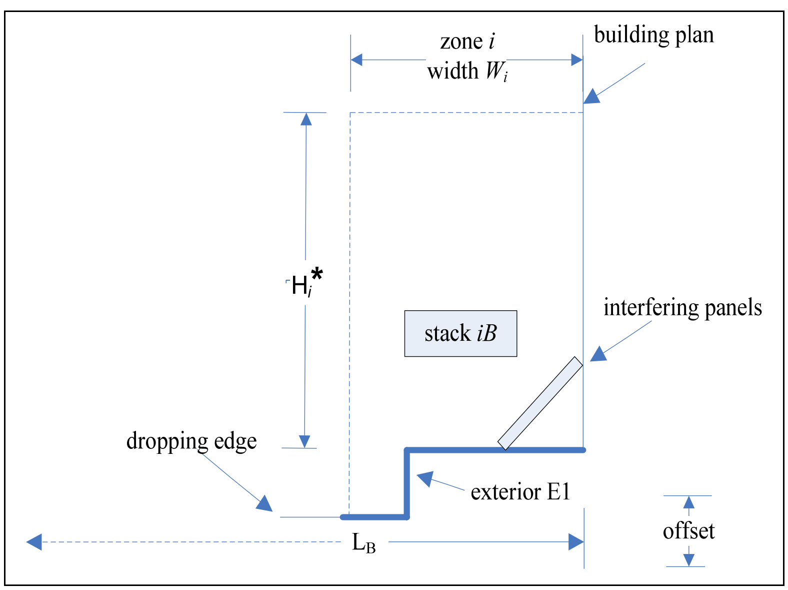


Figure 4.41 Last zone, type B-case g

Situation 1.3 is similar to situation 1.1 except

$$Ystack_{ianew} = Ystack_{iaold} + \text{offset} + L_s * \sqrt{2}/2$$

1.4 When the width of zone *i* is calculated like Figure 4.42:

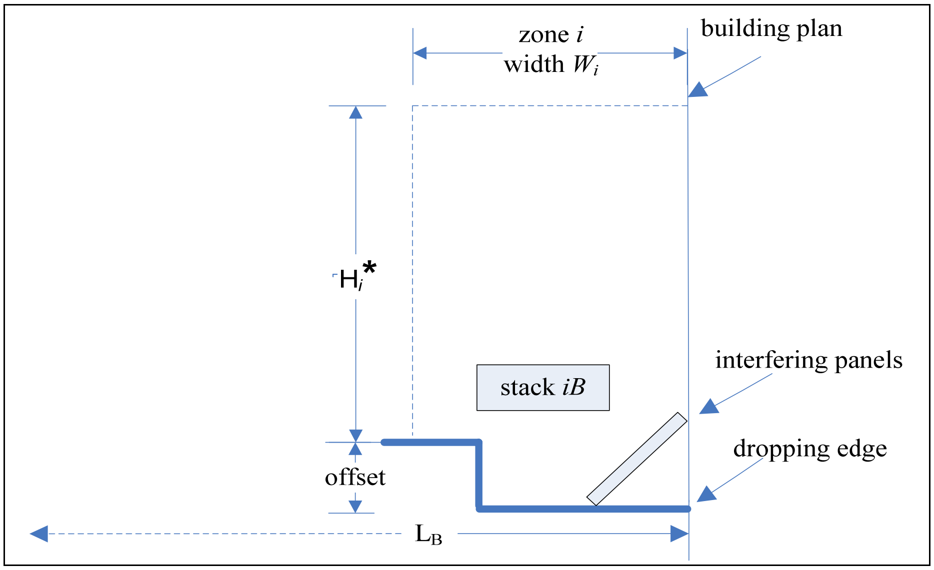


Figure 4.42 Last zone, type B-case h

Situation 1.4 is similar to situation 1.1 except

$$Ystack_{ianew} = Ystack_{iaold} + \text{offset} + L_s * \sqrt{2}/2$$

4.4.2 Experimental results

The panelization problems described in section 4.3.2 and presented in Appendix D were studied using the proposed algorithm, the proposed algorithm was found to be able to solve the interfering panels left in the last stack for these experiments. It could provide a place for workers to put down interfering panels first and then install these panels. The most common case was picked to show as an example. The building plan is in Figure 4.43. The proposed algorithm specified that panel 25, 26 and 31 are interfering panels. When all the other panels are completed, only panel 25, 26, and 31 are left as interfering panels. According to the proposed algorithm, move panel 31 and 26 to the corner C1. At this time, the bottom panel is panel 25, just like Figure 4.44. Then panel 25 can be completed directly like Figure 4.45. The next step, panel 26 can be completed like Figure 4.46. Last step, panel 31 can be completed like Figure 4.47.

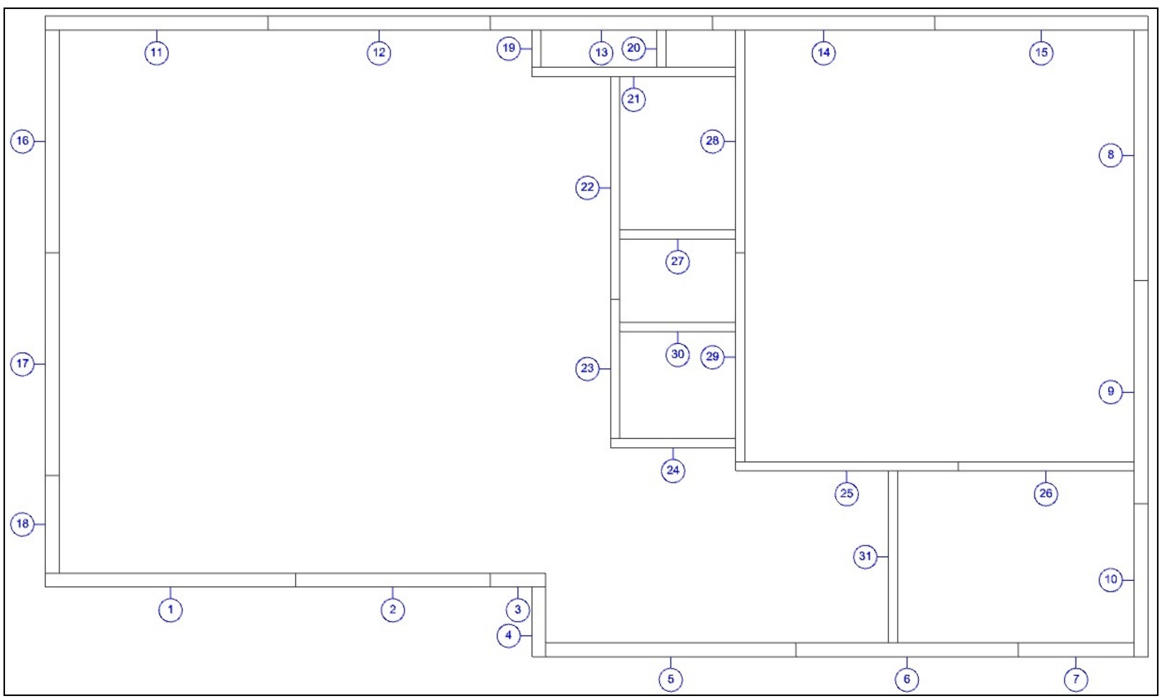


Figure 4.43 Example-interfering panels

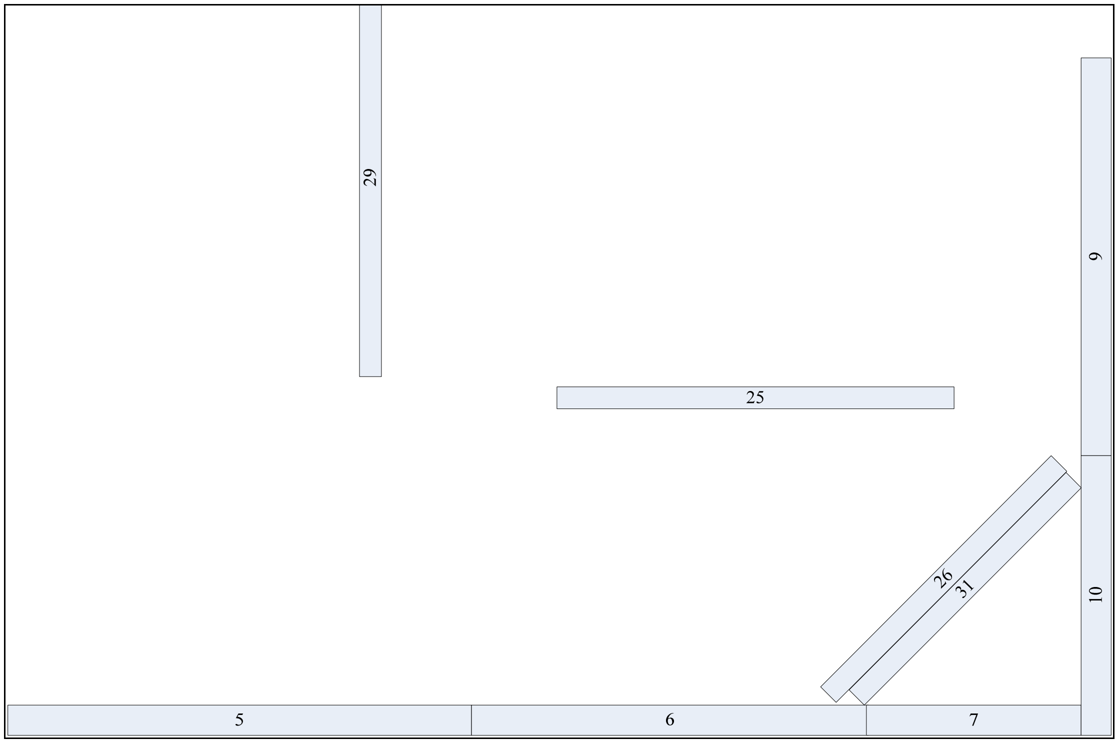


Figure 4.44 Example-move interfering panels

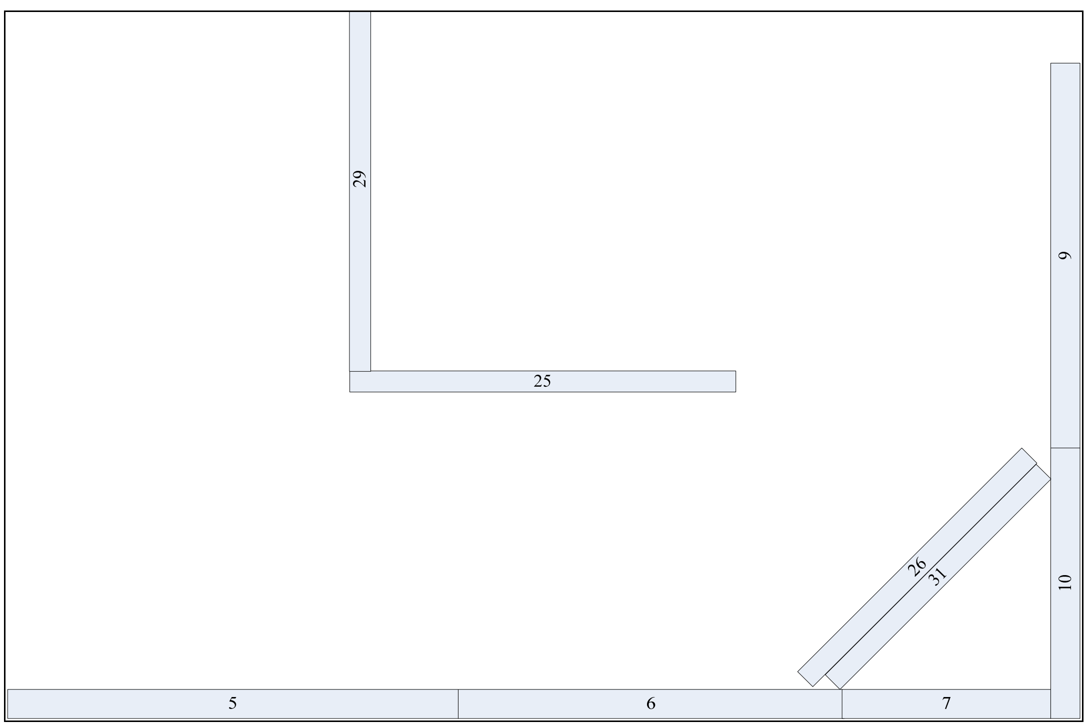


Figure 4.45 Example-install interfering panels-1

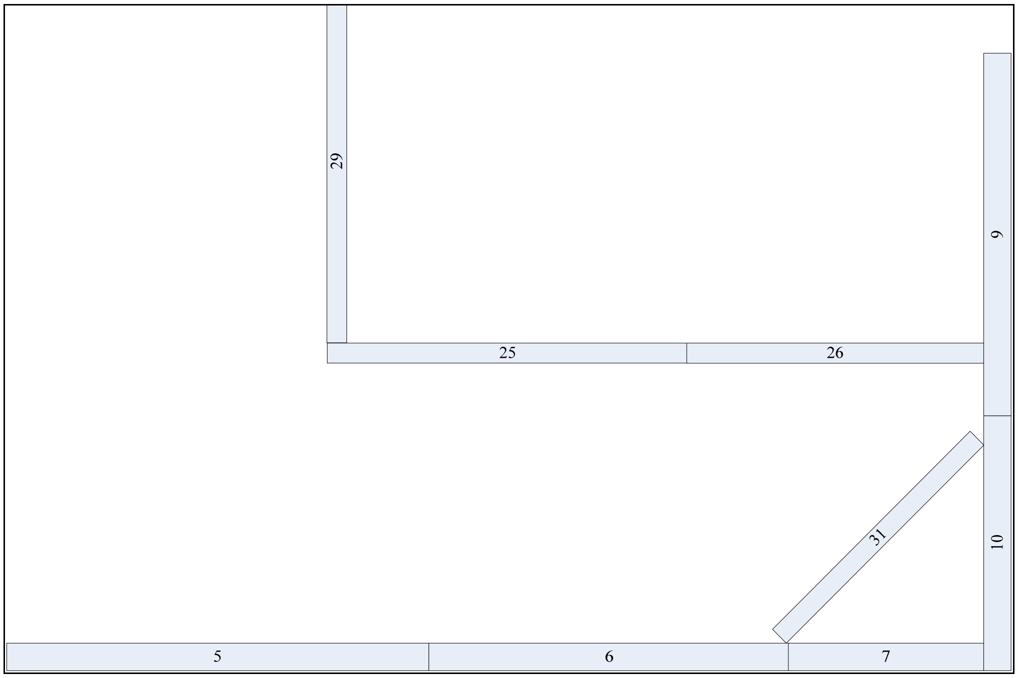


Figure 4.46 Example-install interfering panels-2

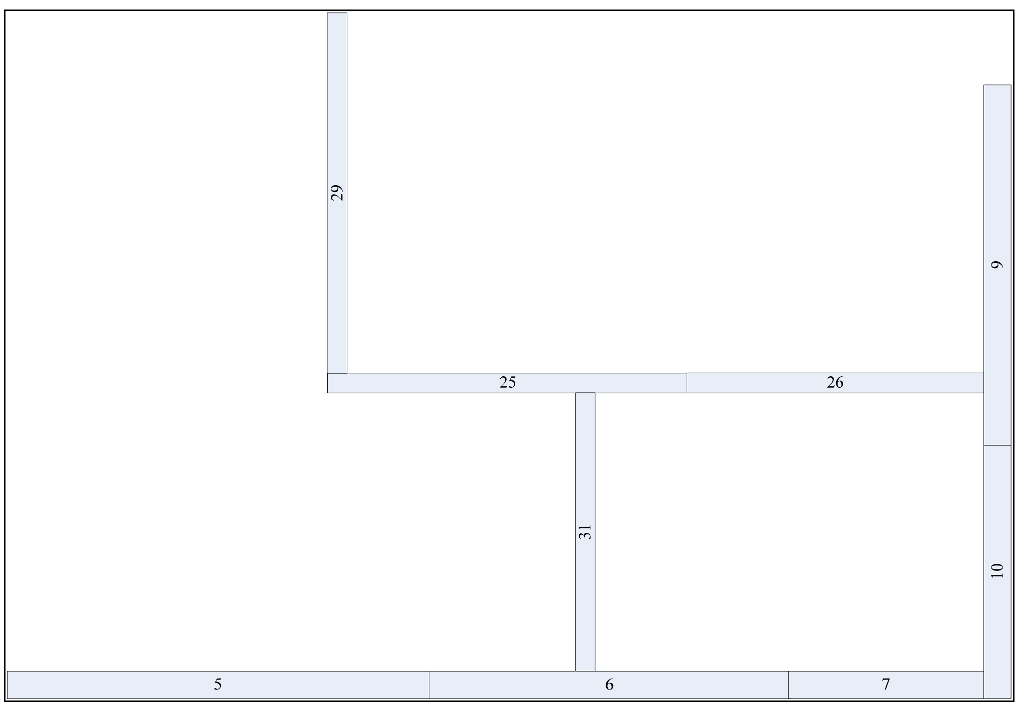


Figure 4.47 Example-install interfering panels-3

Panel 31 needs to be rotated first, so either don't fix panel 25 until after rotation or break panel 31 into two small panels during panelization.

Chapter 5 Worker Assignment in Residential Construction Using Prefabricated Panels

Abstract

A current trend in residential construction is the use of prefabricated wall panels. This chapter proposes an approach which specifies how to handle each panel in advance: how many and which workers should be assigned to each panel, etc. Mathematical models of the corresponding worker assignment problems were developed, where the goal was to minimize total project completion time (subject to worker quantity constraints) and try to assign tasks to workers as evenly as possible. The mathematical models were very difficult to solve large size problems, so a heuristic was developed to solve the worker assignment problem when the panel stacking plan was generated by the proposed algorithm described in Chapter 4. Meanwhile a simple mathematical model was developed to test the performance of the heuristic. The solution of such problems can help panel designers generate better construction plans.

5.1 Introduction

Construction accidents often lead to project delays. However, in practice, construction safety and schedule control are often managed separately (Wang et al. 2006). But designers can positively influence construction site safety by integrating safety considerations into the design process (Gambatese et al. 1999). Prior research efforts aimed at construction safety have seldom considered safety planning at the design stage. Our goal is to address safety from the design stage because integration of safety and human factors into the design phase is a vital necessity (Fadier et al. 2006).

This chapter presents an approach to generate a plan of construction activity and worker assignment, showing the schedule of construction tasks and by whom. The construction schedule is very important to the whole project: a field study of mechanical installation work has shown that over 50% of the total time observed on construction sites is non-value-adding time in the categories of interruption, disturbance, communication and preparation (Vedder et al. 2005). A good construction schedule can reduce non-value-adding time in construction and improve efficiency.

A finite set of construction tasks can be identified via laboratory-based experiments. All the parameters, like ergonomic risk and task time with different quantity of workers, are assumed available. Additional assumptions are as follows: (i) all workers are considered identical, (ii) task time and ergonomic risk are deterministic, (iii) there are no defective panels during the construction, (iv) setup time for all tasks is not considered, and (v) all construction tasks will be completed successively without rework.

5.2 Problem Formulation

The problem may be formulated as follows. There is a set of N prefabricated wall panels to be assembled by workers. The set of workers is denoted W, $W=\{W_1,W_2,\ldots.W_m\}$. Each panel i is defined as a job and consists of a sequence of J_i tasks O_{i1}, $O_{i2},\ldots O_{iji}$: all tasks have to be performed to complete a job. The construction of each task j of a job i (noted O_{ij}) requires at least Q_{ij} number of workers, takes T_{ijk} time units to complete, and has R_{ijk} ergonomic impact on workers when k workers are utilized. For any panel, some tasks may be sequential and thus handled by same workers. We use breakpoint B_{ij} to denote this. To minimize the maximum ergonomic impact of workers, we should assign the tasks to workers as evenly as possible.

The problem is thus to both determine an assignment and a sequence of the tasks on all workers that minimizes total project completion time and distributes all the tasks to workers as evenly as possible with the consideration of ergonomic risk. Minimizing completion time is assumed most important and that is our objective function. We decompose the original problem into two sequential problems. The first step (Model 1) is to determine how many workers are needed to perform each task under the objective of minimizing total project completion time. The solution from Model 1 would be input parameters for second step (Model 2). Model 2 solves the worker assignment problems, which then assigns all the tasks to workers evenly with the consideration of ergonomic impact. Since all workers are considered identical, so the solution from Model 2 is optimal to Model 1.

We formulate the problem as a mixed-integer linear program (MILP), using binary variables that establish the assignments of jobs on workers and continuous variables that decide the time a task is finished.

Sets

Jobs	set of panels (1, 2, 3…..N)
Tasks	set of tasks (1, 2, 3, 4 ….J)
Workers	set of workers (1, 2 ….M)

Parameters

$Q_{i,j}$	the minimum number of workers needed to execute panel i task j
$T_{i,j,k}$	the time needed to execute panel i task j with k workers
J_i	the number of tasks of panel i
$B_{i,j}$	the breakpoint (if the first and second tasks of panel i are required to be sequential, then $B_{i,1}$=0, $B_{i,2}$=1)
H	a big positive number
S	a small positive number

Variables

$X_{i,j,k}$	$X_{i,j,k}$ =1 if panel i, task j performed by k workers, 0 otherwise.
$S_{i,j,p,q}$	$S_{i,j,p,q}$ =1 if the start time of panel p, task q is earlier than the completion time of panel i task j, 0 otherwise.
$E_{i,j,p,q}$	$E_{i,j,p,q}$ =1 if the completion time of panel p, task q is not earlier than the completion time of panel i task j, 0 otherwise.
$O_{i,j,p,q,k}$	$O_{i,j,p,q,k}$ =1 if panel i task j, panel p task q has already been started but not yet completed and panel p task q is performed by k workers, 0 otherwise.
$Z_{i,j}$	completion time of panel i, task j.
C	total project completion time. $C=max\left\{Z_{ij},\ i \in Jobs, j \in Tasks\right\}$

Mathematical Model 1

$$Min\ C \tag{1}$$

Subject to

$$Z_{i,1} \geq \sum_{k \in Workers} T_{i,1,k} X_{i,1,k} \qquad \forall\, i \in Jobs \tag{2}$$

$$Z_{i,j} - \sum_{k \in Workers} T_{i,j,k} X_{i,j,k} \geq Z_{i,j-1} \qquad \forall\, i \in Jobs\ \forall\, j = 2,...,J_i \tag{3}$$

$$Z_{i,1} - \sum_{k \in Workers} T_{i,1,k} X_{i,1,k} \geq Z_{i-1,1} \quad \forall\ i=2, ..., N \tag{4}$$

$$Z_{i,j[i]} - \sum_{k \in Workers} T_{i,J[i],k} X_{i,J[i],k} \geq Z_{i-1,J[i-1]} - \sum_{k \in Workers} T_{i-1,J[i-1],k} X_{i-1,J[i-1],k} \quad \forall\ i=2, ..., N \tag{5}$$

$$\sum_{k \in Workers} k X_{i,j,k} \geq Q_{i,j} \quad \forall\ i \in Jobs,\ \forall\ j \in Tasks \tag{6}$$

$$\sum_{k \in Workers} X_{i,j,k} = 1 \quad \forall\ i \in Jobs,\ \forall\ j \in Task \tag{7}$$

$$O_{i,j,p,q,k} \leq X_{p,q,k} \quad \forall\ i,p \in Jobs, \forall\ j,q \in Tasks,\ \forall\ k \in Workers \tag{8}$$

$$(1- E_{i,j,p,q})H + Z_{p,q} \geq Z_{i,j} \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{9}$$

$$Z_{p,q} - E_{i,j,p,q} H \leq Z_{i,j} - S \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{10}$$

$$Z_{p,q} - \sum_{k \in Workers} T_{p,q,k} X_{p,q,k} \leq Z_{i,j} - S + (1- S_{i,j,p,q})H \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{11}$$

$$Z_{p,q} - \sum_{k \in Workers} T_{p,q,k} X_{p,q,k} \geq Z_{i,j} - S_{i,j,p,q} H \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{12}$$

$$E_{i,j,p,q} + S_{i,j,p,q} \leq 1 + \sum_{k \in Workers} O_{i,j,p,q,k} \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{13}$$

$$E_{i,j,p,q} \geq \sum_{k \in Workers} O_{i,j,p,q,k} \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{14}$$

$$S_{i,j,p,q} \geq \sum_{k \in Workers} O_{i,j,p,q,k} \quad \forall\ i,p \in Jobs \text{ and } i \neq p,\ \forall\ j,q \in Tasks \tag{15}$$

$$\sum_{k \in Workers} k X_{i,j,k} + \sum_{p \in Jobs} \sum_{q \in Tasks} \sum_{k \in Workers} k O_{i,j,p,q,k} \leq M \quad \forall\ i \in Jobs \text{ and } i \neq p,\ \forall\ j \in Tasks \tag{16}$$

$$Z_{i,j} = Z_{i,j-1} + \sum_{k \in Workers} T_{i,j,k} X_{i,j,k} \quad \forall\ i \in Jobs,\ \forall\ j = 2,...,J_i \text{ and } B_{i,j-1} = 0 \tag{17}$$

$$C \geq Z_{i,J[i]} \tag{18}$$

Objective function (1) minimizes total project completion time. Constraints (2) ensures all tasks start from time 0. Constraints (3) and (4) are precedence constraints. Due to the nature of construction activities, constraint (3) ensures for each panel, the subsequent task cannot be started unless the preceding task has been already completed. Constraint (4) forces the subsequent panel cannot be started (lifting) unless the preceding panel has been already started (moved from the stack). Constraints (5) is a construction sequence constraints: according to the construction sequence, the final task (attaching the panel to a connected and completed panel) of preceding panel should precede that of subsequent panel. Constraints (6) forces the construction of task j of job i requires at least $Q_{i,j}$ workers. Constraint (7) forces only k workers are assigned to job i task j. Constraint (8)-(15) force the logical relationship between variables $S_{i,j,p,q}$, $E_{i,j,p,q}$, $O_{i,j,p,q,k}$, and $Z_{i,j}$ which maintain the definition of these variables. Constraint (16) ensures, at any time, number of workers assigned to tasks should not be greater than M. Constraints (17) ensures for each panel, some tasks should be sequential and handled by same workers. Constraints (18) determines total project completion time based on the last completed task.

The solution of Model 1 ($X_{i,j,k}$) tells us how many workers are needed to perform each task under the objective of minimizing the total project completion time. And it will be input parameters for Model 2.

Addition Parameters for Model 2

$X_{i,j,k}$ the solutions from Model 1

$R_{i,j,k}$ the ergonomic impact of panel i task j with k workers

Additional Variables for Model 2

$W_{i,j,k}$ $W_{i,j,k}=1$ if panel i, task j is performed by worker k, 0 otherwise.

$Y_{i,j,p,q}$ $Y_{i,j,p,q}=1$ if panel i, task j precedes panel p, task q (where panel i, task j, panel p and task q are performed by the same worker), 0 otherwise.

Maxrise $Maxrisk=max\left\{\sum_{i\in Jobs}\sum_{j\in Tasks} W_{i,j,k}R_{i,j},\ k\in Workers\right\}$: total ergonomic impact for the busiest worker.

Minrisk $Maxrisk=min\left\{\sum_{i\in Jobs}\sum_{j\in Tasks} W_{i,j,k}R_{i,j},\ k\in Workers\right\}$: total ergonomic impact for the least-busy worker.

Mathematical Model 2

$$Min \;\; maxrisk - minrisk \tag{1}$$

Subject to

$$\sum_{k \in Workers} W_{i,j,k} = \sum_{k \in Workers} kX_{i,j,k} \quad \forall\, i \in Jobs,\ \forall\, j \in Tasks \tag{2}$$

$$Z_{p,q} - Z_{i,j} + H(1-Y_{i,j,p,q}) + H(1 - W_{i,j,k}) + H(1 - W_{p,q,k}) \geq T_{p,q}$$

$$\forall\, i,p \in Jobs \text{ and } i \neq p,\ \forall\, j,q \in Tasks \text{ and } j \neq q,\ \forall\, k \in Workers \tag{3}$$

$$Z_{i,j} - Z_{p,q} + HY_{i,j,p,q} + H(1 - W_{i,j,k}) + H(1 - W_{p,q,k}) \geq T_{i,j}$$

$$\forall\, i,p \in Jobs \text{ and } i \neq p,\ \forall\, j,q \in Tasks \text{ and } j \neq q,\ \forall\, k \in Workers \tag{4}$$

$$\sum_{i \in Jobs} \sum_{j \in Tasks} W_{i,j,k} R_{i,j} \geq Minrisk \quad \forall\, k \in Workers \tag{5}$$

$$\sum_{i \in Jobs} \sum_{j \in Tasks} W_{i,j,k} R_{i,j} \leq Maxrisk \quad \forall\, k \in Workers \tag{6}$$

$$W_{i,\,j-1,k} \leq W_{i,\,j,\,k}$$

$$\forall\, i \in Jobs,\ \forall\, j = 2,...,J_i,\ \forall\, k \in Workers,\ B_{i,j-1} = 0 \text{ and } \sum_{k \in Workers} kX_{i,j-1,k} \leq \sum_{k \in Workers} kX_{i,j,k} \tag{7}$$

$$W_{i,\,j-1,k} \geq W_{i,\,j,\,k}$$

$$\forall\, i \in Jobs,\ \forall\, j = 2,...,J_i,\ \forall\, k \in Workers,\ B_{i,j-1} = 0 \text{ and } \sum_{k \in Workers} kX_{i,j-1,k} \geq \sum_{k \in Workers} kX_{i,j,k} \tag{8}$$

Objective function (1) minimizes the workload difference between workers. Constraint (2) forces that the number of workers assigned to all the tasks will match the results from Model 1. Constraints (3), (4) ensure any worker cannot perform multiple tasks simultaneously. So either constraint (3) or constraint (4) must hold. Constraints (5), (6) calculate the ergonomic impact of the most and least busy worker. Constraints (7), (8) are breakpoint constraints which ensure for each panel, some tasks should be sequential and handled by same workers.

The solution of Model 2 ($W_{i,j,k}$) tells us the worker assignment.

5.3 Results

If we consider the construction tasks as jobs and the workers as machines, construction scheduling closely resembles job shop scheduling, where a set of jobs must be processed on a set of machines and each job can visit different machines and in a different order. Job shop scheduling problems are generally NP-complete, which means that nowadays there is still no polynomial-time algorithm being able to solve the problems optimally (Cheng et al. 2009). Similarly deterministic project scheduling for construction projects is difficult too (Ahuja et al. 2004).

The MILP (generally NP-hard problems) models we present cannot solve large size problems optimally. To test the model performance, the above two mathematical models were implemented. The programs were coded using the AMPL programming language (Fourer et al. 2003) and run using CPLEX optimization software (ILOG, Inc., Mountain View, CA), version 9.0 with default settings. An Intel(R) Xeon(TM) CPU 3.60 GHz with 3.25GB of RAM and Windows XP professional operating system was employed.

Of the above two models, the first one is very hard to solve. We have tested a few cases and found that the maximum size of problem that we can solve optimally is 6 panels (each of which has 5 tasks) and 3 workers (first model: computation time is 15561.1 seconds) or 5 panels (each of which has 5 tasks) and 4 workers (first model: computation time is 19133.5 seconds). Any larger size problem is essentially intractable.

A problem of 5 panels (each of which has 5 tasks) and 4 workers is presented as the example. The parameters are as shown in Table 5.1.

Table 5.1 Input parameters for the example problem

Parameter $Q_{i,j}$

i \ j	1	2	3	4	5
1	2	2	1	2	2
2	1	2	1	2	2
3	2	3	1	1	2
4	2	2	1	2	3
5	1	2	1	2	2

Parameter $T_{i,j,k}$

i \ j	1	2	3	4	5	
1	15	18	15	18	15	k=1
	12	14	11	15	14	2
	12	11	11	14	12	3
	12	10	10	12	12	4
2	15	18	16	17	15	k=1
	14	12	14	15	14	2
	13	11	13	11	11	3
	12	10	10	10	11	4
3	15	18	16	18	15	k=1
	11	13	11	15	14	2
	11	11	11	12	12	3
	10	10	10	12	12	4
4	15	18	15	18	15	k=1
	12	14	11	15	14	2
	12	11	11	13	12	3
	12	10	10	12	12	4
5	15	20	15	18	15	k=1
	12	14	11	14	14	2
	12	13	11	13	12	3
	12	10	10	12	12	4

Parameter $B_{i,j}$

i \ j	1	2	3	4	5
1	0	0	1	0	1
2	0	1	1	1	1
3	0	1	1	0	1
4	0	0	1	0	1
5	0	0	1	1	1

Parameter H	1000
Parameter S	0.5

The above performance parameters are assumed reasonably-accurate predictions generated from laboratory-based experiments. The results generated from the Model 1 are as shown in Table 5.2.

Table 5.2 Output from Model 1 for the example problem

$X_{i,j,k}$						
i \ j	1	2	3	4	5	
1	0	0	0	0	0	k=1
	0	0	1	1	1	2
	0	1	0	0	0	3
	1	0	0	0	0	4
2	1	0	1	0	0	k=1
	0	1	0	0	1	2
	0	0	0	1	0	3
	0	0	0	0	0	4
3	0	0	0	1	0	k=1
	1	0	1	0	1	2
	0	1	0	0	0	3
	0	0	0	0	0	4
4	0	0	1	0	0	k=1
	1	1	0	1	0	2
	0	0	0	0	0	3
	0	0	0	0	1	4
5	1	0	0	0	0	k=1
	0	1	1	1	0	2
	0	0	0	0	0	3
	0	0	0	0	1	4
$Z_{i,j}$						
i \ j	1	2	3	4	5	
1	12	23	34	71	85	
2	27	39	55	104	118	
3	45	56	67	126	140	
4	79	93	108	158	170	
5	119	133	144	158	182	

The results tell us how many workers needed to perform each task and completion time of each task. Then this data is used as input for Model 2. The results generated from Model 2 are shown in Table 5.3.

Table 5.3 Output from Model 2 for the example problem

$W_{i,j,k}$						
i \ j	1	2	3	4	5	
1	1 1 1 1	1 1 1 0	1 1 0 0	1 1 0 0	1 1 0 0	k=1 2 3 4
2	0 0 0 1	0 0 1 1	0 0 1 0	1 1 0 1	0 1 0 1	k=1 2 3 4
3	1 1 0 0	1 1 0 1	0 0 1 1	0 0 1 0	0 0 1 1	k=1 2 3 4
4	0 0 1 1	0 0 1 1	0 0 1 0	0 0 1 1	1 1 1 1	k=1 2 3 4
5	1 0 0 0	1 1 0 0	1 1 0 0	1 1 0 0	1 1 1 1	k=1 2 3 4

The solution of Model 2 ($W_{i,j,k}$) tells us the worker assignment, i.e., which workers should perform which tasks. The computational time for Model 1 is 19133.5 seconds and for Model 2 is 48.177 seconds. Combining the solutions of model 1 and 2, we can obtain the final optimal schedule as shown in Figure 5.1. From the schedule we see that the total project completion time is 182.

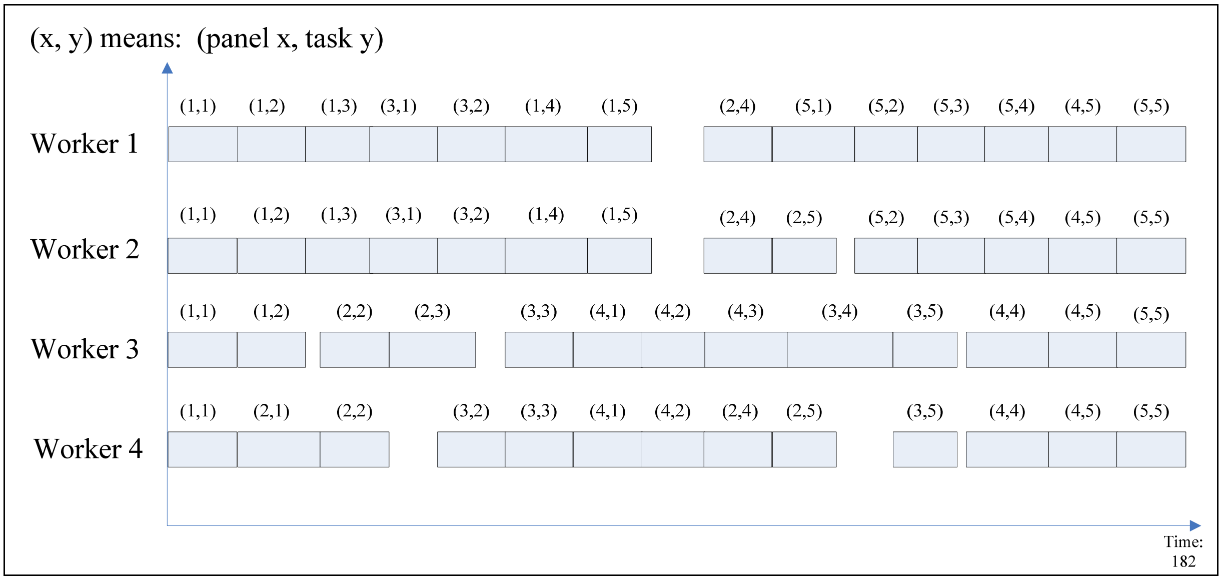


Figure 5.1 Schedule for the example problem

5.4 Simplified Model

Although the mathematical models developed cannot solve large problems, they provide insight into the problem structure and provide a foundation for the development of heuristic (approximate) methods. In order to solve larger size problems, the original problem is simplified as follows: (1) each panel is defined as a job and no more sub tasks will be considered and (2) we assume we have the knowledge that how many workers are required for each panel depending on the panel size and that is the exact number of workers we will assign to the panel. The simplification results in the same workers for all tasks of each panel which means workers are assigned to panels (jobs) and no tasks are considered. The objective here is to balance the workload between workers. Workers are considered identical. The panel stacking plan is available at this point, we multiply panel move distance by panel length as the workload for each panel to account for the fact the larger panels are more difficult for workers to handle.

5.4.1 Simplified Model — Heuristic

To solve real-size problems based upon the simplified model, a heuristic was developed. The heuristic is a greedy algorithm which is simple and straightforward. It will first find out how many workers will be assigned to the panel, and then choose that amount of the least busy workers to the panel. The number of workers assigned to each panel is based on panel length and the fact of if the panel is sheathed or not. This guidance of determining the number of workers needed for each panel is based on lab experiments from ergonomic point of view (Kim et al., 2009). The heuristic detail is described as Figure 5.2.

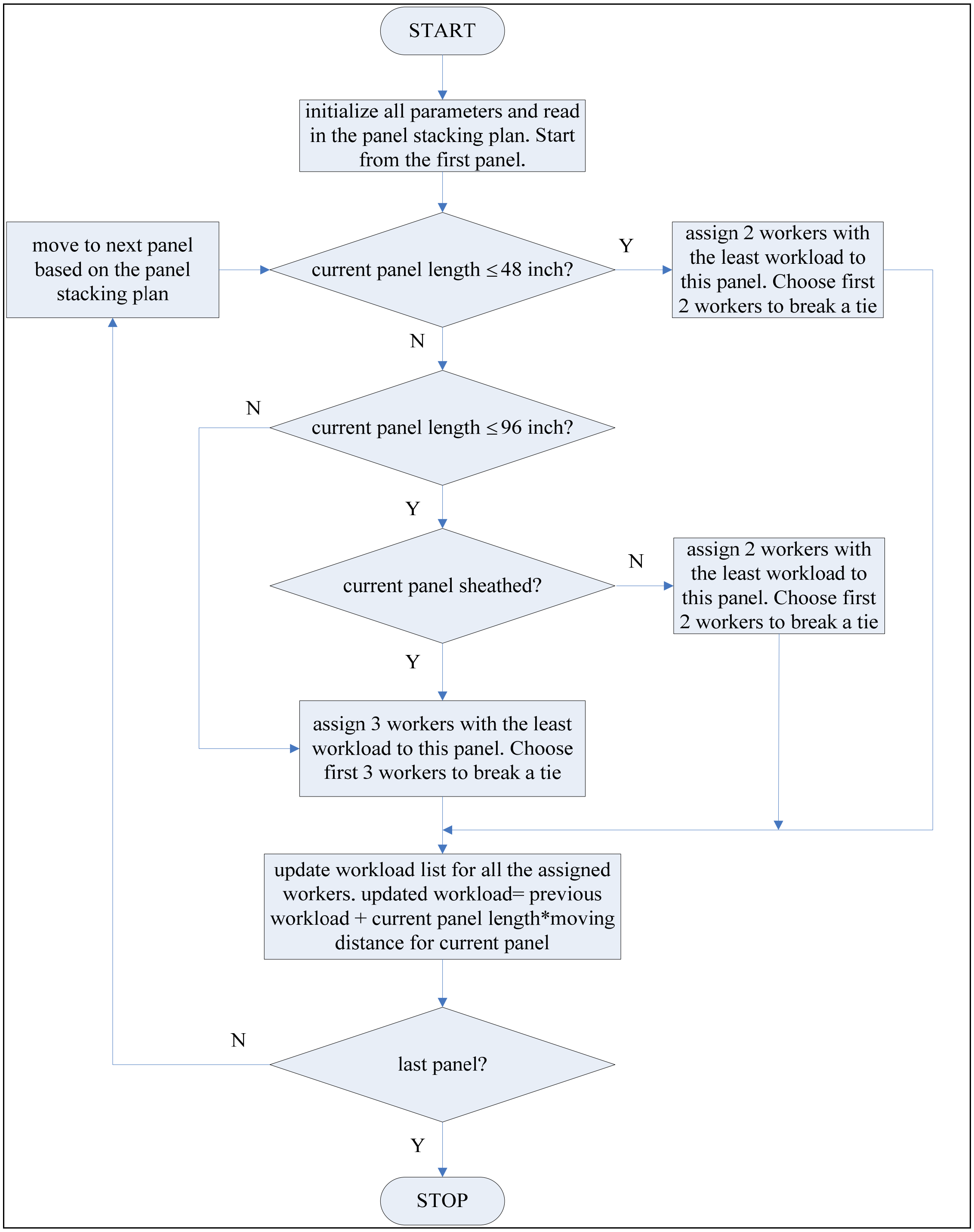


Figure 5.2 Worker Assignment

5.4.2 Simplified Model — Mathematical Model

In order to know how good the heuristic is, a mathematical model was developed to establish the performance of the heuristic.

Parameters

N Total number of panels

M Total number of workers

q_i Number of workers needed for panel *i*.

l_i Workload of panel *i*

c Control parameter. Any worker cannot be assigned c consecutive panels

Sets

Panels Set of panels (1, 2, 3….., N)

Workers Set of workers (1, 2, 3….., M)

Variables

$X_{i,j}$ Binary variable. $X_{i,j}$ =1 if panel *i* is assigned to worker *j*, 0 otherwise

W_{max} Total maximum workload on workers

W_{min} Total minimum workload on workers

Mathematical Model

$$Min\ W_{max} - W_{min} \tag{1}$$

Subject to

$$\sum_{j \in Workers} X_{ij} = q_i \qquad \forall\ i \in Panels \tag{2}$$

$$\sum_{k \in Panels \text{ and } k \geq i, k < i+c} X_{k,j} \leq c-1 \qquad \forall\ i \in Panels,\ j \in Workers, \text{ and } i \leq N-c+1 \tag{3}$$

$$\sum_{i \in Panels} l_i X_{ij} \leq W_{max} \qquad \forall\ j \in Workers \tag{4}$$

$$\sum_{i \in Panels} l_i X_{ij} \geq W_{min} \qquad \forall\ j \in Workers \tag{5}$$

$$\sum_{i \in Panels} X_{ij} \geq \sum_{i \in Panels} X_{i,j+1} \qquad \forall\ j \in Workers \text{ and } j \neq M \tag{6}$$

Objective Function (1) is to balance workload between workers. Constraint (2) forces each panel will be assigned to the pre-determined number of workers. Constraint (3) ensures any worker cannot be assigned *c* consecutive panels from ergonomic point of view. Constraint (4) & (5) determine the maximum and minimum worker load of all workers. The above model is symmetrical and in order to reduce the solution space and running time, two symmetry breaking constraints, constraint (6) and (7), were invested.

$$\sum_{i \in Panels} X_{ij} \geq \sum_{i \in Panels} X_{i,j+1} \qquad \forall\ j \in Workers \text{ and } j \neq M \tag{6}$$

$$\sum_{i \in Panels} l_i X_{ij} \geq \sum_{i \in Panels} l_i X_{i,j+1} \qquad \forall\ j \in Workers \text{ and } j \neq M \tag{7}$$

Through experiments, constraint (6) performed better than constraint (7). Constraint (6) was found to reduce the total running time by average 18.6% while constraint (7) increased total running time.

5.4.3 Simplified Model — Results and Discussions

A set of computational experiments was performed to establish the performance of the heuristic. The cases described in section 4.3.2 and presented in Appendix D were investigated.

Even though the mathematical model described in Chapter 5.4.2 was very simple, it still could only solve the cases with around 30 panels optimally. In order to compare the solutions of the heuristic to optimal solutions, some small cases were chosen to be solved using both the proposed worker assignment heuristic and mathematical model. Since the objective of heuristic and mathematical model is balancing the workload between worker, solutions were compared in terms of $\frac{W_{\max}}{W_{\min}} - 1$.

Experimental results are presented in Table 5.4. In all cases, the gap between heuristic solution and optimal solution ranged from 1.31-3.02%. The average gap is 2.25%. In terms of solution speed, the proposed heuristic solved each problem in less than one second while the mathematical model took several hours to find the optimal solution.

Table 5.4 Computational results for proposed heuristic vs. optimal solution

Case	# of panels	$\frac{W_{\max}}{W_{\min}}-1$ optimal solution	$\frac{W_{\max}}{W_{\min}}-1$ heuristic	Gap
Small1-1	28	0.16%	2.46%	2.30%
Small2-1	27	0.09%	3.11%	3.02%
Small3-1	31	0.04%	2.22%	2.18%
Small4-1	31	0.08%	1.39%	1.31%
Small5-1	36	0.09%	2.54%	2.45%
Average		————		2.25%

Obviously, the proposed heuristic will perform better with the increasing of the number of panels, percentage wise. Five large cases were solved using the proposed heuristic. Experimental results are presented in Table 5.5.

From Table 5.5, it can be seen the average of the value is 0.21%, although the optimal solutions are not available for those large cases, we can easily know that the lower bound of the value is 0, which means the average gap is less than 0.21%. The computational results indicate that the proposed heuristic can effectively balance the workload, especially for larger cases, between workers and solve any size of problems very fast.

Table 5.5 Computational results for proposed heuristic solving large cases

Case	# of panels	$\frac{W_{\max}}{W_{\min}}-1$,heuristic
Large-1	107	0.16%
Large-2	112	0.24%
Large-3	113	0.28%
Large-4	110	0.25%
Large-5	110	0.11%
Average		0.21%

Chapter 6 Conclusions

6.1 Research contributions

The research presented in this dissertation focused on two areas: panel stacking problems in residential construction (with and without consideration of interference) and construction worker assignment problems.

A lean approach to reduce construction workload and the possibility of worker injury was proposed. When interference constraints are not considered, a mathematical model was developed, along with heuristic algorithms which can solve real stacking problems quickly. From computational results it can be concluded the proposed algorithm can dramatically reduce the panel move distance and provide better connectivity without compromising the transportation costs when compared to traditional approach. Overall, it can be seen the proposed research can reduce worker's workload by reducing the total weighted panel move distance and provide much better connectivity in working with panels.

When interference constraints are considered, this research makes three improvements upon Shewchuk (2008).

- The zone width is optimized. Improvements were found in all experimental cases. Improvement on panel move distance ranged from 1.35-47.93% (average: 17.18%), and improvement on interfering panels ranged from 20-100% (average: 59.37%). The computational results indicate the proposed panel stacking algorithm performed better than Shewchuk (2008) in terms of total weighted panel move distance and interfering panels. Also we can conclude that the proposed algorithm can provide more improvement on panel move distance and interfering panels in larger cases than smaller cases. Meanwhile, proposed algorithm can provide more improvement if the preferred panel length 8 ft. is selected.
- The proposed algorithm can solve the non-rectangular cases. Based on computational results, compared to the proposed algorithm, panel designer and IntelliBuild increased 0.10-85.52% (average: 23.17%) and 0.77-136.23% (average: 52.90%), respectively, on the total weighted panel move distance. While Connectivity was always 100% for all cases with the proposed algorithm, it ranged from 69.56-86.95% (average: 79.11%) and 73.33-90.91% (average: 85.85%), however, by the panel designer and IntelliBuild

respectively. The computational results indicate the proposed panel stacking algorithm can decrease the amount of material handling effort in erecting panelized structures. Additionally, it will always guarantee connectivity and reduce the amount of additional work required when panels are installed in the given stack order (as indicated by the connectivity values). Plus, it can avoid interference problems which was not addressed in panel designer or commercial software. Also it can be concluded that the proposed algorithm can provide more improvement on panel move distance in larger cases than smaller cases when preferred panel length 8 ft. is selected.

- The proposed algorithm can solve the interfering panels. From the computational experiments, proposed algorithm was found to be able to solve the interfering panels left in the last stack. It could provide a place for workers to put down the interfering panels first and then install these panels.

Overall, the proposed algorithm can improve the original algorithm (Shewchuk, 2008) by providing less panel move distance, solving non-rectangular cases, and solving the interfering panels. Computational experiments indicate that the proposed algorithm can reduce the construction workload when compared to the panel designer or commercial software by providing less total weighted panel move distance and better connectivity value. It may be useful for panel designers to generate efficient panel stacking plans.

Meanwhile, mathematical models were developed for the construction worker assignment problem. The models worked correctly based on a small case but it is extremely difficult to solve real construction problems so a greedy heuristic was developed to provide worker assignment solution quickly. From experiments of some small cases, the gap between heuristic solution and optimal solution ranged from 1.31-3.02% (average: 2.25%). And the proposed heuristic performs better with the increasing of the number of panels, percentage wise. From experiments of some large cases, the average gap is less than 0.21%. The computational results indicate that the proposed heuristic can effectively balance the workload, especially for larger cases, between workers and solve any size of problems very fast.

6.2 Strengths and limitations

6.2.1 Panel stacking Problem

The proposed approach is based on Shewchuk (2008) and has several improvements:

- It can reduce the workload at the construction site by providing less total weighted panel move distance.
- It will always reduce the amount of additional bracing, fitting, etc., by maintaining connectivity.
- It can avoid interference problems.

Though the proposed approach has the above advantages, it still has some limitations:

- It does not consider the temporary bracing used on the construction site.
- It assumes that blocks are used to keep panels from falling when stacking (Figure 1.6). But the use of blocks should be minimized.
- Stacks always have the long edge parallel to the chosen dropping edge (Figure 1.5), but there may be other ways to put stacks.

6.2.2 Worker assignment

The model discussed in Chapter 5.3 is sophisticated which can minimize total project time subject to worker quantity constraints and try to assign tasks to workers as evenly as possible with the consideration of ergonomic risk. It can help residential construction managers better plan construction activities. But the limitation is obvious: it cannot solve real size problems.

The greedy algorithm discussed in Chapter 5.5 is simple and runs fast. However, it has more assumptions which will result in the same workers for all tasks of each panel, and the number of workers assigned to each panel is determined by the size of the panels.

All the workers are considered identical in both the mathematical models and the algorithm, while in reality it is not true, as the physical conditions of workers are different.

6.3 Future research

For panel stacking problem in residential construction, the current approach has some assumptions. In future research, more realistic situation should be considered.

- When generating stacking plan, current approach does not consider the panel thickness difference of the panels in the same layer, in other words, it allows two panels with different panel thickness to be placed in the same layer. In future research, panel thickness should be taken into account, it should try to put more panels with the same thickness in the same layer.
- Currently, blocks are assumed to be used to keep panels from falling when stacking (Figure 1.6). But more blocks used, more unstable the stack would be. Meanwhile, more effort and material will be needed when stacking panels. So in future research, the use of block should be minimized.
- Current approach does not considered the temporary bracing used on the construction site which might cause interference problems in reality. In future research, this should be taken into account.
- Current approach assumes stacks are delivered to the dropping edge separately, in other words, the second stack will not be delivered to the dropping edge until the first stack is fully completed. In future research, the situation like two or more stacks are delivered to the dropping edge should be considered. Corresponding interference problems should be considered as well.
- Currently, the approach will consider all accessible dropping edges, but only one dropping edge will be selected as the solution based on the panel move distance. In future research, more than one dropping edges should be allowed in the solution, in other words, different stacks may be delivered to different dropping edges based on the structure. Corresponding interference problems should be considered as well.

For worker assignment problems, a more advanced algorithm may be needed if more factors are considered.

- Currently, panel move distance is multiplied by panel length as the workload for each panel to account for the fact that larger panels are more difficult for workers to handle. In future research, more accurate method of predicting the workload may be needed.

- All workers are considered identical in current approach. However, people are different. Therefore in future research, the difference between workers, such as physical conditions and skill sets, should be considered.
- Currently, the heuristic assumed panels are completed one by one, however, in future research, a new heuristic which allows workers to handle more than one panel at a time may be needed.

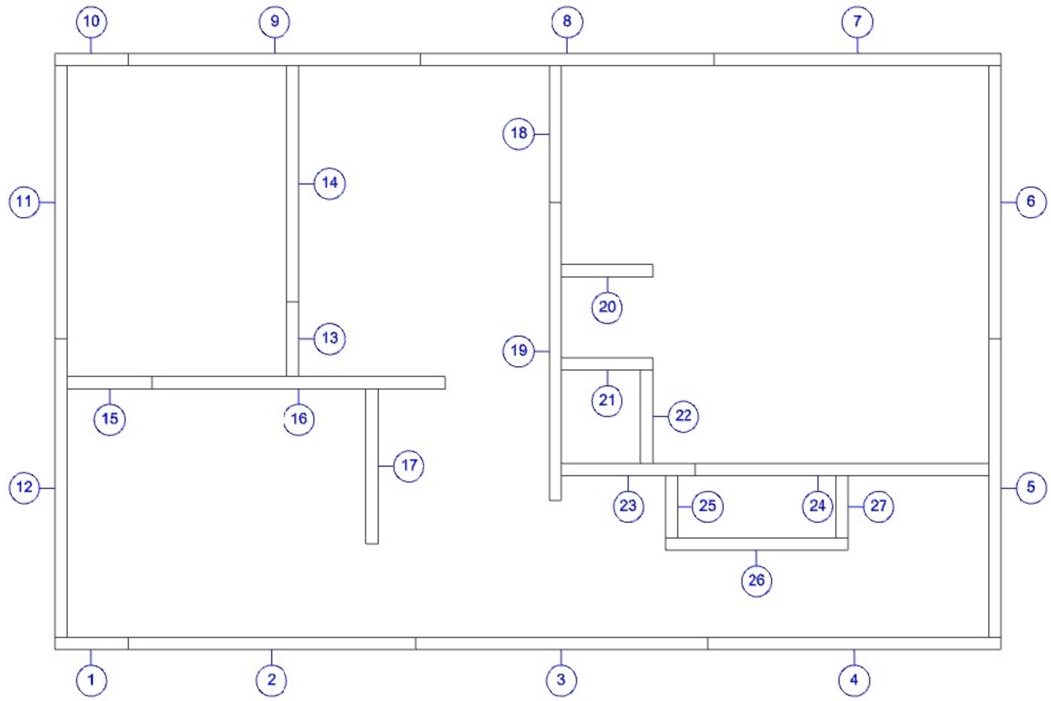
Appendix A: Iterative algorithm

For each stack, we calculate the drop-off location (x location along the dropping edge) via iterative algorithm. $\overline{Y}$ = y location of each stack, q_i = x coordinate, final location of panel i, v_i = y coordinate, final location of panel i.

1. Find Starting Point: $\overline{X} = \dfrac{\sum_i l_i q_i}{\sum_i l_i}$
2. Using $\overline{X}$, $\overline{Y}$ to calculate all $d_i = \sqrt{\left(\overline{X} - q_i\right)^2 + \left(\overline{Y} - v_i\right)^2}$
3. Find new $\overline{X}$ with d_i: $\overline{X} = \dfrac{\sum_i \dfrac{l_i q_i}{d_i}}{\sum_i \dfrac{l_i}{d_i}}$
4. If the stacking location values have converged to an acceptable level, go to step 5, otherwise go to step 2.
5. End

Appendix B: Data Sets and Results (Chapter 3)

Small-1



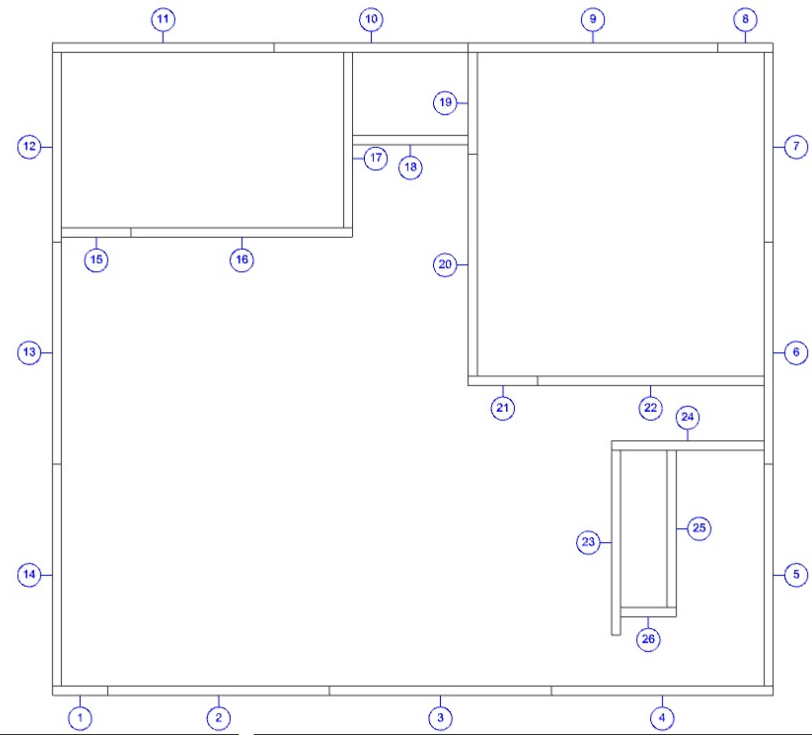
Small-1: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	2	14	17	15
2	1	156	2	2	26	
3	1	156	4	6	18	25
4	1	156	4	11	23	27
5	1	156	6	3	20	10
6	1	156	6	4	21	13
7	1	156	6	5	22	1
8	1	156	60	8		
9	1	156	60	9		
Stack 2						
1	1	156	60	12		
2	1	156	60	16		
3	1	156	60	19		
4	1	156	60	24		
5	1	156	62	7		

Small-1: Proposed approach

** stack#	xloc	#layers	j	#panels	panels			
1	80.3	9	1	2	10	11		
			2	3	12	1	15	
			3	1	2			
			4	1	9			
			5	2	14	13		
			6	2	16	17		
			7	1	3			
			8	2	8	18		
			9	3	19	20	21	
2	223.3	6	1	4	22	23	25	26
			2	2	24	27		
			3	1	4			
			4	1	7			
			5	1	6			
			6	1	5			

Small-2



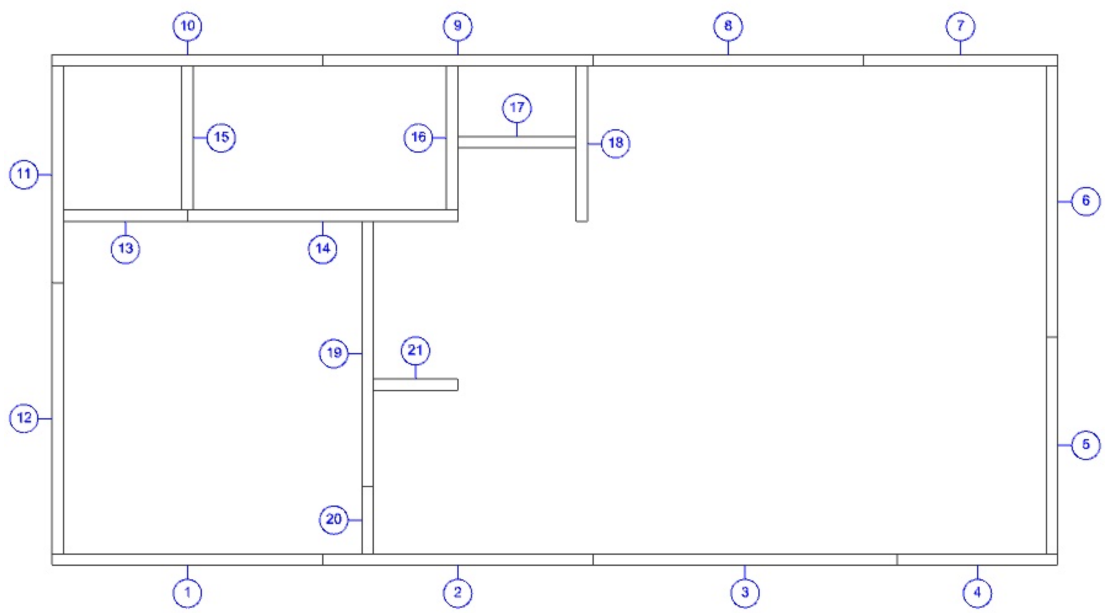
Small-2: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	23	17	
2	1	156	2	2	21	15
3	1	156	4	9	19	
4	1	156	4	10	25	
5	1	156	8	3	26	8
6	1	156	10	4	18	
7	1	156	10	7	24	
8	1	156	36	5	1	
9	1	156	60	6		
Stack 2						
1	1	156	60	11		
2	1	156	60	13		
3	1	156	60	14		
4	1	156	60	16		
5	1	156	60	20		
6	1	156	60	22		
7	1	156	74	12		

Small-2: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	51.3	9	1	1	11		
			2	1	12		
			3	1	13		
			4	3	14	1	15
			5	1	10		
			6	1	17		
			7	1	16		
			8	2	2	18	
			9	2	3	9	
2	259.2	9	1	1	19		
			2	2	20	21	
			3	2	4	8	
			4	1	22		
			5	2	24	23	
			6	2	25	26	
			7	1	7		
			8	1	6		
			9	1	5		

Small-3



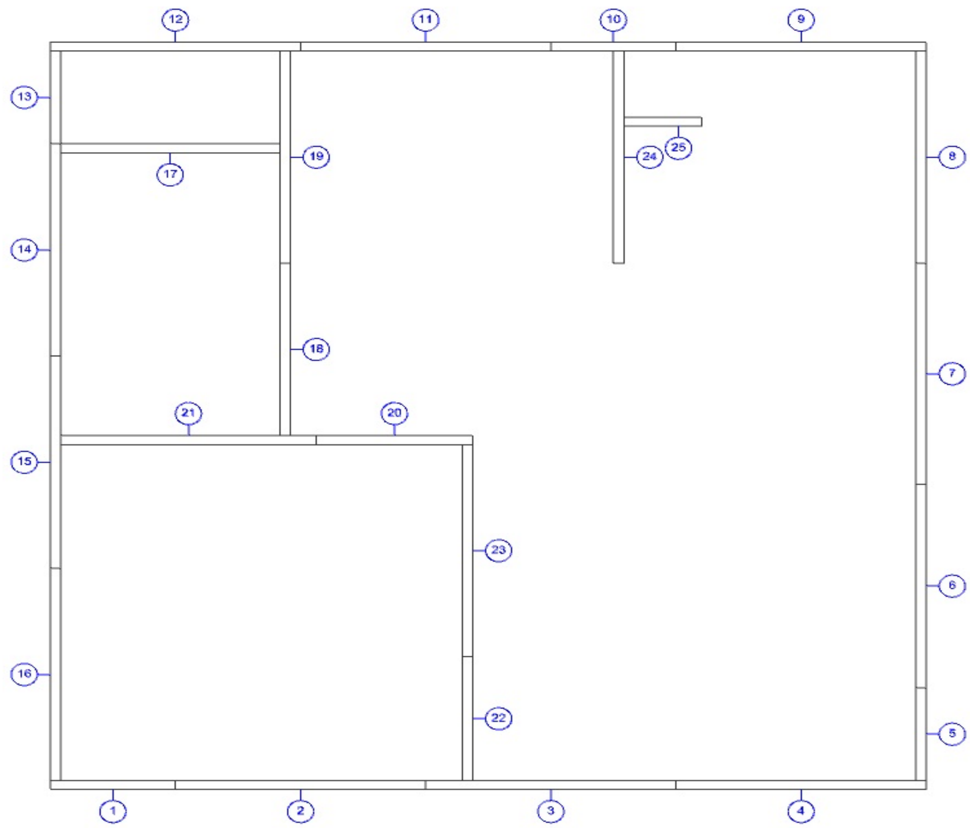
Small-3: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	2	5	11	
2	1	156	3	2	4	
3	1	156	4	3	13	
4	1	156	5	6	18	
5	1	156	8	19	21	20
6	1	156	9	8	15	
7	1	156	9	9	16	
8	1	156	18	10	17	
9	1	156	60	12		
Stack 2						
1	1	156	60	14		
2	1	156	60	1		
3	1	156	87	7		

Small-3: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	96.3	9	1	1	10		
			2	1	11		
			3	2	12	15	
			4	2	13	1	
			5	2	9	16	
			6	1	14		
			7	3	19	20	21
			8	2	2	17	
			9	2	18	8	
2	326.1	4	1	1	3		
			2	2	7	4	
			3	1	6		
			4	1	5		

Small-4



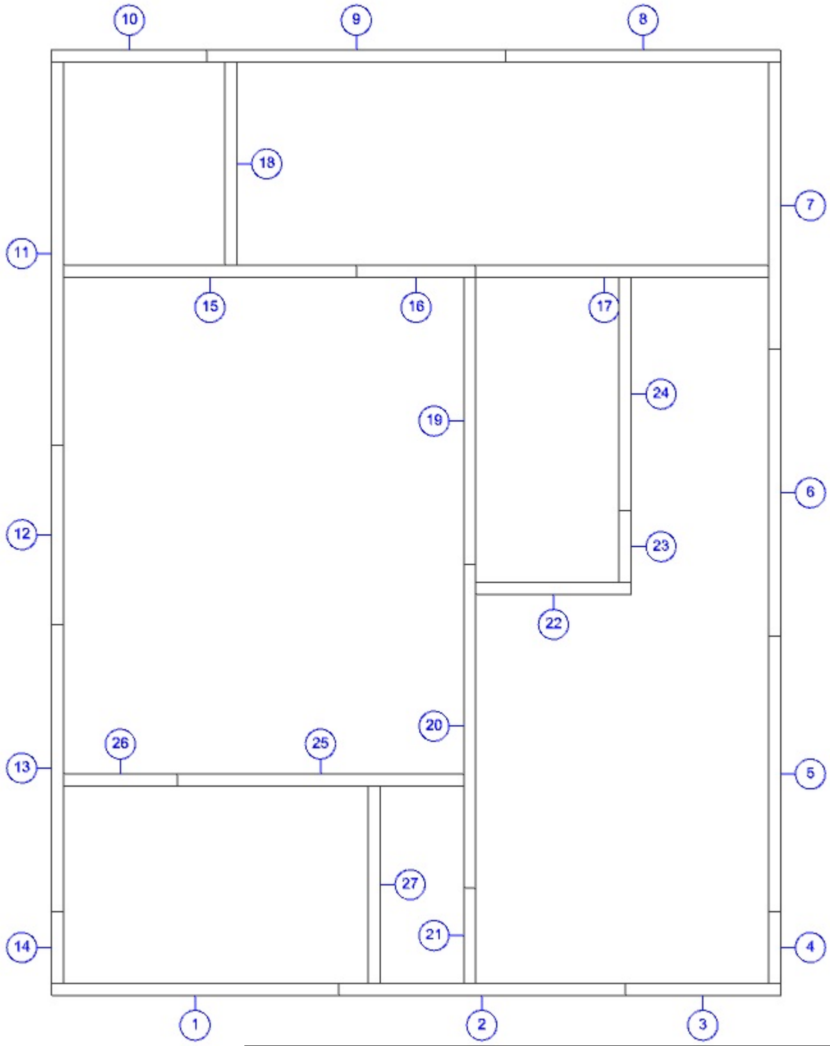
Small-4: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	6	25	24
2	1	156	4	2	21	
3	1	156	12	16	19	
4	1	156	12	3	9	
5	1	156	12	4	1	
6	1	156	18	7	5	
7	1	156	18	8	12	
8	1	156	60	10		
9	1	156	60	11		
Stack 2						
1	1	156	60	13		
2	1	156	60	14		
3	1	156	60	15		
4	1	156	60	18		
5	1	156	60	20		
6	1	156	60	22		
7	1	156	60	23		
8	1	156	78	17		

Small-4: Proposed approach

** stack#	xloc	#layers	j	#panels	panels
1	68.3	9	1	2	12 13
			2	1	14
			3	1	15
			4	2	16 1
			5	1	17
			6	1	19
			7	1	18
			8	1	21
			9	2	2 11
2	230.6	8	1	2	20 23
			2	2	22 10
			3	2	24 25
			4	1	3
			5	2	9 4
			6	1	8
			7	1	7
			8	2	6 5

Small-5



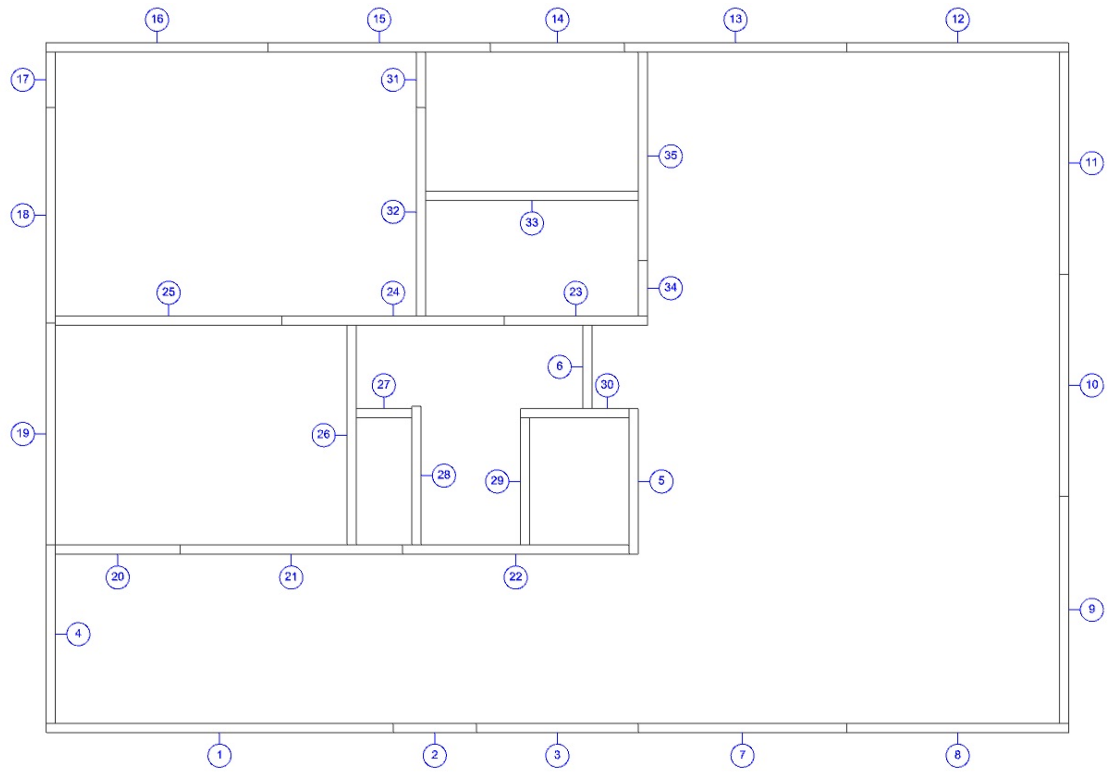
Small-5: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	10	27	
2	1	156	0	2	11	
3	1	156	4	6	20	4
4	1	156	6	19	25	
5	1	156	8	7	3	
6	1	156	8	12	9	
7	1	156	8	14	21	
8	1	156	10	23	17	
9	1	156	12	16	13	22
Stack 2						
1	1	156	20	18	15	
2	1	156	60	24		
3	1	156	60	1		
4	1	156	64	5		
5	1	156	64	8		
5	1	156	90	26		

Small-5: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	30.7	9	1	1	10		
			2	1	11		
			3	2	12	13	
			4	2	14	1	
			5	1	9		
			6	1	18		
			7	1	15		
			8	2	26	16	
			9	2	25	2	
2	183.2	9	1	1	27		
			2	1	19		
			3	2	20	21	
			4	1	8		
			5	1	17		
			6	3	24	23	22
			7	2	3	7	
			8	1	6		
			9	2	5	4	

Med-1



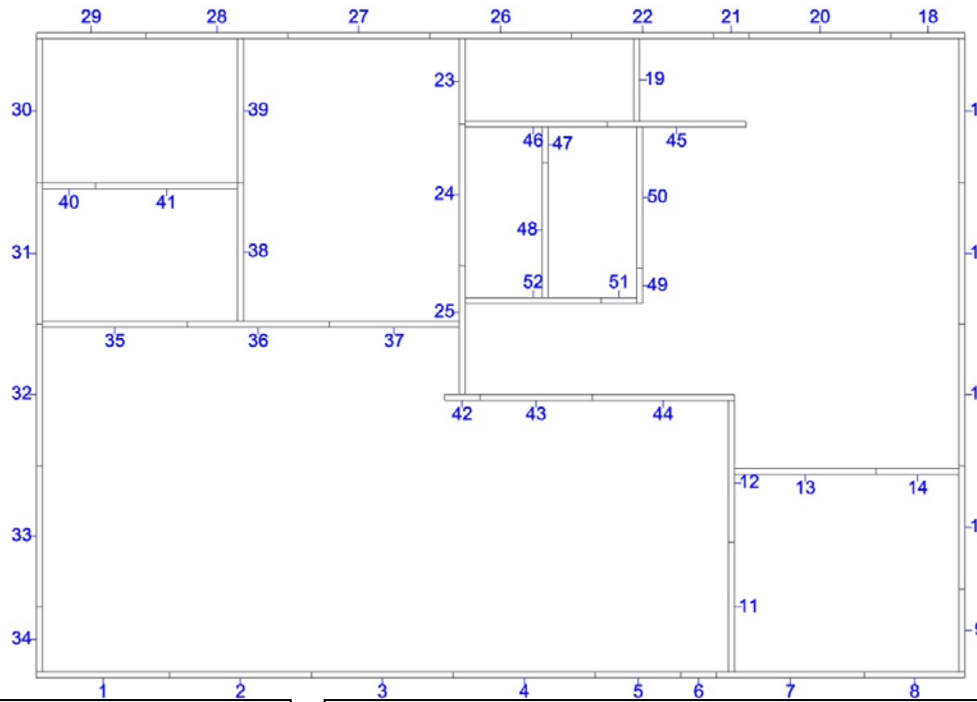
Med-1: Traditional approach

No	Mult	Size	Offcut	Panels	
Stack 1					
1	1	156	0	5	28
2	1	156	0	4	23
3	1	156	0	13	35
4	1	156	0	21	26
5	1	156	6	1	
6	1	156	8	7	14
7	1	156	8	32	20
8	1	156	9	33	29
9	1	156	12	25	2
Stack 2					
1	1	156	18	18	30
2	1	156	36	8	6
3	1	156	36	9	17
4	1	156	36	10	27
5	1	156	36	11	31
6	1	156	36	12	34
7	1	156	60	15	
8	1	156	60	16	
9	1	156	60	19	
Stack 3					
1	1	156	60	22	
2	1	156	60	24	
3	1	156	61	3	

Med-1: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	97.5	9	1	2	16	17	
			2	1	18		
			3	1	19		
			4	1	4		
			5	1	1		
			6	2	25	20	
			7	2	15	31	
			8	2	32	24	
			9	2	26	27	
2	216.5	9	1	2	21	2	
			2	2	28	14	
			3	2	33	35	
			4	2	34	23	
			5	3	6	30	29
			6	2	22	3	
			7	2	5	13	
			8	2	7	12	
			9	1	8		
3	425.6	3	1	1	11		
			2	1	10		
			3	1	9		

Med-2



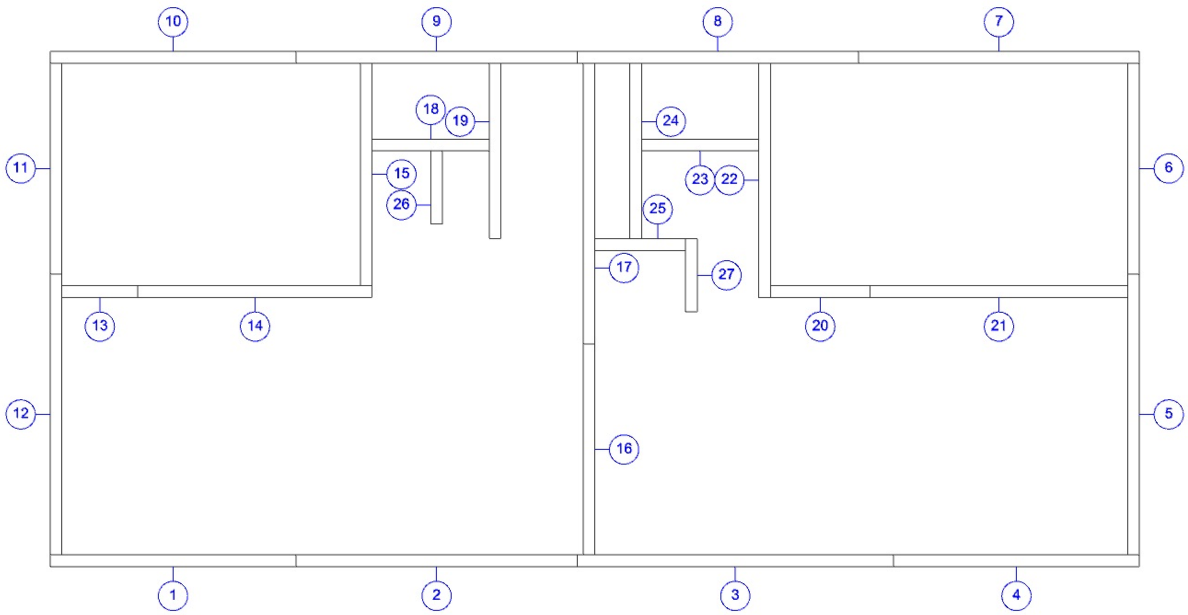
Med-2: Traditional approach

No	Mult	Size	Offcut	Panels	
Stack 1					
1	1	156	0	48	14
2	1	156	0	38	5
3	1	156	0	45	23
4	1	156	0	2	9
5	1	156	0	3	18
6	1	156	4	19	29
7	1	156	4	43	8
8	1	156	18	7	40
9	1	156	18	1	34
Stack 2					
1	1	156	32	4	6
2	1	156	32	10	21
3	1	156	32	11	42
4	1	156	32	12	47
5	1	156	32	13	49
6	1	156	32	15	51
7	1	156	56	16	
8	1	156	56	17	
9	1	156	56	20	
Stack 3					
1	1	156	56	22	
2	1	156	56	24	
3	1	156	56	25	
4	1	156	56	26	
5	1	156	56	27	
6	1	156	56	28	
7	1	156	56	30	
8	1	156	56	31	
9	1	156	56	32	
Stack 4					
l	1	156	56	33	
2	1	156	56	35	
3	1	156	56	36	
4	1	156	56	39	
5	1	156	56	41	
6	1	156	56	44	
7	1	156	56	46	
8	1	156	56	50	
9	1	156	56	52	
Stack 5					
1	1	156	64	37	

Med-2: Proposed approach

** stack#	xloc	#layers	j	#panels	panels
1	22.6	9	1	1	29
			2	1	30
			3	1	31
			4	1	32
			5	2	33 34
			6	2	1 40
			7	1	28
			8	1	41
			9	1	2
2	196.8	9	1	1	35
			2	1	39
			3	1	38
			4	1	36
			5	1	27
			6	1	37
			7	1	3
			8	1	26
			9	2	23 24
3	416.6	9	1	2	25 42
			2	1	4
			3	1	22
			4	2	46 47
			5	1	48
			6	2	52 43
			7	3	19 21 45
			8	3	51 50 49
			9	3	44 5 6
4	491.6	9	1	1	20
			2	1	7
			3	1	12
			4	1	11
			5	2	18 13
			6	2	8 14
			7	1	17
			8	1	16
			9	1	15
5	626.0	2	1	1	10
			2	1	9

Med-3



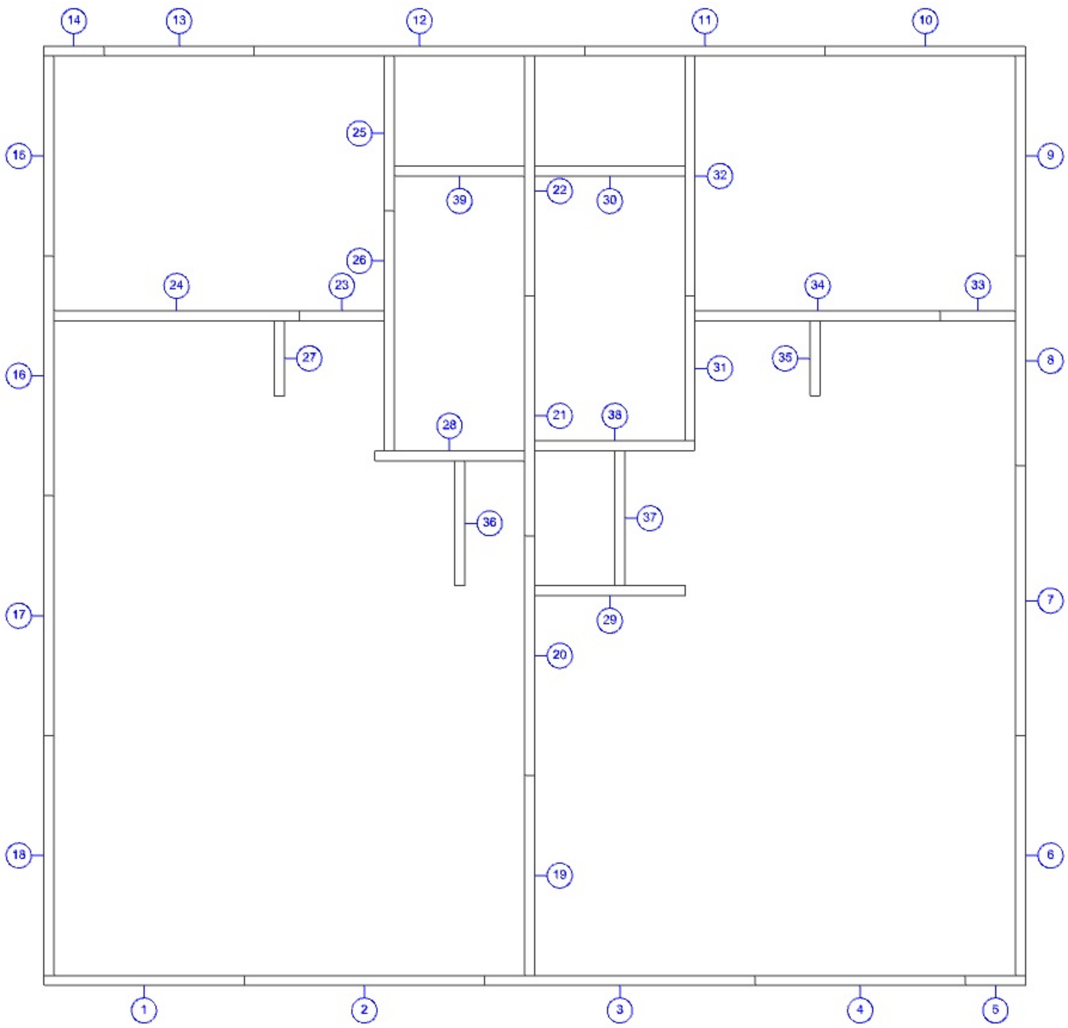
Med-3: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	2	19	
2	1	156	0	5	24	
3	1	156	0	14	21	
4	1	156	0	4	6	
5	1	156	0	10	11	
6	1	156	0	1	16	
7	1	156	11	7	26	13
8	1	156	11	8	27	20
9	1	156	17	3	25	
Stack 2						
1	1	156	20	9	18	
2	1	156	20	12	23	
3	1	156	60	17		
4	1	156	68	15		
5	1	156	76	22		

Med-3: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	106.1	9	1	2	10	11	
			2	1	12		
			3	1	1		
			4	2	13	14	
			5	1	9		
			6	2	15	18	
			7	2	2	26	
			8	2	19	8	
			9	1	17		
2	272.9	8	1	2	16	24	
			2	3	25	23	27
			3	1	3		
			4	1	22		
			5	1	7		
			6	2	20	21	
			7	2	4	6	
			8	1	5		

Med-4



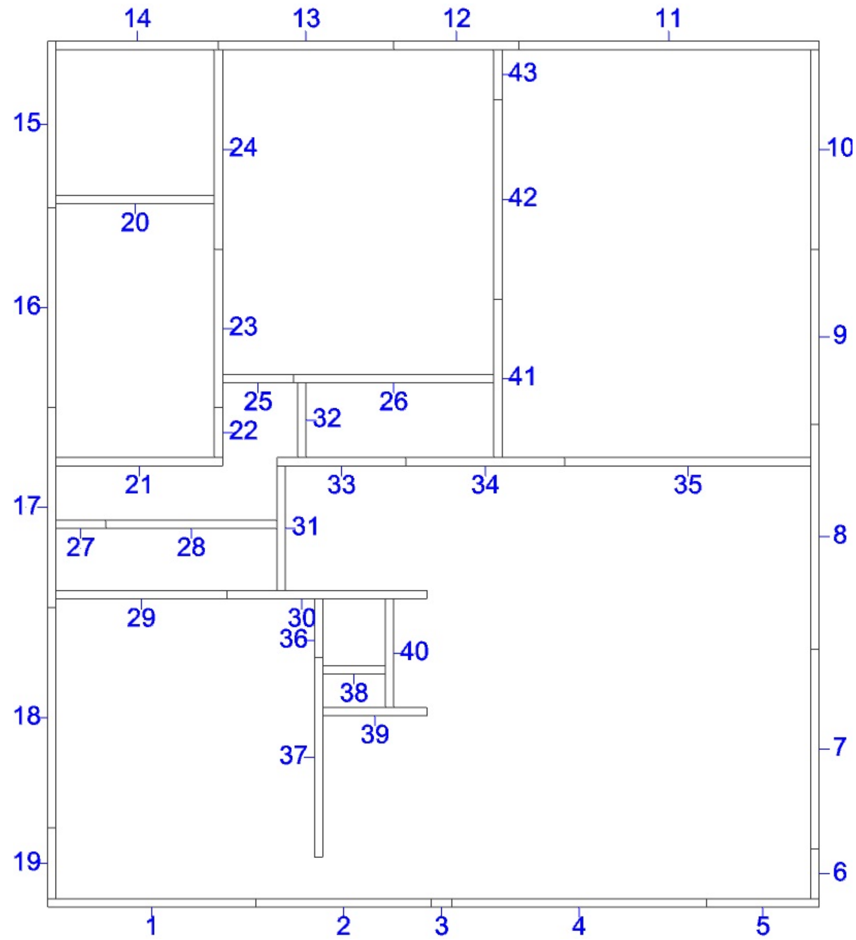
Med-4: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	2	13	
2	1	156	0	6	28	
3	1	156	0	11	29	
4	1	156	0	16	30	
5	1	156	0	12	5	
6	1	156	2	17	31	
7	1	156	2	9	36	14
8	1	156	12	10	38	
9	1	156	14	15	25	
Stack 2						
1	1	156	18	3	27	
2	1	156	18	7	33	
3	1	156	18	34	35	
4	1	156	22	4	39	
5	1	156	22	19	37	
6	1	156	38	8	23	
7	1	156	60	18		
8	1	156	60	20		
9	1	156	60	21		
Stack 3						
1	1	156	60	22		
2	1	156	60	24		
3	1	156	60	26		
4	1	156	60	32		
5	1	156	76	1		

Med-4: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	93.1	9	1	2	14	15	
			2	1	16		
			3	1	17		
			4	1	18		
			5	2	1	13	
			6	1	24		
			7	3	23	27	2
			8	1	12		
			9	2	25	26	
2	193.3	9	1	2	39	28	
			2	2	36	3	
			3	1	22		
			4	1	21		
			5	1	20		
			6	2	19		
			7	2	11	30	
			8	3	38	37	29
			9	2	32	31	
3	354.4	7	1	2	10	4	
			2	2	34	35	
			3	2	5	33	
			4	1	9		
			5	1	8		
			6	1	7		
			7	1	6		

Med-5



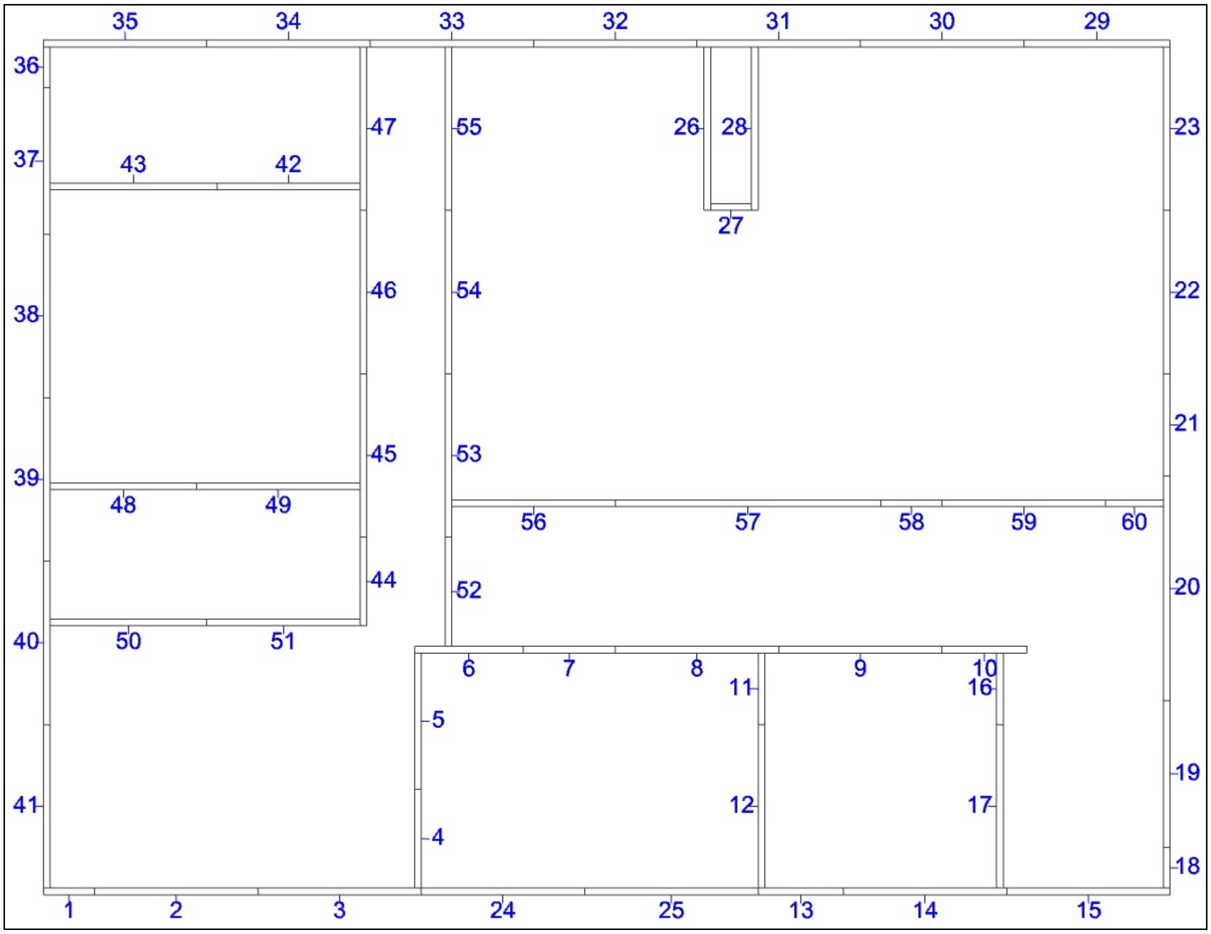
Med-5: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	21	20	
2	1	156	2	1	40	
3	1	156	2	14	23	
4	1	156	4	4		
5	1	156	10	2	33	
6	1	156	10	15	39	3
7	1	156	10	28	25	38
8	1	156	12	11		
9	1	156	12	8	32	
Stack 2						
1	1	156	12	9	12	
2	1	156	12	13	31	
3	1	156	36	7	5	
4	1	156	36	10	6	
5	1	156	36	16	19	
6	1	156	36	17	22	
7	1	156	36	18	27	
8	1	156	36	24	43	
9	1	156	46	29	36	
Stack 3						
1	1	156	60	26		
2	1	156	60	30		
3	1	156	60	34		
4	1	156	60	35		
5	1	156	60	37		
6	1	156	60	42		
7	1	156	80	41		

Med-5: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	5.4	9	1	2	14	15	
			2	1	16		
			3	1	17		
			4	2	18	19	
			5	1	1		
			6	2	20	21	
			7	2	27	13	
			8	2	24	23	
			9	3	22	25	28
2	112.2	9	1	2	29	12	
			2	1	2		
			3	2	26	32	
			4	2	33	31	
			5	2	30	36	
			6	2	37	38	
			7	2	40	39	
			8	2	3	43	
			9	1	42		
3	263.0	9	1	1	41		
			2	1	11		
			3	1	34		
			4	1	4		
			5	1	35		
			6	1	5		
			7	1	10		
			8	1	9		
			9	1	8		
4	372.0	1	1	2	7	6	

Big-1


35
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18
1
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14
15

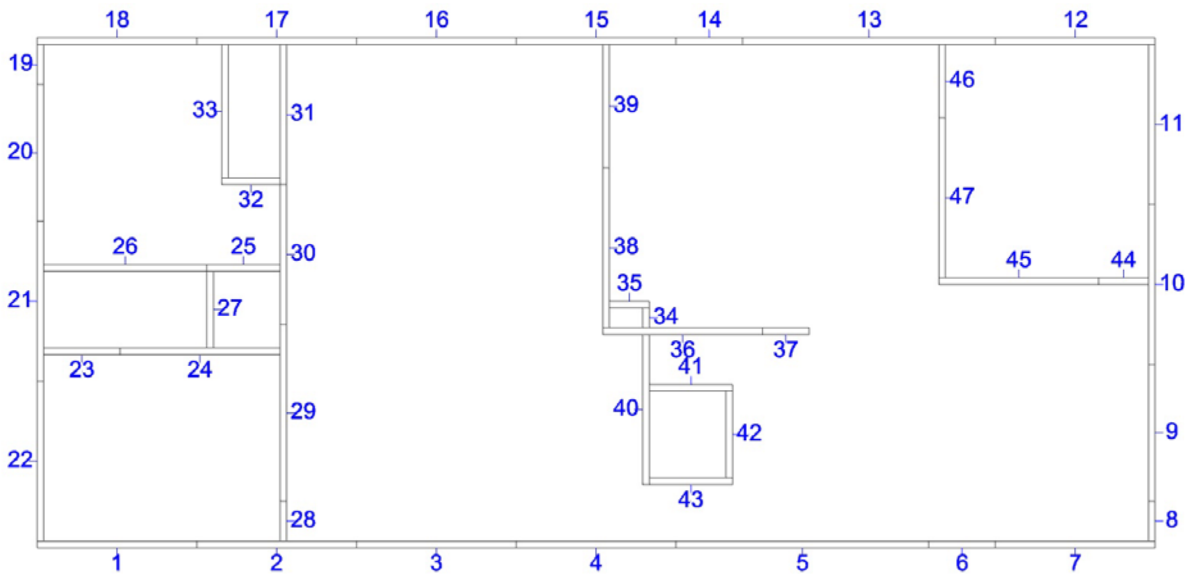
Big-1: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	25	7	10
2	1	156	0	57		
3	1	156	0	20	18	
4	1	156	0	2	6	
5	1	156	0	3	21	
6	1	156	2	5	4	
7	1	156	2	8	16	
8	1	156	4	50	52	
9	1	156	4	19	11	27
Stack 2						
1	1	156	10	42	60	1
2	1	156	18	29	44	
3	1	156	20	37	13	
4	1	156	24	48	36	58
5	1	156	60	9		
6	1	156	60	12		
7	1	156	60	14		
8	1	156	60	15		
9	1	156	60	17		
Stack 3						
1	1	156	60	22		
2	1	156	60	23		
3	1	156	60	24		
4	1	156	60	26		
5	1	156	60	28		
6	1	156	60	30		
7	1	156	60	31		
8	1	156	60	32		
9	1	156	60	33		
Stack 4						
1	1	156	60	34		
2	1	156	60	35		
3	1	156	60	38		
4	1	156	60	39		
5	1	156	60	40		
6	1	156	60	41		
7	1	156	60	43		
8	1	156	60	45		
9	1	156	60	46		
Stack 5						
1	1	156	60	47		
2	1	156	60	49		
3	1	156	60	53		
4	1	156	60	54		
5	1	156	60	55		
6	1	156	60	56		
7	1	156	60	59		
8	1	156	76	51		

Big-1: Proposed approach

** stack#	xloc	#layers	j	#panels	panels	
1	28.7	9	1	2	35	36
			2	1	37	
			3	1	38	
			4	1	39	
			5	1	40	
			6	2	41	1
			7	1	2	
			8	1	43	
			9	1	48	
2	117.0	9	1	1	50	
			2	1	34	
			3	1	42	
			4	1	49	
			5	1	51	
			6	1	3	
			7	1	47	
			8	1	46	
			9	2	45	44
3	232.2	9	1	1	33	
			2	1	24	
			3	1	55	
			4	1	54	
			5	1	53	
			6	2	52	32
			7	1	56	
			8	2	6	5
			9	2	4	7
4	392.1	9	1	1	31	
			2	2	25	13
			3	2	26	27
			4	1	28	
			5	1	57	
			6	2	8	11
			7	1	12	
			8	1	30	
			9	2	14	58
5	506.0	8	1	1	9	
			2	2	10	29
			3	1	15	
			4	2	59	16
			5	2	17	60
			6	2	23	22
			7	2	21	20
			8	2	19	18

Big-2



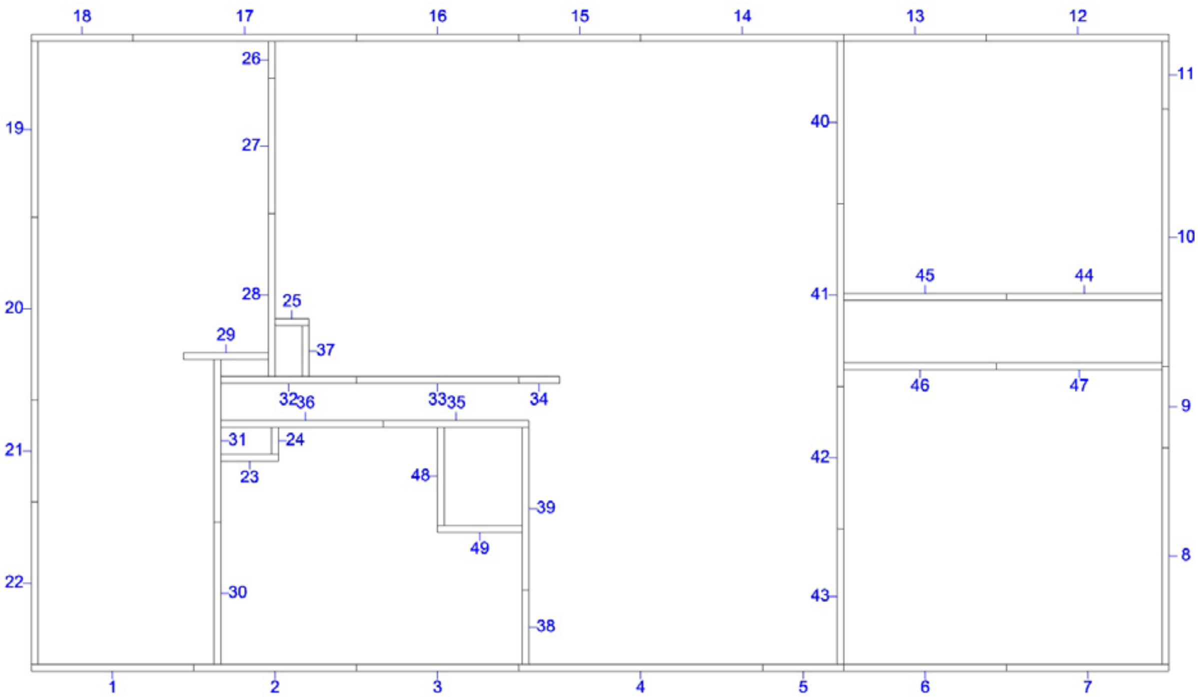
Big-2: Traditional approach

No	Mult	Size	Offcut	Panels
Stack 1				
1	1	156	0	30 23 37
2	1	156	0	31 25 44
3	1	156	0	9 42 6
4	1	156	0	29 43
5	1	156	0	20 39
6	1	156	0	2 46 34
7	1	156	1	3 32 8
8	1	156	4	5
9	1	156	4	13
Stack 2				
1	1	156	12	40 41
2	1	156	12	4 14 19
3	1	156	12	7 28 35
4	1	156	14	10 27
5	1	156	60	11
6	1	156	60	12
7	1	156	60	15
8	1	156	60	16
9	1	156	60	17
Stack 3				
1	1	156	60	18
2	1	156	60	21
3	1	156	60	22
4	1	156	60	24
5	1	156	60	26
6	1	156	60	36
7	1	156	60	38
8	1	156	60	45
9	1	156	60	47
Stack 4				
1	1	156	60	1
2	1	156	76	33

Big-2: Proposed approach

** stack#	xloc	#layers	j	#panels	panels
1	67.4	9	1	2	18 19
			2	1	20
			3	1	21
			4	1	22
			5	1	1
			6	2	26 23
			7	1	17
			8	1	2
			9	2	33 32
2	215.8	9	1	2	25 27
			2	1	24
			3	1	31
			4	1	30
			5	2	29 28
			6	1	16
			7	1	3
			8	1	15
			9	1	4
3	468.9	9	1	1	39
			2	3	38 35 34
			3	2	14 36
			4	1	5
			5	2	40 41
			6	2	42 43
			7	1	13
			8	2	37 46
			9	2	47 6
4	661.7	6	1	1	12
			2	1	7
			3	2	45 44
			4	1	11
			5	1	10
			6	2	9 8

Big-3



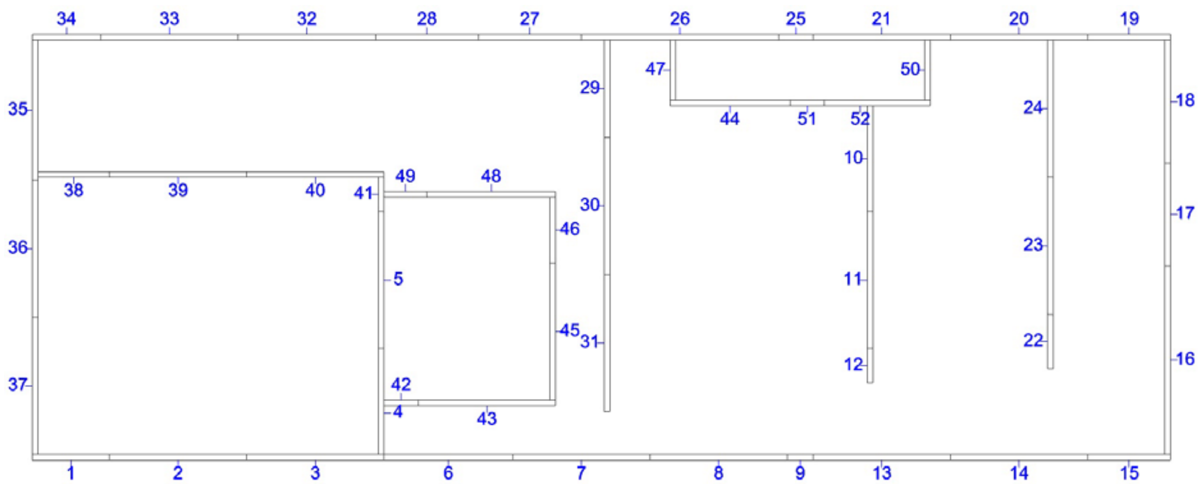
Big-3: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	17	11	
2	1	156	0	13	15	
3	1	156	2	14	23	
4	1	156	2	19	37	25
5	1	156	2	2	48	
6	1	156	4	27	5	26
7	1	156	4	32	9	34
8	1	156	4	10		
9	1	156	10	35	38	24
Stack 2						
1	1	156	12	30	18	
2	1	156	12	42	21	
3	1	156	12	4		
4	1	156	16	44	29	
5	1	156	16	46	49	
6	1	156	28	8		
7	1	156	48	12		
8	1	156	48	20		
9	1	156	48	41		
Stack 3						
1	1	156	60	3		
2	1	156	60	6		
3	1	156	60	7		
4	1	156	60	16		
5	1	156	60	22		
6	1	156	60	28		
7	1	156	60	31		
7	1	156	60	33		
9	1	156	60	36		
Stack 4						
1	1	156	60	39		
2	1	156	60	40		
3	1	156	60	45		
4	1	156	60	47		
5	1	156	60	1		
6	1	156	76	43		

Big-3: Proposed approach

** stack#	xloc	#layers	j	#panels	panels
1	52.7	9	1	1	18
			2	1	19
			3	1	20
			4	2	21 22
			5	1	1
			6	1	17
			7	2	2 26
			8	1	27
			9	2	28 29
2	203.3	9	1	1	31
			2	3	30 25 37
			3	2	32 36
			4	3	24 23 16
			5	2	3 33
			6	2	35 48
			7	3	49 15 34
			8	1	4
			9	2	39 38
3	442.8	9	1	2	14 5
			2	1	40
			3	1	41
			4	1	42
			5	1	43
			6	2	13 6
			7	1	45
			8	1	46
			9	1	12
4	594.7	6	1	1	7
			2	1	44
			3	2	47 11
			4	1	10
			5	1	9
			6	1	8

Big-4



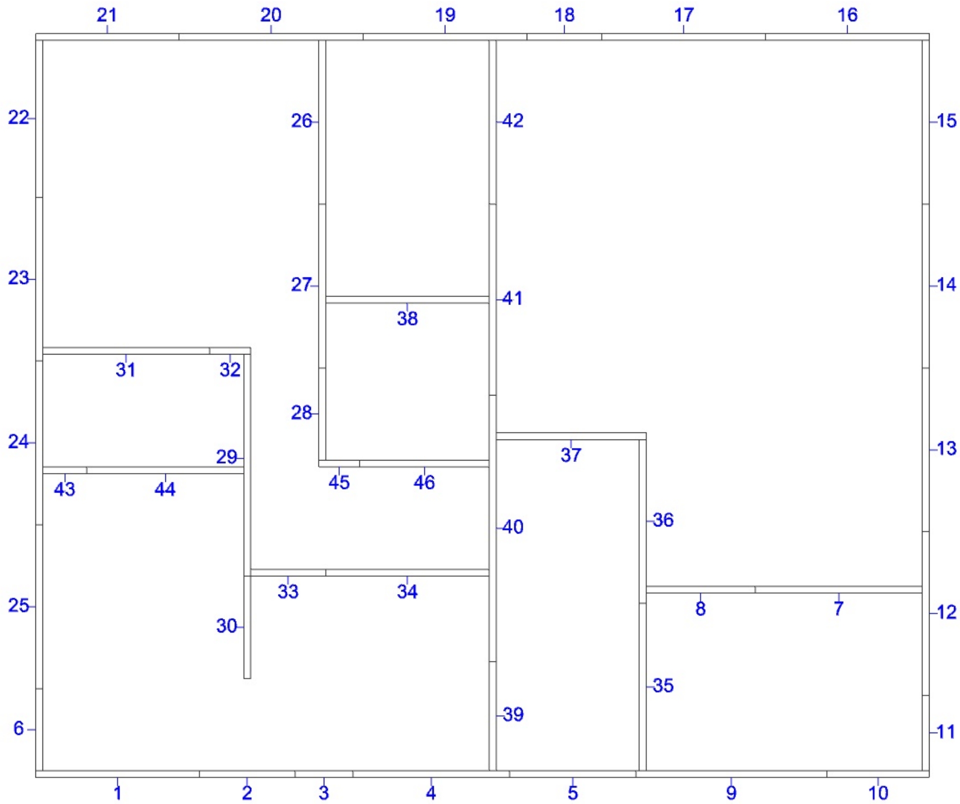
Big-4: Traditional approach

No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	18	17	
2	1	156	0	44	27	
3	1	156	0	16	9	
4	1	156	2	2	15	
5	1	156	2	3	19	
6	1	156	2	47	22	
7	1	156	6	5	1	
8	1	156	8	37	28	
9	1	156	8	4	10	
Stack 2						
1	1	156	12	6	34	
2	1	156	12	7	38	
3	1	156	12	8	12	25
4	1	156	12	11	41	42
5	1	156	12	13	49	51
6	1	156	14	14	46	
7	1	156	14	52	29	
8	1	156	18	26		
9	1	156	20	20	50	
Stack 3						
1	1	156	60	21		
2	1	156	60	23		
3	1	156	60	24		
4	1	156	60	30		
5	1	156	60	31		
6	1	156	60	32		
7	1	156	60	33		
8	1	156	60	35		
9	1	156	60	36		
Stack 4						
1	1	156	60	39		
2	1	156	60	40		
3	1	156	60	43		
4	1	156	60	45		
5	1	156	66	48		

Big-4: Proposed approach

** stack#	xloc	#layers	j	#panels	panels			
1	58.9	9	1	2	34	35		
			2	1	36			
			3	2	37	1		
			4	2	38	33		
			5	1	2			
			6	1	39			
			7	1	32			
			8	1	3			
			9	1	40			
2	288.1	9	1	2	41	5		
			2	2	4	28		
			3	3	6	49	42	
			4	2	27	48		
			5	1	7			
			6	2	46	45		
			7	1	43			
			8	1	26			
			9	2	29	30		
3	634.0	9	1	1	31			
			2	2	47	8		
			3	4	44	9	25	51
			4	1	21			
			5	1	13			
			6	2	50	52		
			7	1	10			
			8	2	11	12		
			9	1	20			
4	516.7	6	1	1	14			
			2	1	24			
			3	2	23	22		
			4	2	19	15		
			5	2	18	17		
			6	1	16			

Big-5



Big-5: Traditional approach

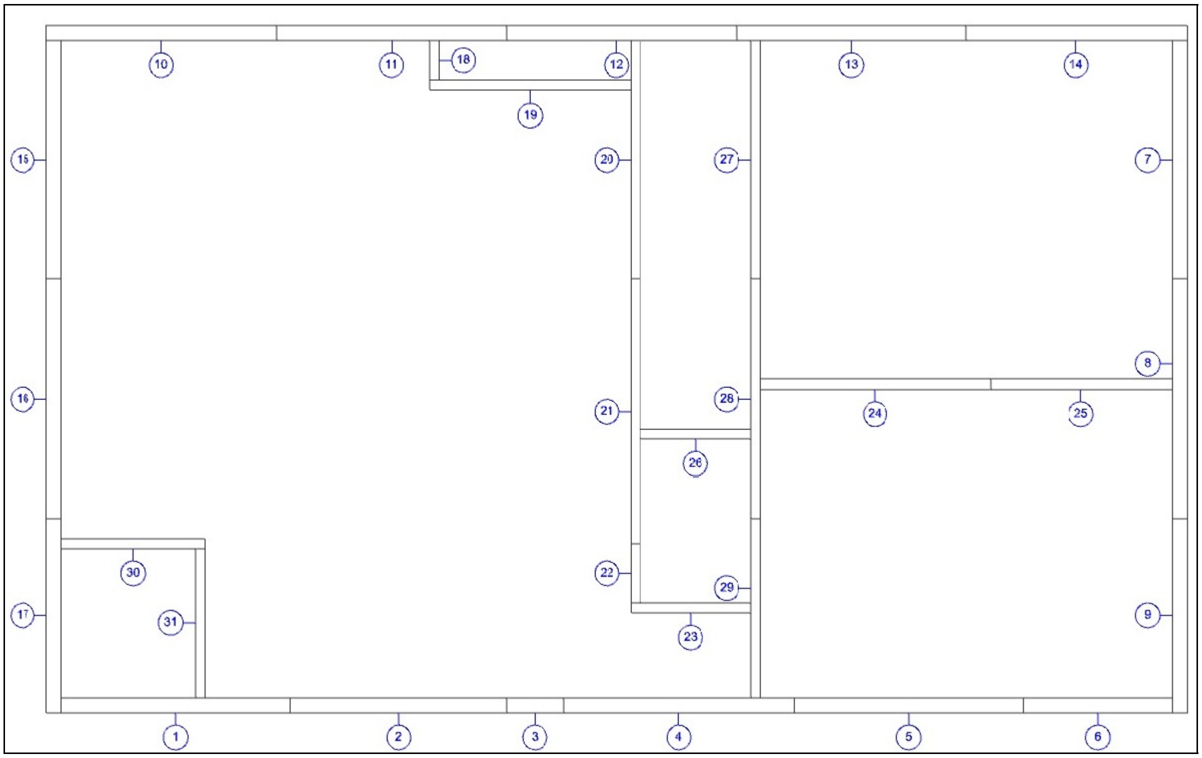
No	Mult	Size	Offcut	Panels		
Stack 1						
1	1	156	0	40		
2	1	156	0	4	6	
3	1	156	0	9	11	
4	1	156	0	20	8	
5	1	156	0	1	10	
6	1	156	0	7	30	
7	1	156	2	29	32	
8	1	156	2	12	35	
9	1	156	2	46	28	39
Stack 2						
1	1	156	2	13	3	43
2	1	156	2	14	5	45
3	1	156	12	37	2	
4	1	156	20	22	18	
5	1	156	20	44	33	
6	1	156	60	15		
7	1	156	60	16		
8	1	156	60	17		
9	1	156	60	19		
Stack 3						
1	1	156	60	23		
2	1	156	60	24		
3	1	156	60	25		
4	1	156	60	26		
5	1	156	60	27		
6	1	156	60	31		
7	1	156	60	34		
8	1	156	60	36		
9	1	156	60	38		
Stack 4						
1	1	156	60	41		
2	1	156	60	42		
3	1	156	72	21		

Big-5: Proposed approach

** stack#	xloc	#layers	j	#panels	panels		
1	25.7	9	1	1	21		
			2	1	22		
			3	1	23		
			4	1	24		
			5	1	25		
			6	2	6	1	
			7	2	31	43	
			8	1	20		
			9	2	2	32	
2	190.7	9	1	1	44		
			2	1	29		
			3	2	30	3	
			4	1	26		
			5	2	27	28	
			6	2	33	19	
			7	1	4		
			8	2	38	45	
			9	1	46		
3	304.7	9	1	1	34		
			2	1	42		
			3	1	41		
			4	1	40		
			5	3	39	18	5
			6	2	37	17	
			7	1	9		
			8	2	36	35	
			9	2	8	16	
4	509.3	5	1	2	10	7	
			2	1	15		
			3	1	14		
			4	1	13		
			5	2	12	11	

Appendix C: Data Sets and Results (Chapter 3)

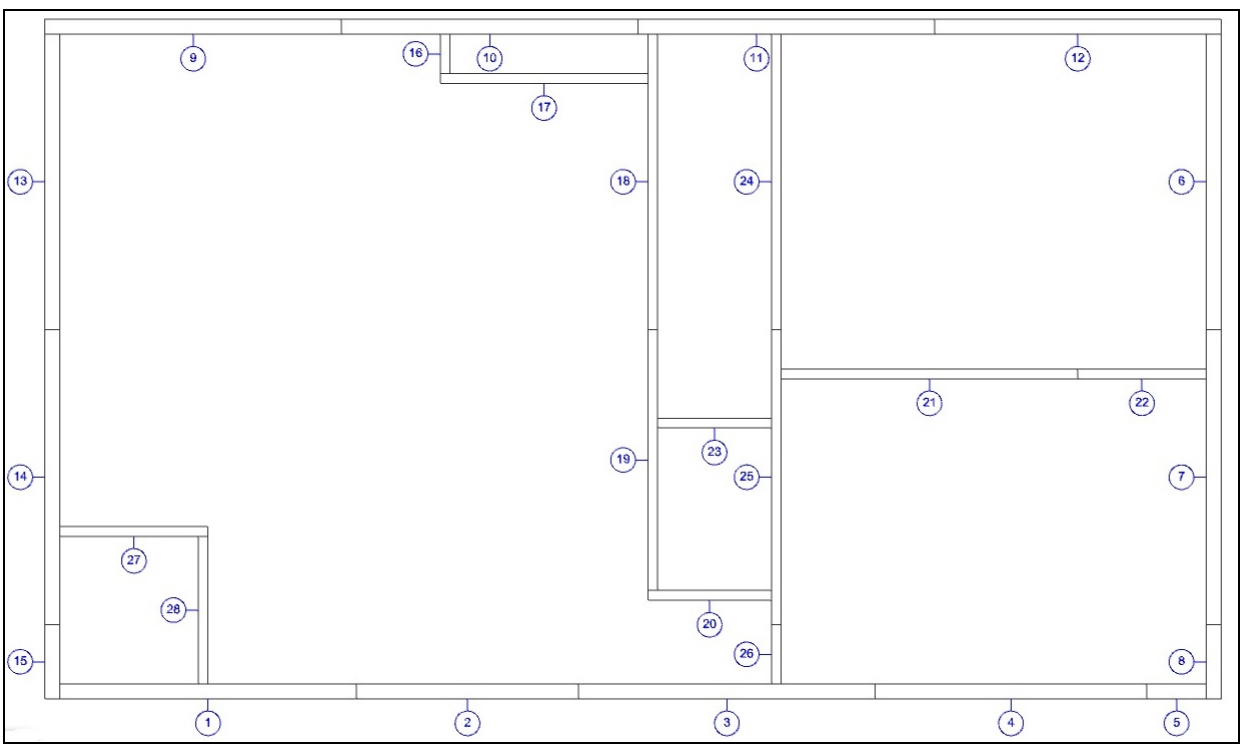
S1-1




```
S1-1: Shewchuk (2008)
**zone      left edge X coordinate
 1            6.0
 2          222.0
** NStacks
4
** stack                flush
**   #    zone type    edge      xloc    yloc   #layers   j   #panels   panels        orientation
     1     1     A     RIGHT    114.0    48.0       6     1      1       10              2
                                                          2      1       11              2
                                                          3      1       15              1
                                                          4      1       16              1
                                                          5      2       18 17           1 1
                                                          6      1       1               3
     2     2     A     RIGHT    346.0    48.0       7     1      1       12              2
                                                          2      1       13              2
                                                          3      1       14              2
                                                          4      1       7               2
                                                          5      1       8               2
                                                          6      1       9               2
                                                          7      1       19              2
     3     2     B     LEFT     346.0    90.0       4     1      2       2 3             3 3
                                                          2      2       30 31           3 1
                                                          3      1       20              1
                                                          4      1       21              1
     4     2     B     LEFT     346.0    90.0       8     1      1       4               3
                                                          2      1       5               3
                                                          3      1       6               3
                                                          4      1       27              1
                                                          5      2       26 28           3 1
                                                          6      1       24              3
                                                          7      2       25 22           3 1
                                                          8      2       23 29           3 1
** # of interfering panels
8: 27 26 28 24 25 22 23 29
```

```
S1-1: Proposed algorithm
** Nzones
3
**zone      left edge X coordinate
 1             6.0
 2           210.0
 3           254.0
** NStacks
5
** stack               flush
**   #    zone type    edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1     1     A     RIGHT   114.0   48.0      6       1      1       10           2
                                                          2      1       11           2
                                                          3      1       15           1
                                                          4      1       16           1
                                                          5      2       18 17        1 1
                                                          6      1       1            3
     2     2     A     RIGHT   330.0   48.0      3       1      1       12           2
                                                          2      1       13           2
                                                          3      1       19           2
     3     2     B     LEFT    330.0   90.0      4       1      2       2 3          3 3
                                                          2      1       4            3
                                                          3      1       5            3
                                                          4      2       30 31        3 1
     4     3     A     RIGHT   362.0   48.0      4       1      1       14           2
                                                          2      1       7            2
                                                          3      1       8            2
                                                          4      1       9            2
     5     3     B     LEFT    362.0   90.0     10       1      1       20           1
                                                          2      2       21 22        1 1
                                                          3      1       27           1
                                                          4      1       6            3
                                                          5      1       29           1
                                                          6      1       23           3
                                                          7      1       25           3
                                                          8      1       24           3
                                                          9      1       28           1
                                                         10      1       26           3
** # of interfering panels
6:   29 23 25 24 28 26
```

S1-2

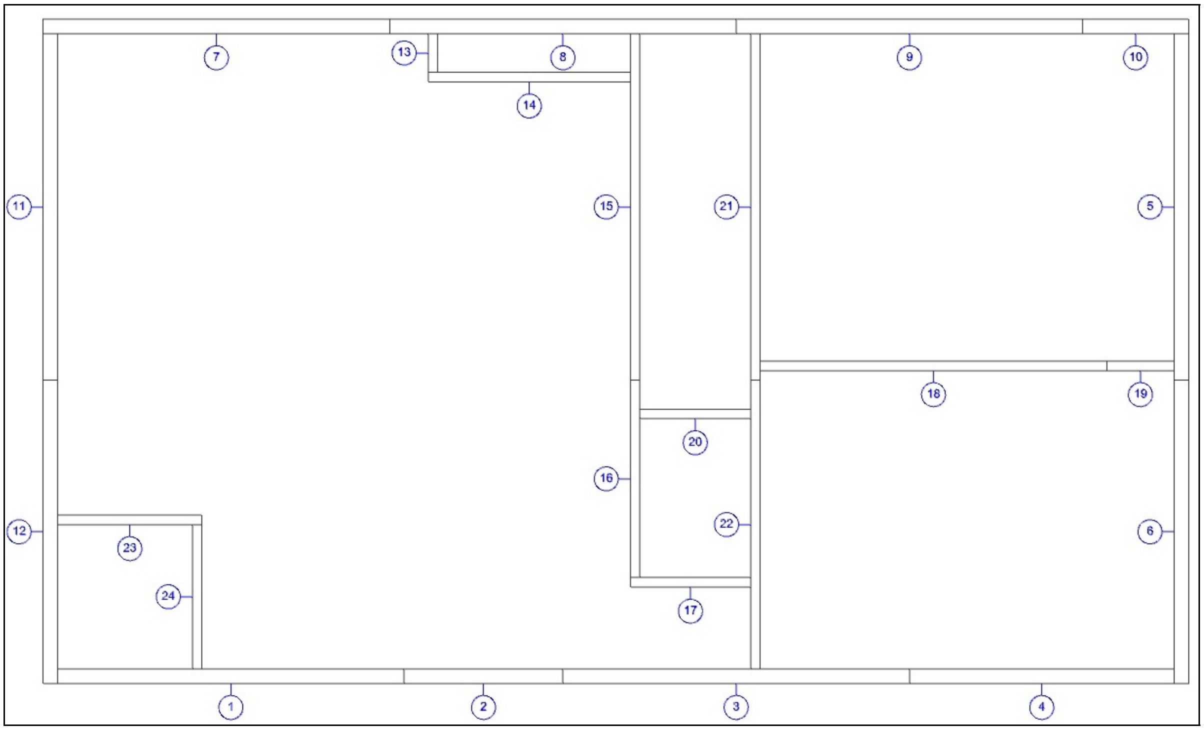


```
S1-2: Shewchuk (2008)
** Nzones
2
**zone      left edge X coordinate
  1            6.0
  2          222.0
** NStacks
4
** stack                flush
**   #    zone type   edge     xloc   yloc   #layers   j   #panels   panels    orientation
     1     1    A     RIGHT   114.0   48.0      5          1         1    9          2
                                                           2         1    13         1
                                                           3         1    14         1
                                                           4         1    15         1
                                                           5         1    1          3
     2     2    A     RIGHT   346.0   48.0      6          1         1    10         2
                                                           2         1    11         2
                                                           3         1    12         2
                                                           4         1    6          2
                                                           5         1    7          2
                                                           6         3    17 16 8    2 2 2
     3     2    B     LEFT    346.0   90.0      2          1         1    2          3
                                                           2         2    27 28      3 1
     4     2    B     LEFT    346.0   90.0      9          1         1    3          3
                                                           2         2    4 5        3 3
                                                           3         1    18         1
                                                           4         1    24         1
                                                           5         1    19         1
                                                           6         2    23 20      3 3
                                                           7         1    25         1
                                                           8         1    21         3
                                                           9         2    22 26      3 1
** # of interfering panels
9:   18 24 19 23 20 25 21 22 26
```

```
S1-2: Proposed algorithm
** Nzones
3
**zone      left edge X coordinate
  1            6.0
  2          211.0
  3          254.0
** NStacks
5
** stack                flush
**   #    zone type   edge     xloc   yloc   #layers   j   #panels   panels    orientation
     1     1    A     RIGHT   114.0   48.0      5          1         1    9          2
                                                           2         1    13         1
                                                           3         1    14         1
                                                           4         1    15         1
                                                           5         1    1          3
     2     2    A     RIGHT   330.0   48.0      3          1         1    10         2
                                                           2         2    16 11      1 2
                                                           3         1    17         2
     3     2    B     LEFT    330.0   90.0      3          1         1    2          3
                                                           2         1    3          3
                                                           3         2    27 28      3 1
     4     3    A     RIGHT   362.0   48.0      4          1         1    12         2
                                                           2         1    6          2
                                                           3         1    7          2
                                                           4         1    8          2
     5     3    B     LEFT    362.0   90.0     10          1         1    18         1
                                                           2         1    19         1
                                                           3         2    4 5        3 3
                                                           4         1    24         1
                                                           5         1    26         1
                                                           6         1    22         3
                                                           7         1    21         3
                                                           8         1    25         1
                                                           9         1    20         3
                                                          10         1    23         3

** # of interfering panels
7:   24 26 22 21 25 20 23
```

S1-3



S1-3: Shewchuk (2008)

** Nzones
2

**zone left edge X coordinate
1 6.0
2 206.5

** NStacks
4

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	4	1	1	7	2
							2	1	11	1
							3	1	12	1
							4	1	1	3
2	2	A	RIGHT	348.2	57.3	5	1	1	8	2
							2	1	9	2
							3	1	10	2
							4	1	5	2
							5	2	13 6	2 2
3	2	B	LEFT	348.2	99.3	2	1	2	2 23	3 3
							2	1	24	1
4	2	B	LEFT	348.2	99.3	9	1	1	3	3
							2	1	4	3
							3	1	14	2
							4	1	15	1
							5	1	21	1
							6	1	18	3
							7	2	19 16	3 1
							8	2	20 17	3 3
							9	1	22	1

** # of interfering panels
9: 14 15 21 18 19 16 20 17 22

S1-3: Proposed algorithm

** Nzones
3

**zone left edge X coordinate

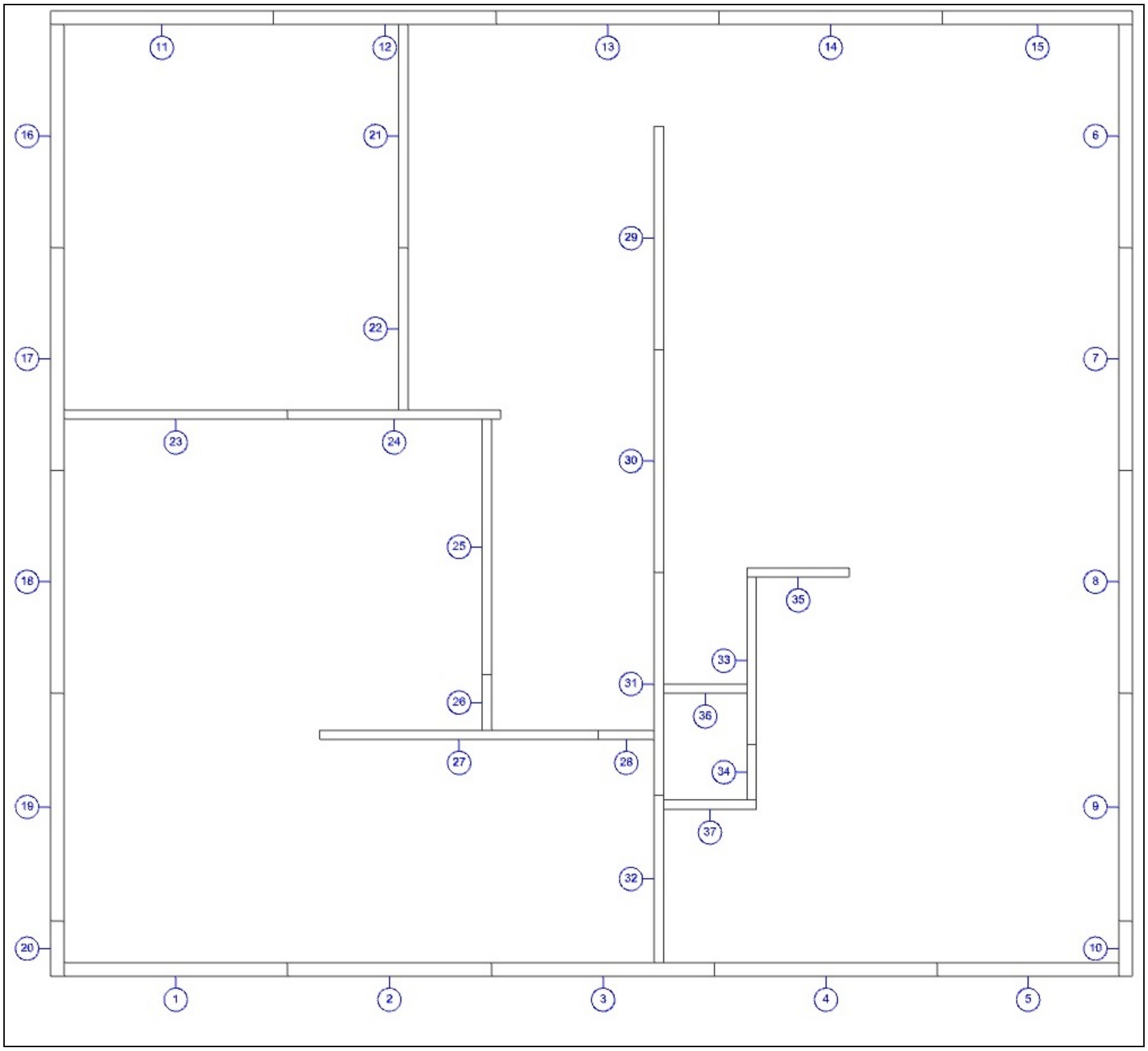
1	6.0
2	203.5
3	249.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	4	1	1	7	2
							2	1	11	1
							3	1	12	1
							4	1	1	3
2	2	A	RIGHT	336.7	57.3	3	1	1	8	2
							2	1	9	2
							3	2	14 13	2 1
3	2	B	LEFT	336.7	99.3	3	1	1	2	3
							2	1	3	3
							3	2	23 24	3 1
4	3	A	RIGHT	359.8	57.3	3	1	1	10	2
							2	1	5	2
							3	1	6	2
5	3	B	LEFT	359.8	99.3	9	1	1	15	1
							2	1	4	3
							3	1	16	1
							4	1	21	1
							5	1	22	1
							6	1	17	3
							7	1	20	3
							8	1	19	3
							9	1	18	3

** # of interfering panels
7: 16 21 22 17 20 19 18

S2-1



11
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22
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18
8
35
33
31
36
26
27
28
34
19
9
37
32
20
10
1
2
3
4
5

S2-1: Shewchuk (2008)
** Nzones: 2
** NStacks: 3

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	1	11	2
							2	1	12	2
							3	1	16	1
							4	1	17	1
							5	1	18	1
							6	2	20 19	1 1
							7	1	21	1
							8	1	22	1
							9	1	23	2
							10	1	24	2
							11	1	1	3
2	2	A	RIGHT	341.0	48.0	8	1	1	13	2
							2	1	14	2
							3	1	15	2
							4	1	6	2
							5	1	7	2
							6	1	8	2
							7	2	10 9	2 2
							8	1	29	2
3	2	B	LEFT	341.0	90.0	10	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	5	3
							5	2	25 26	1 1
							6	2	30 35	1 2
							7	2	27 28	3 3
							8	2	31 36	1 3
							9	2	33 32	1 1
							10	2	34 37	1 3

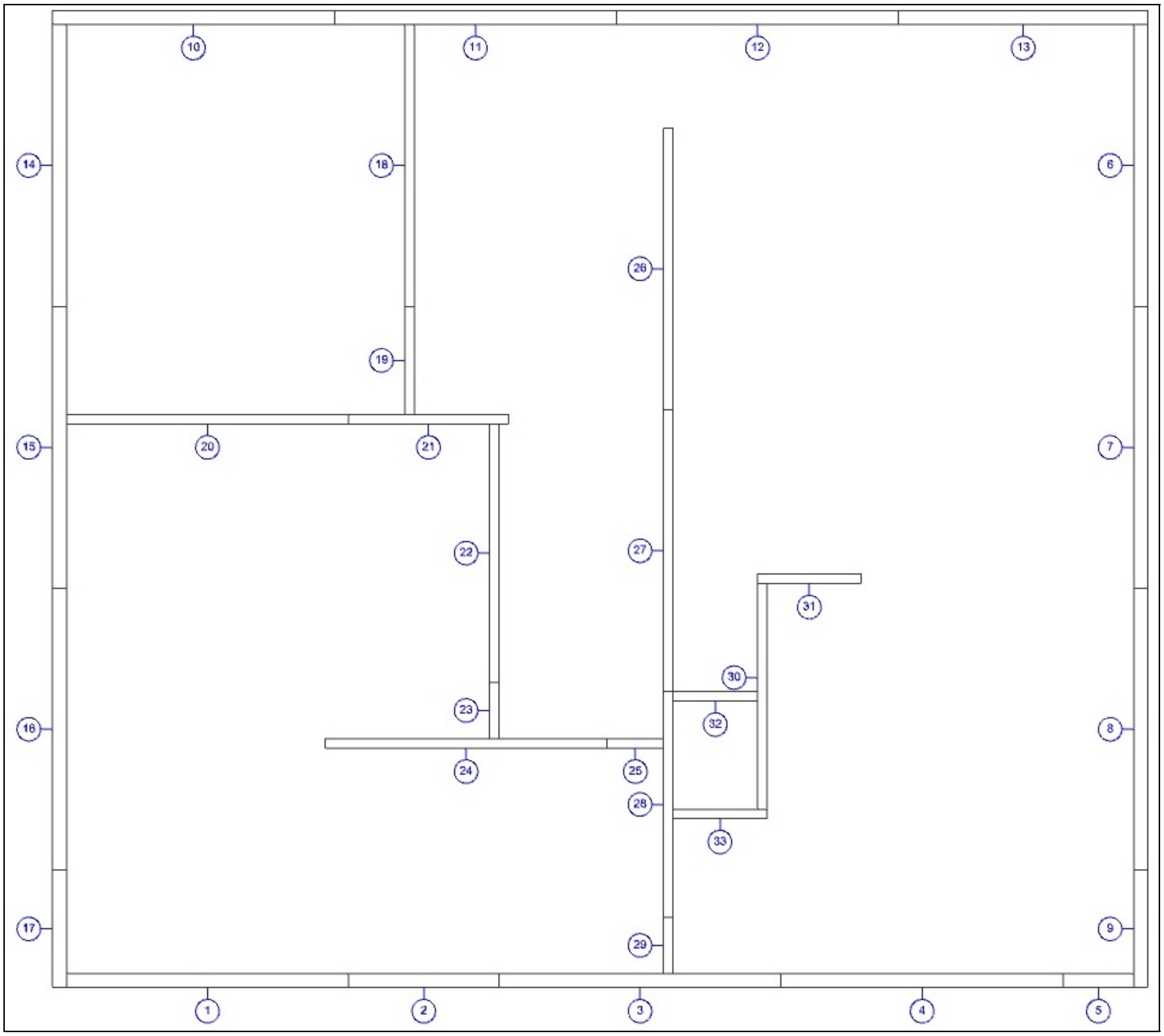
** # of interfering panels
12: 25 26 30 35 27 28 31 36 33 32 34 37

S2-1: Proposed algorithm
** Nzones: 3
** NStacks: 5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	1	11	2
							2	1	12	2
							3	1	16	1
							4	1	17	1
							5	1	18	1
							6	2	20 19	1 1
							7	1	21	1
							8	1	22	1
							9	1	23	2
							10	1	24	2
							11	1	1	3
2	2	A	RIGHT	330.0	48.0	2	1	1	13	2
							2	1	14	2
3	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	2	25 26	1 1
4	3	A	RIGHT	352.0	48.0	6	1	1	15	2
							2	1	6	2
							3	1	7	2
							4	1	8	2
							5	2	10 9	2 2
							6	1	29	2
5	3	B	LEFT	352.0	90.0	10	1	1	27 28	3 3
							2	1	30	1
							3	1	5	3
							4	1	37	3
							5	1	34	1
							6	1	32	1
							7	1	33	1
							8	1	36	3
							9	1	31	1
							10	1	35	2

** # of interfering panels
7: 37 34 32 33 36 31 35

S2-2



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21
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31
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16
23
32
8
24
25
28
33
17
29
9
1
2
3
4
5

S2-2: Shewchuk (2008)
** Nzones: 2
** NStacks: 4

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	8	1	1	10	2
							2	1	14	1
							3	1	15	1
							4	1	16	1
							5	1	17	1
							6	1	20	2
							7	1	21	2
							8	1	1	3
2	2	A	RIGHT	341.0	48.0	10	1	1	11	2
							2	1	12	2
							3	1	13	2
							4	1	6	2
							5	1	7	2
							6	1	8	2
							7	1	9	2
							8	1	18	2
							9	1	19	2
							10	1	26	2
3	2	B	LEFT	341.0	90.0	11	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	5	3
							5	2	22 23	1 1
							6	1	27	1
							7	1	31	2
							8	2	24 25	3 3
							9	2	28 32	1 3
							10	2	30 33	1 3
							11	1	29	1

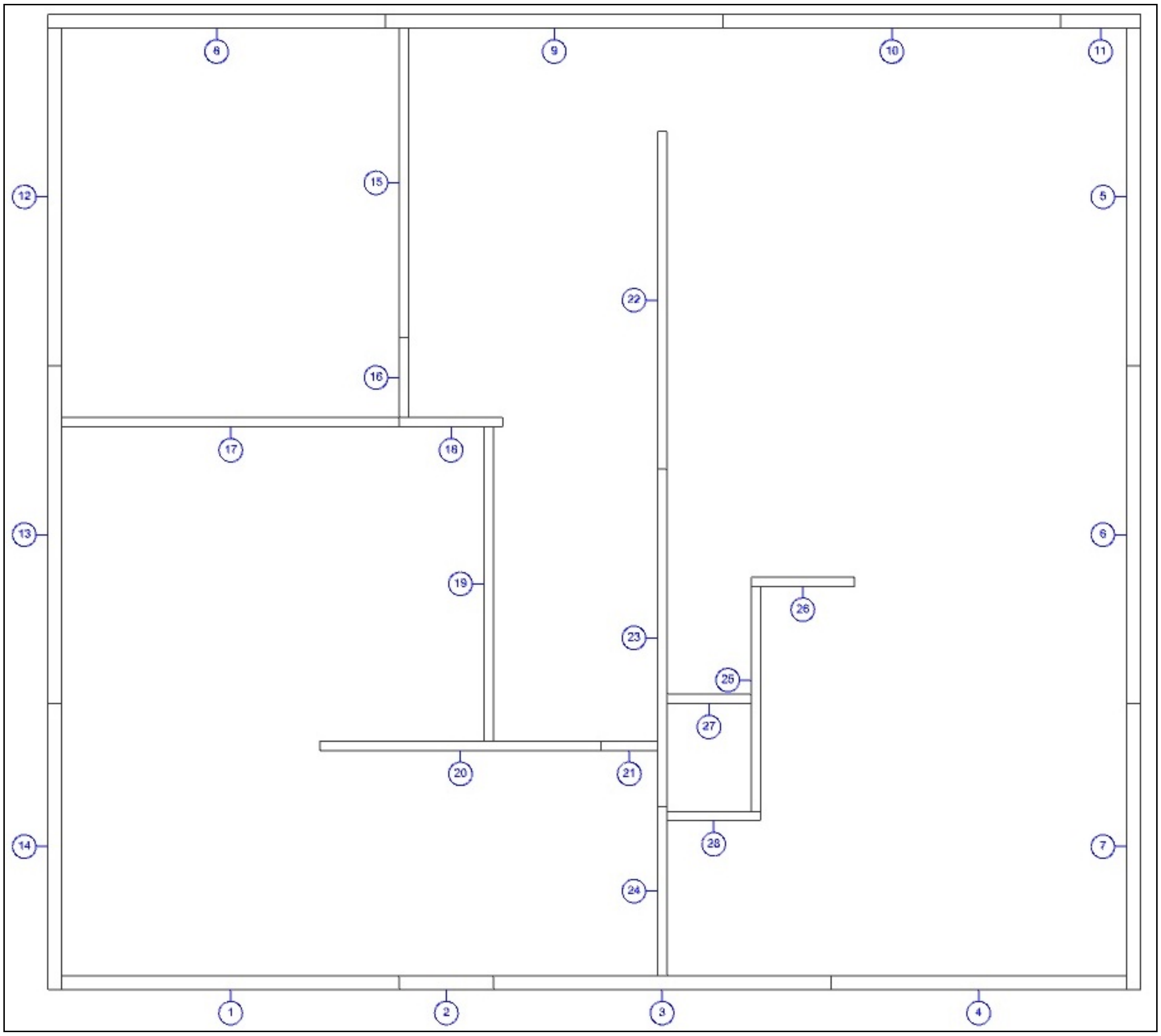
** # of interfering panels
11: 22 23 27 31 24 25 28 32 30 33 29

S2-2: Proposed algorithm
** Nzones: 3
** NStacks: 5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	8	1	1	10	2
							2	1	14	1
							3	1	15	1
							4	1	16	1
							5	1	17	1
							6	1	20	2
							7	1	21	2
							8	1	1	3
2	2	A	RIGHT	330.0	48.0	4	1	1	11	2
							2	1	12	2
							3	1	18	1
							4	1	19	1
3	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	2	22 23	1 1
4	3	A	RIGHT	352.0	48.0	6	1	1	13	2
							2	1	6	2
							3	1	7	2
							4	1	8	2
							5	1	9	2
							6	1	26	2
5	3	B	LEFT	352.0	90.0	9	1	1	24 25	3 3
							2	1	27	1
							3	1	5	3
							4	1	29	1
							5	1	33	3
							6	1	30	1
							7	1	32	3
							8	1	28	1
							9	1	31	2

** # of interfering panels
6: 29 33 30 32 28 31

S2-3

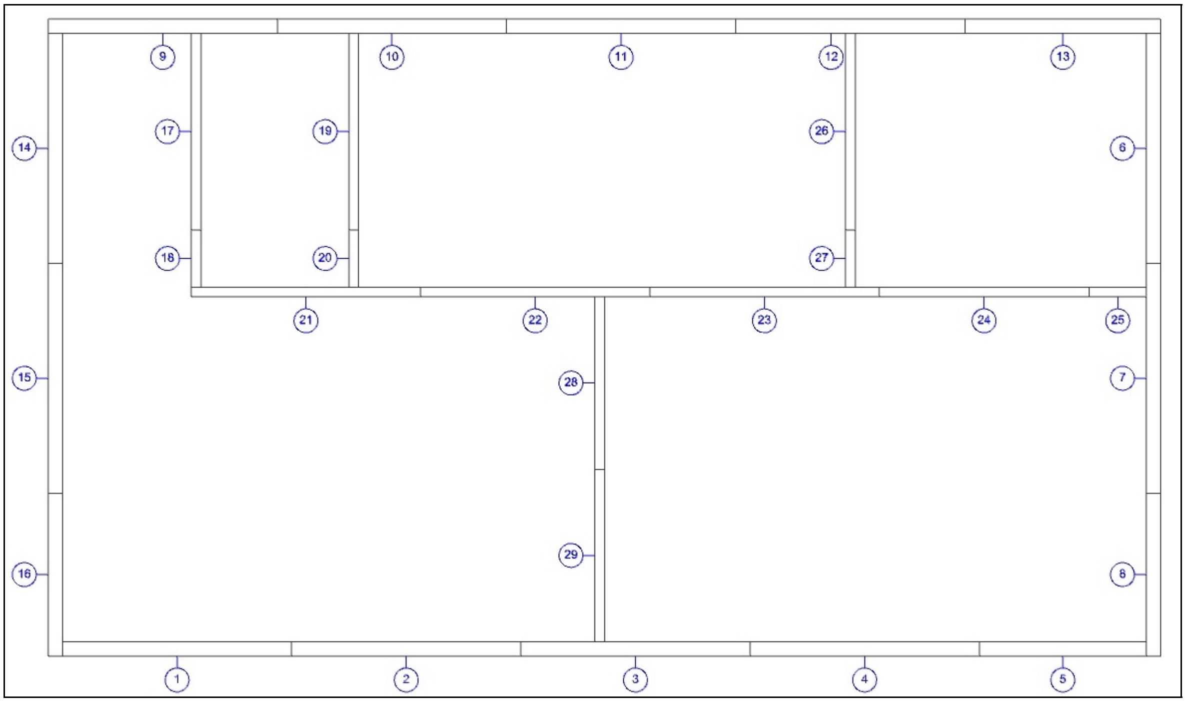


```
S2-3: Shewchuk (2008)
** Nzones: 2
**zone      left edge X coordinate
 1           6.0
 2         226.5
** NStacks: 3
** stack              flush
**   #    zone type   edge    xloc   yloc  #layers  j  #panels  panels    orientation
     1     1    A     RIGHT   116.2  57.3     7        1     1    8          2
                                                       2     1    12         1
                                                       3     1    13         1
                                                       4     1    14         1
                                                       5     1    17         2
                                                       6     1    18         2
                                                       7     1    1          3
     2     2    A     RIGHT   343.2  57.3     8        1     1    9          2
                                                       2     1    10         2
                                                       3     1    11         2
                                                       4     1    5          2
                                                       5     1    6          2
                                                       6     1    7          2
                                                       7     1    15         2
                                                       8     1    16         2
     3     2    B     LEFT    343.2  99.3     3        1     1    2          3
                                                       2     1    3          3
                                                       3     1    4          3
                                                       4     1    19         1
                                                       5     1    22         1
                                                       6     2    20 21      3 3
                                                       7     1    23         1
                                                       8     2    26 27      3 3
                                                       9     1    24         1
                                                      10     2    25 28      1 3

** # of interfering panels
10: 19 22 20 21 23 26 27 24 25 28
```

```
S2-3: Proposed algorithm
** Nzones: 3
**zone      left edge X coordinate
 1           6.0
 2         214.5
 3         239.5
** NStacks: 5
** stack              flush
**   #    zone type   edge    xloc   yloc  #layers  j  #panels  panels    orientation
     1     1    A     RIGHT   116.2  57.3     7        1     1    8          2
                                                       2     1    12         1
                                                       3     1    13         1
                                                       4     1    14         1
                                                       5     1    17         2
                                                       6     1    18         2
                                                       7     1    1          3
     2     2    A     RIGHT   336.7  57.3     4        1     1    9          2
                                                       2     1    10         2
                                                       3     1    15         1
                                                       4     1    16         1
     3     2    B     LEFT    336.7  99.3     3        1     1    2          3
                                                       2     1    3          3
                                                       3     1    19         1
     4     3    A     RIGHT   349.8  57.3     4        1     1    11         2
                                                       2     1    5          2
                                                       3     1    6          2
                                                       4     1    7          2
     5     3    B     LEFT    349.8  99.3     9        1     1    20 21      3 3
                                                       2     1    22         1
                                                       3     1    4          3
                                                       4     1    28         3
                                                       5     1    25         1
                                                       6     1    24         1
                                                       7     1    27         3
                                                       8     1    26         3
                                                       9     1    23         1
** # of interfering panels
6: 28 25 24 27 26 23
```

S3-1

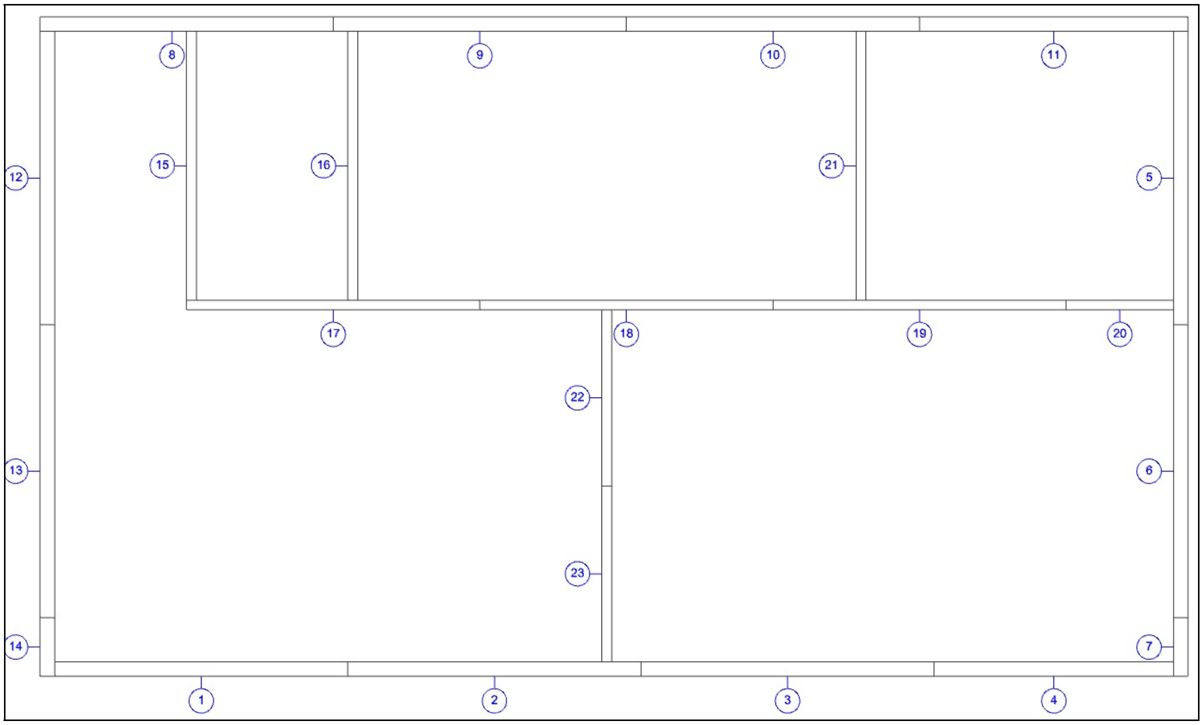


```
S3-1: Shewchuk (2008)
** Nzones: 2
**zone      left edge X coordinate
 1           6.0
 2         222.0
** NStacks: 4

** stack                flush
**   #    zone type     edge     xloc    yloc   #layers   j   #panels   panels       orientation
     1     1     A      RIGHT   114.0    48.0       6         1        1      9              2
                                                              2        1      10             2
                                                              3        1      14             1
                                                              4        1      15             1
                                                              5        1      16             1
                                                              6        1      1              3
     2     2     A      RIGHT   343.0    48.0       6         1        1      11             2
                                                              2        1      12             2
                                                              3        1      13             2
                                                              4        1      6              2
                                                              5        1      7              2
                                                              6        1      8              2
     3     2     B      LEFT    343.0    90.0       5         1        1      2              3
                                                              2        1      17             1
                                                              3        3      19 18 20       1 1 1
                                                              4        1      21             3
                                                              5        2      26 27          1 1
     4     2     B      LEFT    343.0    90.0       7         1        1      3              3
                                                              2        1      4              3
                                                              3        1      22             3
                                                              4        1      23             3
                                                              5        2      24 25          3 3
                                                              6        2      28 29          1 1
                                                              7        1      5              3
** # of interfering panels
6: 22 23 24 25 28 29
```

```
S3-1: Proposed algorithm
** Nzones
3
**zone      left edge X coordinate
 1           6.0
 2         210.0
 3         258.0
** NStacks
5
** stack                flush
**   #    zone type     edge     xloc    yloc   #layers   j   #panels   panels       orientation
     1     1     A      RIGHT   114.0    48.0       6         1        1      9              2
                                                              2        1      10             2
                                                              3        1      14             1
                                                              4        1      15             1
                                                              5        1      16             1
                                                              6        1      1              3
     2     2     A      RIGHT   330.0    48.0       2         1        1      11             2
                                                              2        1      12             2
     3     2     B      LEFT    330.0    90.0       6         1        1      2              3
                                                              2        1      3              3
                                                              3        1      4              3
                                                              4        1      17             1
                                                              5        3      19 18 20       1 1 1
                                                              6        1      21             3
     4     3     A      RIGHT   356.0    48.0       4         1        1      13             2
                                                              2        1      6              2
                                                              3        1      7              2
                                                              4        1      8              2
     5     3     B      LEFT    356.0    90.0       7         1        2      28 29          1 1
                                                              2        1      26 27     1 1
                                                              3        1      5              3
                                                              4        1      25             3
                                                              5        1      24             3
                                                              6        1      23             3
                                                              7        1      22             3
** # of interfering panels
4: 25 24 23 22
```

S3-2



S3-2: Shewchuk (2008)

** Nzones

2

**zone	left edge X coordinate
1	6.0
2	222.0

** NStacks

4

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	4	1	1	8	2
							2	1	12	1
							3	2	14 13	1 1
							4	1	1	3
2	2	A	RIGHT	343.0	48.0	5	1	1	9	2
							2	1	10	2
							3	1	11	2
							4	1	5	2
							5	2	7 6	2 2
3	2	B	LEFT	343.0	90.0	4	1	1	15	1
							2	1	16	1
							3	1	17	3
							4	1	21	1
4	2	B	LEFT	343.0	90.0	7	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	18	3
							5	1	19	3
							6	2	20 22	3 1
							7	1	23	1

** # of interfering panels

5: 18 19 20 22 23

S3-2: Proposed algorithm

** Nzones

3

**zone	left edge X coordinate
1	6.0
2	209.0
3	248.0

** NStacks

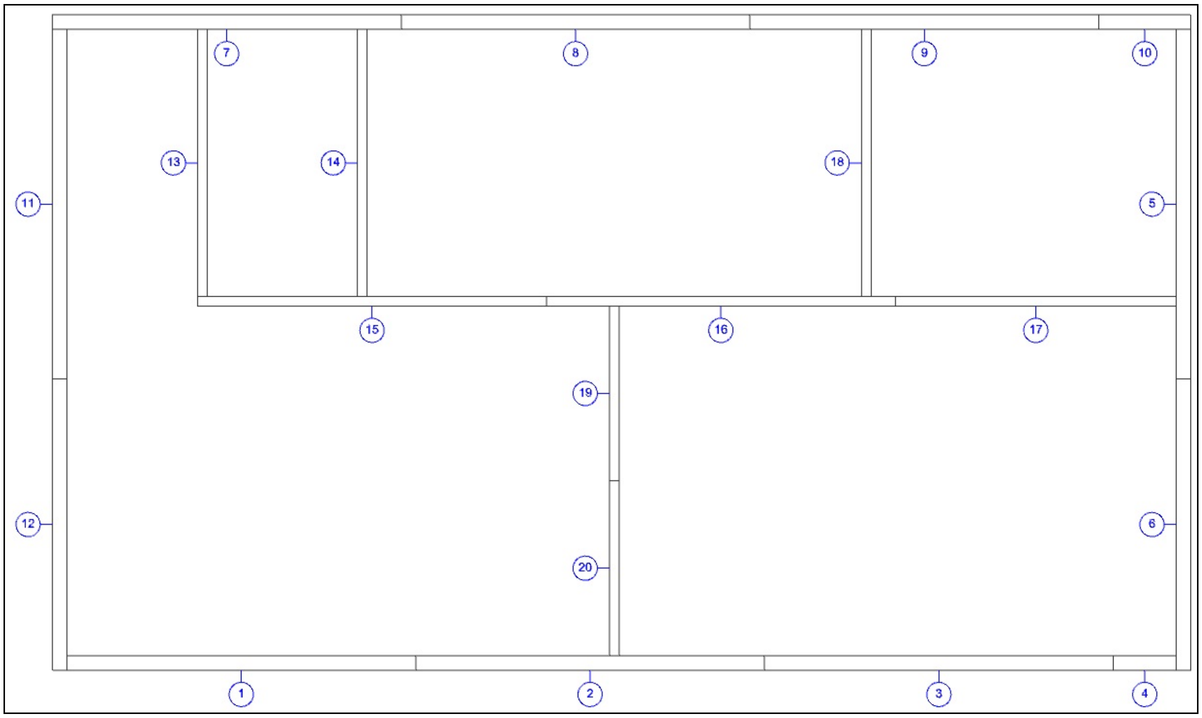
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	4	1	1	8	2
							2	1	12	1
							3	2	14 13	1 1
							4	1	1	3
2	2	A	RIGHT	330.0	48.0	2	1	1	9	2
							2	1	10	2
3	2	B	LEFT	330.0	90.0	5	1	1	2	3
							2	1	3	3
							3	1	15	1
							4	1	16	1
							5	1	17	3
4	3	A	RIGHT	356.0	48.0	3	1	1	11	2
							2	1	5	2
							3	2	7 6	2 2
5	3	B	LEFT	356.0	90.0	6	1	2	22 23	1 1
							2	1	21	1
							3	1	4	3
							4	1	20	3
							5	1	19	3
							6	1	18	3

** # of interfering panels

3: 20 19 18

S3-3



```
S3-3: Shewchuk (2008)
** Nzones
2

**zone    left edge X coordinate
 1          6.0
 2        226.5

** NStacks
4

** stack              flush
**   #   zone type    edge     xloc   yloc  #layers  j  #panels  panels     orientation
     1     1    A     RIGHT   116.2   57.3     4         1        1     7           2
                                                         2        1     11          1
                                                         3        1     12          1
                                                         4        1     1           3
     2     2    A     RIGHT   345.2   57.3     5         1        1     8           2
                                                         2        1     9           2
                                                         3        1     10          2
                                                         4        1     5           2
                                                         5        1     6           2
     3     2    B     LEFT    345.2   99.3     5         1        1     13          1
                                                         2        1     14          1
                                                         3        1     15          3
                                                         4        1     18          1
                                                         5        1     16          3
     4     2    B     LEFT    345.2   99.3     5         1        1     2           3
                                                         2        1     3           3
                                                         3        1     4           3
                                                         4        1     17          3
                                                         5        2     19 20       1 1

** # of interfering panels
3:   17 19 20
```

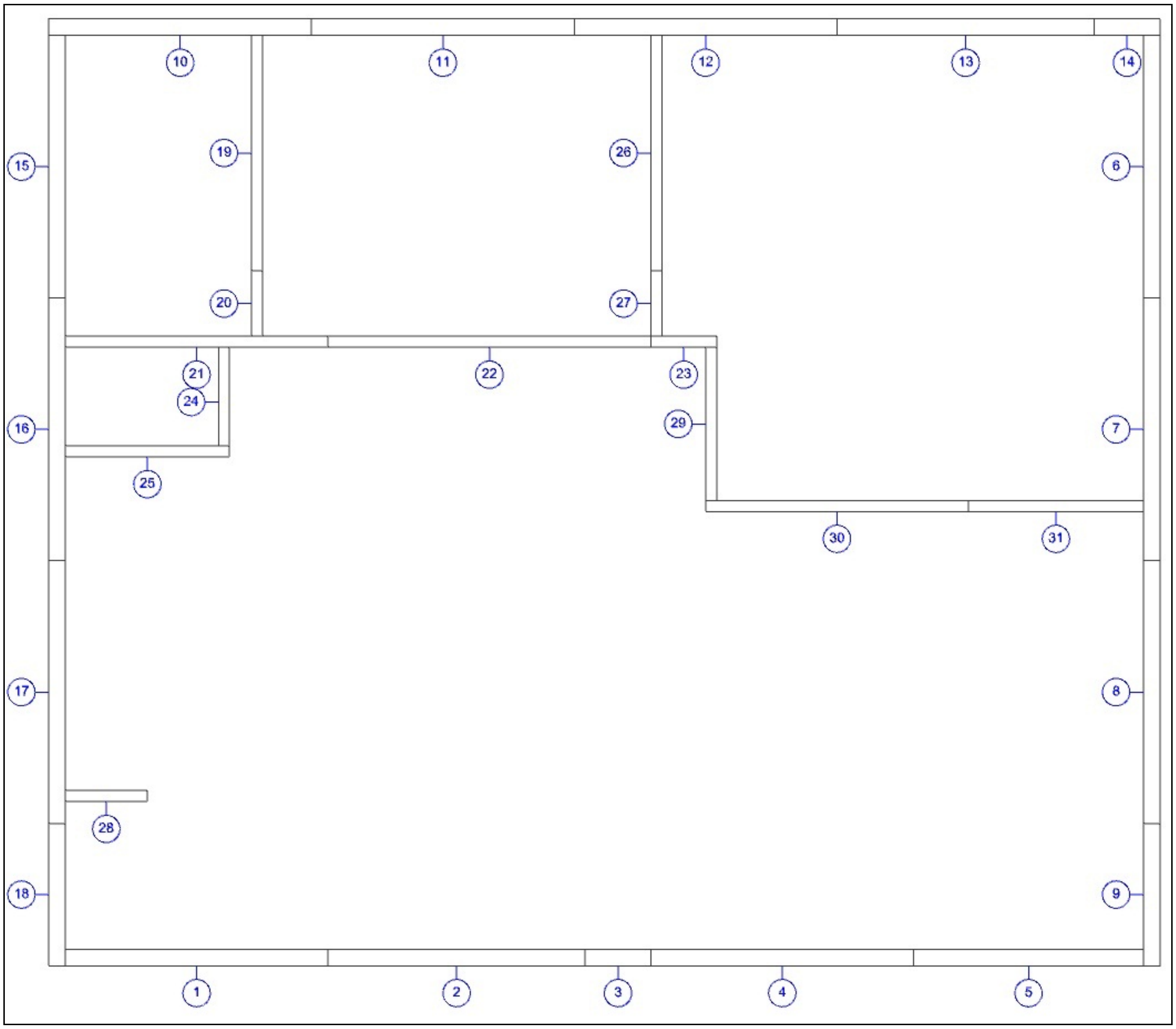
```
S3-3: Proposed algorithm
** Nzones
3

**zone    left edge X coordinate
 1          6.0
 2        212.5
 3        243.5

** NStacks
5

** stack              flush
**   #   zone type    edge     xloc   yloc  #layers  j  #panels  panels     orientation
     1     1    A     RIGHT   116.2   57.3     4         1        1     7           2
                                                         2        1     11          1
                                                         3        1     12          1
                                                         4        1     1           3
     2     2    A     RIGHT   336.7   57.3     2         1        1     8           2
                                                         2        1     9           2
     3     2    B     LEFT    336.7   99.3     5         1        1     2           3
                                                         2        1     3           3
                                                         3        1     13          1
                                                         4        1     14          1
                                                         5        1     15          3
     4     3    A     RIGHT   353.8   57.3     3         1        1     10          2
                                                         2        1     5           2
                                                         3        1     6           2
     5     3    B     LEFT    353.8   99.3     5         1        2     19 20       1 1
                                                         2        1     18          1
                                                         3        1     4           3
                                                         4        1     17          3
                                                         5        1     16          3
** # of interfering panels
2: 17 16
```

S4-1


10
11
12
13
14
15
19
26
6
20
27
21
22
23
24
16
29
7
25
30
31
17
8
28
18
9
1
2
3
4
5

```
S4-1: Shewchuk (2008)
** Nzones
1

**zone      left edge X coordinate
  1           6.0

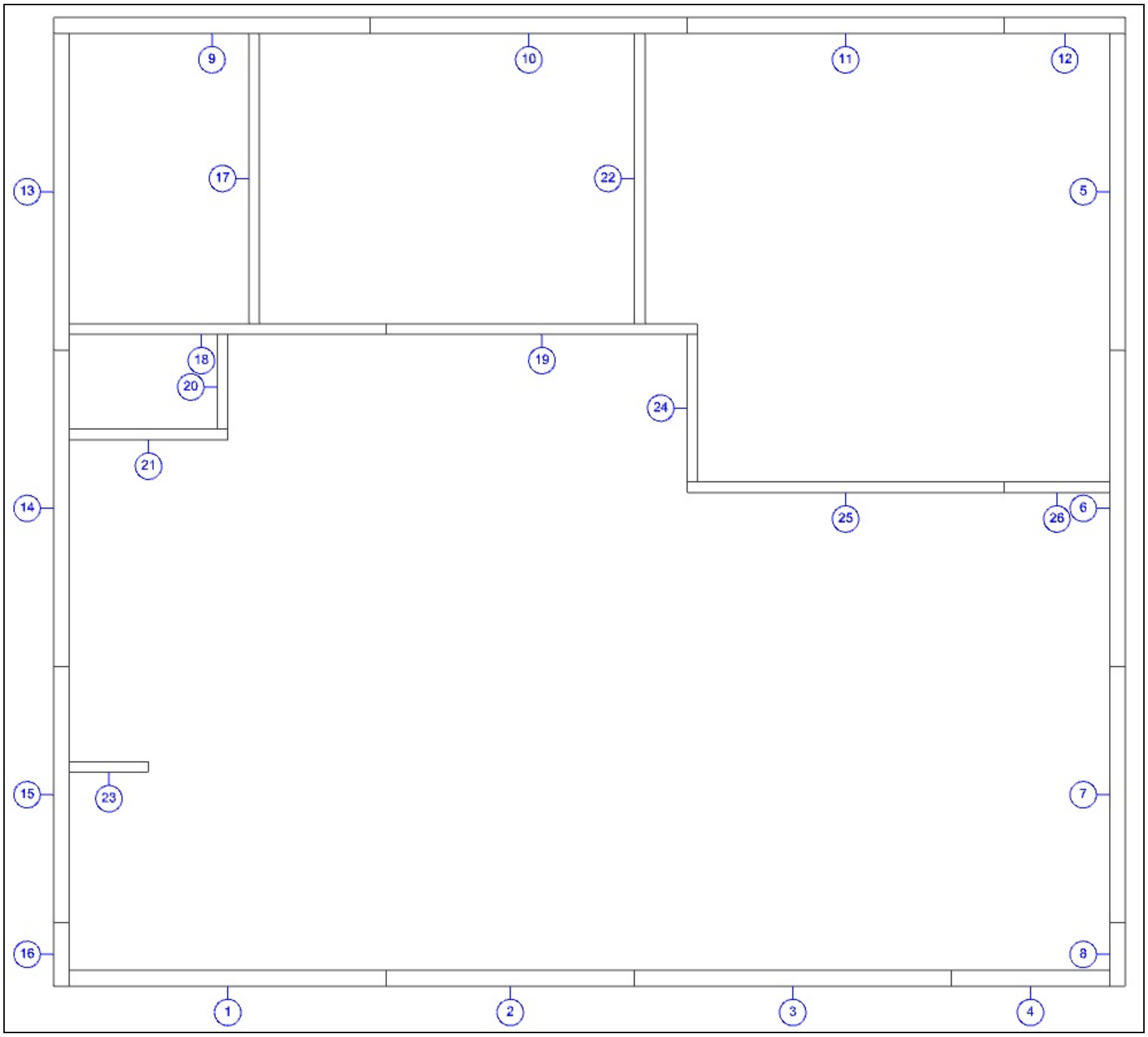
** NStacks
2

** stack                flush
**    #    zone type    edge    xloc   yloc   #layers  j   #panels   panels      orientation
      1     1     A     RIGHT   203.0 106.5      9         1      1     10             2
                                                           2      1     11             2
                                                           3      1     12             2
                                                           4      2     14 13          2 2
                                                           5      1     6              2
                                                           6      1     15             2
                                                           7      1     16             2
                                                           8      1     17             2
                                                           9      2     19 18          2 2
      2     1     B     RIGHT   203.0 106.5     13         1      3     27 20 26       1 1 1
                                                           2      1     21             2
                                                           3      2     23 22          2 2
                                                           4      1     7              1
                                                           5      1     8              1
                                                           6      1     1              3
                                                           7      2     2 3            3 3
                                                           8      1     4              3
                                                           9      1     5              3
                                                          10      2     9 24           1 1
                                                          11      2     25 29          3 1
                                                          12      1     30             3
                                                          13      2     31 28          3 3

** # of interfering panels
7: 9 24 25 29 30 31 28
```

```
S4-1: Proposed algorithm
** Nzones
2
**zone      left edge X coordinate
  1           6.0
  2         184.0
** NStacks
3
** stack                flush
**    #    zone type    edge    xloc   yloc   #layers  j   #panels   panels      orientation
      1     1     A     RIGHT   114.0   48.0     9         1      1     10             2
                                                           2      1     11             2
                                                           3      1     15             1
                                                           4      1     16             1
                                                           5      1     17             1
                                                           6      2     19 18          1 1
                                                           7      2     21 20          2 1
                                                           8      1     22             2
                                                           9      1     1              3
      2     2     A     RIGHT   292.0   48.0     7         1      1     12             2
                                                           2      2     14 13          2 2
                                                           3      1     6              2
                                                           4      1     7              2
                                                           5      1     8              2
                                                           6      2     26 9           2 2
                                                           7      2     23 27          2 2
      3     2     B     LEFT    292.0   90.0     7         1      3     24 25 28       1 2 3
                                                           2      1     29             1
                                                           3      2     2 3            3 3
                                                           4      1     4              3
                                                           5      1     5              3
                                                           6      1     31             3
                                                           7      1     30             2
** # of interfering panels
2: 31 30
```

S4-2



S4-2: Shewchuk (2008)
** Nzones
1

**zone left edge X coordinate
1 6.0

** NStacks
2

** stack				flush							
**	#	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
	1	1	A	RIGHT	203.0	106.5	8	1	1	9	2
								2	1	10	2
								3	1	11	2
								4	1	12	2
								5	1	5	2
								6	1	13	2
								7	1	14	2
								8	2	16 15	2 2
	2	1	B	RIGHT	203.0	106.5	14	1	1	17	1
								2	1	22	1
								3	1	18	2
								4	1	19	2
								5	1	6	1
								6	2	7 8	1 1
								7	1	1	3
								8	1	2	3
								9	1	3	3
								10	1	4	3
								11	2	20 21	1 2
								12	1	24	1
								13	1	25	2
								14	2	26 23	2 3

** # of interfering panels
6: 20 21 24 25 26 23

S4-2: Proposed algorithm
** Nzones
2

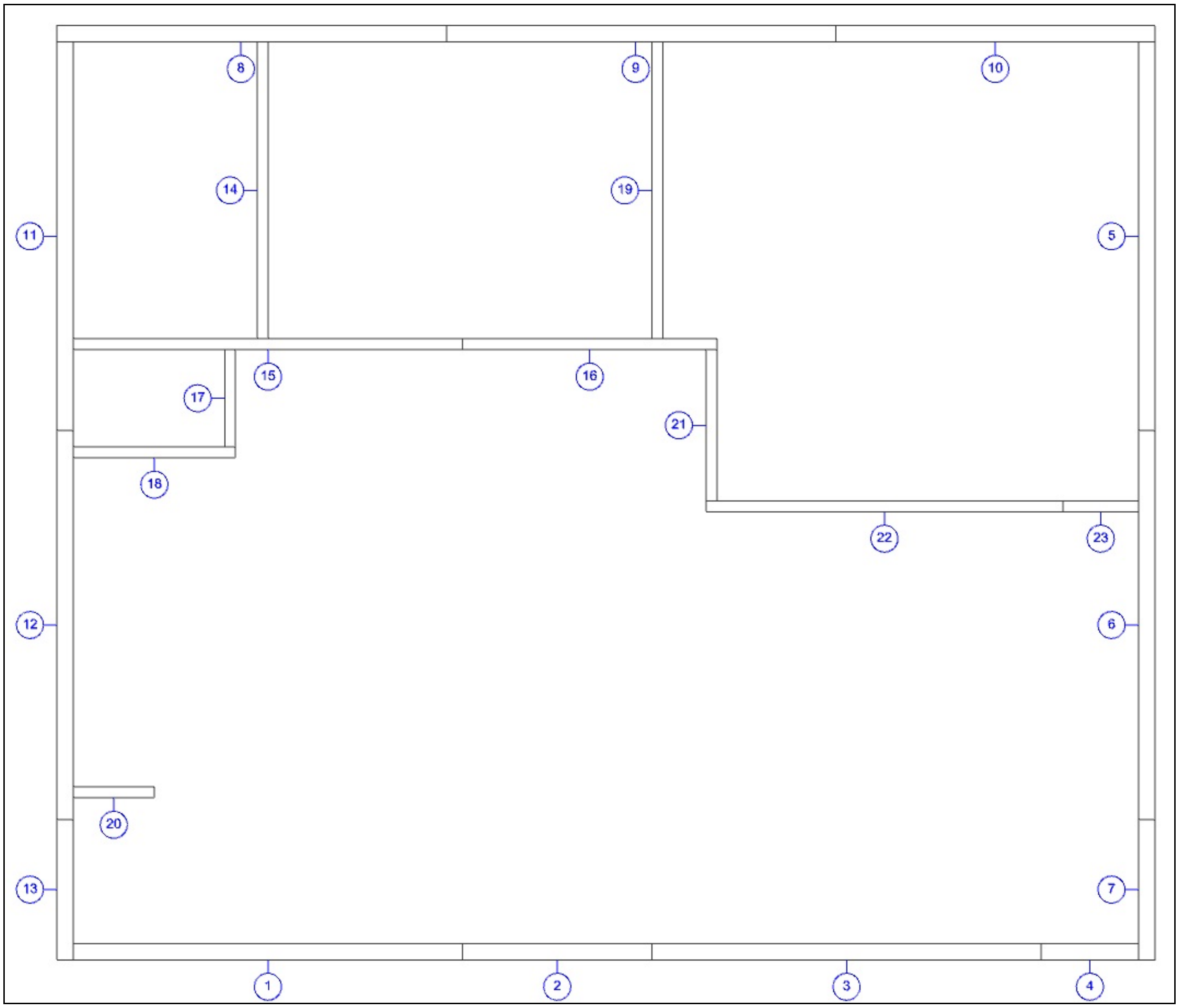
**zone left edge X coordinate
1 6.0
2 184.0

** NStacks
3

** stack				flush							
**	#	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
	1	1	A	RIGHT	114.0	48.0	7	1	1	9	2
								2	1	13	1
								3	1	14	1
								4	2	16 15	1 1
								5	1	17	1
								6	1	18	2
								7	1	1	3
	2	2	A	RIGHT	292.0	48.0	8	1	1	10	2
								2	1	11	2
								3	1	12	2
								4	1	5	2
								5	1	6	2
								6	2	8 7	2 2
								7	1	22	2
								8	1	19	2
	3	2	B	LEFT	292.0	90.0	7	1	3	20 21 23	1 2 3
								2	1	24	1
								3	1	2	3
								4	1	3	3
								5	1	4	3
								6	1	26	2
								7	1	25	2

** # of interfering panels
2: 26 25

S4-3



S4-3: Shewchuk (2008)
** Nzones
1

**zone	left edge X coordinate
1	6.0

** NStacks
2

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	203.0	115.8	6	1	1	8	2
							2	1	9	2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
2	1	B	LEFT	203.0	115.8	14	1	1	5	1
							2	1	6	1
							3	1	7	1
							4	1	14	1
							5	1	19	1
							6	1	15	2
							7	2	16 17	2 1
							8	1	1	3
							9	1	2	3
							10	1	3	3
							11	1	4	3
							12	2	18 21	2 1
							13	1	22	2
							14	2	23 20	2 3

** # of interfering panels
5: 18 21 22 23 20

S4-3: Proposed algorithm
** Nzones
2

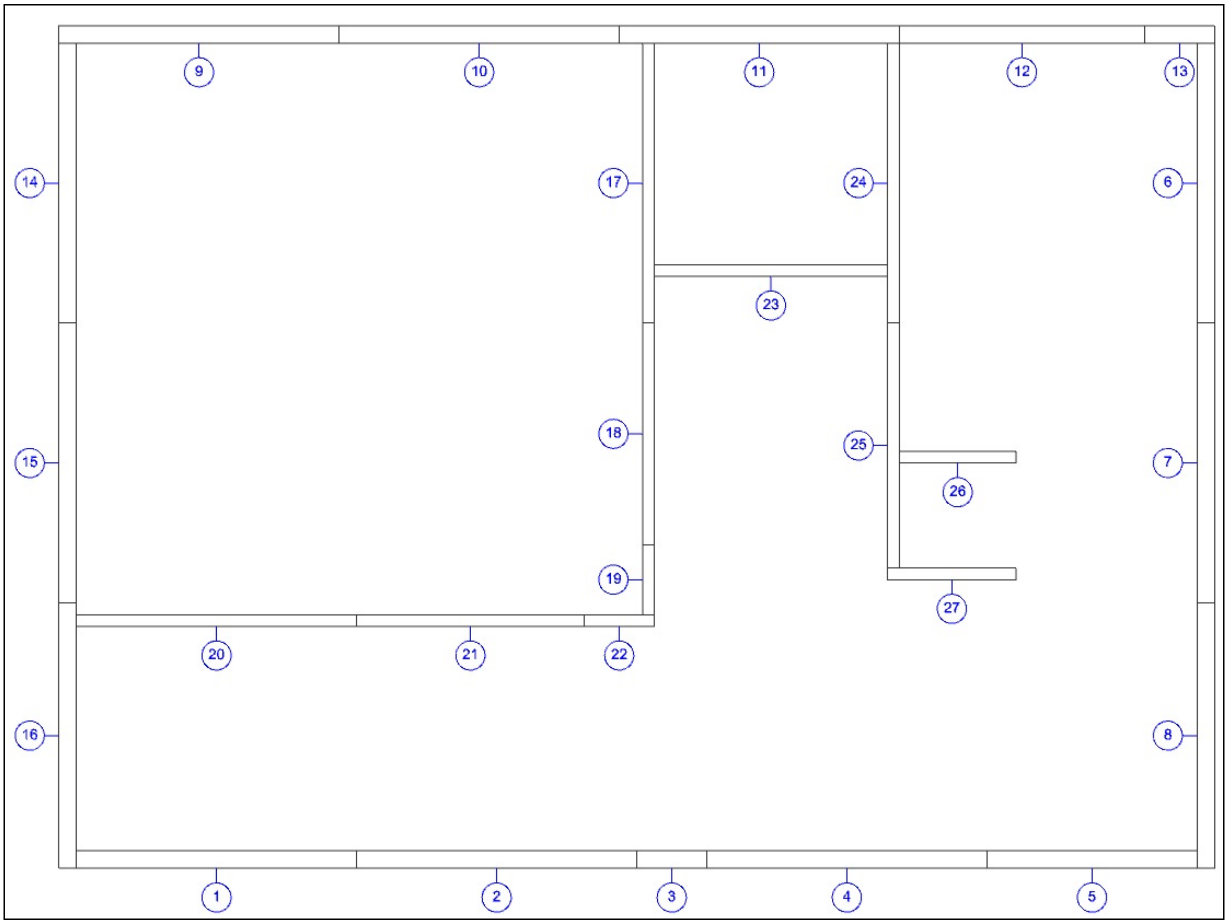
**zone	left edge X coordinate
1	6.0
2	179.5

** NStacks
3

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	5	1	1	8	2
							2	1	11	1
							3	1	12	1
							4	1	13	1
							5	1	1	3
2	2	A	RIGHT	289.8	57.3	5	1	1	9	2
							2	1	10	2
							3	1	5	2
							4	1	6	2
							5	1	7	2
3	2	B	LEFT	289.8	99.3	11	1	1	14	1
							2	1	15	2
							3	3	17 18 20	1 2 3
							4	1	19	1
							5	1	2	3
							6	1	3	3
							7	1	4	3
							8	1	23	3
							9	1	22	3
							10	1	21	1
							11	1	16	2

** # of interfering panels
4: 23 22 21 16

S5-1



```
S5-1: Shewchuk (2008)
** Nzones
1
**zone      left edge X coordinate
  1          6.0
** NStacks
2
** stack                flush
**    #    zone type    edge     xloc    yloc   #layers   j   #panels   panels        orientation
      1     1     A     RIGHT    198.0 106.5       7          1       1     9                2
                                                            2       1     10               2
                                                            3       1     11               2
                                                            4       2     13 12            2 2
                                                            5       1     14               2
                                                            6       1     15               2
                                                            7       1     16               2
      2     1     B     LEFT     198.0 106.5      14          1       1     6                1
                                                            2       1     7                1
                                                            3       1     8                1
                                                            4       1     17               1
                                                            5       1     23               2
                                                            6       1     24               1
                                                            7       2     18               1
                                                            8       1     1                3
                                                            9       2     2 3              3 3
                                                            10      1     4                3
                                                            11      1     5 19             3 1
                                                            12      2     25 26            1 2
                                                            13      2     27 20            2 2
                                                            14      2     21 22            2 2

** # of interfering panels
7: 19 25 26 27 20 21 22
```

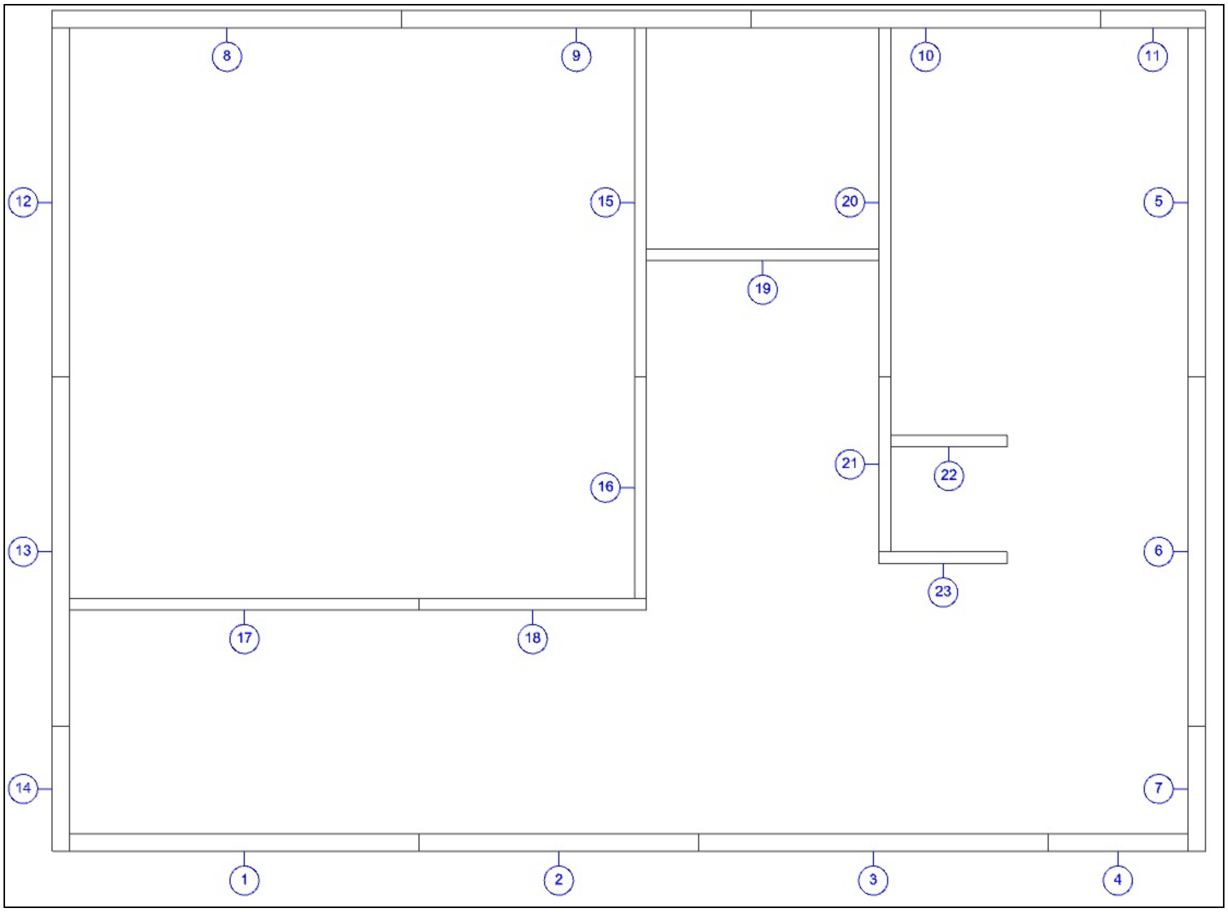
```
S5-1: Proposed algorithm
** Nzones
2

**zone      left edge X coordinate
  1          6.0
  2        174.0

** NStacks
3

** stack                flush
**    #    zone type    edge     xloc    yloc   #layers   j   #panels   panels        orientation
      1     1     A     RIGHT    114.0   48.0      6          1       1     9                2
                                                            2       1     10               2
                                                            3       1     14               1
                                                            4       1     15               1
                                                            5       1     16               1
                                                            6       1     1                3
      2     2     A     RIGHT    282.0   48.0      8          1       1     11               2
                                                            2       2     13 12            2 2
                                                            3       1     6                2
                                                            4       1     7                2
                                                            5       1     8                2
                                                            6       2     3 2              3 3
                                                            7       1     4                3
                                                            8       1     5                3
      3     2     B     LEFT     282.0   90.0     11          1       1     20               3
                                                            2       1     21               2
                                                            3       1     17               1
                                                            4       1     23               2
                                                            5       1     18               1
                                                            6       1     19               1
                                                            7       1     22               2
                                                            8       1     27               2
                                                            9       1     26               2
                                                            10      1     25               1
                                                            11      1     24               1
** # of interfering panels
4: 27 26 25 24
```

S5-2



```
S5-2: Shewchuk (2008)
** Nzones
1

**zone    left edge X coordinate
  1          6.0

** NStacks
2

** stack               flush
**   #   zone type     edge    xloc   yloc  #layers   j   #panels   panels      orientation
     1     1    A     RIGHT   198.0 106.5       7       1       1     8               2
                                                        2       1     9               2
                                                        3       1     10              2
                                                        4       1     11              2
                                                        5       1     12              2
                                                        6       1     13              2
                                                        7       1     14              2
     2     1    B     LEFT    198.0 106.5      14       1       1     5               1
                                                        2       1     6               1
                                                        3       1     7               1
                                                        4       1     15              1
                                                        5       1     19              2
                                                        6       1     20              1
                                                        7       1     1               3
                                                        8       1     2               3
                                                        9       1     3               3
                                                        10      1     4               3
                                                        11      2     16 21           1 1
                                                        12      2     22 23           2 2
                                                        13      1     17              2
                                                        14      1     18              2
** # of interfering panels
6: 16 21 22 23 17 18
```

```
S5-2: Proposed algorithm
** Nzones
2

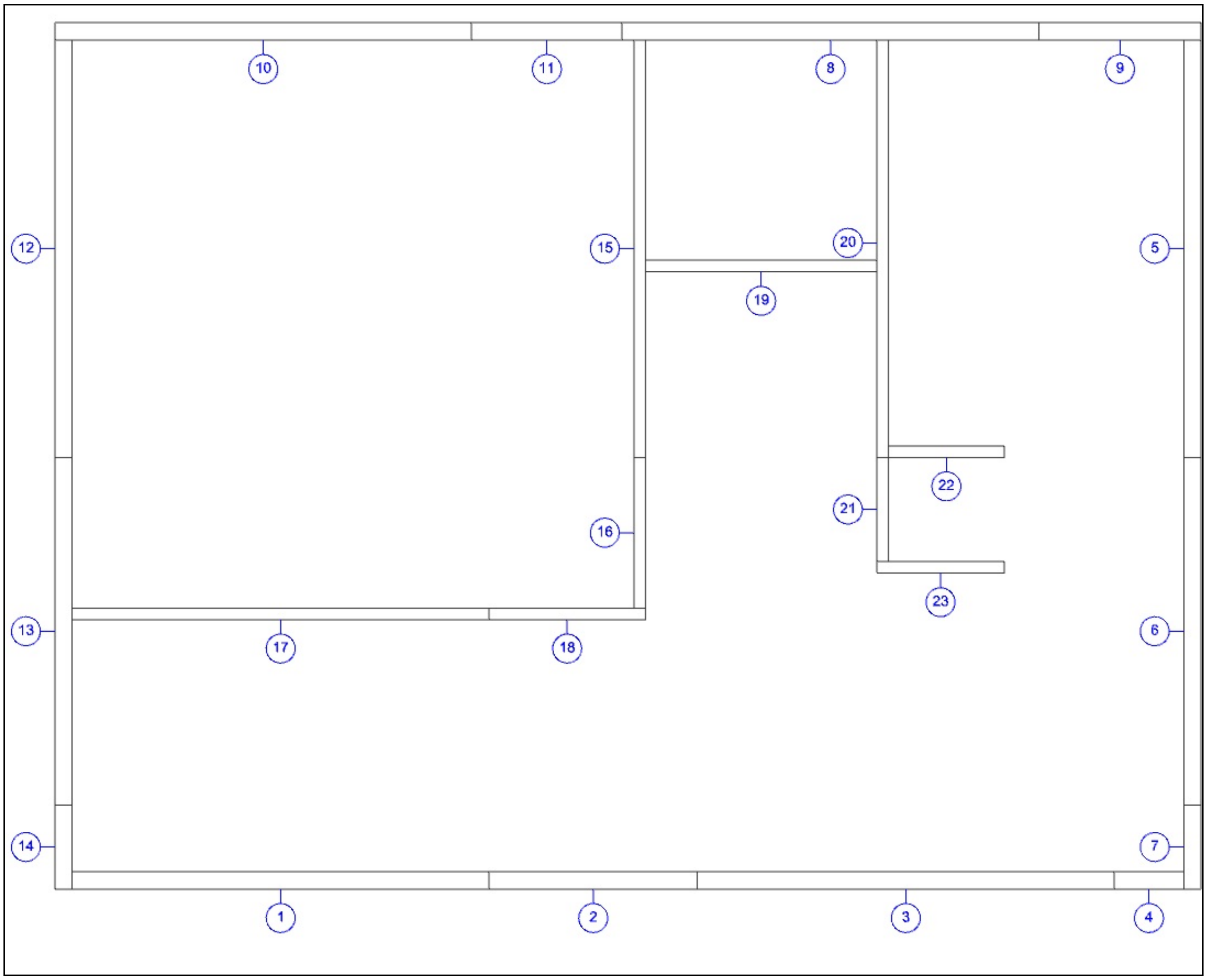
**zone    left edge X coordinate
  1          6.0
  2        176.0

** NStacks
3

** stack               flush
**   #   zone type     edge    xloc   yloc  #layers   j   #panels   panels      orientation
     1     1    A     RIGHT   114.0   48.0      5       1       1     8               2
                                                        2       1     12              1
                                                        3       1     13              1
                                                        4       1     14              1
                                                        5       1     1               3
     2     2    A     RIGHT   282.0   48.0      8       1       1     9               2
                                                        2       1     10              2
                                                        3       1     11              2
                                                        4       1     5               2
                                                        5       1     6               2
                                                        6       2     2 7             3 2
                                                        7       1     3               3
                                                        8       1     4               3
     3     2    B     LEFT    282.0   90.0      9       1       1     17              3
                                                        2       1     15              1
                                                        3       1     19              2
                                                        4       1     16              1
                                                        5       1     18              2
                                                        6       1     23              2
                                                        7       1     22              2
                                                        8       1     21              1
                                                        9       1     20              1

** # of interfering panels
4: 23 22 21 20
```

S5-3



S5-3: Shewchuk (2008)
** Nzones
1

**zone left edge X coordinate
1 6.0

** NStacks
2

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	198.0	115.8	7	1	1	10	2
							2	1	11	2
							3	1	8	2
							4	1	9	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
2	1	B	LEFT	198.0	115.8	14	1	1	5	1
							2	1	6	1
							3	1	7	1
							4	1	15	1
							5	1	19	2
							6	1	20	1
							7	1	1	3
							8	1	2	3
							9	1	3	3
							10	1	4	3
							11	3	22 16 21	2 1 1
							12	1	23	2
							13	1	17	2
							14	1	18	2

** # of interfering panels
6: 22 16 21 23 17 18

S5-3: Proposed algorithm
** Nzones
2

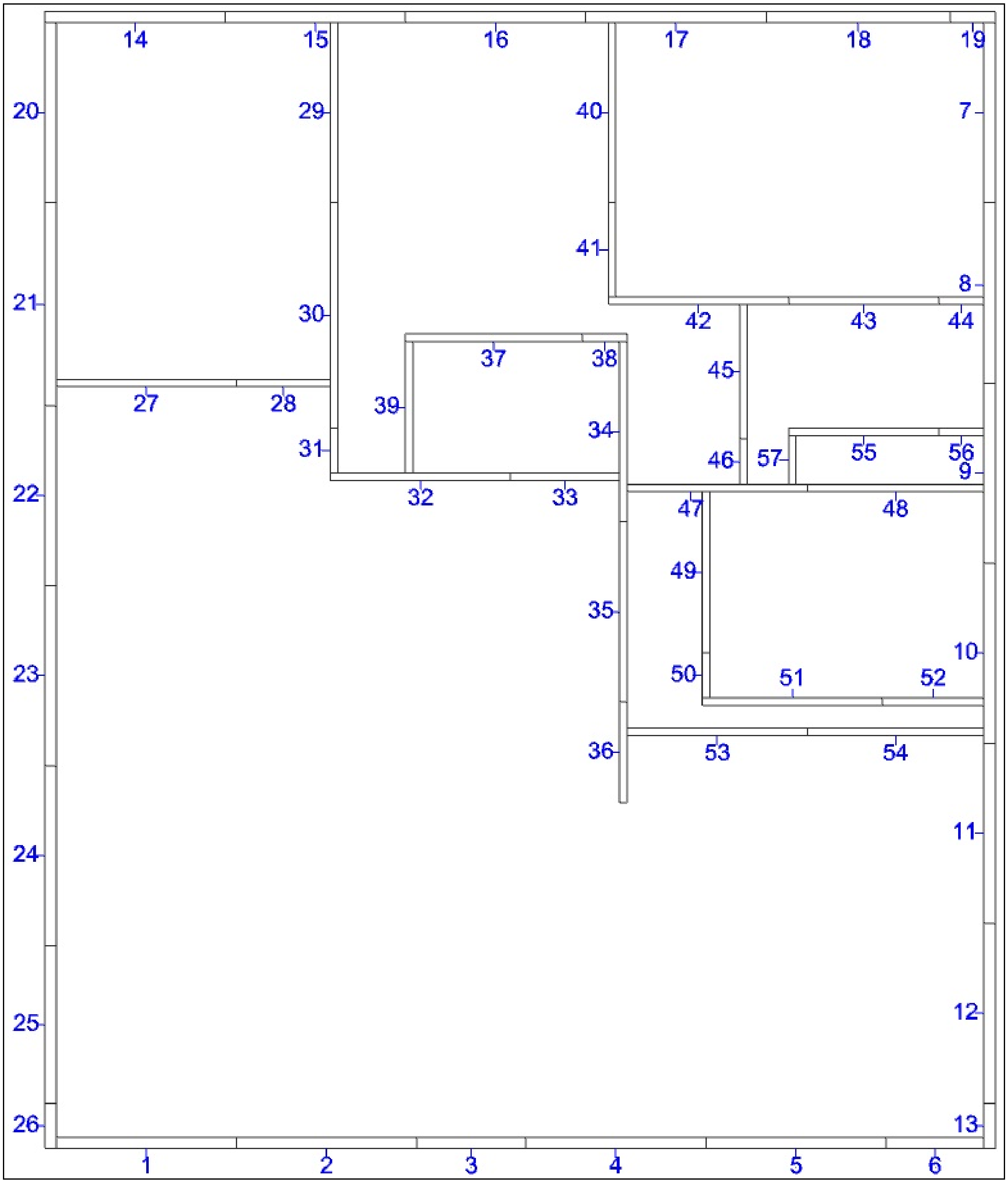
**zone left edge X coordinate
1 6.0
2 169.5

** NStacks
3

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	6	1	1	10	2
							2	1	11	2
							3	1	12	1
							4	1	13	1
							5	1	14	1
							6	1	1	3
2	2	A	RIGHT	279.8	57.3	7	1	1	8	2
							2	1	9	2
							3	1	5	2
							4	1	6	2
							5	2	2 7	3 2
							6	1	3	3
							7	1	4	3
3	2	B	LEFT	279.8	99.3	9	1	1	17	3
							2	1	15	1
							3	1	19	2
							4	1	16	1
							5	1	18	2
							6	1	23	2
							7	1	21	1
							8	1	22	2
							9	1	20	1

** # of interfering panels
4: 23 21 22 20

M1-1


14
15
16
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18
19
20
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40
7
41
8
21
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42
43
44
37
38
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27
28
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31
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57
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56
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22
32
33
47
48
49
35
10
23
50
51
52
36
53
54
11
24
25
12
26
13
1
2
3
4
5
6

```
M1-1: Shewchuk (2008)
** Nzones
2

**zone     left edge X coordinate
 1           6.0
 2         222.0

** NStacks
5

** stack               flush
**   #    zone type    edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1      1    A     RIGHT    114.0   48.0      13          1         1    14              2
                                                               2         1    15              2
                                                               3         1    20              1
                                                               4         1    21              1
                                                               5         1    22              1
                                                               6         1    23              1
                                                               7         1    24              1
                                                               8         2    26 25           1 1
                                                               9         1    29              1
                                                              10         1    27              2
                                                              11         1    28              2
                                                              12         2    31 30           1 1
                                                              13         1    1               3
     2      2    A     RIGHT    361.0   48.0      13          1         1    16              2
                                                               2         1    17              2
                                                               3         2    19 18           2 2
                                                               4         1    7               2
                                                               5         1    8               2
                                                               6         1    9               2
                                                               7         1    10              2
                                                               8         1    11              2
                                                               9         2    13 12           2 2
                                                              10         1    40              2
                                                              11         1    41              2
                                                              12         1    42              2
                                                              13         2    44 43           2 2
     3      2    A     RIGHT    361.0   48.0      11          1         2    38 37           2 2
                                                               2         1    39              2
                                                               3         1    32              2
                                                               4         1    33              2
                                                               5         1    34              2
                                                               6         1    45              2
                                                               7         3    46 56 55        2 2 2
                                                               8         2    47 57           2 2
                                                               9         1    48              2
                                                              10         1    35              2
                                                              11         2    49              2
     4      2    B     LEFT     361.0   90.0       4          1         1    2               3
                                                               1         1    3               3
                                                               2         1    4               3
                                                               3         1    5               3
                                                               4         1    6               3
     5      2    B     LEFT     361.0   90.0       5          1         1    50 51           2 2
                                                               2         1    52              2
                                                               3         1    36              1
                                                               4         1    53              2
                                                               5         1    54              2
** # of interfering panels
6:   50 51 52 36 53 54
```

M1-1: Proposed algorithm

** Nzones
3

**zone left edge X coordinate

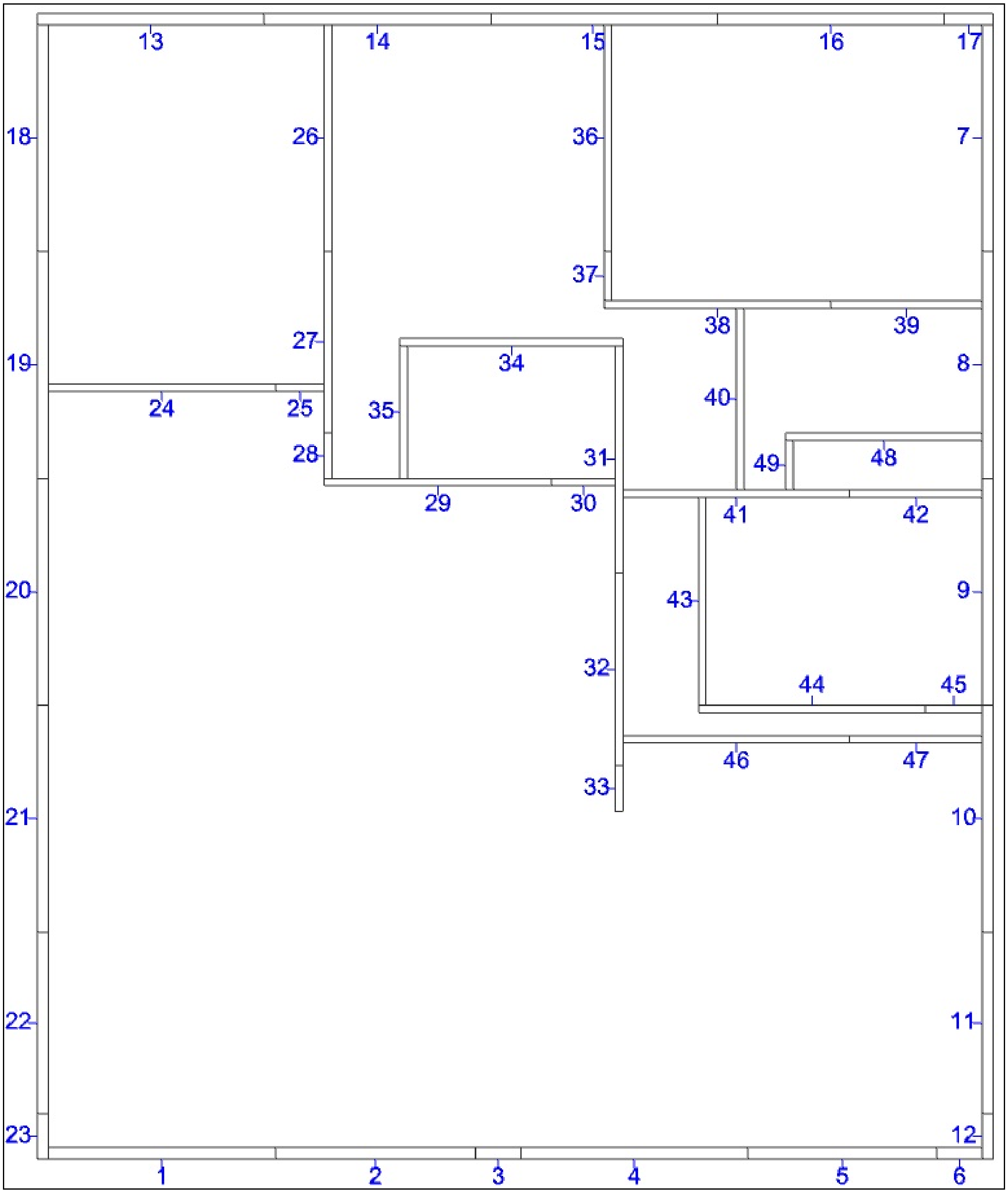
zone	left edge X coordinate
1	6.0
2	210.0
3	284.0

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	13	1	1	14	2
							2	1	15	2
							3	1	20	1
							4	1	21	1
							5	1	22	1
							6	1	23	1
							7	1	24	1
							8	2	26 25	1 1
							9	1	29	1
							10	1	27	2
							11	1	28	2
							12	2	31 30	1 1
							13	1	1	3
2	2	A	RIGHT	330.0	48.0	12	1	1	16	2
							2	1	17	2
							3	1	40	1
							4	1	41	1
							5	1	42	2
							6	1	32	2
							7	1	33	2
							8	1	34	1
							9	2	46 45	1 1
							10	1	47	2
							11	1	35	1
							12	2	50 49	1 1
3	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	39	1
4	3	A	RIGHT	392.0	48.0	13	1	2	19 18	2 2
							2	1	7	2
							3	1	8	2
							4	1	9	2
							5	1	10	2
							6	1	11	2
							7	2	13 12	2 2
							8	2	44 43	2 2
							9	2	38 37	2 2
							10	3	57 56 55	2 2 2
							11	1	48	2
							12	1	51	2
							13	1	52	2
5	3	B	LEFT	392.0	90.0	5	1	1	36	1
							2	1	5	3
							3	1	6	3
							4	1	54	2
							5	1	53	2

** # of interfering panels
2: 54 53

M1-2


13
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18
26
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7
37
38
39
27
34
19
8
24
25
35
40
28
31
49
48
29
30
41
42
20
43
9
32
44
45
46
47
33
21
10
22
11
23
12
1
2
3
4
5
6

```
M1-2: Shewchuk (2008)

** Nzones
2

**zone      left edge X coordinate
  1             6.0
  2           222.0

** NStacks
5

** stack                  flush
**    #     zone type    edge     xloc    yloc   #layers   j   #panels   panels       orientation
      1      1     A     RIGHT   114.0    48.0       9          1        1    13              2
                                                                2        1    18              1
                                                                3        1    19              1
                                                                4        1    20              1
                                                                5        1    21              1
                                                                6        2    23 22           1 1
                                                                7        1    24              2
                                                                8        2    27 25           1 2
                                                                9        2    1 28            3 1
      2      2     A     RIGHT   361.0    48.0      13          1        1    14              2
                                                                2        1    15              2
                                                                3        1    16              2
                                                                4        1    17              2
                                                                5        1    7               2
                                                                6        1    8               2
                                                                7        1    9               2
                                                                8        1    10              2
                                                                9        2    12 11           2 2
                                                               10        1    26              2
                                                               11        1    36              2
                                                               12        1    37              2
                                                               13        1    38              2
      3      2     A     RIGHT   361.0    48.0      10          1        1    39              2
                                                                2        1    34              2
                                                                3        1    35              2
                                                                4        1    29              2
                                                                5        1    30              2
                                                                6        1    31              2
                                                                7        1    40              2
                                                                8        2    49 48           2 2
                                                                9        1    41              2
                                                               10        1    42              2
      4      2     B     LEFT    361.0    90.0       3          1        2    2 3             3 3
                                                                2        1    4               3
                                                                3        2    5 6             3 3
      5      2     B     LEFT    361.0    90.0       6          1        1    32              1
                                                                2        1    43              2
                                                                3        1    44              2
                                                                4        1    45              2
                                                                5        1    46              2
                                                                6        2    47 33           2 1

** # of interfering panels
7: 32 43 44 45 46 47 33
```

M1-2: Proposed algorithm

** Nzones
3

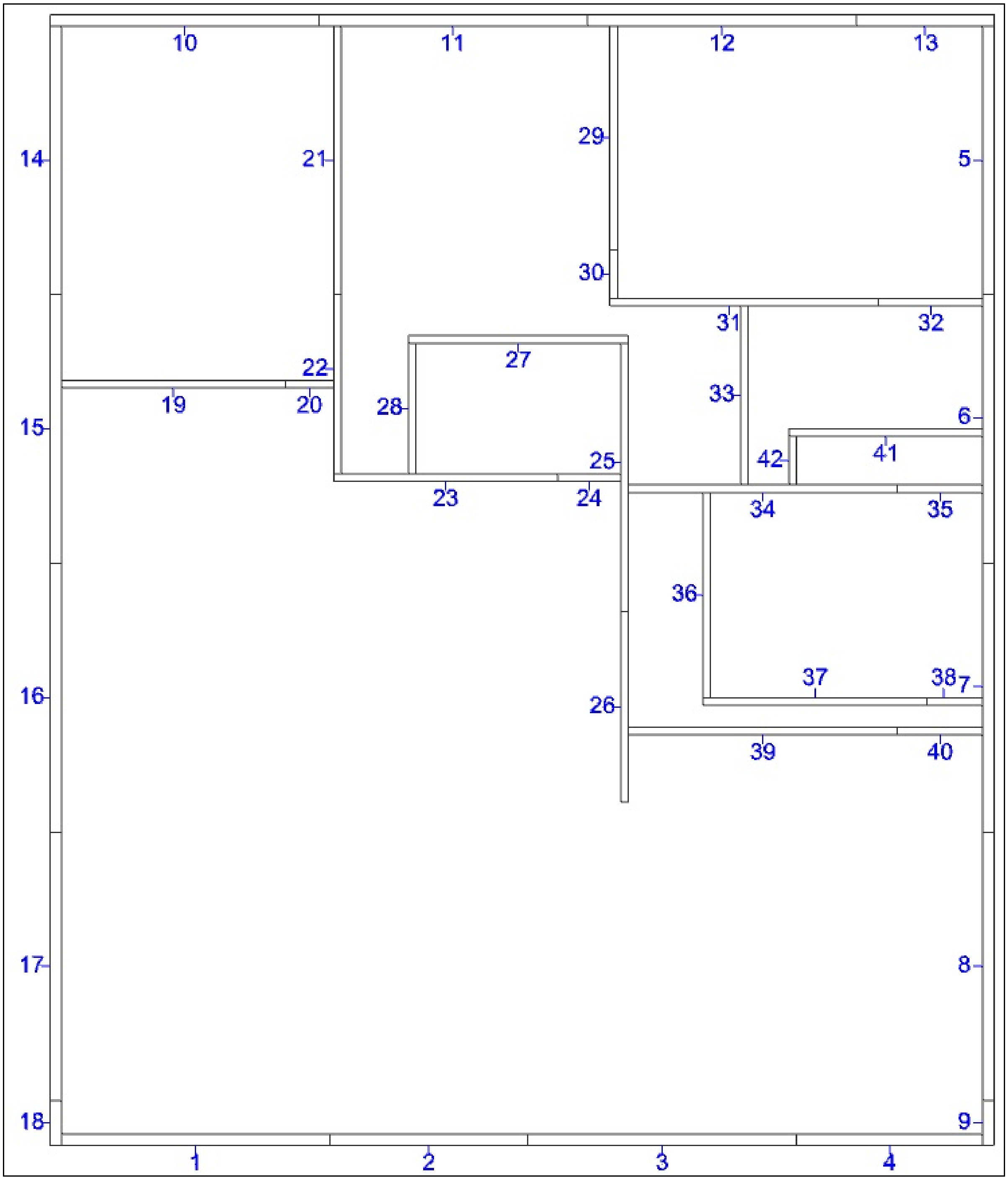
**zone	left edge X coordinate
1	6.0
2	209.0
3	284.0

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	9	1	1	13	2
							2	1	18	1
							3	1	19	1
							4	1	20	1
							5	1	21	1
							6	2	23 22	1 1
							7	1	24	2
							8	2	27 25	1 2
							9	2	1 28	3 1
2	2	A	RIGHT	330.0	48.0	12	1	1	14	2
							2	1	15	2
							3	1	26	1
							4	1	36	1
							5	1	37	1
							6	1	38	2
							7	1	29	2
							8	1	30	2
							9	1	31	1
							10	1	40	1
							11	1	41	2
							12	1	43	1
3	2	B	LEFT	330.0	90.0	3	1	2	2 3	3 3
							2	1	4	3
							3	1	35	1
4	3	A	RIGHT	392.0	48.0	13	1	1	16	2
							2	1	17	2
							3	1	7	2
							4	1	8	2
							5	1	9	2
							6	1	10	2
							7	2	12 11	2 2
							8	1	39	2
							9	1	34	2
							10	2	49 48	2 2
							11	1	42	2
							12	1	44	2
							13	1	45	2
5	3	B	LEFT	392.0	90.0	4	1	2	5 6	3 3
							2	2	33 47	1 2
							3	1	46	2
							4	1	32	1

** # of interfering panels
4: 33 47 46 32

M1-3


10
11
12
13
14
21
29
5
30
31
32
27
22
33
19
20
28
6
15
25
42
41
23
24
34
35
36
16
26
37
38
7
39
40
17
8
18
9
1
2
3
4

M1-3: Shewchuk (2008)

** Nzones
2

**zone	left edge X coordinate
1	6.0
2	226.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	8	1	1	10	2
							2	1	14	1
							3	1	15	1
							4	1	16	1
							5	1	17	1
							6	2	19 18	2 1
							7	2	22 20	1 2
							8	1	1	3
2	2	A	RIGHT	363.2	57.3	13	1	1	11	2
							2	1	12	2
							3	1	13	2
							4	1	5	2
							5	1	6	2
							6	1	7	2
							7	1	8	2
							8	1	9	2
							9	1	21	2
							10	1	29	2
							11	1	30	2
							12	1	31	2
							13	1	32	2
3	2	A	RIGHT	363.2	57.3	12	1	1	27	2
							2	1	28	2
							3	1	23	2
							4	1	24	2
							5	1	25	2
							6	1	33	2
							7	2	42 41	2 2
							8	1	34	2
							9	1	35	2
							10	1	36	2
							11	1	37	2
							12	1	38	2
4	2	B	LEFT	363.2	99.3	3	1	1	2	3
							2	1	3	3
							3	1	4	3
5	2	B	LEFT	363.2	99.3	5	1	1	26	1
							2	1	37	2
							3	1	38	2
							4	1	39	2
							5	1	40	2

** # of interfering panels
5: 26 37 38 39 40

M1-3: Proposed algorithm

** Nzones
3

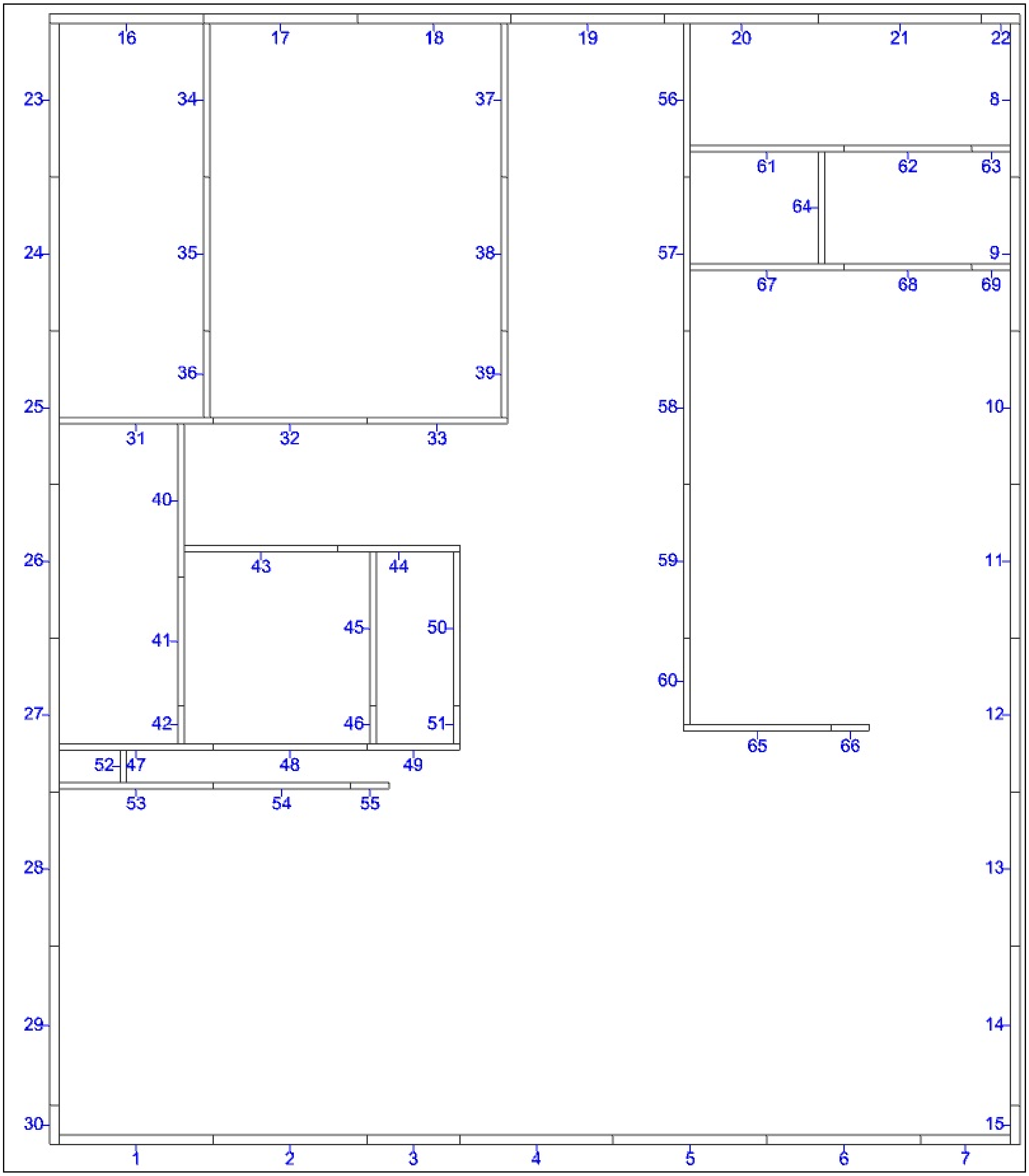
**zone	left edge X coordinate
1	6.0
2	222.5
3	279.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	8	1	1	10	2
							2	1	14	1
							3	1	15	1
							4	1	16	1
							5	1	17	1
							6	2	19 18	2 1
							7	2	22 20	1 2
							8	1	1	3
2	2	A	RIGHT	336.7	57.3	10	1	1	11	2
							2	1	12	2
							3	1	21	1
							4	1	29	1
							5	1	30	1
							6	1	31	2
							7	1	23	2
							8	1	24	2
							9	1	25	1
							10	1	33	1
3	2	B	LEFT	336.7	99.3	3	1	1	2	3
							2	1	3	3
							3	1	28	1
4	3	A	RIGHT	389.8	57.3	13	1	1	13	2
							2	1	5	2
							3	1	6	2
							4	1	7	2
							5	1	8	2
							6	2	32 9	2 2
							7	1	27	2
							8	2	42 41	2 2
							9	1	34	2
							10	1	35	2
							11	1	36	2
							12	1	37	2
							13	1	38	2
5	3	B	LEFT	389.8	99.3	4	1	1	4	1
							2	1	40	2
							3	1	39	2
							4	1	26	1

** # of interfering panels
3: 40 39 26

M2-1


16
17
18
19
20
21
22
23
34
37
56
8
61
62
63
64
24
35
38
57
9
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47
48
49
53
54
55
28
13
29
14
30
15
1
2
3
4
5
6
7

```
M2-1: Shewchuk (2008)
** Nzones
2

**zone      left edge X coordinate
  1             6.0
  2           222.0

** NStacks
6

** stack                 flush
**    #    zone type    edge      xloc    yloc   #layers   j   #panels   panels      orientation
      1     1     A     RIGHT    114.0    48.0     13          1        1    16             2
                                                                2        1    17             2
                                                                3        1    23             1
                                                                4        1    24             1
                                                                5        1    25             1
                                                                6        1    26             1
                                                                7        1    27             1
                                                                8        1    28             1
                                                                9        2    30 29          1 1
                                                               10        1    34             1
                                                               11        1    35             1
                                                               12        1    36             1
                                                               13        1    31             2
      2     1     A     RIGHT    114.0    48.0      9          1        1    32             2
                                                                2        1    40             1
                                                                3        1    43             2
                                                                4        2    42 41          1 1
                                                                5        1    47             2
                                                                6        2    52 48          1 2
                                                                7        1    53             2
                                                                8        2    55 54          2 2
                                                                9        1    1              3
      3     2     A     RIGHT    411.0    48.0     12          1        1    18             2
                                                                2        1    19             2
                                                                3        1    20             2
                                                                4        2    22 21          2 2
                                                                5        1    8              2
                                                                6        1    9              2
                                                                7        1    10             2
                                                                8        1    11             2
                                                                9        1    12             2
                                                               10        1    13             2
                                                               11        2    15 14          2 2
                                                               12        1    37             2
      4     2     A     RIGHT    411.0    48.0      9          1        1    56             2
                                                                2        1    61             2
                                                                3        2    63 62          2 2
                                                                4        1    38             2
                                                                5        1    57             2
                                                                6        1    64             2
                                                                7        1    67             2
                                                                8        2    69 68          2 2
                                                                9        2    33 39          2 2
      5     2     B     LEFT     411.0    90.0      6          1        1    2              3
                                                                2        1    3              3
                                                                3        1    4              3
                                                                4        1    5              3
                                                                5        1    6              3
                                                                6        1    7              3
      6     2     B     LEFT     411.0    90.0      8          1        1    58             1
                                                                2        1    44             2
                                                                3        1    45             1
                                                                4        1    50             1
                                                                5        3    46 51 59       1 1 1
                                                                6        1    49             2
                                                                7        1    60             1
                                                                8        2    66 65          2 2

** # of interfering panels
3: 60 66 65
```

```
M2-1: Proposed algorithm
** Nzones
3

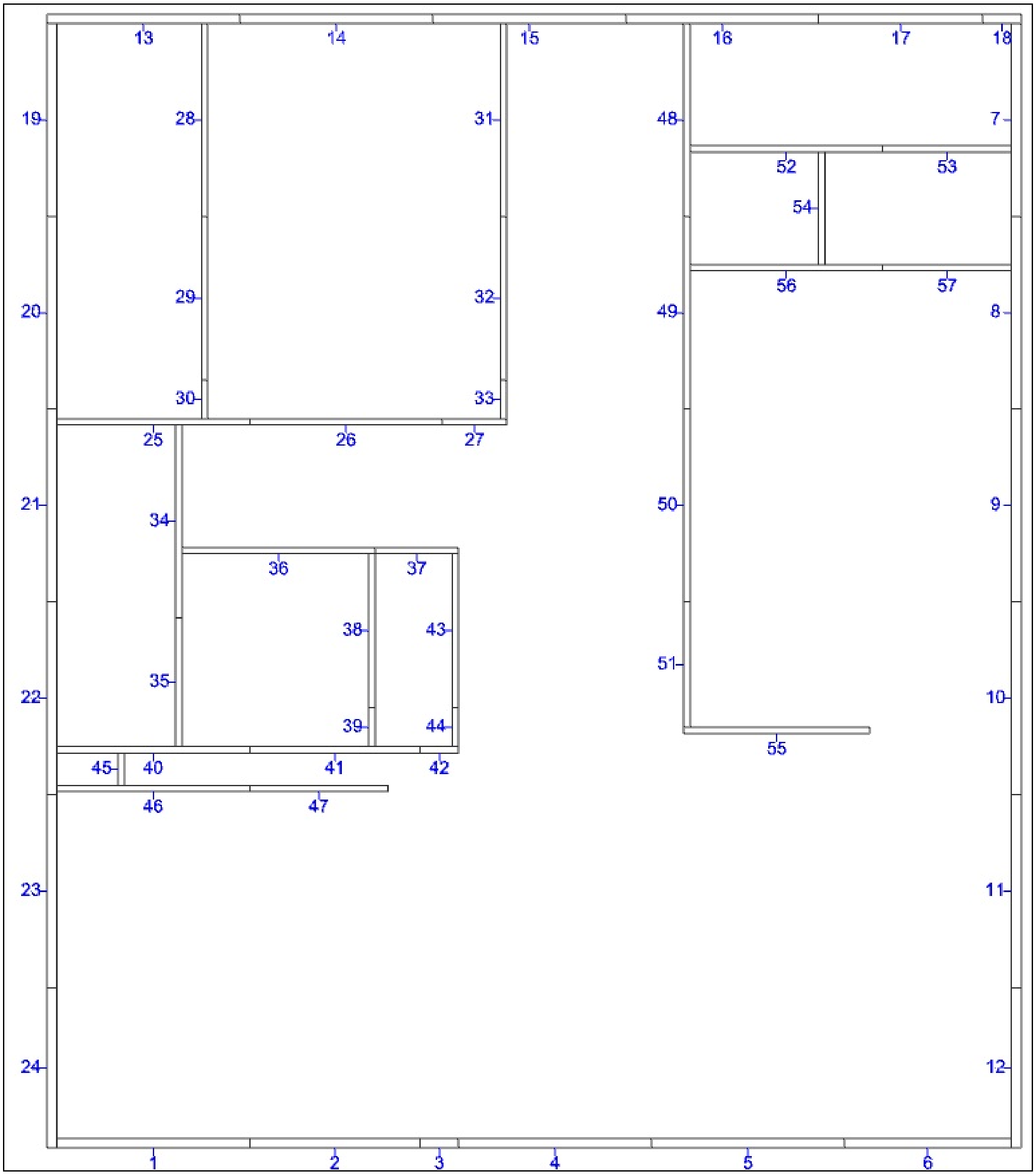
**zone      left edge X coordinate
 1            6.0
 2          212.0
 3          384.0

** NStacks
6

** stack                 flush
**    #    zone type    edge      xloc    yloc   #layers   j   #panels   panels        orientation
      1     1     A     RIGHT    114.0    48.0       13        1        1     16              2
                                                               2        1     17              2
                                                               3        1     23              1
                                                               4        1     24              1
                                                               5        1     25              1
                                                               6        1     26              1
                                                               7        1     27              1
                                                               8        1     28              1
                                                               9        2     30 29           1 1
                                                              10        1     34              1
                                                              11        1     35              1
                                                              12        1     36              1
                                                              13        1     31              2
      2     1     A     RIGHT    114.0    48.0        9        1        1     32              2
                                                               2        1     40              1
                                                               3        1     43              2
                                                               4        2     42 41           1 1
                                                               5        1     47              2
                                                               6        2     52 48           1 2
                                                               7        1     53              2
                                                               8        2     55 54           2 2
                                                               9        1     1               3
      3     2     A     RIGHT    330.0    48.0        9        1        1     18              2
                                                               2        1     19              2
                                                               3        1     37              1
                                                               4        1     38              1
                                                               5        2     33 39           2 1
                                                               6        1     44              2
                                                               7        1     45              1
                                                               8        3     51 46 50        1 1 1
                                                               9        1     49              2
      4     2     B     LEFT     330.0    90.0        3        1        1     2               3
                                                               2        1     3               3
                                                               3        1     4               3
      5     3     A     RIGHT    492.0    48.0       13        1        1     20              2
                                                               2        2     22 21           2 2
                                                               3        1     8               2
                                                               4        1     9               2
                                                               5        1     10              2
                                                               6        1     11              2
                                                               7        1     12              2
                                                               8        1     13              2
                                                               9        2     15 14           2 2
                                                              10        1     56              2
                                                              11        1     61              2
                                                              12        2     63 62           2 2
                                                              13        1     57              2
      6     3     A     RIGHT    492.0    48.0       10        1        1     61              3
                                                               2        2     62 63           3 1
                                                               3        1     57              1
                                                               4        1     64              1
                                                               5        1     67              1
                                                               6        2     68 69           2 2
                                                               7        1     58              2
                                                               8        1     59              1
                                                               9        1     60              1
                                                              10        2     65 66           2 2

** # of interfering panels
0
```

M2-2


13
14
15
16
17
18
19
28
31
48
7
52
53
54
20
29
32
49
56
57
8
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```
M2-2: Shewchuk (2008)

** Nzones
2

**zone     left edge X coordinate
  1          6.0
  2        222.0

** NStacks
6

** stack                flush
**   #    zone type     edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1     1    A      RIGHT    114.0    48.0     14           1       1     13          2
                                                               2       1     19          1
                                                               3       1     20          1
                                                               4       1     21          1
                                                               5       1     22          1
                                                               6       1     23          1
                                                               7       1     24          1
                                                               8       1     28          1
                                                               9       2     30 29       1 1
                                                              10       1     25          2
                                                              11       1     34          1
                                                              12       1     36          2
                                                              13       1     35          1
                                                              14       2     39 38       1 1
     2     1    A      RIGHT    114.0    48.0      4           1       2     45 40       1 2
                                                               2       1     46          2
                                                               3       1     47          2
                                                               4       1     1           3
     3     2    A      RIGHT    411.0    48.0     12           1       1     14          2
                                                               2       1     15          2
                                                               3       1     16          2
                                                               4       2     18 17       2 2
                                                               5       1     7           2
                                                               6       1     8           2
                                                               7       1     9           2
                                                               8       1     10          2
                                                               9       1     11          2
                                                              10       1     12          2
                                                              11       1     31          2
                                                              12       1     48          2
     4     2    A      RIGHT    411.0    48.0      3           1       1     52          2
                                                               2       1     53          2
                                                               3       2     33 32       2 2
     5     2    B      LEFT     411.0    90.0      3           1       2     2 3         3 3
                                                               2       1     4           3
                                                               3       1     5           3
     6     2    B      LEFT     411.0    90.0     12           1       2     32 33       1 1
                                                               2       1     49          1
                                                               3       1     54          1
                                                               4       1     56          2
                                                               5       1     57          2
                                                               6       1     26          2
                                                               7       2     27 37       2 2
                                                               8       1     43          1
                                                               9       2     50 44       1 1
                                                              10       1     51          1
                                                              11       2     41 42       2 2
                                                              12       1     55          2

** # of interfering panels
1: 55
```

M2-2: Proposed algorithm

** Nzones
3

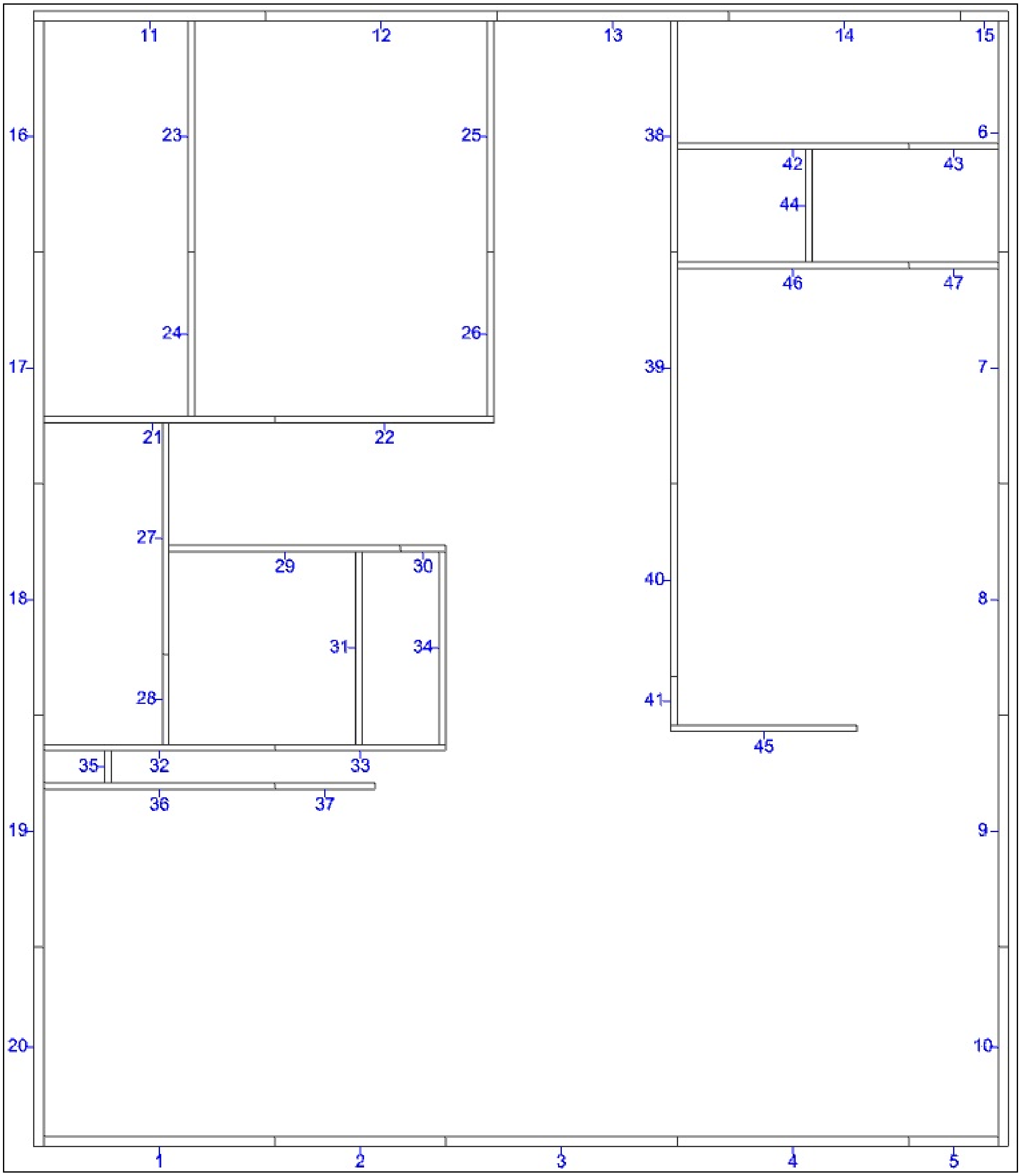
**zone	left edge X coordinate
1	6.0
2	211.4
3	384.0

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	14	1	1	13	2
							2	1	19	1
							3	1	20	1
							4	1	21	1
							5	1	22	1
							6	1	23	1
							7	1	24	1
							8	1	28	1
							9	2	30 29	1 1
							10	1	25	2
							11	1	34	1
							12	1	36	2
							13	1	35	1
							14	2	39 38	1 1
2	1	A	RIGHT	114.0	48.0	4	1	2	45 40	1 2
							2	1	46	2
							3	1	47	2
							4	1	1	3
3	2	A	RIGHT	330.0	48.0	8	1	1	14	2
							2	1	15	2
							3	1	31	1
							4	2	33 32	1 1
							5	1	26	2
							6	2	37 27	2 2
							7	2	44 43	1 1
							8	2	42 41	2 2
4	2	B	LEFT	330.0	90.0	2	1	2	2 3	3 3
							2	1	4	3
5	3	A	RIGHT	492.0	48.0	13	1	1	16	2
							2	2	18 17	2 2
							3	1	7	2
							4	1	8	2
							5	1	9	2
							6	1	10	2
							7	1	11	2
							8	1	12	2
							9	1	48	2
							10	1	52	2
							11	1	53	2
							12	1	49	2
							13	1	54	2
6	3	A	RIGHT	492.0	48.0	7	1	1	49	3
							2	1	54	2
							3	1	56	2
							4	1	57	1
							5	1	50	1
							6	1	51	1
							7	1	55	1

** # of interfering panels
0

M2-3



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10
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4
5

M2-3: Shewchuk (2008)

** Nzones
2

**zone	left edge X coordinate
1	6.0
2	226.5

** NStacks
5

** stack			flush						
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	11	2
							2	1	16	1
							3	1	17	1
							4	1	18	1
							5	1	19	1
							6	1	20	1
							7	1	23	1
							8	1	24	1
							9	1	21	2
							10	1	27	1
							11	1	28	1
							12	1	32	2
							13	1	1	3
2	2	A	RIGHT	413.2	57.3	13	1	1	12	2
							2	1	13	2
							3	1	14	2
							4	1	15	2
							5	1	6	2
							6	1	7	2
							7	1	8	2
							8	1	9	2
							9	1	10	2
							10	1	25	2
							11	1	38	2
							12	1	42	2
							13	1	43	2
3	2	A	RIGHT	413.2	57.3	6	1	1	26	2
							2	1	22	2
							3	1	39	2
							4	1	44	2
							5	1	46	2
							6	1	47	2
4	2	B	LEFT	413.2	99.3	4	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	5	3
4	2	B	LEFT	413.2	99.3	11	1	1	29	2
							2	1	30	2
							3	1	31	1
							4	1	34	1
							5	1	40	1
							6	1	41	1
							7	1	33	2
							8	1	35	1
							9	1	36	2
							10	1	37	2
							11	1	45	2

** # of interfering panels
1: 45

M2-3: Proposed algorithm

** Nzones
3

**zone left edge X coordinate

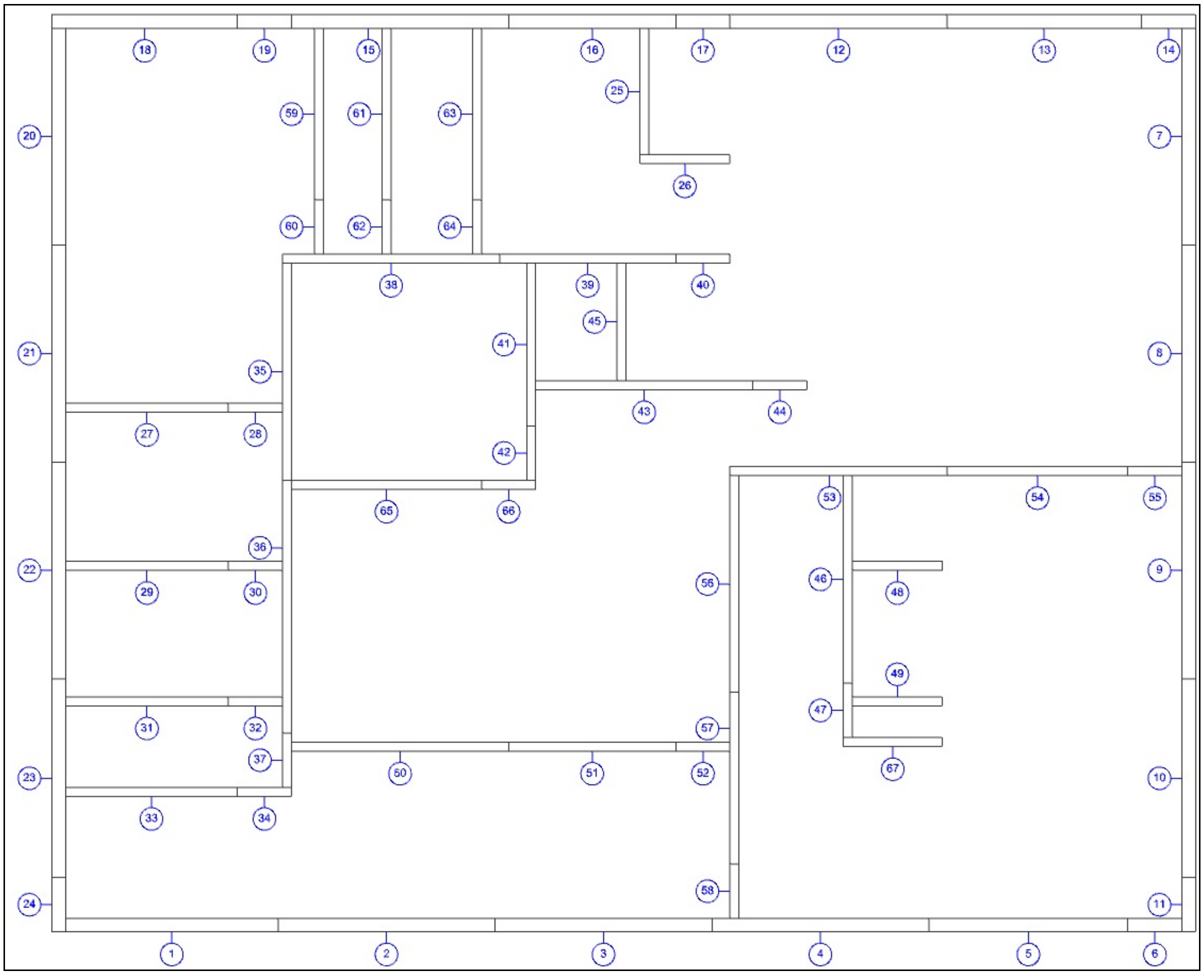
1	6.0
2	214.5
3	379.5

** NStacks
4

** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	11	2
							2	1	16	1
							3	1	17	1
							4	1	18	1
							5	1	19	1
							6	1	20	1
							7	1	23	1
							8	1	24	1
							9	1	21	2
							10	1	27	1
							11	1	28	1
							12	1	32	2
							13	1	1	3
2	2	A	RIGHT	336.7	57.3	13	1	1	12	2
							2	1	13	2
							3	1	25	1
							4	1	38	1
							5	1	26	1
							6	1	22	2
							7	1	39	1
							8	1	29	2
							9	1	30	2
							10	1	31	1
							11	1	34	1
							12	1	40	1
							13	2	33 41	2 1
3	2	B	LEFT	336.7	99.3	5	1	1	2	3
							2	1	3	3
							3	1	35	1
							4	1	36	2
							5	1	37	2
4	3	A	RIGHT	489.8	57.3	14	1	1	14	2
							2	1	4	3
							3	1	14	2
							4	1	15	2
							5	1	6	1
							6	1	7	1
							7	1	8	1
							8	1	9	1
							9	1	10	1
							10	1	42	2
							11	2	44 43	1 2
							12	1	46	2
							13	1	47	2
							14	1	45	2

** # of interfering panels
0

M3-1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```
M3-1: Shewchuk (2008)

** Nzones
2

**zone      left edge X coordinate
  1           6.0
  2         222.0

** NStacks
5

** stack                 flush
**    #    zone type     edge     xloc    yloc   #layers   j   #panels   panels        orientation
      1      1     A     RIGHT   114.0   48.0      14           1         2      19 18          2 2
                                                                2         1      15             2
                                                                3         1      20             1
                                                                4         1      21             1
                                                                5         1      22             1
                                                                6         2      24 23          1 1
                                                                7         1      59             1
                                                                8         1      61             1
                                                                9         3      62 60 63       1 1 1
                                                               10         2      38 64          2 1
                                                               11         2      28 27          2 2
                                                               12         1      35             1
                                                               13         2      30 29          2 2
                                                               14         2      66 65          2 2
      2      1     A     RIGHT   114.0   48.0       1           1         1      1              3
      3      2     A     RIGHT   361.0   48.0      13           1         2      17 16          2 2
                                                                2         1      12             2
                                                                3         2      14 13          2 2
                                                                4         1      7              2
                                                                5         1      8              2
                                                                6         1      9              2
                                                                7         2      11 10          2 2
                                                                8         2      26 25          2 2
                                                                9         2      40 39          2 2
                                                               10         2      45 41          2 2
                                                               11         3      42 44 43       2 2 2
                                                               12         1      53             2
                                                               13         3      48 55 54       2 2 2
      4      2     B     LEFT    361.0   90.0       7           1         1      2              3
                                                                2         2      31 32          2 2
                                                                3         2      36 37          1 1
                                                                4         1      50             2
                                                                5         1      51             2
                                                                6         2      33 34          3 3
                                                                7         1      56             1
      5      2     B     LEFT    361.0   90.0       6           1         1      3              3
                                                                2         1      4              3
                                                                3         2      5 6            3 3
                                                                4         1      46             1
                                                                5         2      52 57          2 1
                                                                6         4      47 49 67 58    1 2 2 1

** # of interfering panels
7: 46 52 57 47 49 67 58
```

M3-1: Proposed algorithm

** Nzones
3

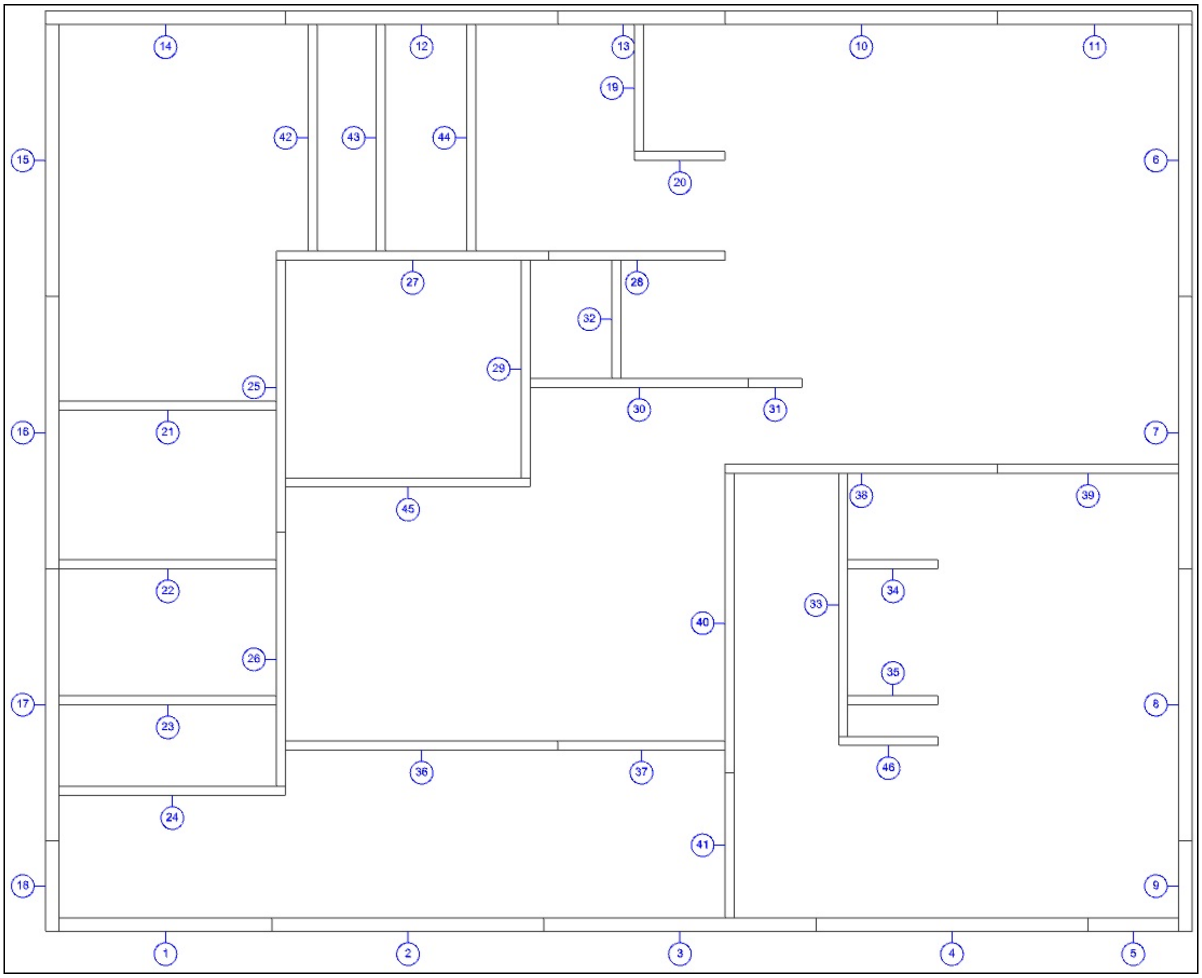
**zone	left edge X coordinate
1	6.0
2	211.0
3	284.0

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	15	1	2	19 18	2 2
							2	1	15	2
							3	1	20	1
							4	1	21	1
							5	1	22	1
							6	2	24 23	1 1
							7	1	59	1
							8	1	61	1
							9	3	62 60 63	1 1 1
							10	2	38 64	2 1
							11	2	28 27	2 2
							12	1	35	1
							13	2	30 29	2 2
							14	2	66 65	2 2
							15	1	1	3
2	2	A	RIGHT	330.0	48.0	6	1	2	17 16	2 2
							2	1	12	2
							3	2	26 25	2 1
							4	2	40 39	2 2
							5	2	45 41	1 1
							6	3	42 44 43	1 2 2
3	2	B	LEFT	330.0	90.0	7	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	2	31 32	2 2
							5	2	36 37	1 1
							6	1	50	2
							7	2	33 34	3 2
4	3	A	RIGHT	392.0	48.0	8	1	2	14 13	2 2
							2	1	7	2
							3	1	8	2
							4	1	9	2
							5	2	11 10	2 2
							6	1	53	2
							7	3	48 55 54	2 2 2
							8	2	6 5	3 3
5	3	B	LEFT	392.0	90.0	8	1	2	51 52	2 2
							2	1	56	1
							3	1	58	1
							4	1	67	2
							5	1	49	2
							6	1	47	1
							7	1	57	1
							8	1	46	1

** # of interfering panels
6: 58 67 49 47 57 46

M3-2



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5

M3-2: Shewchuk (2008)

** Nzones
2

**zone left edge X coordinate
1 6.0
2 222.0

** NStacks
5

** stack ** #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	52.5	9	1	1	14	2
							2	1	15	1
							3	1	16	1
							4	1	17	1
							5	2	21 18	2 1
							6	1	25	1
							7	1	45	2
							8	1	22	2
							9	1	1	3
2	2	A	RIGHT	361.0	52.5	13	1	1	12	2
							2	1	13	2
							3	1	10	2
							4	1	11	2
							5	1	6	2
							6	1	7	2
							7	1	8	2
							8	2	42 9	2 2
							9	1	43	2
							10	1	44	2
							11	2	20 19	2 2
							12	1	27	2
							13	1	28	2
3	2	A	RIGHT	361.0	52.5	5	1	1	29	2
							2	1	32	2
							3	2	31 30	2 2
							4	1	38	2
							5	2	34 39	2 2
4	2	B	LEFT	361.0	94.5	6	1	1	2	3
							2	1	23	2
							3	1	26	1
							4	1	24	3
							5	1	36	2
							6	1	37	2
5	2	B	LEFT	361.0	94.5	7	1	1	3	3
							2	1	4	3
							3	1	5	3
							4	1	40	1
							5	1	33	1
							6	2	35 46	2 2
							7	1	41	1

** # of interfering panels
5: 40 33 35 46 41

M3-2: Proposed algorithm

```
** Nzones
3

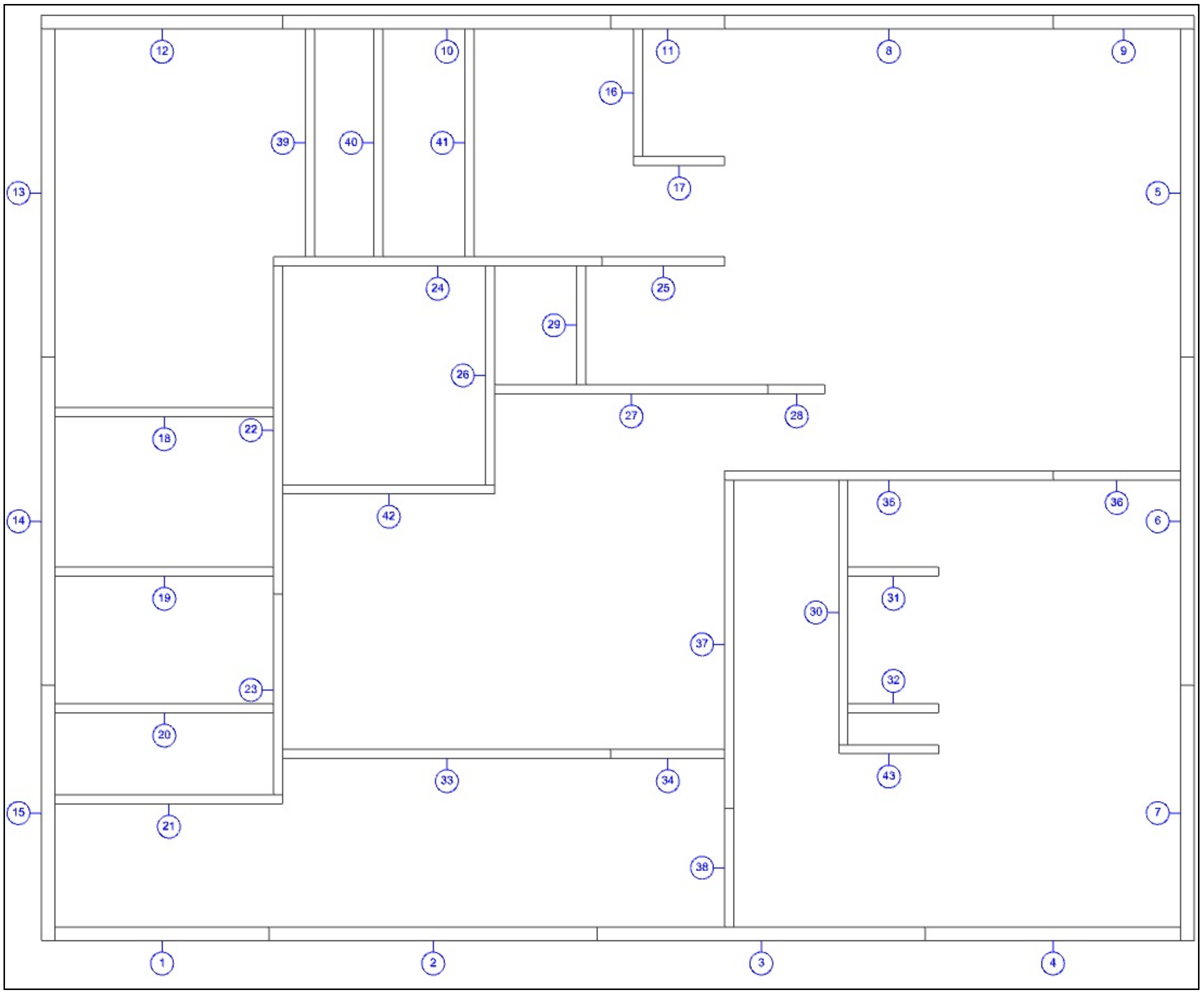
**zone      left edge X coordinate
 1            6.0
 2          211.0
 3          284.0

** NStacks
5

** stack               flush
**   #    zone type    edge    xloc   yloc  #layers  j  #panels  panels    orientation
     1     1    A      RIGHT   114.0  52.5     9     1     1     14            2
                                                     2     1     15            1
                                                     3     1     16            1
                                                     4     1     17            1
                                                     5     2     21 18         2 1
                                                     6     1     25            1
                                                     7     1     45            2
                                                     8     1     22            2
                                                     9     1     1             3
     2     2    A      RIGHT   330.0  52.5    12     1     1     12            2
                                                     2     1     13            2
                                                     3     1     10            2
                                                     4     1     42            1
                                                     5     1     43            1
                                                     6     1     44            1
                                                     7     2     20 19         2 1
                                                     8     1     27            2
                                                     9     1     28            2
                                                    10     1     29            1
                                                    11     1     32            1
                                                    12     2     31 30         2 2
     3     2    B      LEFT    330.0  94.5     5     1     1     2             3
                                                     2     1     3             3
                                                     3     1     23            2
                                                     4     1     26            1
                                                     5     1     24            2
     4     3    A      RIGHT   392.0  52.5     9     1     1     11            2
                                                     2     1     6             2
                                                     3     1     7             2
                                                     4     1     8             2
                                                     5     1     9             2
                                                     6     1     38            2
                                                     7     2     39          2
                                                     8     1     4             3
                                                     9     1     5             3
     5     3    B      LEFT    392.0  94.5     7     1     1     36            2
                                                     2     1     37            2
                                                     3     1     40            1
                                                     4     1     41            1
                                                     5     1     46            2
                                                     6     2     35 34         2 2
                                                     7     1     33            1


** # of interfering panels
4:   46 35 34 33
```

M3-3



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21
38
1
2
3
4

M3-3: Shewchuk (2008)

** Nzones
2

**zone left edge X coordinate
1 6.0
2 226.5

** NStacks
5

** stack ** #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	9	1	1	12	2
							2	1	13	1
							3	1	14	1
							4	1	15	1
							5	1	18	2
							6	1	19	2
							7	1	22	1
							8	1	42	2
							9	1	1	3
2	2	A	RIGHT	363.2	57.3	14	1	1	10	2
							2	1	11	2
							3	1	8	2
							4	1	9	2
							5	1	5	2
							6	1	6	2
							7	1	7	2
							8	1	39	2
							9	1	40	2
							10	1	41	2
							11	2	17 16	2 2
							12	1	24	2
							13	1	25	2
							14	1	26	2
3	2	A	RIGHT	363.2	57.3	5	1	1	29	2
							2	1	27	2
							3	1	28	2
							4	1	35	2
							5	2	31 36	2 2
4	2	B	LEFT	363.2	99.3	5	1	1	20	2
							2	1	23	1
							3	1	21	3
							4	1	33	2
							5	1	34	2
5	2	B	LEFT	363.2	99.3	6	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	37	1
							5	1	30	1
							6	3	32 43 38	2 2 1

** # of interfering panels
5: 37 30 32 43 38

M3-3: Proposed algorithm

** Nzones
3

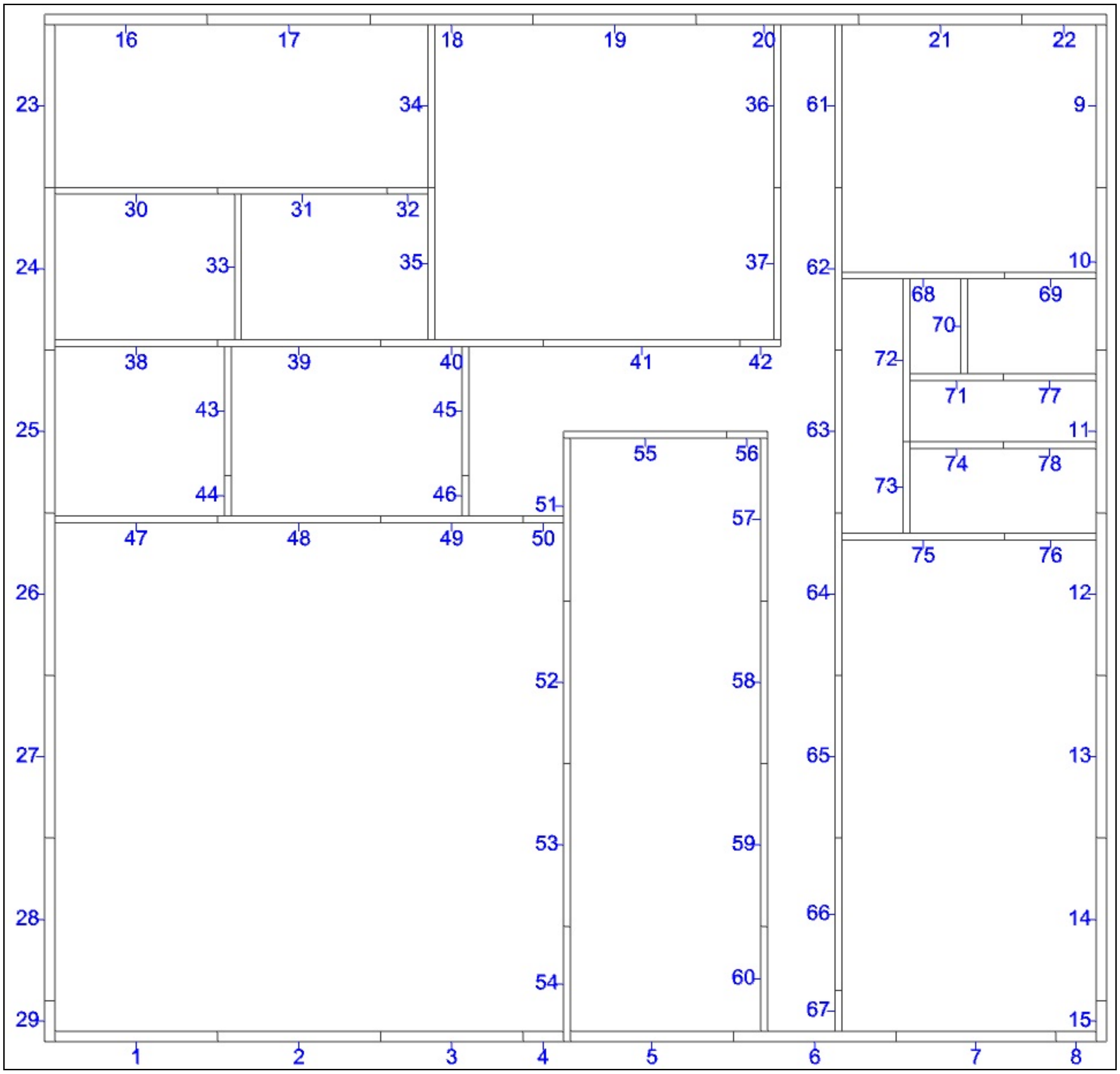
**zone	left edge X coordinate
1	6.0
2	213.5
3	279.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	9	1	1	12	2
							2	1	13	1
							3	1	14	1
							4	1	15	1
							5	1	18	2
							6	1	19	2
							7	1	22	1
							8	1	42	2
							9	1	1	3
2	2	A	RIGHT	336.7	57.3	13	1	1	10	2
							2	1	11	2
							3	1	8	2
							4	1	39	1
							5	1	40	1
							6	1	41	1
							7	2	17 16	2 1
							8	1	24	2
							9	1	25	2
							10	1	26	1
							11	1	29	1
							12	1	27	2
							13	1	28	2
3	2	B	LEFT	336.7	99.3	5	1	1	2	3
							2	1	3	3
							3	1	20	2
							4	1	23	1
							5	1	21	3
4	3	A	RIGHT	389.8	57.3	9	1	1	9	2
							2	1	5	2
							3	1	6	2
							4	1	7	2
							5	1	35	2
							6	1	36	2
							7	1	37	1
							8	1	38	1
							9	1	4	3
5	3	B	LEFT	389.8	99.3	5	1	1	33	2
							2	1	34	2
							3	1	43	2
							4	2	31 32	2 2
							5	1	30	1

** # of interfering panels
4: 43 31 32 30

M4-1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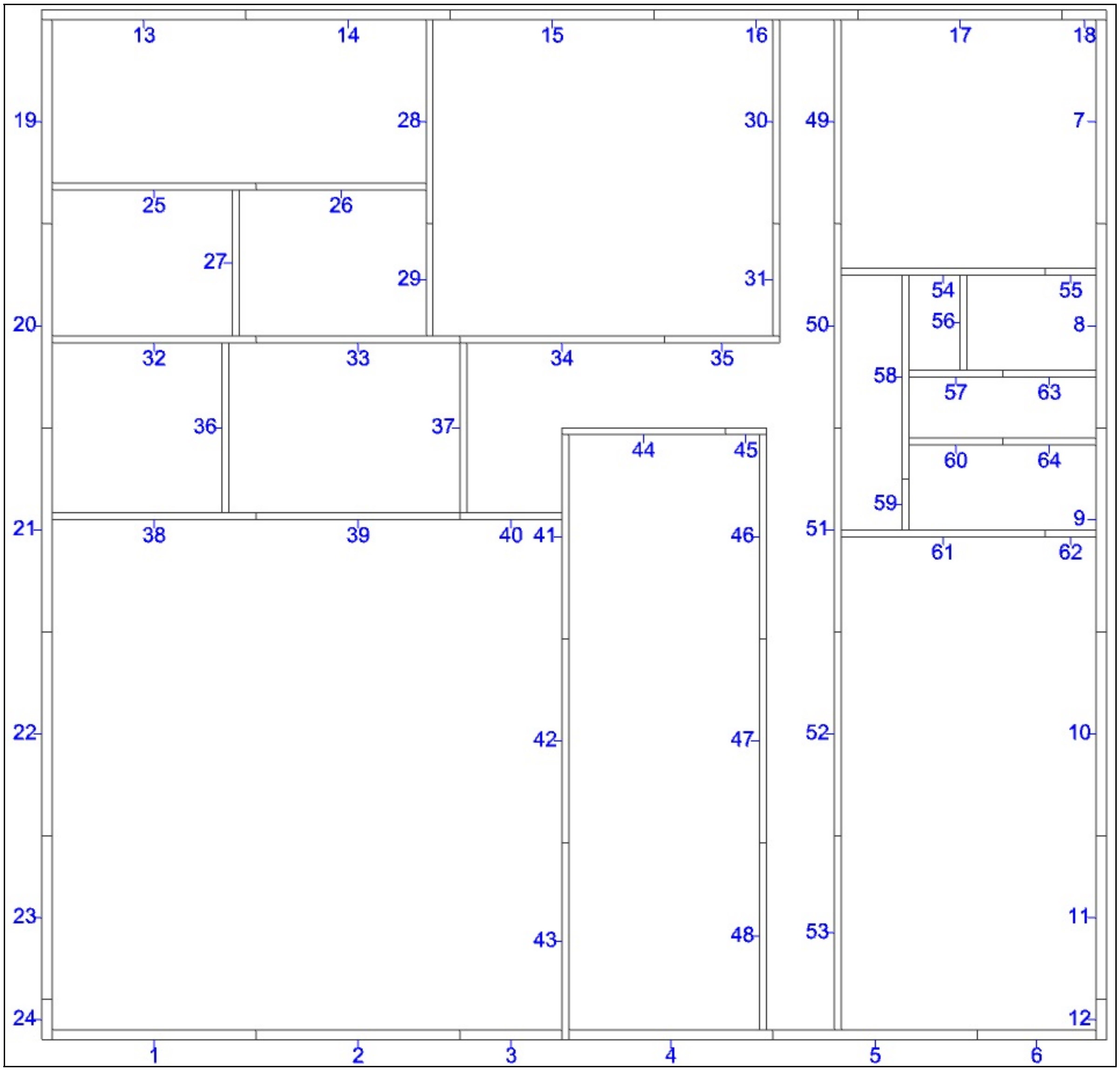
```
M4-1: Shewchuk (2008)
** Nzones
2
**zone     left edge X coordinate
 1          6.0
 2        222.0
** NStacks
8
** stack              flush
**   #   zone type    edge     xloc   yloc   #layers  j   #panels   panels     orientation
     1    1    A     RIGHT    114.0   48.0    13         1         1   16             2
                                                         2         1   17             2
                                                         3         1   23             1
                                                         4         1   24             1
                                                         5         1   25             1
                                                         6         1   26             1
                                                         7         1   27             1
                                                         8         2   29 28          1 1
                                                         9         1   30             2
                                                        10         1   31             2
                                                        11         1   33             1
                                                        12         1   38             2
                                                        13         1   39             2
     2    1    A     RIGHT    114.0   48.0     4         1         2   44 43          1 1
                                                         2         1   47             2
                                                         3         1   48             2
                                                         4         1   1              3
     3    2    A     RIGHT    421.0   48.0    12         1         1   18             2
                                                         2         1   19             2
                                                         3         1   20             2
                                                         4         1   21             2
                                                         5         1   22             2
                                                         6         1   9              2
                                                         7         1   10             2
                                                         8         1   11             2
                                                         9         1   12             2
                                                        10         1   13             2
                                                        11         2   15 14          2 2
                                                        12         1   34             2
     4    2    A     RIGHT    421.0   48.0    14         1         1   36             2
                                                         2         2   32 61          2 2
                                                         3         1   35             2
                                                         4         1   37             2
                                                         5         1   40             2
                                                         6         2   42 41          2 2
                                                         7         1   45             2
                                                         8         1   62             2
                                                         9         1   68             2
                                                        10         1   69             2
                                                        11         3   46 56 55       2 2 2
                                                        12         2   50 49          2 2
                                                        13         1   51             2
                                                        14         1   57             2
     5    2    A     RIGHT    421.0   48.0     3         1         1   63             2
                                                         2         1   72             2
                                                         3         2   71 70          2 2
     6    2    A     RIGHT    421.0   48.0     4         1         2   73 77          2 2
                                                         2         2   78 74          2 2
                                                         3         1   75             2
                                                         4         1   76             2
     7    2    B     LEFT     421.0   90.0     6         1         1   2              3
                                                         2         1   52             1
                                                         3         1   58             1
                                                         4         1   53             1
                                                         5         1   59             1
                                                         6         1   60             1
     8    2    B     LEFT     421.0   90.0     8         1         2   3 4            3 3
                                                         2         1   54             1
                                                         3         1   5              3
                                                         4         1   6              3
                                                         5         2   7 8            3 3
                                                         6         1   64             1
                                                         7         1   65             1
                                                         8         2   66 67          1 1
** # of interfering panels
4: 64 65 66 67
```

```
M4-1: Proposed algorithm
** Nzones
3
**zone      left edge X coordinate
 1            6.0
 2          222.0
 3          404.0
** NStacks
7
** stack                  flush
**   #    zone type   edge      xloc   yloc  #layers   j  #panels  panels       orientation
     1     1    A     RIGHT    114.0   48.0    13         1       1    16             2
                                                          2       1    17             2
                                                          3       1    23             1
                                                          4       1    24             1
                                                          5       1    25             1
                                                          6       1    26             1
                                                          7       1    27             1
                                                          8       2    29 28          1 1
                                                          9       1    30             2
                                                         10       1    31             2
                                                         11       1    33             1
                                                         12       1    38             2
                                                         13       1    39             2
     2     1    A     RIGHT    114.0   48.0     4         1       2    44 43          1 1
                                                          2       1    47             2
                                                          3       1    48             2
                                                          4       1    1              3
     3     2    A     RIGHT    330.0   48.0     9         1       1    18             2
                                                          2       1    19             2
                                                          3       2    32 34          2 1
                                                          4       1    35             1
                                                          5       1    40             2
                                                          6       2    42 41          2 2
                                                          7       2    46 45          1 1
                                                          8       2    50 49          2 2
                                                          9       1    51             1
     4     2    B     LEFT     330.0   90.0     4         1       1    2              3
                                                          2       2    3 4            3 3
                                                          3       1    54             1
                                                          4       1    5              3
     5     3    A     RIGHT    512.0   48.0    13         1       1    20             2
                                                          2       1    21             2
                                                          3       1    22             2
                                                          4       1    9              2
                                                          5       1    10             2
                                                          6       1    11             2
                                                          7       1    12             2
                                                          8       1    13             2
                                                          9       2    15 14          2 2
                                                         10       1    36             2
                                                         11       1    61             2
                                                         12       1    37             2
                                                         13       1    62             2
     6     3    A     RIGHT    512.0   48.0    12         1       1    68             2
                                                          2       1    69             2
                                                          3       2    56 55          2 2
                                                          4       1    57             2
                                                          5       1    63             2
                                                          6       1    72             2
                                                          7       2    71 70          2 2
                                                          8       2    73 77          2 2
                                                          9       2    78 74          2 2
                                                         10       1    64             1
                                                         11       1    75             2
                                                         12       1    76             2
     7     3    B     LEFT     512.0   90.0     9         1       1    52             1
                                                          2       1    53             1
                                                          3       1    58             1
                                                          4       1    59             1
                                                          5       1    65             1
                                                          6       1    60             1
                                                          7       1    66 67          1 1
                                                          8       1    6              3
                                                          9       2    7 8            3 3
** # of interfering panels
0
```

M4-2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11
24
12
1
2
3
4
5
6

M4-2: Shewchuk (2008)

** Nzones
2

**zone	left edge X coordinate
1	6.0
2	222.0

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	12	1	1	13	2
							2	1	19	1
							3	1	20	1
							4	1	21	1
							5	1	22	1
							6	2	24 23	1 1
							7	1	25	2
							8	1	27	1
							9	1	32	2
							10	1	36	1
							11	1	38	2
							12	1	1	3
2	2	A	RIGHT	421.0	48.0	12	1	1	14	2
							2	1	15	2
							3	1	16	2
							4	1	17	2
							5	1	18	2
							6	1	7	2
							7	1	8	2
							8	1	9	2
							9	1	10	2
							10	2	12 11	2 2
							11	1	26	2
							12	1	28	2
3	2	A	RIGHT	421.0	48.0	17	1	1	30	2
							2	1	49	2
							3	2	31 29	2 2
							4	1	33	2
							5	1	34	2
							6	1	35	2
							7	1	37	2
							8	1	50	2
							9	1	54	2
							10	2	44 55	2 2
							11	2	39 45	2 2
							12	1	40	2
							13	1	41	2
							14	1	46	2
							16	1	58	2
							17	2	57 56	2 2
4	2	A	RIGHT	421.0	48.0	4	1	2	60 63	2 2
							2	2	59 64	2 2
							3	1	61	2
							4	1	62	2
5	2	B	LEFT	421.0	90.0	9	1	1	42	1
							2	1	2	3
							3	1	3	3
							4	1	43	1
							5	1	47	1
							6	1	48	1
							7	1	4	3
							8	1	5	3
							9	1	6	3
6	2	B	LEFT	421.0	90.0	3	1	1	51	2
							2	1	52	1
							3	1	53	1

** # of interfering panels
3: 51 52 53

M4-2: Proposed algorithm

** Nzones
3

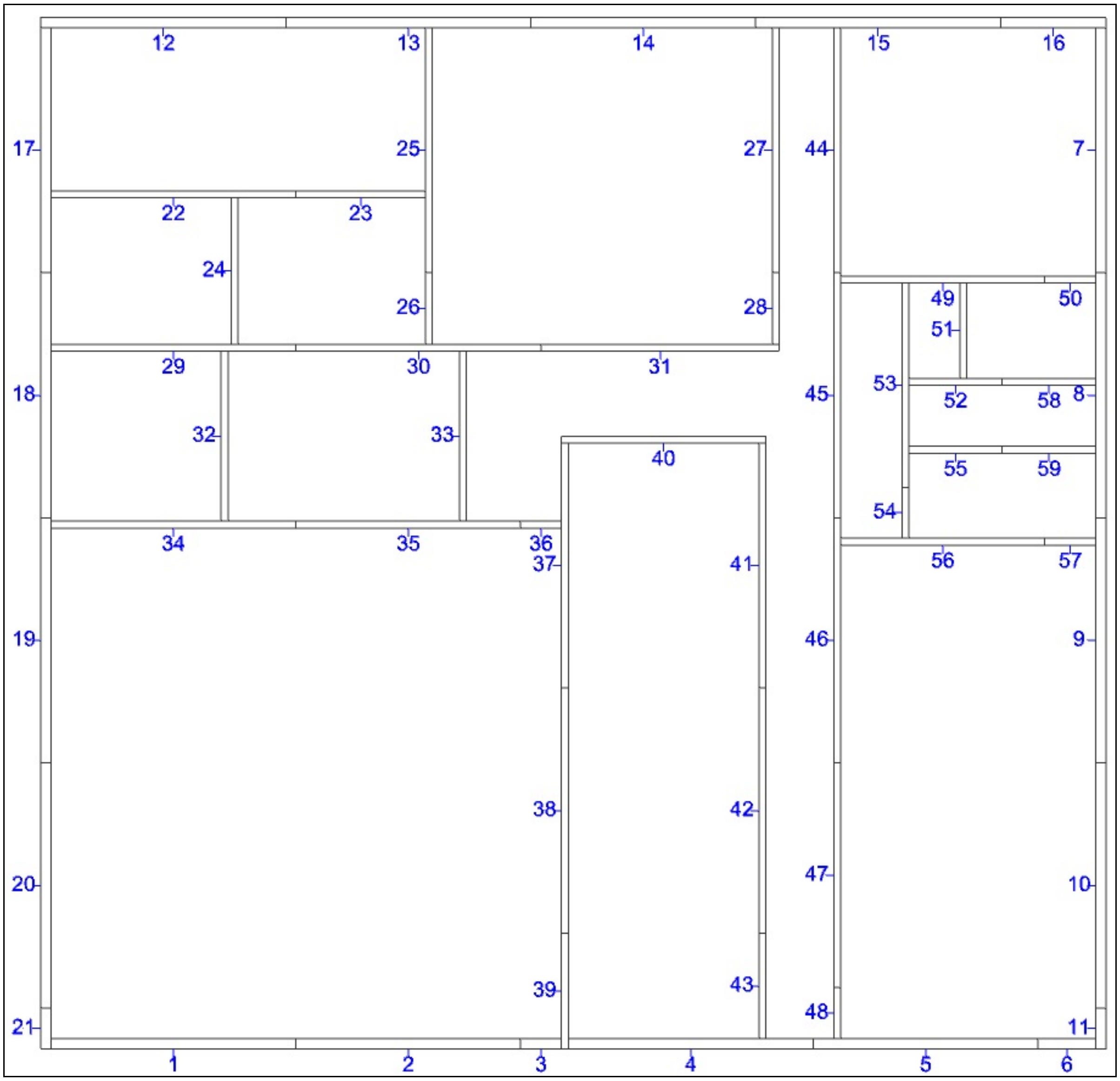
**zone	left edge X coordinate
1	6.0
2	211.0
3	408.0

** NStacks
6

** stack ** #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	12	1	1	13	2
							2	1	19	1
							3	1	20	1
							4	1	21	1
							5	1	22	1
							6	2	24 23	1 1
							7	1	25	2
							8	1	27	1
							9	1	32	2
							10	1	36	1
							11	1	38	2
							12	1	1	3
2	2	A	RIGHT	330.0	48.0	12	1	1	14	2
							2	1	15	2
							3	1	26	2
							4	1	28	1
							5	1	29	1
							6	1	33	2
							7	1	34	2
							8	1	35	2
							9	1	37	1
							10	1	39	2
							11	1	40	2
							12	1	41	1
3	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	1	43	1
							4	1	4	3
4	3	A	RIGHT	512.0	48.0	13	1	1	16	2
							2	1	17	2
							3	1	18	2
							4	1	7	2
							5	1	8	2
							6	1	9	2
							7	1	10	2
							8	2	12 11	2 2
							9	1	30	2
							10	1	49	2
							11	1	31	2
							12	1	50	2
							13	1	54	2
5	3	A	RIGHT	512.0	48.0	9	1	2	44 55	2 2
							2	2	46 45	2 2
							3	1	51	2
							4	1	58	2
							5	2	57 56	2 2
							6	2	60 63	2 2
							7	2	59 64	2 2
							8	1	61	2
							9	1	62	2
6	3	B	LEFT	512.0	90.0	6	1	1	42	1
							2	1	47	1
							3	1	48	1
							4	1	52 53	1 1
							5	1	5	3
							6	1	6	3

** # of interfering panels
0

M4-3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46
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42
20
47
10
39
43
48
21
11
1
2
3
4
5
6

M4-3: Shewchuk (2008)

** Nzones
2

**zone	left edge X coordinate
1	6.0
2	226.5

** NStacks
6

** stack ** #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	12	2
							2	1	17	1
							3	1	18	1
							4	1	19	1
							5	1	20	1
							6	1	21	1
							7	1	22	2
							8	1	23	2
							9	1	24	1
							10	1	29	2
							11	1	32	1
							12	1	34	2
							13	1	1	3
2	2	A	RIGHT	423.2	57.3	13	1	1	13	2
							2	1	14	2
							3	1	15	2
							4	1	16	2
							5	1	7	2
							6	1	8	2
							7	1	9	2
							8	1	10	2
							9	1	11	2
							10	1	25	2
							11	1	27	2
							12	1	44	2
							13	2	28 26	2 2
3	2	A	RIGHT	423.2	57.3	13	1	1	30	2
							2	1	31	2
							3	1	33	2
							4	1	40	2
							5	1	35	2
							6	1	36	2
							7	1	45	2
							8	1	49	2
							9	1	50	2
							10	1	53	2
							11	2	52 51	2 2
							12	2	55 58	2 2
							13	2	54 59	2 2
4	2	A	RIGHT	423.2	57.3	2	1	1	56	2
							2	1	57	2
5	2	B	LEFT	423.2	99.3	3	1	1	37	1
							2	1	41	1
							3	1	38	1
6	2	B	LEFT	423.2	99.3	10	1	1	2	3
							2	2	3 39	3 1
							3	1	42	1
							4	1	43	1
							5	1	46	1
							6	1	4	3
							7	1	5	3
							8	1	6	3
							9	1	47	1
							10	1	48	1

** # of interfering panels
2: 47 48

M4-3: Proposed algorithm

** Nzones
3

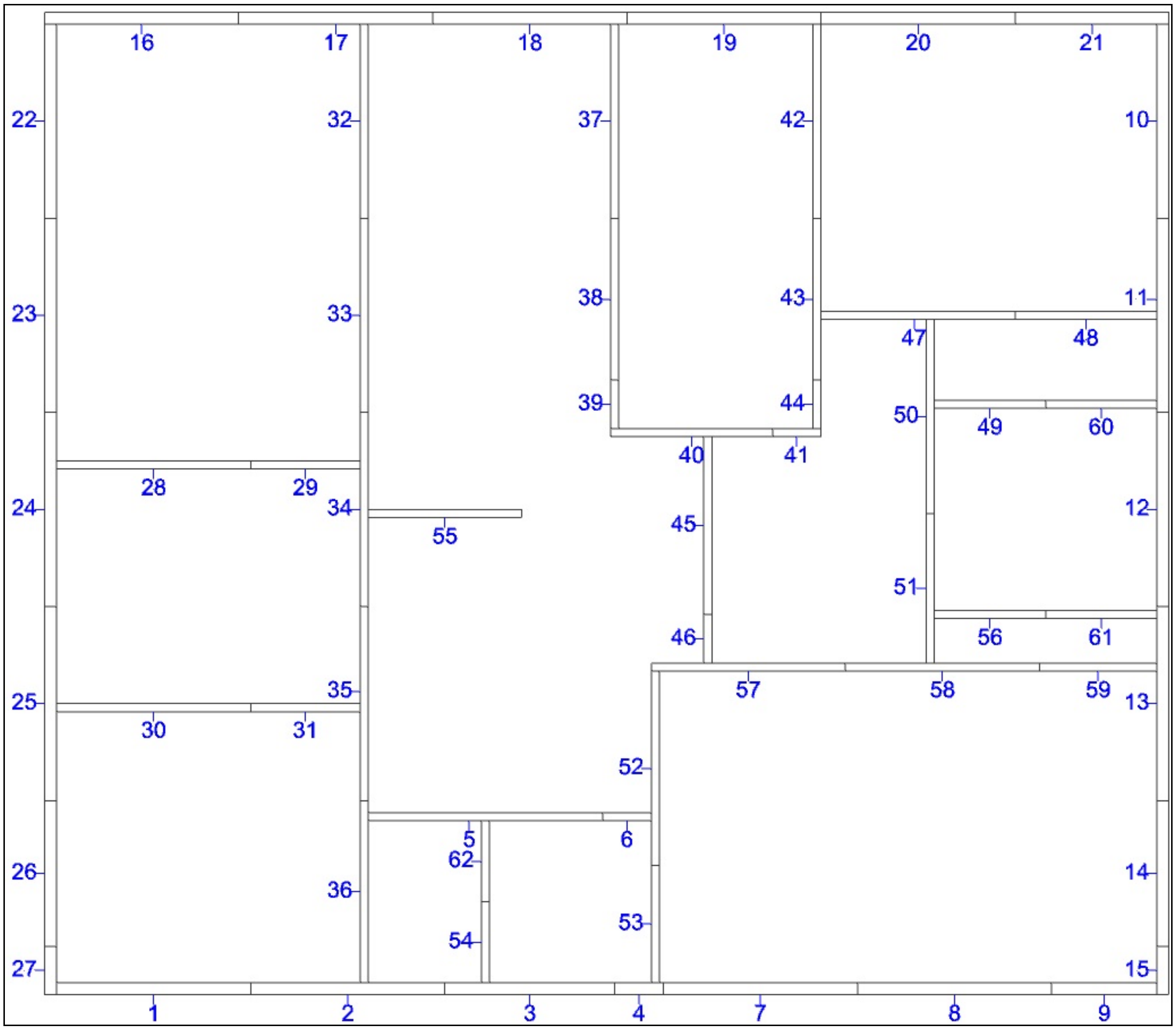
**zone	left edge X coordinate
1	6.0
2	215.5
3	399.5

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	12	2
							2	1	17	1
							3	1	18	1
							4	1	19	1
							5	1	20	1
							6	1	21	1
							7	1	22	2
							8	1	23	2
							9	1	24	1
							10	1	29	2
							11	1	32	1
							12	1	34	2
							13	1	1	3
2	2	A	RIGHT	336.7	57.3	9	1	1	13	2
							2	1	14	2
							3	1	25	1
							4	1	26	1
							5	1	30	2
							6	1	31	2
							7	1	33	1
							8	1	35	2
							9	1	36	2
3	2	B	LEFT	336.7	99.3	2	1	1	2	3
							2	2	3 39	3 1
4	3	A	RIGHT	509.8	57.3	14	1	1	15	2
							2	1	16	2
							3	1	7	2
							4	1	8	2
							5	1	9	2
							6	1	10	2
							7	1	11	2
							8	1	27	2
							9	1	44	2
							10	1	28	2
							11	1	40	2
							12	1	45	2
							13	1	49	2
							14	1	50	2
5	3	A	RIGHT	509.8	57.3	7	1	1	53	2
							2	2	52 51	2 2
							3	2	55 58	2 2
							4	2	54 59	2 2
							5	1	46	1
							6	1	56	2
							7	1	57	2
6	3	B	LEFT	509.8	99.3	9	1	1	37	1
							2	1	38	1
							3	1	41	1
							4	1	42	1
							5	1	43	1
							6	2	47 48	1 1
							7	1	4	3
							8	1	5	3
							9	1	6	3

** # of interfering panels
0

M5-1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27
15
1
2
3
4
7
8
9

M5-1: Shewchuk (2008)

** Nzones
2

**zone left edge X coordinate
1 6.0
2 222.0

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	14	1	1	16	2
							2	1	17	2
							3	1	22	1
							4	1	23	1
							5	1	24	1
							6	1	25	1
							7	2	27 26	1 1
							8	1	32	1
							9	1	33	1
							10	1	28	2
							11	1	29	2
							12	1	34	1
							13	1	30	2
							14	1	31	2
2	1	A	RIGHT	114.0	48.0	1	1	1	1	2
3	2	A	RIGHT	386.0	48.0	13	1	1	18	2
							2	1	19	2
							3	1	20	2
							4	1	21	2
							5	1	10	2
							6	1	11	2
							7	1	12	2
							8	1	13	2
							9	2	15 14	2 2
							10	1	37	2
							11	1	42	2
							12	1	38	2
							13	1	43	2
4	2	A	RIGHT	386.0	48.0	9	1	1	47	2
							2	3	44 39 48	2 2 2
							3	2	41 40	2 2
							4	1	55	2
							5	1	45	2
							6	1	50	2
							7	3	46 60 49	2 2 2
							8	1	51	2
							9	1	57	2
5	2	B	LEFT	386.0	90.0	7	1	1	2	3
							2	1	35	1
							3	2	36 62	1 1
							4	1	54	1
							5	2	5 6	2 2
							6	1	52	1
							7	1	53	1
6	2	B	LEFT	386.0	90.0	7	1	2	3 4	3 3
							2	1	7	3
							3	1	8	3
							4	1	9	3
							5	2	56 61	2 2
							6	1	58	2
							7	1	59	2

** # of interfering panels
4: 56 61 58 59

```
M5-1: Proposed algorithm

** Nzones
3

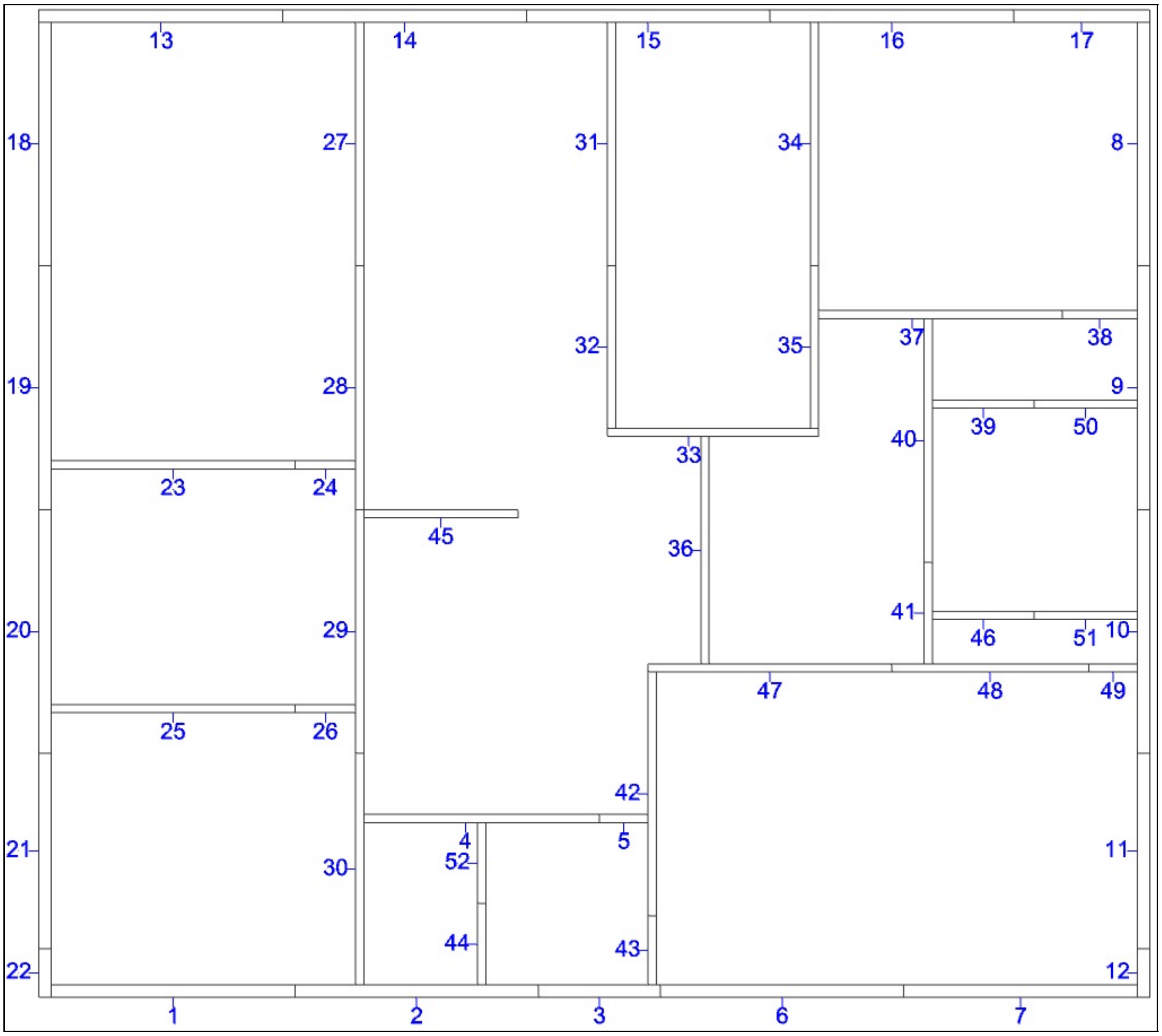
**zone      left edge X coordinate
  1           6.0
  2         212.0
  3         334.0

** NStacks
6

** stack                flush
**   #    zone type   edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1      1     A     RIGHT   114.0   48.0      14          1        1     16              2
                                                              2        1     17              2
                                                              3        1     22              1
                                                              4        1     23              1
                                                              5        1     24              1
                                                              6        1     25              1
                                                              7        2     27 26           1 1
                                                              8        1     32              1
                                                              9        1     33              1
                                                             10        1     28              2
                                                             11        1     29              2
                                                             12        1     34              1
                                                             13        1     30              2
                                                             14        1     31              2
     2      1     A     RIGHT   114.0   48.0       1          1        1     1               2
     3      2     A     RIGHT   330.0   48.0      10          1        1     18              2
                                                              2        1     19              2
                                                              3        1     37              1
                                                              4        1     42              1
                                                              5        1     38              1
                                                              6        3     44 39 43        1 1 1
                                                              7        2     41 40           2 2
                                                              8        1     55              2
                                                              9        2     46 45           1 1
                                                             10        1     57              2
     4      2     B     LEFT    330.0   90.0       5          1        1     2               3
                                                              2        2     3 4             3 3
                                                              3        1     7               3
                                                              4        1     35              1
                                                              5        1     36              1
     5      3     A     RIGHT   442.0   48.0      14          1        1     20              2
                                                              2        1     21              2
                                                              3        1     10              2
                                                              4        1     11              2
                                                              5        1     12              2
                                                              6        1     13              2
                                                              7        2     15 14           2 2
                                                              8        1     47              2
                                                              9        1     48              2
                                                             10        1     50              2
                                                             11        2     60 49           2 2
                                                             12        2     56 51           2 2
                                                             13        1     61              2
                                                             14        1     58              2
     6      3     B     LEFT    442.0   48.0       7          1        1     59              1
                                                              2        1     8               1
                                                              3        1     9               1
                                                              4        2     5 6             2 2
                                                              5        2     62 54           1 1
                                                              6        2     52              2
                                                              7        1     53              2

** # of interfering panels
0
```

M5-2



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M5-2: Shewchuk (2008)

** Nzones
2

**zone	left edge X coordinate
1	6.0
2	222.0

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	12	1	1	13	2
							2	1	18	1
							3	1	19	1
							4	1	20	1
							5	2	22 21	1 1
							6	1	23	2
							7	1	24	2
							8	1	28	1
							9	1	25	2
							10	1	26	2
							11	1	29	1
							12	1	1	2
2	2	A	RIGHT	381.5	48.0	13	1	1	14	2
							2	1	15	2
							3	1	16	2
							4	1	17	2
							5	1	8	2
							6	1	9	2
							7	1	10	2
							8	2	12 11	2 2
							9	1	27	2
							10	1	31	2
							11	1	34	2
							12	1	32	2
							13	1	35	2
3	2	A	RIGHT	381.5	48.0	8	1	1	37	2
							2	2	33 38	2 2
							3	1	45	2
							4	1	36	2
							5	1	40	2
							6	2	50 39	2 2
							7	1	41	2
							8	1	47	2
4	2	B	LEFT	381.5	90.0	5	1	1	30	1
							2	2	4 5	2 2
							3	2	52 44	1 1
							4	1	42	1
							5	1	43	1
5	2	B	LEFT	381.5	90.0	6	1	1	2	3
							2	1	3	3
							3	1	6	3
							4	1	7	3
							5	2	46 51	2 2
							6	2	48 49	2 2

** # of interfering panels
4: 46 51 48 49

```
M5-2: Proposed algorithm

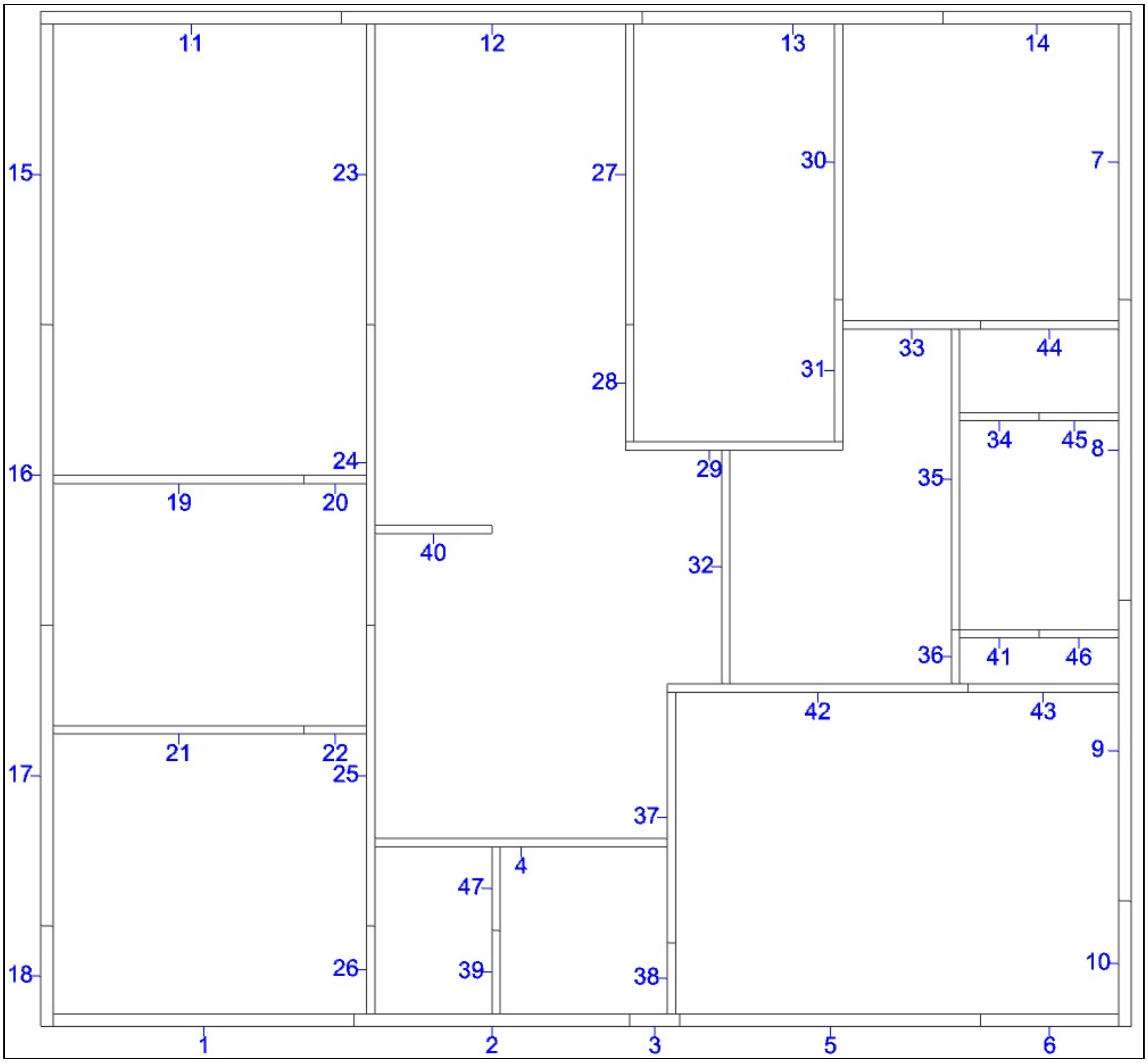
** Nzones
3

**zone    left edge X coordinate
  1          6.0
  2        211.0
  3        325.0

** NStacks
5

** stack              flush
**   #    zone type   edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1     1    A     RIGHT   114.0    48.0     12          1         1    13            2
                                                            2         1    18            1
                                                            3         1    19            1
                                                            4         1    20            1
                                                            5         2    22 21         1 1
                                                            6         1    23            2
                                                            7         1    24            2
                                                            8         1    28            1
                                                            9         1    25            2
                                                           10         1    26            2
                                                           11         1    29            1
                                                           12         1    1             2
     2     2    A     RIGHT   330.0    48.0      9          1         1    14            2
                                                            2         1    15            2
                                                            3         1    27            1
                                                            4         1    31            1
                                                            5         1    32            1
                                                            6         1    33            2
                                                            7         1    45            2
                                                            8         1    36            1
                                                            9         1    47            2
     3     2    B     LEFT    330.0    90.0      4          1         1    2             3
                                                            2         1    3             3
                                                            3         1    6             3
                                                            4         1    30            1
     4     3    A     RIGHT   433.0    48.0     14          1         1    16            2
                                                            2         1    17            2
                                                            3         1    8             2
                                                            4         1    9             2
                                                            5         1    10            2
                                                            6         2    12 11         2 2
                                                            7         1    34            2
                                                            8         1    35            2
                                                            9         1    37            2
                                                           10         1    38            2
                                                           11         1    40            2
                                                           12         2    50 39         2 2
                                                           13         2    46 41         2 2
                                                           14         1    51            2
     5     3    A     RIGHT   433.0    48.0      6          1         2    49 48         1 1
                                                            2         1    7             1
                                                            3         2    4 5           1 1
                                                            4         1    52 44       2 1
                                                            5         1    42            2
                                                            6         1    43            1
** # of interfering panels
0
```

M5-3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M5-3: Shewchuk (2008)

** Nzones
2

**zone left edge X coordinate

1	6.0
2	226.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	12	1	1	11	2
							2	1	15	1
							3	1	16	1
							4	1	17	1
							5	1	18	1
							6	1	19	2
							7	1	20	2
							8	1	24	1
							9	1	40	2
							10	1	21	2
							11	1	22	2
							12	1	1	3
2	2	A	RIGHT	371.2	57.3	14	1	1	12	2
							2	1	13	2
							3	1	14	2
							4	1	7	2
							5	1	8	2
							6	1	9	2
							7	1	10	2
							8	1	23	2
							9	1	27	2
							10	1	30	2
							11	2	31 28	2 2
							12	2	44 33	2 2
							13	1	29	2
							14	1	32	2
3	2	A	RIGHT	371.2	57.3	5	1	1	35	2
							2	4	41 36 45 34	2 2 2 2
							3	1	46	2
							4	1	42	2
							5	1	43	2
4	2	B	LEFT	371.2	99.3	3	1	1	25	1
							2	3	26 47 39	1 1 1
							3	1	4	2
5	2	B	LEFT	371.2	99.3	6	1	1	2	3
							2	1	3	3
							3	1	5	3
							4	1	6	3
							5	1	37	1
							6	1	38	1

** # of interfering panels
2: 37 38

M5-3: Proposed algorithm

** Nzones
3

**zone left edge X coordinate

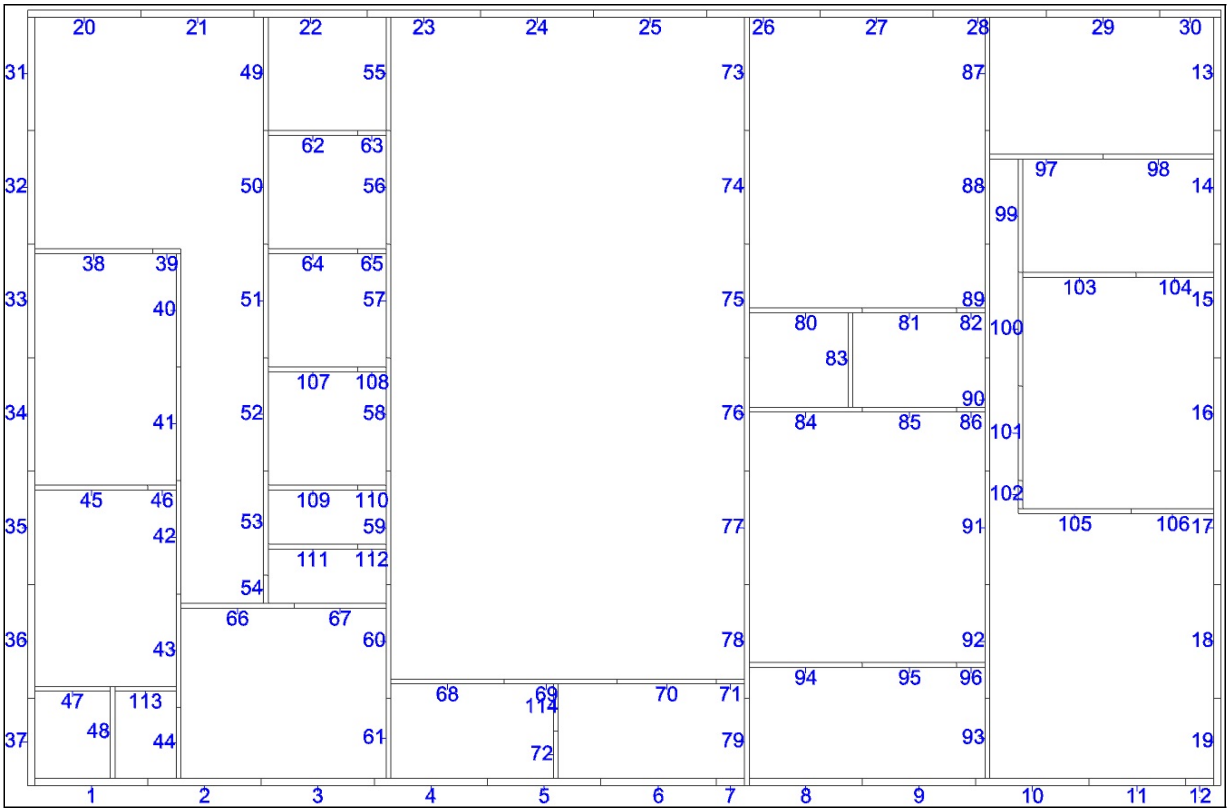
**zone	left edge X coordinate
1	6.0
2	211.5
3	295.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	12	1	1	11	2
							2	1	15	1
							3	1	16	1
							4	1	17	1
							5	1	18	1
							6	1	19	2
							7	1	20	2
							8	1	24	1
							9	1	40	2
							10	1	21	2
							11	1	22	2
							12	1	1	3
2	2	A	RIGHT	336.7	57.3	9	1	1	12	2
							2	1	13	2
							3	1	23	1
							4	1	27	1
							5	1	30	1
							6	2	31 28	1 1
							7	1	29	2
							8	1	32	1
							9	1	42	2
3	2	B	LEFT	336.7	99.3	4	1	1	2	3
							2	1	3	3
							3	1	25	1
							4	1	26	1
4	3	A	RIGHT	405.8	57.3	11	1	1	14	2
							2	1	7	2
							3	1	8	2
							4	1	9	2
							5	2	33 10	2 2
							6	1	44	2
							7	1	35	2
							8	4	41 36 45 34	2 2 2 2
							9	2	43 46	2 2
							10	1	5	3
							11	1	6	3
5	3	B	LEFT	405.8	99.3	4	1	1	4	2
							2	2	47 39	1 1
							3	1	37	1
							4	1	38	1

** # of interfering panels
0

L1-1



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```
L1-1: Shewchuk (2008)
** Nzones
4
** NStacks
13
**zone     left edge X coordinate
 1          6.0
 2        222.0
 3        438.0
 4        654.0
** stack              flush
**   #   zone type   edge      xloc   yloc  #layers  j   #panels   panels      orientation
     1     1    A    RIGHT   114.0   48.0     13        1     1     20            2
                                                        2     1     21            2
                                                        3     1     31            1
                                                        4     1     32            1
                                                        5     1     33            1
                                                        6     1     34            1
                                                        7     1     35            1
                                                        8     1     36            1
                                                        9     1     37            1
                                                       10     2     39 38         2 2
                                                       11     1     40            1
                                                       12     1     41            1
                                                       13     2     46 45         2 2
     2     1    A    RIGHT   114.0   48.0      3        1     1     42            1
                                                        2     1     47            2
                                                        3     1     1             2
     3     2    A    RIGHT   330.0   48.0     16        1     1     22            2
                                                        2     1     23            2
                                                        3     1     49            1
                                                        4     1     55            1
                                                        5     1     50            1
                                                        6     2     63 62         2 2
                                                        7     1     56            1
                                                        8     1     51            1
                                                        9     2     65 64         2 2
                                                       10     1     57            1
                                                       11     1     52            1
                                                       12     2     108 107         2 2
                                                       13     1     58            1
                                                       14     1     53            1
                                                       15     2     110 109       2 2
                                                       16     3     54 112 111    1 2 2
     4     2    A    RIGHT   330.0   48.0      5        1     1     59            1
                                                        2     1     66            2
                                                        3     1     67            2
                                                        4     1     60            1
                                                        5     1     68            2
     5     2    B    LEFT    330.0   90.0      6        1     1     2             3
                                                        2     1     3             3
                                                        3     1     4             3
                                                        4     2     48 113        1 2
                                                        5     1     43            1
                                                        6     1     44            1
     6     3    A    RIGHT   546.0   48.0      5        1     1     24            2
                                                        2     1     25            2
                                                        3     1     69            2
                                                        4     2     71 70         2 2
                                                        5     1     78            1
     7     3    B    LEFT    546.0   90.0      3        1     1     5             3
                                                        2     2     6 7           3 3
                                                        3     2     79 61         1 1
     8     4    A    RIGHT   830.0   48.0     11        1     1     26            2
                                                        2     1     27            2
                                                        3     1     28            2
                                                        4     1     29            2
                                                        5     1     30            2
                                                        6     1     13            2
                                                        7     1     14            2
                                                        8     1     15            2
                                                        9     1     16            2
                                                       10     1     17            2
                                                       11     1     18            2
```

L1-1: Shewchuk (2008)

9	4	A	RIGHT	830.0	48.0	17	1	1	19	2
							2	1	73	2
							3	1	87	2
							4	1	74	2
							5	1	88	2
							6	1	97	2
							7	1	98	2
							8	1	75	2
							9	1	80	2
							10	2	82 81	2 2
							11	1	76	2
							12	1	83	2
							13	1	89	2
							14	1	99	2
							15	1	84	2
							16	2	86 85	2 2
							17	1	90	2
10	4	A	RIGHT	830.0	48.0	7	1	1	100	2
							2	1	103	2
							3	1	104	2
							4	1	77	2
							5	2	102 101	2 2
							6	1	94	2
							7	2	96 95	2 2
11	4	B	LEFT	830.0	90.0	1	1	2	114 72	1 1
12	4	B	LEFT	830.0	90.0	4	1	1	8	3
							2	1	9	3
							3	1	10	3
							4	2	11 12	3 3
13	4	B	LEFT	830.0	90.0	5	1	1	91	1
							2	1	105	2
							3	1	106	2
							4	1	92	1
							5	1	93	1

** # of interfering panels
5: 91 105 106 92 93

L1-1: Proposed algorithm
** Nzones 5
** NStacks 13

**zone	left edge X coordinate
1	6.0
2	212.0
3	416.0
4	642.0
5	790.0

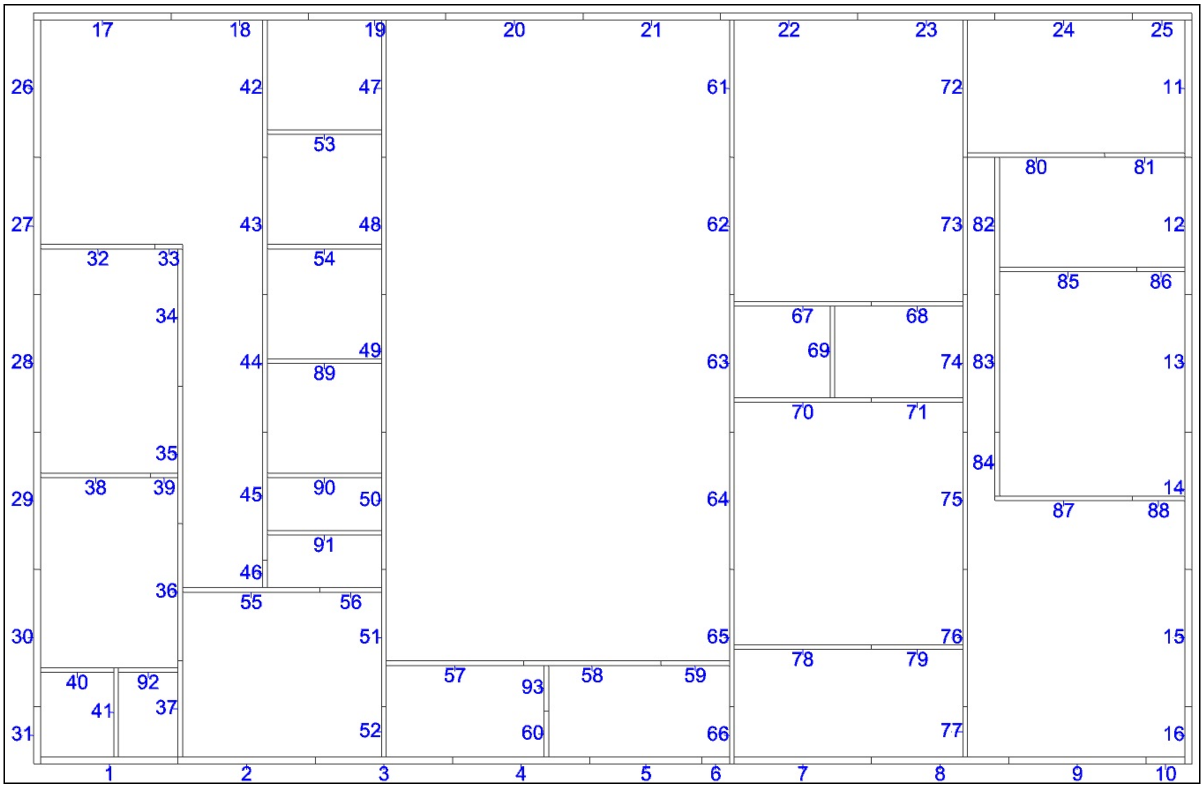
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	13	1	1	20	2
							2	1	21	2
							3	1	31	1
							4	1	32	1
							5	1	33	1
							6	1	34	1
							7	1	35	1
							8	1	36	1
							9	1	37	1
							10	2	39 38	2 2
							11	1	40	1
							12	1	41	1
							13	2	46 45	2 2
2	1	A	RIGHT	114.0	48.0	3	1	1	42	1
							2	1	47	2
							3	1	1	2
3	2	A	RIGHT	330.0	48.0	16	1	1	22	2
							2	1	23	2
							3	1	49	1
							4	1	55	1
							5	1	50	1
							6	2	63 62	2 2
							7	1	56	1
							8	1	51	1
							9	2	65 64	2 2
							10	1	57	1
							11	1	52	1
							12	2	108 107	2 2
							13	1	58	1
							14	1	53	1
							15	2	110 109	2 2
							16	3	54 112 111	1 2 2

L1-1: Proposed algorithm

4	2	A	RIGHT	330.0	48.0	5	1	1	59	1
							2	1	66	2
							3	1	67	2
							4	1	60	1
							5	1	68	2
5	2	B	LEFT	330.0	90.0	6	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	2	48 113	1 2
							5	1	43	1
							6	1	44	1
6	3	A	RIGHT	546.0	48.0	5	1	1	24	2
							2	1	25	2
							3	1	69	2
							4	2	71 70	2 2
							5	1	78	1
7	4	B	LEFT	546.0	90.0	6	1	1	5	3
							2	2	6 7	3 3
							3	1	79	1
							4	1	77	1
							5	2	61 114	1 1
							6	1	72	1
8	4	A	RIGHT	762.0	48.0	16	1	1	26	2
							2	1	27	2
							3	1	28	2
							4	1	73	1
							5	1	87	1
							6	1	74	1
							7	1	88	1
							8	1	75	1
							9	1	80	2
							10	2	82 81	2 2
							11	1	76	1
							12	1	83	1
							13	1	89	1
							14	1	84	2
							15	2	86 85	2 2
							16	1	90	1
9	4	A	RIGHT	762.0	48.0	3	1	1	91	1
							2	1	94	2
							3	2	96 95	2 2
10	4	B	LEFT	762.0	90.0	2	1	1	8	3
							2	1	9	3
11	5	A	RIGHT	898.0	48.0	13	1	1	29	2
							2	1	30	2
							3	1	13	2
							4	1	14	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	19	2
							10	1	97	2
							11	1	98	2
							12	1	99	2
							13	1	100	2
12	5	A	RIGHT	898.0	48.0	7	1	1	103	2
							2	1	104	2
							3	2	102 101	2 2
							4	1	105	2
							5	1	106	2
							6	1	10	2
							7	2	12 11	2 2
13	5	B	LEFT	898.0	90.0	1	1	1	93	1
							4	1	92	1

** # of interfering panels
2: 93 92

L1-2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L1-2: Shewchuk (2008)

```
** Nzones 4
** NStacks 11
**zone      left edge X coordinate
 1           6.0
 2         222.0
 3         438.0
 4         654.0
** stack                 flush
**   #    zone type    edge      xloc    yloc   #layers   j  #panels   panels      orientation
     1     1    A      RIGHT    114.0    48.0     14       1     1      17              2
                                                           2     1      26              1
                                                           3     1      27              1
                                                           4     1      28              1
                                                           5     1      29              1
                                                           6     1      30              1
                                                           7     1      31              1
                                                           8     2      33 32           2 2
                                                           9     1      34              1
                                                          10     2      39 38           2 2
                                                          11     1      35              1
                                                          12     1      36              1
                                                          13     1      40              2
                                                          14     1       1              2
     2     2    A      RIGHT    330.0    48.0     16       1     1      18              2
                                                           2     1      19              2
                                                           3     1      42              1
                                                           4     1      53              2
                                                           5     1      47              1
                                                           6     1      43              1
                                                           7     1      54              2
                                                           8     1      48              1
                                                           9     1      44              1
                                                          10     1      89              2
                                                          11     1      49              1
                                                          12     1      45              1
                                                          13     1      90              2
                                                          14     2      46 91           1 2
                                                          15     1      50              1
                                                          16     1      55              2
     3     2    A      RIGHT    330.0    48.0      1       1     1      56              2
     4     2    B      LEFT     330.0    90.0      4       1     1      2               3
                                                           2     1      3               3
                                                           3     2      41 92           1 2
                                                           4     1      37              1
     5     3    A      RIGHT    546.0    48.0      2       1     1      20              2
                                                           2     1      21              2
     6     3    B      LEFT     546.0    90.0      6       1     1      4               3
                                                           2     2      5 6             3 3
                                                           3     1      66              1
                                                           4     1      51              1
                                                           5     1      57              2
                                                           6     1      52              1
     7     4    A      RIGHT    830.0    48.0     12       1     1      22              2
                                                           2     1      23              2
                                                           3     1      24              2
                                                           4     1      25              2
                                                           5     1      11              2
                                                           6     1      12              2
                                                           7     1      13              2
                                                           8     1      14              2
                                                           9     1      15              2
                                                          10     1      16              2
                                                          11     1      61              2
                                                          12     1      72              2
     8     4    A      RIGHT    830.0    48.0     17       1     1      80              2
                                                           2     1      81              2
                                                           3     1      62              2
                                                           4     1      73              2
                                                           5     1      82              2
                                                           6     1      85              2
                                                           7     1      86              2
                                                           8     1      63              2
                                                           9     1      67              2
                                                          10     1      68              2
                                                          11     1      69              2
                                                          12     1      70              2
                                                          13     1      71              2
                                                          14     1      74              2
                                                          15     1      83              2
                                                          16     1      64              2
                                                          17     1      75              2
```

L1-2: Shewchuk (2008)

9	4	A	RIGHT	830.0	48.0	5	1	1	84	2
							2	1	58	2
							3	1	59	2
							4	1	78	2
							5	1	79	2
10	4	B	LEFT	830.0	90.0	3	1	1	93	1
							2	1	65	1
							3	1	60	1
11	4	B	LEFT	830.0	90.0	5	1	1	7	3
							2	1	8	3
							3	1	9	3
							4	1	10	3
							5	1	76	1
							6	1	77	1
							7	1	87	2
							8	1	88	2

** # of interfering panels
4: 76 77 87 88

L1-2: Proposed algorithm
** Nzones 5
** NStacks 11

**zone	left edge X coordinate
1	6.0
2	213.0
3	429.0
4	642.0
5	788.0

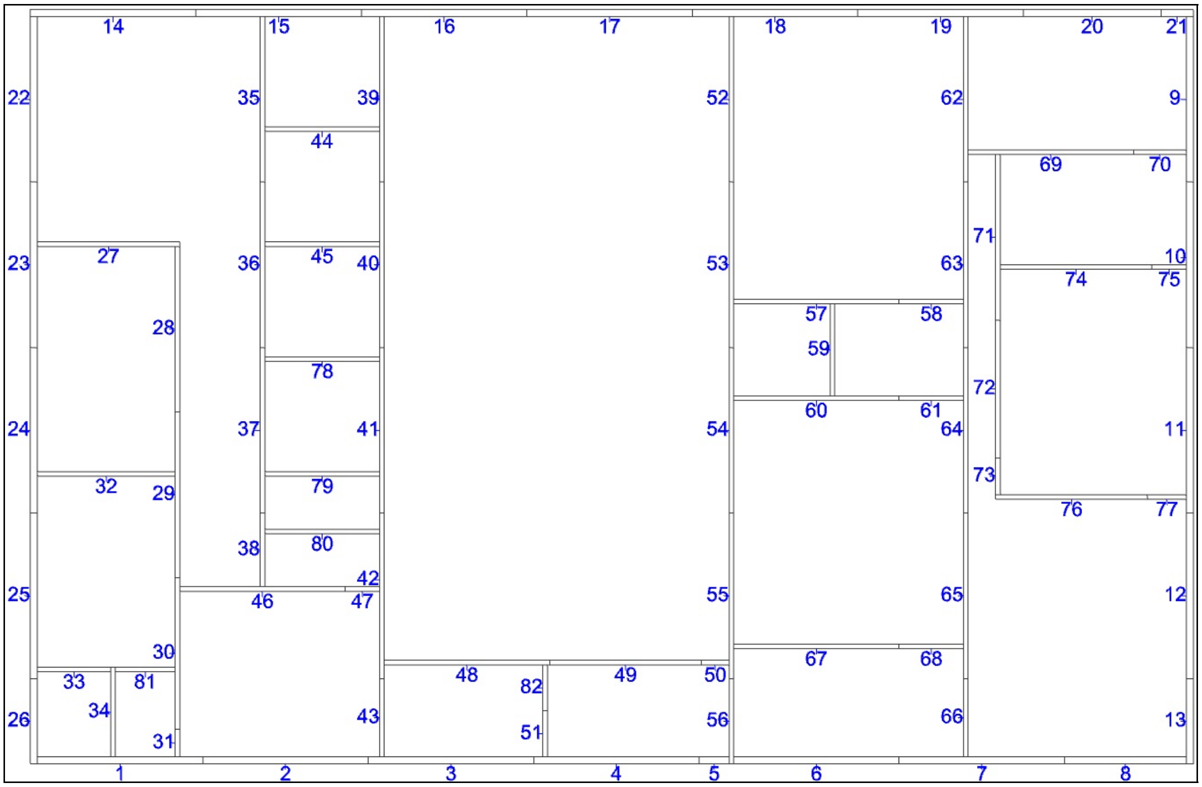
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	13	1	1	17	2
							2	1	26	1
							3	1	27	1
							4	1	28	1
							5	1	29	1
							6	1	30	1
							7	1	31	1
							8	2	33 32	2 2
							9	1	34	1
							10	2	39 38	2 2
							11	1	35	1
							12	1	36	1
							13	1	40	2
							13	1	1	2
2	2	A	RIGHT	330.0	48.0	17	1	1	18	2
							2	1	19	2
							3	1	42	1
							4	1	53	2
							5	1	47	1
							6	1	43	1
							7	1	54	2
							8	1	48	1
							9	1	44	1
							10	1	89	2
							11	1	49	1
							12	1	45	1
							13	1	90	2
							14	2	46 91	1 2
							15	1	50	1
							16	1	55	2
							17	1	56	2
3	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	2	41 92	1 2
							4	1	37	1
4	3	A	RIGHT	546.0	48.0	2	1	1	20	2
							2	1	21	2
5	3	B	LEFT	546.0	90.0	9	1	1	4	3
							2	2	5 6	3 3
							3	1	66	1
							4	1	51	1
							5	1	57	2
							6	1	58	2
							7	3	59 52 93	2 1 1
							8	1	65	1
							9	1	60	1

L1-2: Proposed algorithm

6	4	A	RIGHT	762.0	48.0	16	1	1	22	2
							2	1	23	2
							3	1	61	1
							4	1	72	1
							5	1	62	1
							6	1	73	1
							7	1	63	1
							8	1	67	2
							9	1	68	2
							10	1	69	1
							11	1	70	2
							12	1	71	2
							13	1	74	1
							14	1	64	1
							16	1	78	2
7	4	A	RIGHT	762.0	48.0	1	1	1	79	2
8	4	B	LEFT	762.0	90.0	2	1	1	7	3
							2	1	8	3
9	5	A	RIGHT	898.0	48.0	13	1	1	24	2
							2	1	25	2
							3	1	11	2
							4	1	12	2
							5	1	13	2
							6	1	14	2
							7	1	15	2
							8	1	16	2
							9	1	80	2
							10	1	81	2
							11	1	82	2
							12	1	85	2
							13	1	86	2
10	5	A	RIGHT	898.0	48.0	6	1	1	83	2
							2	1	84	2
							3	1	87	2
							4	1	88	2
							5	1	9	2
							6	1	10	2
11	5	B	LEFT	898.0	90.0	3	1	1	77	1
							2	1	76	1
							15	1	75	1

** # of interfering panels
3: 77 76 75

L1-3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L1-3: Shewchuk (2008)

```
** Nzones 4
**zone       left edge X coordinate
 1            6.0
 2          226.5
 3          446.9
 4          667.4
** NStacks 10
** stack                flush
**    #    zone type    edge     xloc    yloc   #layers   j   #panels   panels       orientation
      1     1    A      RIGHT    116.2   57.3     11          1          1    14              2
                                                              2          1    22              1
                                                              3          1    23              1
                                                              4          1    24              1
                                                              5          1    25              1
                                                              6          1    26              1
                                                              7          1    27              2
                                                              8          1    28              1
                                                              9          1    32              2
                                                             10          1    29              1
                                                             11          1    1               2
      2     2    A      RIGHT    336.7   57.3     16          1          1    15              2
                                                              2          1    16              2
                                                              3          1    35              1
                                                              4          1    44              2
                                                              5          1    39              1
                                                              6          1    36              1
                                                              7          1    45              2
                                                              8          1    40              1
                                                              9          1    37              1
                                                             10          1    78              2
                                                             11          1    79              2
                                                             12          1    41              1
                                                             13          1    38              1
                                                             14          1    80              2
                                                             15          1    46              2
                                                             16          1    47              2
      3     2    B      LEFT     336.7   99.3      6          1          1    2               3
                                                              2          1    3               3
                                                              3          2    33 34           2 1
                                                              4          1    81              2
                                                              5          1    30              1
                                                              6          1    31              1
      4     3    A      RIGHT    557.1   57.3      1          1          1    17              2
      5     3    B      LEFT     557.1   99.3      4          1          1    4               3
                                                              2          2    5 56            3 1
                                                              3          1    42              1
                                                              4          1    43              1
      6     4    A      RIGHT    836.7   57.3     13          1          1    18              2
                                                              2          1    19              2
                                                              3          1    20              2
                                                              4          1    21              2
                                                              5          1    9               2
                                                              6          1    10              2
                                                              7          1    11              2
                                                              8          1    12              2
                                                              9          1    13              2
                                                             10          1    52              2
                                                             11          1    62              2
                                                             12          1    69              2
                                                             13          1    70              2
      7     4    A      RIGHT    836.7   57.3     15          1          1    53              2
                                                              2          1    57              2
                                                              3          1    58              2
                                                              4          1    54              2
                                                              5          1    59              2
                                                              6          1    63              2
                                                              7          1    71              2
                                                              8          1    74              2
                                                              9          1    75              2
                                                             10          1    60              2
                                                             11          1    61              2
                                                             12          1    64              2
                                                             13          1    72              2
                                                             14          1    73              2
                                                             15          1    48              2
```

L1-3: Shewchuk (2008)

8	4	A	RIGHT	836.7	57.3	4	1	1	49	2
							2	1	50	2
							3	1	67	2
							4	1	68	2
9	4	B	LEFT	836.7	99.3	3	1	1	82	1
							2	1	55	1
							3	1	51	1
10	4	B	LEFT	836.7	99.3	7	1	1	6	3
							2	1	7	3
							3	1	8	3
							4	1	76	2
							5	1	77	2
							6	1	66	1
							7	1	65	1

** # of interfering panels
4: 76 77 66 65

L1-3: Proposed algorithm

** Nzones
5

**zone	left edge X coordinate
1	6.0
2	226.5
3	446.9
4	667.4
5	785.5

** NStacks
10

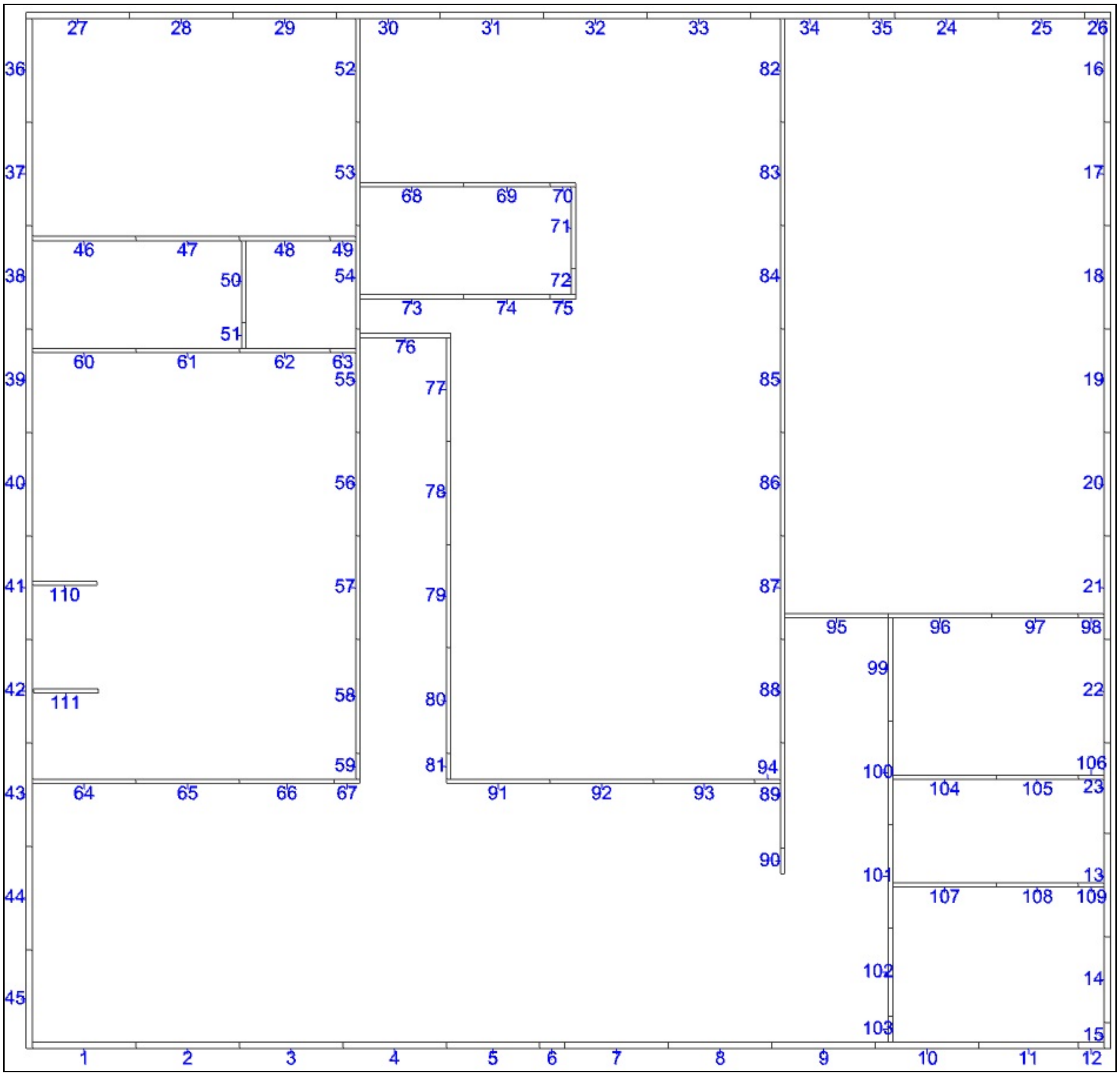
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	11	1	1	14	2
							2	1	22	1
							3	1	23	1
							4	1	24	1
							5	1	25	1
							6	1	26	1
							7	1	27	2
							8	1	28	1
							9	1	32	2
							10	1	29	1
							11	1	1	2
2	2	A	RIGHT	336.7	57.3	16	1	1	15	2
							2	1	16	2
							3	1	35	1
							4	1	44	2
							5	1	39	1
							6	1	36	1
							7	1	45	2
							8	1	40	1
							9	1	37	1
							10	1	78	2
							11	1	79	2
							12	1	41	1
							13	1	38	1
							14	1	80	2
							15	1	46	2
							16	1	47	2
3	2	B	LEFT	336.7	99.3	6	1	1	2	3
							2	1	3	3
							3	2	33 34	2 1
							4	1	81	2
							5	1	30	1
							6	1	31	1
4	3	A	RIGHT	557.1	57.3	1	1	1	17	2

L1-3: Proposed algorithm

5	3	B	LEFT	557.1	99.3	8	1	1	4	3
							2	2	5 56	3 1
							3	1	42	1
							4	1	48	2
							5	1	49	2
							6	3	50 43 82	2 1 1
							7	1	55	1
							8	1	51	1
6	4	A	RIGHT	777.6	57.3	15	1	1	18	2
							2	1	19	2
							3	1	52	1
							4	1	62	1
							5	1	53	1
							6	1	57	2
							7	1	58	2
							8	1	54	1
							9	1	59	1
							10	1	63	1
							11	1	60	2
							12	1	61	2
							13	1	64	1
							14	1	67	2
							15	1	68	2
7	4	B	LEFT	777.6	99.3	1	1	1	6	3
8	5	A	RIGHT	895.8	57.3	13	1	1	20	2
							2	1	21	2
							3	1	9	2
							4	1	10	2
							5	1	11	2
							6	1	12	2
							7	1	13	2
							8	1	69	2
							9	1	70	2
							10	1	71	2
							11	1	74	2
							12	1	75	2
							13	1	72	2
9	5	A	RIGHT	895.8	57.3	2	1	1	7	2
							2	1	8	2
10	5	B	LEFT	895.8	99.3	5	1	1	65	1
							2	1	66	1
							3	1	77	2
							4	1	76	2
							5	1	73	2

** # of interfering panels
2: 77 76 73

L2-1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```
L2-1: Shewchuk (2008)
** Nzones
4
**zone      left edge X coordinate
 1            6.0
 2          222.0
 3          438.0
 4          654.0
** NStacks
12
** stack                flush
**   #    zone type    edge     xloc    yloc   #layers   j   #panels   panels        orientation
     1     1    A     RIGHT   114.0   48.0      11         1        1     27             2
                                                           2        1     28             2
                                                           3        1     36             1
                                                           4        1     37             1
                                                           5        1     38             1
                                                           6        1     39             1
                                                           7        1     40             1
                                                           8        1     41             1
                                                           9        1     42             1
                                                          10        1     43             1
                                                          11        1     44             1
     2     1    A     RIGHT   114.0   48.0       9         1        1     45             1
                                                           2        1     46             2
                                                           3        1     47             2
                                                           4        1     60             2
                                                           5        1     61             2
                                                           6        1     110            2
                                                           7        1     64             2
                                                           8        1     65             2
                                                           9        1     1              3
     3     2    A     RIGHT   330.0   48.0      16         1        1     29             2
                                                           2        1     30             2
                                                           3        1     52             1
                                                           4        1     53             1
                                                           5        1     68             2
                                                           6        2     49 48          2 2
                                                           7        2     51 50          1 1
                                                           8        1     54             1
                                                           9        1     73             2
                                                          10        2     63 62          2 2
                                                          11        1     55             1
                                                          12        1     76             2
                                                          13        1     56             1
                                                          14        1     77             1
                                                          15        1     57             1
                                                          16        1     78             1
     4     2    A     RIGHT   330.0   48.0       4         1        1     58             1
                                                           2        1     79             1
                                                           3        2     59 80          1 1
                                                           4        3     67 66 81       2 2 1
     5     2    B     LEFT    330.0   90.0       3         1        1     2              3
                                                           2        1     3              3
                                                           3        1     4              3
     6     3    A     RIGHT   546.0   48.0       7         1        1     31             2
                                                           2        1     32             2
                                                           3        2     70 69          2 2
                                                           4        2     72 71          1 1
                                                           5        2     75 74          2 2
                                                           6        1     91             2
                                                           7        1     92             2
     7     3    B     LEFT    546.0   90.0       2         1        2     5 6            3 3
                                                           2        1     7              3
     8     4    A     RIGHT   827.0   48.0      11         1        1     33             2
                                                           2        2     35 34          2 2
                                                           3        1     24             2
                                                           4        2     26 25          2 2
                                                           5        1     16             2
                                                           6        1     17             2
                                                           7        1     18             2
                                                           8        1     19             2
                                                           9        1     20             2
                                                          10        1     21             2
                                                          11        1     22             2
```

L2-1: Shewchuk (2008)

9	4	A	RIGHT	827.0	48.0	16	1	1	23	2
							2	1	13	2
							3	2	15 14	2 2
							4	1	82	2
							5	1	83	2
							6	1	84	2
							7	1	85	2
							8	1	86	2
							9	1	111	2
							10	1	87	2
							11	1	95	2
							12	1	96	2
							13	2	98 97	2 2
							14	1	88	2
							15	1	99	2
							16	2	94 93	2 2
10	4	A	RIGHT	827.0	48.0	4	1	1	89	2
							2	1	100	2
							3	1	104	2
							4	2	106 105	2 2
11	4	B	LEFT	827.0	90.0	1	1	2	90 101	1 1
12	4	B	LEFT	827.0	90.0	7	1	1	8	3
							2	1	9	3
							3	1	10	3
							4	2	11 12	3 3
							5	1	107	2
							6	2	108 109	2 2
							7	2	102 103	1 1

** # of interfering panels
5: 107 108 109 102 103

L2-1: Proposed algorithm

** Nzones
5

**zone	left edge X coordinate
1	6.0
2	212.0
3	418.0
4	624.0
5	784.0

** NStacks
12

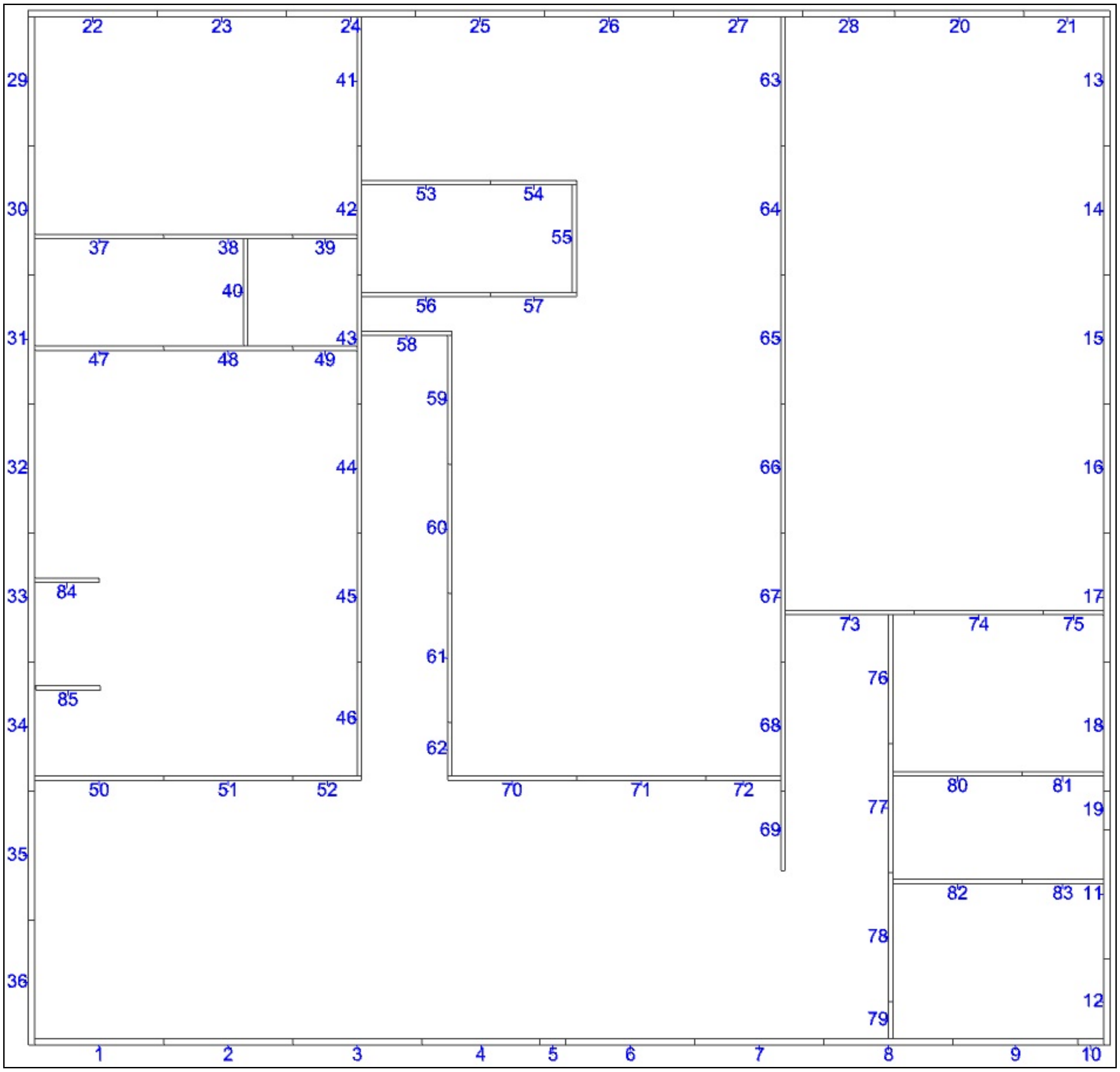
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	1	27	2
							2	1	28	2
							3	1	36	1
							4	1	37	1
							5	1	38	1
							6	1	39	1
							7	1	40	1
							8	1	41	1
							9	1	42	1
							10	1	43	1
							11	1	44	1
2	1	A	RIGHT	114.0	48.0	9	1	1	45	1
							2	1	46	2
							3	1	47	2
							4	1	60	2
							5	1	61	2
							6	1	110	2
							7	1	64	2
							8	1	65	2
							9	1	1	3

L2-1: Proposed algorithm

3	2	A	RIGHT	330.0	48.0	16	1	1	29	2
							2	1	30	2
							3	1	52	1
							4	1	53	1
							5	1	68	2
							6	2	49 48	2 2
							7	2	51 50	1 1
							8	1	54	1
							9	1	73	2
							10	2	63 62	2 2
							11	1	55	1
							12	1	76	2
							13	1	56	1
							14	1	77	1
							15	1	57	1
							16	1	78	1
4	2	A	RIGHT	330.0	48.0	4	1	1	58	1
							2	1	79	1
							3	2	59 80	1 1
							4	3	67 66 81	2 2 1
5	2	B	LEFT	330.0	90.0	3	1	1	2	3
							2	1	3	3
							3	1	4	3
6	3	A	RIGHT	546.0	48.0	7	1	1	31	2
							2	1	32	2
							3	2	70 69	2 2
							4	2	72 71	1 1
							5	2	75 74	2 2
							6	1	91	2
							7	1	92	2
7	3	B	LEFT	546.0	90.0	2	1	2	5 6	3 3
							2	1	7	3
8	4	A	RIGHT	762.0	48.0	14	1	1	33	2
							2	2	35 34	2 2
							3	1	82	1
							4	1	83	1
							5	1	84	1
							6	1	85	1
							7	1	86	1
							8	1	87	1
							9	1	95	2
							10	1	88	1
							11	1	99	1
							12	2	94 93	2 2
							13	1	89	1
							14	1	100	1
9	4	B	LEFT	762.0	90.0	2	1	1	8	3
							2	1	9	3
10	5	A	RIGHT	892.0	48.0	11	1	1	24	2
							2	2	26 25	2 2
							3	1	16	2
							4	1	17	2
							5	1	18	2
							6	1	19	2
							7	1	20	2
							8	1	21	2
							9	1	22	2
							10	1	23	2
							11	1	13	2
11	5	A	RIGHT	892.0	48.0	8	1	2	15 14	2 2
							2	1	111	2
							3	1	96	2
							4	2	98 97	2 2
							5	1	104	2
							6	2	106 105	2 2
							7	1	10	3
							8	2	12 11	3 3
12	5	B	LEFT	892.0	90.0	7	1	1	90	1
							2	1	101	1
							3	1	107	2
							4	1	108	2
							5	1	109	2
							6	1	102	1
							7	1	103	1

** # of interfering panels
0

L2-2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```
L2-2: Shewchuk (2008)

** Nzones
4

**zone      left edge X coordinate
 1             6.0
 2           222.0
 3           438.0
 4           654.0

** NStacks
11

** stack                flush
**   #    zone type   edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1     1    A     RIGHT   114.0   48.0     13         1        1    22            2
                                                          2        1    29            1
                                                          3        1    30            1
                                                          4        1    31            1
                                                          5        1    32            1
                                                          6        1    33            1
                                                          7        1    34            1
                                                          8        1    35            1
                                                          9        1    36            1
                                                         10        1    37            2
                                                         11        1    47            2
                                                         12        1    84            2
                                                         13        1    50            2
     2     1    A     RIGHT   114.0   48.0      1         1        1     1            3
     3     2    A     RIGHT   330.0   48.0     16         1        1    23            2
                                                          2        1    24            2
                                                          3        1    41            1
                                                          4        1    38            2
                                                          5        1    39            2
                                                          6        1    40            1
                                                          7        1    42            1
                                                          8        1    53            2
                                                          9        1    48            2
                                                         10        1    49            2
                                                         11        1    43            1
                                                         12        1    56            2
                                                         13        1    58            2
                                                         14        1    44            1
                                                         15        1    59            1
                                                         16        1    45            1
     4     2    A     RIGHT   330.0   48.0      6         1        1    60            1
                                                          2        1    46            1
                                                          3        1    61            1
                                                          4        1    62            1
                                                          5        1    51            2
                                                          6        1    52            2
     5     2    B     LEFT    330.0   90.0      2         1        1    2             3
                                                          2        1    3             3
     6     3    A     RIGHT   546.0   48.0      7         1        1    25            2
                                                          2        1    26            2
                                                          3        1    54            2
                                                          4        1    55            1
                                                          5        1    57            2
                                                          6        1    70            2
                                                          7        1    71            2
     7     3    B     LEFT    546.0   90.0      2         1        2    4 5           3 3
                                                          2        1    6             3
```

```
L2-2: Shewchuk (2008)

     8     4     A     RIGHT   827.0   48.0     11      1      1     27          2
                                                       2      1     28          2
                                                       3      1     20          2
                                                       4      1     21          2
                                                       5      1     13          2
                                                       6      1     14          2
                                                       7      1     15          2
                                                       8      1     16          2
                                                       9      1     17          2
                                                      10      1     18          2
                                                      11      1     19          2
     9     4     A     RIGHT   827.0   48.0     15      1      1     11          2
                                                       2      1     12          2
                                                       3      1     63          2
                                                       4      1     64          2
                                                       5      1     65          2
                                                       6      1     66          2
                                                       7      1     85          2
                                                       8      1     67          2
                                                       9      1     73          2
                                                      10      1     74          2
                                                      11      2     72 75       2 2
                                                      12      1     68          2
                                                      13      1     76          2
                                                      14      1     80          2
                                                      15      1     81          2
    10     4     B     LEFT    827.0   90.0      2      1      1     69          1
                                                       2      1     77          1
    11     4     B     LEFT    827.0   90.0      6      1      1     7           3
                                                       2      1     8           3
                                                       3      2     9 10        3 3
                                                       4      1     78          1
                                                       5      1     82          2
                                                       6      2     83 79       2 1

** # of interfering panels
4: 78 82 83 79
```

```
L2-2: Proposed algorithm

** Nzones
5

**zone      left edge X coordinate
  1           6.0
  2         213.0
  3         428.0
  4         650.0
  5         784.0

** NStacks
11

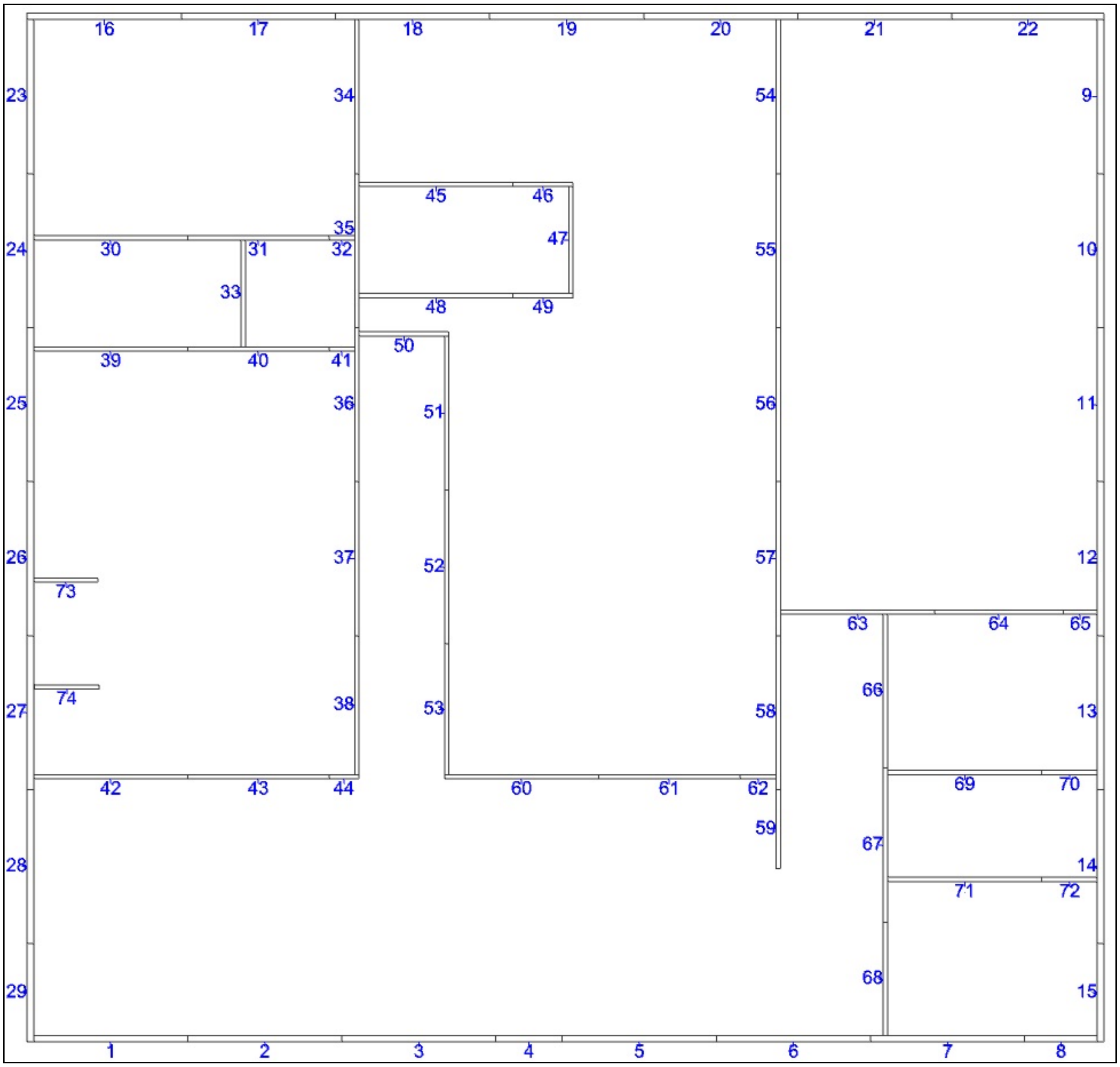
** stack                flush
**   #    zone type     edge     xloc    yloc   #layers  j   #panels   panels      orientation
     1     1     A      RIGHT   114.0    48.0     14          1      1     22          2
                                                              2      1     29          1
                                                              3      1     30          1
                                                              4      1     31          1
                                                              5      1     32          1
                                                              6      1     33          1
                                                              7      1     34          1
                                                              8      1     35          1
                                                              9      1     36          1
                                                             10      1     37          2
                                                             11      1     47          2
                                                             12      1     84          2
                                                             13      1     50          2
                                                             14      1     1           3
```

L2-2: Proposed algorithm

2	2	A	RIGHT	330.0	48.0	16	1	1	23	2
							2	1	24	2
							3	1	41	1
							4	1	38	2
							5	1	39	2
							6	1	40	1
							7	1	42	1
							8	1	53	2
							9	1	48	2
							10	1	49	2
							11	1	43	1
							12	1	56	2
							13	1	58	2
							14	1	44	1
							15	1	59	1
							16	1	45	1
3	2	A	RIGHT	330.0	48.0	6	1	1	60	1
							2	1	46	1
							3	1	61	1
							4	1	62	1
							5	1	51	2
							6	1	52	2
4	2	B	LEFT	330.0	90.0	2	1	1	2	3
							2	1	3	3
5	3	A	RIGHT	546.0	48.0	7	1	1	25	2
							2	1	26	2
							3	1	54	2
							4	1	55	1
							5	1	57	2
							6	1	70	2
							7	1	71	2
6	3	B	LEFT	546.0	90.0	2	1	2	4 5	3 3
							2	1	6	3
7	4	A	RIGHT	762.0	48.0	11	1	1	27	2
							2	1	28	2
							3	1	63	1
							4	1	64	1
							5	1	65	1
							6	1	66	1
							7	1	67	1
							8	1	73	2
							9	1	72	2
							10	1	68	1
							11	1	76	1
8	4	B	LEFT	762.0	90.0	2	1	1	7	3
							2	1	8	3
9	5	A	RIGHT	892.0	48.0	12	1	1	20	2
							2	1	21	2
							3	1	13	2
							4	1	14	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	19	2
							10	1	11	2
							11	2	85 12	2 2
							12	1	74	2
10	5	A	RIGHT	892.0	48.0	4	1	1	75	2
							2	1	80	2
							3	1	81	2
							4	2	10 9	3 3
11	5	B	LEFT	892.0	90.0	6	1	1	69	1
							2	1	77	1
							6	1	78	1
							4	1	82	2
							5	1	83	2
							3	1	79	1

** # of interfering panels
0

L2-3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59
67
28
14
71
72
68
29
15
1
2
3
4
5
6
7
8

```
L2-3: Shewchuk (2008)
** Nzones
4
**zone     left edge X coordinate
 1            6.0
 2          226.5
 3          446.9
 4          667.4
** NStacks
10
** stack                  flush
**   #    zone type   edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1      1    A    RIGHT   116.2    57.3     13          1         1   16            2
                                                            2         1   23            1
                                                            3         1   24            1
                                                            4         1   25            1
                                                            5         1   26            1
                                                            6         1   27            1
                                                            7         1   28            1
                                                            8         1   29            1
                                                            9         1   30            2
                                                           10         1   39            2
                                                           11         1   73            2
                                                           12         1   42            2
                                                           13         1   1             3
     2      2    A    RIGHT   336.7    57.3     16          1         1   17            2
                                                            2         1   18            2
                                                            3         1   34            1
                                                            4         1   31            2
                                                            5         2   33 32         1 2
                                                            6         1   35            1
                                                            7         1   40            2
                                                            8         1   41            2
                                                            9         1   36            1
                                                           10         1   50            2
                                                           11         1   37            1
                                                           12         1   51            1
                                                           13         1   38            1
                                                           14         1   52            1
                                                           15         1   53            1
                                                           16         1   43            2
     3      2    A    RIGHT   336.7    57.3      1          1         1   44            2
     4      2    B    LEFT    336.7    99.3      2          1         1   2             3
                                                            2         1   3             3
     5      3    A    RIGHT   557.1    57.3      8          1         1   19            2
                                                            2         1   45            2
                                                            3         1   46            2
                                                            4         1   47            1
                                                            5         1   48            2
                                                            6         1   49            2
                                                            7         1   60            2
                                                            8         1   61            2
     6      3    B    LEFT    557.1    99.3      2          1         1   4             3
                                                            2         1   5             3
     7      4    A    RIGHT   833.7    57.3     12          1         1   20            2
                                                            2         1   21            2
                                                            3         1   22            2
                                                            4         1   9             2
                                                            5         1   10            2
                                                            6         1   11            2
                                                            7         1   12            2
                                                            8         1   13            2
                                                            9         1   14            2
                                                           10         1   15            2
                                                           11         1   54            2
                                                           12         1   55            2
     8      4    A    RIGHT   833.7    57.3     10          1         1   56            2
                                                            2         1   74            2
                                                            3         1   57            2
                                                            4         1   63            2
                                                            5         1   64            2
                                                            6         2   62 65         2 2
                                                            7         1   58            2
                                                            8         1   66            2
                                                            9         1   69            2
                                                           10         1   70            2
```

L2-3: Shewchuk (2008)

9	4	B	LEFT	833.7	99.3	1	1	1	59	1
10	4	B	LEFT	833.7	99.3	7	1	1	6	3
							2	1	7	3
							3	1	8	3
							4	1	67	1
							5	1	71	2
							6	1	72	2
							7	1	68	1

** # of interfering panels
4: 67 71 72 68

L2-3: Proposed algorithm

** Nzones
5

**zone	left edge X coordinate
1	6.0
2	218.5
3	437.9
4	657.4
5	779.5

** NStacks
11

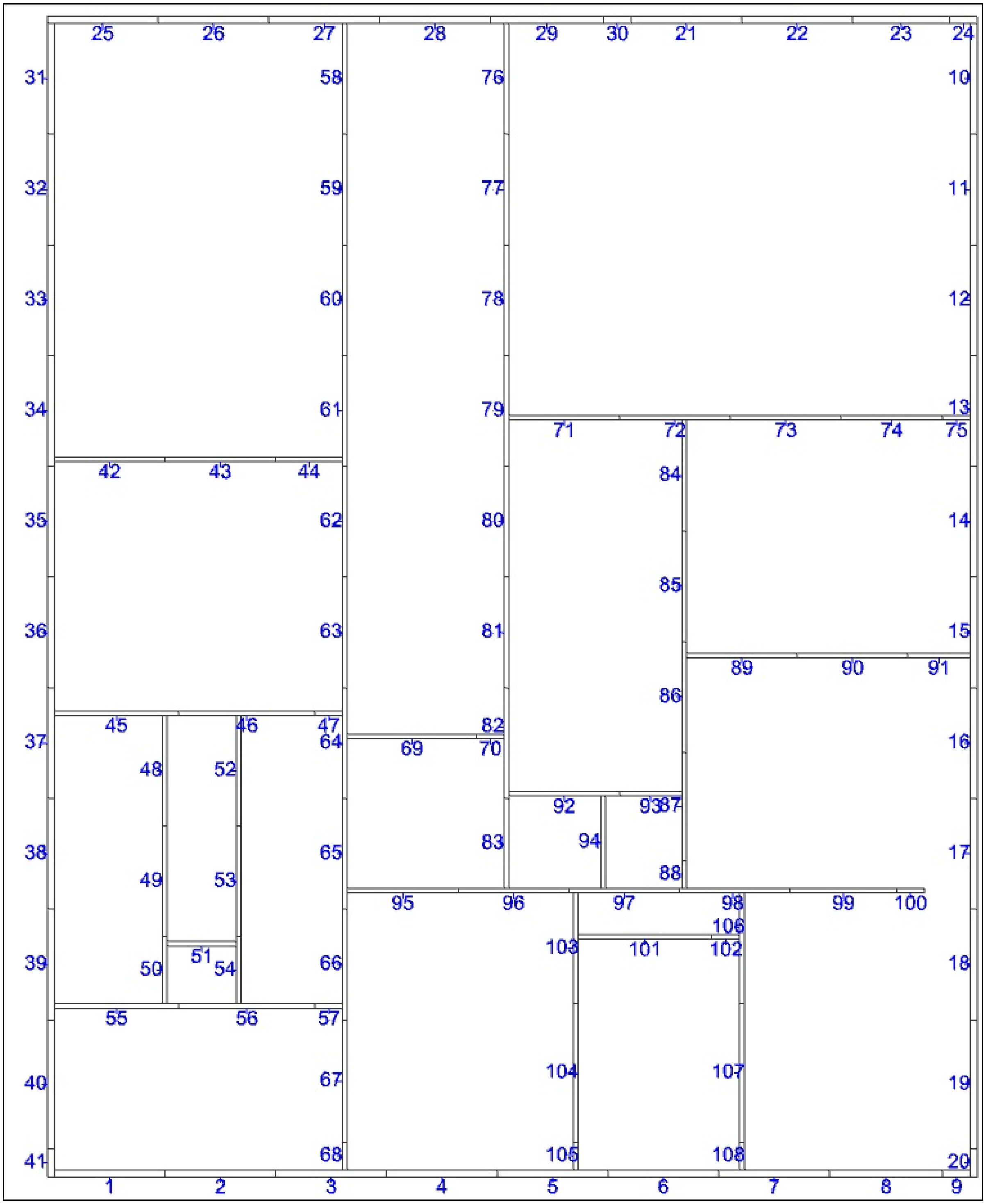
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	16	2
							2	1	23	1
							3	1	24	1
							4	1	25	1
							5	1	26	1
							6	1	27	1
							7	1	28	1
							8	1	29	1
							9	1	30	2
							10	1	39	2
							11	1	73	2
							12	1	42	2
							13	1	1	3
2	2	A	RIGHT	336.7	57.3	16	1	1	17	2
							2	1	18	2
							3	1	34	1
							4	1	31	2
							5	2	33 32	1 2
							6	1	35	1
							7	1	40	2
							8	1	41	2
							9	1	36	1
							10	1	50	2
							11	1	37	1
							12	1	51	1
							13	1	38	1
							14	1	52	1
							15	1	53	1
							16	1	43	2
3	2	A	RIGHT	336.7	57.3	1	1	1	44	2
4	2	B	LEFT	336.7	99.3	2	1	1	2	3
							2	1	3	3
5	3	A	RIGHT	557.1	57.3	8	1	1	19	2
							2	1	45	2
							3	1	46	2
							4	1	47	1
							5	1	48	2
							6	1	49	2
							7	1	60	2
							8	1	61	2

L2-3: Proposed algorithm

6	4	B	LEFT	557.1	99.3	2	1	1	4	3
							2	1	5	3
7	4	A	RIGHT	777.6	57.3	10	1	1	20	2
							2	1	21	2
							3	1	54	1
							4	1	55	1
							5	1	56	1
							6	1	57	1
							7	1	63	2
							8	1	62	2
							9	1	58	1
							10	1	66	1
8	4	B	LEFT	777.6	99.3	1	1	1	6	3
9	5	A	RIGHT	889.8	57.3	15	1	1	22	2
							2	1	9	2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
							8	1	15	2
							9	1	74	2
							10	1	64	2
							11	1	65	2
							12	1	69	2
							13	1	70	2
							14	1	7	3
							15	1	8	3
10	5	B	LEFT	889.8	99.3	4	1	1	59	1
							2	1	67	1
							3	1	71	2
							4	2	72 68	1 2

** # of interfering panels
0

L3-1


25 26 27 28 29 30 21 22 23 24
31 58 76 10
32 59 77 11
33 60 78 12
34 61 79 13
71 72 73 74 75
42 43 44
84
35 62 80 14
85
36 63 81 15
89 90 91
86
45 46 47 64 82 70 69
37 16
48 52
92 93 87
94
38 65 83 17
49 53 88
95 96 97 98 99 100
106
103 101 102
39 50 51 54 66 18
55 56 57
40 67 104 107 19
41 68 105 108 20
1 2 3 4 5 6 7 8 9

```
L3-1: Shewchuk (2008)
** Nzones
3
**zone      left edge X coordinate
 1            6.0
 2          222.0
 3          438.0
** NStacks
10
** stack                  flush
**   #   zone type    edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1     1    A     RIGHT    114.0   48.0      11          1         1    25             2
                                                              2         1    26             2
                                                              3         1    31             1
                                                              4         1    32             1
                                                              5         1    33             1
                                                              6         1    34             1
                                                              7         1    35             1
                                                              8         1    36             1
                                                              9         1    37             1
                                                             10         1    38             1
                                                             11         1    39             1
     2     1    A     RIGHT    114.0   48.0       6          1         2    41 40          1 1
                                                              2         1    42             2
                                                              3         1    43             2
                                                              4         1    45             2
                                                              5         1    48             1
                                                              6         1    1              3
     3     2    A     RIGHT    330.0   48.0      16          1         1    27             2
                                                              2         1    28             2
                                                              3         1    58             1
                                                              4         1    59             1
                                                              5         1    60             1
                                                              6         1    44             2
                                                              7         1    61             1
                                                              8         1    62             1
                                                              9         1    63             1
                                                             10         2    47 46          2 2
                                                             11         1    52             1
                                                             12         1    64             1
                                                             13         2    70 69          2 2
                                                             14         1    82             1
                                                             15         1    65             1
                                                             16         1    83             1
     4     2    A     RIGHT    330.0   48.0       1          1         1    95             2
     5     2    B     LEFT     330.0   90.0       8          1         1    2              3
                                                              2         1    3              3
                                                              3         1    4              3
                                                              4         1    49             1
                                                              5         1    53             1
                                                              6         2    50 51          1 2
                                                              7         1    54             1
                                                              8         1    55             3
     6     3    A     RIGHT    619.0   48.0      11          1         2    30 29          2 2
                                                              2         1    21             2
                                                              3         1    22             2
                                                              4         2    24 23          2 2
                                                              5         1    10             2
                                                              6         1    11             2
                                                              7         1    12             2
                                                              8         1    13             2
                                                              9         1    14             2
                                                             10         1    15             2
                                                             11         1    16             2
     7     3    A     RIGHT    619.0   48.0      16          1         1    17             2
                                                              2         1    18             2
                                                              3         2    20 19          2 2
                                                              4         1    76             2
                                                              5         1    77             2
                                                              6         1    78             2
                                                              7         1    79             2
                                                              8         1    71             2
                                                              9         1    72             2
                                                             10         1    73             2
                                                             11         2    75 74          2 2
                                                             12         1    80             2
                                                             13         1    84             2
                                                             14         1    81             2
                                                             15         1    85             2
                                                             16         1    86             2
```

L3-1: Shewchuk (2008)

8	3	A	RIGHT	619.0	48.0	10	1	1	89	2
							2	1	90	2
							3	1	91	2
							4	1	92	2
							5	2	94 93	2 2
							6	2	88 87	2 2
							7	1	96	2
							8	1	97	2
							9	1	98	2
							10	2	100 99	2 2
9	3	B	LEFT	619.0	90.0	4	1	2	56 57	3 3
							2	1	66	1
							3	2	67 68	1 1
							4	1	103	1
10	3	B	LEFT	619.0	90.0	9	1	1	5	3
							2	1	6	3
							3	1	7	3
							4	2	8 9	3 3
							5	2	101 102	2 2
							6	1	106	1
							7	1	104	1
							8	2	107 105	1 1
							9	1	108	1

** Ninfeasible
7: 101 102 106 104 107 105 108

L3-1: Proposed algorithm
** Nzones
4

**zone	left edge X coordinate
1	6.0
2	211.0
3	418.0
4	584.0

** NStacks
11

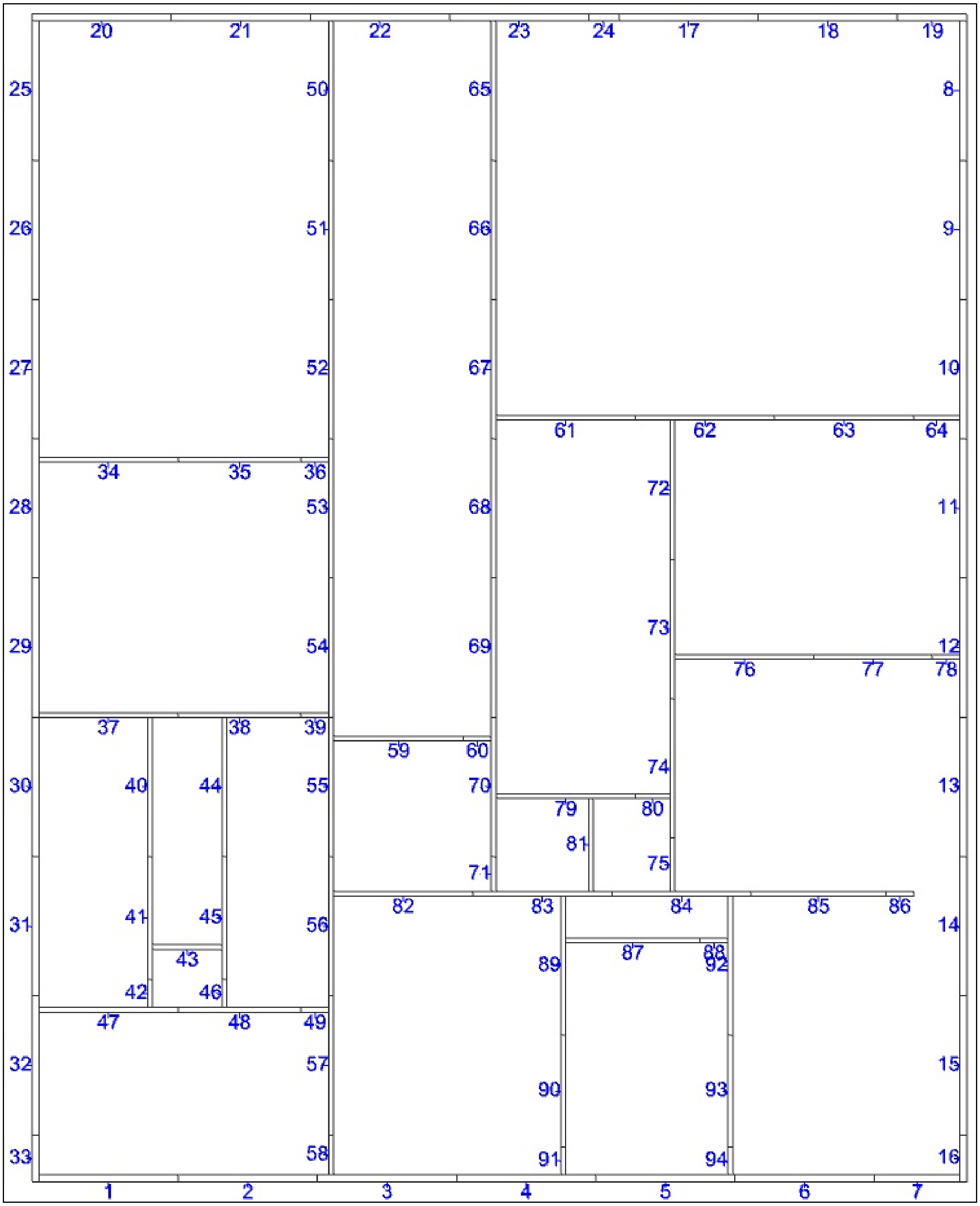
** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	1	25	2
							2	1	26	2
							3	1	31	1
							4	1	32	1
							5	1	33	1
							6	1	34	1
							7	1	35	1
							8	1	36	1
							9	1	37	1
							10	1	38	1
							11	1	39	1
2	1	A	RIGHT	114.0	48.0	6	1	2	41 40	1 1
							2	1	42	2
							3	1	43	2
							4	1	45	2
							5	1	48	1
							6	1	1	3
3	2	A	RIGHT	330.0	48.0	17	1	1	27	2
							2	1	28	2
							3	1	58	1
							4	1	59	1
							5	1	60	1
							6	1	44	2
							7	1	61	1
							8	1	62	1
							9	1	63	1
							10	2	47 46	2 2
							11	1	52	1
							12	1	64	1
							13	2	70 69	2 2
							14	1	82	1
							15	1	65	1
							16	1	83	1
							17	1	95	2

L3-1: Proposed algorithm

5	2	B	LEFT	330.0	90.0	8	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	49	1
							5	1	53	1
							6	2	50 51	1 2
							7	1	54	1
							8	1	55	3
6	3	A	RIGHT	546.0	48.0	16	1	2	30 29	2 2
							2	1	21	2
							3	1	76	1
							4	1	77	1
							5	1	78	1
							6	1	79	1
							7	1	71	2
							8	1	72	2
							9	1	80	1
							10	1	84	1
							11	1	81	1
							12	1	85	1
							13	1	86	1
							14	1	89	2
							15	1	92	2
							16	2	94 93	1 2
7	3	A	RIGHT	546.0	48.0	4	1	2	88 87	1 1
							2	1	96	2
							3	1	97	2
							4	1	98	2
8	3	B	LEFT	546.0	90.0	9	1	1	5	3
							2	1	6	3
							3	2	56 57	3 3
							4	1	66	1
							5	1	103	1
							6	1	101	2
							7	1	67	1
							8	2	104 68	1 1
							9	1	105	1
9	4	A	RIGHT	692.0	48.0	11	1	1	22	2
							2	2	24 23	2 2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
							8	1	15	2
							9	1	16	2
							10	1	17	2
							11	1	18	2
10	4	A	RIGHT	692.0	48.0	8	1	2	20 19	2 2
							2	1	73	2
							3	2	75 74	2 2
							4	1	90	2
							5	1	91	2
							6	2	100 99	2 2
							7	1	7	3
							8	2	9 8	3 3
11	4	B	LEFT	692.0	90.0	4	1	1	102	2
							2	1	108	1
							3	1	107	1
							4	1	106	1

** # of interfering panels
3: 108 107 106

L3-2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14
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87
88
92
89
42
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47
48
49
32
57
90
93
15
33
58
91
94
16
1
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3
4
5
6
7

```
L3-2: Shewchuk (2008)
** Nzones 3
**zone      left edge X coordinate
 1           6.0
 2         222.0
 3         438.0
** NStacks 9
** stack                flush
**   #    zone type    edge    xloc   yloc   #layers   j   #panels   panels      orientation
     1     1    A     RIGHT   114.0   48.0    12           1         1   20            2
                                                           2         1   25            1
                                                           3         1   26            1
                                                           4         1   27            1
                                                           5         1   28            1
                                                           6         1   29            1
                                                           7         1   30            1
                                                           8         1   31            1
                                                           9         1   32            1
                                                          10         1   33            1
                                                          11         1   34            2
                                                          12         1   37            2
     2     1    A     RIGHT   114.0   48.0     2           1         1   40            1
                                                           2         1   1             3
     3     2    A     RIGHT   330.0   48.0    14           1         1   21            2
                                                           2         1   22            2
                                                           3         1   50            1
                                                           4         1   51            1
                                                           5         1   52            1
                                                           6         2   36 35         2 2
                                                           7         1   53            1
                                                           8         2   39 38         2 2
                                                           9         1   54            1
                                                          10         1   44            1
                                                          11         1   55            1
                                                          12         2   60 59         2 2
                                                          13         1   70            1
                                                          14         1   71            1
     4     2    B     LEFT    330.0   90.0     6           1         1   2             3
                                                           2         1   3             3
                                                           3         1   41            1
                                                           4         1   43            2
                                                           5         2   45 42         1 1
                                                           6         2   46 47         1 3
     5     3    A     RIGHT   619.0   48.0    11           1         1   23            2
                                                           2         1   24            2
                                                           3         1   17            2
                                                           4         1   18            2
                                                           5         1   19            2
                                                           6         1   8             2
                                                           7         1   9             2
                                                           8         1   10            2
                                                           9         1   11            2
                                                          10         1   12            2
                                                          11         1   13            2
     6     3    A     RIGHT   619.0   48.0    16           1         1   14            2
                                                           2         1   15            2
                                                           3         1   16            2
                                                           4         1   65            2
                                                           5         1   66            2
                                                           6         1   67            2
                                                           7         1   61            2
                                                           8         1   62            2
                                                           9         1   63            2
                                                          10         1   64            2
                                                          11         1   68            2
                                                          12         1   72            2
                                                          13         1   69            2
                                                          14         1   73            2
                                                          15         1   76            2
                                                          16         2   78 77         2 2
     7     3    A     RIGHT   619.0   48.0     8           1         1   79            2
                                                           2         2   81 80         2 2
                                                           3         1   74            2
                                                           4         1   75            2
                                                           5         1   82            2
                                                           6         1   83            2
                                                           7         1   84            2
                                                           8         2   86 85         2 2
```

L3-2: Shewchuk (2008)

8	3	B	LEFT	619.0	90.0	5	1	1	56	1
							2	2	48 49	3 3
							3	1	57	1
							4	1	58	1
							5	1	89	1
9	3	B	LEFT	619.0	90.0	8	1	1	4	3
							2	1	5	3
							3	1	6	3
							4	1	7	3
							5	2	87 88	2 2
							6	1	92	1
							7	1	90	1
							8	3	93 91 94	1 1 1

** # of interfering panels
6: 88 92 90 93 91 94

L3-2: Proposed algorithm

** Nzones
4

**zone	left edge X coordinate
1	6.0
2	215.0
3	430.0
4	584.0

** NStacks
9

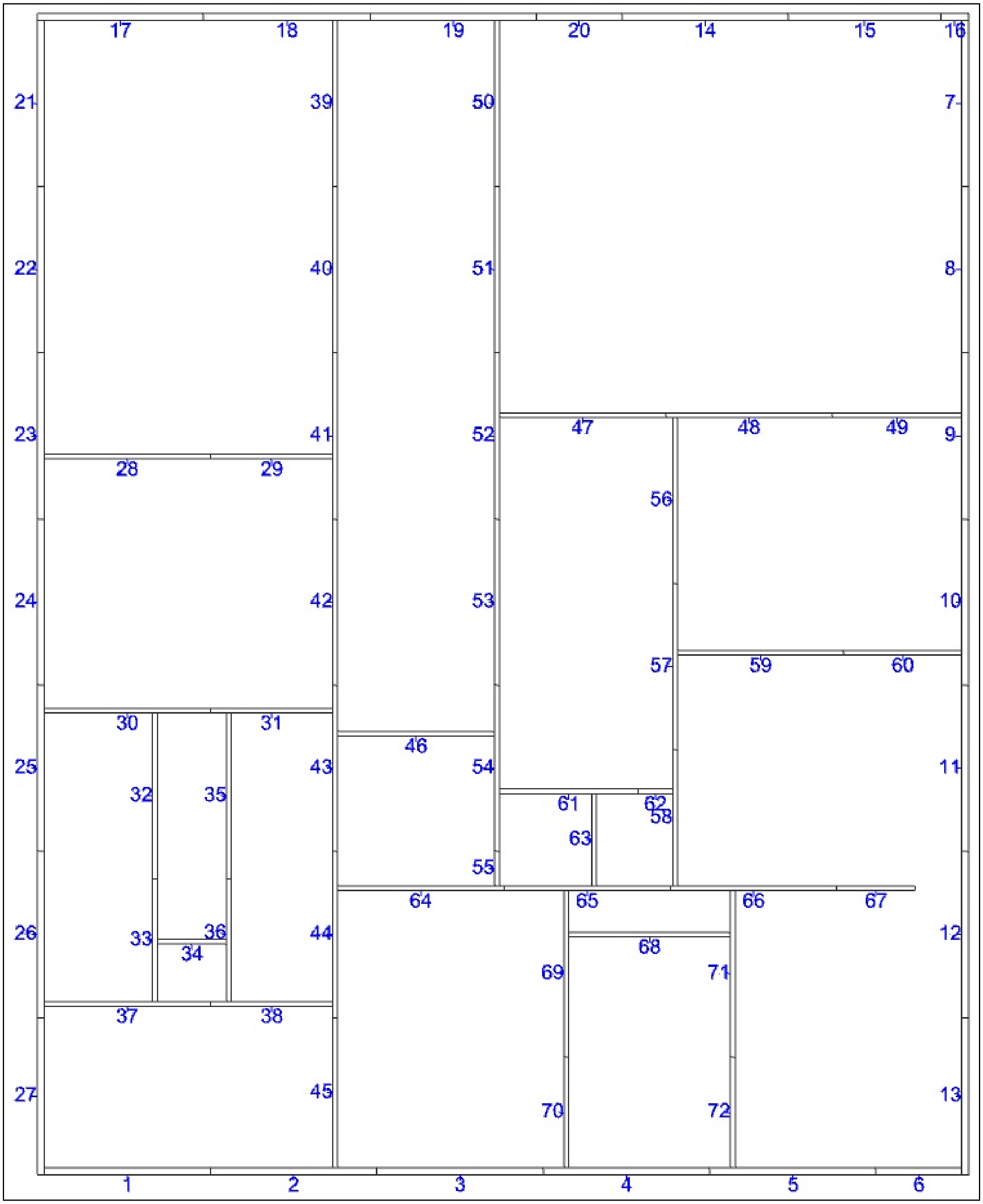
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	14	1	1	20	2
							2	1	25	1
							3	1	26	1
							4	1	27	1
							5	1	28	1
							6	1	29	1
							7	1	30	1
							8	1	31	1
							9	1	32	1
							10	1	33	1
							11	1	34	2
							12	1	37	2
							13	1	40	1
							14	1	1	3
2	2	A	RIGHT	330.0	48.0	14	1	1	21	2
							2	1	22	2
							3	1	50	1
							4	1	51	1
							5	1	52	1
							6	2	36 35	2 2
							7	1	53	1
							8	2	39 38	2 2
							9	1	54	1
							10	1	44	1
							11	1	55	1
							12	2	60 59	2 2
							13	1	70	1
							14	1	71	1
3	2	B	LEFT	330.0	90.0	6	1	1	2	3
							2	1	3	3
							3	1	41	1
							4	1	43	2
							5	2	45 42	1 1
							6	2	46 47	1 3

L3-2: Proposed algorithm

4	3	A	RIGHT	546.0	48.0	16	1	1	23	2
							2	1	24	2
							3	1	17	2
							4	1	65	1
							5	1	66	1
							6	1	67	1
							7	1	61	2
							8	1	62	2
							9	1	68	1
							10	1	72	1
							11	1	69	1
							12	1	73	1
							13	1	79	2
							14	2	81 80	1 2
							15	1	74	1
							16	1	75	1
5	3	A	RIGHT	546.0	48.0	2	1	1	83	2
							2	1	84	2
6	3	B	LEFT	546.0	90.0	10	1	1	4	3
							2	1	5	3
							3	1	56	1
							4	1	82	2
							5	2	48 49	3 3
							6	1	57	1
							7	1	89	1
							8	1	87	2
							9	2	58 90	1 1
							10	1	91	1
7	4	A	RIGHT	692.0	48.0	12	1	1	18	2
							2	1	19	2
							3	1	8	2
							4	1	9	2
							5	1	10	2
							6	1	11	2
							7	1	12	2
							8	1	13	2
							9	1	14	2
							10	1	15	2
							11	1	16	2
							12	1	63	2
8	4	A	RIGHT	692.0	48.0	6	1	1	64	2
							2	1	76	2
							3	2	78 77	2 2
							4	2	86 85	2 2
							5	1	6	3
							6	1	7	3
9	4	B	LEFT	692.0	90.0	4	1	1	88	2
							2	1	94	1
							3	1	93	1
							4	1	92	1

** # of interfering panels
3: 94 93 92

L3-3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11
32
35
61
62
58
63
55
64
65
66
67
26
33
36
44
12
34
68
69
71
37
38
27
45
70
72
13
1
2
3
4
5
6

```
L3-3: Shewchuk (2008)
** Nzones
3
**zone      left edge X coordinate
 1           6.0
 2         226.5
 3         446.9
** NStacks
8
** stack                flush
**   #    zone type     edge     xloc    yloc   #layers   j   #panels   panels   orientation
     1     1    A       RIGHT   116.2    57.3     12           1         1       17          2
                                                               2         1       21          1
                                                               3         1       22          1
                                                               4         1       23          1
                                                               5         1       24          1
                                                               6         1       25          1
                                                               7         1       26          1
                                                               8         1       27          1
                                                               9         1       28          2
                                                              10         1       30          2
                                                              11         1       32          1
                                                              12         1       1           3
     2     2    A       RIGHT   336.7    57.3     16           1         1       18          2
                                                               2         1       19          2
                                                               3         1       39          1
                                                               4         1       50          1
                                                               5         1       40          1
                                                               6         1       51          1
                                                               7         1       29          2
                                                               8         1       41          1
                                                               9         1       52          1
                                                              10         1       42          1
                                                              11         1       53          1
                                                              12         1       31          2
                                                              13         1       35          1
                                                              14         1       43          1
                                                              15         1       46          2
                                                              16         1       54          1
     3     2    A       RIGHT   336.7    57.3      2           1         1       55          1
                                                               2         1       64          2
     4     2    B       LEFT    336.7    99.3      6           1         1       2           3
                                                               2         1       3           3
                                                               3         1       33          1
                                                               4         1       34          2
                                                               5         1       36          1
                                                               6         1       37          3
     5     3    A       RIGHT   623.5    57.3     12           1         1       20          2
                                                               2         1       14          2
                                                               3         1       15          2
                                                               4         1       16          2
                                                               5         1       7           2
                                                               6         1       8           2
                                                               7         1       9           2
                                                               8         1       10          2
                                                               9         1       11          2
                                                              10         1       12          2
                                                              11         1       13          2
                                                              12         1       47          2
     6     3    A       RIGHT   623.5    57.3     12           1         1       48          2
                                                               2         1       49          2
                                                               3         1       56          2
                                                               4         1       57          2
                                                               5         1       59          2
                                                               6         1       60          2
                                                               7         1       61          2
                                                               8         2       63 62       2 2
                                                               9         1       58          2
                                                              10         1       65          2
                                                              11         1       66          2
                                                              12         1       67          2
     7     3    B       LEFT    623.5    99.3      3           1         1       38          3
                                                               2         1       44          1
                                                               3         1       45          1
     8     3    B       LEFT    623.5    99.3      8           1         1       4           3
                                                               2         1       5           3
                                                               3         1       6           3
                                                               4         1       69          1
                                                               5         1       68          2
                                                               6         1       71          1
                                                               7         1       70          1
                                                               8         1       72          1
** # of interfering panels
5: 69 68 71 70 72
```

L3-3: Proposed algorithm
** Nzones 4
**zone left edge X coordinate

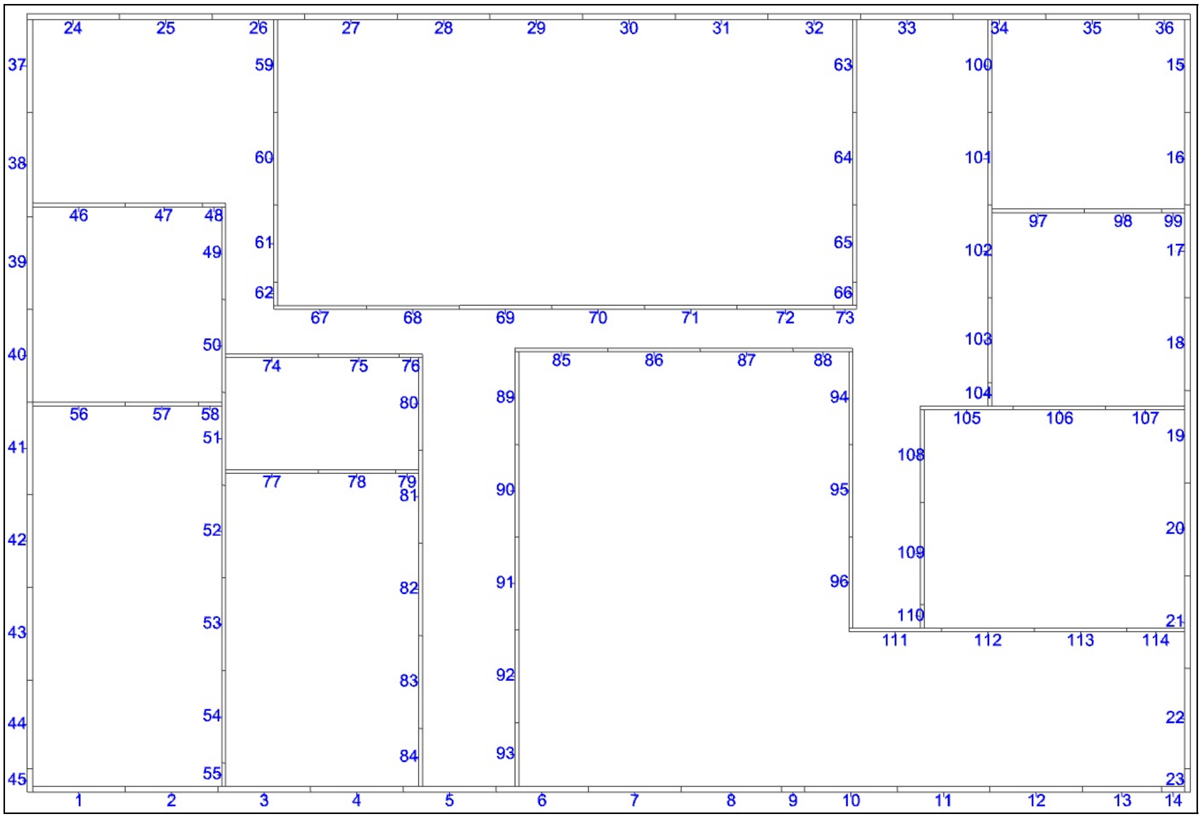
zone	left edge X coordinate
1	6.0
2	218.5
3	440.9
4	579.5

** NStacks 9

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	12	1	1	17	2
							2	1	21	1
							3	1	22	1
							4	1	23	1
							5	1	24	1
							6	1	25	1
							7	1	26	1
							8	1	27	1
							9	1	28	2
							10	1	30	2
							11	1	32	1
							12	1	1	3
2	2	A	RIGHT	336.7	57.3	16	1	1	18	2
							2	1	19	2
							3	1	39	1
							4	1	50	1
							5	1	40	1
							6	1	51	1
							7	1	29	2
							8	1	41	1
							9	1	52	1
							10	1	42	1
							11	1	53	1
							12	1	31	2
							13	1	35	1
							14	1	43	1
							15	1	46	2
							16	1	54	1
3	2	A	RIGHT	336.7	57.3	2	1	1	55	1
							2	1	64	2
4	2	B	LEFT	336.7	99.3	6	1	1	2	3
							2	1	3	3
							3	1	33	1
							4	1	34	2
							5	1	36	1
							6	1	37	3
5	3	A	RIGHT	557.1	57.3	7	1	1	20	2
							2	1	14	2
							3	1	47	2
							4	1	61	2
							5	2	63 62	1 2
							6	1	58	1
							7	1	65	2
6	3	B	LEFT	557.1	99.3	7	1	1	4	3
							2	1	57	1
							3	1	38	3
							4	1	44	1
							5	1	45	1
							6	1	69	1
							7	1	70	1
7	4	A	RIGHT	689.8	57.3	13	1	1	15	2
							2	1	16	2
							3	1	7	2
							4	1	8	2
							5	1	9	2
							6	1	10	2
							7	1	11	2
							8	1	12	2
							9	1	13	2
							10	1	48	2
							11	1	49	2
							12	1	56	2
							13	1	59	2
8	4	A	RIGHT	689.8	57.3	5	1	1	60	2
							2	1	66	2
							3	1	67	2
							4	1	5	3
							5	1	6	3
9	4	B	LEFT	689.8	99.3	3	1	1	68	2
							2	1	72	1
							3	1	71	1

** # of interfering panels
2: 72 71

L4-1



L4-1: Shewchuk (2008)

** Nzones
5

**zone	left edge X coordinate
1	6.0
2	222.0
3	438.0
4	654.0
5	870.0

** NStacks
13

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	12	1	1	24	2
							2	1	25	2
							3	1	37	1
							4	1	38	1
							5	1	39	1
							6	1	40	1
							7	1	41	1
							8	1	42	1
							9	1	43	1
							10	2	45 44	1 1
							11	1	46	2
							12	2	48 47	2 2
2	1	A	RIGHT	114.0	48.0	7	1	1	49	1
							2	1	50	1
							3	1	56	2
							4	2	58 57	2 2
							5	1	51	1
							6	1	52	1
							7	1	1	3

L4-1: Shewchuk (2008)

3	2	A	RIGHT	330.0	48.0	12	1	1	26	2
							2	1	27	2
							3	1	59	1
							4	1	60	1
							5	2	62 61	1 1
							6	1	67	2
							7	1	74	2
							8	2	76 75	2 2
							9	1	80	1
							10	1	77	2
							11	2	79 78	2 2
							12	1	81	1
4	2	B	LEFT	330.0	90.0	5	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	53	1
							5	2	54 55	1 1
5	3	A	RIGHT	546.0	48.0	5	1	1	28	2
							2	1	29	2
							3	1	68	2
							4	1	69	2
							5	1	70	2
6	3	B	LEFT	546.0	90.0	5	1	1	5	3
							2	1	6	3
							3	1	82	1
							4	1	83	1
							5	1	84	1
7	4	A	RIGHT	762.0	48.0	8	1	1	30	2
							2	1	31	2
							3	1	32	2
							4	1	63	1
							5	1	64	1
							6	2	66 65	1 1
							7	1	71	2
							8	2	73 72	2 2
8	4	B	LEFT	762.0	90.0	3	1	1	7	3
							2	2	8 9	3 3
							3	1	93	1
9	5	A	RIGHT	1035.0	48.0	11	1	1	33	2
							2	1	34	2
							3	1	35	2
							4	1	36	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	19	2
							10	1	20	2
							11	1	21	2
10	5	A	RIGHT	1035.0	48.0	17	1	2	23 22	2 2
							2	1	100	2
							3	1	101	2
							4	1	102	2
							5	1	97	2
							6	2	99 98	2 2
							7	1	85	2
							8	1	86	2
							9	1	87	2
							10	1	88	2
							11	1	89	2
							12	1	94	2
							13	2	104 103	2 2
							14	1	105	2
							15	1	106	2
							16	1	107	2
							17	1	90	2
11	5	A	RIGHT	1035.0	48.0	2	1	1	95	2
							2	1	108	2
12	5	B	LEFT	1035.0	90.0	4	1	1	91	1
							2	1	96	1
							3	1	92	1
							4	2	109 110	1 1
13	5	B	LEFT	1035.0	90.0	8	1	1	10	3
							2	1	11	3
							3	1	12	3
							4	2	13 14	3 3
							5	1	111	3
							6	1	112	3
							7	1	113	3
							8	1	114	2

** Ninfeasible
5: 110 111 112 113 114

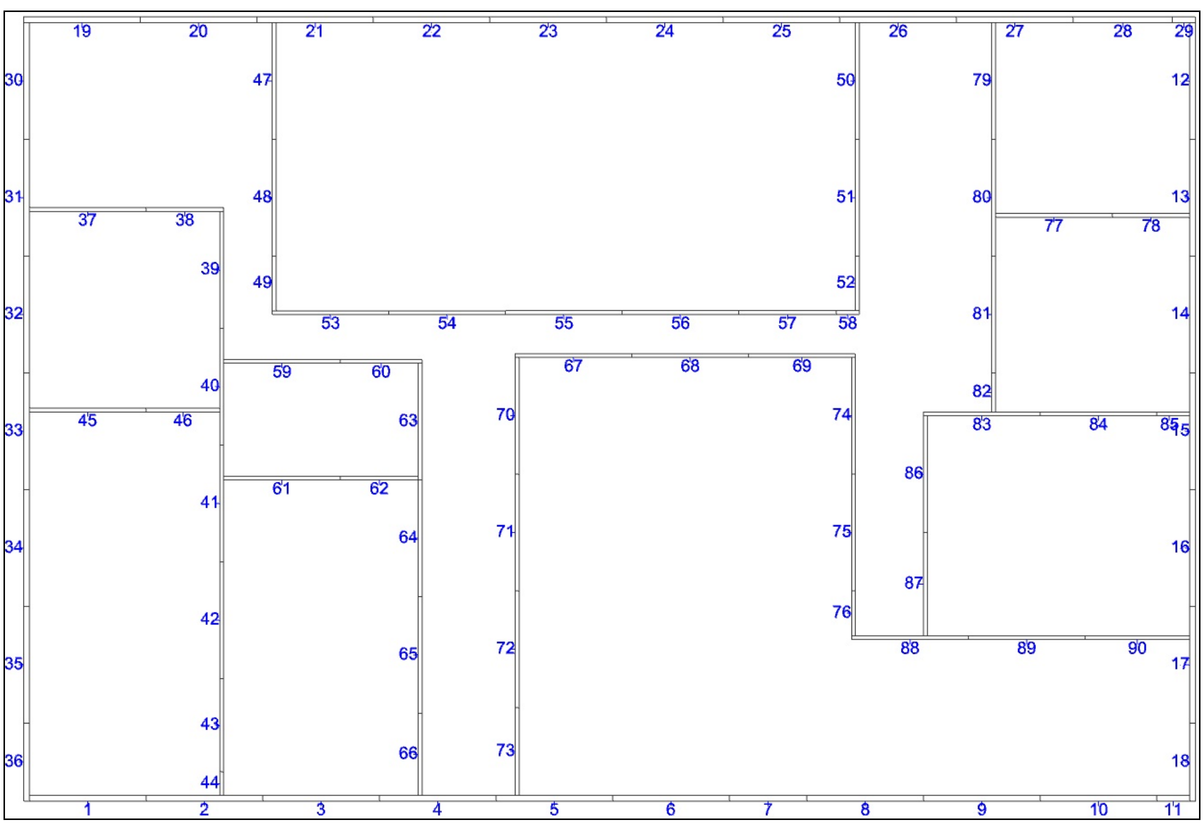
```
L4-1: Proposed algorithm
** Nzones
6
**zone     left edge X coordinate
  1          6.0
  2        210.0
  3        428.0
  4        634.0
  5        860.0
  6        984.0
** NStacks
13
** stack                flush
**  #   zone type  edge    xloc   yloc  #layers  j  #panels  panels   orientation
    1    1    A    RIGHT  114.0   48.0    12        1        1   24        2
                                                    2        1   25        2
                                                    3        1   37        1
                                                    4        1   38        1
                                                    5        1   39        1
                                                    6        1   40        1
                                                    7        1   41        1
                                                    8        1   42        1
                                                    9        1   43        1
                                                   10        2   45 44     1 1
                                                   11        1   46        2
                                                   12        2   48 47     2 2
    2    1    A    RIGHT  114.0   48.0     7        1        1   49        1
                                                    2        1   50        1
                                                    3        1   56        2
                                                    4        2   58 57     2 2
                                                    5        1   51        1
                                                    6        1   52        1
                                                    7        1   1         3
    3    2    A    RIGHT  330.0   48.0    12        1        1   26        2
                                                    2        1   27        2
                                                    3        1   59        1
                                                    4        1   60        1
                                                    5        2   62 61     1 1
                                                    6        1   67        2
                                                    7        1   74        2
                                                    8        2   76 75     2 2
                                                    9        1   80        1
                                                   10        1   77        2
                                                   11        2   79 78     2 2
                                                   12        1   81        1
    4    2    B    LEFT   330.0   90.0     5        1        1   2         3
                                                    2        1   3         3
                                                    3        1   4         3
                                                    4        1   53        1
                                                    5        2   54 55     1 1
    5    3    A    RIGHT  546.0   48.0     5        1        1   28        2
                                                    2        1   29        2
                                                    3        1   68        2
                                                    4        1   69        2
                                                    5        1   70        2
    6    3    B    LEFT   546.0   90.0     5        1        1   5         3
                                                    2        1   6         3
                                                    3        1   82        1
                                                    4        1   83        1
                                                    5        2   84 93     1 1
    7    4    A    RIGHT  762.0   48.0     8        1        1   30        2
                                                    2        1   31        2
                                                    3        1   32        2
                                                    4        1   63        1
                                                    5        1   64        1
                                                    6        2   66 65     1 1
                                                    7        1   71        2
                                                    8        2   73 72     2 2
    8    4    B    LEFT   762.0   90.0     5        1        1   7         3
                                                    2        2   8 9       3 3
                                                    3        1   33        2
                                                    4        1   92        1
                                                    5        1   10        3
    9    5    A    RIGHT  978.0   48.0     7        1        1   34        2
                                                    2        1   100       1
                                                    3        1   101       1
                                                    4        1   102       1
                                                    5        2   104 103   1 1
                                                    6        1   105       2
                                                    7        1   108       1
```

L4-1: Proposed algorithm

10	5	B	LEFT	978.0	90.0	1	1	1	11	3
11	6	A	RIGHT	1092.0	48.0	12	1	1	35	2
							2	1	36	2
							3	1	15	2
							4	1	16	2
							5	1	17	2
							6	1	18	2
							7	1	19	2
							8	1	20	2
							9	1	21	2
							10	2	23 22	2 2
							11	1	97	2
							12	2	99 98	2 2
12	6	A	RIGHT	1092.0	48.0	12	1	1	85	2
							2	1	86	2
							3	1	87	2
							4	1	88	2
							5	1	89	2
							6	1	94	2
							7	1	106	2
							8	1	107	2
							9	1	90	2
							10	1	95	2
							11	1	12	3
							12	2	14 13	3 3
13	6	B	LEFT	1092.0	90.0	7	1	1	91	1
							2	1	96	1
							3	2	109 110	1 1
							4	1	111	3
							5	1	112	2
							6	1	113	2
							7	1	114	2

** # of interfering panels
0

L4-2



```
L4-2: Shewchuk (2008)
** Nzones
5
**zone      left edge X coordinate
  1          6.0
  2        222.0
  3        438.0
  4        654.0
  5        870.0
** NStacks
12
** stack                flush
**   #   zone type   edge     xloc    yloc  #layers   j  #panels  panels     orientation
     1     1    A    RIGHT   114.0   48.0     13         1     1    19          2
                                                         2     1    30          1
                                                         3     1    31          1
                                                         4     1    32          1
                                                         5     1    33          1
                                                         6     1    34          1
                                                         7     1    35          1
                                                         8     1    36          1
                                                         9     1    37          2
                                                        10     1    38          2
                                                        11     1    39          1
                                                        12     1    45          2
                                                        13     1    46          2
     2     1    A    RIGHT   114.0   48.0      3         1     1    40          1
                                                         2     1    41          1
                                                         3     1    1           3
     3     2    A    RIGHT   330.0   48.0     11         1     1    20          2
                                                         2     1    21          2
                                                         3     1    47          1
                                                         4     1    48          1
                                                         5     1    49          1
                                                         6     1    53          2
                                                         7     1    59          2
                                                         8     1    60          2
                                                         9     1    61          2
                                                        10     1    62          2
                                                        11     1    63          1
     4     2    B    LEFT    330.0   90.0      4         1     1    2           3
                                                         2     1    3           3
                                                         3     1    42          1
                                                         4     2    43 44       1 1
     5     3    A    RIGHT   546.0   48.0      4         1     1    22          2
                                                         2     1    23          2
                                                         3     1    54          2
                                                         4     1    55          2
     6     3    B    LEFT    546.0   90.0      5         1     1    4           3
                                                         2     1    5           3
                                                         3     1    64          1
                                                         4     1    65          1
                                                         5     1    66          1
     7     4    A    RIGHT   762.0   48.0      4         1     1    24          2
                                                         2     1    25          2
                                                         3     1    56          2
                                                         4     2    58 57       2 2
     8     4    B    LEFT    762.0   90.0      3         1     1    6           3
                                                         2     1    7           3
                                                         3     1    73          1
     9     5    A    RIGHT   1035.0   48.0    12         1     1    26          2
                                                         2     1    27          2
                                                         3     2    29 28       2 2
                                                         4     1    12          2
                                                         5     1    13          2
                                                         6     1    14          2
                                                         7     1    15          2
                                                         8     1    16          2
                                                         9     1    17          2
                                                        10     1    18          2
                                                        11     1    50          2
                                                        12     1    79          2
    10     5    A    RIGHT   1035.0   48.0    15         1     1    51          2
                                                         2     1    80          2
                                                         3     1    77          2
                                                         4     2    52 78       2 2
                                                         5     1    67          2
                                                         6     1    68          2
                                                         7     1    69          2
                                                         8     1    70          2
                                                         9     1    74          2
```

L4-2: Shewchuk (2008)

							10	1	81	2
							11	1	82	2
							12	1	83	2
							13	1	84	2
							14	1	85	2
							15	1	86	2
11	5	B	LEFT	1035.0	90.0	4	1	1	71	1
							2	1	75	1
							3	1	72	1
							4	1	76	1
12	5	B	LEFT	1035.0	90.0	8	1	1	8	3
							2	1	9	3
							3	1	10	3
							4	1	11	3
							5	1	87	1
							6	1	88	3
							7	1	89	3
							8	1	90	2

** # of interfering panels
4: 87 88 89 90

L4-2: Proposed algorithm
** Nzones
6

**zone	left edge X coordinate
1	6.0
2	210.0
3	428.0
4	642.0
5	858.0
6	984.0

** NStacks
13

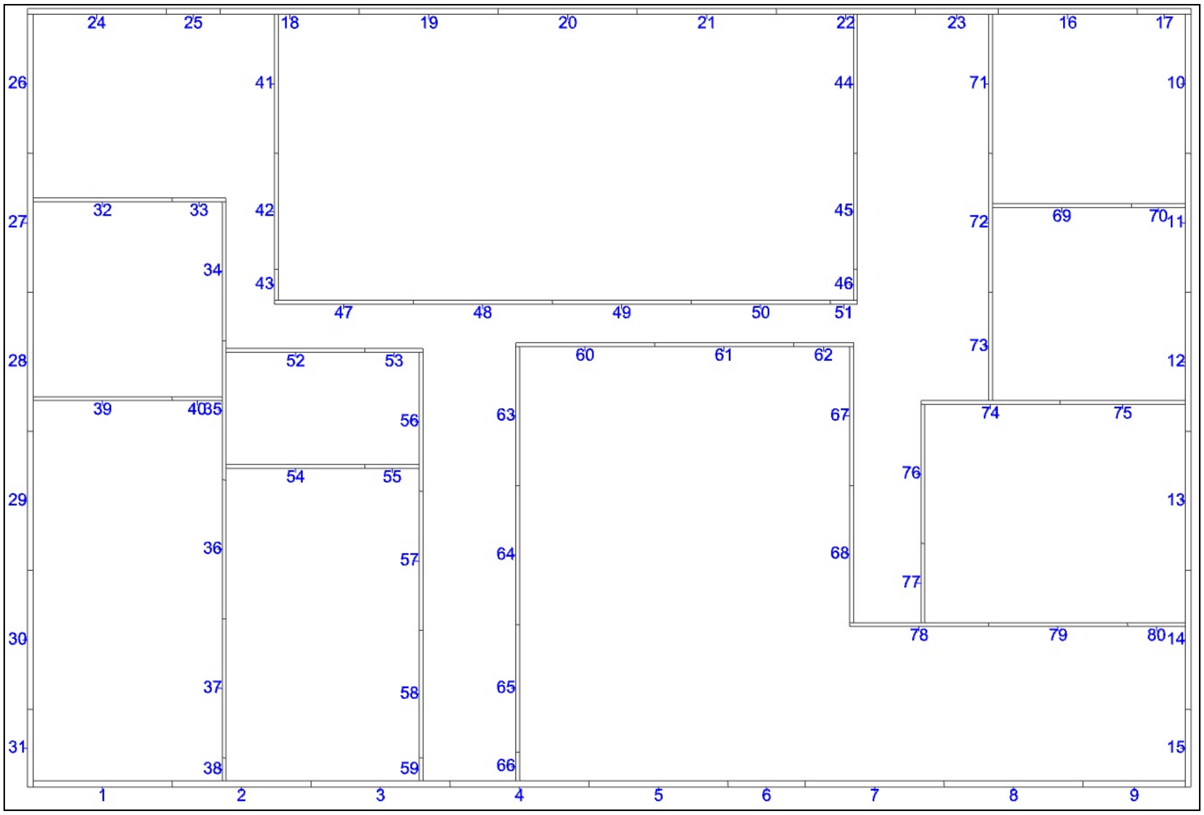
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	13	1	1	19	2
							2	1	30	1
							3	1	31	1
							4	1	32	1
							5	1	33	1
							6	1	34	1
							7	1	35	1
							8	1	36	1
							9	1	37	2
							10	1	38	2
							11	1	39	1
							12	1	45	2
							13	1	46	2
2	1	A	RIGHT	114.0	48.0	3	1	1	40	1
							2	1	41	1
							3	1	1	3
3	2	A	RIGHT	330.0	48.0	11	1	1	20	2
							2	1	21	2
							3	1	47	1
							4	1	48	1
							5	1	49	1
							6	1	53	2
							7	1	59	2
							8	1	60	2
							9	1	61	2
							10	1	62	2
							11	1	63	1
4	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	1	42	1
							4	2	43 44	1 1
5	3	A	RIGHT	546.0	48.0	4	1	1	22	2
							2	1	23	2
							3	1	54	2
							4	1	55	2
6	3	B	LEFT	546.0	90.0	6	1	1	4	3
							2	1	5	3
							3	1	64	1
							4	1	65	1
							5	1	66	1
							6	1	73	1

L4-2: Proposed algorithm

7	4	A	RIGHT	762.0	48.0	4	1	1	24	2
							2	1	25	2
							3	1	56	2
							4	2	58 57	2 2
8	4	B	LEFT	762.0	90.0	8	1	1	6	3
							2	1	7	3
							3	1	26	2
							4	1	50	1
							5	1	51	1
							6	1	52	1
							7	1	72	1
							8	1	8	3
9	5	A	RIGHT	978.0	48.0	7	1	1	27	2
							2	1	79	1
							3	1	80	1
							4	1	81	1
							5	1	82	1
							6	1	83	2
							7	1	86	1
10	5	B	LEFT	978.0	90.0	1	1	1	9	3
11	6	A	RIGHT	1092.0	48.0	13	1	2	29 28	2 2
							2	1	12	2
							3	1	13	2
							4	1	14	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	77	2
							10	1	78	2
							11	1	67	2
							12	1	68	2
							13	1	69	2
12	6	A	RIGHT	1092.0	48.0	6	1	1	70	2
							2	1	74	2
							3	1	84	2
							4	1	85	2
							5	1	10	3
							6	1	11	3
13	6	B	LEFT	1092.0	90.0	7	1	1	71	1
							2	1	75	1
							3	1	76	1
							4	1	87	1
							5	1	88	3
							6	1	89	2
							7	1	90	2

** # of interfering panels
0

L4-3



L4-3: Shewchuk (2008)
** Nzones
5

**zone	left edge X coordinate
1	6.0
2	226.5
3	446.9
4	667.4
5	887.8

** NStacks
12

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	24	2
							2	1	25	2
							3	1	26	1
							4	1	27	1
							5	1	28	1
							6	1	29	1
							7	1	30	1
							8	1	31	1
							9	1	32	2
							10	1	33	2
							11	1	34	1
							12	1	39	2
							13	1	40	2
2	1	A	RIGHT	116.2	57.3	2	1	1	35	1
							2	1	1	3
3	2	A	RIGHT	336.7	57.3	10	1	1	18	2
							2	1	41	1
							3	1	42	1
							4	1	43	1
							5	1	47	2
							6	1	52	2
							7	1	53	2
							8	1	54	2
							9	1	55	2
							10	1	56	1

L4-3: Shewchuk (2008)

4	2	B	LEFT	336.7	99.3	5	1	1	2	3
							2	1	3	3
							3	1	36	1
							4	1	37	1
							5	1	38	1
5	3	A	RIGHT	557.1	57.3	3	1	1	19	2
							2	1	20	2
							3	1	48	2
6	3	B	LEFT	557.1	99.3	4	1	1	4	3
							2	1	57	1
							3	1	58	1
							4	1	59	1
7	4	A	RIGHT	777.6	57.3	4	1	1	21	2
							2	1	49	2
							3	1	50	2
							4	1	51	2
8	4	B	LEFT	777.6	99.3	2	1	1	5	3
							2	2	6 66	3 1
9	5	A	RIGHT	1043.9	57.3	12	1	1	22	2
							2	1	23	2
							3	1	16	2
							4	1	17	2
							5	1	10	2
							6	1	11	2
							7	1	12	2
							8	1	13	2
							9	1	14	2
							10	1	15	2
							11	1	44	2
							12	1	71	2
10	5	A	RIGHT	1043.9	57.3	14	1	1	45	2
							2	1	46	2
							3	1	72	2
							4	1	69	2
							5	1	70	2
							6	1	60	2
							7	1	61	2
							8	1	62	2
							9	1	63	2
							10	1	67	2
							11	1	73	2
							12	1	74	2
							13	1	75	2
							14	1	76	2
11	5	B	LEFT	1043.9	99.3	4	1	1	64	1
							2	1	68	1
							3	1	65	1
							4	1	77	1
12	5	B	LEFT	1043.9	99.3	6	1	1	7	3
							2	1	8	3
							3	1	9	3
							4	1	78	3
							5	1	79	3
							6	1	80	2

** # of interfering panels
3: 78 79 80

L4-3: Proposed algorithm

** Nzones
6

**zone	left edge X coordinate
1	6.0
2	213.5
3	432.9
4	653.4
5	868.8
6	979.5

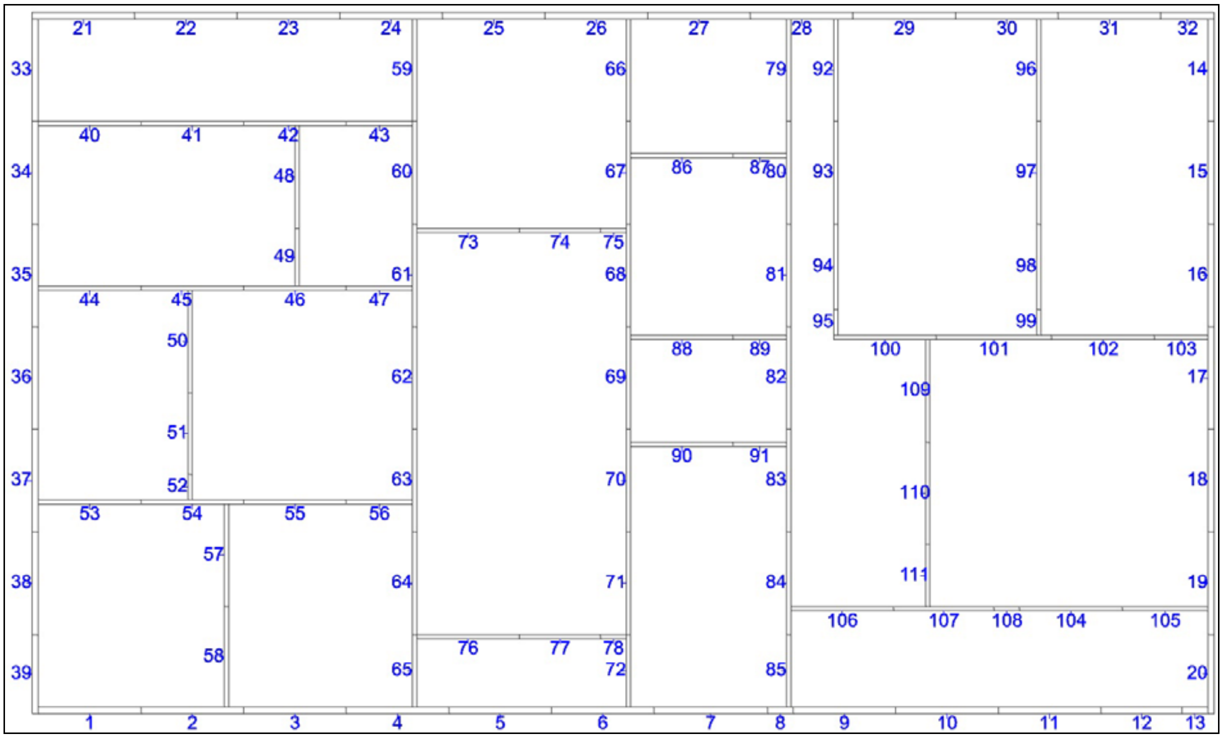
** NStacks
12

L4-3: Proposed algorithm

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	24	2
							2	1	25	2
							3	1	26	1
							4	1	27	1
							5	1	28	1
							6	1	29	1
							7	1	30	1
							8	1	31	1
							9	1	32	2
							10	1	33	2
							11	1	34	1
							12	1	39	2
							13	1	40	2
2	1	A	RIGHT	116.2	57.3	2	1	1	35	1
							2	1	1	3
3	2	A	RIGHT	336.7	57.3	10	1	1	18	2
							2	1	41	1
							3	1	42	1
							4	1	43	1
							5	1	47	2
							6	1	52	2
							7	1	53	2
							8	1	54	2
							9	1	55	2
							10	1	56	1
4	2	B	LEFT	336.7	99.3	5	1	1	2	3
							2	1	3	3
							3	1	36	1
							4	1	37	1
							5	1	38	1
5	3	A	RIGHT	557.1	57.3	3	1	1	19	2
							2	1	20	2
							3	1	48	2
6	3	B	LEFT	557.1	99.3	4	1	1	4	3
							2	1	57	1
							3	1	58	1
							4	2	59 66	1 1
7	4	A	RIGHT	777.6	57.3	4	1	1	21	2
							2	1	49	2
							3	1	50	2
							4	1	51	2
8	4	B	LEFT	777.6	99.3	8	1	1	5	3
							2	1	6	3
							3	1	22	2
							4	1	44	1
							5	1	45	1
							6	1	46	1
							7	1	65	1
							8	1	7	3
9	5	A	RIGHT	998.1	57.3	6	1	1	23	2
							2	1	71	1
							3	1	72	1
							4	1	73	1
							5	1	74	2
							6	1	76	1
10	4	B	LEFT	998.1	99.3	1	1	1	8	3
11	6	A	RIGHT	1089.8	57.3	17	1	1	16	2
							2	1	17	2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
							8	1	15	2
							9	1	69	2
							10	1	70	2
							11	1	60	2
							12	1	61	2
							13	1	62	2
							14	1	63	2
							15	1	67	2
							16	1	75	2
							17	1	9	3
12	6	B	LEFT	1089.8	99.3	6	1	1	64	1
							2	1	68	1
							3	1	77	1
							4	1	78	2
							5	1	79	2
							6	1	80	2

** # of interfering panels
0

L5-1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11
12
13

```
L5-1: Shewchuk (2008)
** Nzones
5
**zone      left edge X coordinate
  1            6.0
  2          222.0
  3          438.0
  4          654.0
  5          870.0
** NStacks
13
** stack                flush
**   #   zone type   edge    xloc   yloc  #layers  j  #panels   panels   orientation
     1    1    A     RIGHT   114.0  48.0    13         1     1    21          2
                                                       2     1    22          2
                                                       3     1    33          1
                                                       4     1    34          1
                                                       5     1    35          1
                                                       6     1    36          1
                                                       7     1    37          1
                                                       8     1    38          1
                                                       9     1    39          1
                                                      10     1    40          2
                                                      11     1    41          2
                                                      12     1    44          2
                                                      13     1    45          2
     2    1    A     RIGHT   114.0  48.0     6         1     1    50          1
                                                       2     2    52 51       1 1
                                                       3     1    53          2
                                                       4     1    54          2
                                                       5     1    57          1
                                                       6     1    1           2
     3    2    A     RIGHT   330.0  48.0    14         1     1    23          2
                                                       2     1    24          2
                                                       3     1    59          1
                                                       4     1    42          2
                                                       5     1    43          2
                                                       6     1    48          1
                                                       7     1    60          1
                                                       8     1    49          1
                                                       9     1    46          2
                                                      10     1    47          2
                                                      11     1    61          1
                                                      12     1    62          1
                                                      13     1    55          2
                                                      14     1    56          2
     4    2    A     RIGHT   330.0  48.0     2         1     1    63          1
                                                       2     1    64          1
     5    2    B     LEFT    330.0  90.0     4         1     1    2           3
                                                       2     1    3           3
                                                       3     1    4           3
                                                       4     1    58          1
     6    3    A     RIGHT   546.0  48.0    10         1     1    25          2
                                                       2     1    26          2
                                                       3     1    66          1
                                                       4     1    67          1
                                                       5     1    73          2
                                                       6     2    75 74       2 2
                                                       7     1    68          1
                                                       8     1    69          1
                                                       9     1    70          1
                                                      10     1    71          1
     7    3    B     LEFT    546.0  90.0     3         1     1    5           3
                                                       2     1    6           3
                                                       3     1    65          1
     8    4    A     RIGHT   762.0  48.0    14         1     1    27          2
                                                       2     1    28          2
                                                       3     1    29          2
                                                       4     1    79          1
                                                       5     1    92          1
                                                       6     1    86          2
                                                       7     1    87          2
                                                       8     1    80          1
                                                       9     1    93          1
                                                      10     1    81          1
                                                      11     1    94          1
                                                      12     1    88          2
                                                      13     1    89          2
                                                      14     2    95 82       1 1
```

L5-1: Shewchuk (2008)

9	4	A	RIGHT	762.0	48.0	2	1	1	100	2
							2	1	90	2
10	4	B	RIGHT	762.0	48.0	7	1	1	91	2
							2	1	83	1
							4	1	84	1
							5	1	85	1
11	4	B	LEFT	762.0	90.0	5	1	2	7 8	3 3
							2	1	9	3
							3	1	76	2
							4	2	77 78	2 2
							5	1	72	1
12	5	A	RIGHT	985.0	48.0	12	1	1	30	2
							2	1	31	2
							3	1	32	2
							4	1	14	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	19	2
							10	1	20	2
							11	1	96	2
							12	1	97	2
13	5	B	LEFT	985.0	90.0	14	1	1	10	3
							2	1	11	3
							3	2	12 13	3 3
							4	2	98 99	1 1
							5	1	101	2
							6	1	102	2
							7	1	103	2
							8	1	109	1
							9	1	110	1
							10	1	111	1
							11	1	106	2
							12	2	107	2
							13	2	108 104	2 2
							14	1	105	2

** Ninfeasible
5: 106 107 108 104 105

L5-1: Proposed algorithm
** Nzones
6

**zone	left edge X coordinate
1	6.0
2	213.0
3	425.0
4	640.0
5	850.0
6	884.0

** NStacks
13

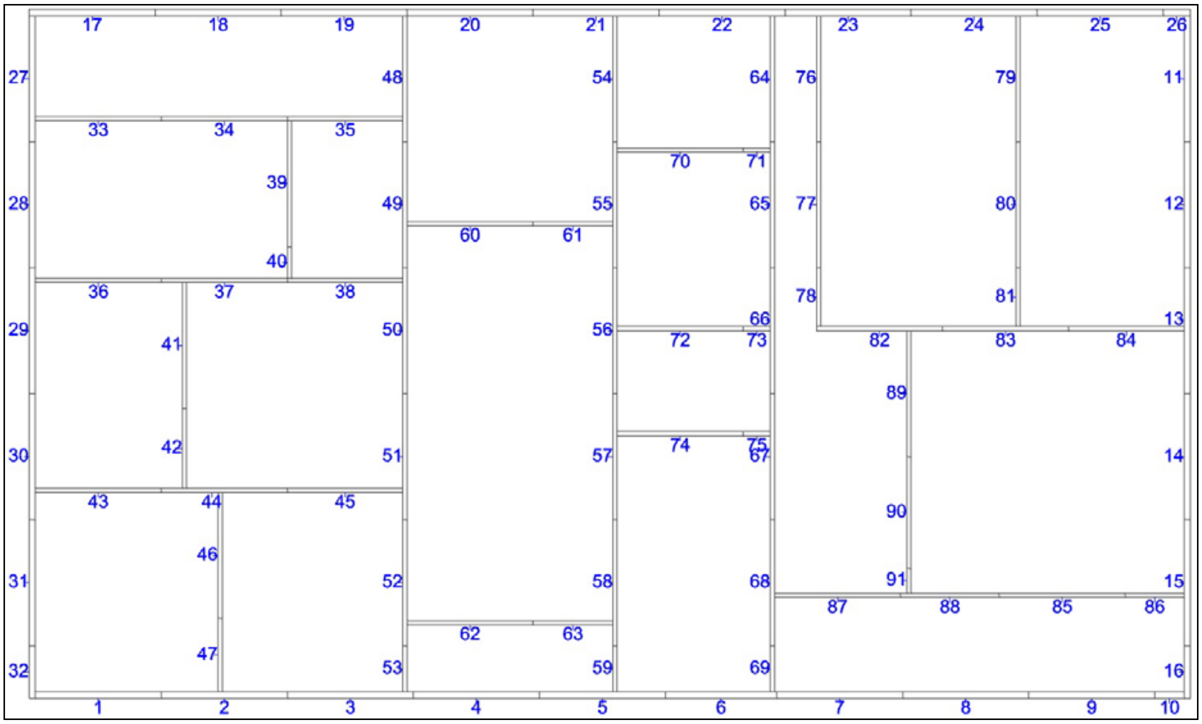
** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	13	1	1	21	2
							2	1	22	2
							3	1	33	1
							4	1	34	1
							5	1	35	1
							6	1	36	1
							7	1	37	1
							8	1	38	1
							9	1	39	1
							10	1	40	2
							11	1	41	2
							12	1	44	2
							13	1	45	2
2	1	A	RIGHT	114.0	48.0	6	1	1	50	1
							2	2	52 51	1 1
							3	1	53	2
							4	1	54	2
							5	1	57	1
							6	1	1	2
3	2	A	RIGHT	330.0	48.0	16	1	1	23	2
							2	1	24	2
							3	1	59	1
							4	1	42	2
							5	1	43	2

L5-1: Proposed algorithm

							6	1	48	1
							7	1	60	1
							8	1	49	1
							9	1	46	2
							10	1	47	2
							11	1	61	1
							12	1	62	1
							13	1	55	2
							14	1	56	2
							15	1	63	1
							16	1	64	1
4	2	B	LEFT	330.0	90.0	4	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	1	58	1
5	3	A	RIGHT	546.0	48.0	10	1	1	25	2
							2	1	26	2
							3	1	66	1
							4	1	67	1
							5	1	73	2
							6	2	75 74	2 2
							7	1	68	1
							8	1	69	1
							9	1	70	1
							10	1	71	1
6	3	B	LEFT	546.0	90.0	6	1	1	5	3
							2	1	6	3
							3	1	65	1
							4	1	76	2
							5	2	77 78	2 2
							6	1	72	1
7	4	A	RIGHT	762.0	48.0	14	1	1	27	2
							2	1	28	2
							3	1	29	2
							4	1	79	1
							5	1	92	1
							6	1	86	2
							7	1	87	2
							8	1	80	1
							9	1	93	1
							10	1	81	1
							11	1	94	1
							12	1	88	2
							13	1	89	2
							14	2	95 82	1 1
8	4	A	RIGHT	762.0	48.0	2	1	1	100	2
							2	1	90	2
9	5	A	RIGHT	762.0	48.0	7	1	1	91	2
							2	1	83	1
							3	1	109	1
							4	1	84	1
							5	1	110	1
							6	1	111	1
							7	1	106	2
10	5	B	LEFT	762.0	90.0	3	1	2	7 8	3 3
							2	1	9	3
							3	1	85	1
11	6	A	RIGHT	978.0	48.0	9	1	1	30	2
							2	1	31 32	2 2
							3	1	14	2
							4	1	15	2
							5	1	16	2
							6	1	17	2
							7	1	18	2
							8	1	19	2
							9	1	20	2
12	6	A	RIGHT	978.0	48.0	6	1	1	96	1
							2	1	97	1
							3	2	99 98	1 1
							4	1	101	2
							5	1	102 103	2 2
							6	1	107	2
13	6	B	LEFT	992.0	90.0	12	1	1	10	3
							2	1	11	2
							3	2	12 13	2 2
							4	1	105	2 2
							5	2	104 108	2 2

** # of interfering panels
3: 105 104 108

L5-2




```
L5-2: Shewchuk (2008)

** Nzones
5

**zone      left edge X coordinate
 1            6.0
 2          222.0
 3          438.0
 4          654.0
 5          870.0

** NStacks
10

** stack                   flush
**    #     zone type      edge      xloc    yloc   #layers   j   #panels   panels       orientation
      1       1     A      RIGHT   114.0    48.0       11         1         1      17              2
                                                                  2         1      27              1
                                                                  3         1      28              1
                                                                  4         1      29              1
                                                                  5         1      30              1
                                                                  6         1      31              1
                                                                  7         1      32              1
                                                                  8         1      33              2
                                                                  9         1      36              2
                                                                 10         1      43              2
                                                                 11         1       1              2
```

L5-2: Shewchuk (2008)

2	2	A	RIGHT	330.0	48.0	16	1	1	18	2
							2	1	19	2
							3	1	34	2
							4	1	35	2
							5	1	39	1
							6	1	48	1
							7	1	40	1
							8	1	49	1
							9	1	37	2
							10	1	38	2
							11	1	41	1
							12	1	50	1
							13	1	42	1
							14	1	44	2
							15	1	45	2
							16	1	46	1
3	2	A	RIGHT	330.0	48.0	1	1	1	51	1
4	2	B	LEFT	330.0	90.0	3	1	1	2	3
							2	1	3	3
							3	1	47	1
5	3	A	RIGHT	546.0	48.0	8	1	1	20	2
							2	1	21	2
							3	1	54	1
							4	1	60	2
							5	1	61	2
							6	1	55	1
							7	1	56	1
							8	1	57	1
6	3	B	LEFT	546.0	90.0	4	1	1	4	3
							2	1	5	3
							3	1	52	1
							4	1	53	1
7	4	A	RIGHT	762.0	48.0	15	1	1	22	2
							2	1	23	2
							3	1	64	1
							4	1	76	1
							5	1	70	2
							6	1	71	2
							7	1	65	1
							8	1	77	1
							9	1	72	2
							10	1	73	2
							11	1	66	1
							12	1	78	1
							13	1	74	2
							14	1	75	2
							15	1	67	1
8	4	B	LEFT	762.0	90.0	6	1	1	6	3
							2	1	7	3
							3	1	62	2
							4	1	63	2
							5	1	58	1
							6	1	59	1
9	5	A	RIGHT	985.0	48.0	12	1	1	24	2
							2	1	25	2
							3	1	26	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
							8	1	15	2
							9	1	16	2
							10	1	79	2
							11	1	80	2
							12	1	81	2
10	5	B	LEFT	985.0	90.0	14	1	1	8	3
							2	1	9	3
							3	1	10	3
							4	1	82	2
							5	1	83	2
							6	1	84	2
							7	1	89	1
							8	1	68	1
							9	2	91 90	1 1
							10	1	87	2
							11	1	88	2
							12	1	69	1
							13	1	85	2
							14	1	86	2

** # of interfering panels
2: 85 86

L5-2: Proposed algorithm
** Nzones
6

**zone	left edge X coordinate
1	6.0
2	210.0
3	423.0
4	638.0
5	860.0
6	884.0

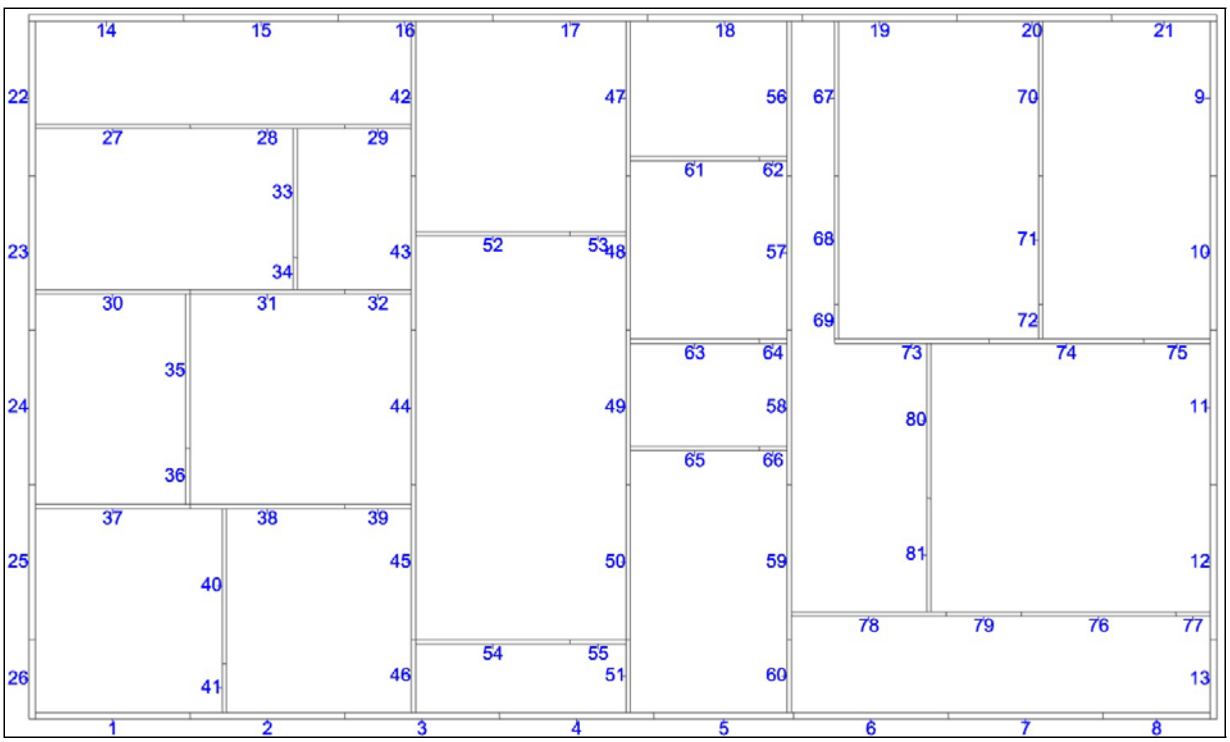
** NStacks
10

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	1	17	2
							2	1	27	1
							3	1	28	1
							4	1	29	1
							5	1	30	1
							6	1	31	1
							7	1	32	1
							8	1	33	2
							9	1	36	2
							10	1	43	2
							11	1	1	2
2	2	A	RIGHT	330.0	48.0	16	1	1	18	2
							2	1	19	2
							3	1	34	2
							4	1	35	2
							5	1	39	1
							6	1	48	1
							7	1	40	1
							8	1	49	1
							9	1	37	2
							10	1	38	2
							11	1	41	1
							12	1	50	1
							13	1	42	1
							14	1	44	2
							15	1	45	2
							16	1	46	1
3	2	A	RIGHT	330.0	48.0	1	1	1	51	1
4	2	B	LEFT	330.0	90.0	3	1	1	2	3
							2	1	3	3
							3	1	47	1
5	3	A	RIGHT	546.0	48.0	8	1	1	20	2
							2	1	21	2
							3	1	54	1
							4	1	60	2
							5	1	61	2
							6	1	55	1
							7	1	56	1
							8	1	57	1
6	4	B	LEFT	546.0	90.0	7	1	1	4	3
							2	1	5	3
							3	1	52	1
							4	1	62	2
							5	1	63	2
							6	1	58	1
							7	2	53 59	1 1
7	5	A	RIGHT	762.0	48.0	15	1	1	22	2
							2	1	23	2
							3	1	64	1
							4	1	76	1
							5	1	70	2
							6	1	71	2
							7	1	65	1
							8	1	77	1
							9	1	72	2
							10	1	73	2
							11	1	66	1
							12	1	78	1
							13	1	74	2
							14	1	75	2
							15	1	67	1
8	5	B	LEFT	762.0	90.0	8	1	1	6	3
							2	1	7	3

L5-2: Proposed algorithm

							3	1	82	2
							4	1	89	1
							5	1	68	1
							6	2	90 91	1 1
							7	1	87	2
							8	1	69	1
9	6	A	RIGHT	978.0	48.0	8	1	1	24	2
							2	1	25	2
							3	1	79	1
							4	1	80	1
							5	1	81	1
							6	1	83	2
							7	1	88	2
							8	1	85	2
10	6	B	LEFT	992.0	90.0	11	1	1	8	2
							2	1	9	2
							3	1	26	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
							8	1	15	2
							9	1	16	2
							10	1	84	2

L5-3



```
L5-3: Shewchuk (2008)
** Nzones
4
**zone      left edge X coordinate
 1            6.0
 2          226.5
 3          446.9
 4          667.4
** NStacks
10
** stack                  flush
**   #    zone type    edge      xloc    yloc   #layers   j   #panels   panels       orientation
     1      1     A     RIGHT    116.2   57.3      12          1        1    14             2
                                                               2        1    22             1
                                                               3        1    23             1
                                                               4        1    24             1
                                                               5        1    25             1
                                                               6        1    26             1
                                                               7        1    27             2
                                                               8        1    30             2
                                                               9        1    35             1
                                                              10        1    36             1
                                                              11        1    37             2
                                                              12        1    1              2
     2      2     A     RIGHT    336.7   57.3      13          1        1    15             2
                                                               2        1    16             2
                                                               3        1    28             2
                                                               4        1    29             2
                                                               5        1    33             1
                                                               6        1    42             1
                                                               7        1    34             1
                                                               8        1    31             2
                                                               9        1    32             2
                                                              10        1    43             1
                                                              11        1    44             1
                                                              12        1    38             2
                                                              13        1    39             2
     3      2     B     LEFT     336.7   99.3       4          1        1    2              3
                                                               2        1    3              3
                                                               3        1    40             1
                                                               4        1    41             1
     4      3     A     RIGHT    557.1   57.3       6          1        1    17             2
                                                               2        1    47             1
                                                               3        1    52             2
                                                               4        1    53             2
                                                               5        1    48             1
                                                               6        1    49             1
     5      3     B     LEFT     557.1   99.3       3          1        1    4              3
                                                               2        1    45             1
                                                               3        1    46             1
     6      4     A     RIGHT    883.7   57.3      13          1        1    18             2
                                                               2        1    19             2
                                                               3        1    20             2
                                                               4        1    21             2
                                                               5        1    9              2
                                                               6        1    10             2
                                                               7        1    11             2
                                                               8        1    12             2
                                                               9        1    13             2
                                                              10        1    61             2
                                                              11        1    62             2
                                                              12        1    56             2
                                                              13        1    67             2
     7      4     A     RIGHT    883.7   57.3      17          1        1    70             2
                                                               2        1    57             2
                                                               3        1    68             2
                                                               4        1    71             2
                                                               5        1    63             2
                                                               6        1    64             2
                                                               7        1    65             2
                                                               8        1    66             2
                                                               9        1    58             2
                                                              10        2    72 69          2 2
                                                              11        1    73             2
                                                              12        1    74             2
                                                              13        1    75             2
                                                              14        1    80             2
                                                              15        1    81             2
```

L5-3: Shewchuk (2008)

8	4	A	RIGHT	883.7	57.3	17	1	1	78	2
9	4	B	LEFT	883.7	99.3	5	1	1	50	1
							2	1	54	2
							3	2	55 51	2 1
							4	1	59	1
							5	1	60	1
10	4	B	LEFT	883.7	99.3	7	1	1	5	3
							2	1	6	3
							3	1	7	3
							4	1	8	3
							5	1	79	2
							6	1	76	2
							7	1	77	2

** # of interfering panels
3: 79 76 77

L5-3: Proposed algorithm
** Nzones
5

**zone	left edge X coordinate
1	6.0
2	216.5
3	427.9
4	651.4
5	879.5

** NStacks
9

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	12	1	1	14	2
							2	1	22	1
							3	1	23	1
							4	1	24	1
							5	1	25	1
							6	1	26	1
							7	1	27	2
							8	1	30	2
							9	1	35	1
							10	1	36	1
							11	1	37	2
							12	1	1	2
2	2	A	RIGHT	336.7	57.3	13	1	1	15	2
							2	1	16	2
							3	1	28	2
							4	1	29	2
							5	1	33	1
							6	1	42	1
							7	1	34	1
							8	1	31	2
							9	1	32	2
							10	1	43	1
							11	1	44	1
							12	1	38	2
							13	1	39	2
3	2	B	LEFT	336.7	99.3	4	1	1	2	3
							2	1	3	3
							3	1	40	1
							4	1	41	1
4	3	A	RIGHT	557.1	57.3	6	1	1	17	2
							2	1	47	1
							3	1	52	2
							4	1	53	2
							5	1	48	1
							6	1	49	1
5	3	B	LEFT	557.1	99.3	6	1	1	4	3
							2	1	45	1
							3	1	50	1
							4	1	46	1
							5	1	54	2
							6	2	55 51	2 1

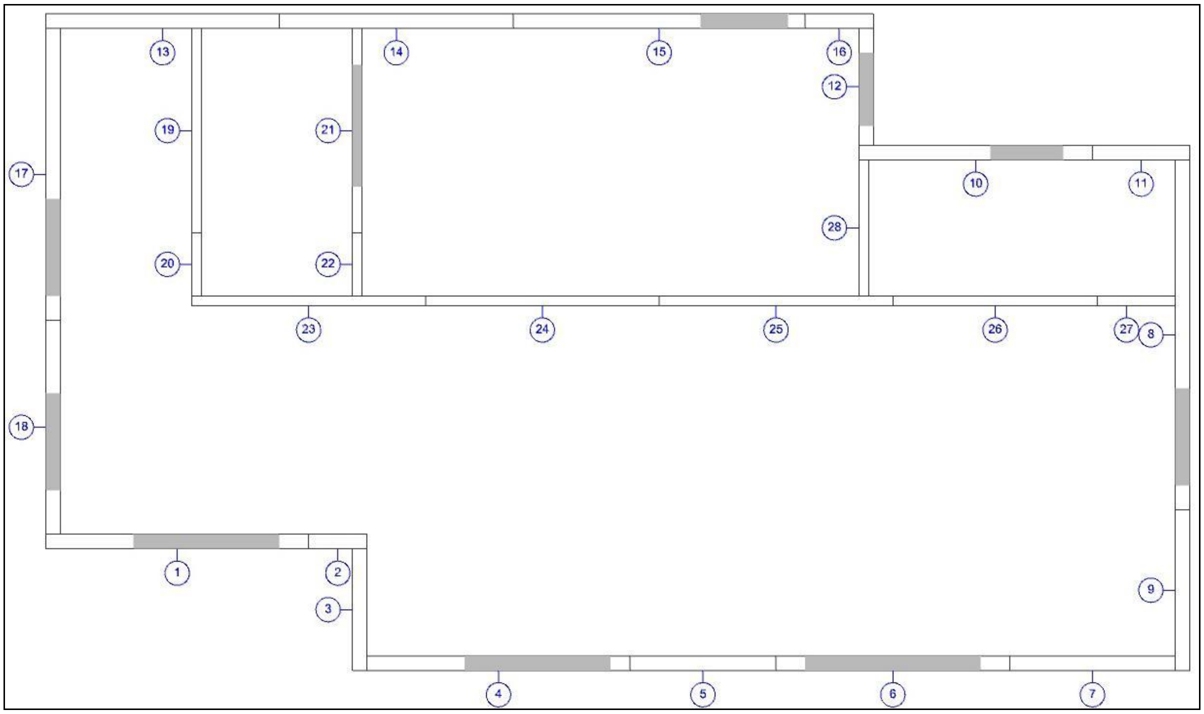
L5-3: Proposed algorithm

6	4	A	RIGHT	777.6	57.3	14	1	1	18	2
							2	1	19	2
							3	1	61	2
							4	1	62	2
							5	1	56	1
							6	1	67	1
							7	1	57	1
							8	1	68	1
							9	1	63	2
							10	1	64	2
							11	1	65	2
							12	1	66	2
							13	1	58	1
							14	1	69	1
7	4	B	LEFT	777.6	99.3	2	1	1	5	3
							2	1	6	3
8	5	A	RIGHT	989.8	57.3	14	1	1	20	2
							2	1	21	2
							3	1	9	2
							4	1	10	2
							5	1	11	2
							6	1	12	2
							7	1	13	2
							8	1	70	2
							9	1	71	2
							10	1	72	2
							11	1	73	2
							12	1	74	2
							13	1	75	2
							14	1	80	2
9	5	B	LEFT	989.8	57.3	9	1	1	81	1
							2	1	78	1
							3	1	79	1
							4	1	76	2
							5	1	7	2
							6	1	8	1
							7	1	59	1
							8	1	60	2
							9	1	77	2

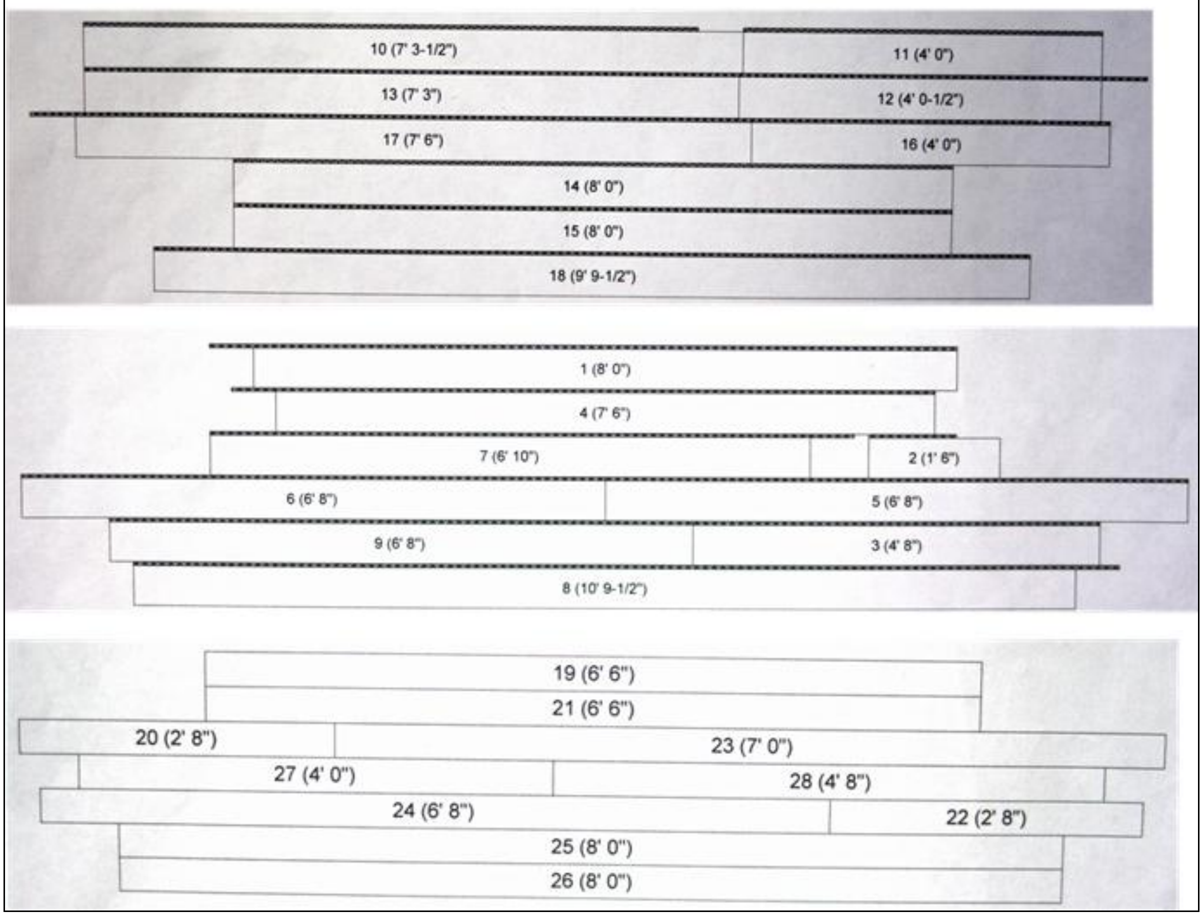
** # of interfering panels
1: 77

Appendix D: Data Sets and Results (Section 4.3, 4.4, & 5.4)

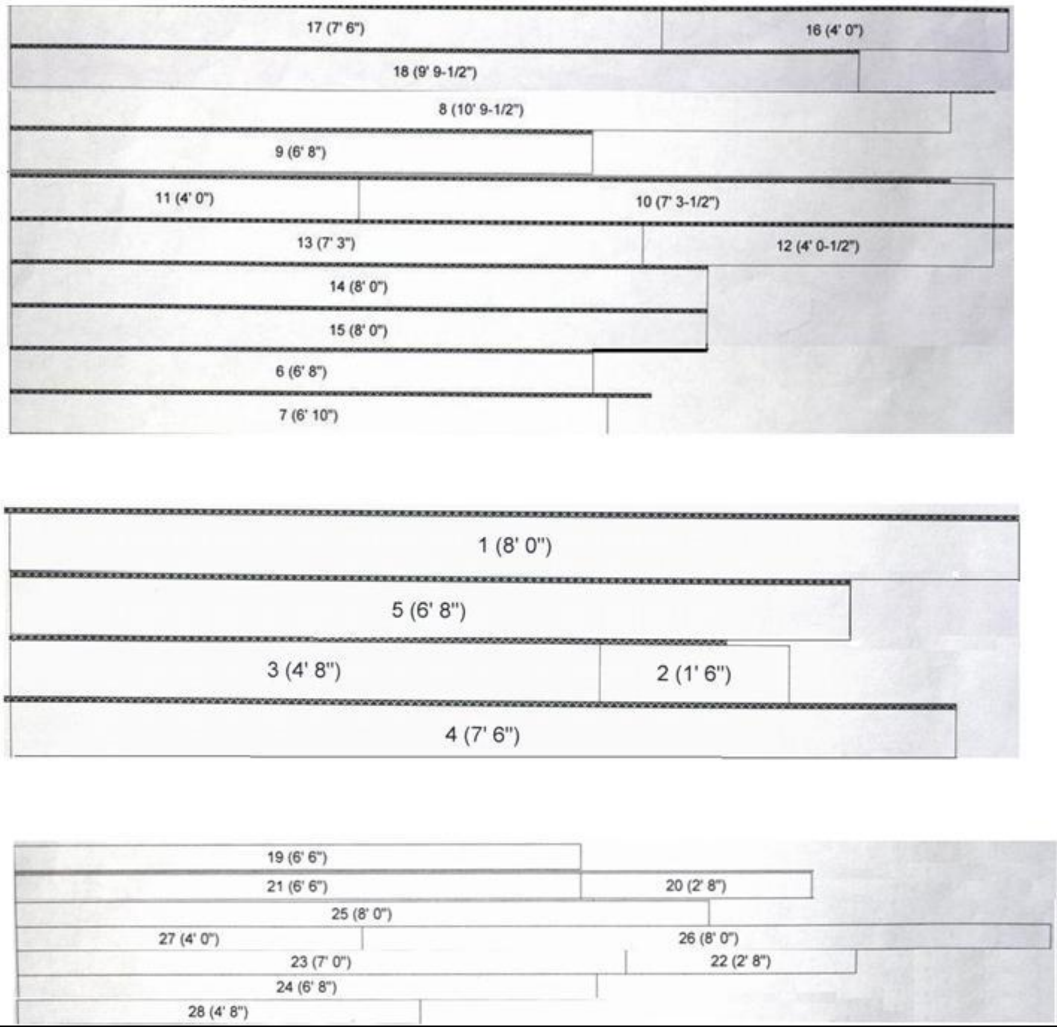
S1-1



S1-1: Panel Designer



S1-1: IntelliBuild



S1-1: Proposed algorithm

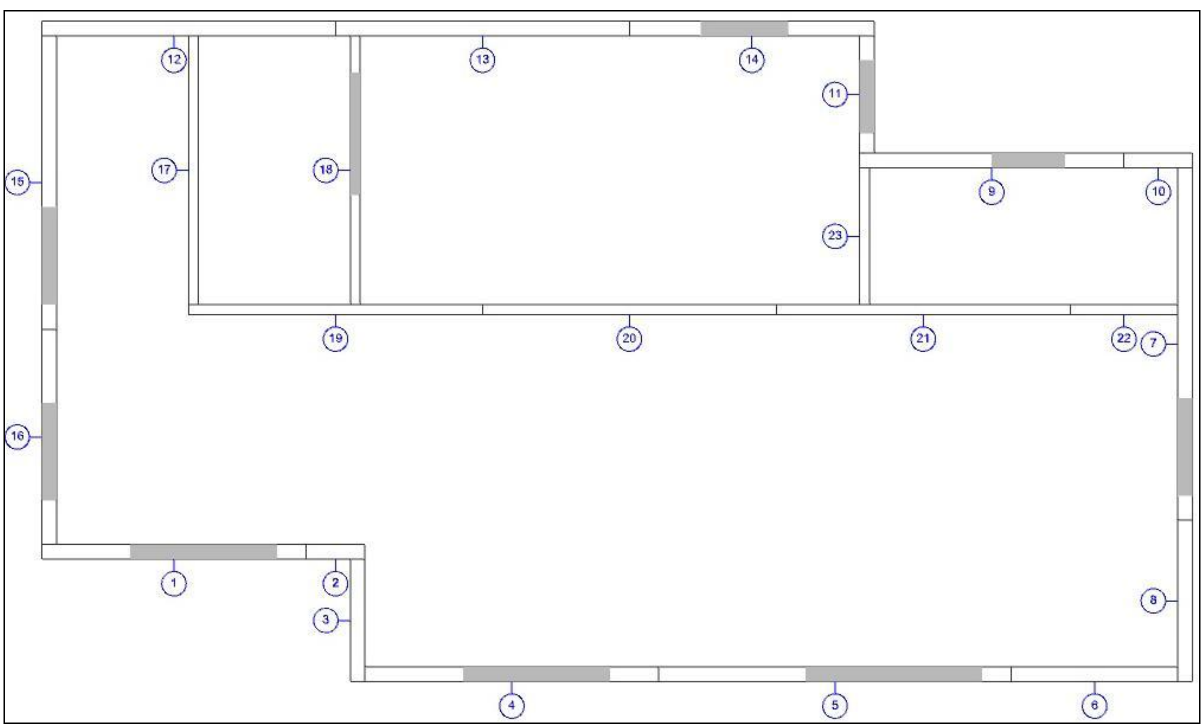
** Nzones: 3

**zone	left edge X coordinate
1	6.0
2	212.0
3	243.5

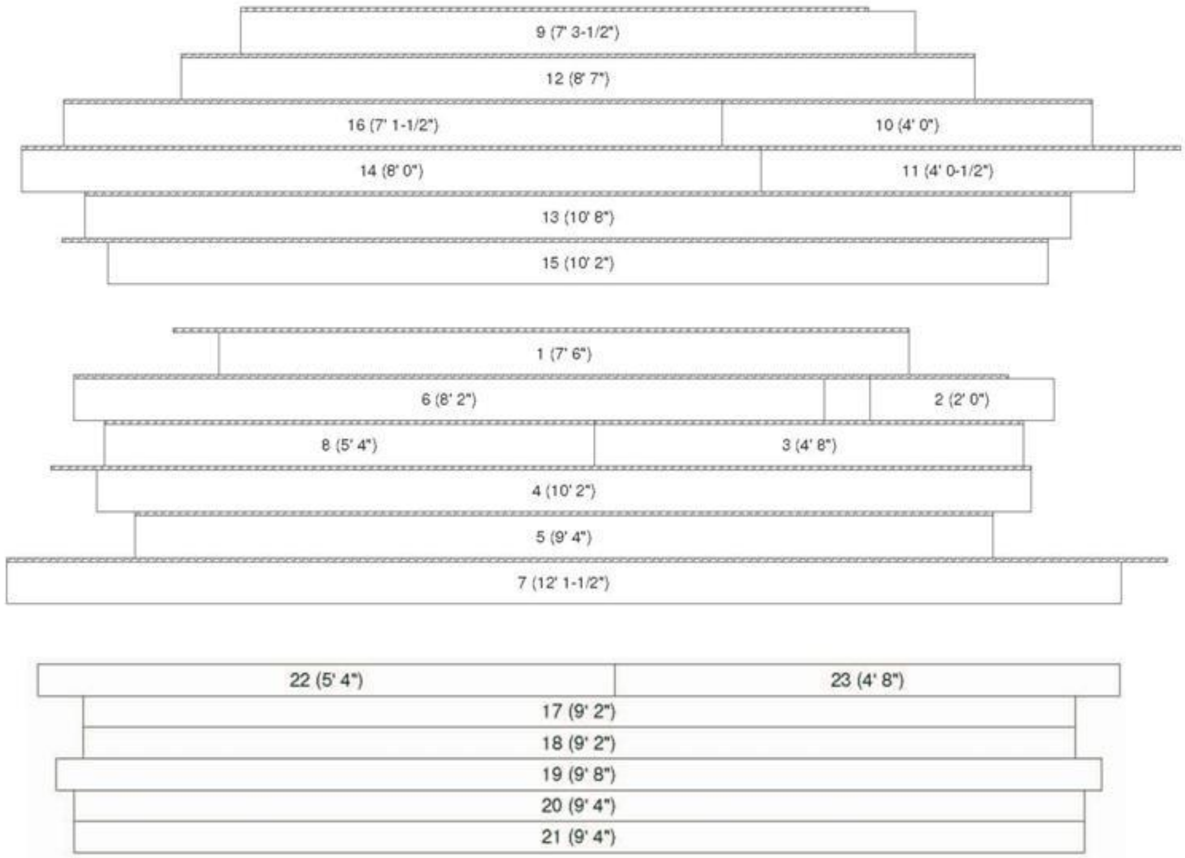
** NStacks: 6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	87.3	5	1	1	13	2
							2	1	14	2
							3	1	17	1
							4	1	18	1
							5	1	1	3
2	2	A	RIGHT	330.0	87.3	2	1	1	15	2
							2	1	16	2
3	2	B	LEFT	330.0	99.3	5	1	1	19	1
							2	3	21 20 22	1 1 1
							3	1	23	3
							4	2	24 2	3 3
							5	1	3	1
4	3	A	RIGHT	353.8	57.3	4	1	2	10 12	2 2
							2	1	11	2
							3	1	8	2
							4	1	9	2
5	3	B	LEFT	353.8	99.3	8	1	1	4	3
							2	1	28	1
							3	1	5	3
							4	1	6	3
							5	1	7	3
							6	1	25	3
							7	1	26	3
							8	1	27	3

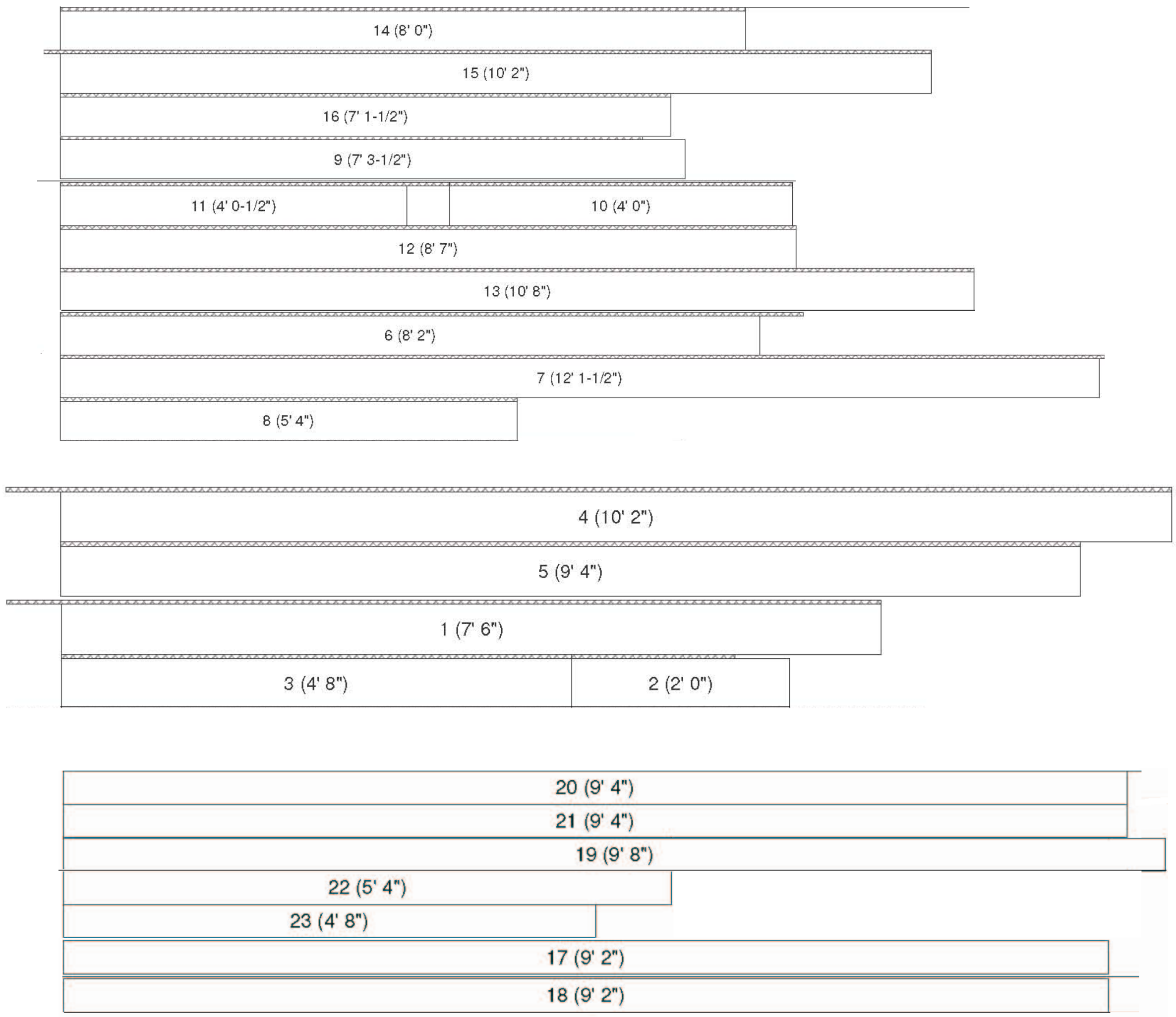
S1-2



S1-2: Panel Designer

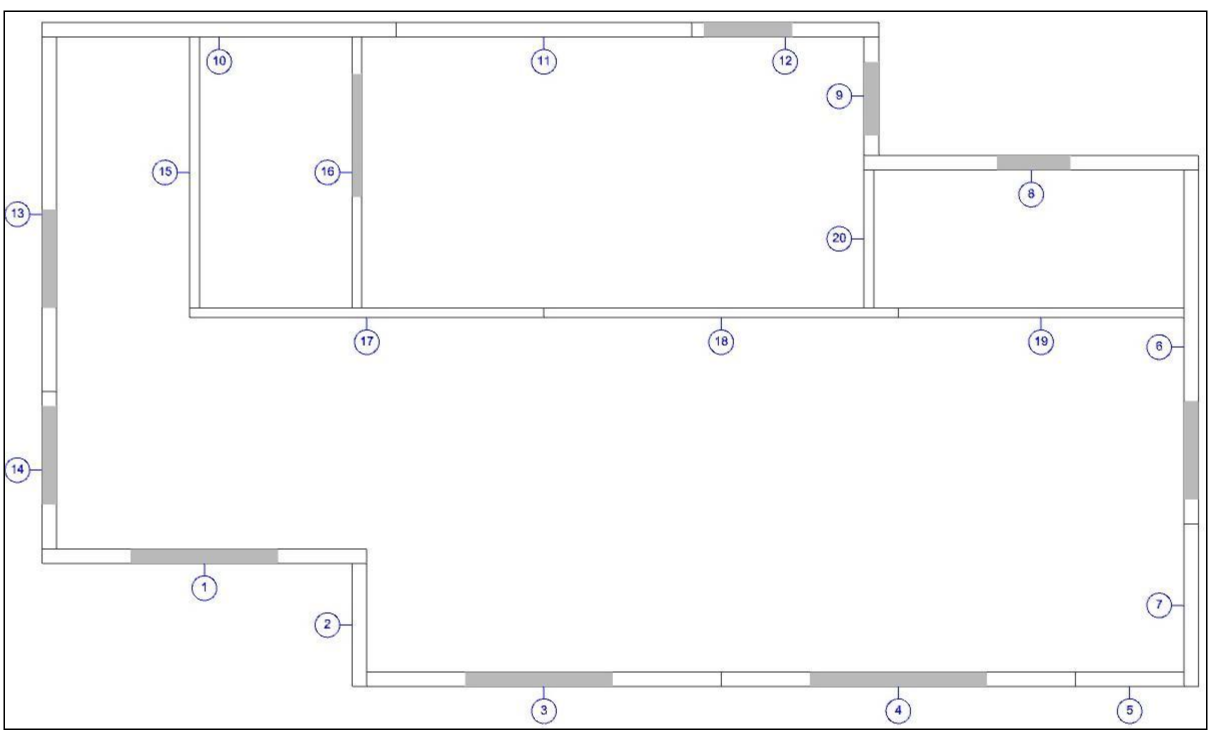


S1-2: IntelliBuild

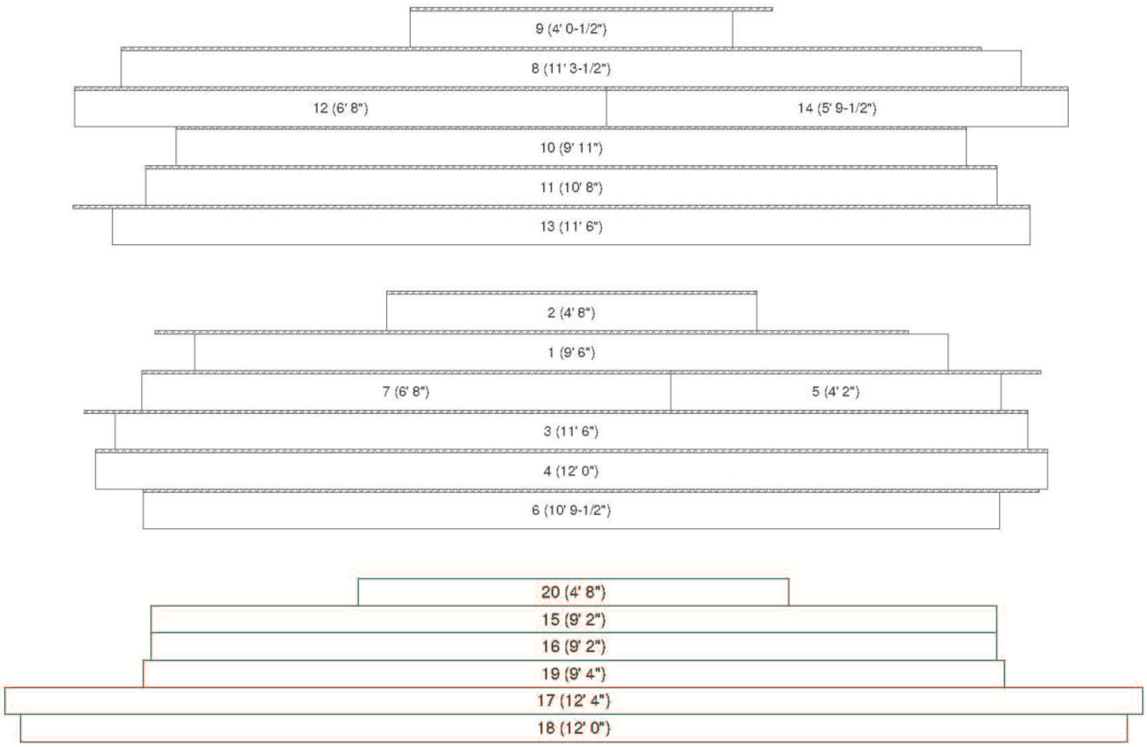


```
S1-2: Proposed algorithm
** Nzones
3
**zone      left edge X coordinate
 1           6.0
 2         220.0
 3         243.5
** NStacks
5
** stack                flush
**   #    zone type   edge     xloc   yloc  #layers  j  #panels   panels       orientation
     1      1     A     RIGHT   114.0   87.3       4     1       1    12              2
                                                         2       1    15              1
                                                         3       1    16              1
                                                         4       1    1               3
     2      2     A     RIGHT   332.2   87.3       2     1       1    13              2
                                                         2       1    14              2
     3      2     B     LEFT    332.2   99.3       4     1       1    17              1
                                                         2       1    18              1
                                                         3       2    19 2            3 3
                                                         4       1    3               1
     4      3     A     RIGHT   353.8   57.3       4     1       1    11              2
                                                         2       2    10 9            2 2
                                                         3       1    7               2
                                                         4       1    8               2
     5      3     B     LEFT    353.8   99.3       7     1       1    23              1
                                                         2       1    4               3
                                                         3       1    5               3
                                                         4       1    6               3
                                                         5       1    20              3
                                                         6       1    21              3
                                                         7       1    22              3
```

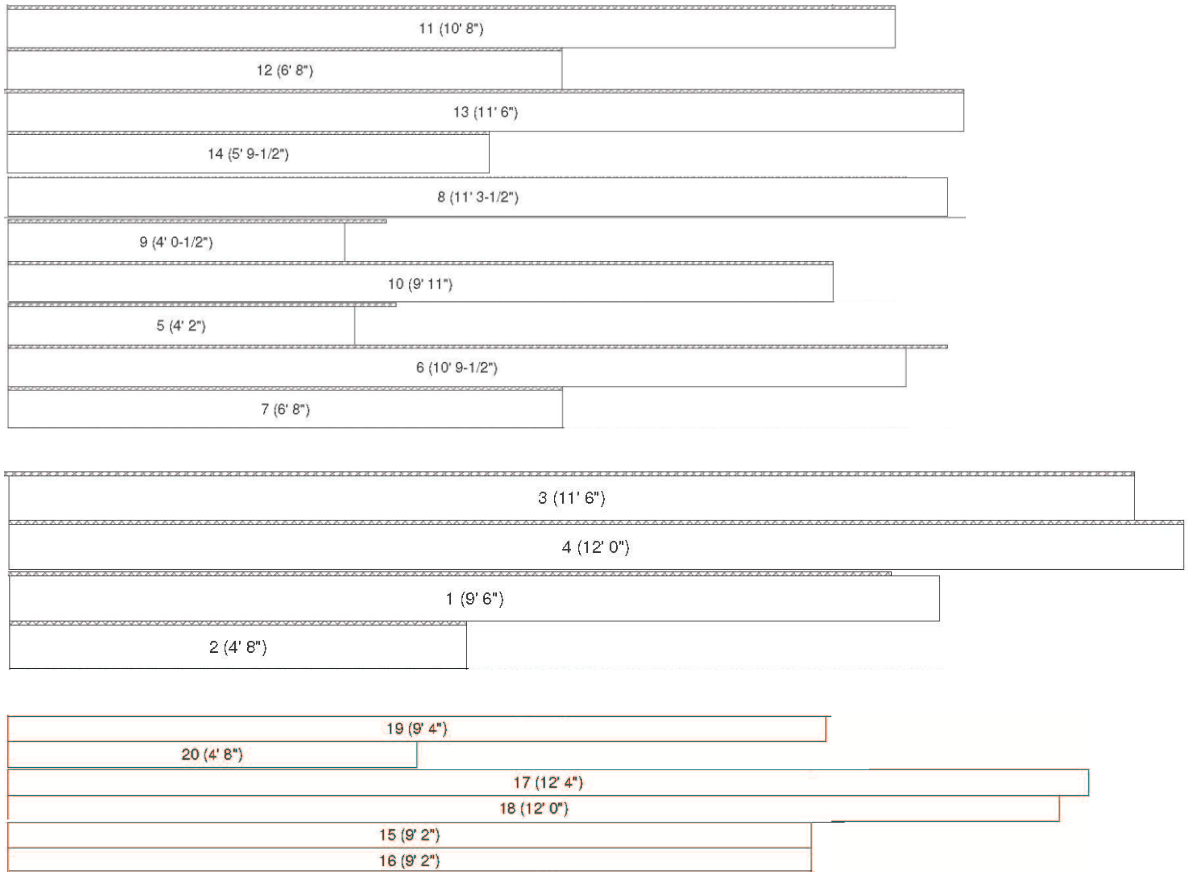
S1-3



S1-3: Panel Designer



S1-3: IntelliBuild



S1-3: Proposed algorithm

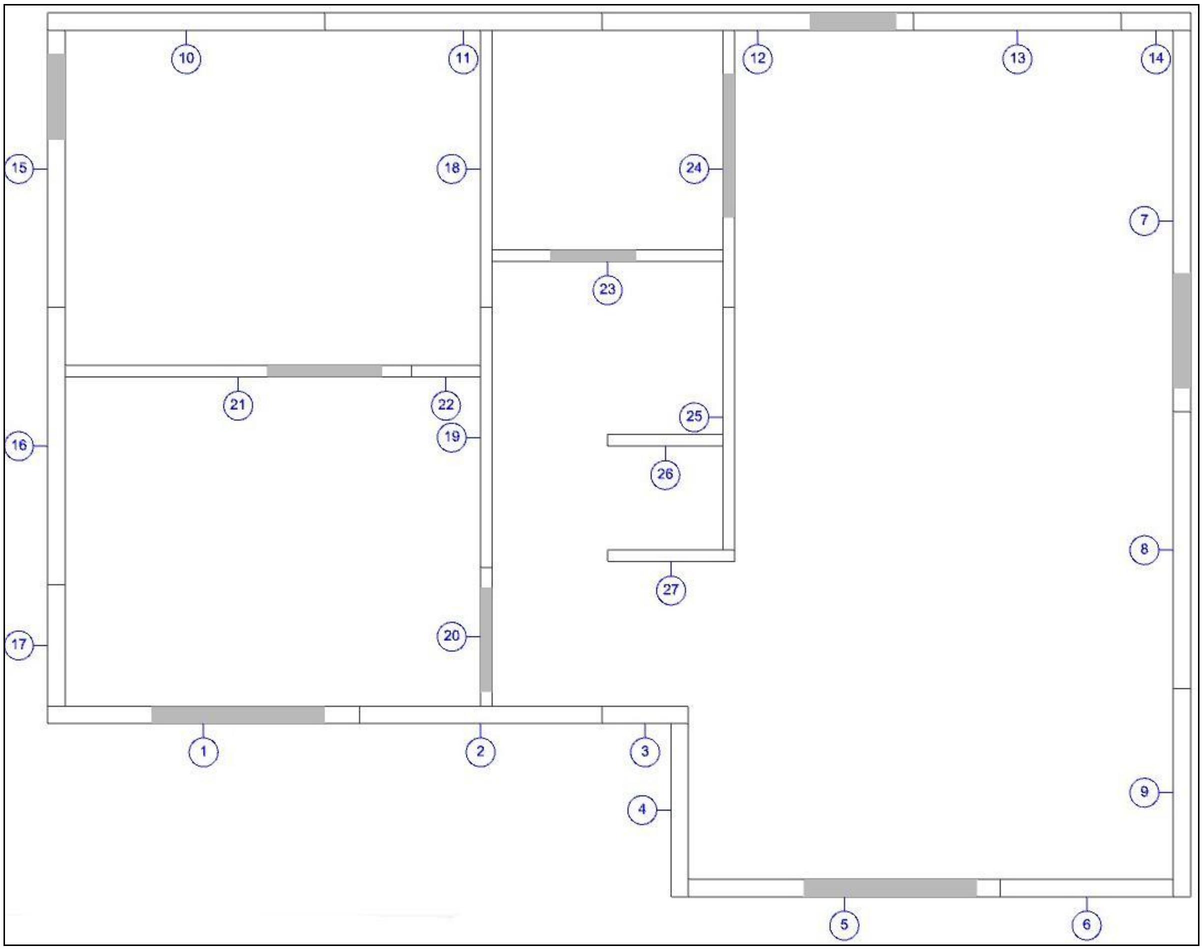
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	226.5
3	243.5

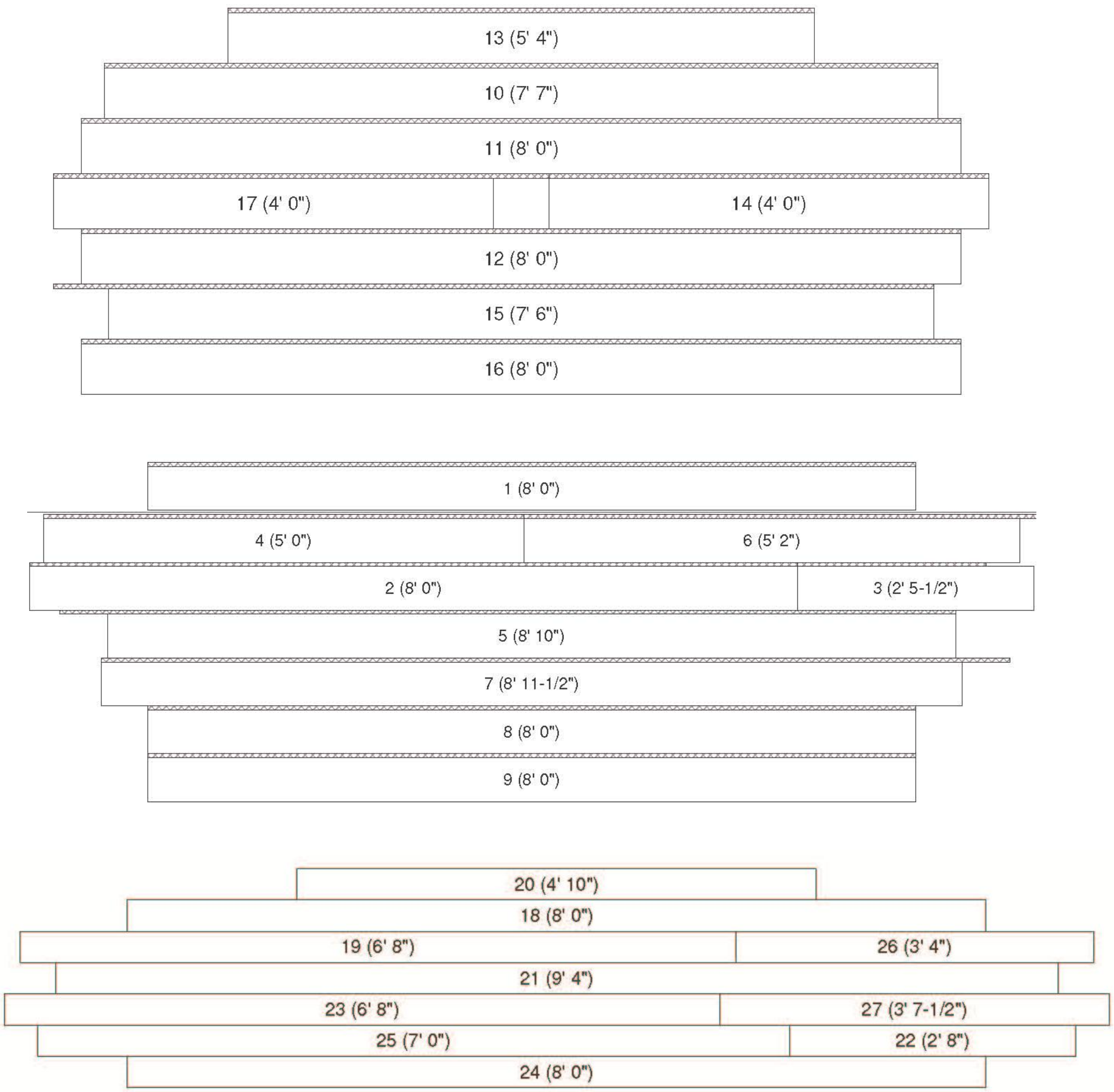
** NStacks
5

** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	87.3	4	1	1	10	2
							2	1	13	1
							3	1	14	1
							4	1	1	3
2	2	A	RIGHT	336.7	87.3	2	1	1	11	2
							2	1	12	2
3	2	B	LEFT	336.7	99.3	6	1	1	2	1
							2	1	3	3
							3	1	4	3
							4	1	15	1
							5	1	16	1
							6	1	17	3
4	3	A	RIGHT	353.8	57.3	4	1	1	9	2
							2	1	8	2
							3	1	6	2
							4	1	7	2
5	3	B	LEFT	353.8	99.3	4	1	1	20	1
							2	1	5	3
							3	1	18	3
							4	1	19	3

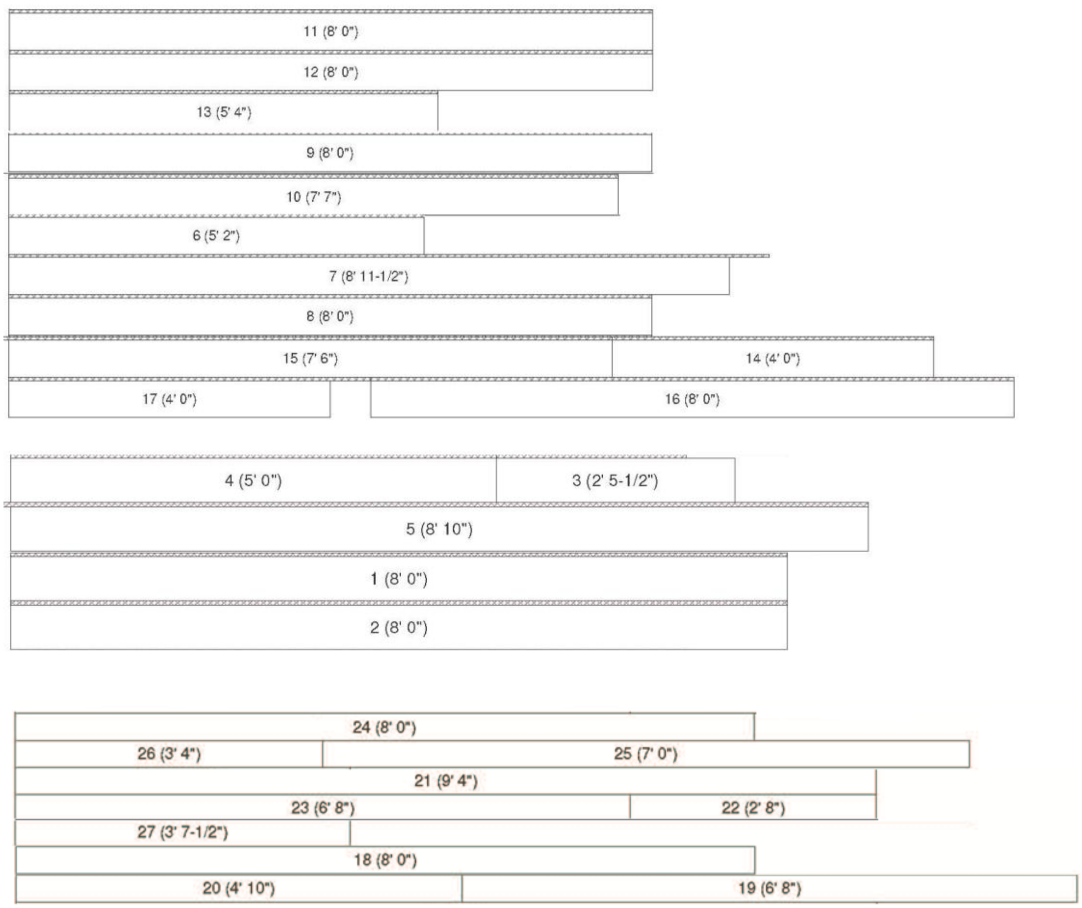
S2-1



S2-1: Panel Designer



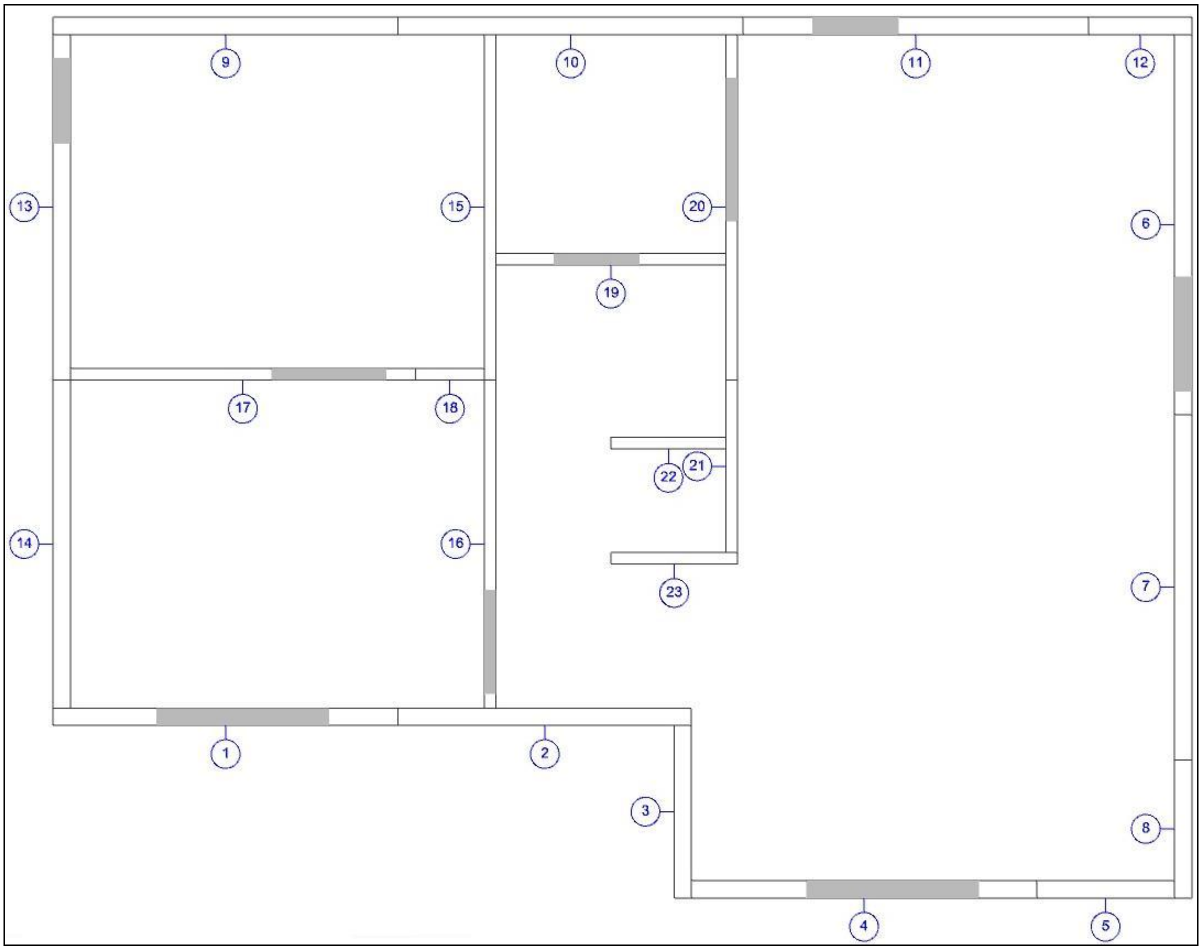
S2-1: IntelliBuild



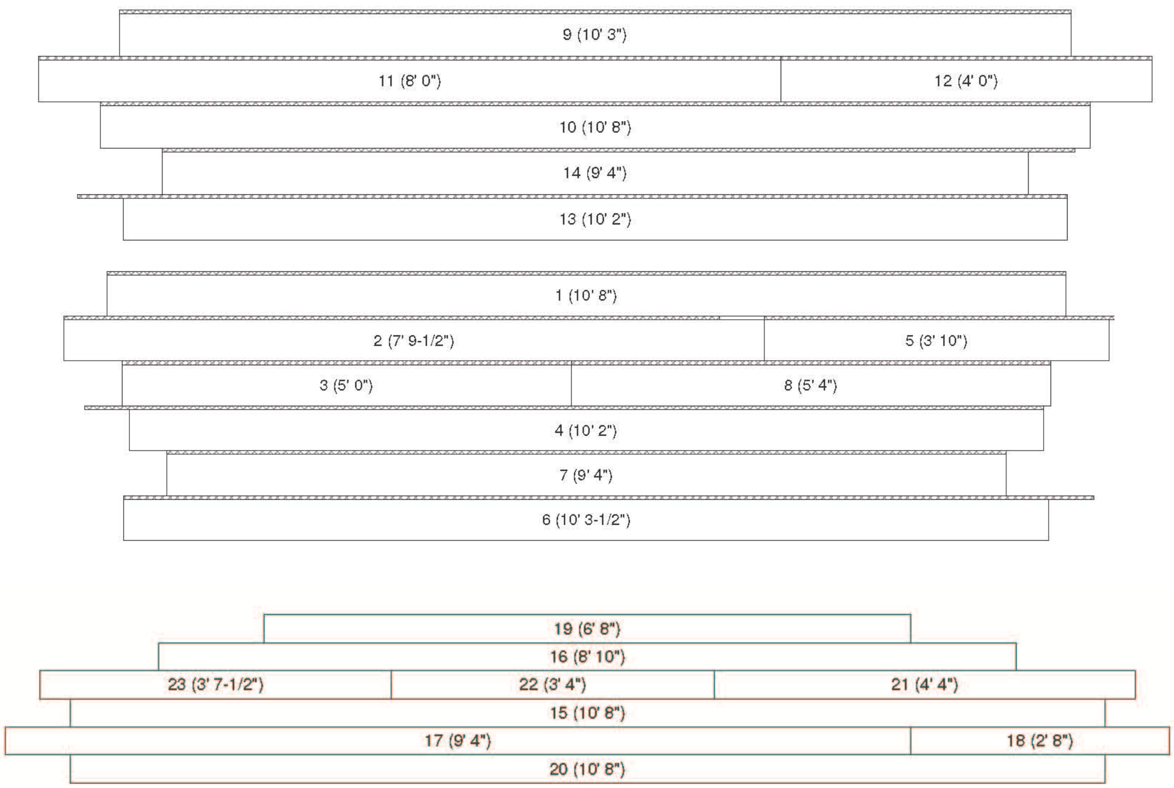
S2-1: Proposed algorithm

```
** Nzones
2
**zone      left edge X coordinate
 1             6.0
 2           174.0
** NStacks
3
** stack                 flush
**   #    zone type      edge      xloc    yloc   #layers  j   #panels   panels        orientation
     1     1     A       RIGHT    114.0    92.5       5        1         1    10              2
                                                               2         1    11              2
                                                               3         1    15              1
                                                               4         2    17 16           1 1
                                                               5         1    1               3
     2     2     A       RIGHT    282.0    92.5       6        1         1    12              2
                                                               2         2    14 13           2 2
                                                               3         1    7               2
                                                               4         1    8               2
                                                               5         1    9               2
                                                               6         2    3 2             3 3
     3     2     B       LEFT     282.0    94.5       4        1         1    18              1
                                                               2         2    21 22           2 2
                                                               3         2    19 20           1 1
                                                               4         1    23              2
                                                               5         1    4               1
                                                               6         1    5               3
                                                               7         1    6               3
                                                               8         1    24              1
                                                               9         1    25              1
                                                               10        1    26              3
                                                               11        1    27              3
```

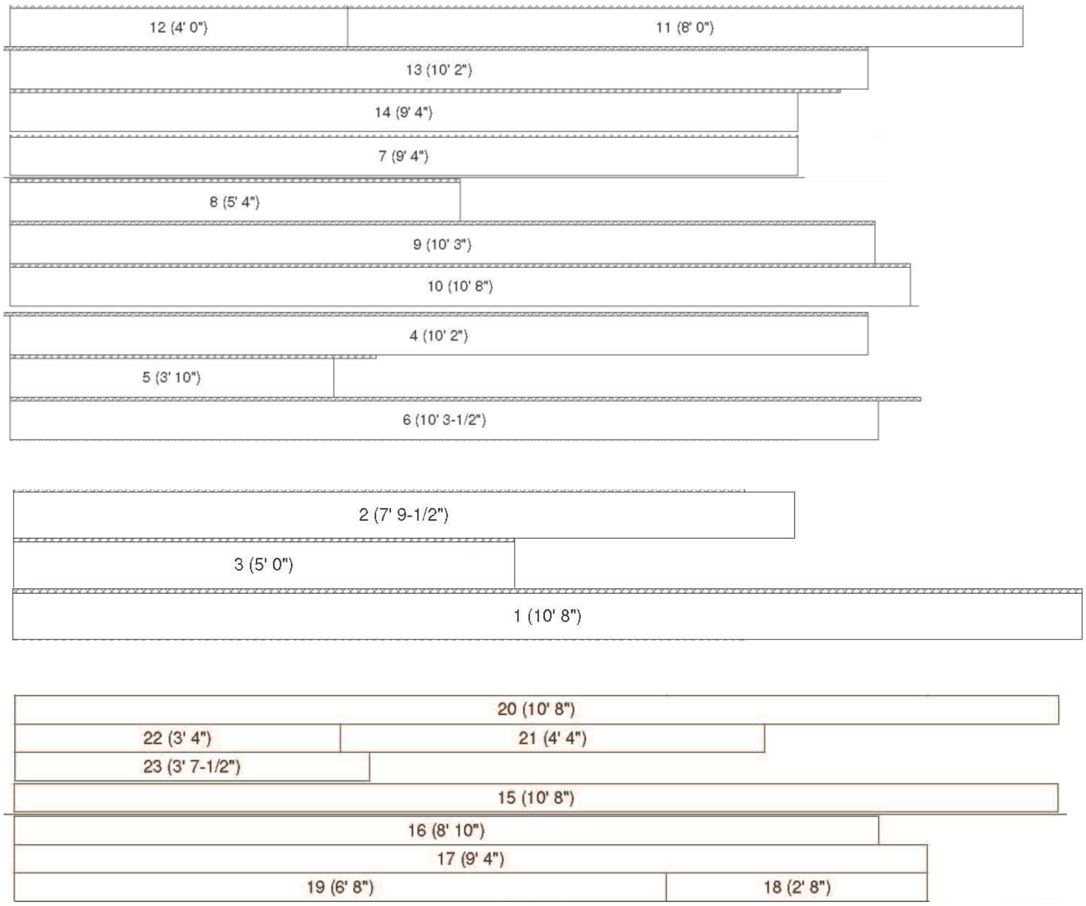
S2-2



S2-2: Panel Designer



S2-2: IntelliBuild

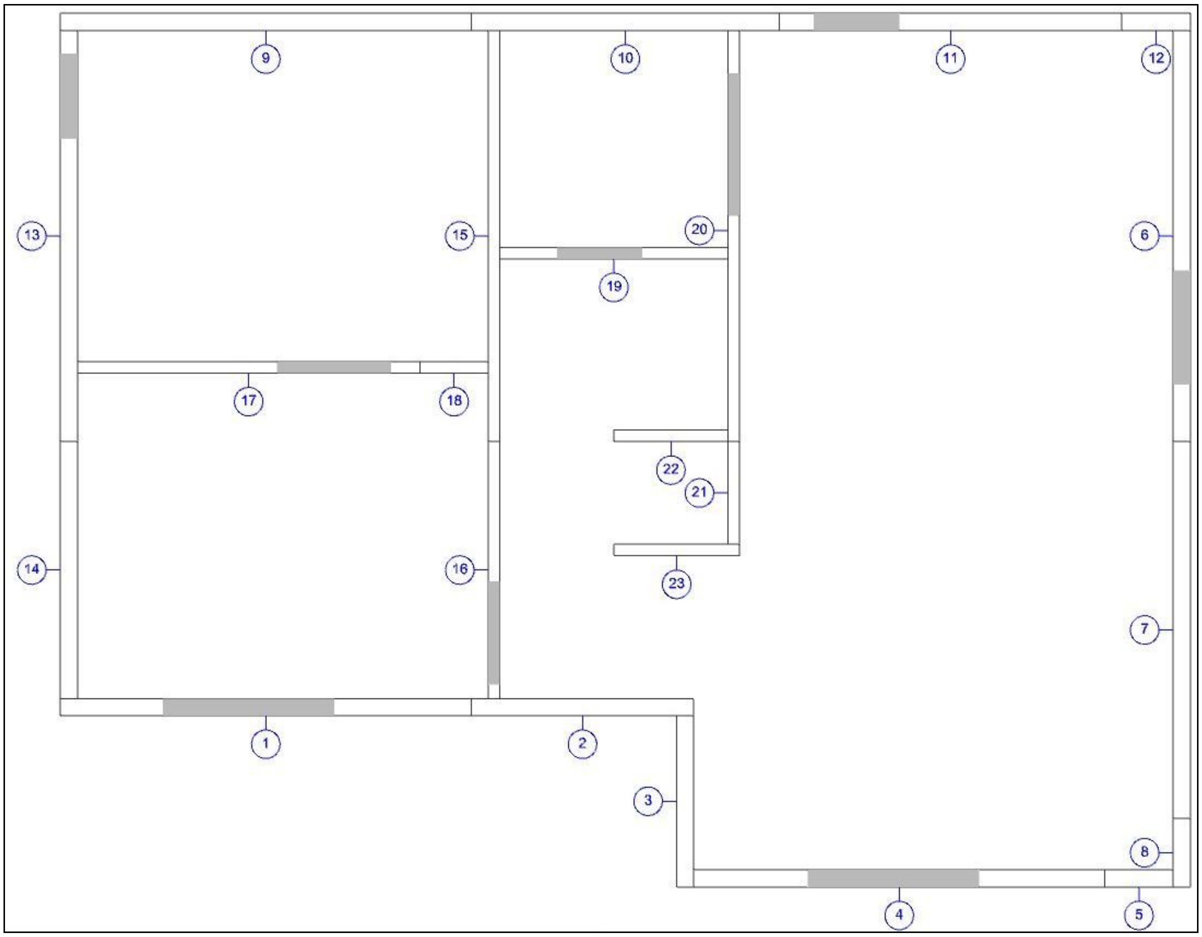


S2-2: Proposed algorithm

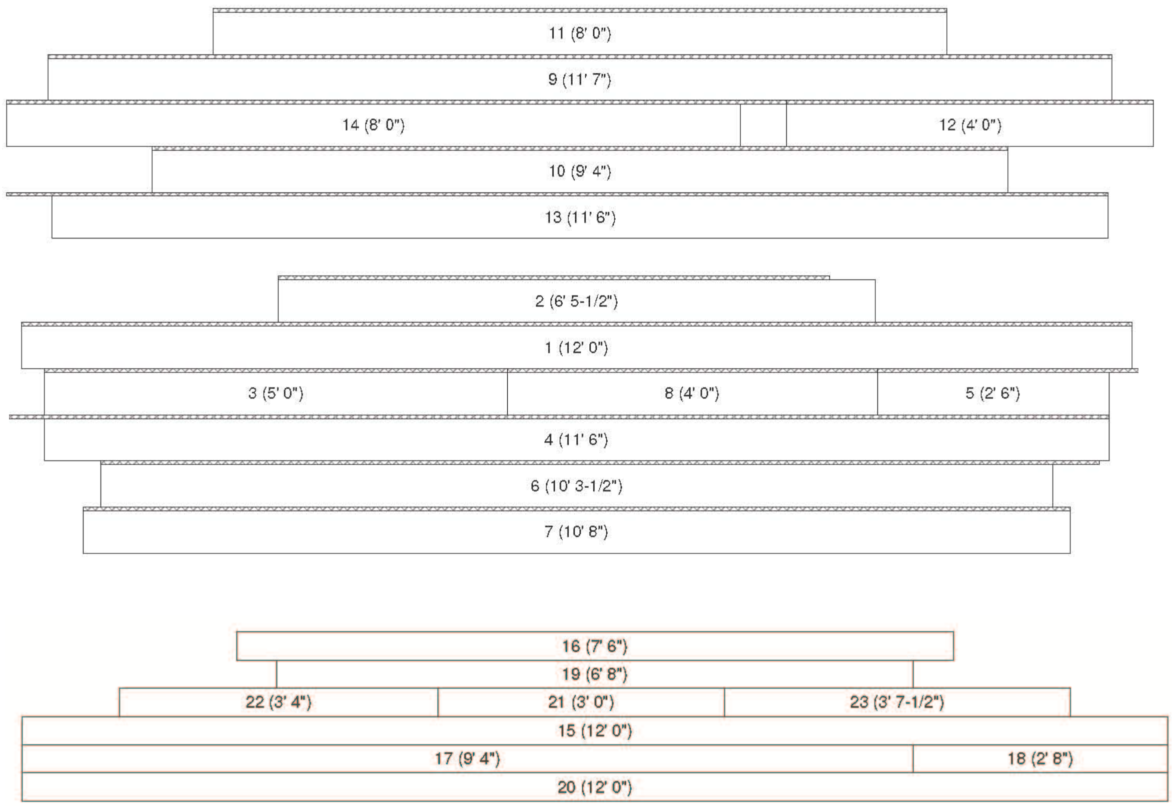
** Nzones
2
**zone left edge X coordinate
1 6.0
2 174.0
** NStacks
3

** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	52.5	4	1	1	9	2
							2	1	13	1
							3	1	14	1
							4	1	1	3
2	2	A	RIGHT	282.0	52.5	7	1	1	10	2
							2	1	11	2
							3	1	12	2
							4	1	6	2
							5	1	7	2
							6	1	8	2
							7	1	2	3
3	2	B	LEFT	282.0	94.5	11	1	2	17 18	2 2
							2	1	15	1
							3	1	16	1
							4	1	19	2
							5	1	3	1
							6	1	4	3
							7	1	5	3
							8	1	20	1
							9	1	21	1
							10	1	22	3
							11	1	23	3

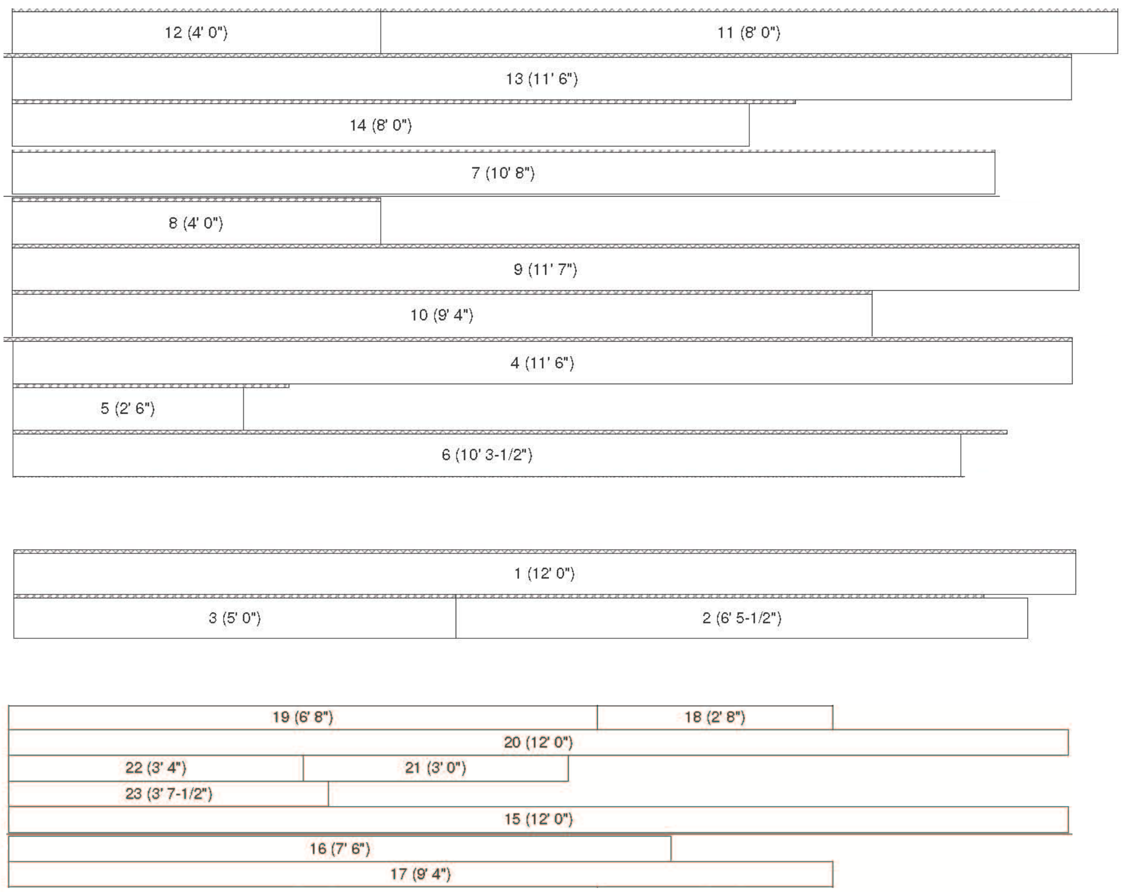
S2-3



S2-3: Panel Designer



S2-3: IntelliBuild



S2-3: Proposed algorithm

** Nzones
2

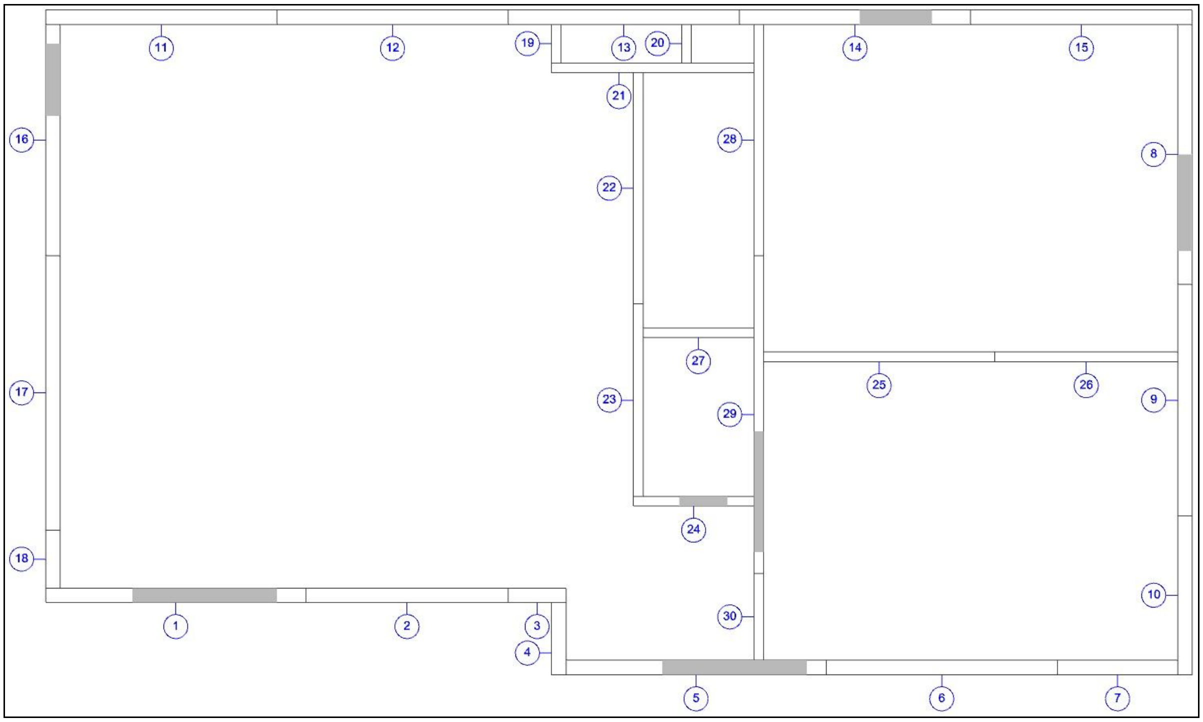
**zone left edge X coordinate

1	6.0
2	169.5

** NStacks
3

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	4	1	1	9	2
							2	1	13	1
							3	1	14	1
							4	1	1	3
2	2	A	RIGHT	279.8	57.3	5	1	1	10	2
							2	2	12 11	2 2
							3	1	6	2
							4	1	7	2
							5	2	2 8	3 2
3	2	B	LEFT	279.8	99.3	11	1	2	17 18	2 2
							2	1	15	1
							3	1	16	1
							4	1	19	2
							5	1	3	1
							6	1	4	3
							7	1	5	3
							8	1	20	1
							9	1	22	3
							10	1	21	1
							11	1	23	3

S3-1




```
S2-3: Proposed algorithm
** Nzones: 3

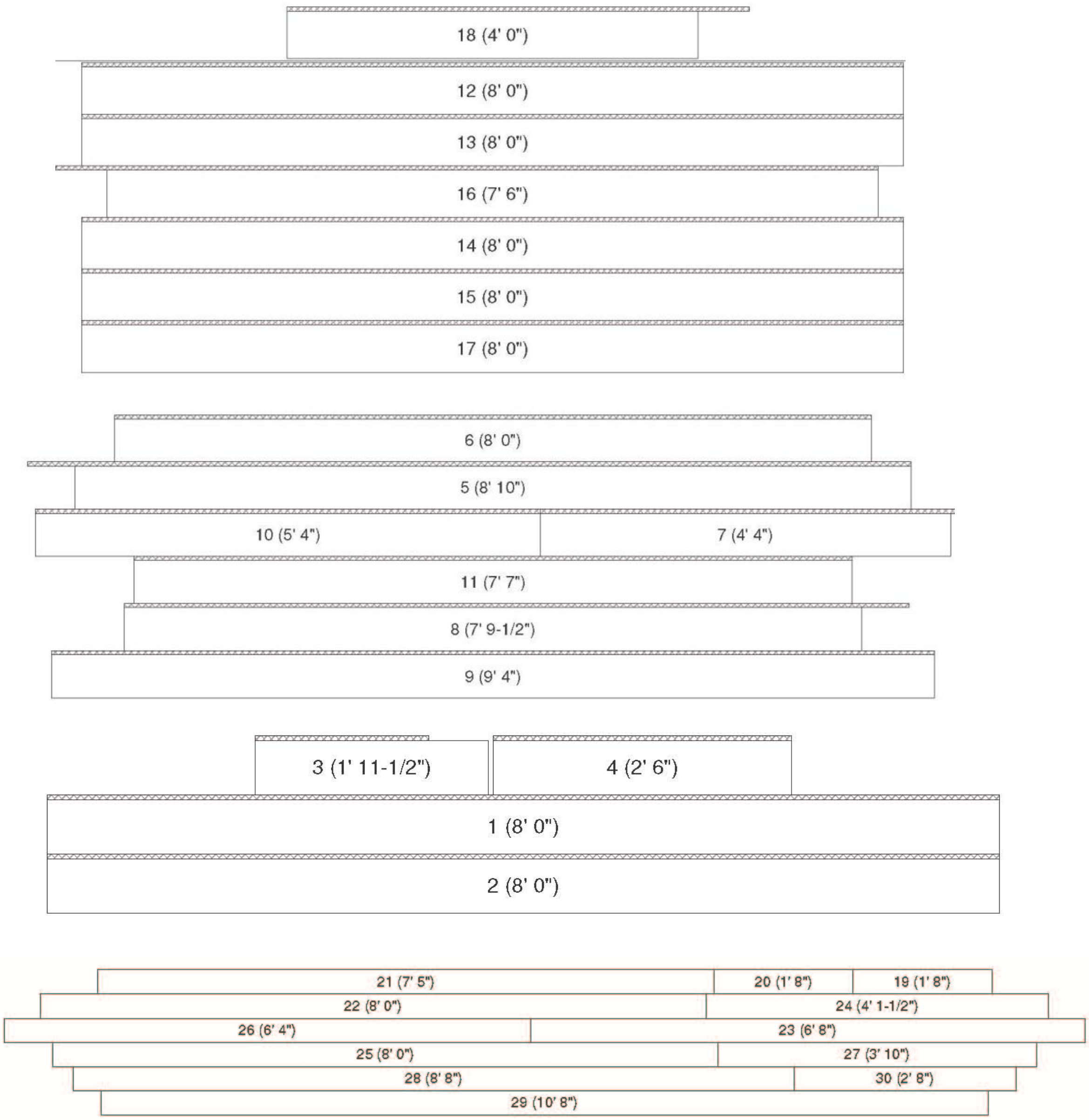
**zone      left edge X coordinate
 1           6.0
 2         214.5
 3         239.5

** NStacks: 5

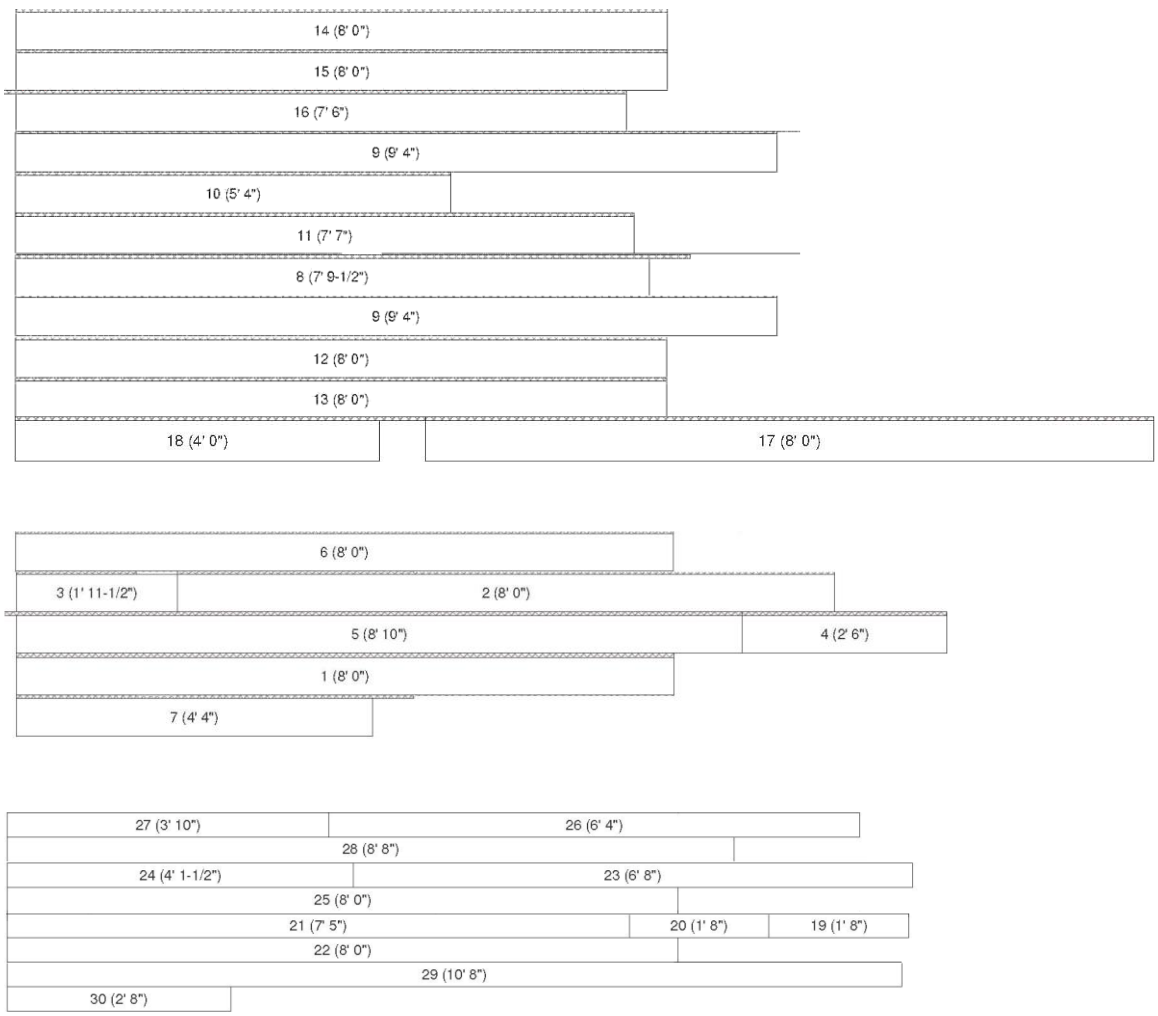
** stack                flush
**   #    zone type     edge      xloc   yloc  #layers  j  #panels  panels      orientation
     1     1    A       RIGHT    116.2   57.3     7         1        1    8          2
                                                            2        1    12         1
                                                            3        1    13         1
                                                            4        1    14         1
                                                            5        1    17         2
                                                            6        1    18         2
                                                            7        1    1          3
     2     2    A       RIGHT    336.7   57.3     4         1        1    9          2
                                                            2        1    10         2
                                                            3        1    15         1
                                                            4        1    16         1
     3     2    B       LEFT     336.7   99.3     3         1        1    2          3
                                                            2        1    3          3
                                                            3        1    19         1
     4     3    A       RIGHT    349.8   57.3     4         1        1    11         2
                                                            2        1    5          2
                                                            3        1    6          2
                                                            4        1    7          2
     5     3    B       LEFT     349.8   99.3     9         1        1    20 21      3 3
                                                            2        1    22         1
                                                            3        1    4          3
                                                            4        1    28         3
                                                            5        1    25         1
                                                            6        1    24         1
                                                            7        1    27         3
                                                            8        1    26         3
                                                            9        1    23         1

** # of interfering panels
6: 28 25 24 27 26 23
```

S3-1: Panel Designer

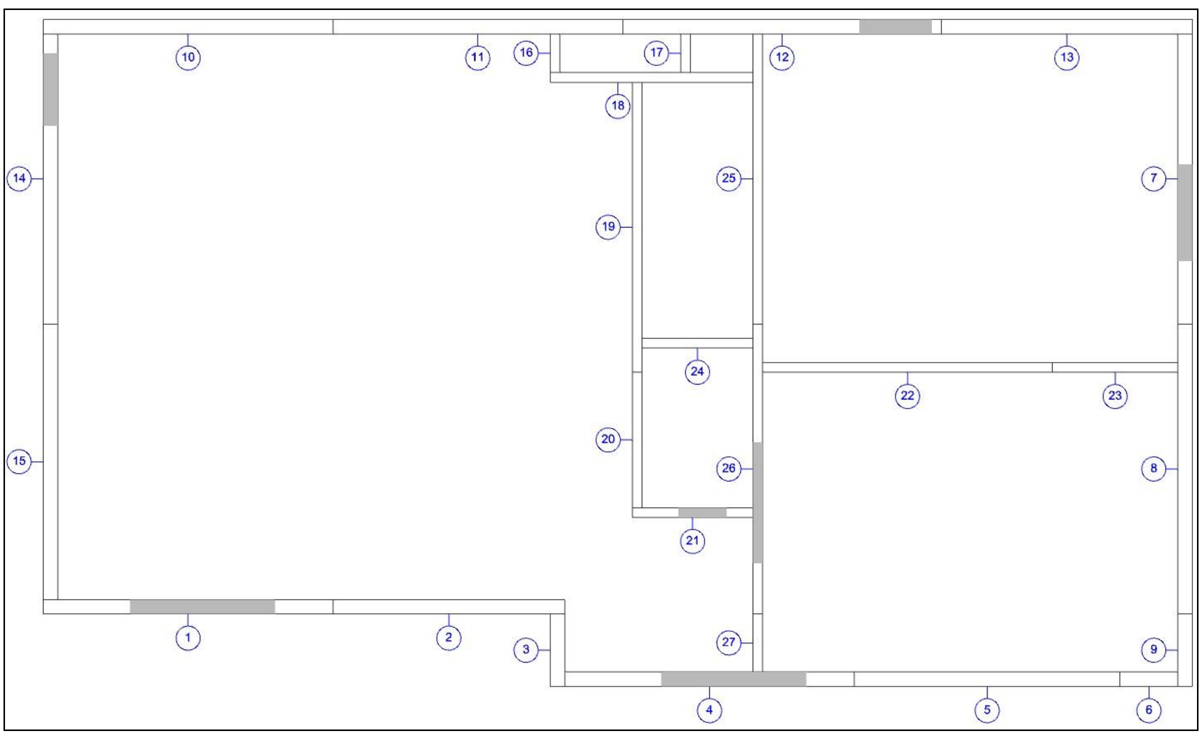


S3-1: IntelliBuild

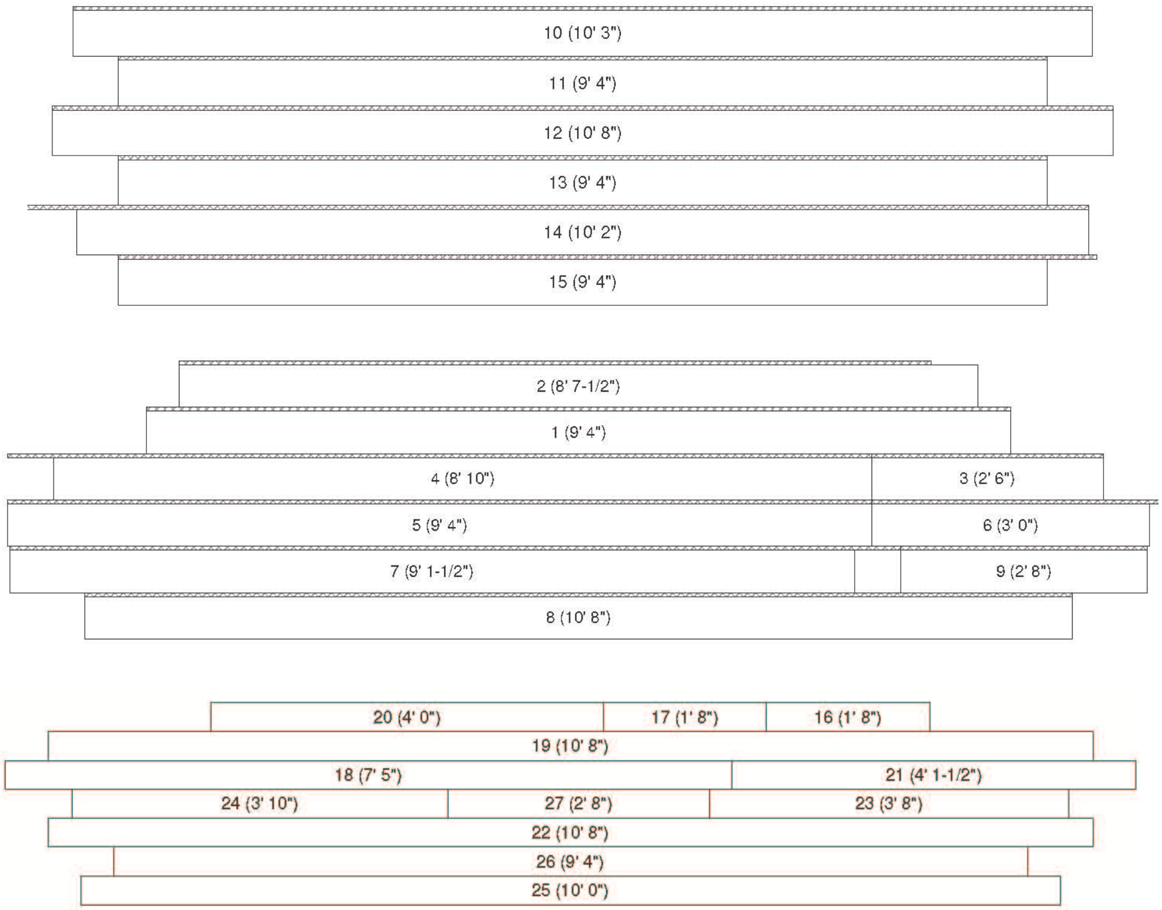


```
S3-1: Proposed algorithm
** Nzones
3
**zone      left edge X coordinate
 1             6.0
 2           222.0
 3           254.0
** NStacks
5
** stack                flush
**   #    zone type   edge      xloc   yloc  #layers  j   #panels   panels      orientation
     1      1    A    RIGHT   114.0   72.5       5         1         1     11              2
                                                           2         1     12              2
                                                           3         1     16              1
                                                           4         2     18 17           1 1
                                                           5         1     1               3
     2      2    A    RIGHT   330.0   72.5       3         1         1     13              2
                                                           2         3     20 19 14        1 1 2
                                                           3         1     21              2
     3      2    B    LEFT    330.0   94.5       1         1         3     2 3 4           3 3 1
     4      3    A    RIGHT   362.0   72.5       4         1         1     15              2
                                                           2         1     8               2
                                                           3         1     9               2
                                                           4         1     10              2
     5      3    B    LEFT    362.0   94.5      10         1         1     22              1
                                                           2         1     23              1
                                                           3         1     28              1
                                                           4         2     27 24           3 3
                                                           5         1     29              1
                                                           6         1     6               3
                                                           7         1     7               3
                                                           8         1     25              3
                                                           9         1     26              3
                                                          10         1     30 5            1 3
```

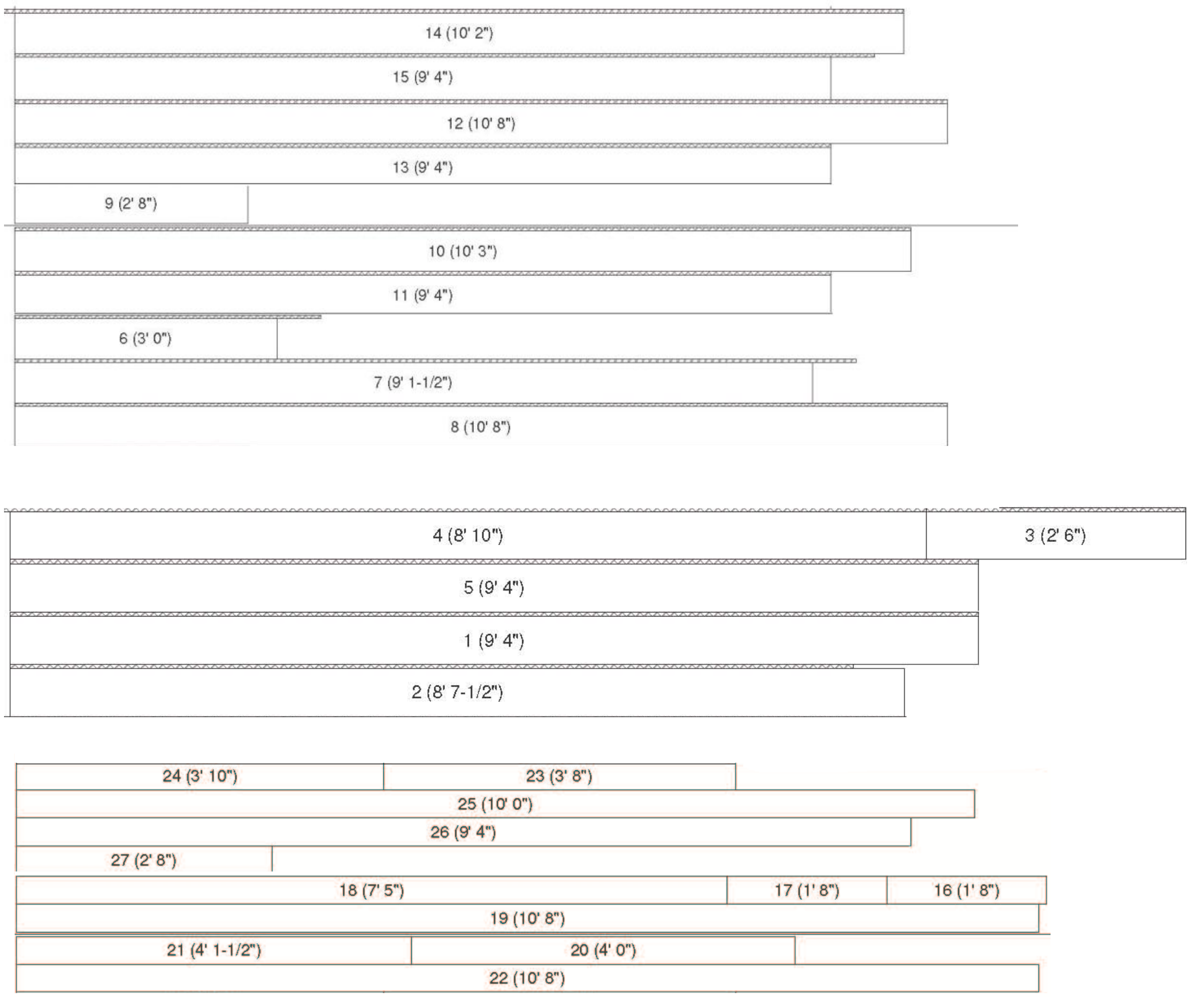
S3-2



S3-2: Panel Designer

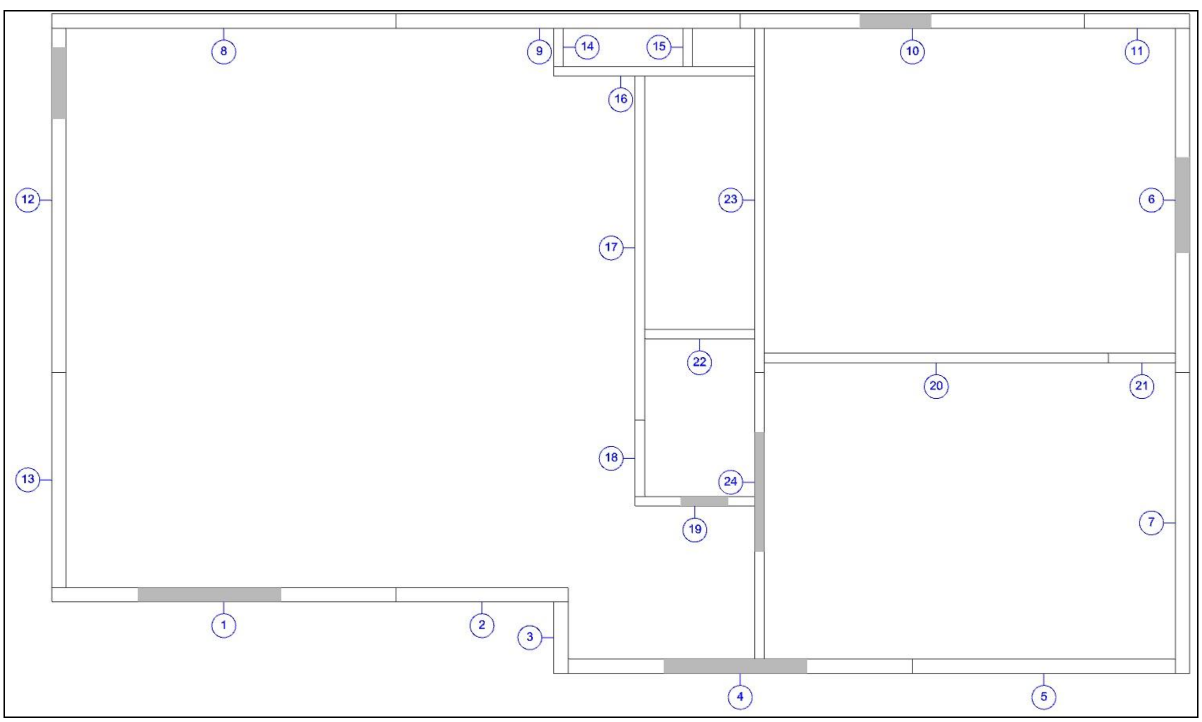


S3-2: IntelliBuild

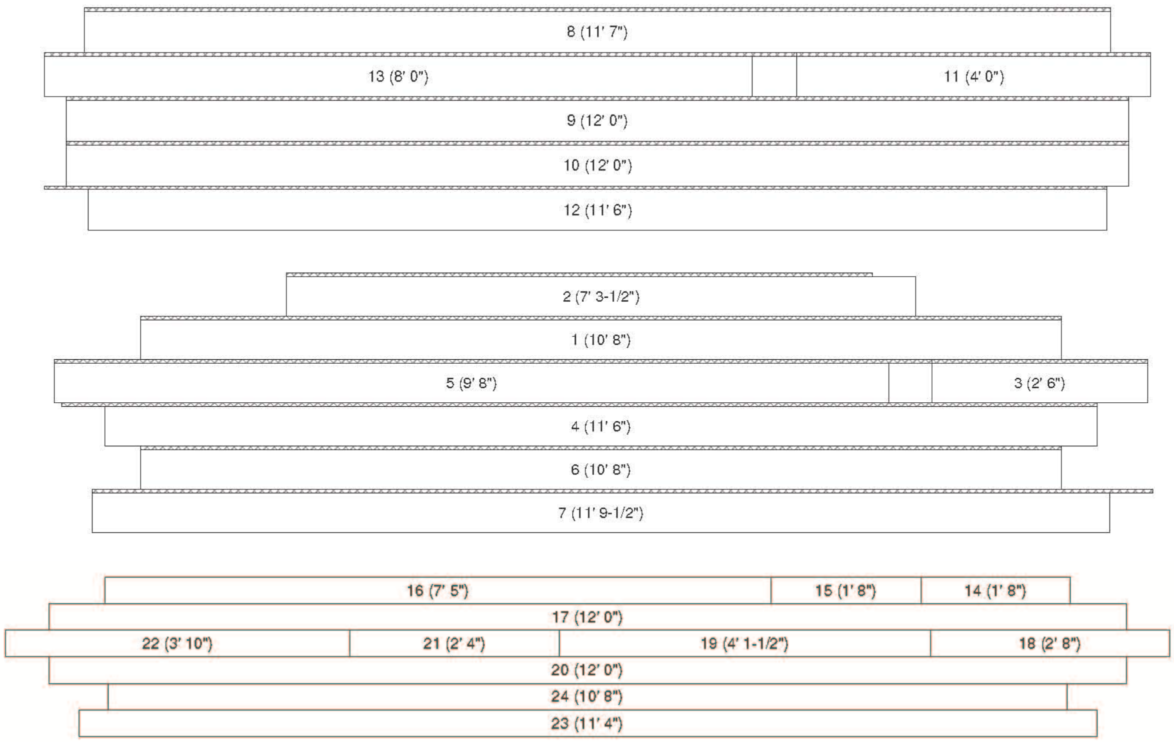


```
S3-2: Proposed algorithm
** Nzones 3
**zone      left edge X coordinate
 1            6.0
 2          212.0
 3          254.0
** NStacks 5
** stack                flush
**    #    zone type    edge     xloc    yloc   #layers   j   #panels   panels       orientation
      1     1    A      RIGHT    114.0   72.5      4          1         1      10           2
                                                              2         1      14           1
                                                              3         1      15           1
                                                              4         1      1            3
      2     2    A      RIGHT    330.0   72.5      3          1         1      11           2
                                                              2         1      12           2
                                                              3         3      18 17 16     2 1 1
      3     2    B      LEFT     330.0   94.5      1          1         2      2 3          3 1
      4     3    A      RIGHT    362.0   52.5      4          1         1      13           2
                                                              2         1      7            2
                                                              3         1      8            2
                                                              4         1      9            2
      5     3    B      LEFT     362.0   94.5     11          1         1      19           1
                                                              2         1      20           1
                                                              3         1      25           1
                                                              4         1      24           3
                                                              5         1      21           3
                                                              6         1      26           1
                                                              7         1      4            3
                                                              8         1      27           1
                                                              9         2      5 6          3 3
                                                             10         1      22           3
                                                             11         1      23           3
```

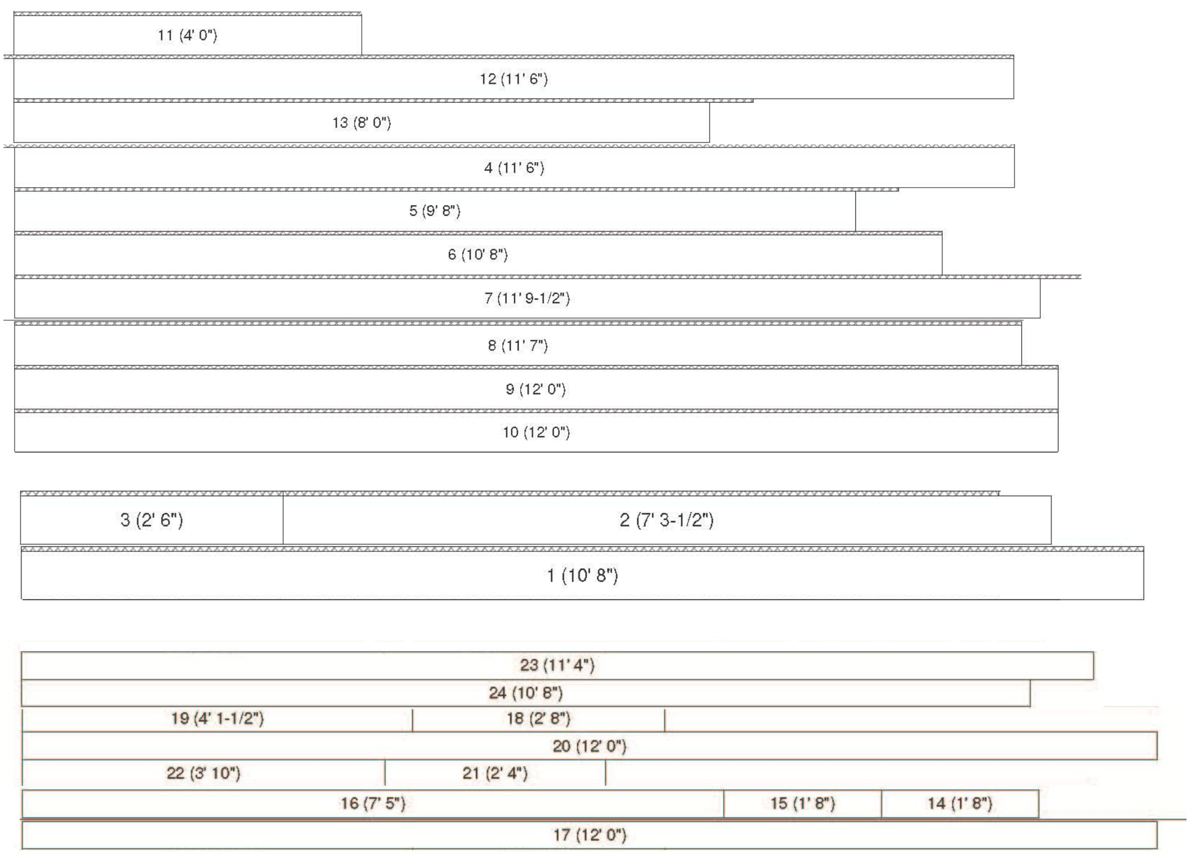
S3-3



S3-3: Panel Designer



S3-3: IntelliBuild



S3-3: Proposed algorithm

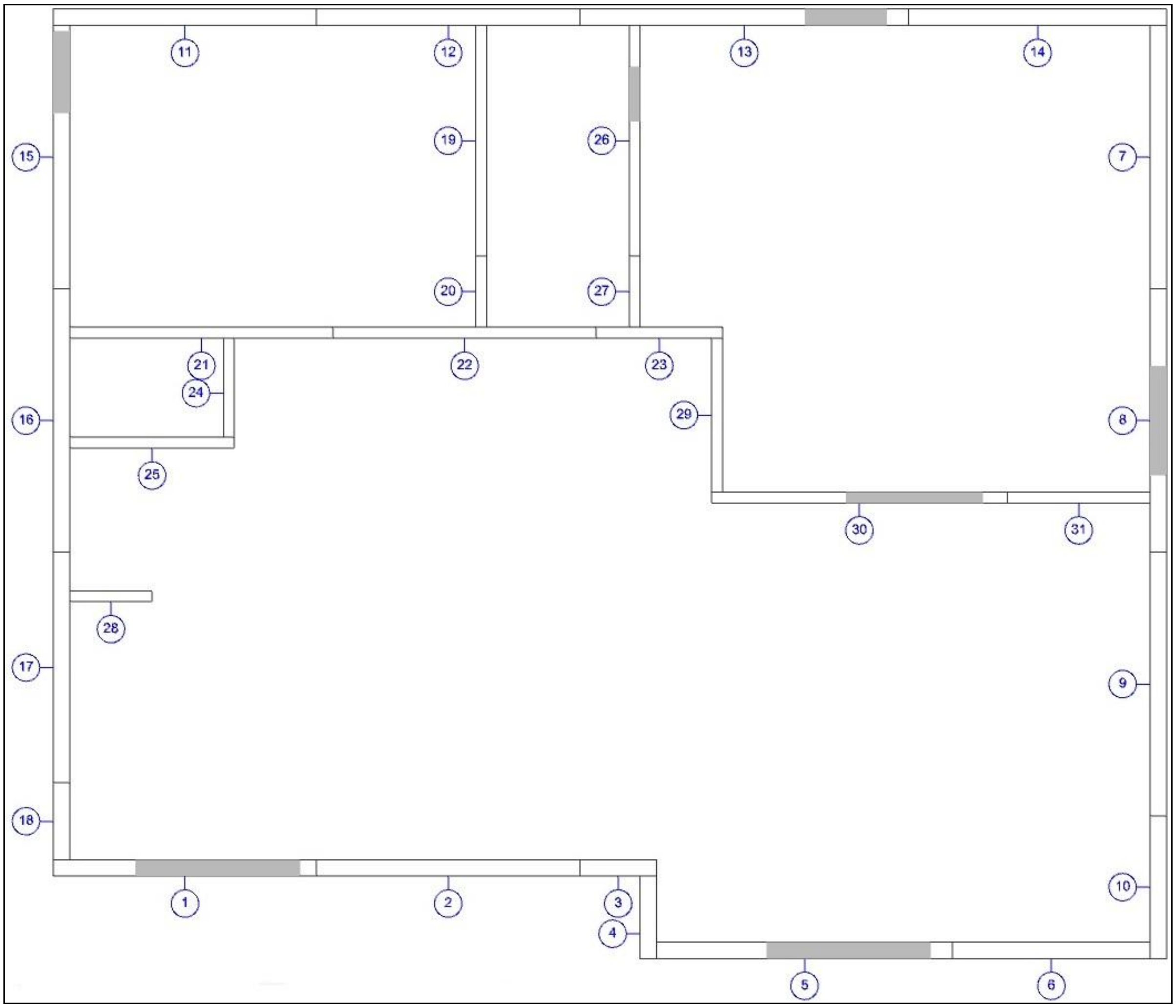
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	226.5
3	249.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	72.5	4	1	1	8	2
							2	1	12	1
							3	1	13	1
							4	1	1	3
2	2	A	RIGHT	336.7	57.3	3	1	1	9	2
							2	1	10	2
							3	3	16 15 14	2 1 1
3	2	B	LEFT	336.7	99.3	1	1	2	2 3	3 1
4	3	A	RIGHT	359.8	57.3	3	1	1	11	2
							2	1	6	2
							3	1	7	2
5	3	B	LEFT	359.8	99.3	8	1	1	17	1
							2	1	18	1
							3	2	22 23	3 1
							4	1	4	3
							5	1	5	3
							6	1	20	3
							7	2	21 19	3 3
							8	1	24	1

S4-1


11
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23
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25
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17
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18
1
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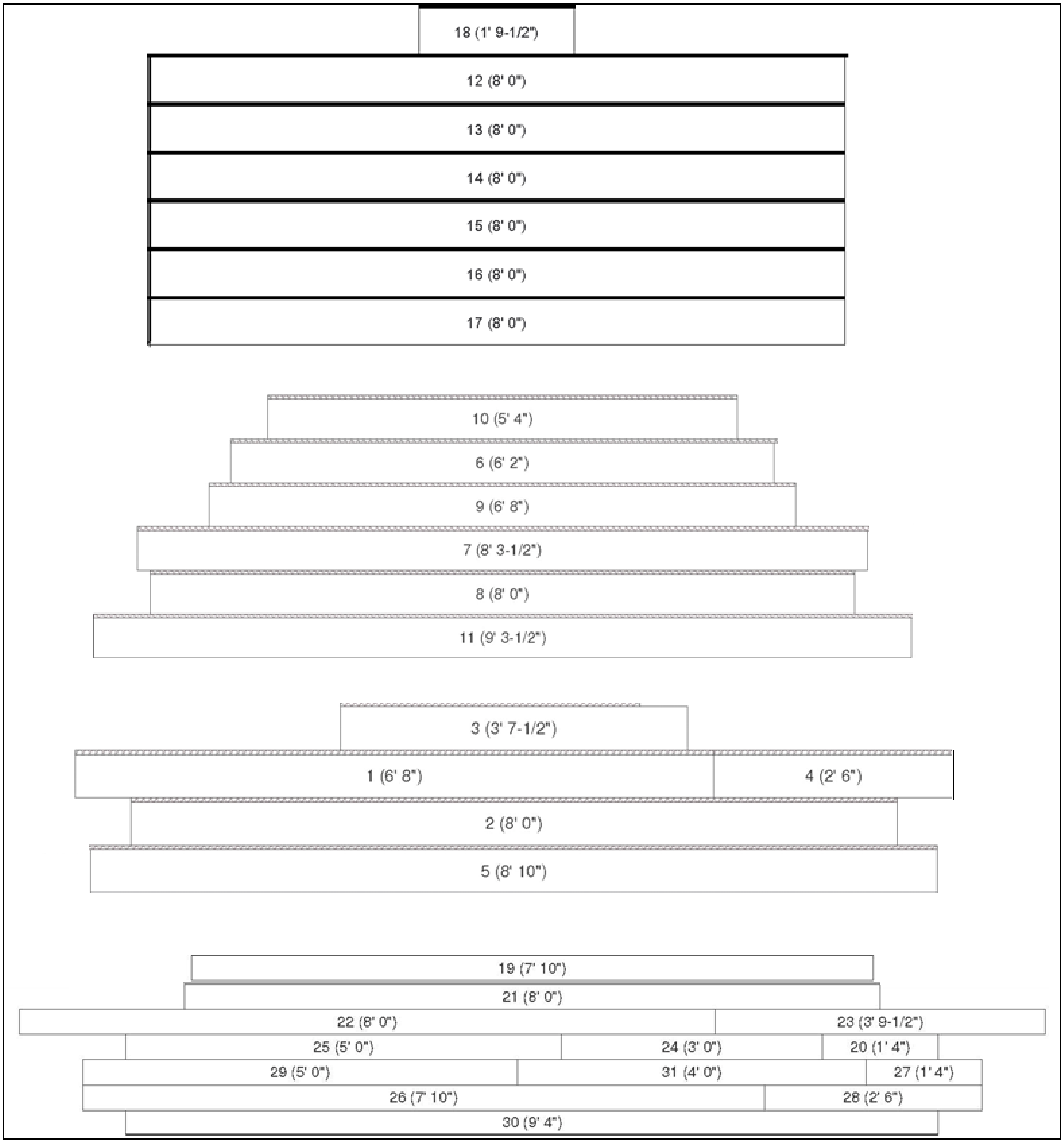
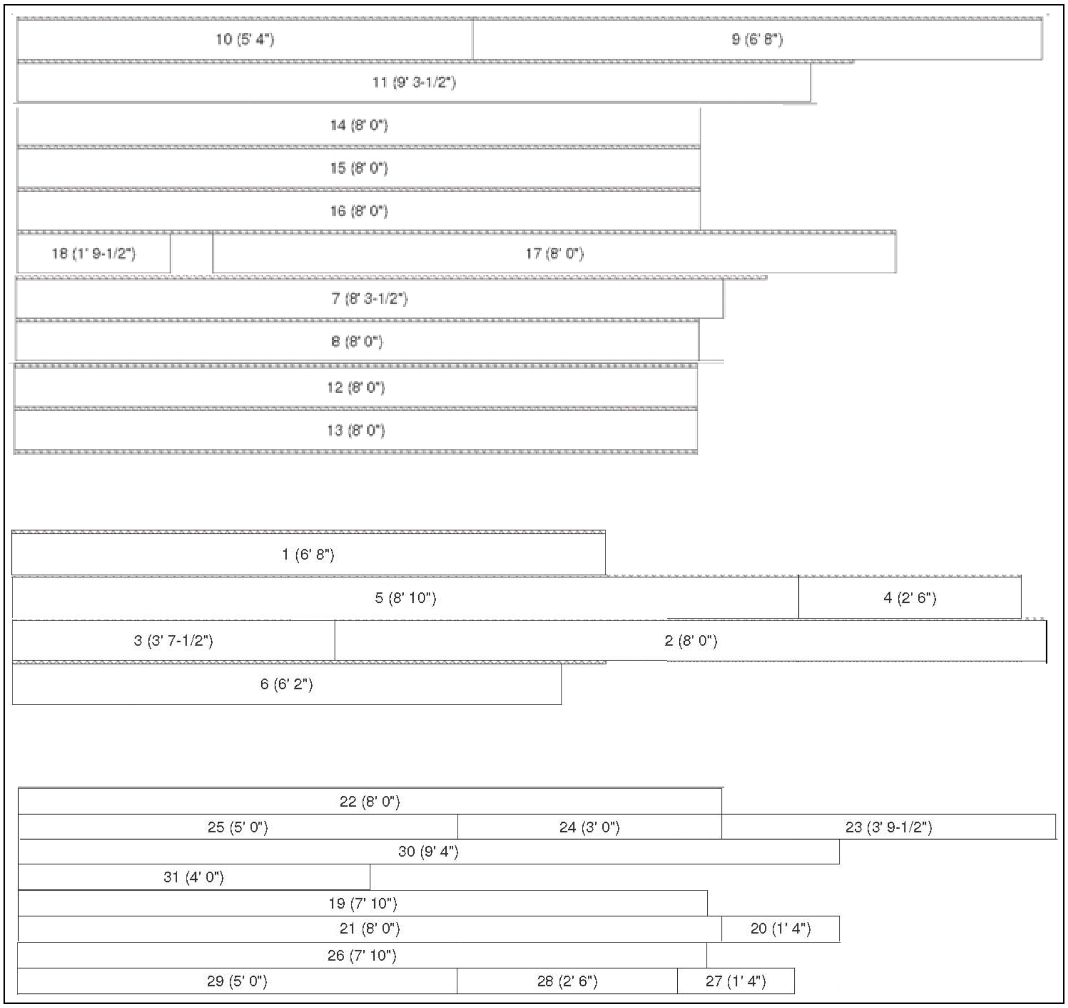
3
4
10
5
6

S4-1: Panel Designer



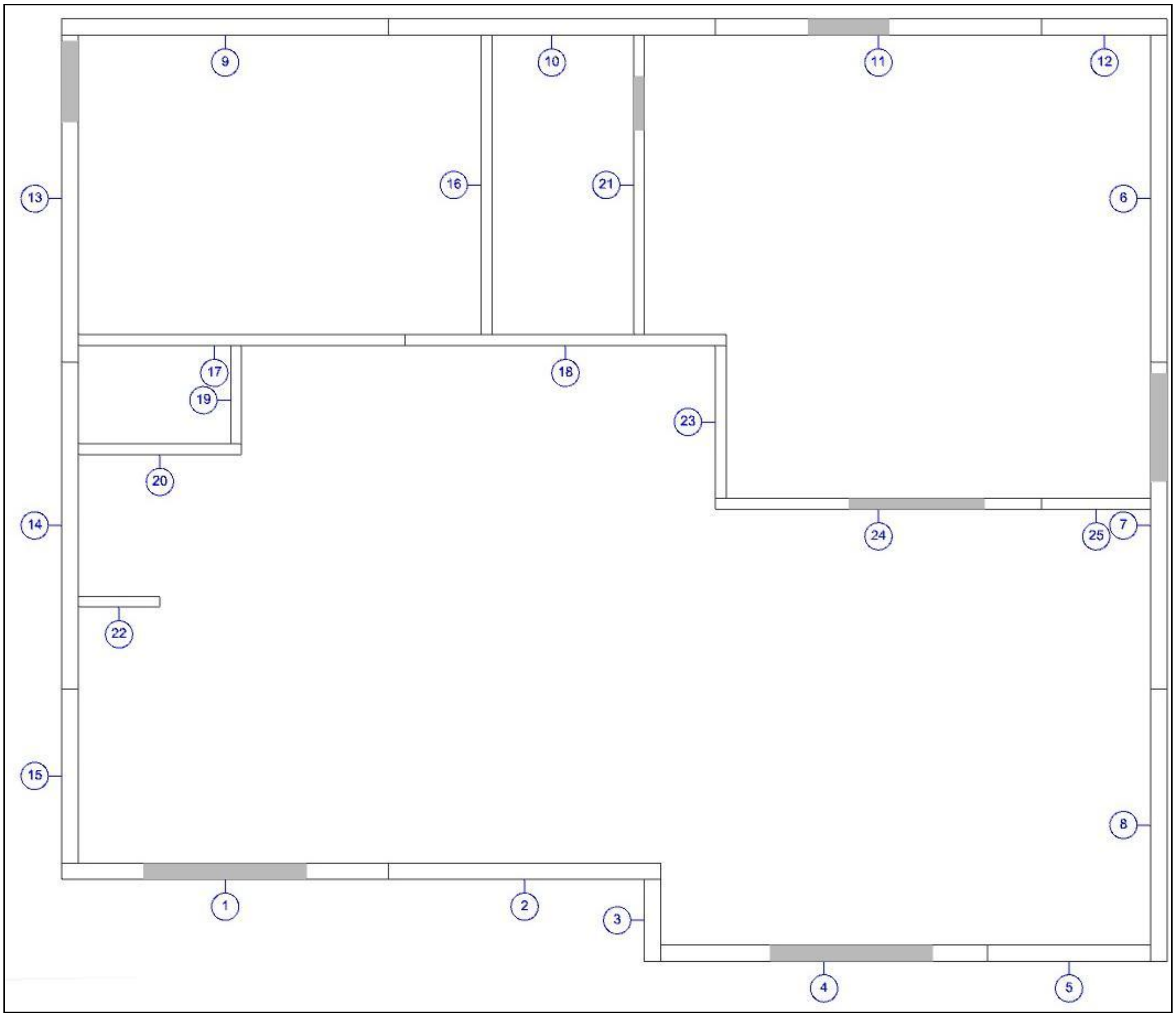
S4-1: IntelliBuild



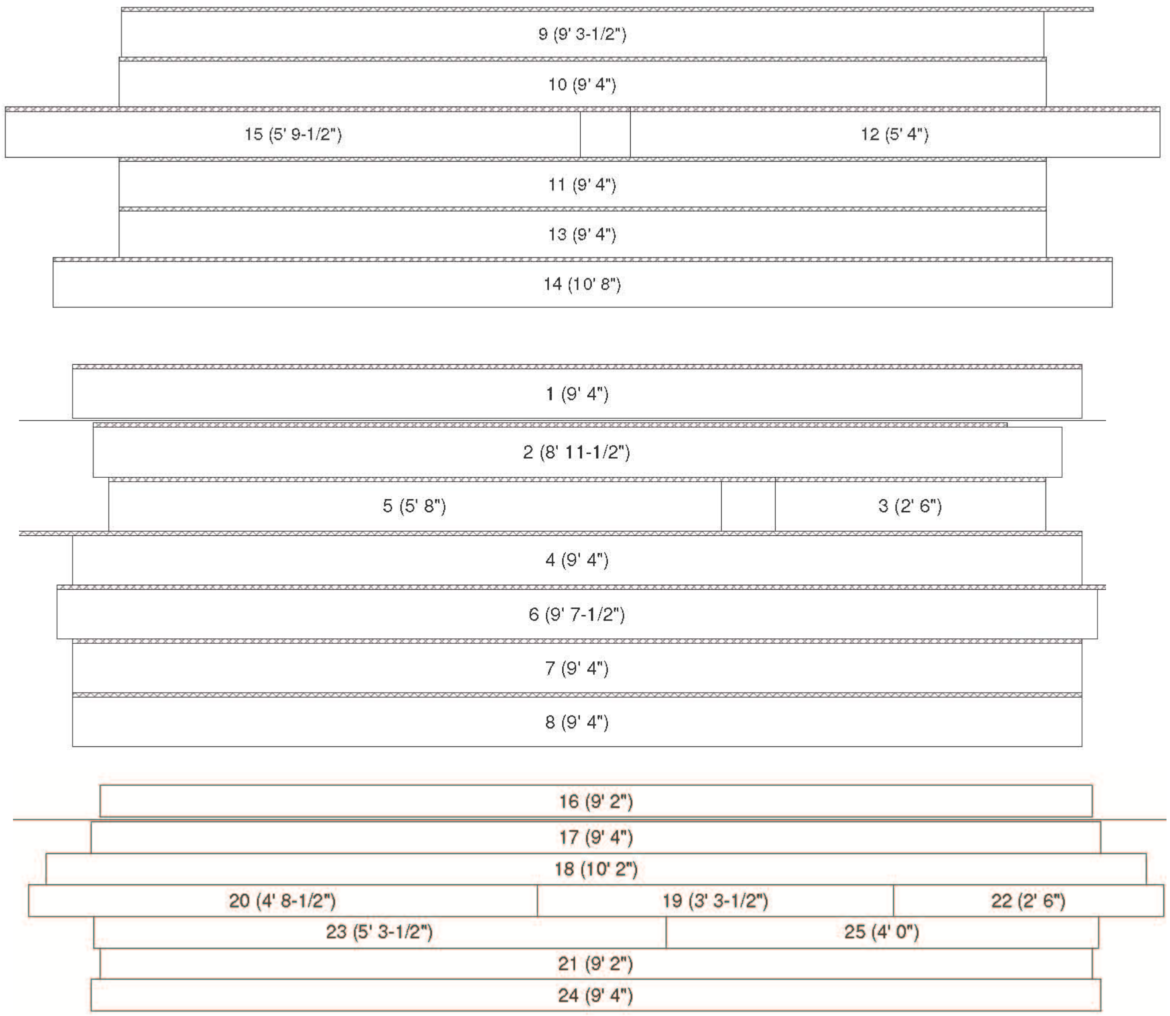
S4-1: Proposed algorithm
** Nzones 2
**zone left edge X coordinate
1 6.0 2 184.0
** NStacks 3

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	9	1	1	11	2
							2	1	12	2
							3	1	15	1
							4	1	16	1
							5	2	18 17	1 1
							6	1	1	3
							7	2	20 19	1 1
							8	1	21	2
							9	1	22	2
2	2	A	RIGHT	292.0	48.0	8	1	1	13	2
							2	1	14	2
							3	1	7	2
							4	1	8	2
							5	1	9	2
							6	2	26 10	2 2
							7	2	23 27	2 2
							8	2	3 2	3 3
3	2	B	LEFT	292.0	90.0	6	1	3	24 25 28	1 2 3
							2	1	29 4	1 1
							3	2	5	3
							4	1	6	3
							5	1	30	3
							6	1	31	2

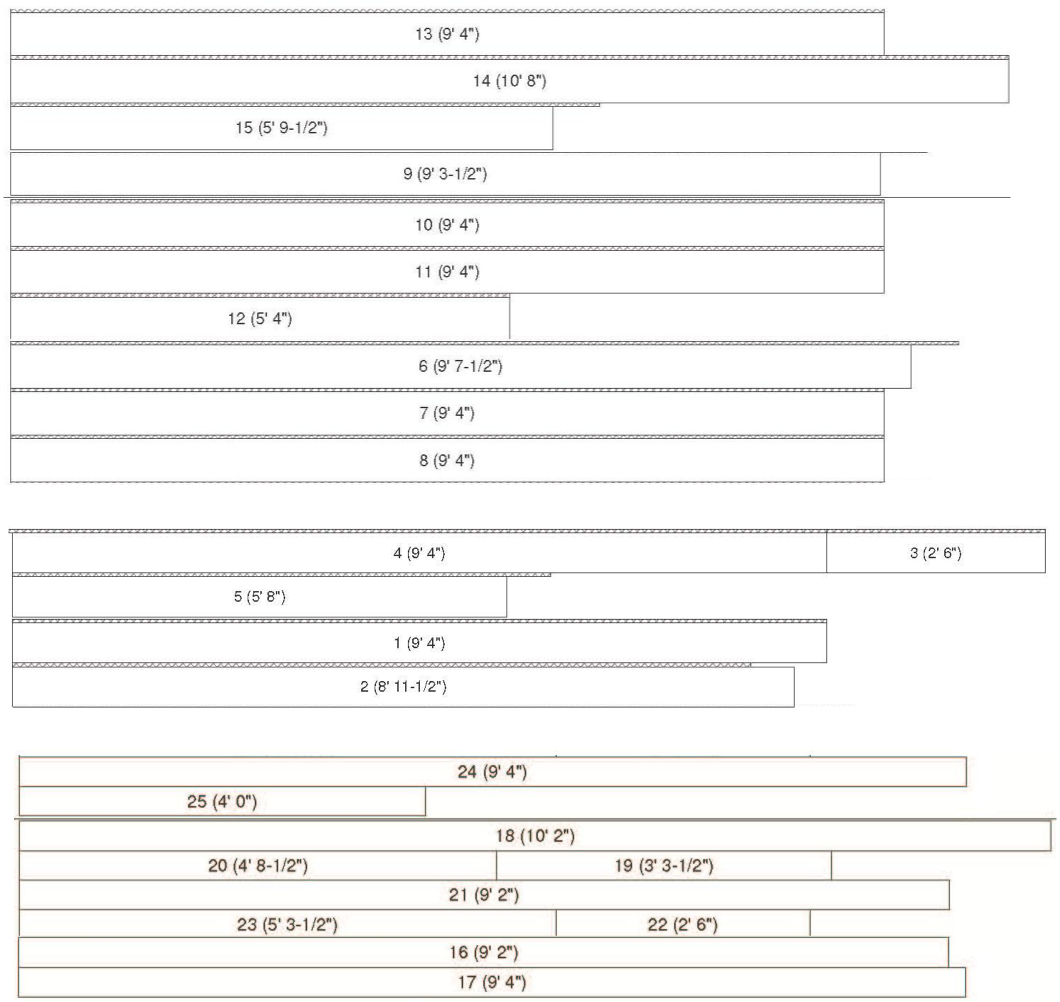
S4-2



S4-2: Panel Designer



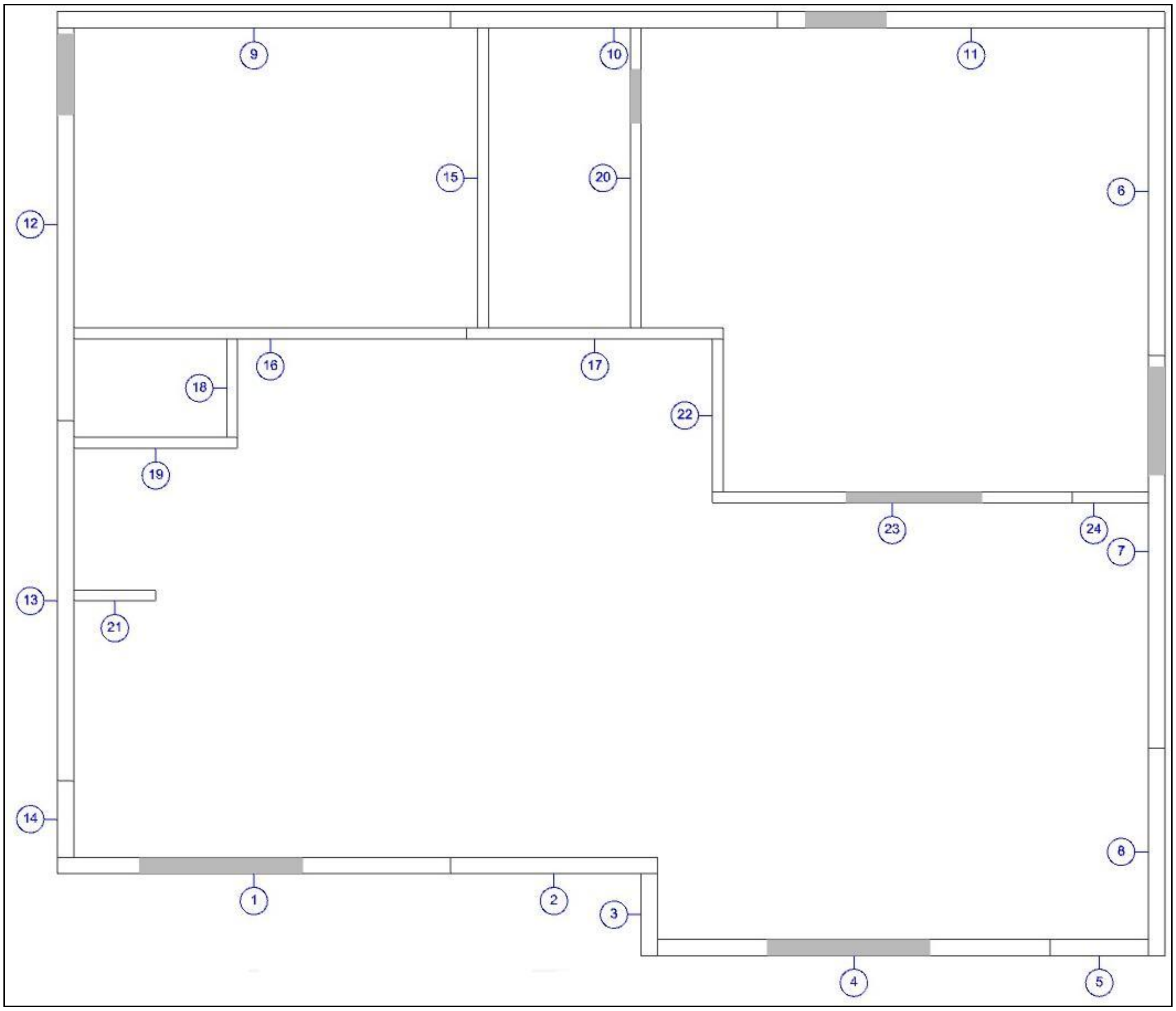
S4-2: IntelliBuild



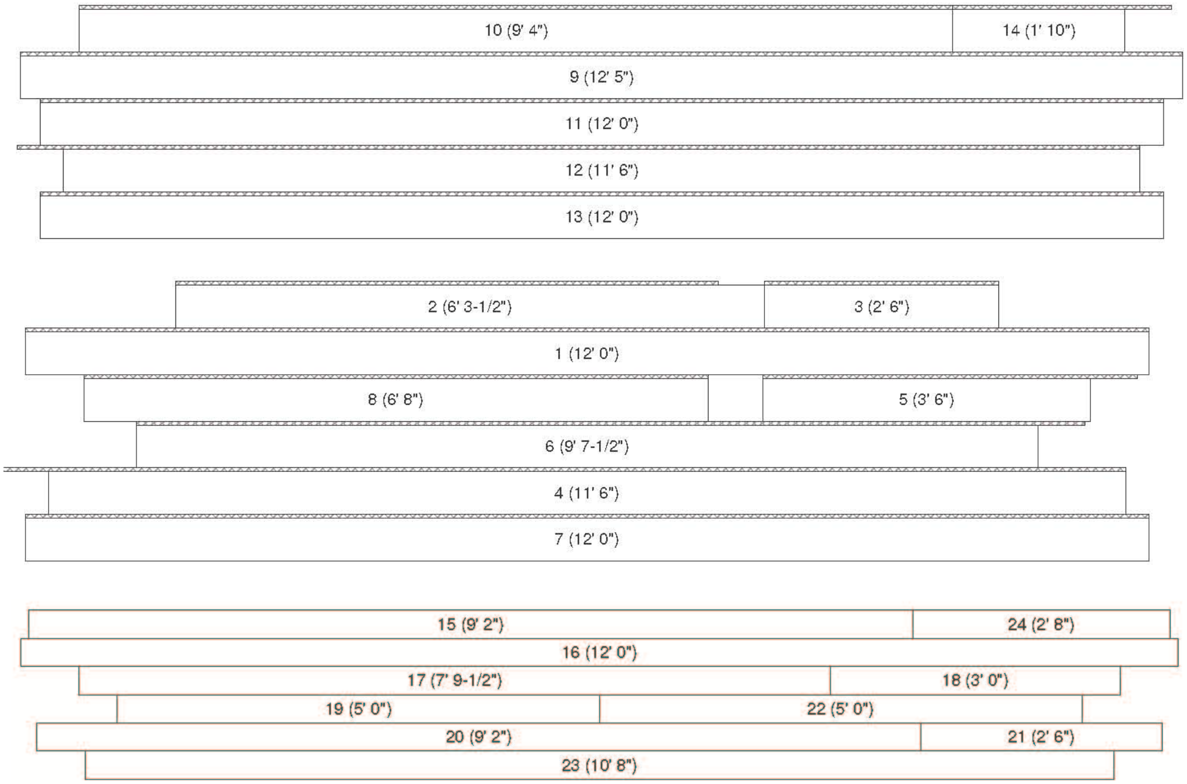
S4-2: Proposed algorithm

```
** Nzones 2
**zone      left edge X coordinate
 1           6.0       2          184.0
** NStacks 3
** stack                flush
**   #    zone type    edge      xloc    yloc   #layers   j   #panels   panels        orientation
     1     1     A     RIGHT    114.0    48.0       6          1        1     9              2
                                                               2        1     13             1
                                                               3        1     14             1
                                                               4        1     15             1
                                                               5        1     1              3
                                                               6        1     17             2
     2     2     A     RIGHT    292.0    48.0      10          1        1     10             2
                                                               2        1     11             2
                                                               3        1     12             2
                                                               4        1     6              2
                                                               5        1     7              2
                                                               6        1     8              2
                                                               7        1     16             2
                                                               8        1     21             2
                                                               9        1     18             2
                                                              10        1     2              3
     3     2     B     LEFT     292.0    90.0       7          1        3     19 20 22       1 2 3
                                                               2        1     23             1
                                                               3        1     3              1
                                                               4        1     4              3
                                                               5        1     5              3
                                                               6        1     25             3
                                                               7        1     24             2
```

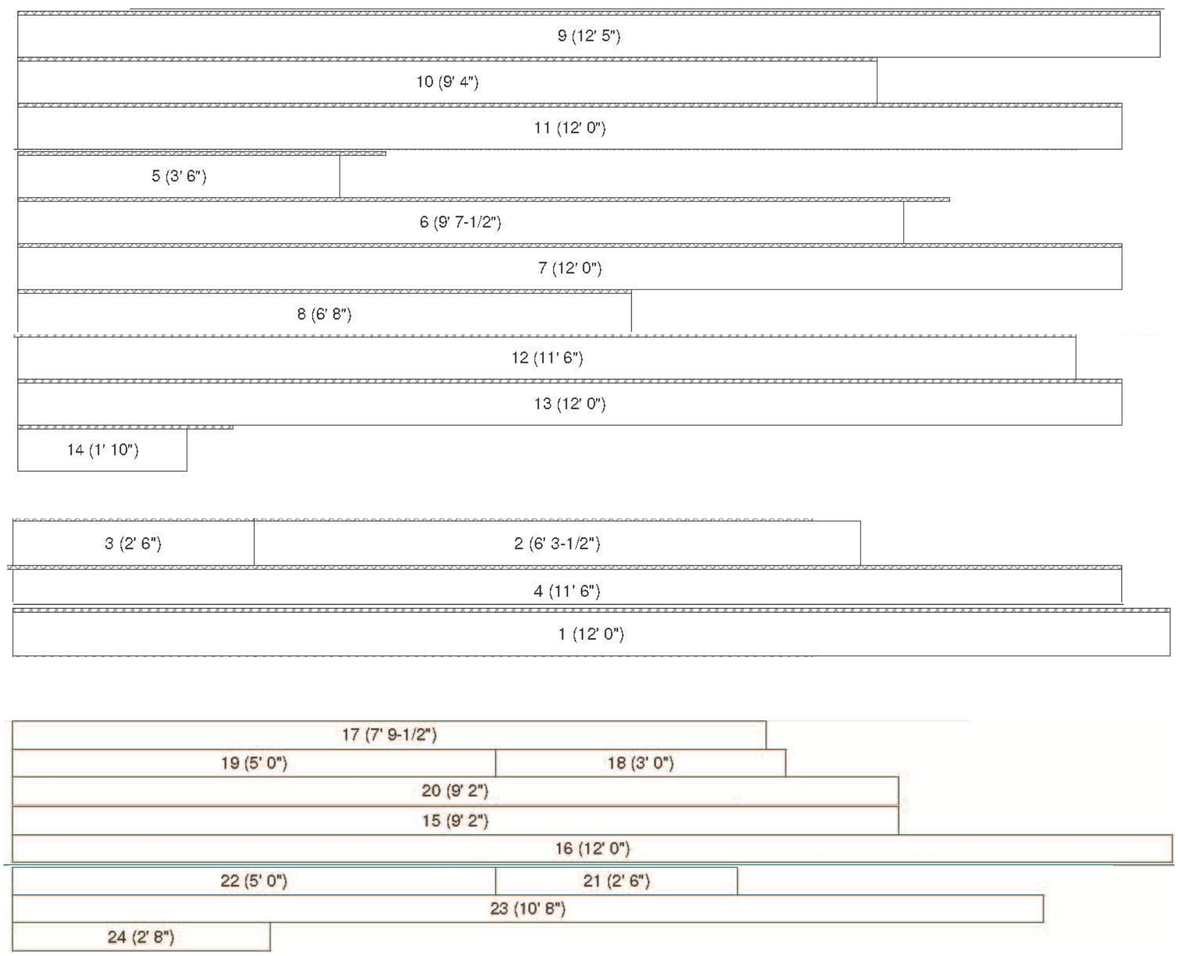
S4-3



S4-3: Panel Designer



S4-3: IntelliBuild

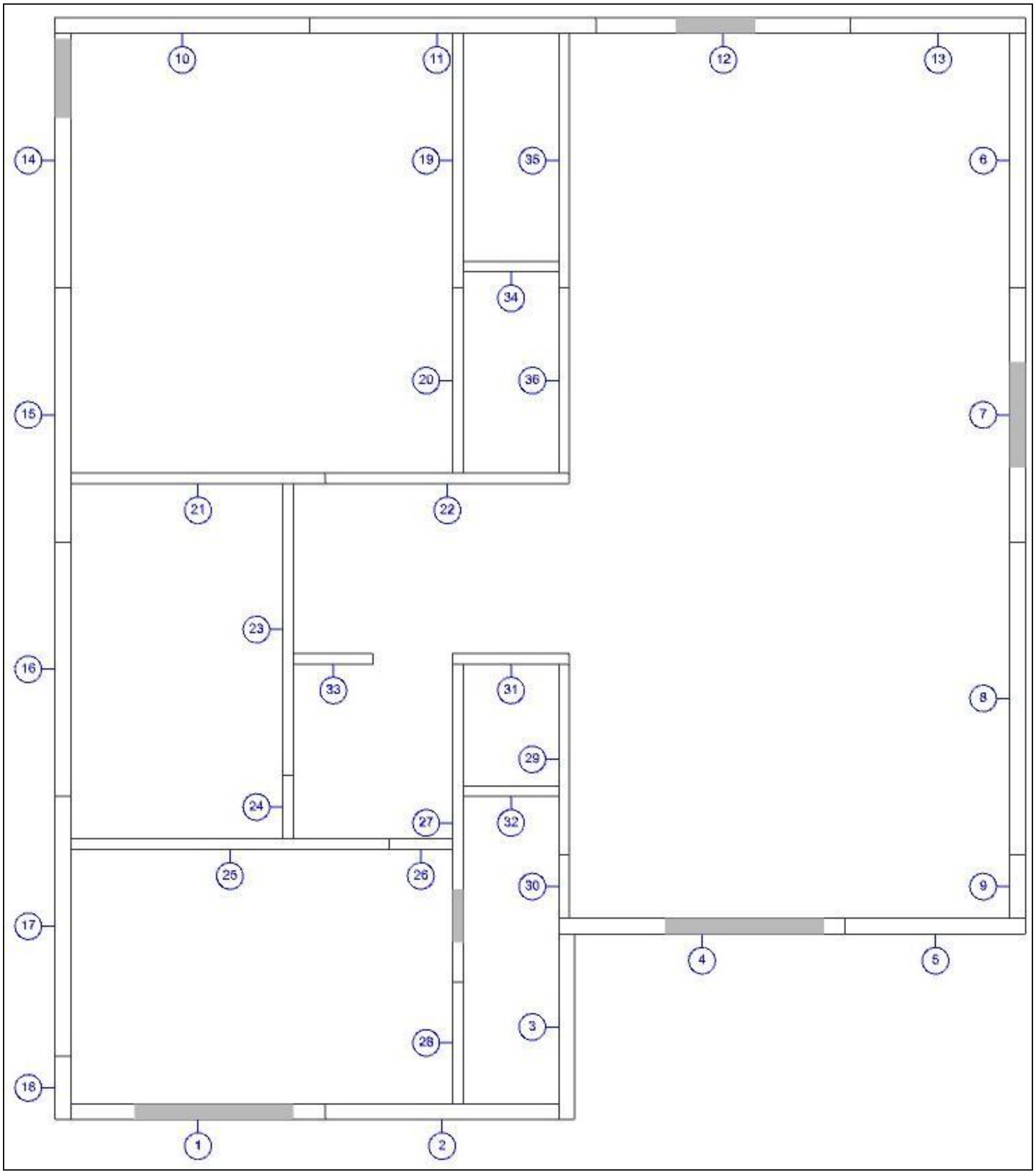


S4-3: Proposed algorithm

** Nzones
2
**zone left edge X coordinate
1 6.0
2 179.5
** NStacks
3

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	5	1	1	9	2
							2	1	12	1
							3	1	13	1
							4	1	14	1
							5	1	1	3
2	2	A	RIGHT	289.8	57.3	6	1	1	10	2
							2	1	11	2
							3	1	6	2
							4	1	7	2
							5	1	8	2
							6	1	2	3
3	2	B	LEFT	289.8	99.3	11	1	1	15	1
							2	1	16	2
							3	3	18 19 21	1 2 3
							4	1	20	1
							5	1	17	2
							6	1	22	1
							7	1	3	1
							8	1	4	3
							9	1	5	3
							10	1	24	3
							11	1	23	3

S5-1



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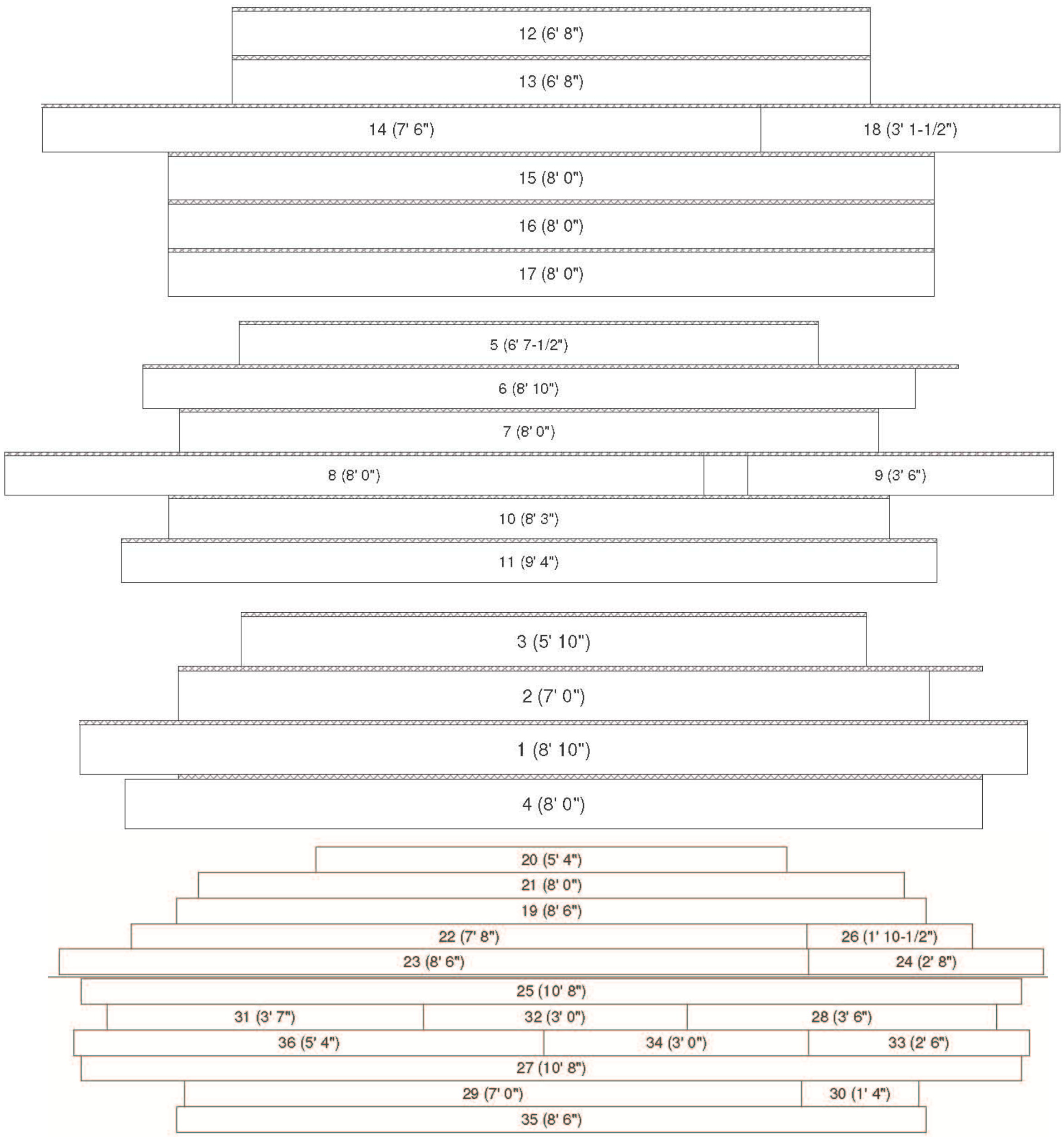
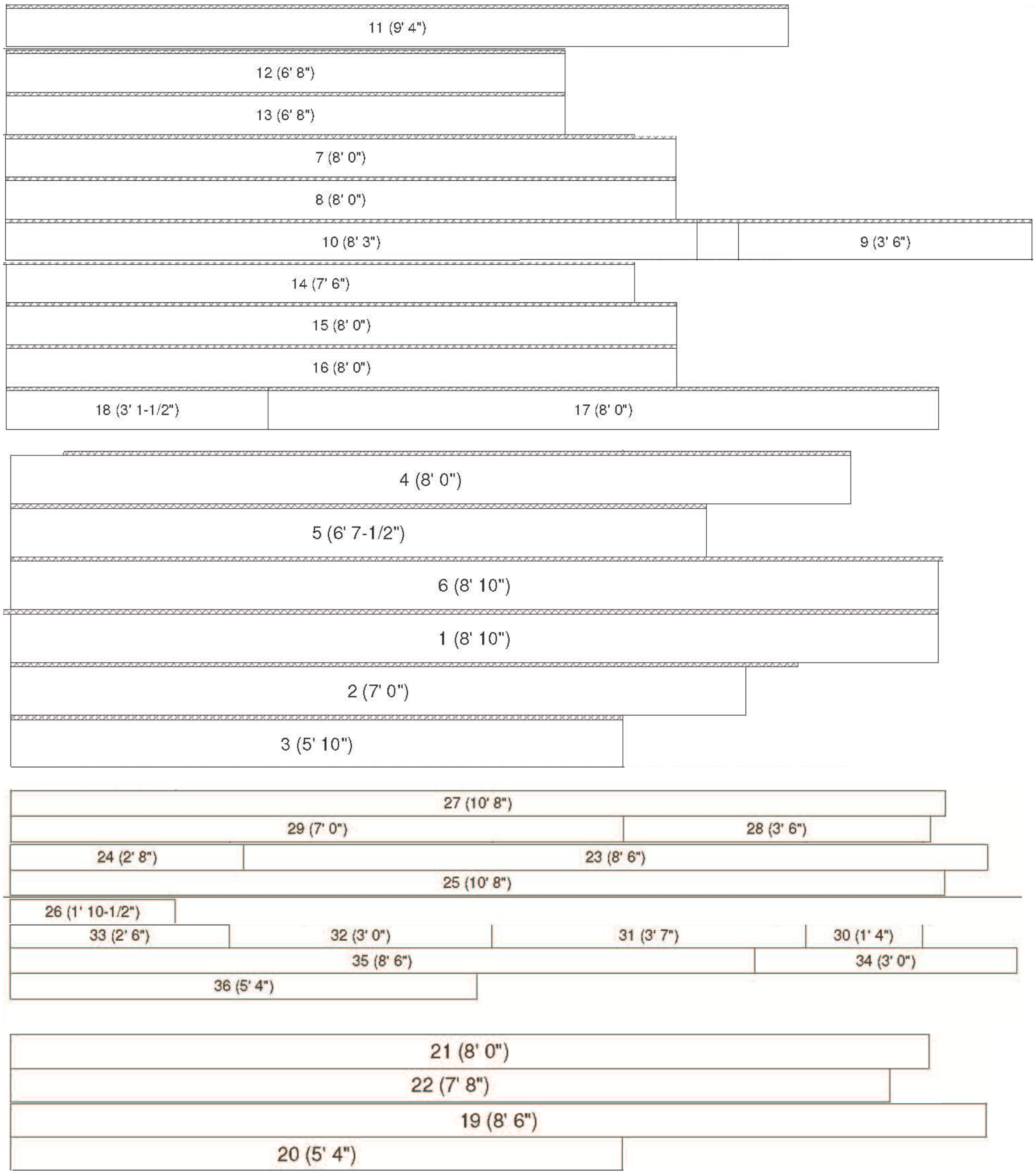
32
25
26
30
9
17
4
5
3
28
18
1
2

S5-1: Panel Designer



S5-1: IntelliBuild



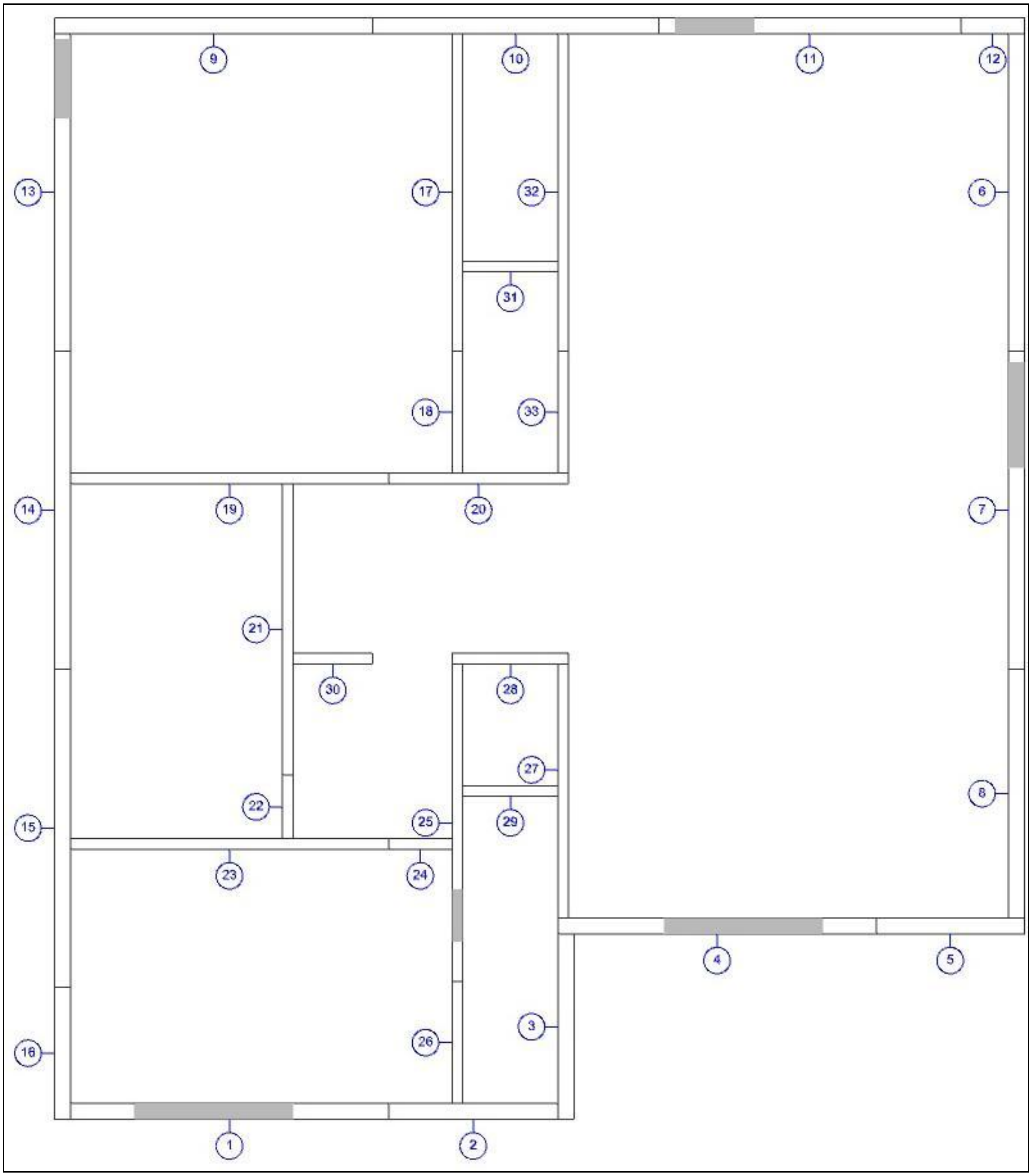
```
S5-1: Proposed algorithm
** Nzones
2

**zone       left edge X coordinate
  1              6.0
  2          144.0

** NStacks
3

** stack                  flush
**    #     zone type   edge       xloc    yloc    #layers    j    #panels    panels        orientation
      1       1      A      RIGHT    114.0    48.0        13         1          1       10                 2
                                                                     2          1       11                 2
                                                                     3          1       14                 1
                                                                     4          1       15                 1
                                                                     5          1       16                 1
                                                                     6          2       18 17              1 1
                                                                     7          2       34 19              2 1
                                                                     8          1       35                 1
                                                                     9          2       36 20              1 1
                                                                    10          1       21                 2
                                                                    11          1       22                 2
                                                                    12          1       1                  3
                                                                    13          1       2                  3
      2       2      A      RIGHT    252.0    48.0         8         1          1       12                 2
                                                                     2          1       13                 2
                                                                     3          1       6                  2
                                                                     4          1       7                  2
                                                                     5          2       9 8                2 2
                                                                     6          1       3                  1
                                                                     7          1       4                  3
                                                                     8          1       5                  3
      3       2      B      LEFT     252.0    100.0        9         1          2       23 33              1 2
                                                                     2          2       24 25              1 3
                                                                     3          1       26                 3
                                                                     4          1       27                 1
                                                                     5          1       28                 1
                                                                     6          1       31                 2
                                                                     7          1       32                 3
                                                                     8          1       29                 1
                                                                     9          1       30                 1
```

S5-2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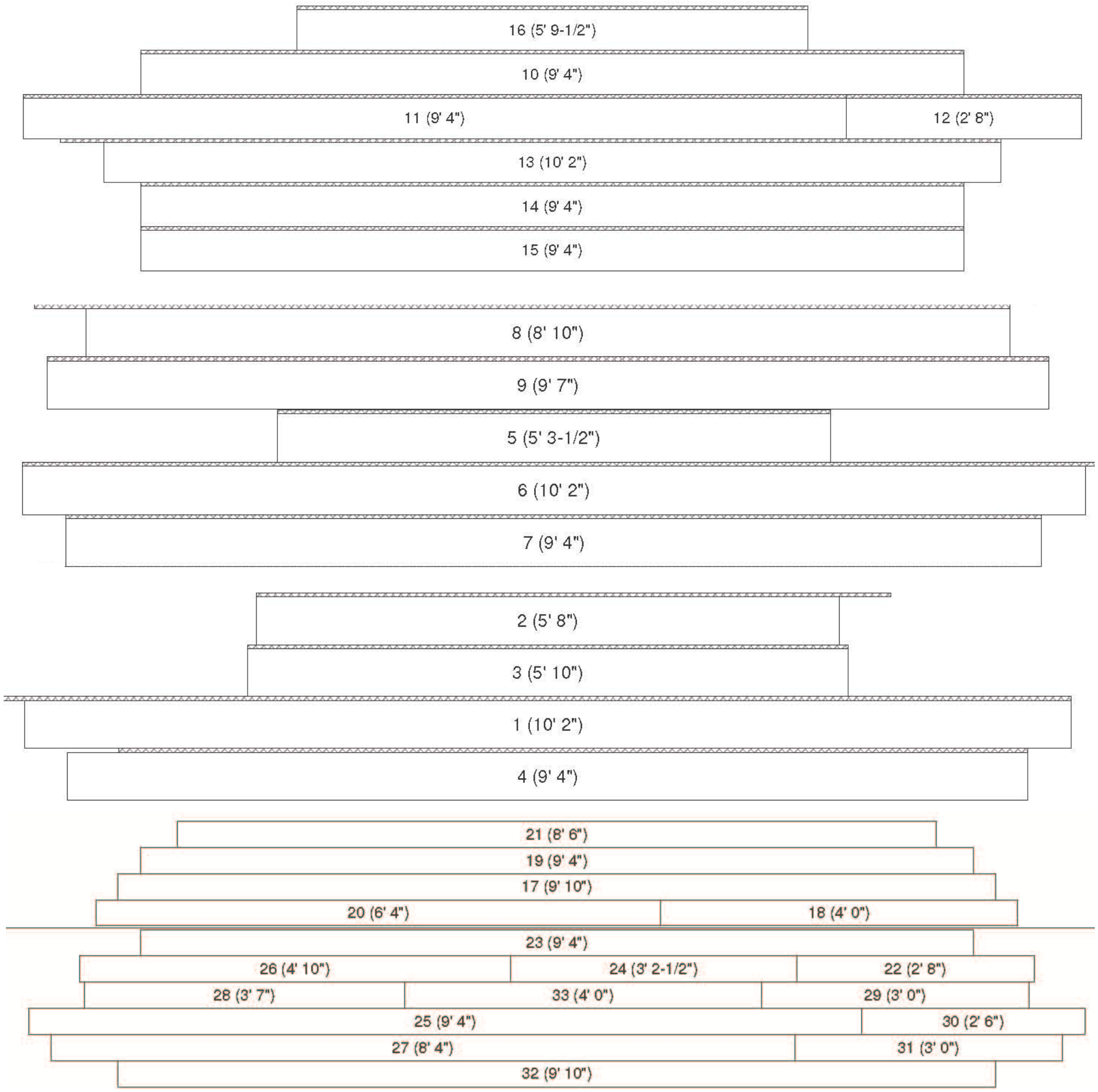
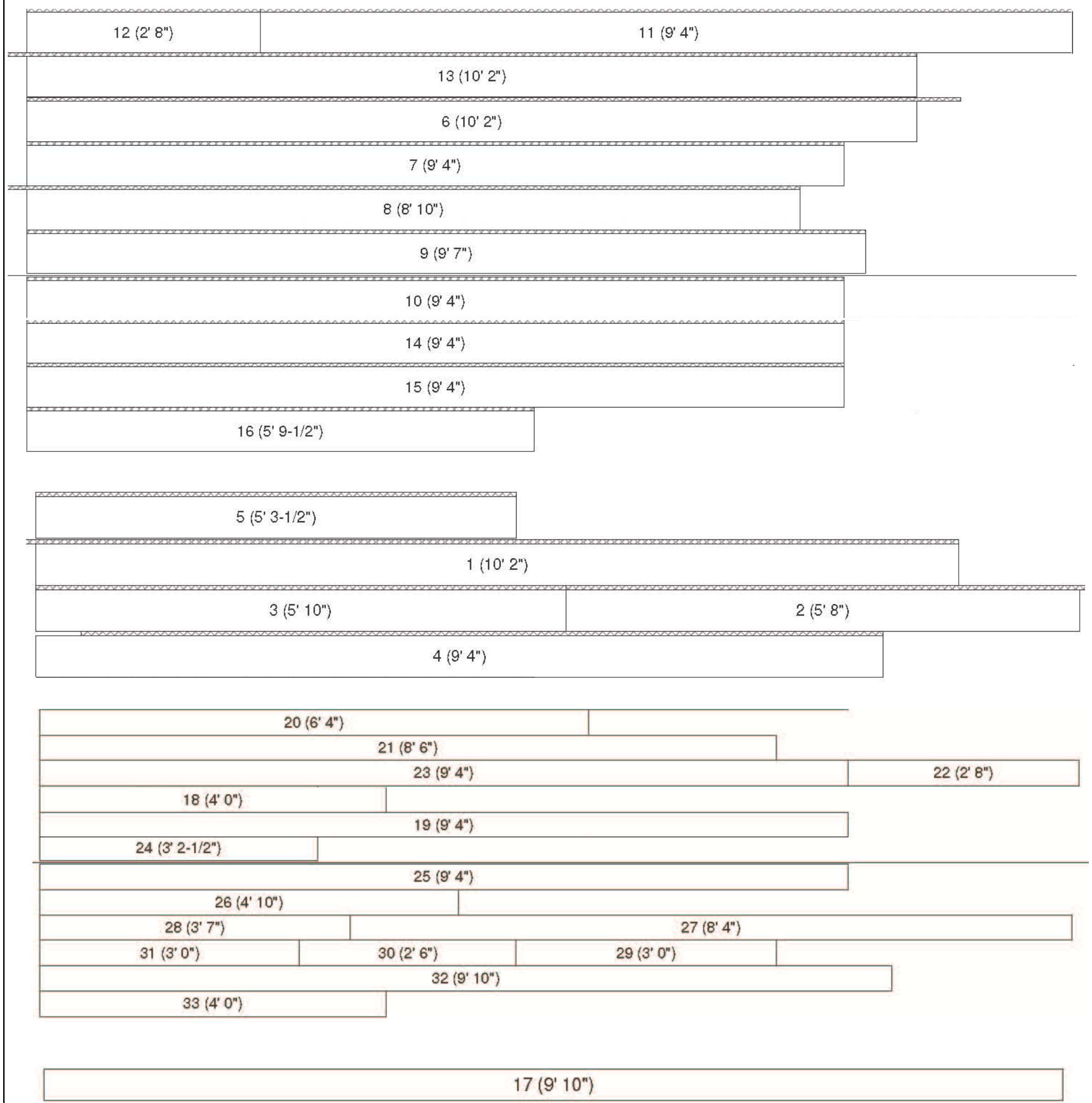
S5-2: Panel Designer



S5-2: IntelliBuild



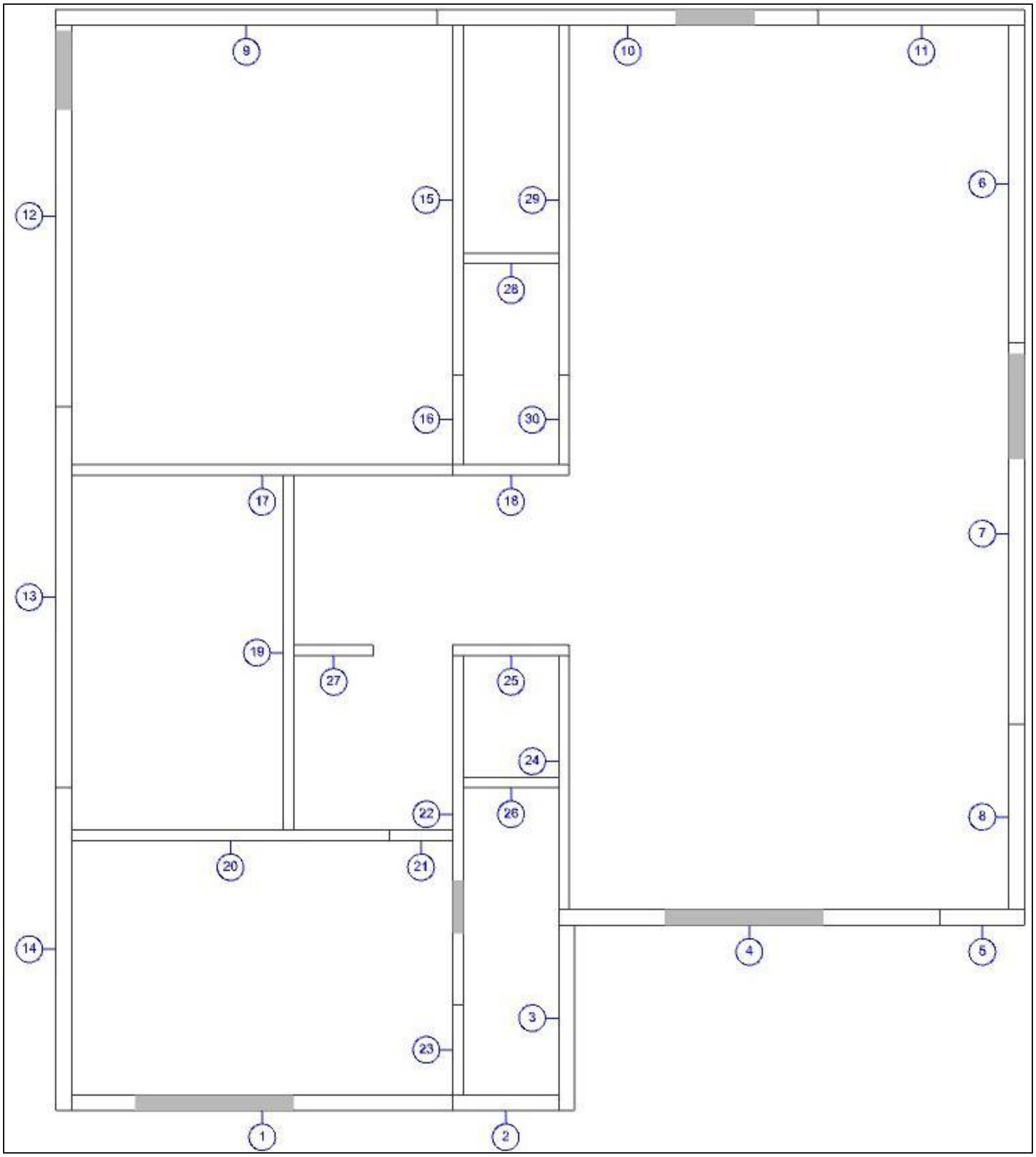
```
S5-2: Proposed algorithm
** Nzones
2

**zone      left edge X coordinate
  1             6.0
  2           144.0

** NStacks
3

** stack                 flush
**    #     zone type    edge      xloc    yloc    #layers   j   #panels   panels      orientation
      1      1     A      RIGHT    114.0    48.0        7         1        1      9                2
                                                                   2        1      13               1
                                                                   3        1      14               1
                                                                   4        1      15               1
                                                                   5        1      16               1
                                                                   6        1      19               2
                                                                   7        1      1                3
      2      2     A      RIGHT    252.0    48.0       13         1        1      10               2
                                                                   2        2      12 11            2 2
                                                                   3        1      6                2
                                                                   4        1      7                2
                                                                   5        1      8                2
                                                                   6        1      17               2
                                                                   7        1      31               2
                                                                   8        1      32               2
                                                                   9        2      33 18         2 2
                                                                  10        1      20               2
                                                                  11        2      2 3              3 1
                                                                  12        1      4                3
                                                                  13        1      5                3
      3      2     B      LEFT     252.0    90.0        6         1        2      21 30            1 2
                                                                   2        2      22 23            1 3
                                                                   3        2      24 25         1 3
                                                                   4        2      26 28         1 2
                                                                   5        1      29               3
                                                                   6        1      27               1
```

S5-3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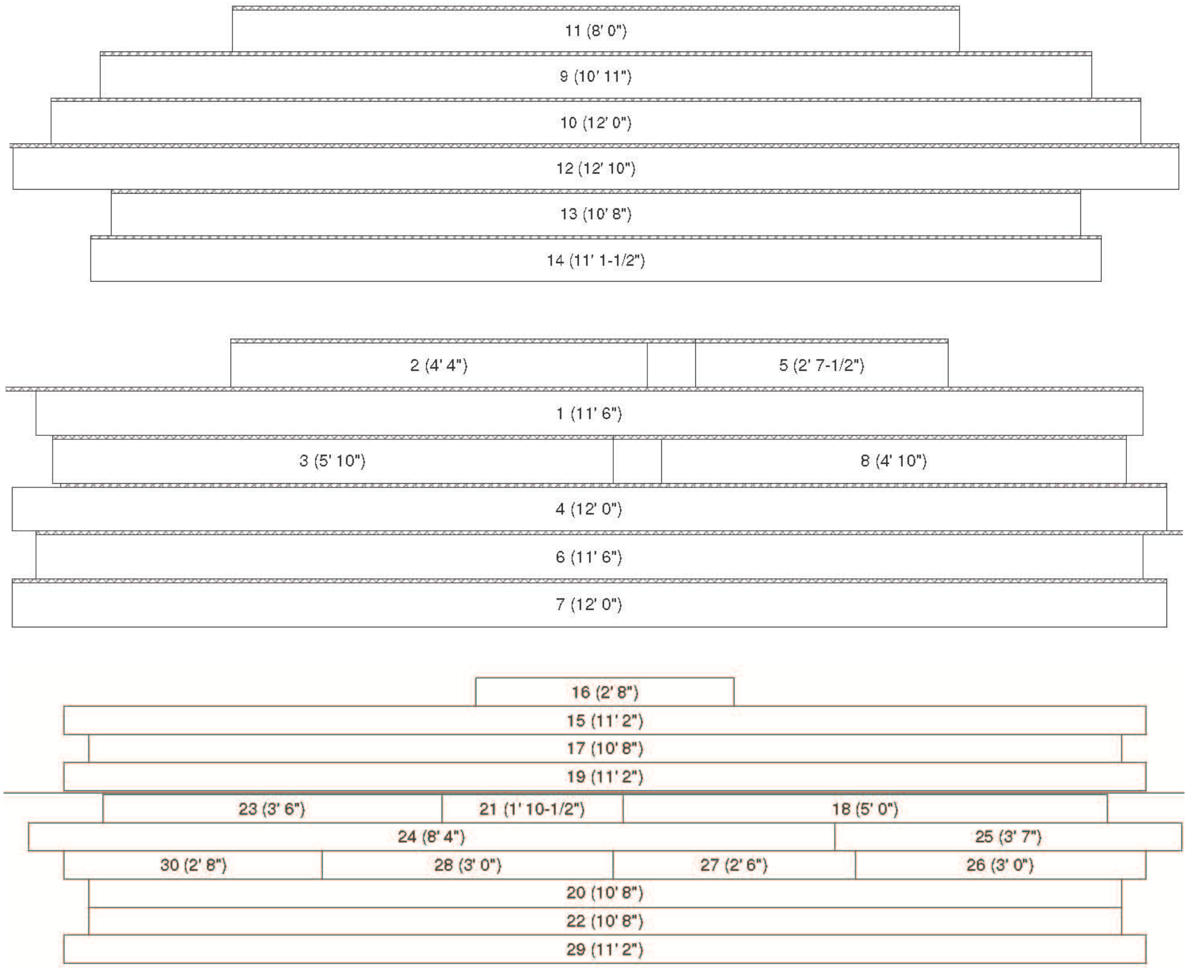
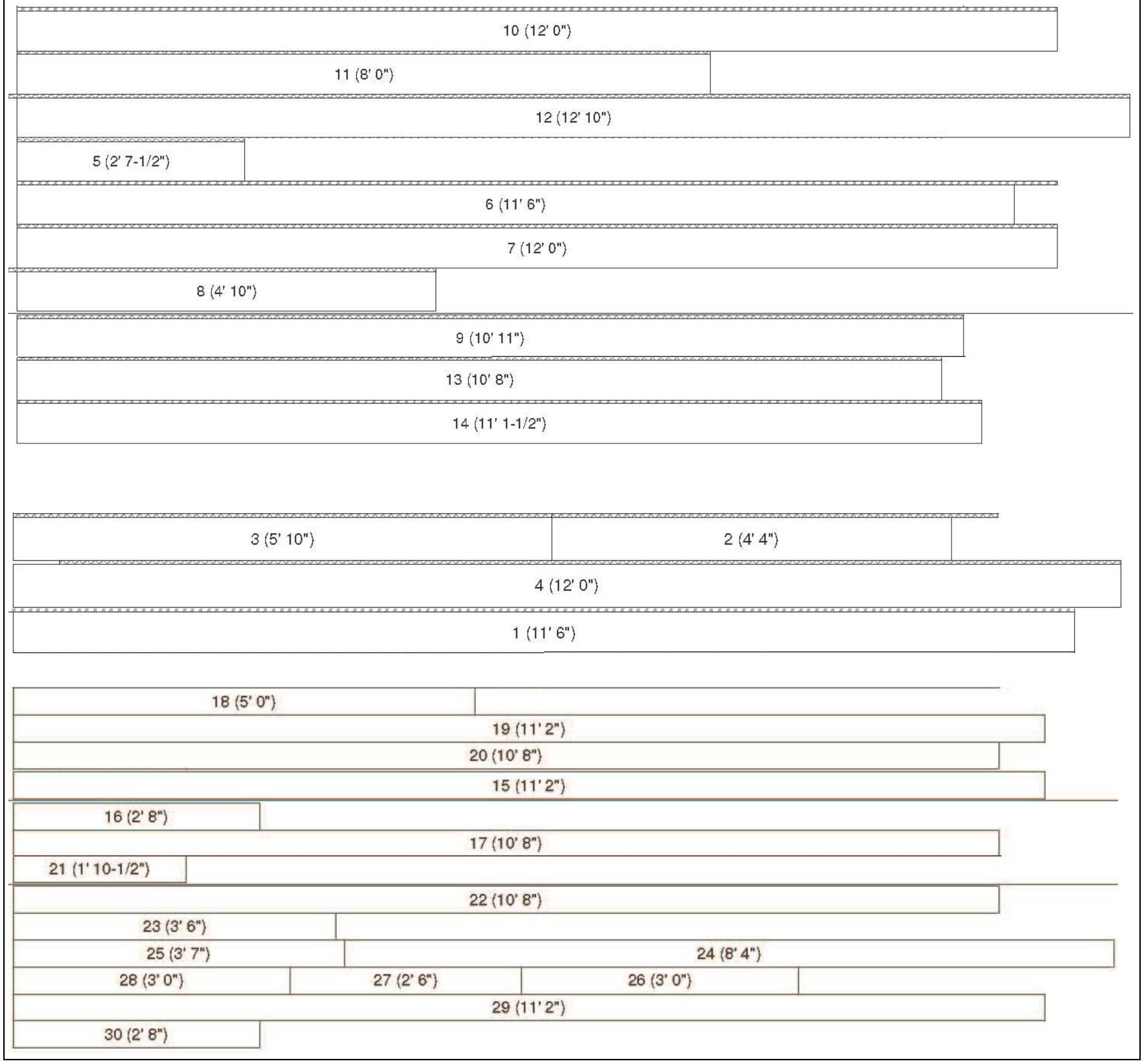
S5-3: Panel Designer

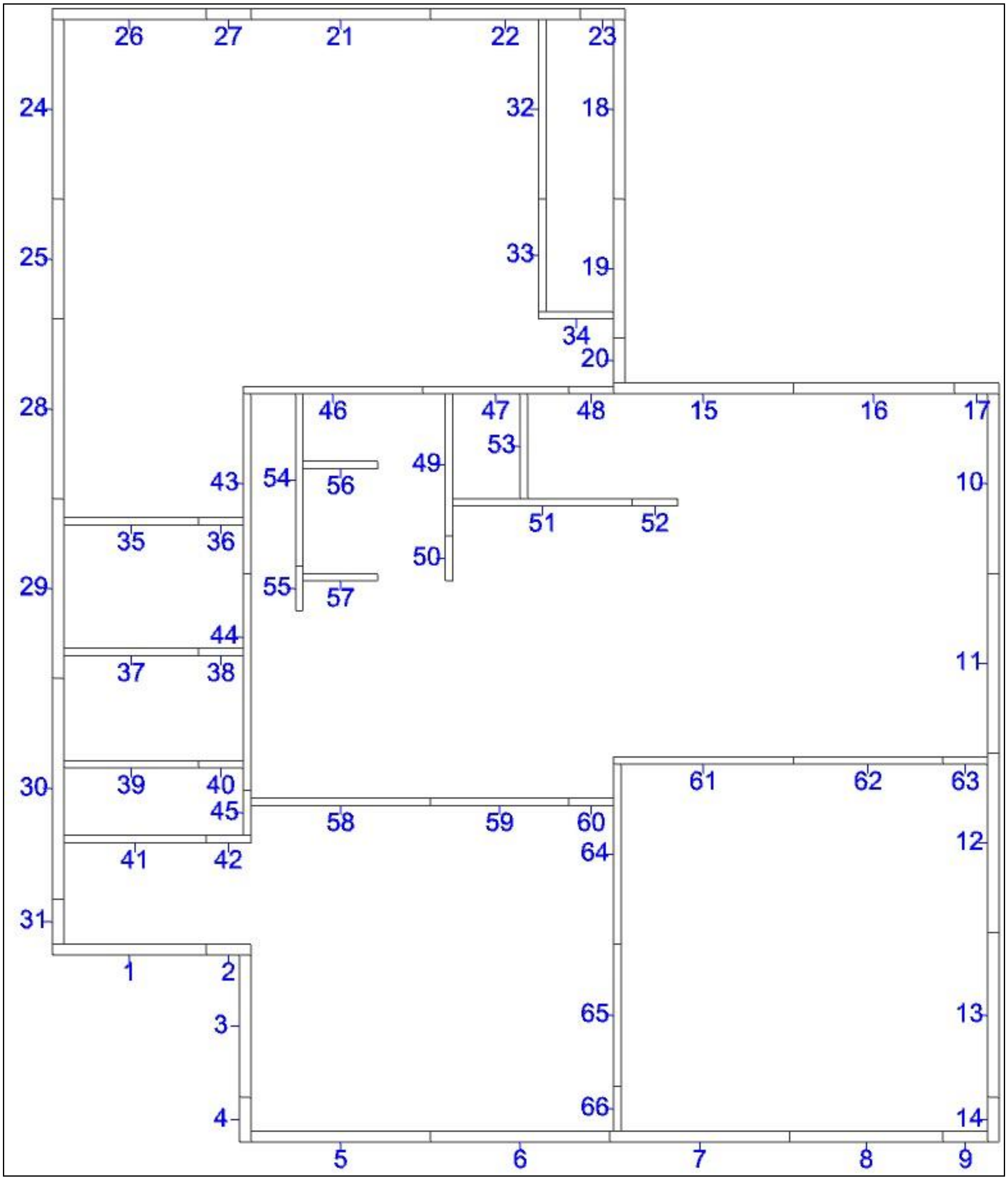


S5-3: IntelliBuild



```
S5-3: Proposed algorithm
** Nzones 2
**zone      left edge X coordinate
 1            6.0
 2          139.5
** NStacks 3
** stack                  flush
**   #   zone type   edge    xloc    yloc  #layers  j  #panels  panels    orientation
     1    1     A    RIGHT   116.2   57.3     6         1        1     9            2
                                                        2        1     12           1
                                                        3        1     13           1
                                                        4        1     14           1
                                                        5        1     17           2
                                                        6        1     1            3
     2    2     A    RIGHT   249.8   57.3    11         1        1     10           2
                                                        2        1     11           2
                                                        3        1     6            2
                                                        4        1     7            2
                                                        5        1     8            2
                                                        6        2     3 2          3 1
                                                        7        2     5 4          3 3
                                                        8        1     15           2
                                                        9        1     28           2
                                                        10       1     29           2
                                                        11       3     18 30 16     2 2 2
     3    2     B    LEFT    249.8   99.3     6         1        1     19           1
                                                        2        1     27           3
                                                        3        2     20 21        3 3
                                                        4        2     22 23        1 1
                                                        5        2     25 26        3 2
                                                        6        1     24           1
```

M1-1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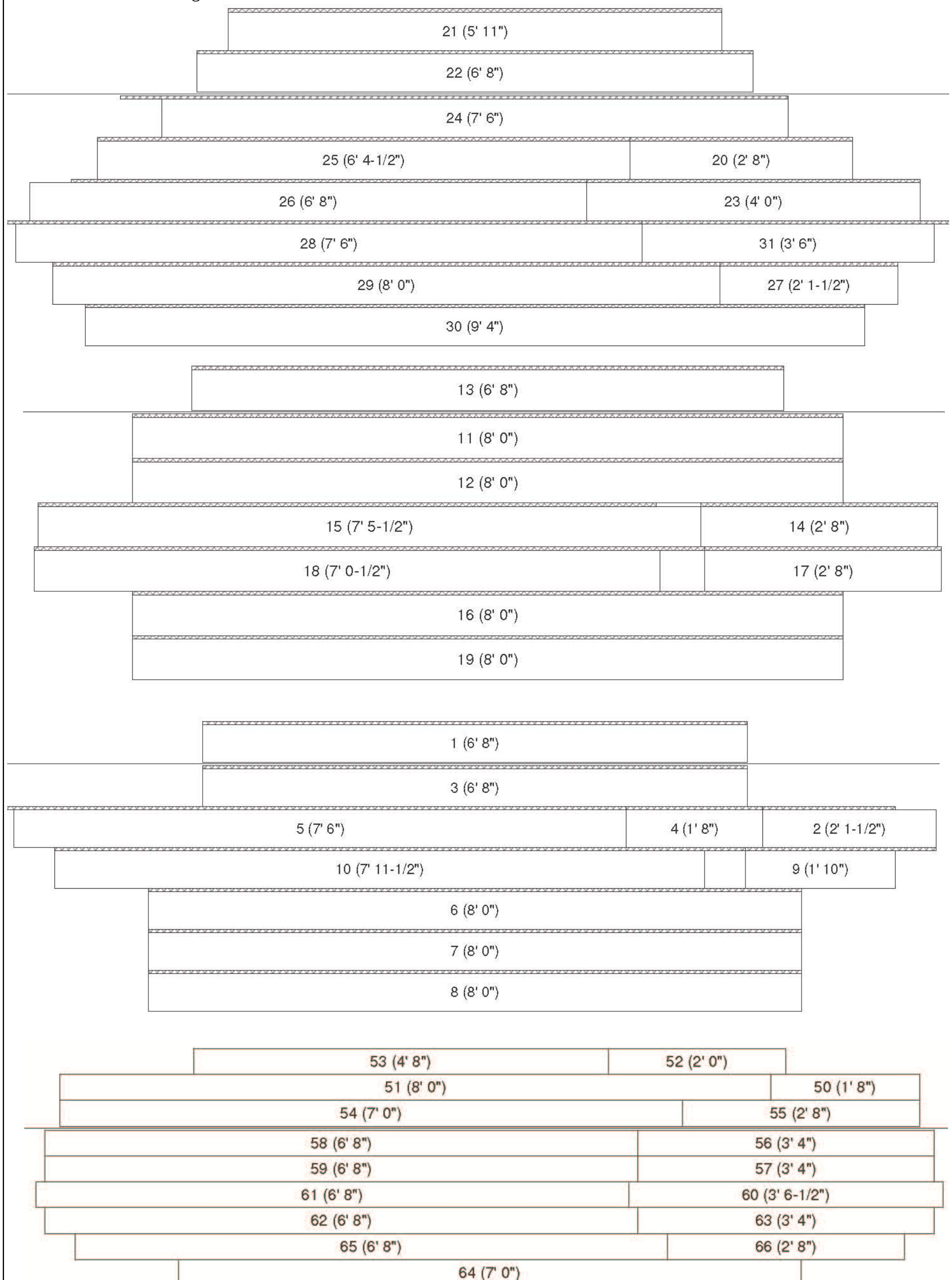
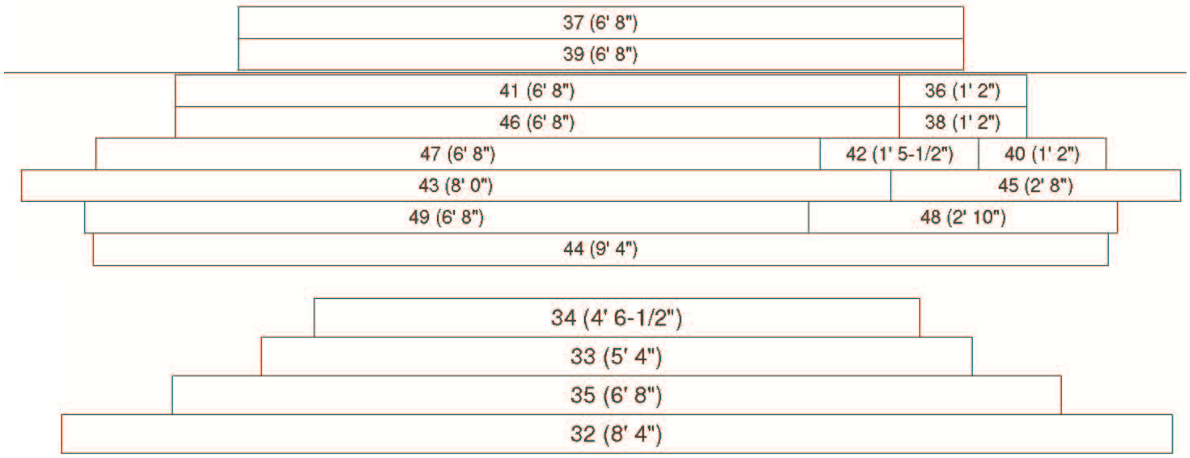
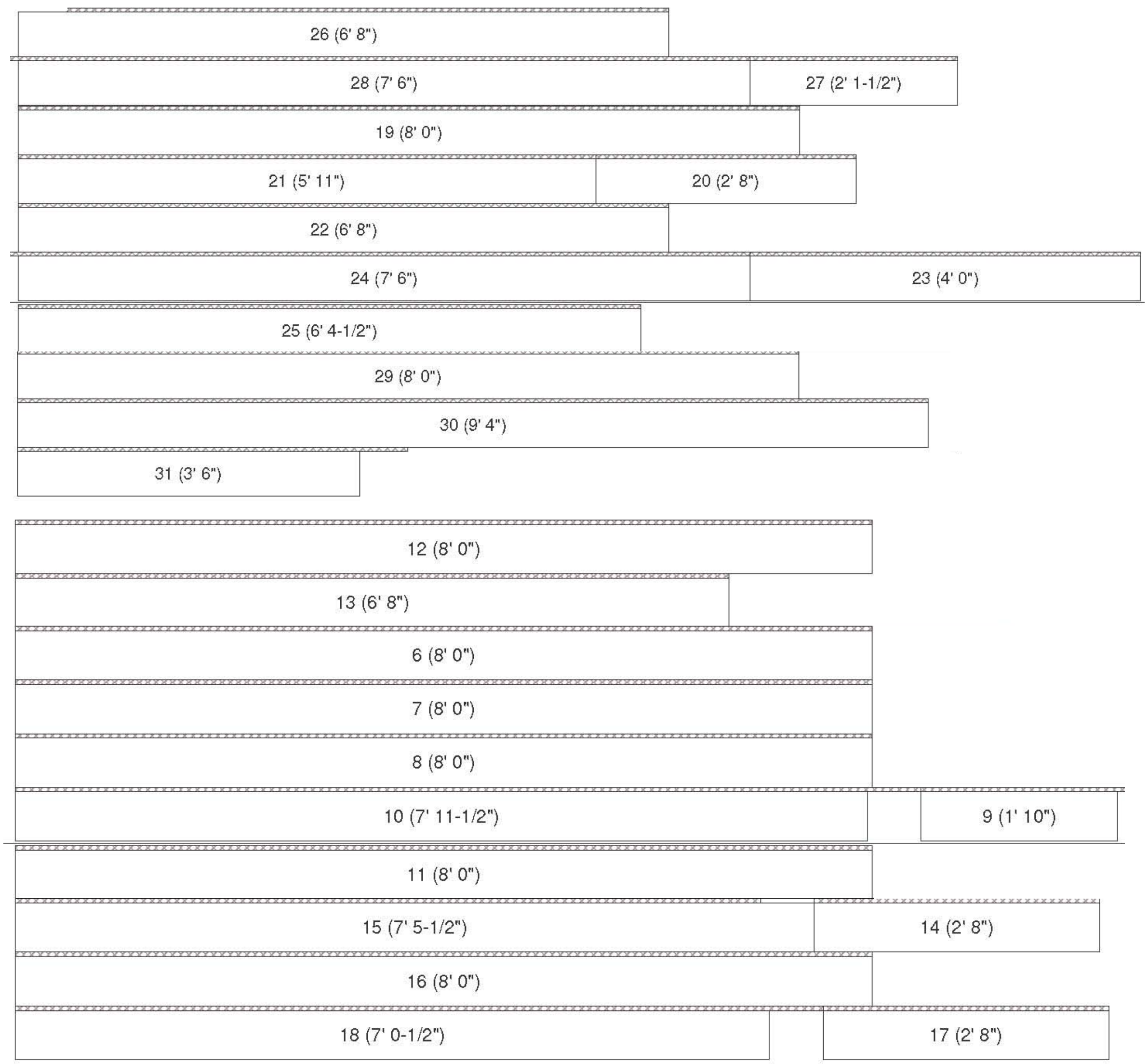
M1-1: Panel Designer



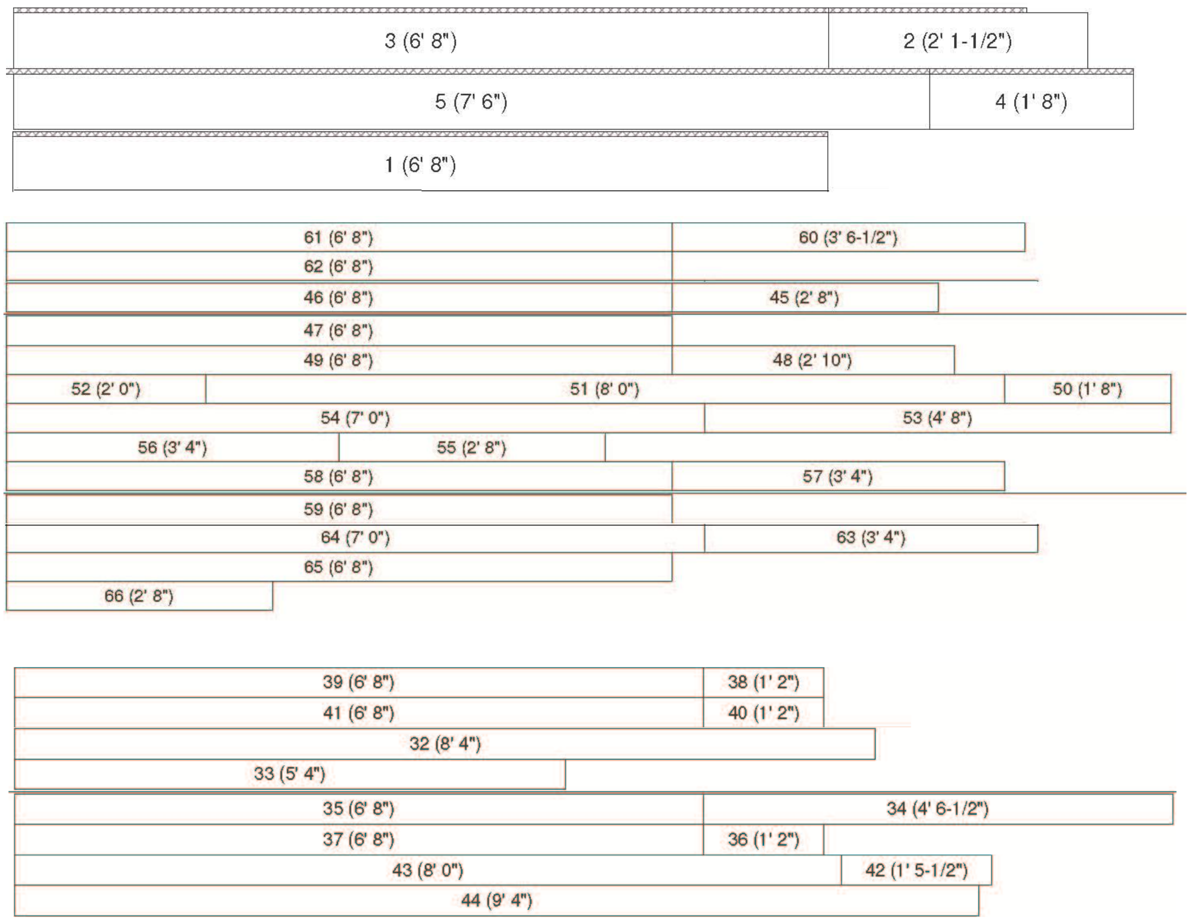
M1-1: Panel Designer



M1-1: IntelliBuild



M1-1: IntelliBuild



M1-1: Proposed algorithm

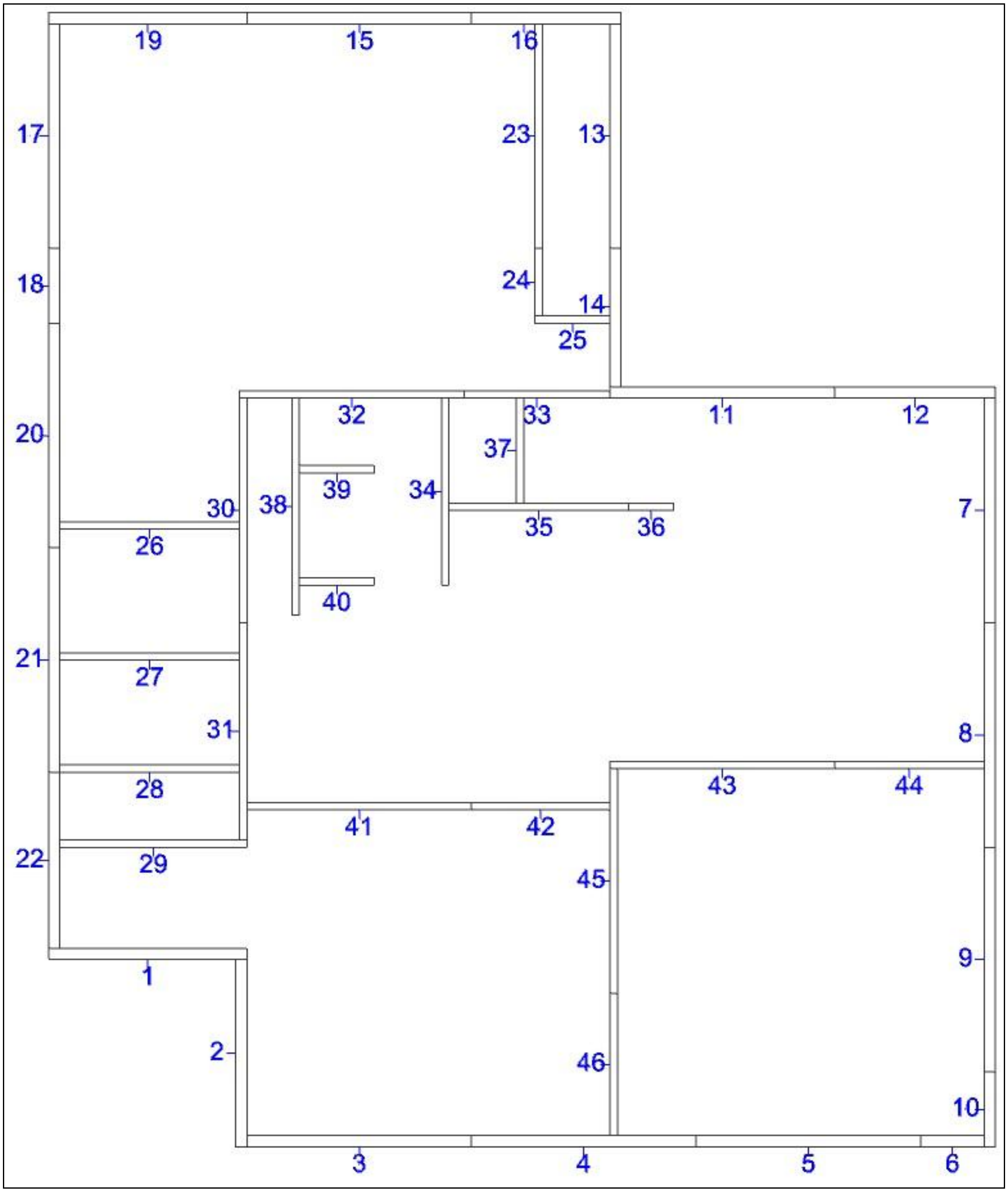
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	212.0
3	284.0

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	2	27 26	2 2
							2	1	21	2
							3	1	24	1
							4	1	25	1
							5	1	28	1
							6	1	29	1
							7	2	31 30	1 1
							8	1	1	3
							9	2	36 35	2 2
							10	1	43	1
							11	2	38 37	2 2
2	2	A	RIGHT	330.0	48.0	12	1	2	23 22	2 2
							2	1	32	1
							3	1	18	1
							4	2	19 33	1 1
							5	2	20 34	1 2
							6	1	15	2
							7	1	46	2
							8	2	48 47	2 2
							9	2	56 54	2 1
							10	2	53 49	1 1
							11	3	55 52 51	1 2 2
							12	2	50 57	1 2
3	2	B	LEFT	330.0	90.0	6	1	2	39 40	2 2
							2	2	44 45	1 1
							3	1	58	2
							4	3	41 42 2	3 3 3
							5	2	3 4	1 1
							6	1	5	3
4	3	A	RIGHT	392.0	48.0	5	1	2	17 16	2 2
							2	1	10	2
							3	1	11	2
							4	1	12	2
							5	2	14 13	2 2
5	3	B	LEFT	392.0	90.0	8	1	2	59 60	2 2
							2	1	6	3
							3	1	7	3
							4	2	8 9	3 3
							5	1	64	1
							6	1	61	2
							7	2	62 63	2 2
							8	2	65 66	1 1

M1-2



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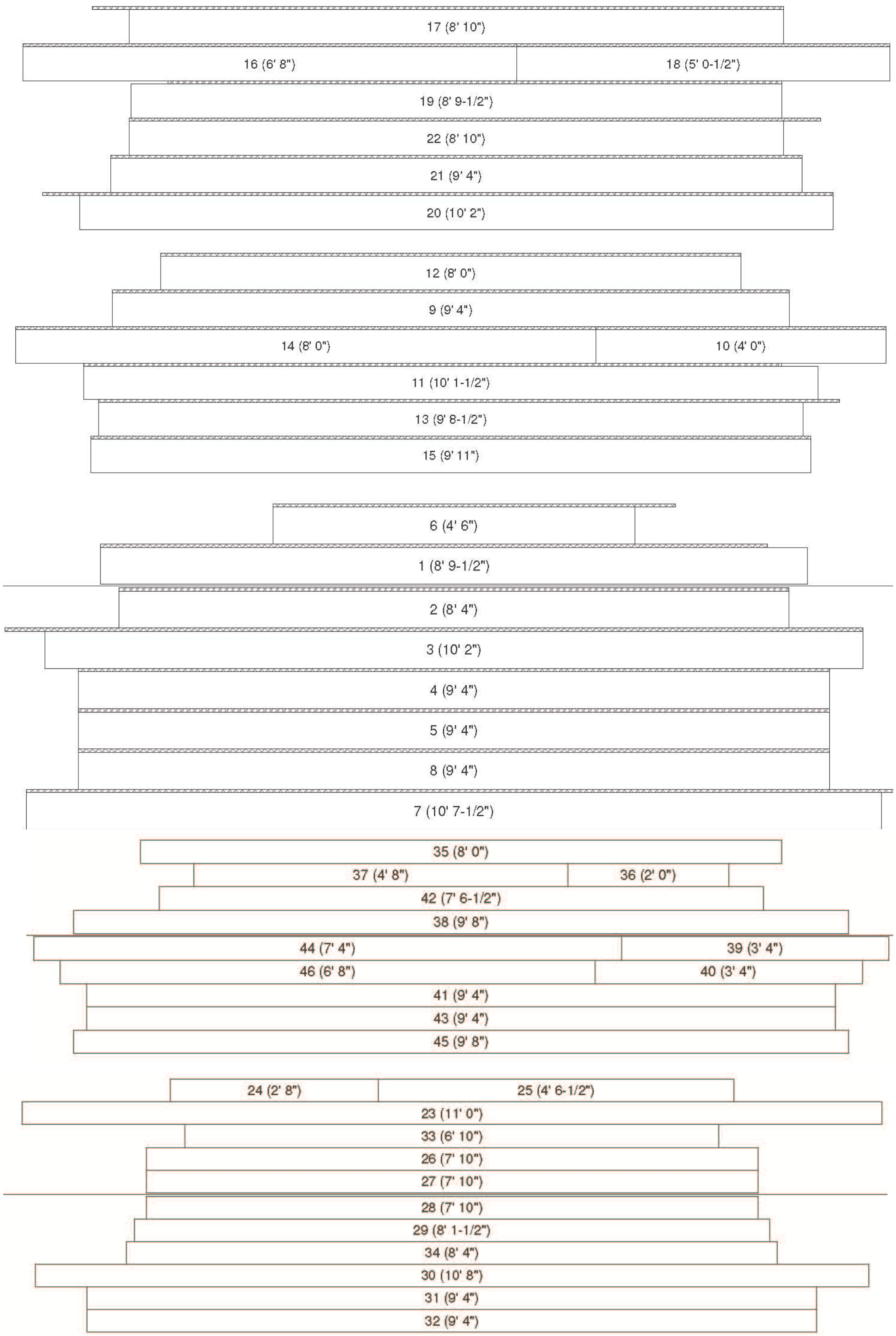
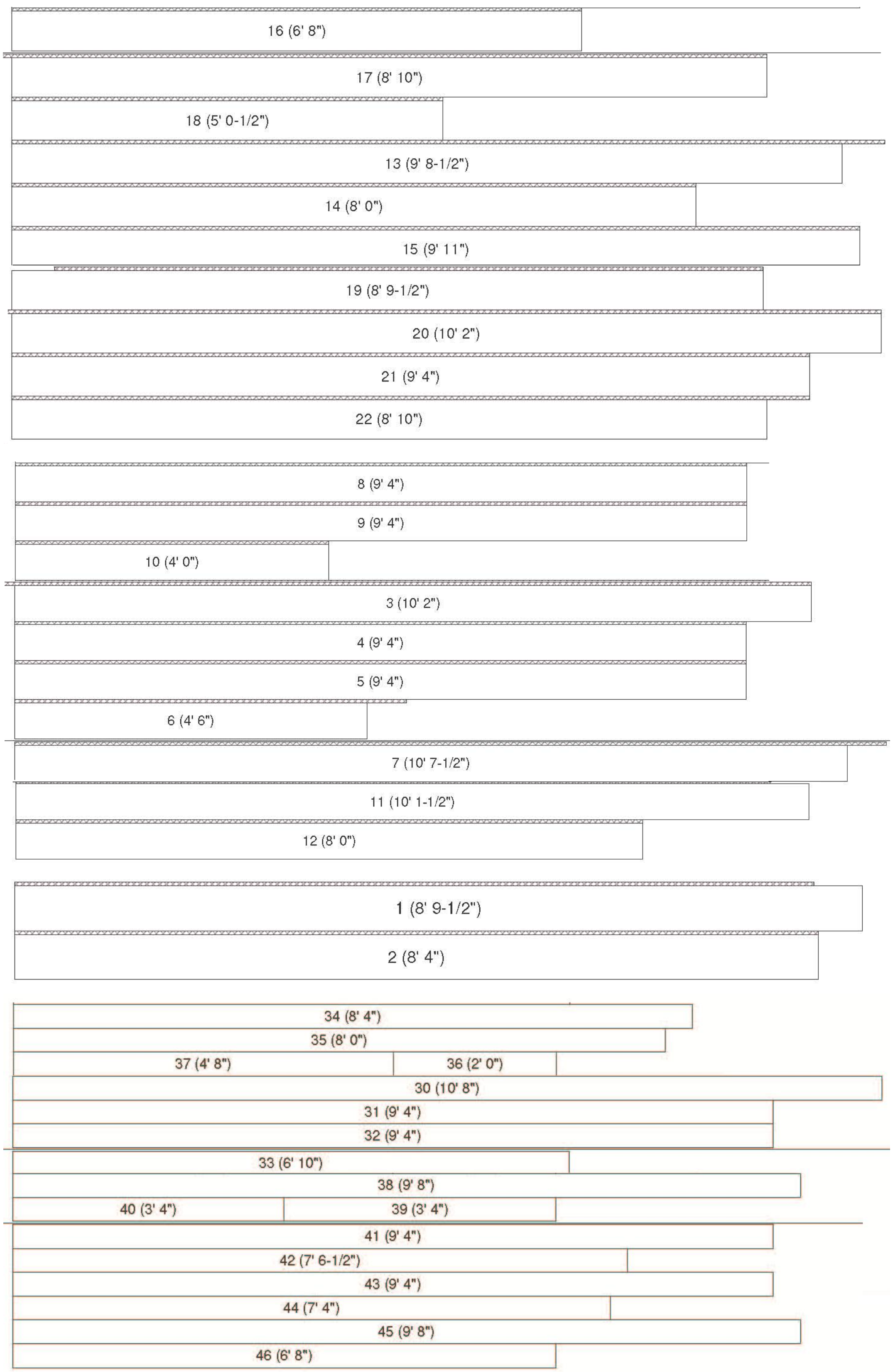
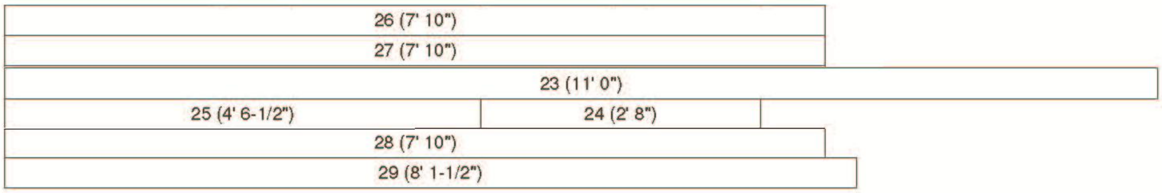
M1-2: Panel Designer



M1-2: IntelliBuild



M1-2: IntelliBuild



M1-2: Proposed algorithm

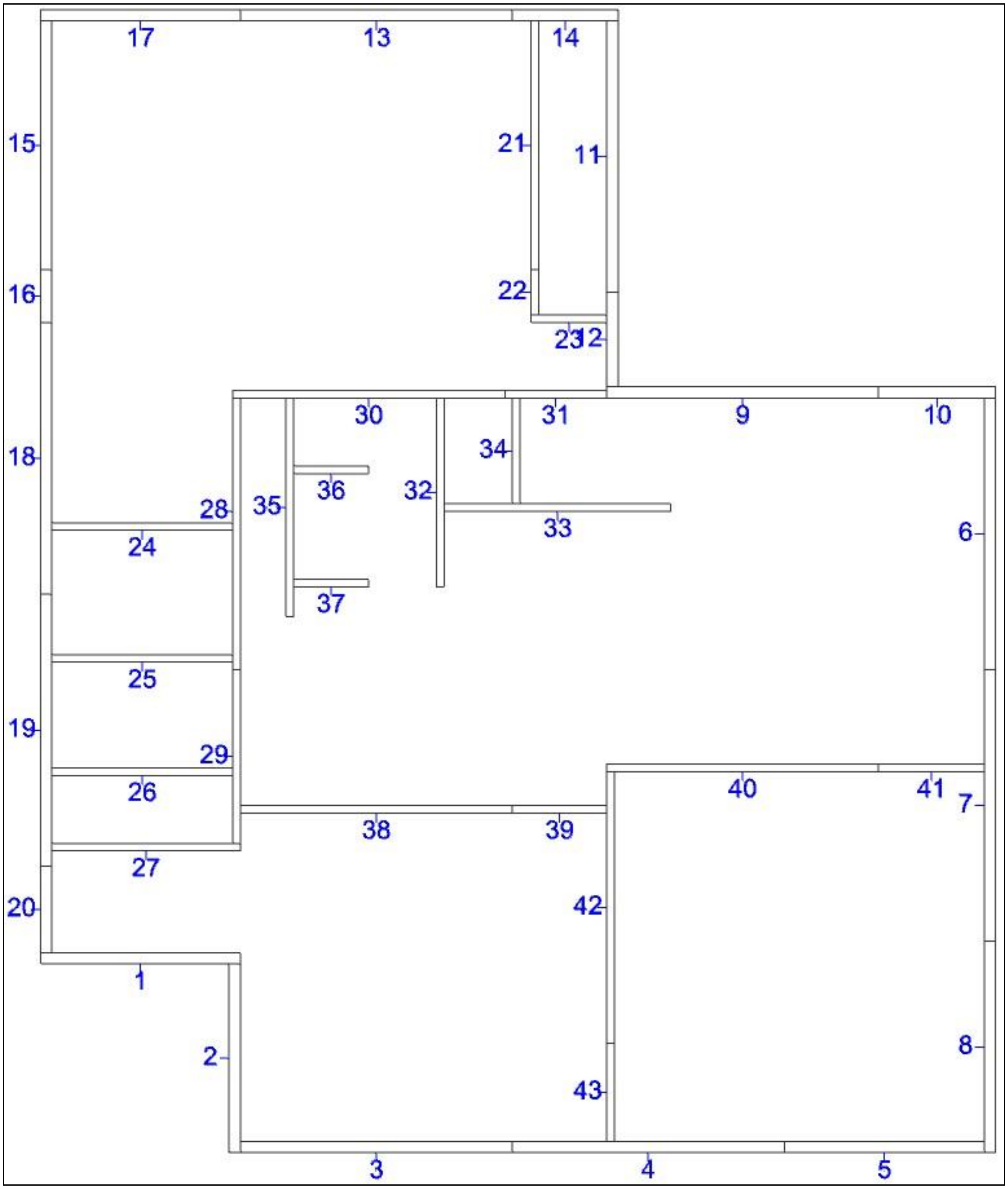
```
** Nzones
3

**zone       left edge X coordinate
 1             6.0
 2           222.0
 3           284.0

** NStacks
5

** stack                flush
**   #    zone type     edge     xloc   yloc  #layers  j   #panels   panels     orientation
     1     1    A      RIGHT   114.0   48.0     10         1         1    19           2
                                                           2         1    17           1
                                                           3         1    18           1
                                                           4         1    20           1
                                                           5         1    21           1
                                                           6         1    22           1
                                                           7         1    1            3
                                                           8         1    26           2
                                                           9         1    30           1
                                                          10         1    27           2
     2     2    A      RIGHT   330.0   48.0     14         1         1    15           2
                                                           2         1    16           2
                                                           3         1    23           1
                                                           4         1    13           1
                                                           5         2    14 24        1 1
                                                           6         1    25           2
                                                           7         1    11           2
                                                           8         1    32           2
                                                           9         1    33           2
                                                          10         1    38           1
                                                          11         2    40 39        2 2
                                                          12         1    34           1
                                                          13         1    37           1
                                                          14         2    36 35        2 2
     3     2    B      LEFT    330.0   90.0      6         1         1    2            1
                                                           2         1    3            3
                                                           3         1    4            3
                                                           4         1    28           2
                                                           5         1    31           1
                                                           6         1    29           2
     4     3    A      RIGHT   392.0   48.0      5         1         1    12           2
                                                           2         1    7            2
                                                           3         1    8            2
                                                           4         1    9            2
                                                           5         1    10           2
     5     3    B      LEFT    392.0   90.0      8         1         1    41           2
                                                           2         1    42           2
                                                           3         1    5            3
                                                           4         1    6            3
                                                           5         1    45           1
                                                           6         1    43           2
                                                           7         1    44           2
                                                           8         1    46           1
```

M1-3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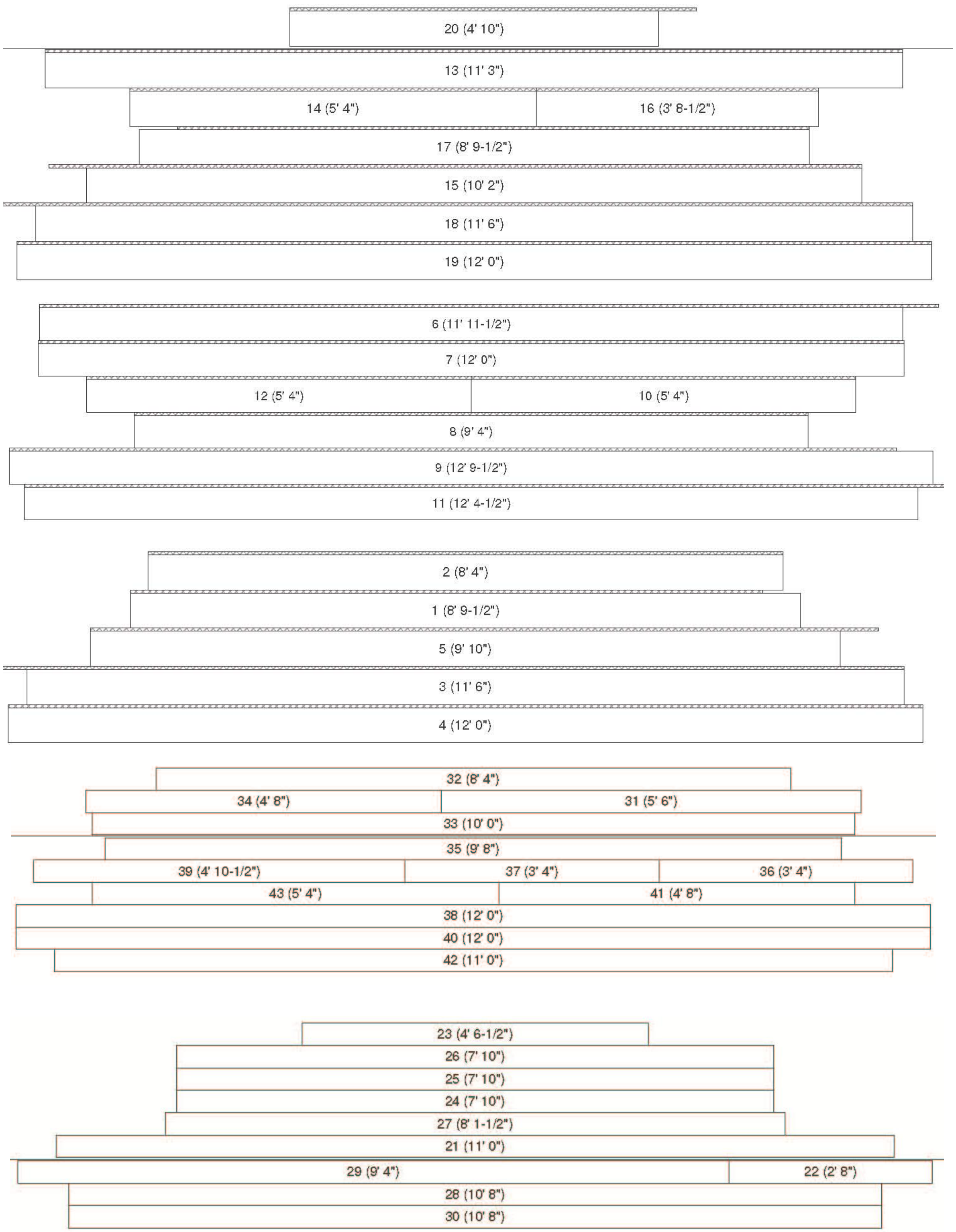
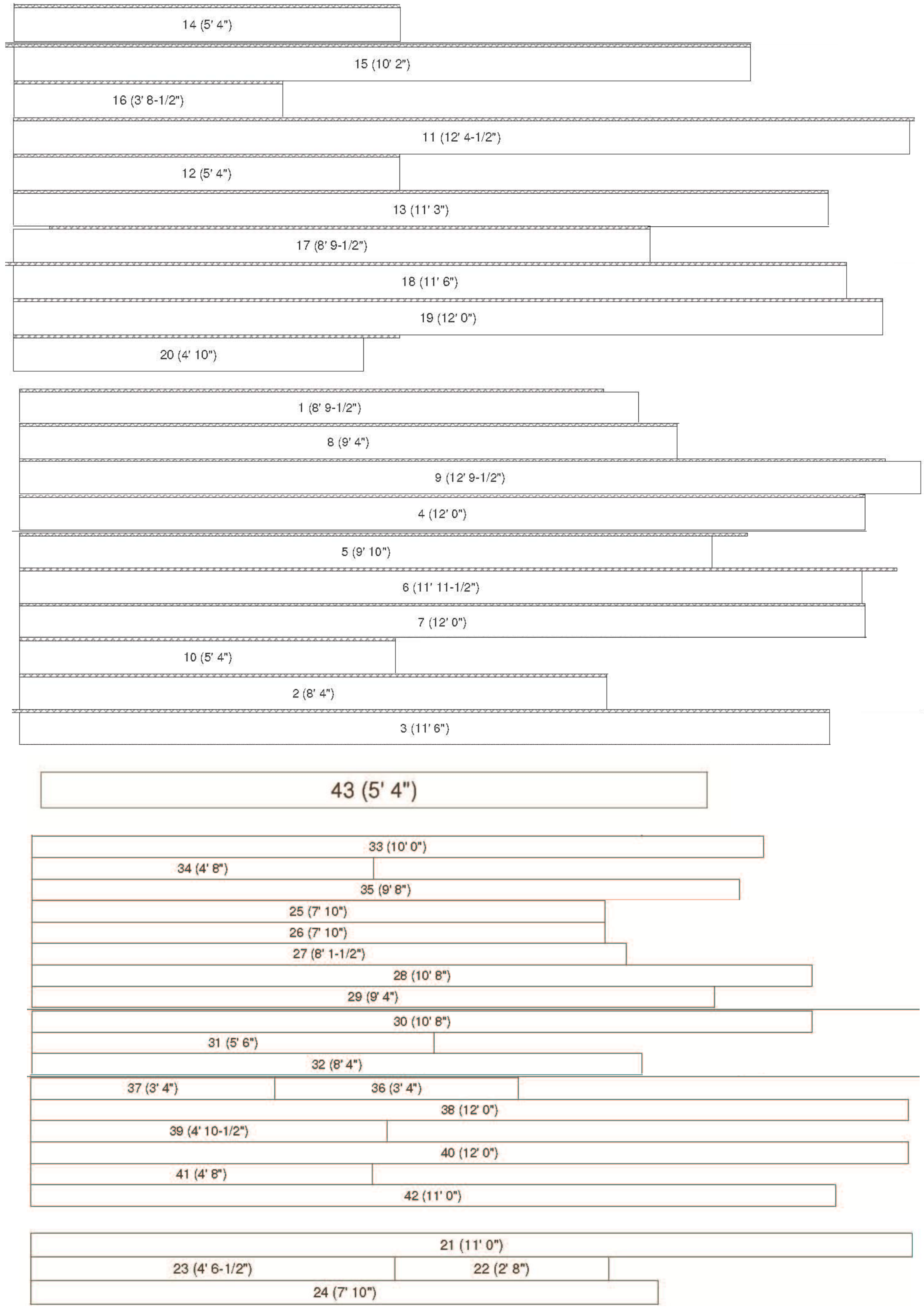
M1-3: Panel Designer



M1-3: IntelliBuild



M1-3: Proposed algorithm

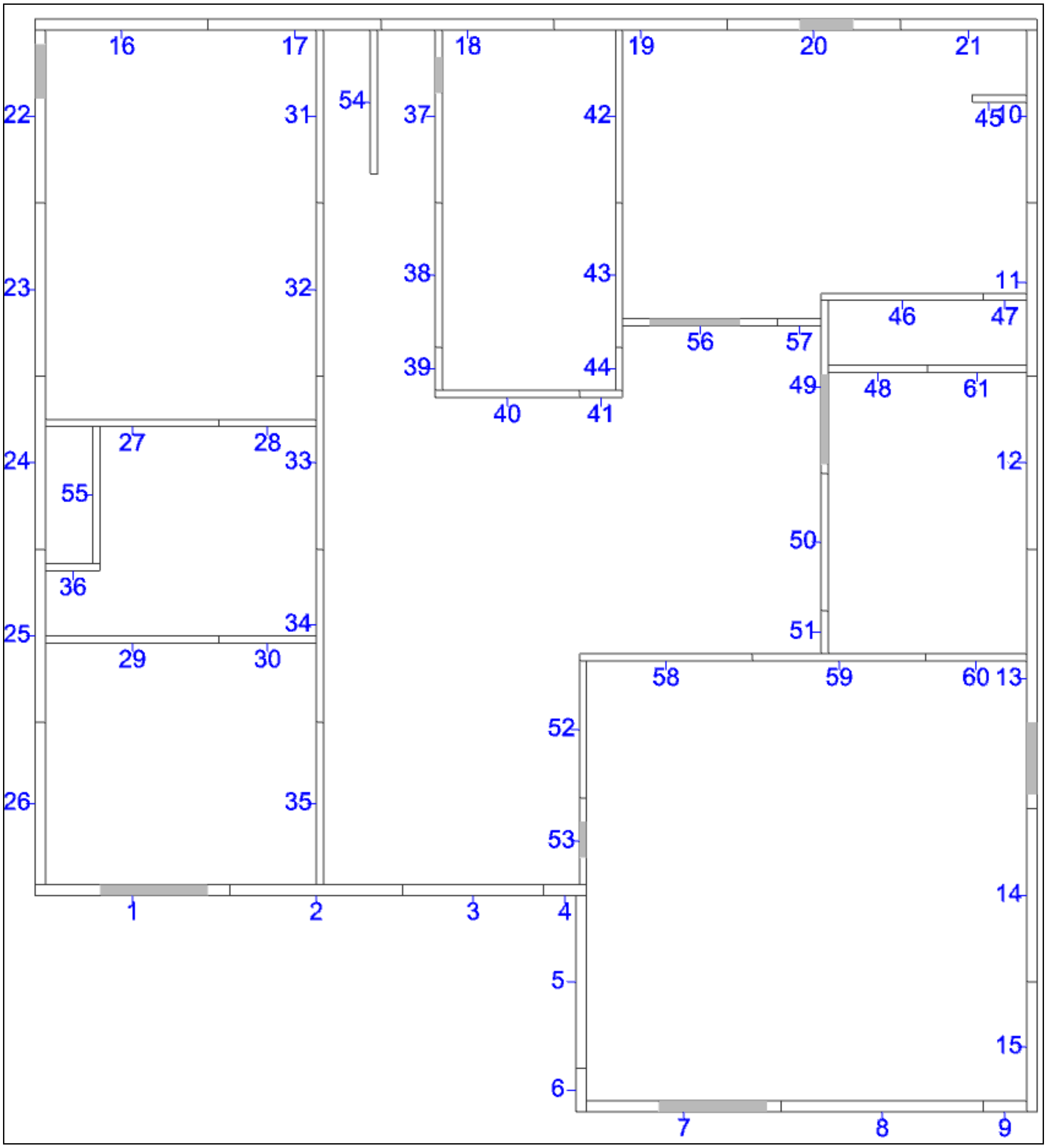
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	216.5
3	279.5

** NStacks
5

**	stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
	1	1	A	RIGHT	116.2	57.3	10	1	1	17	2
								2	1	15	1
								3	1	16	1
								4	1	18	1
								5	1	19	1
								6	1	20	1
								7	1	1	3
								8	1	24	2
								9	1	25	2
								10	1	28	1
	2	2	A	RIGHT	336.7	57.3	13	1	1	13	2
								2	1	14	2
								3	1	21	1
								4	1	11	1
								5	3	23 12 22	2 1 1
								6	1	9	2
								7	1	30	2
								8	1	31	2
								9	1	35	1
								10	2	37 36	2 2
								11	1	32	1
								12	1	34	1
								13	1	33	2
	3	2	B	LEFT	336.7	99.3	6	1	1	2	1
								2	1	3	3
								3	1	4	3
								4	1	26	2
								5	1	29	1
								6	1	27	3
	4	3	A	RIGHT	389.8	57.3	4	1	1	10	2
								2	1	6	2
								3	1	7	2
								4	1	8	2
	5	3	B	LEFT	389.8	99.3	7	1	1	38	2
								2	1	39	2
								3	1	5	3
								4	1	42	1
								5	1	40	2
								6	1	41	2
								7	1	43	1

M2-1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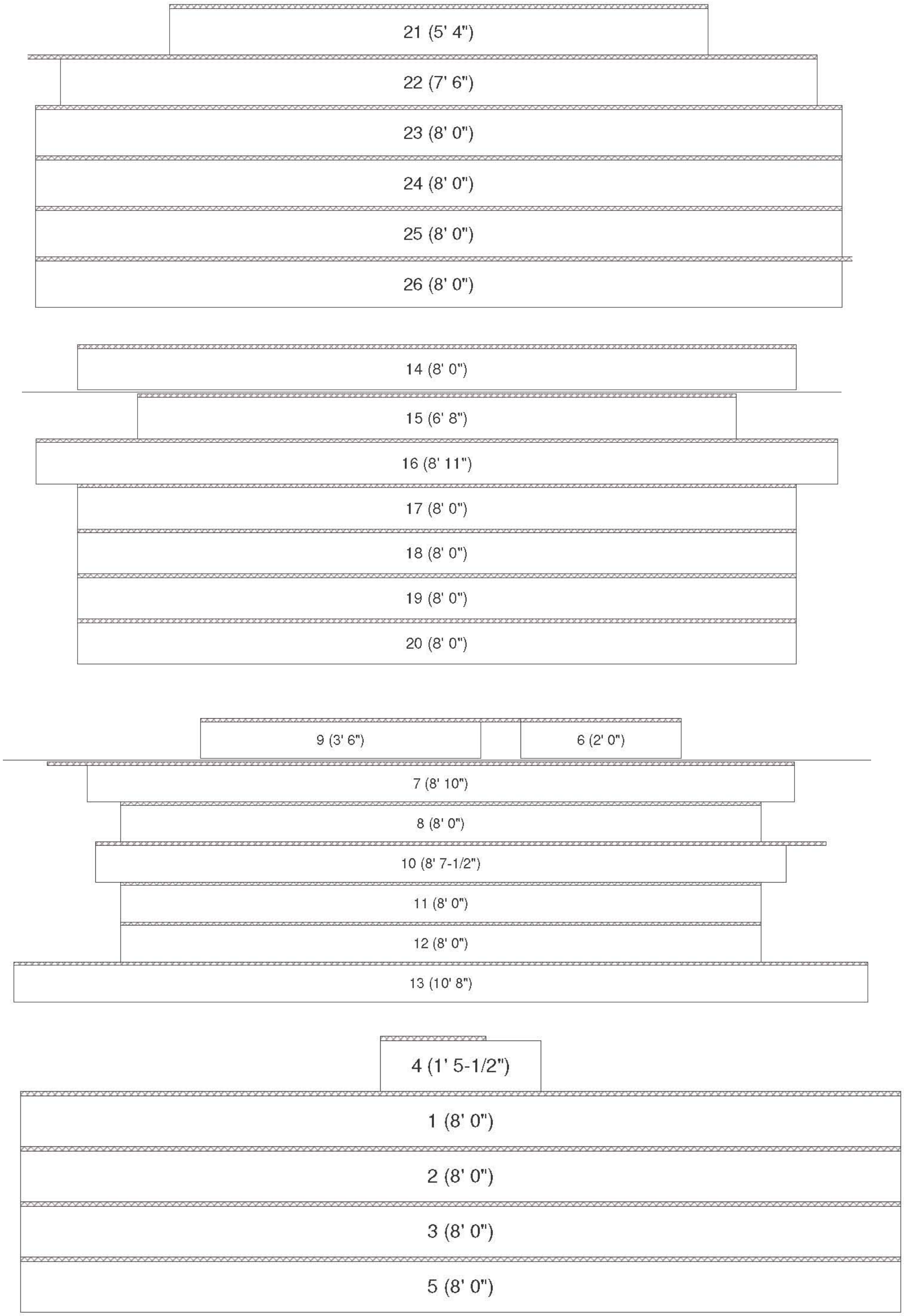
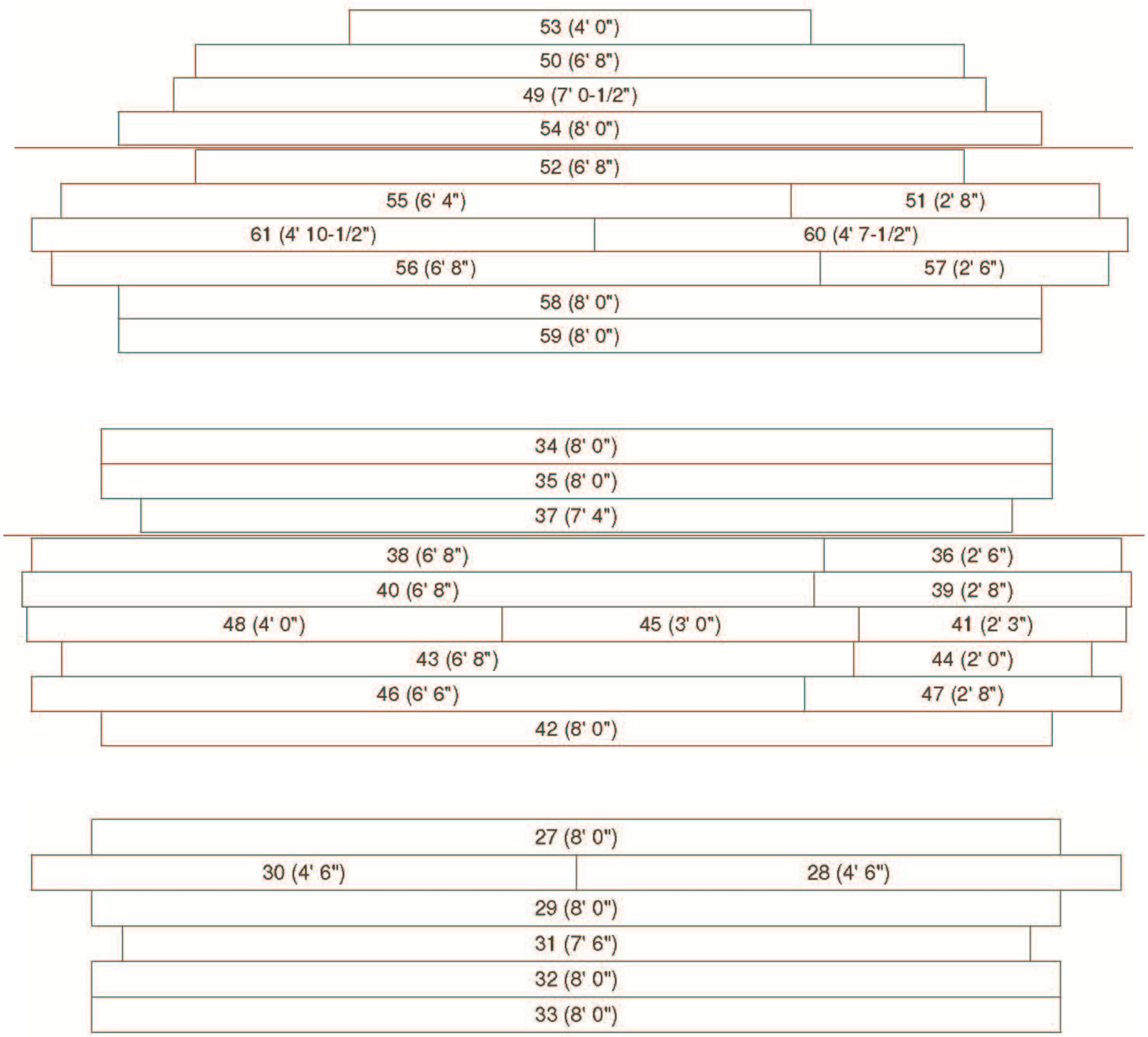
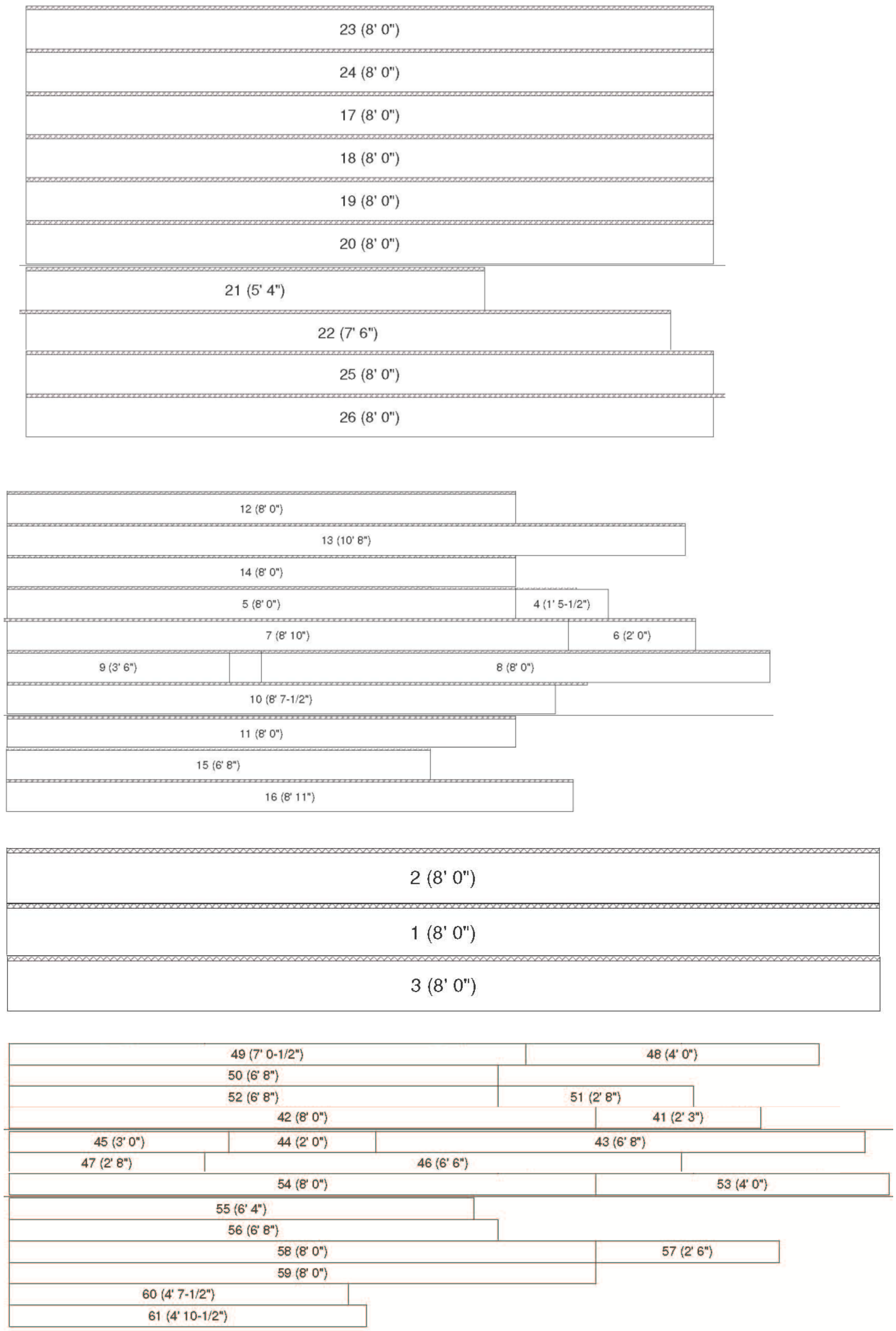
M2-1: Panel Designer



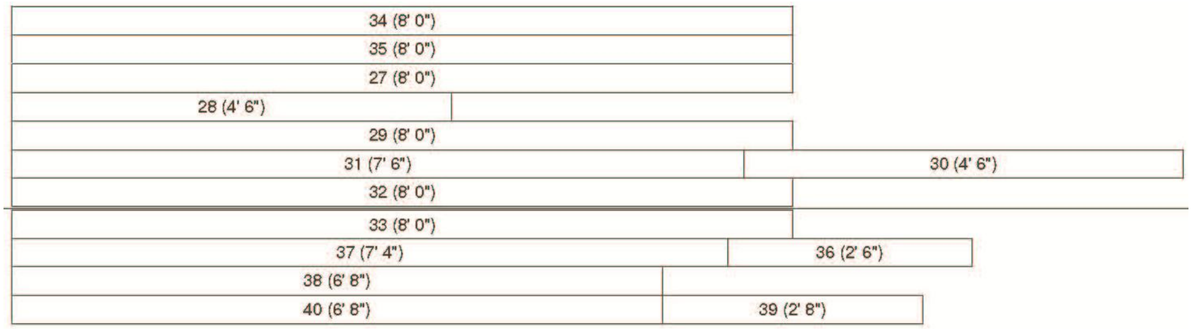
M2-1: Panel Designer



M2-1: IntelliBuild



M2-1: IntelliBuild



M2-1: Proposed algorithm

** Nzones

3

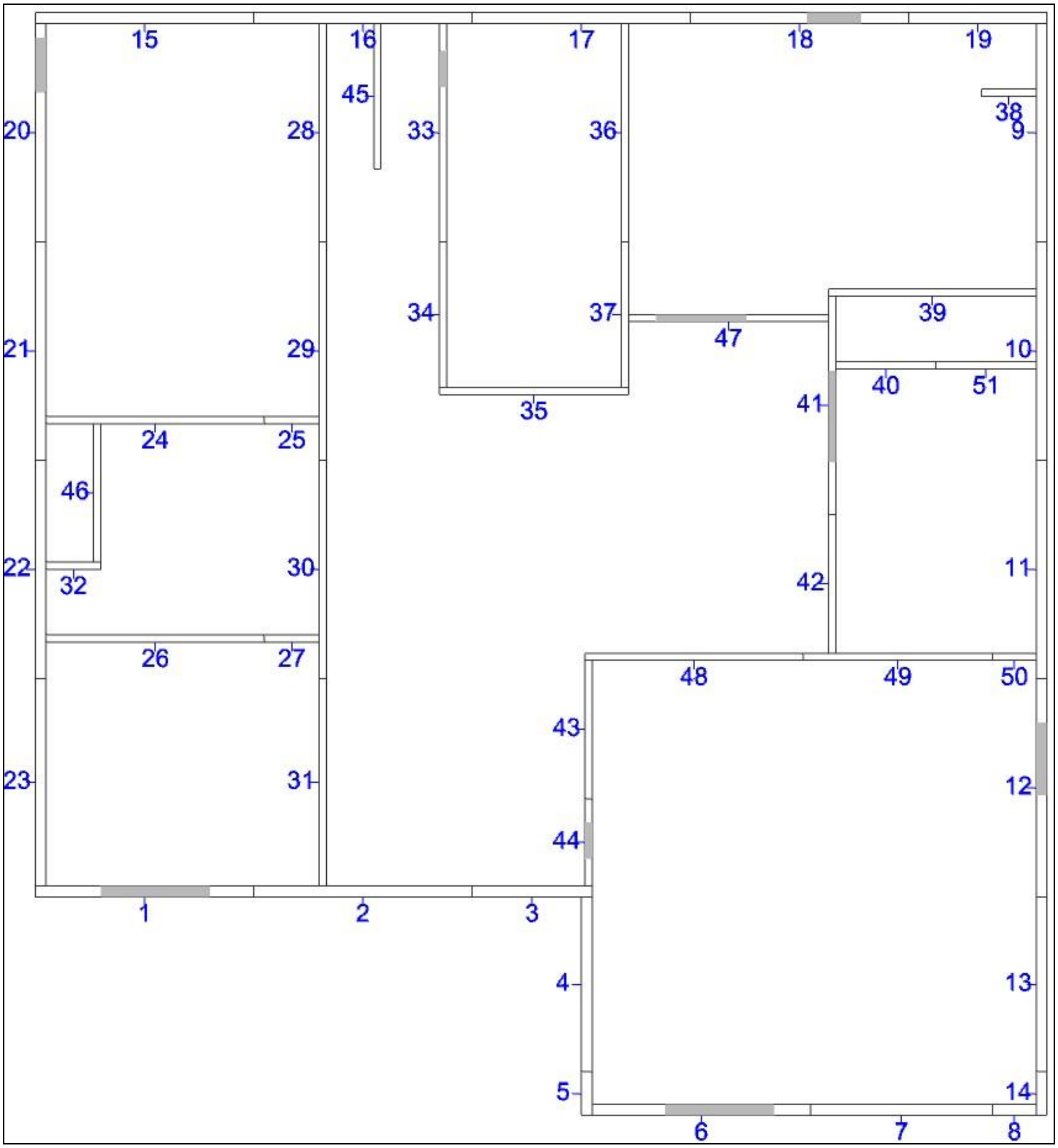
**zone	left edge X coordinate
1	6.0
2	210.0
3	329.5

** NStacks

6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	87.3	13	1	1	16	2
							2	1	17	2
							3	1	22	1
							4	1	23	1
							5	1	24	1
							6	1	25	1
							7	1	26	1
							8	1	1	3
							9	1	31	1
							10	1	54	1
							11	1	32	1
							12	1	27	2
							13	2	55 28	1 2
2	1	A	RIGHT	114.0	87.3	3	1	2	36 33	2 1
							2	1	29	2
							3	1	30	2
3	2	A	RIGHT	330.0	87.3	8	1	1	18	2
							2	1	19	2
							3	1	37	1
							4	1	42	1
							5	1	38	1
							6	1	43	1
							7	3	39 57 56	1 2 2
							8	3	41 40 44	2 2 1
4	2	B	LEFT	330.0	99.3	3	1	1	34	1
							2	1	35	1
							3	1	2	3
5	3	A	RIGHT	439.8	57.3	12	1	1	20	2
							2	1	21	2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	14	2
							8	2	45 15	2 2
							9	2	47 46	2 2
							10	1	49	2
							11	2	61 48	2 2
							12	2	51 50	2 2
6	3	A	RIGHT	439.8	57.3	8	1	1	58	3
							2	1	59	1
							3	2	3 60	2 1
							4	2	5 4	2 2
							5	2	7 6	3 2
							6	2	8	3
							7	2	52 9	1 3
							8	1	53	2

M2-2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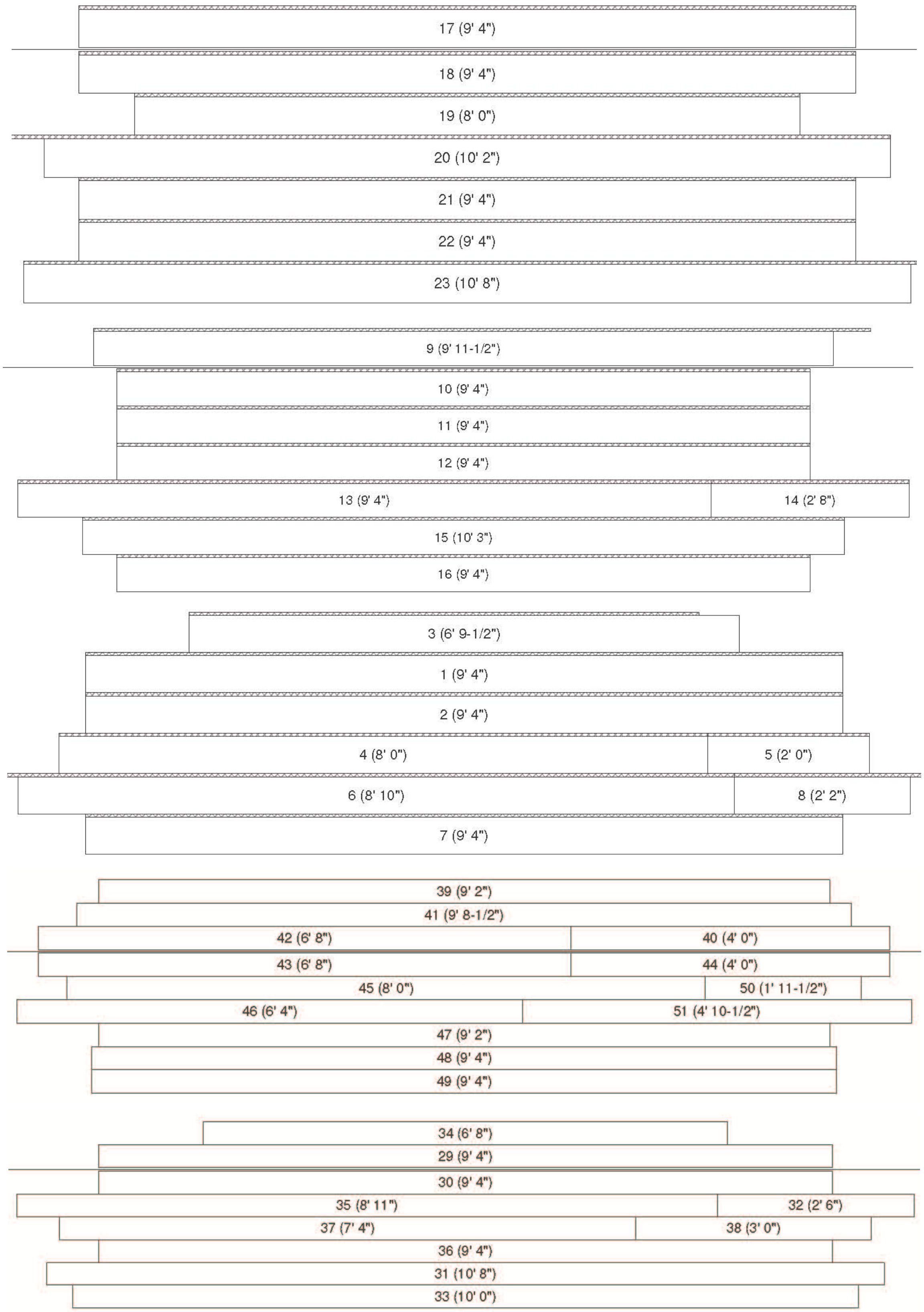
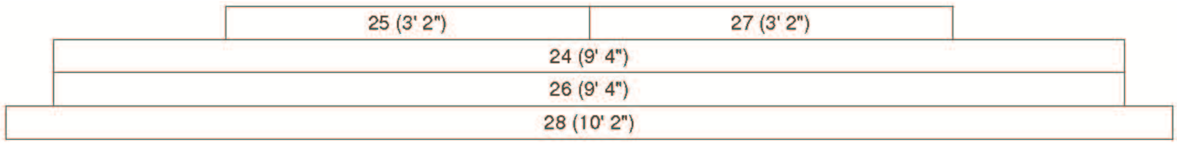
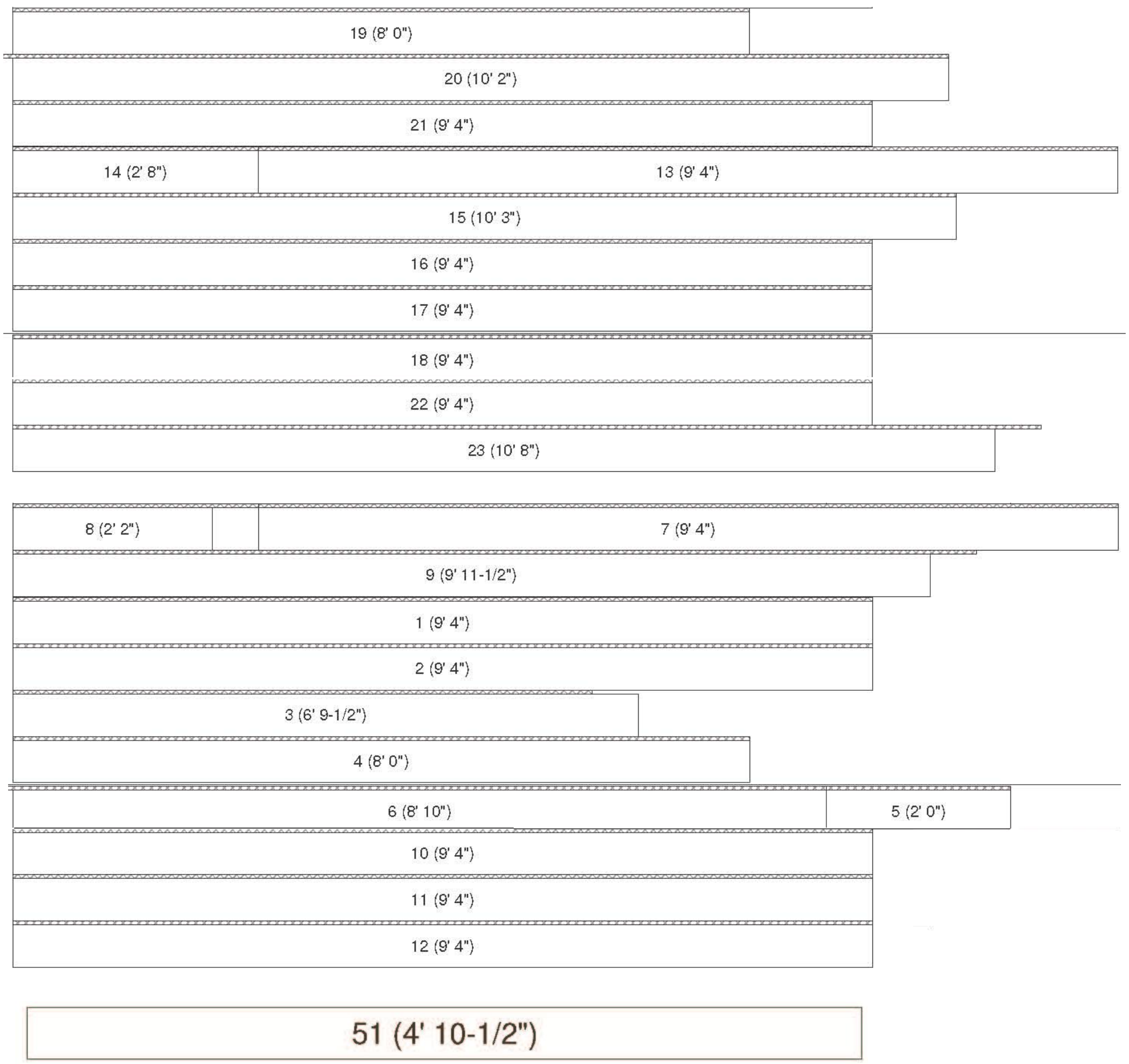
M2-2: Panel Designer



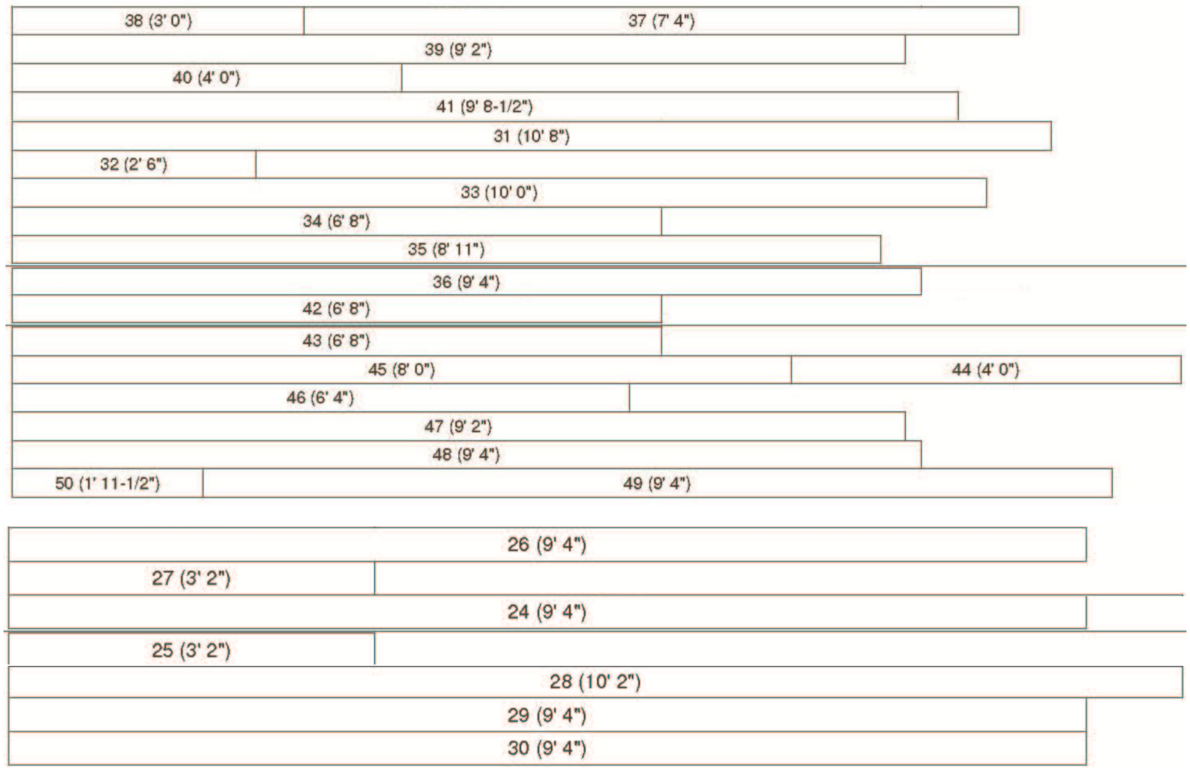
M2-2: Panel Designer



M2-2: IntelliBuild



M2-2: IntelliBuild



M2-2: Proposed algorithm

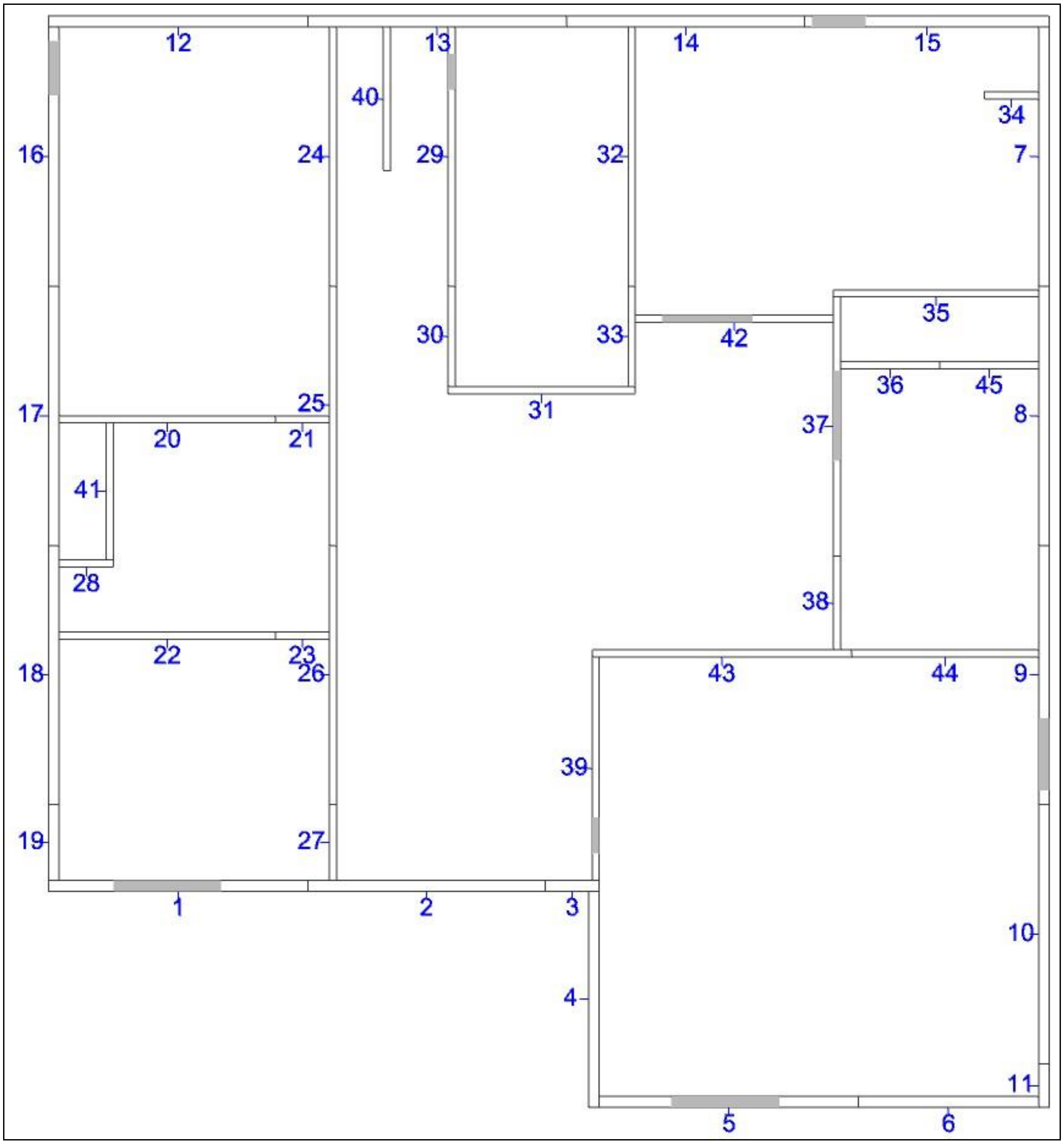
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	212.0
3	334.0

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	68.0	13	1	1	15	2
							2	1	20	1
							3	1	21	1
							4	1	22	1
							5	1	23	1
							6	1	1	3
							7	1	24	2
							8	2	46 25	1 2
							9	1	29	1
							10	1	32	2
							11	1	26	2
							12	1	27	2
							13	1	30	1
2	2	A	RIGHT	330.0	68.0	10	1	1	16	2
							2	1	17	2
							3	1	28	1
							4	1	45	1
							5	1	33	1
							6	1	36	1
							7	1	34	1
							8	1	37	1
							9	1	47	2
							10	1	35	2
3	2	B	LEFT	330.0	90.0	1	1	1	31	1
4	3	A	RIGHT	442.0	48.0	13	1	1	18	2
							2	1	19	2
							3	1	9	2
							4	1	10	2
							5	1	11	2
							6	1	12	2
							7	2	14 13	2 2
							8	2	39 38	2 2
							9	1	41	2
							10	2	51 40	2 2
							11	1	42	2
							12	1	48	2
							13	2	50 49	2 2
5	3	A	RIGHT	442.0	48.0	7	1	1	2	1
							2	1	3	2
							3	1	4	2
							4	2	6 5	2 2
							5	1	7	2
							6	1	43 8	2 2
							7	1	44	2

M2-3



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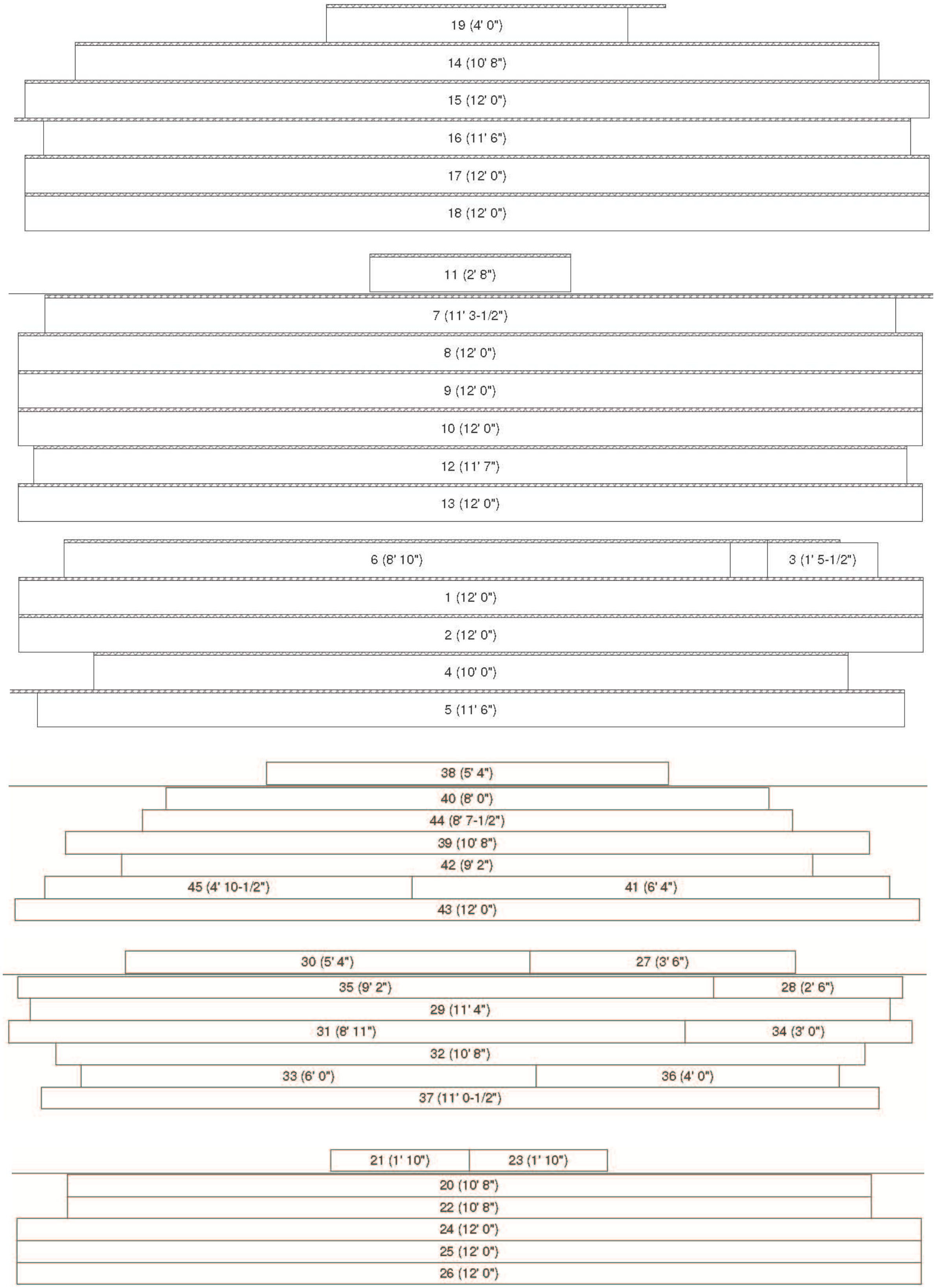
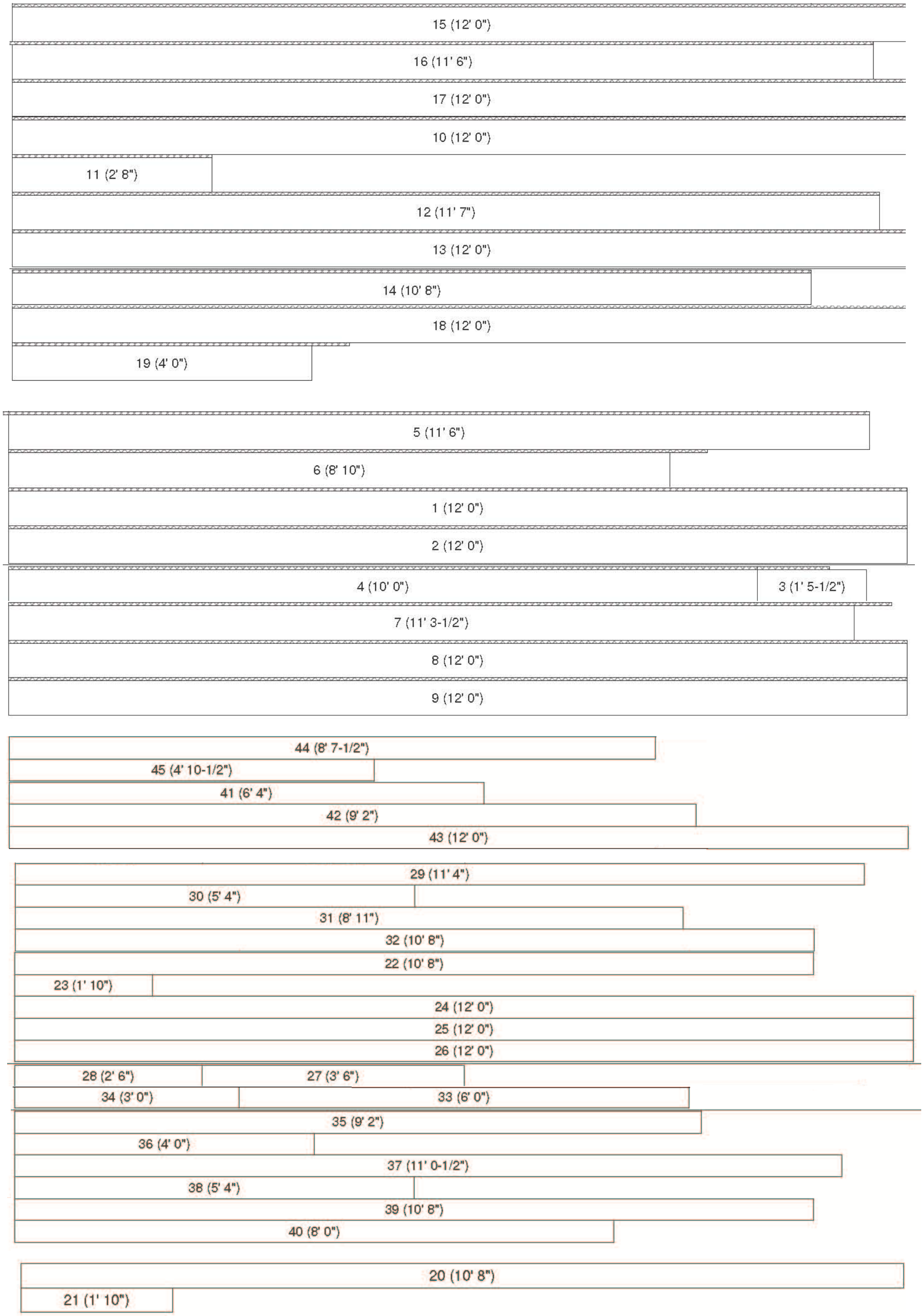
M2-3: Panel Designer



M2-3: IntelliBuild



M2-3: Proposed algorithm

** Nzones
3

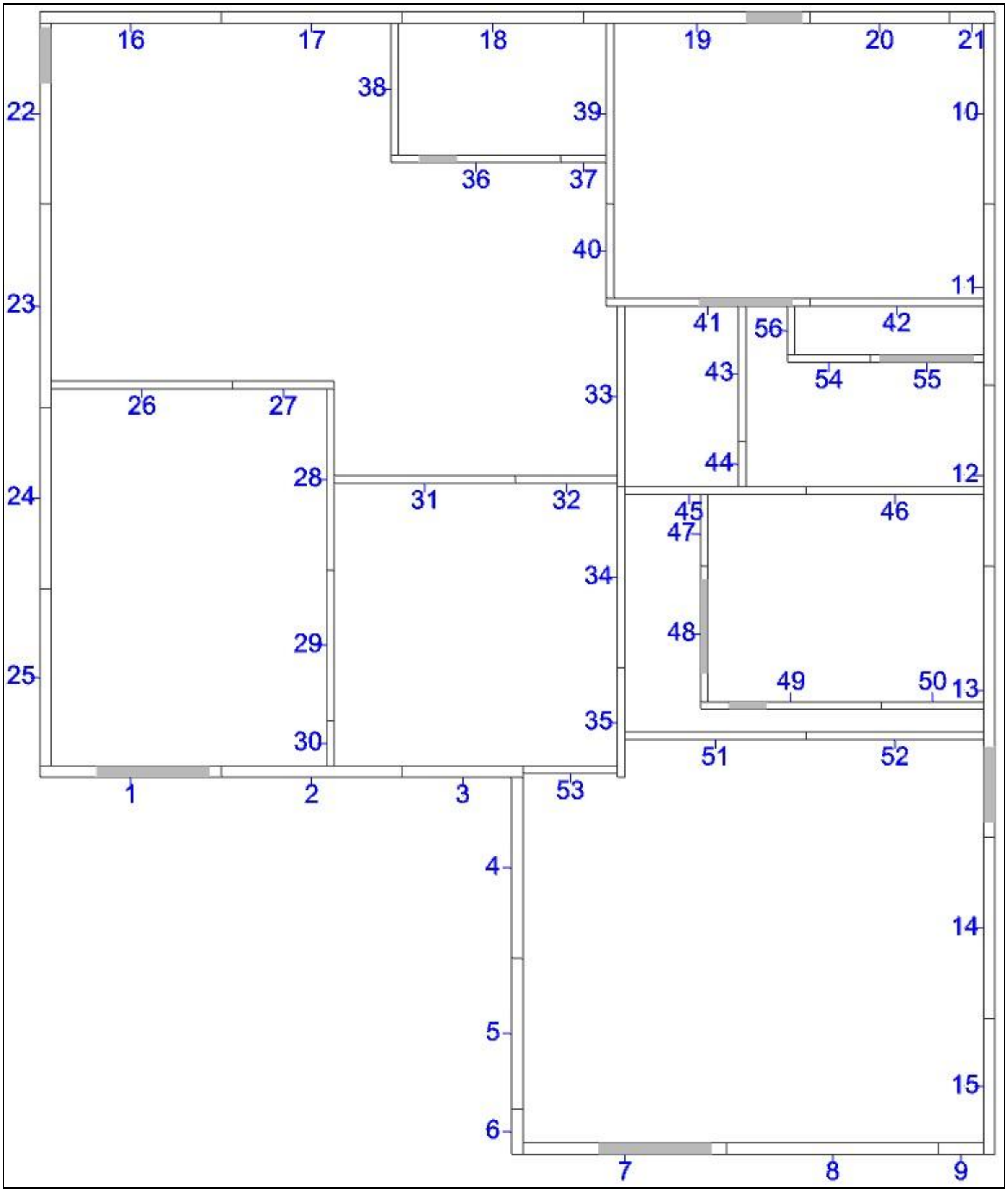
**zone left edge X coordinate

1	6.0
2	216.5
3	329.5

** NStacks
5

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	77.3	12	1	1	12	2
							2	1	16	1
							3	1	17	1
							4	1	18	1
							5	1	19	1
							6	1	1	3
							7	1	20	2
							8	2	41 21	1 2
							9	1	25	1
							10	1	28	2
							11	1	22	2
							12	1	23	2
2	2	A	RIGHT	336.7	77.3	12	1	1	13	2
							2	1	14	2
							3	1	24	1
							4	1	40	1
							5	1	29	1
							6	1	32	1
							7	2	33 30	1 1
							8	1	42	2
							9	1	31	2
							10	1	37	1
							11	1	38	1
							12	1	43	2
3	2	B	LEFT	336.7	99.3	3	1	1	2	3
							2	1	26	1
							3	1	27	1
4	3	A	RIGHT	439.8	57.3	8	1	1	15	2
							2	1	7	2
							3	1	8	2
							4	1	9	1
							5	2	11 10	1 1
							6	2	3 4	3 1
							7	1	5	3
							8	1	6	3
5	3	A	RIGHT	439.8	57.3	4	1	2	35 34	2 2
							2	2	45 36	2 2
							3	1	44	2
							4	1	39	1

M3-1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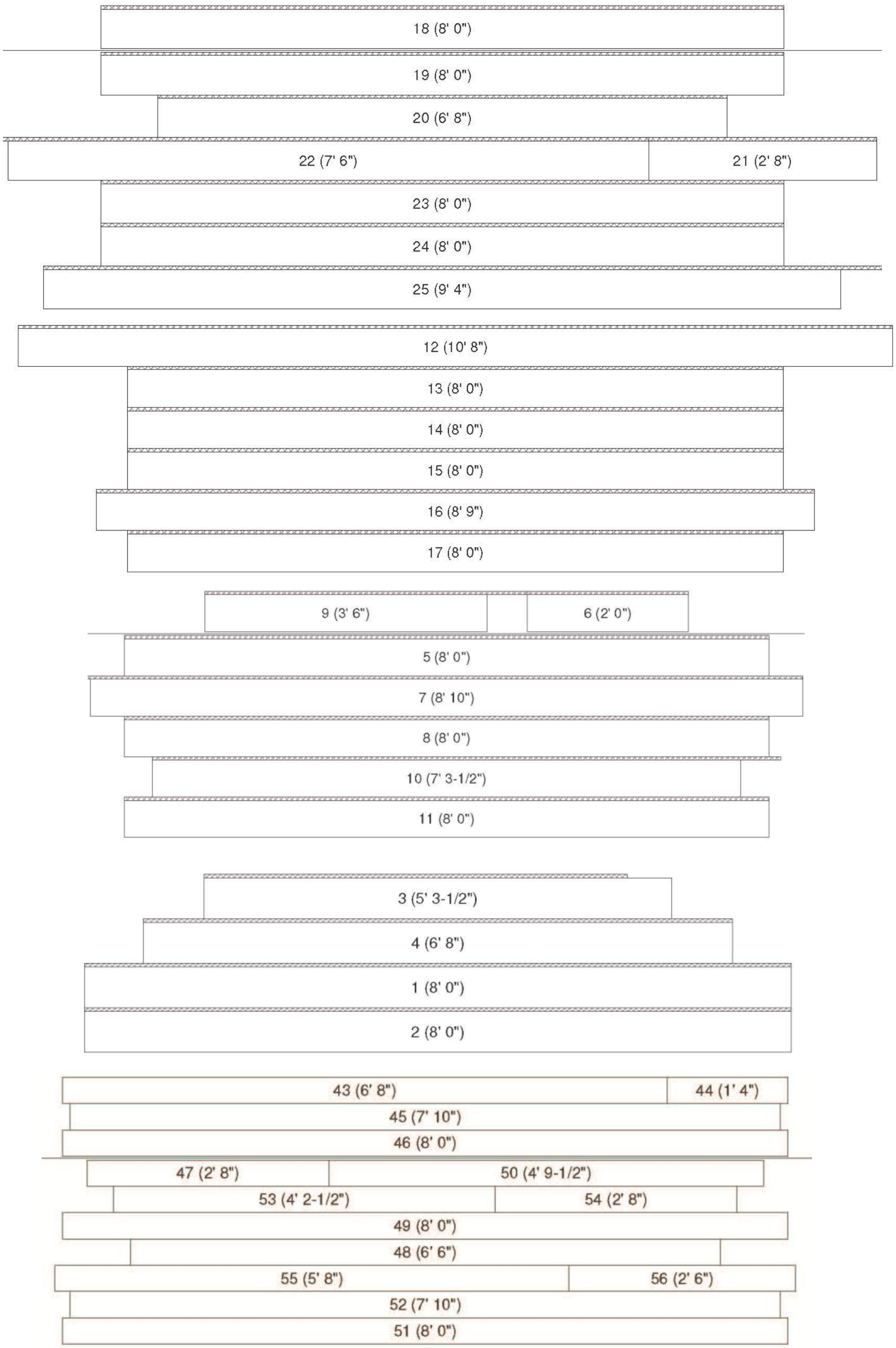
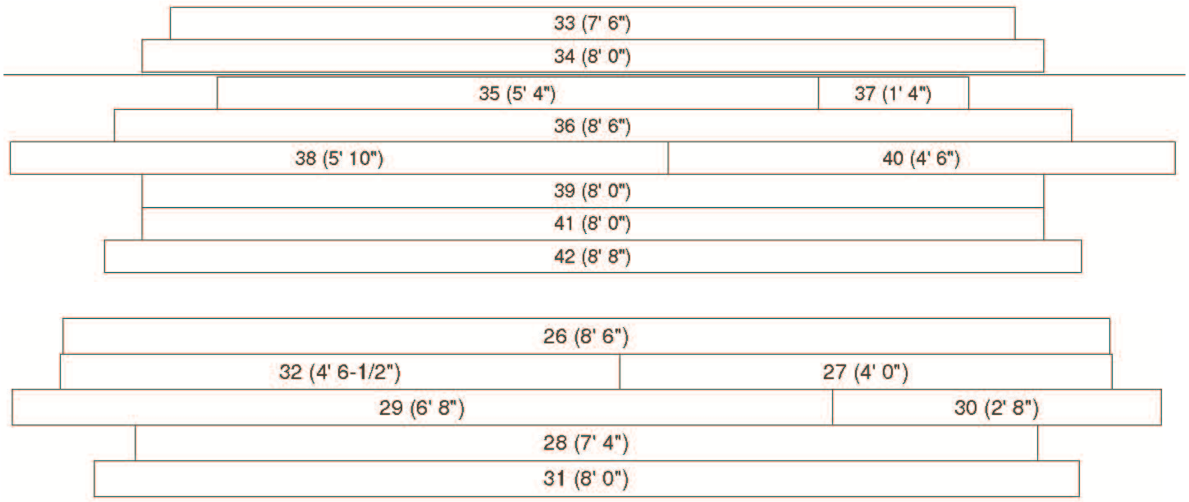
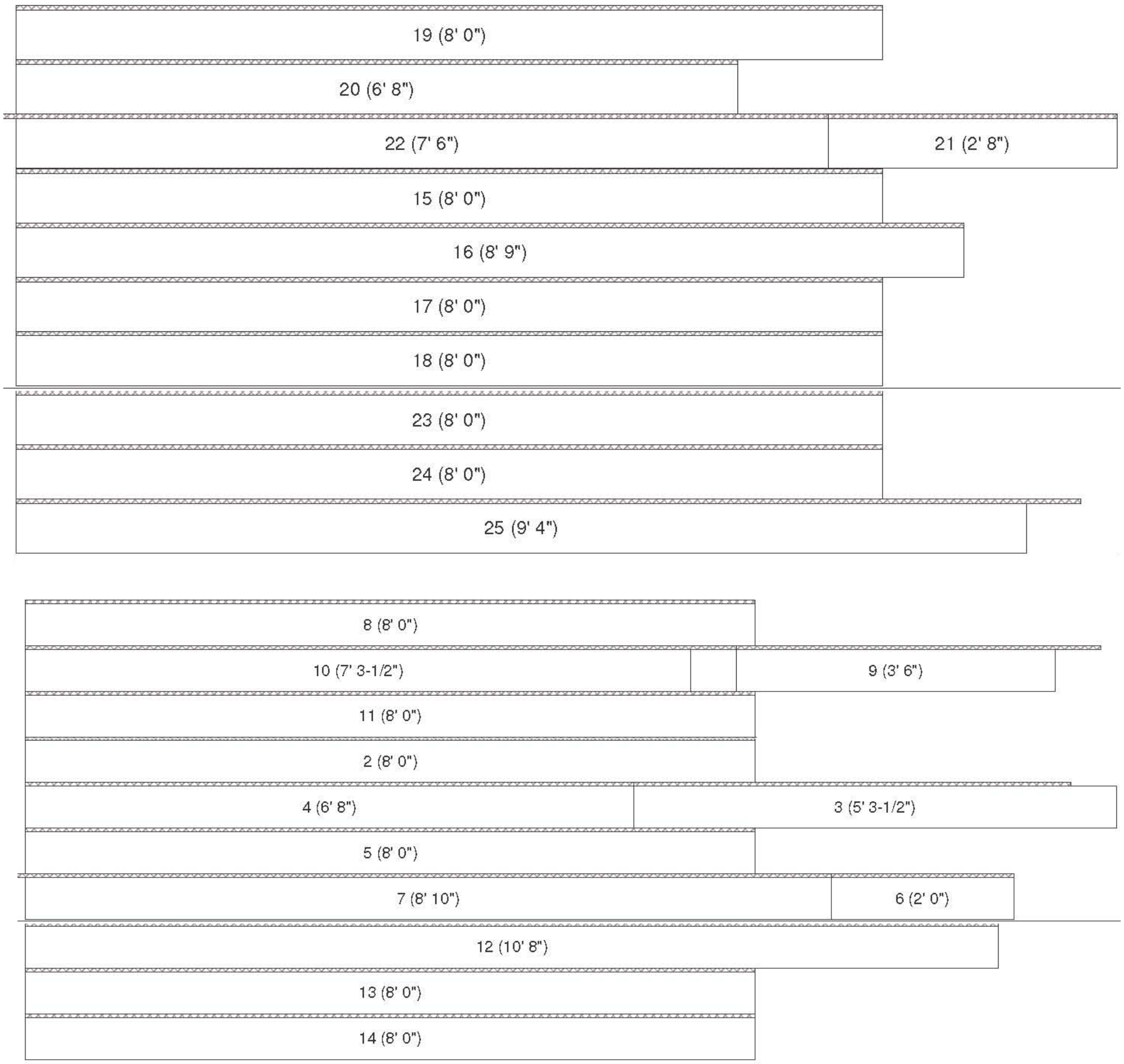
M3-1: Panel Designer



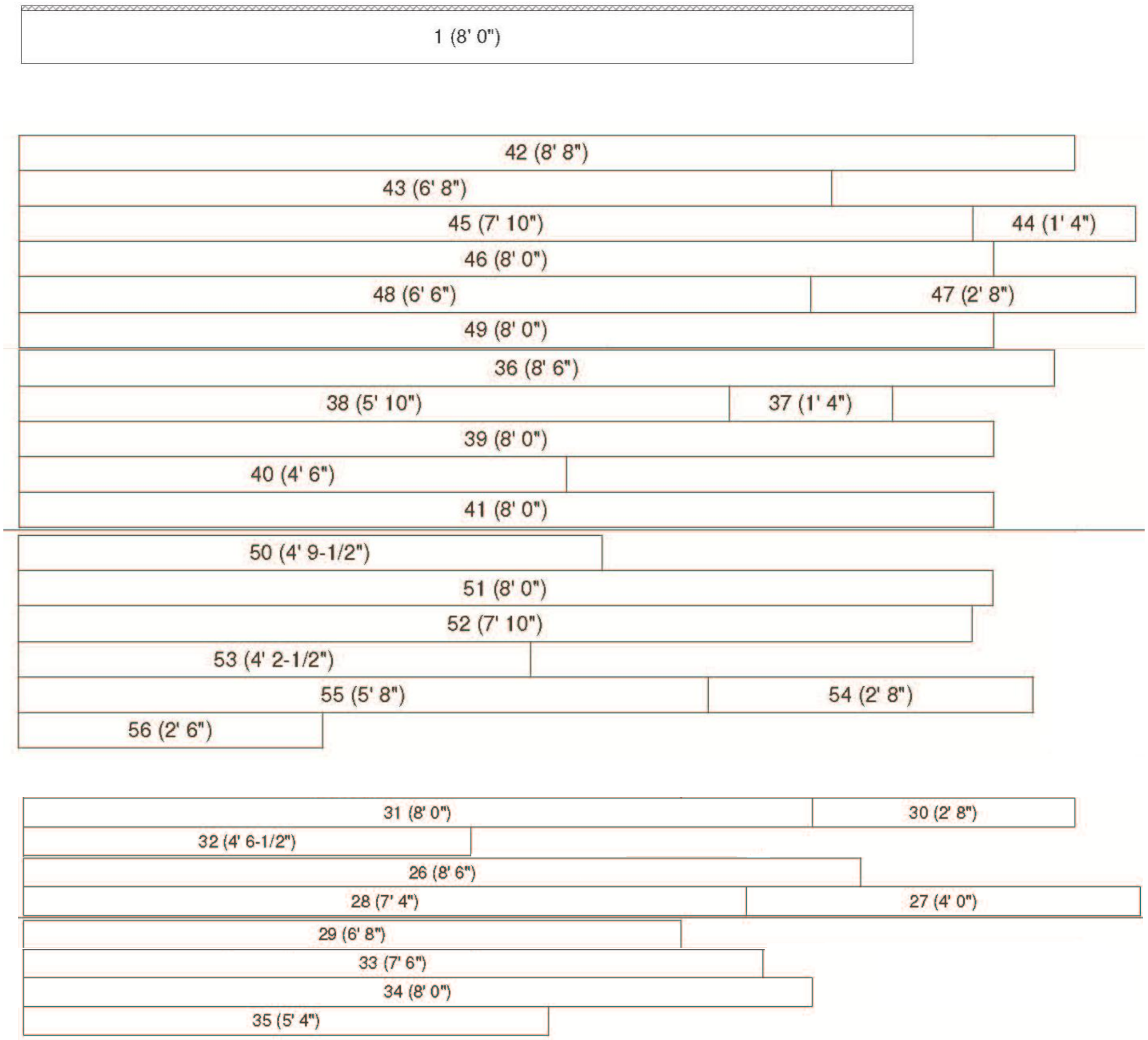
M3-1: Panel Designer



M3-1: IntelliBuild



M3-1: IntelliBuild



M3-1: Proposed algorithm

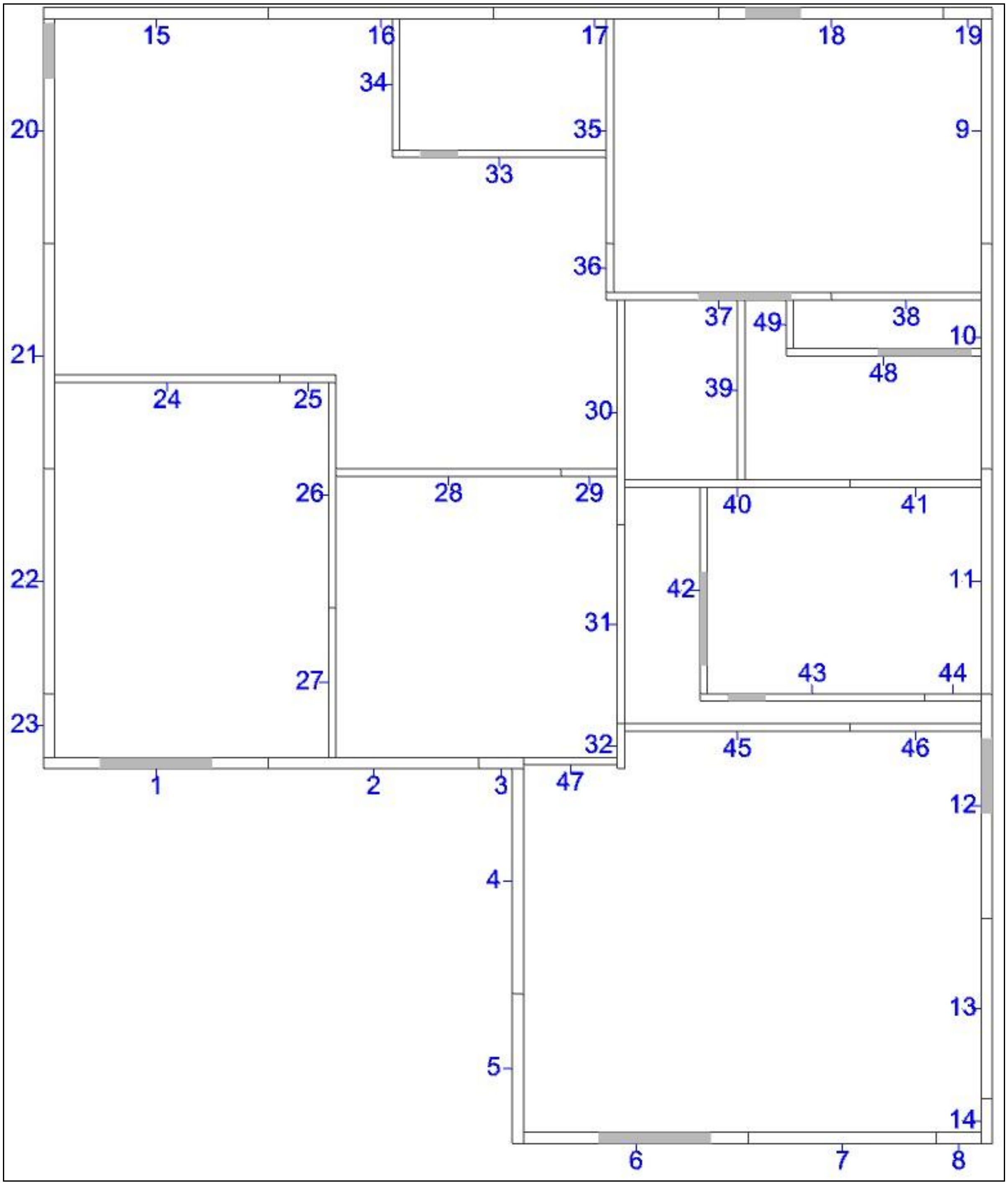
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	222.0
3	279.5

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	87.3	11	1	1	16	2
							2	1	17	2
							3	1	22	1
							4	1	23	1
							5	1	24	1
							6	1	25	1
							7	1	1	2
							8	1	38	1
							9	1	26	2
							10	1	27	2
							11	1	28	1
2	2	A	RIGHT	330.0	87.3	13	1	1	18	2
							2	1	19	2
							3	2	37 36	2 2
							4	1	39	1
							5	1	40	1
							6	1	41	2
							7	1	31	2
							8	1	32	2
							9	1	33	1
							10	3	44 56 43	1 1 1
							11	1	34	1
							12	2	47 45	1 2
							13	1	48	1
3	2	B	LEFT	330.0	99.3	3	1	2	29 30	1 1
							2	1	2	2
							3	1	3	2
4	3	A	RIGHT	389.8	57.3	12	1	2	21 20	2 2
							2	1	10	2
							3	1	11	2
							4	1	12	2
							5	1	13	2
							6	1	14	2
							7	1	15	2
							8	2	54 42	2 2
							9	1	55	2
							10	1	46	2
							11	1	49	2
							12	1	50	2
5	3	A	RIGHT	389.8	57.3	3	1	1	4	2
							2	1	5	2
							3	1	6	1
6	3	B	LEFT	389.8	99.3	6	1	1	53	2
							2	1	7	3
							3	2	8 9	3 3
							4	1	35	1
							5	1	51	2
							6	1	52	2

M3-2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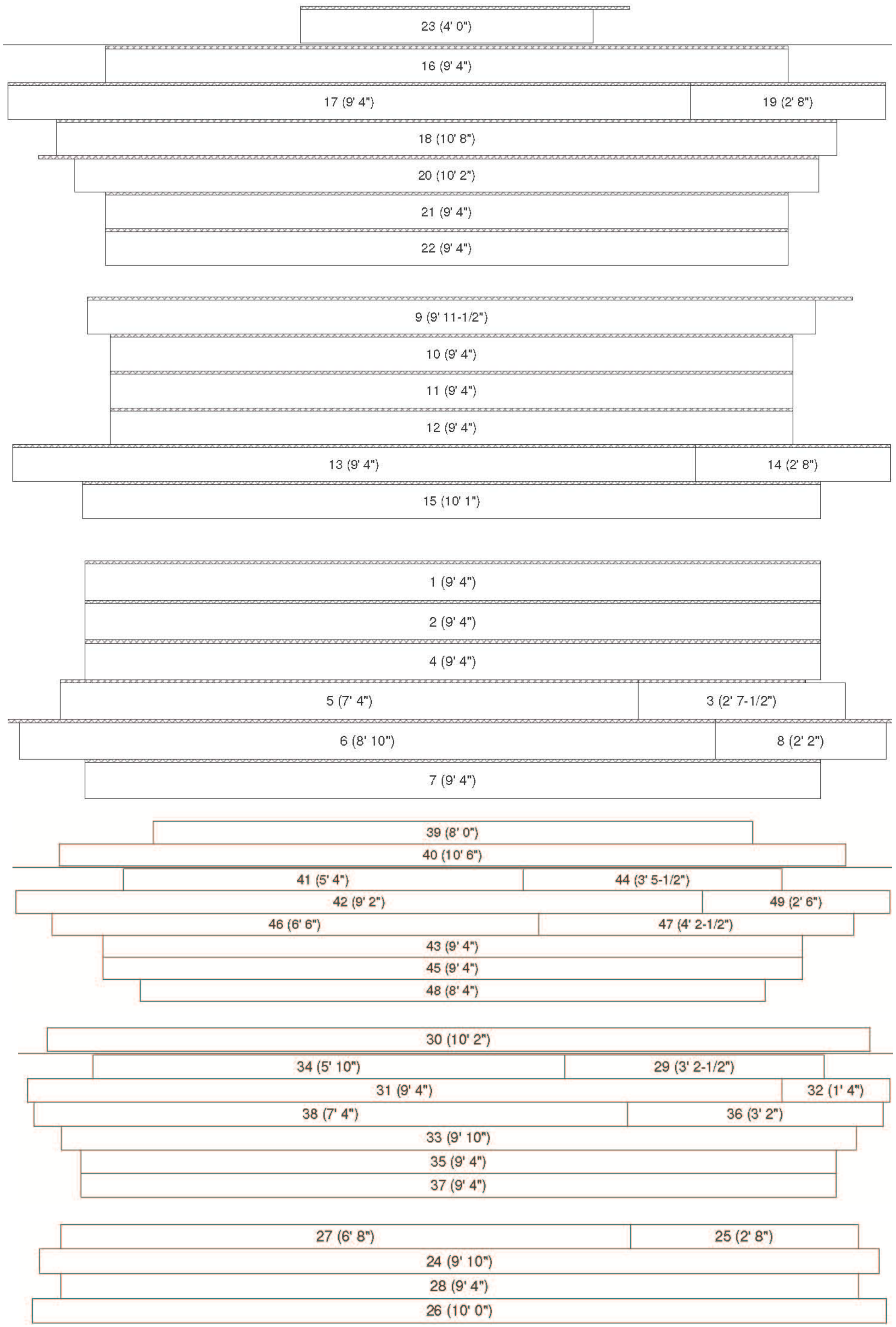
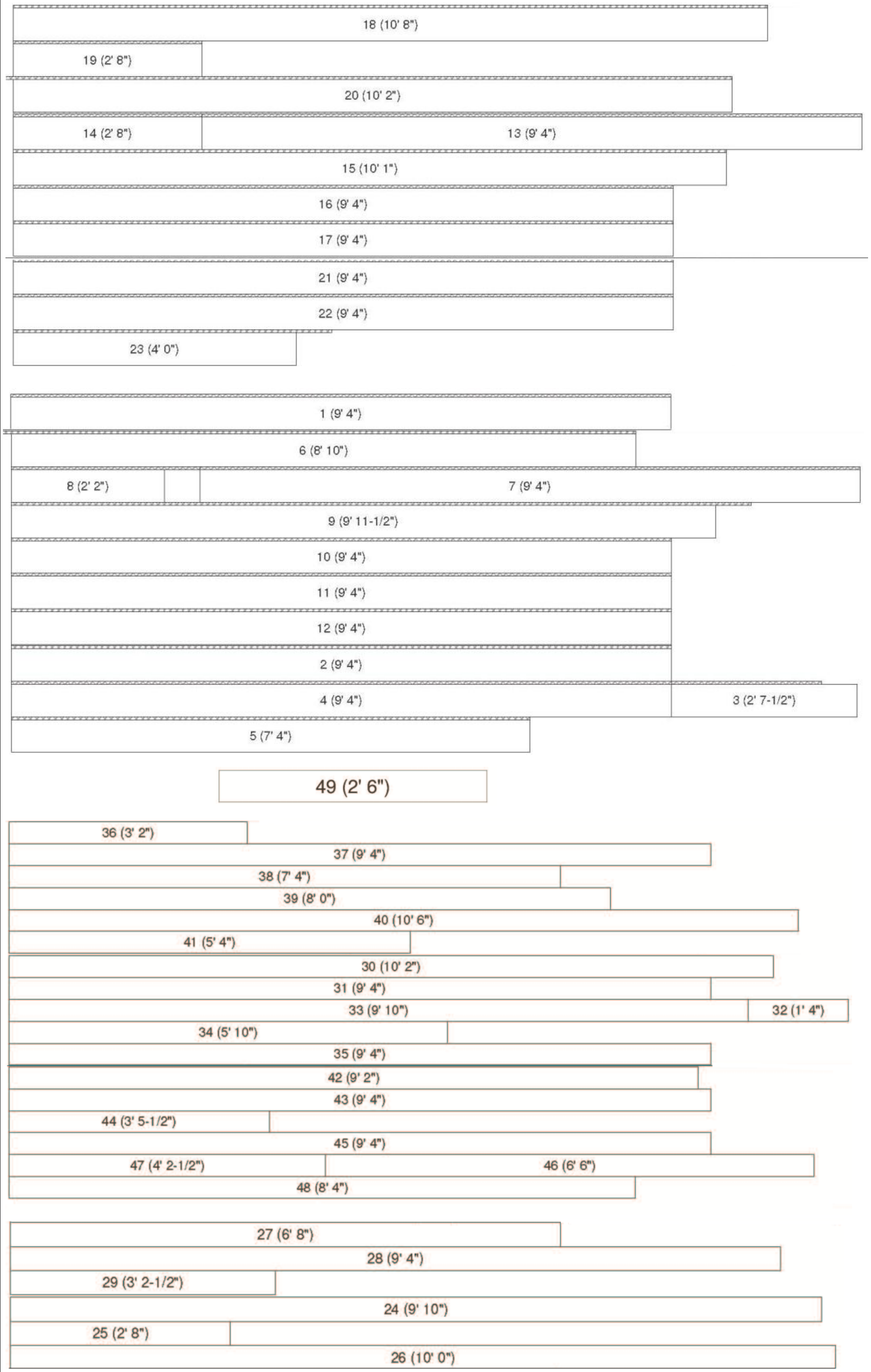
M3-2: Panel Designer



M3-2: IntelliBuild



```
M3-2: Proposed algorithm

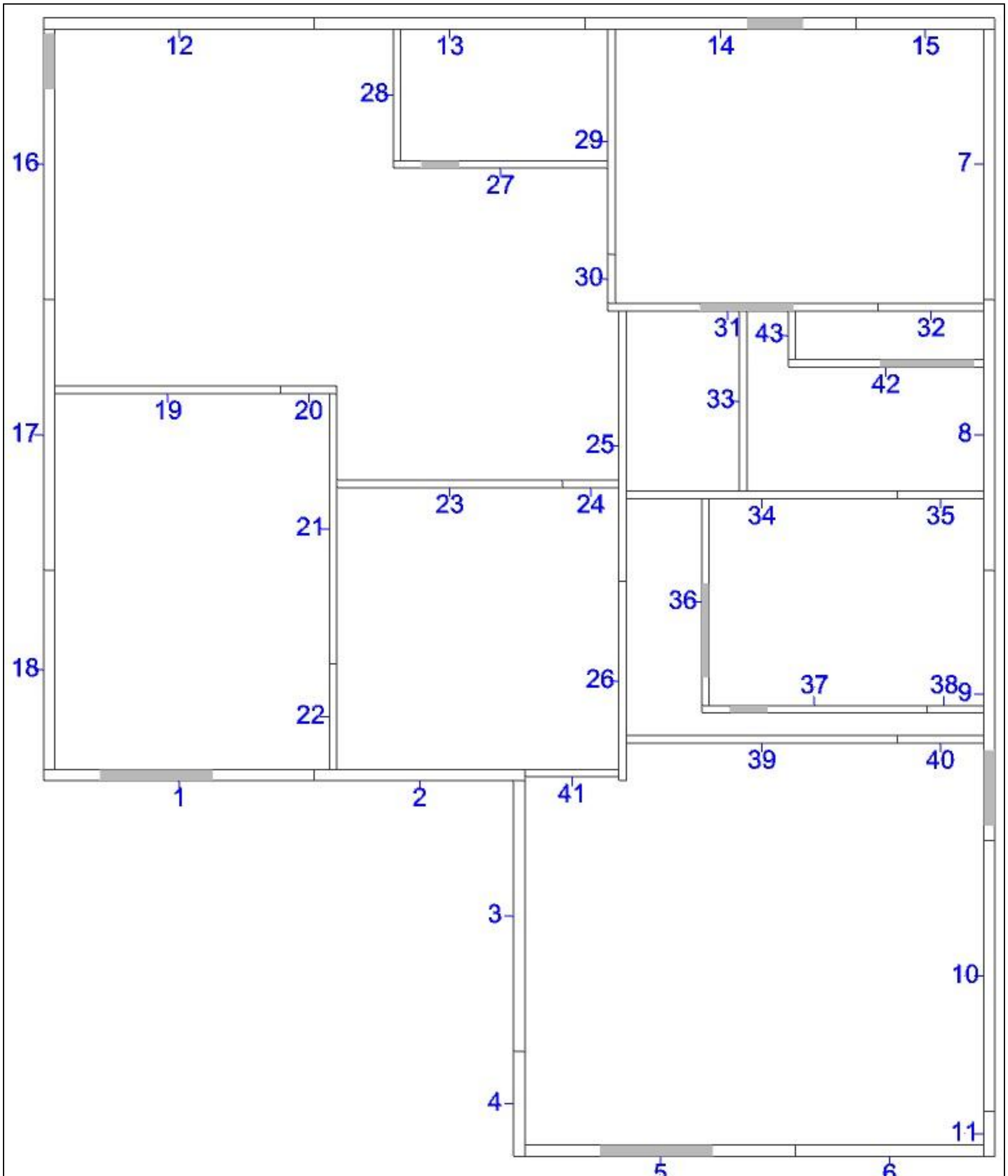
** Nzones
3

**zone      left edge X coordinate
 1           6.0
 2         210.0
 3         284.0

** NStacks
5

** stack                 flush
**   #    zone type   edge     xloc    yloc   #layers   j   #panels   panels      orientation
     1     1     A    RIGHT   114.0   78.0      9          1         1    15          2
                                                           2         1    20          1
                                                           3         1    21          1
                                                           4         1    22          1
                                                           5         1    23          1
                                                           6         1    1           2
                                                           7         1    24          2
                                                           8         1    25          2
                                                           9         1    26          1
     2     2     A    RIGHT   330.0   78.0     14          1         1    16          2
                                                           2         1    17          2
                                                           3         1    34          1
                                                           4         1    33          2
                                                           5         1    35          1
                                                           6         1    36          1
                                                           7         1    37          2
                                                           8         1    28          2
                                                           9         1    29          2
                                                          10         1    30          1
                                                          11         2    49 39       1 1
                                                          12         1    40          2
                                                          13         1    31          1
                                                          14         1    42          1
     3     2     B    LEFT    330.0   90.0      1          1         1    27          1
     4     3     A    RIGHT   392.0   48.0     13          1         1    18          2
                                                           2         1    19          2
                                                           3         1    9           2
                                                           4         1    10          2
                                                           5         1    11          2
                                                           6         1    12          2
                                                           7         2    14 13       2 2
                                                           8         1    38          2
                                                           9         1    48          2
                                                          10         1    41          2
                                                          11         1    43          2
                                                          12         2    2 44        2 2
                                                          13         2    47 3        2 2
     5     3     B    LEFT    392.0   90.0      7          1         1    4           2
                                                           2         1    5           1
                                                           3         1    6           3
                                                           4         2    7 8         3 3
                                                           5         1    32          1
                                                           6         1    45          2
                                                           7         1    46          2
```

M3-3



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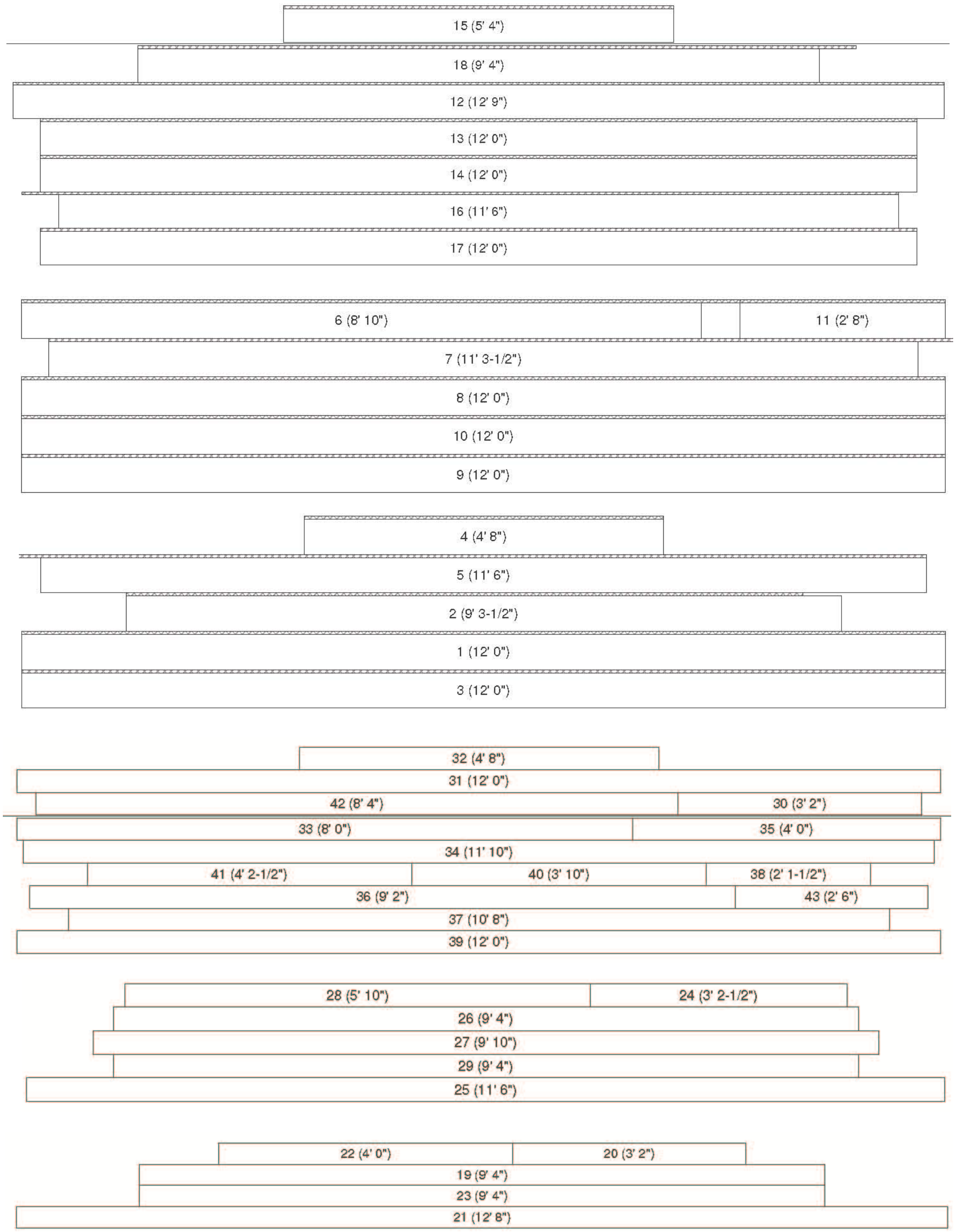
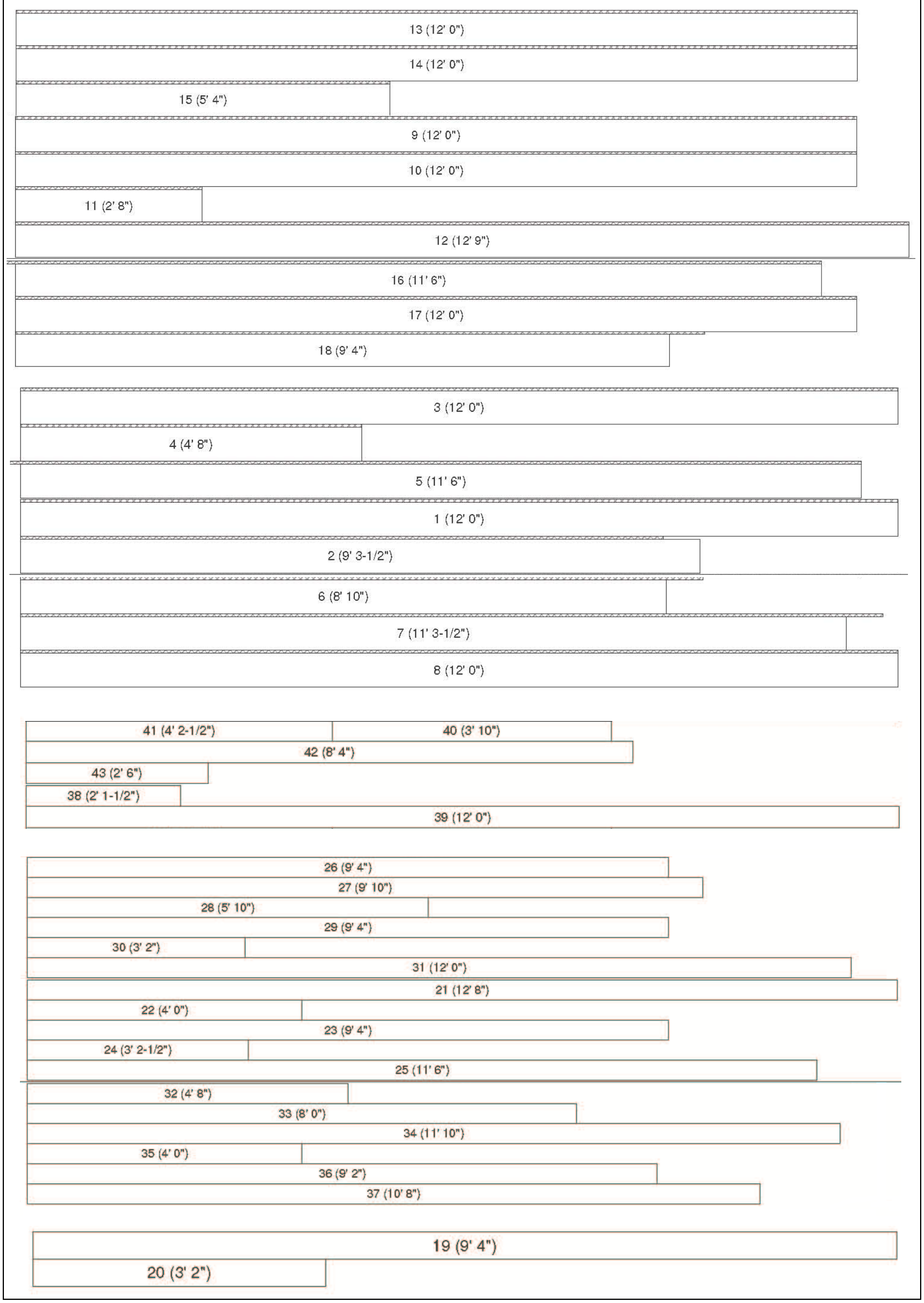
M3-3: Panel Designer



M3-3: IntelliBuild



```
M3-3: Proposed algorithm

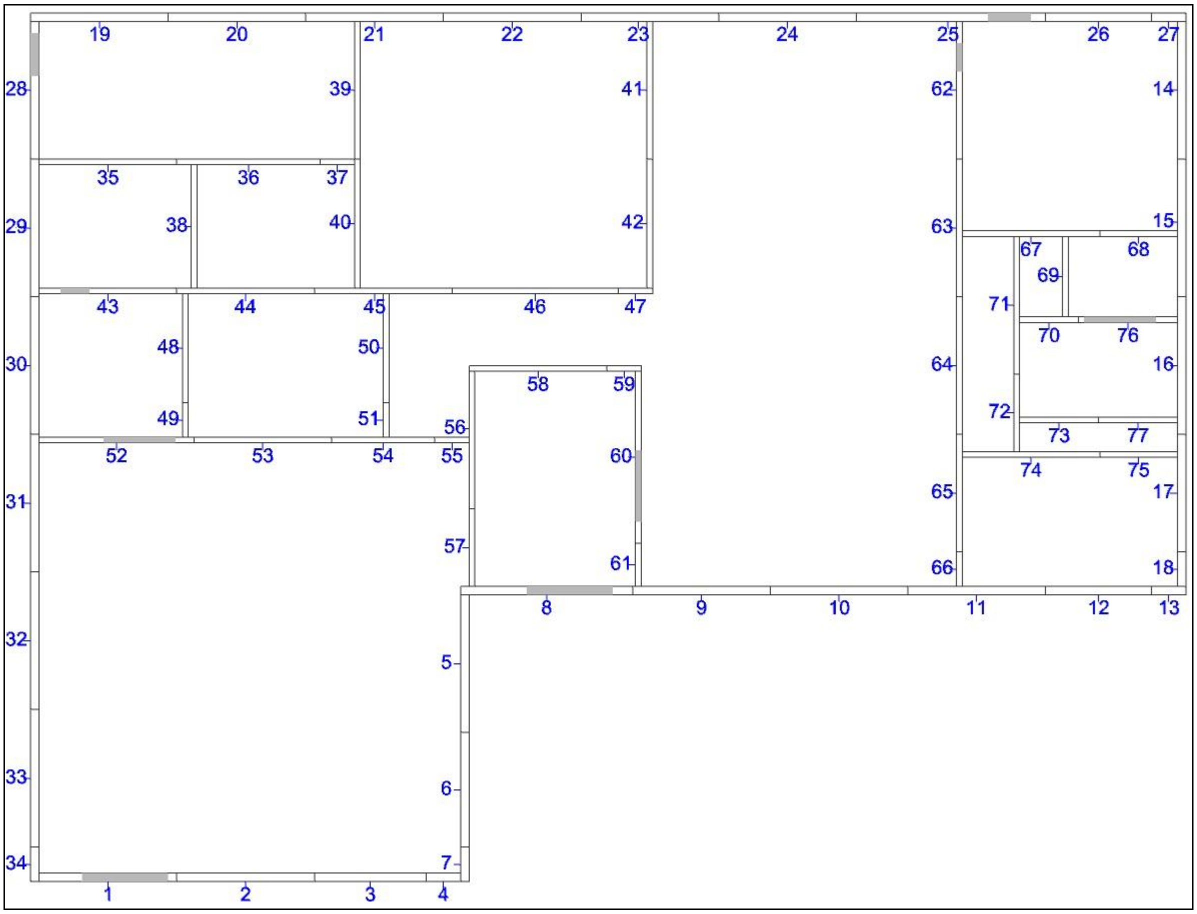
** Nzones
3

**zone      left edge X coordinate
 1           6.0
 2         220.5
 3         279.5

** NStacks
6

** stack                 flush
**    #    zone type    edge      xloc    yloc   #layers   j   #panels   panels       orientation
      1     1     A     RIGHT    116.2    77.3       8        1         1      12          2
                                                             2         1      16          1
                                                             3         1      17          1
                                                             4         1      18          1
                                                             5         1      1           2
                                                             6         1      19          2
                                                             7         1      20          2
                                                             8         1      21          1
      2     2     A     RIGHT    336.7    77.3      11        1         1      13          2
                                                             2         1      14          2
                                                             3         1      28          1
                                                             4         1      27          2
                                                             5         1      29          1
                                                             6         1      30          1
                                                             7         1      31          2
                                                             8         1      23          2
                                                             9         1      24          2
                                                            10         1      25          1
                                                            11         2      43 33       1 1
      3     2     B     LEFT     336.7    99.3       1        1         1      22          1
      4     3     A     RIGHT    389.8    57.3      14        1         1      15          2
                                                             2         1      7           2
                                                             3         1      8           2
                                                             4         1      9           2
                                                             5         1      10          2
                                                             6         2      32 11       2 2
                                                             7         1      42          2
                                                             8         1      34          2
                                                             9         1      35          2
                                                            10         1      2           2
                                                            11         1      3           2
                                                            12         1      4           1
                                                            13         1      36          2
                                                            14         1      37          2
      5     3     A     RIGHT    389.8    57.3       1        1         1      38          2
      6     3     B     LEFT     389.8    99.3       6        1         1      41          2
                                                             2         1      5           3
                                                             3         1      6           3
                                                             4         1      26          1
                                                             5         1      39          2
                                                             6         1      40          2
```

M4-1



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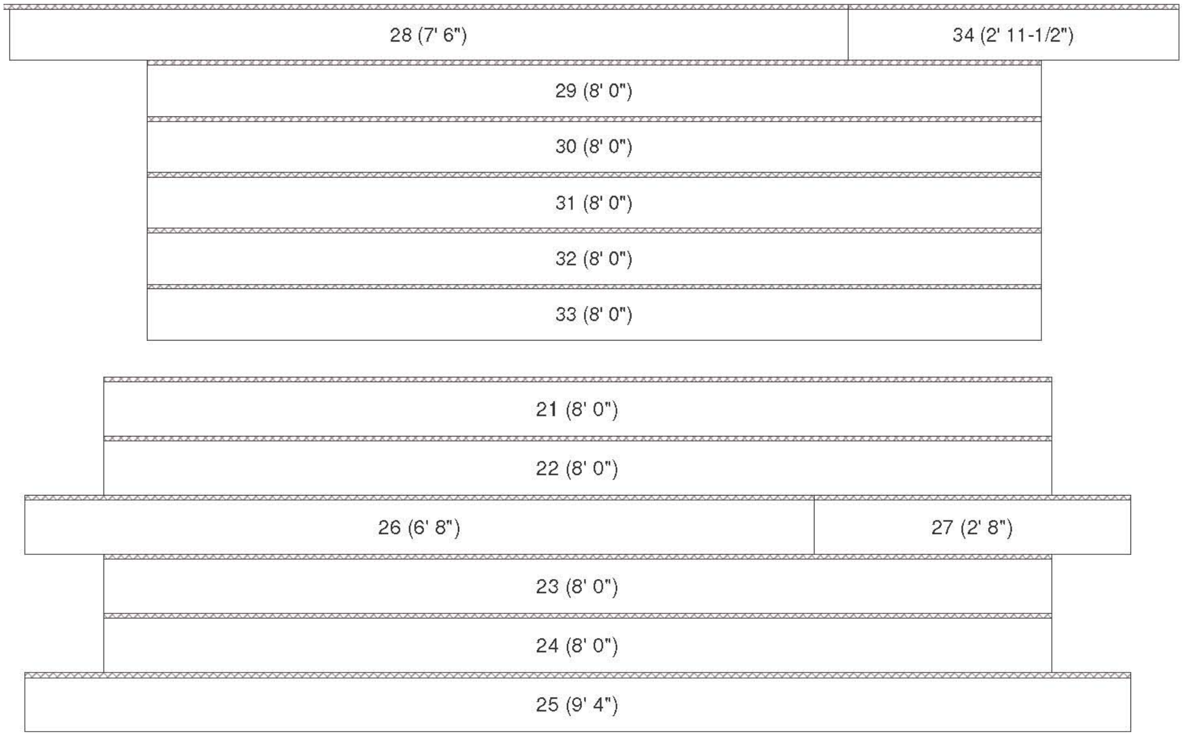
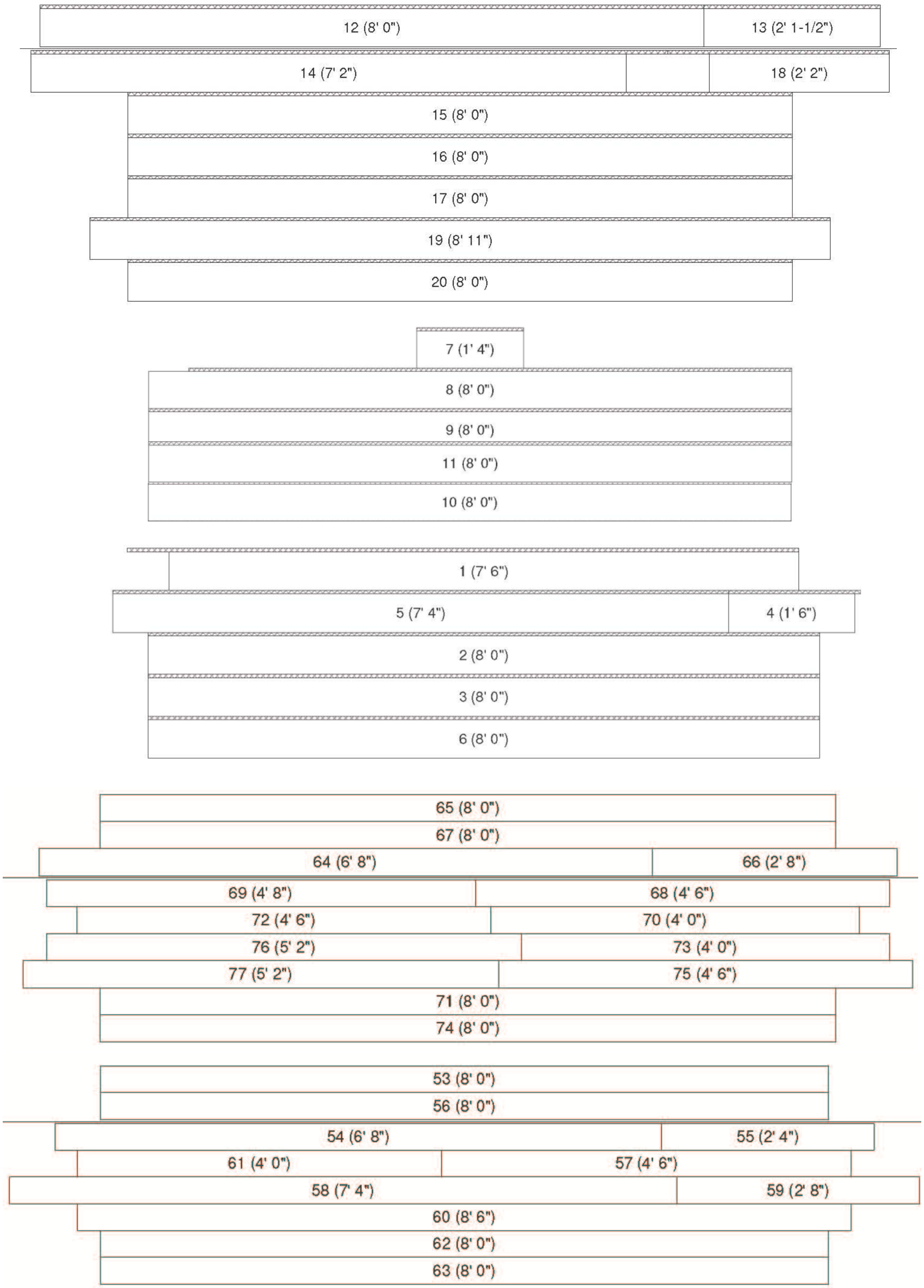
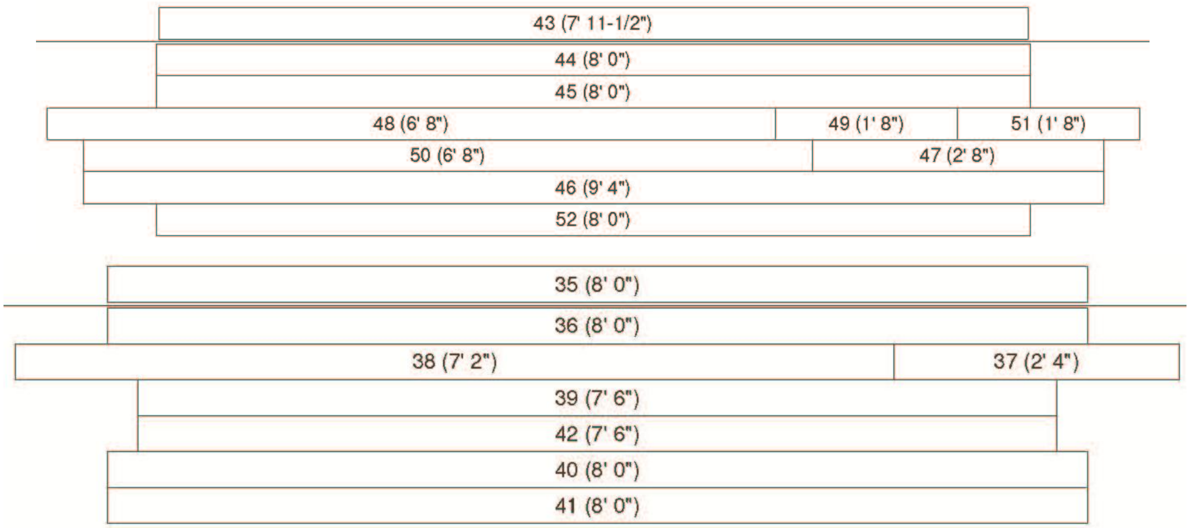
M4-1: Panel Designer



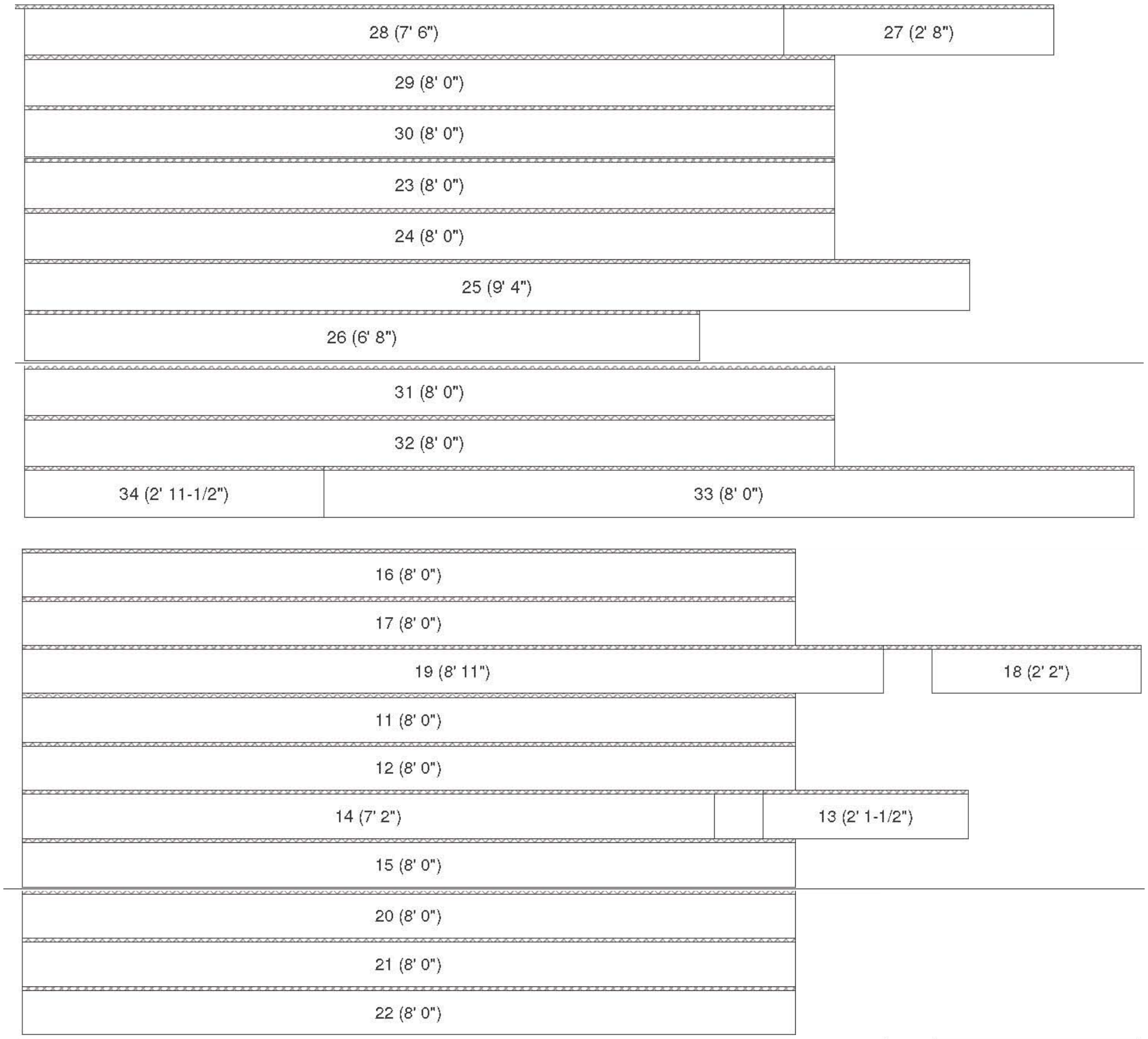
M4-1: Panel Designer



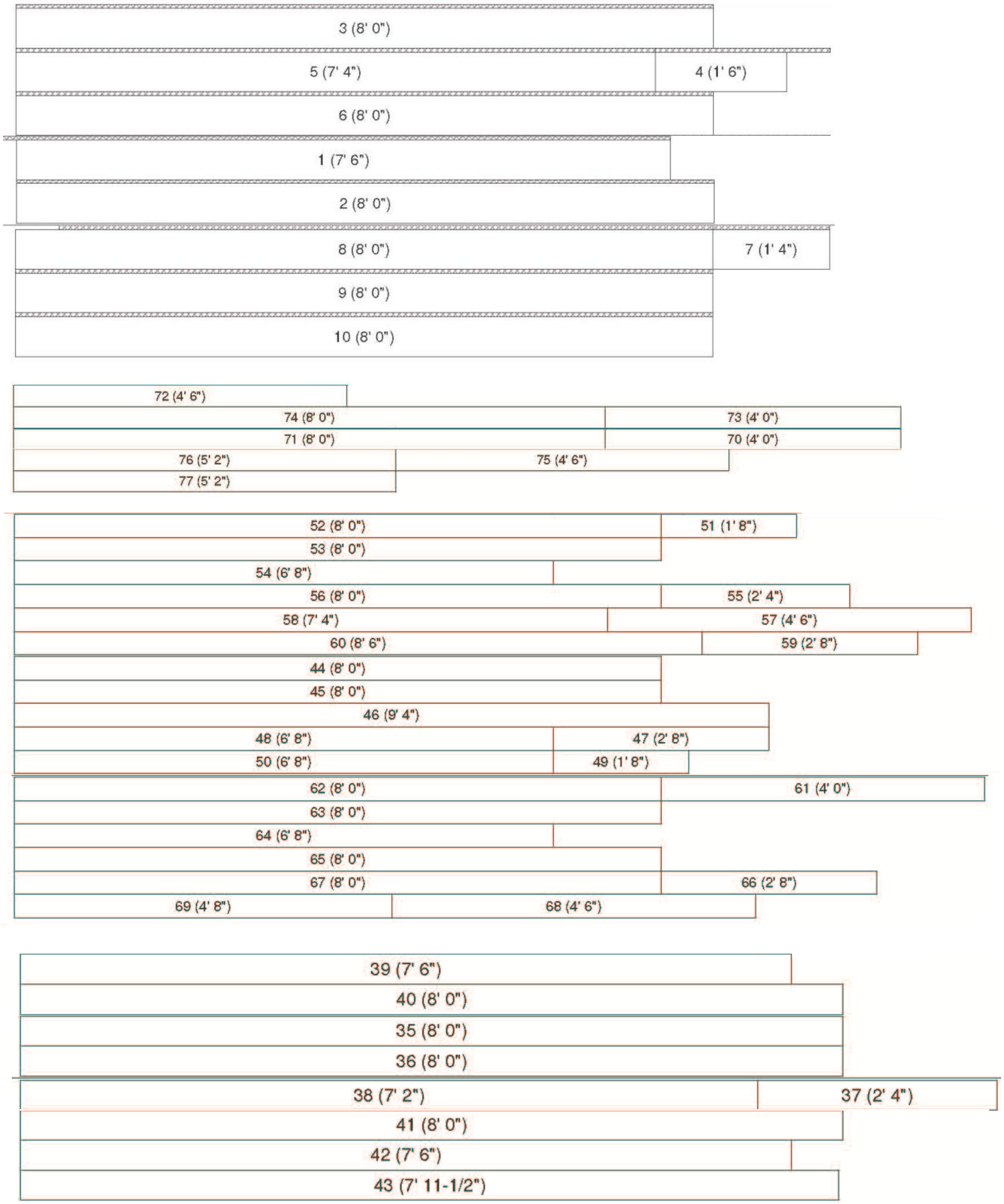
M4-1: Panel Designer



M4-1: IntelliBuild

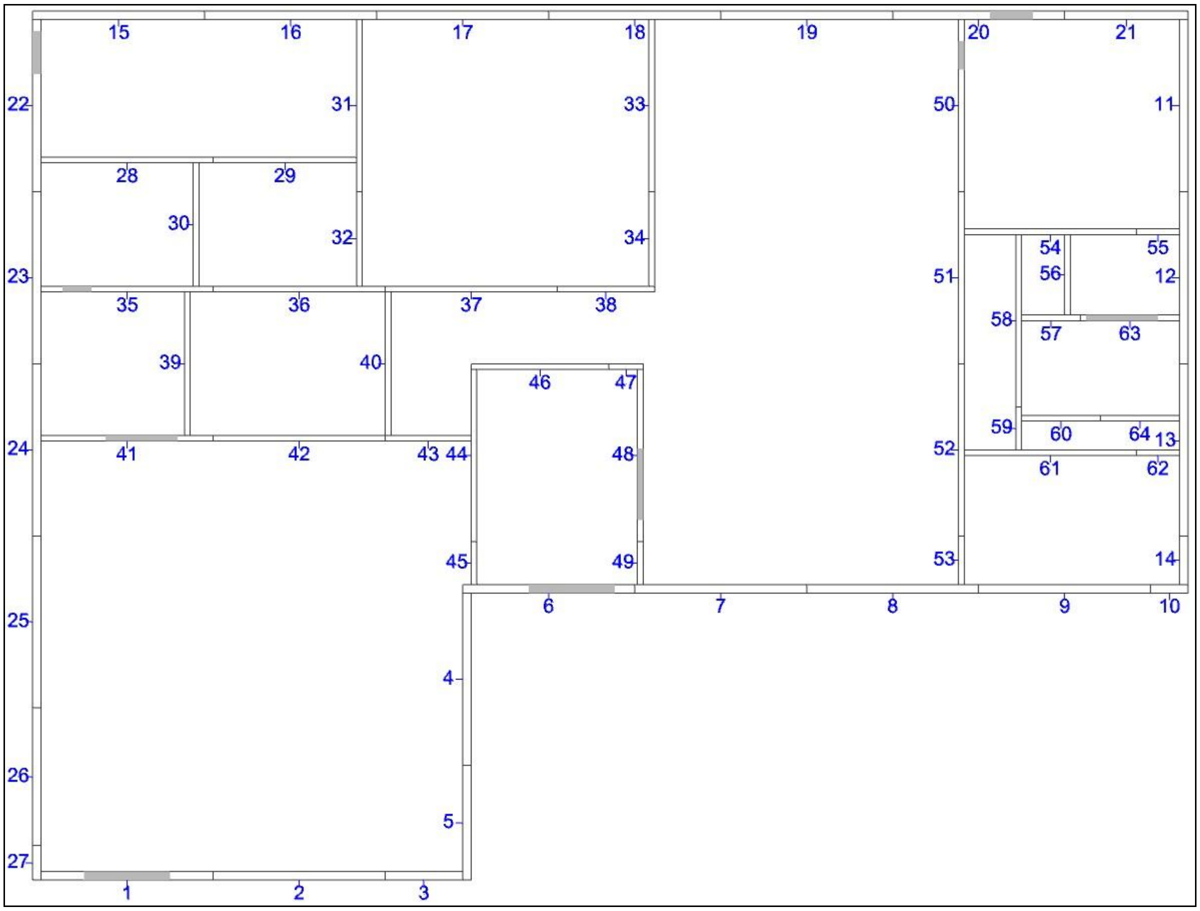


M4-1: IntelliBuild

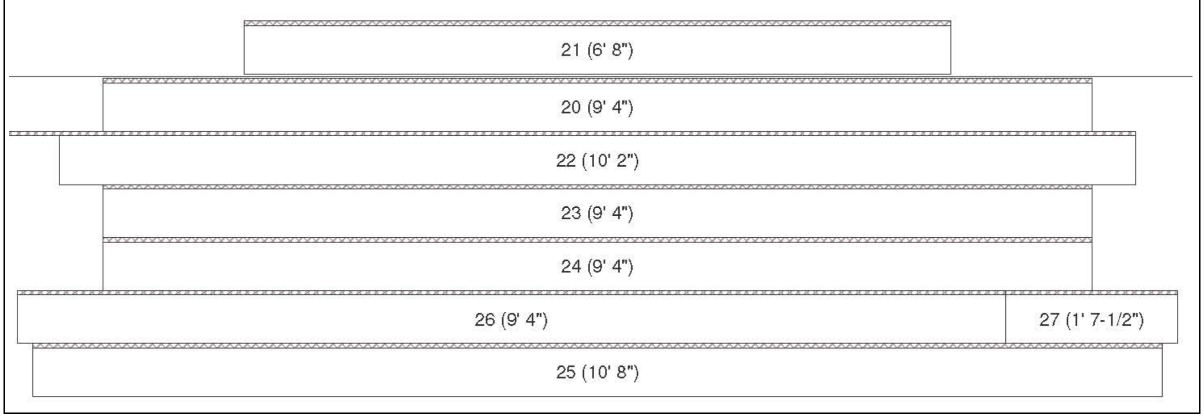


```
M4-1: Proposed algorithm
** Nzones
4
**zone      left edge X coordinate
 1           6.0
 2         222.0
 3         438.0
 4         584.0
** NStacks
9
** stack               flush
**   #    zone type    edge     xloc   yloc   #layers   j   #panels   panels      orientation
     1     1    A     RIGHT    114.0   52.5     13          1       1    19           2
                                                            2       1    20           2
                                                            3       1    28           1
                                                            4       1    29           1
                                                            5       1    30           1
                                                            6       1    31           1
                                                            7       1    32           1
                                                            8       2    34 33        1 1
                                                            9       1    35           2
                                                           10       1    36           2
                                                           11       1    38           1
                                                           12       1    43           2
                                                           13       1    44           2
     2     1    A     RIGHT    114.0   52.5      4          1       2    49 48        1 1
                                                            2       1    52           2
                                                            3       1    53           2
                                                            4       1    1            3
     3     2    A     RIGHT    330.0   52.5      9          1       1    21           2
                                                            2       1    22           2
                                                            3       2    37 39        2 1
                                                            4       1    40           1
                                                            5       1    45           2
                                                            6       2    47 46        2 2
                                                            7       2    51 50        1 1
                                                            8       2    55 54        2 2
                                                            9       1    56           1
     4     2    B     LEFT     330.0   94.5      2          1       1    2            3
                                                            2       2    3 4          3 3
     5     3    A     RIGHT    546.0   52.5      6          1       1    23           2
                                                            2       1    24           2
                                                            3       1    41           1
                                                            4       1    42           1
                                                            5       2    59 58        2 2
                                                            6       1    60           1
     6     3    B     LEFT     546.0   94.5      5          1       3    7 57 61      1 1 1
                                                            2       1    6            1
                                                            3       1    5            1
                                                            4       1    8            2
                                                            5       1    9            2
     7     4    A     RIGHT    692.0   52.5     14          1       1    25           2
                                                            2       2    27 26        2 2
                                                            3       1    14           2
                                                            4       1    15           2
                                                            5       1    16           2
                                                            6       3    13 18 17     2 2 2
                                                            7       1    62           2
                                                            8       1    63           2
                                                            9       1    67           2
                                                           10       1    68           2
                                                           11       1    64           2
                                                           12       1    71           2
                                                           13       2    70 69        2 2
                                                           14       1    76           2
     8     4    A     RIGHT    692.0   92.5      5          1       2    73 72        2 2
                                                            2       1    77           2
                                                            3       1    10           2
                                                            4       1    11           2
                                                            5       1    12           2
     9     4    B     LEFT     692.0  124.5      3          1       1    66 75        1 2
                                                            2       1    74           2
                                                            3       1    65           2
```

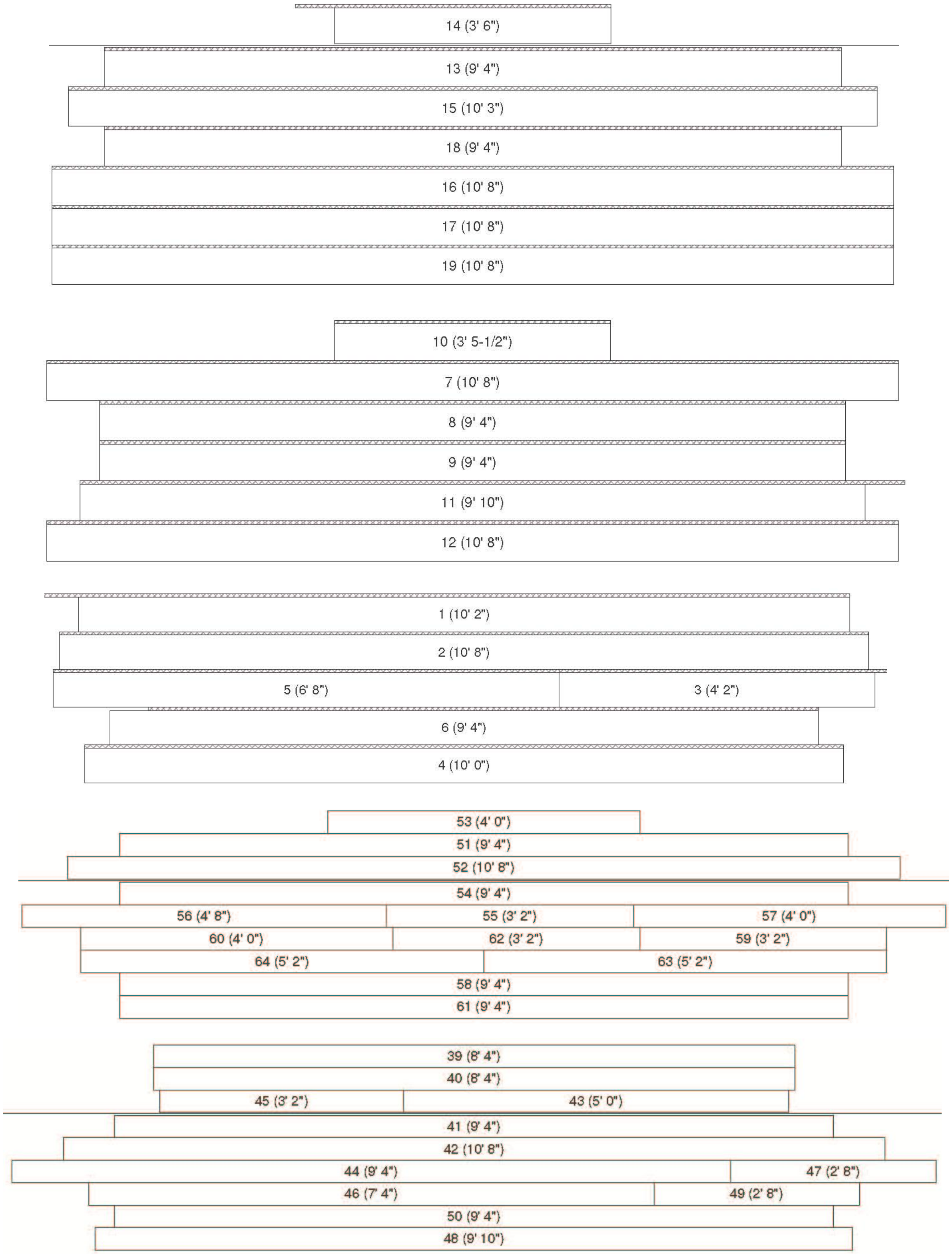
M4-2

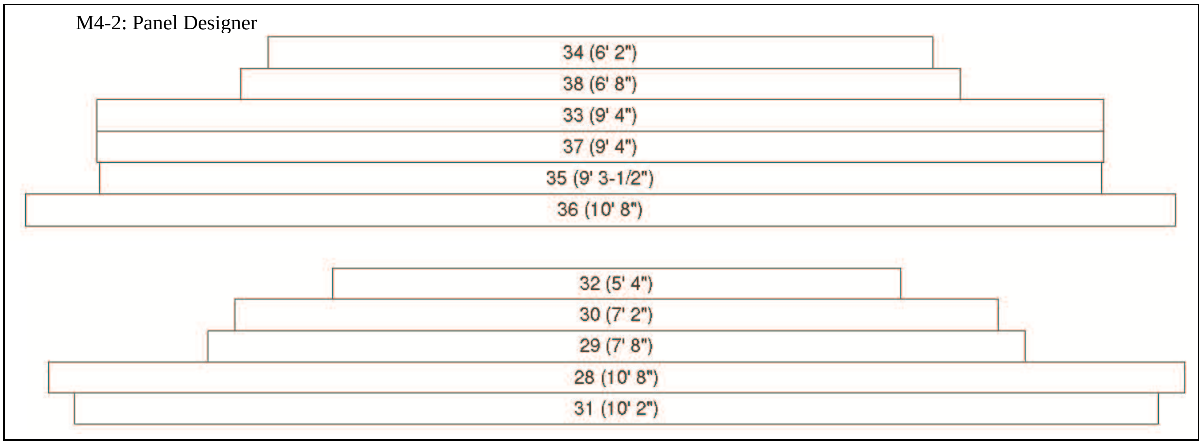


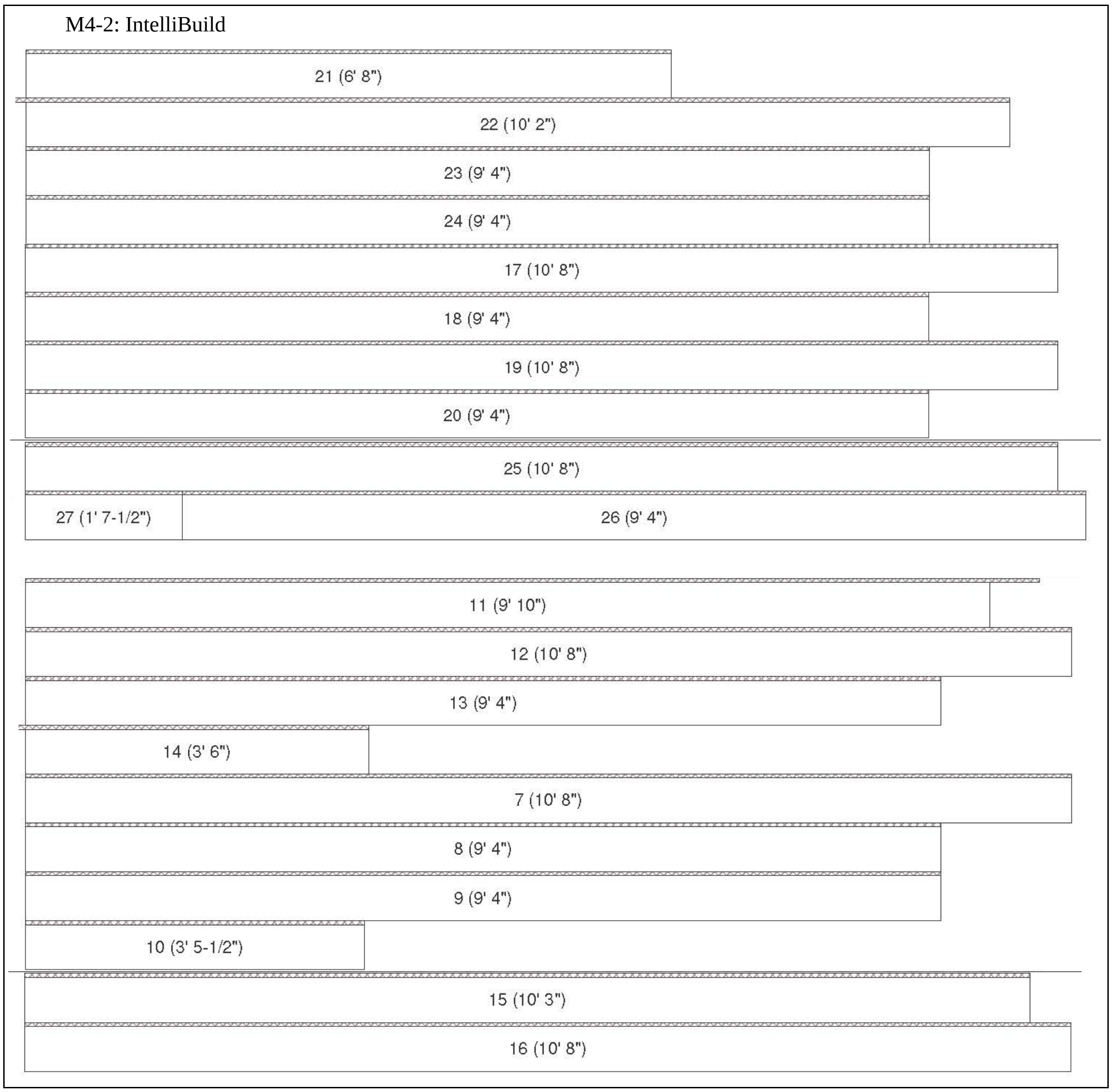
M4-2: Panel Designer



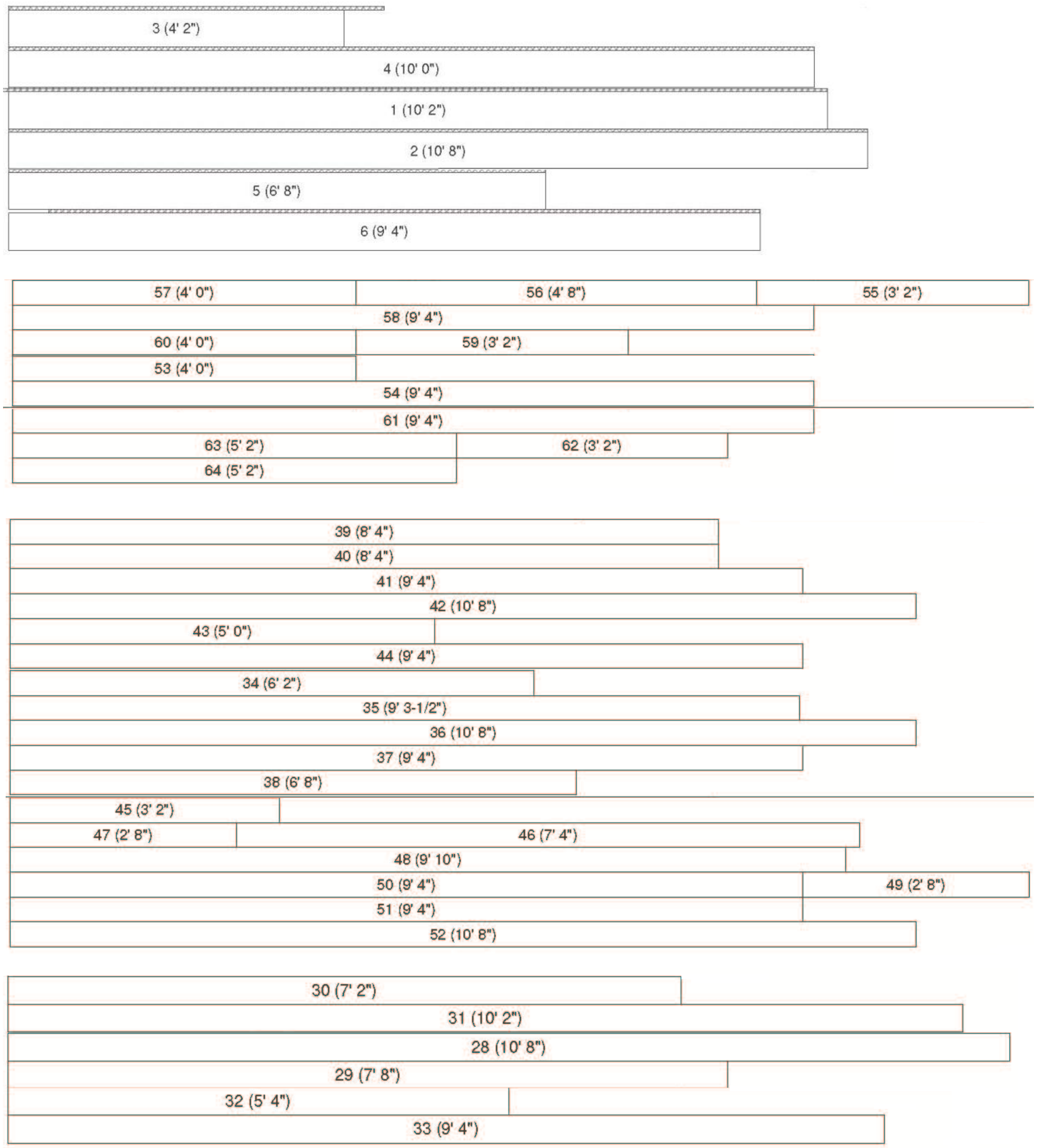
M4-2: Panel Designer




M4-2: Panel Designer
34 (6' 2")
38 (6' 8")
33 (9' 4")
37 (9' 4")
35 (9' 3-1/2")
36 (10' 8")
32 (5' 4")
30 (7' 2")
29 (7' 8")
28 (10' 8")
31 (10' 2")


M4-2: IntelliBuild
21 (6' 8")
22 (10' 2")
23 (9' 4")
24 (9' 4")
17 (10' 8")
18 (9' 4")
19 (10' 8")
20 (9' 4")
25 (10' 8")
27 (1' 7-1/2")
26 (9' 4")
11 (9' 10")
12 (10' 8")
13 (9' 4")
14 (3' 6")
7 (10' 8")
8 (9' 4")
9 (9' 4")
10 (3' 5-1/2")
15 (10' 3")
16 (10' 8")

M4-2: IntelliBuild



M4-2: Proposed algorithm

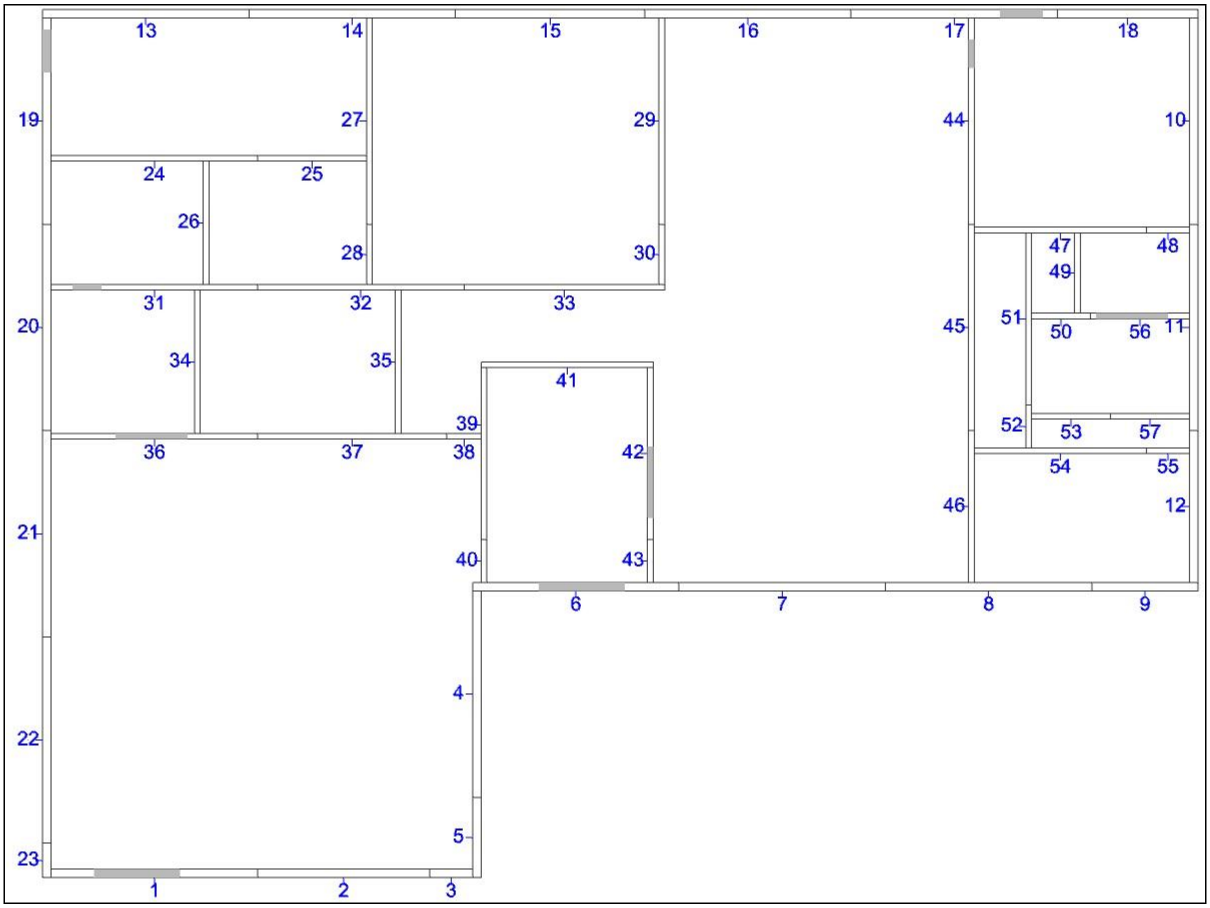
** Nzones
4

**zone	left edge X coordinate
1	6.0
2	222.0
3	438.0
4	584.0

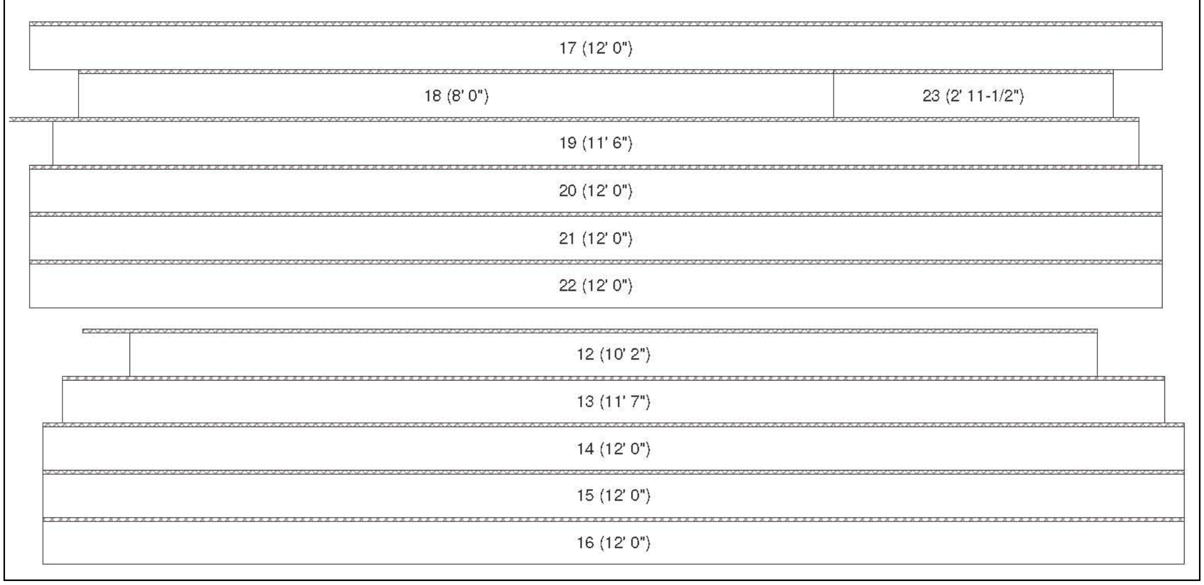
** NStacks
8

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	12	1	1	15	2
							2	1	22	1
							3	1	23	1
							4	1	24	1
							5	1	25	1
							6	2	27 26	1 1
							7	1	28	2
							8	1	30	1
							9	1	35	2
							10	1	39	1
							11	1	41	2
							12	1	1	3
2	2	A	RIGHT	330.0	48.0	12	1	1	16	2
							2	1	17	2
							3	1	29	2
							4	1	31	1
							5	1	32	1
							6	1	36	2
							7	1	37	2
							8	1	38	2
							9	1	40	1
							10	1	42	2
							11	1	43	2
							12	1	44	1
3	2	B	LEFT	330.0	90.0	2	1	1	2	3
							2	1	3	3
4	3	A	RIGHT	546.0	88.0	6	1	1	18	2
							2	1	19	2
							3	1	33	1
							4	1	34	1
							5	2	47 46	2 2
							6	1	48	1
5	3	B	LEFT	546.0	100.0	4	1	3	5	1
							2	1	4	1
							3	1	6	2
							4	1	7	2
							5	2	45 49	1 1
6	4	A	RIGHT	692.0	88.0	13	1	1	20	2
							2	1	21	2
							3	1	11	2
							4	1	12	2
							5	1	13	2
							6	2	10 14	2 2
							7	1	50	2
							8	1	51	2
							9	1	54	2
							10	1	55	2
							11	1	58	2
							12	2	57 56	2 2
							13	2	59 63	2 2
7	4	A	RIGHT	692.0	88.0	3	1	2	64 60	2 2
							2	1	8	2
							3	1	9	2
8	4	B	LEFT	692.0	100.0	3	1	2	53 62	1 2
							2	1	61	2
							3	1	52	2

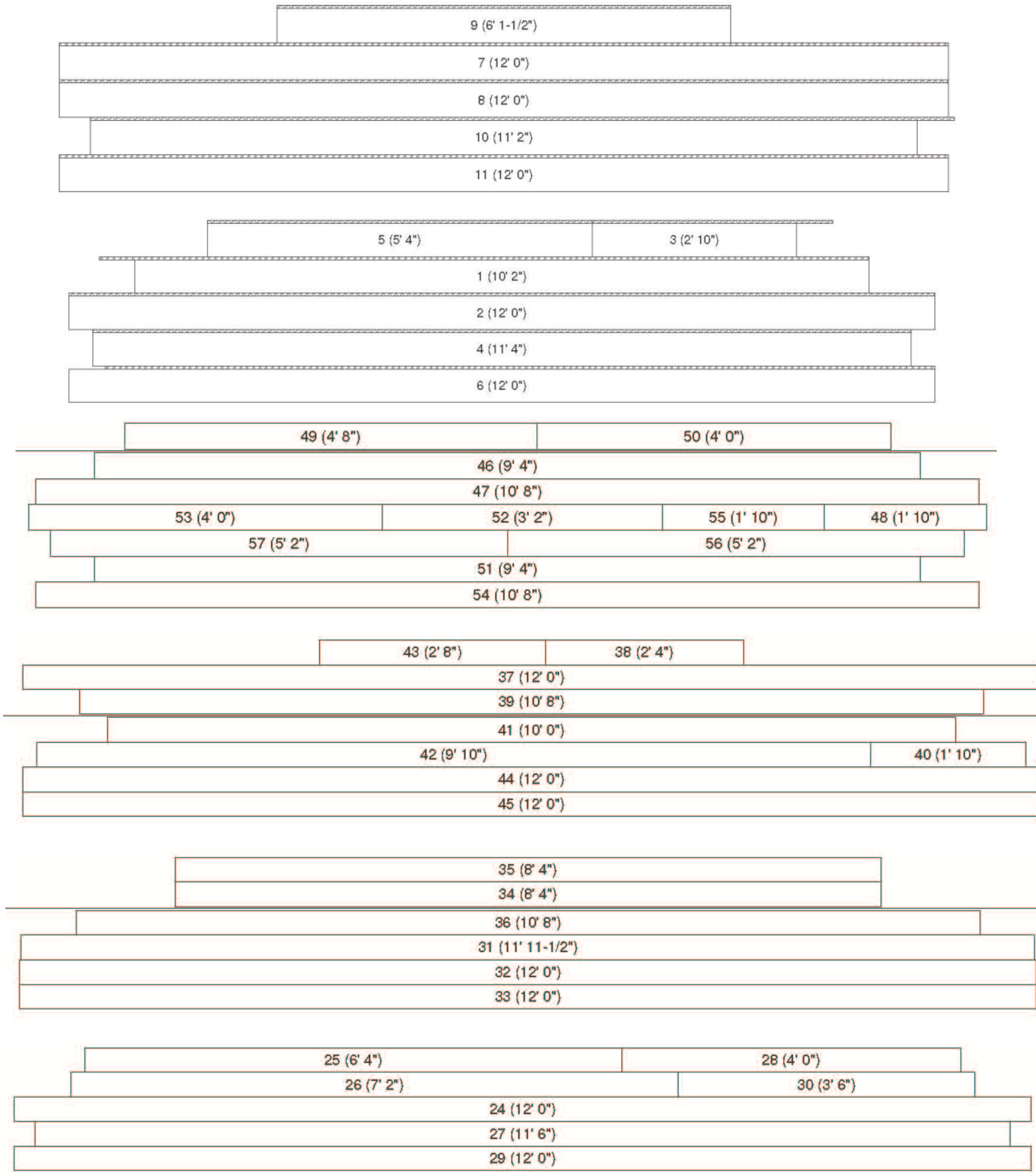
M4-3



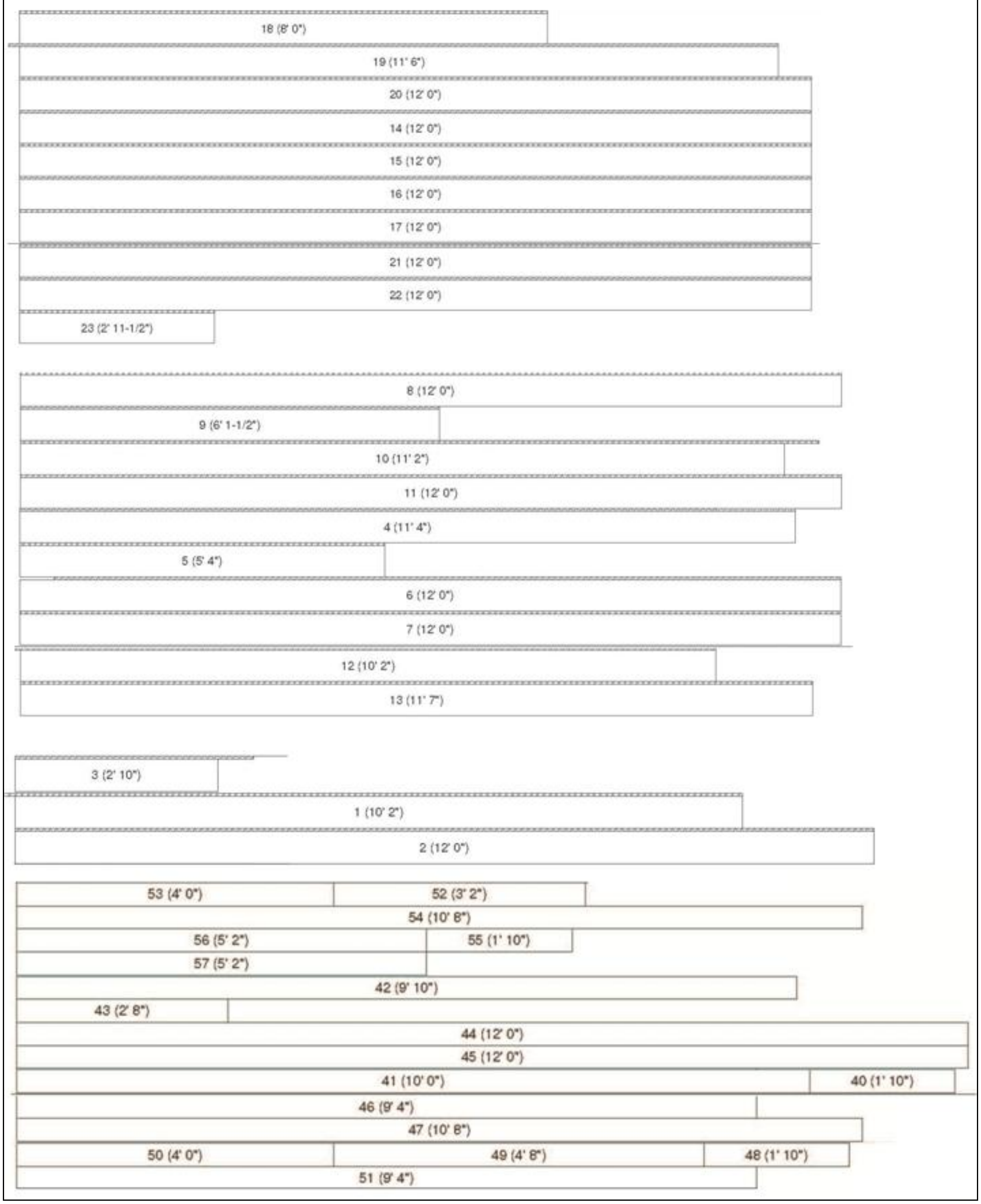
M4-3: Panel Designer



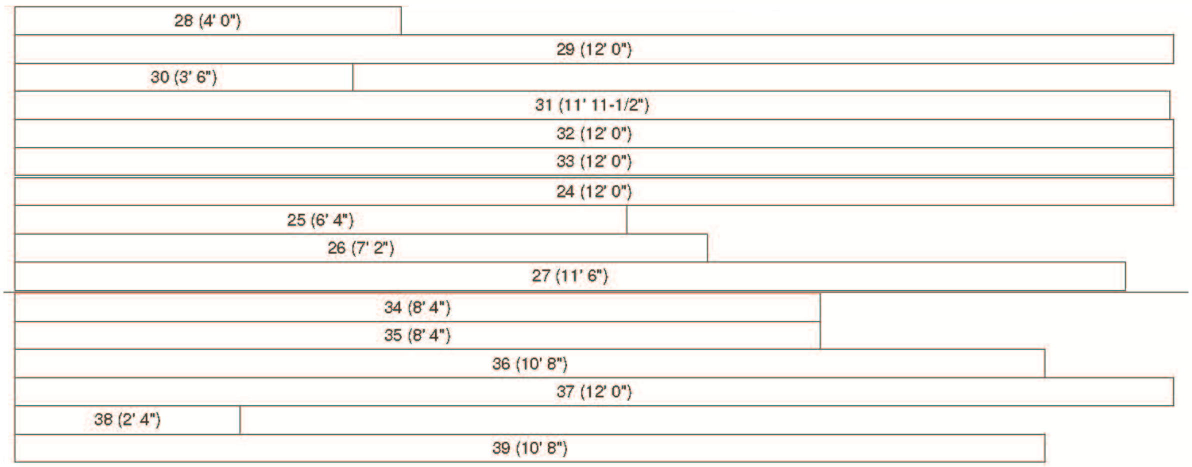
M4-3: Panel Designer



M4-3: IntelliBuild



M4-3: IntelliBuild



M4-3: Proposed algorithm

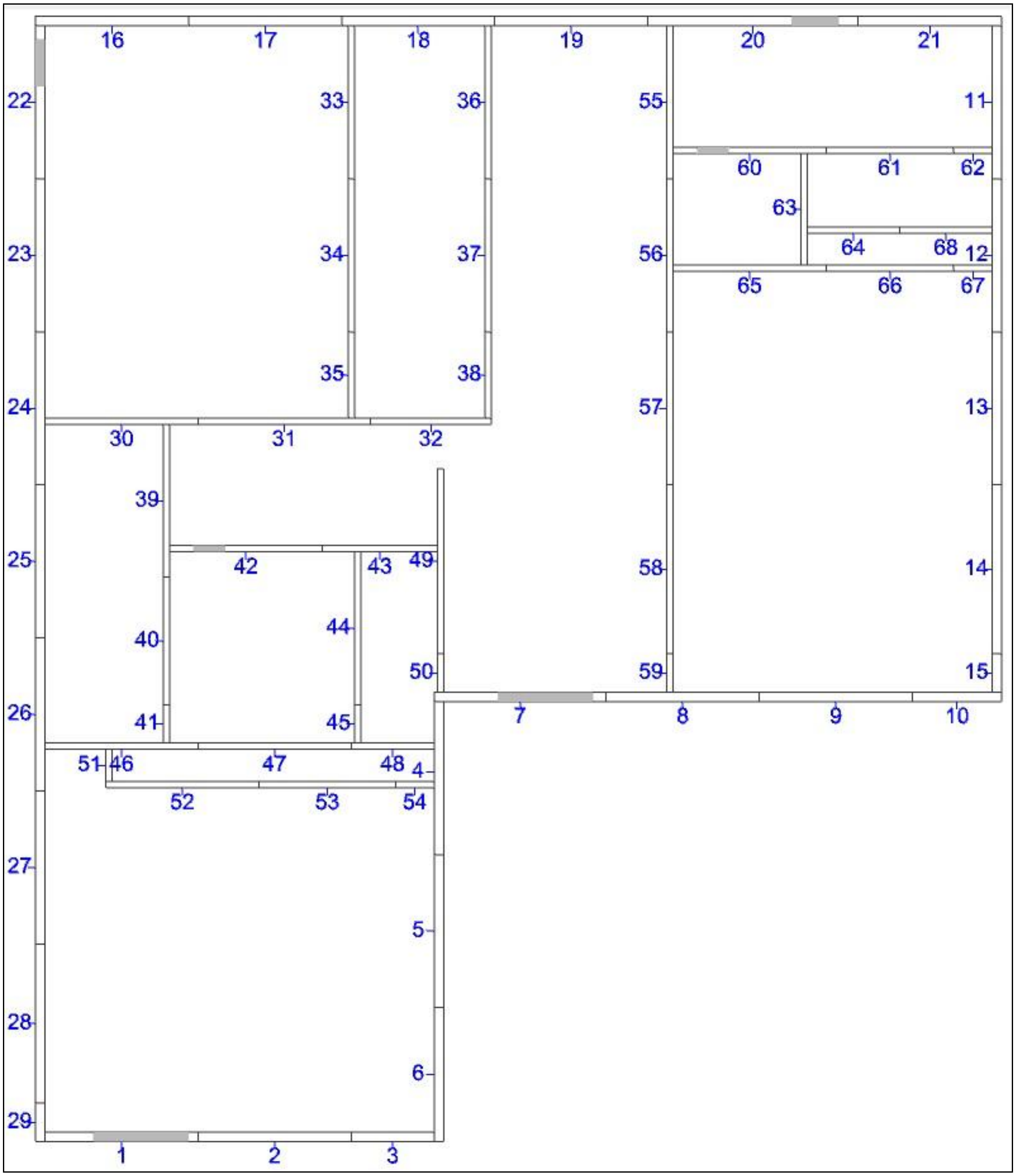
** Nzones
4

**zone	left edge X coordinate
1	6.0
2	226.5
3	446.9
4	579.5

** NStacks
8

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	13	2
							2	1	19	1
							3	1	20	1
							4	1	21	1
							5	1	22	1
							6	1	23	1
							7	1	24	2
							8	1	25	2
							9	1	26	1
							10	1	31	2
							11	1	34	1
							12	1	36	2
							13	1	1	3
2	2	A	RIGHT	336.7	97.3	9	1	1	14	2
							2	1	15	2
							3	1	27	1
							4	1	28	1
							5	1	32	2
							6	1	33	2
							7	1	35	1
							8	1	37	2
							9	2	39 38	1 2
3	2	B	LEFT	336.7	129.3	2	1	1	2	3
							2	1	3	3
4	3	A	RIGHT	557.1	97.3	5	1	1	16	2
							2	1	29	1
							3	1	30	1
							4	1	41	2
							5	1	42	1
5	3	B	LEFT	557.1	129.3	3	1	1	5	1
							2	1	4	1
							3	3	6 40 43	2 1 1
6	4	A	RIGHT	689.8	97.3	14	1	1	17	2
							2	1	18	2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	9	2
							7	1	44	2
							8	1	45	2
							9	1	47	2
							10	1	48	2
							11	1	51	2
							12	2	50 49	2 2
							13	2	52 56	2 2
							14	2	57 53	2 2
7	4	A	RIGHT	689.8	97.3	2	1	1	7	2
							2	1	8	2
8	4	B	LEFT	689.8	129.3	3	1	1	55	2
							2	1	54	2
							3	1	46	1

M5-1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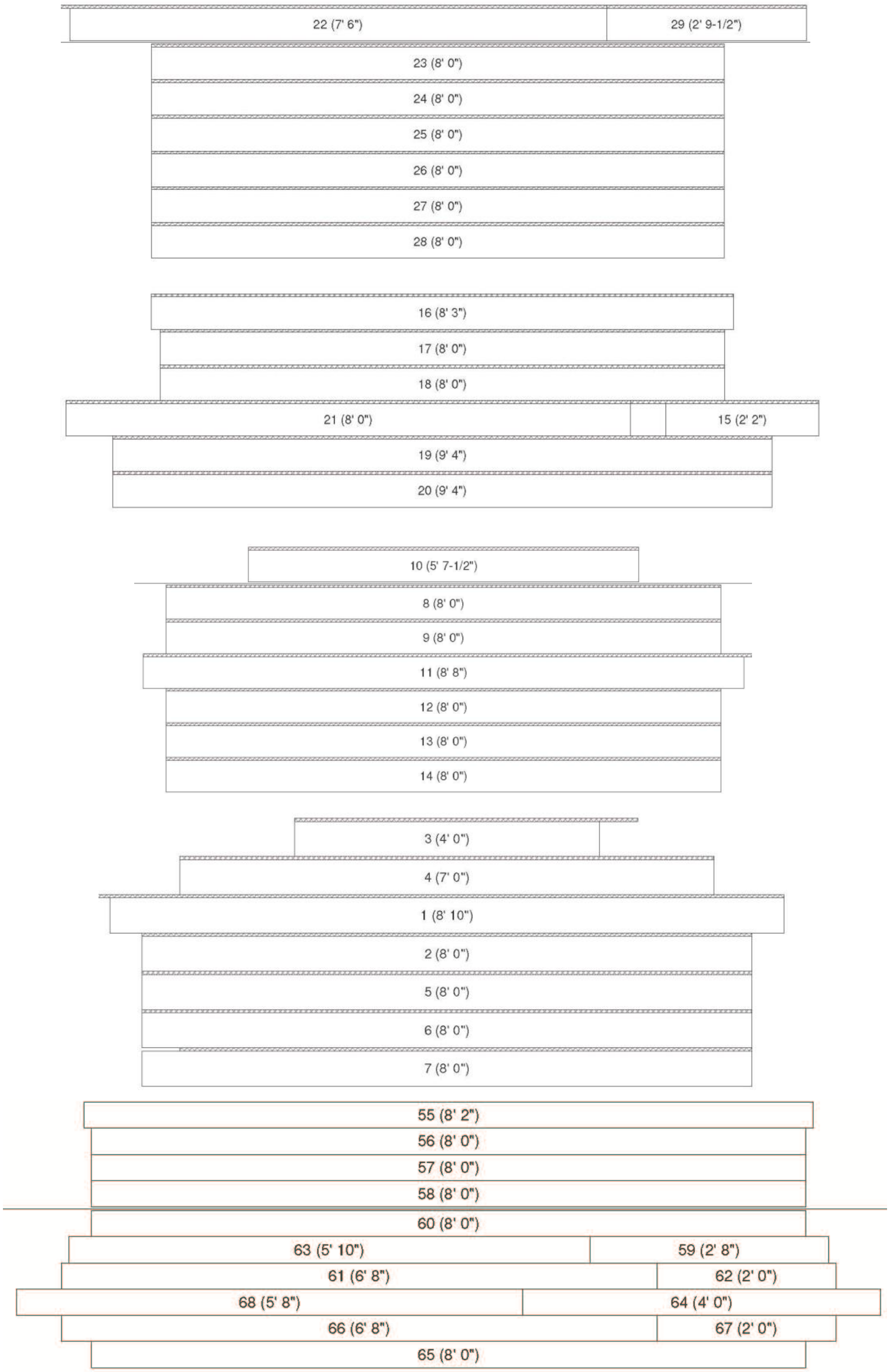
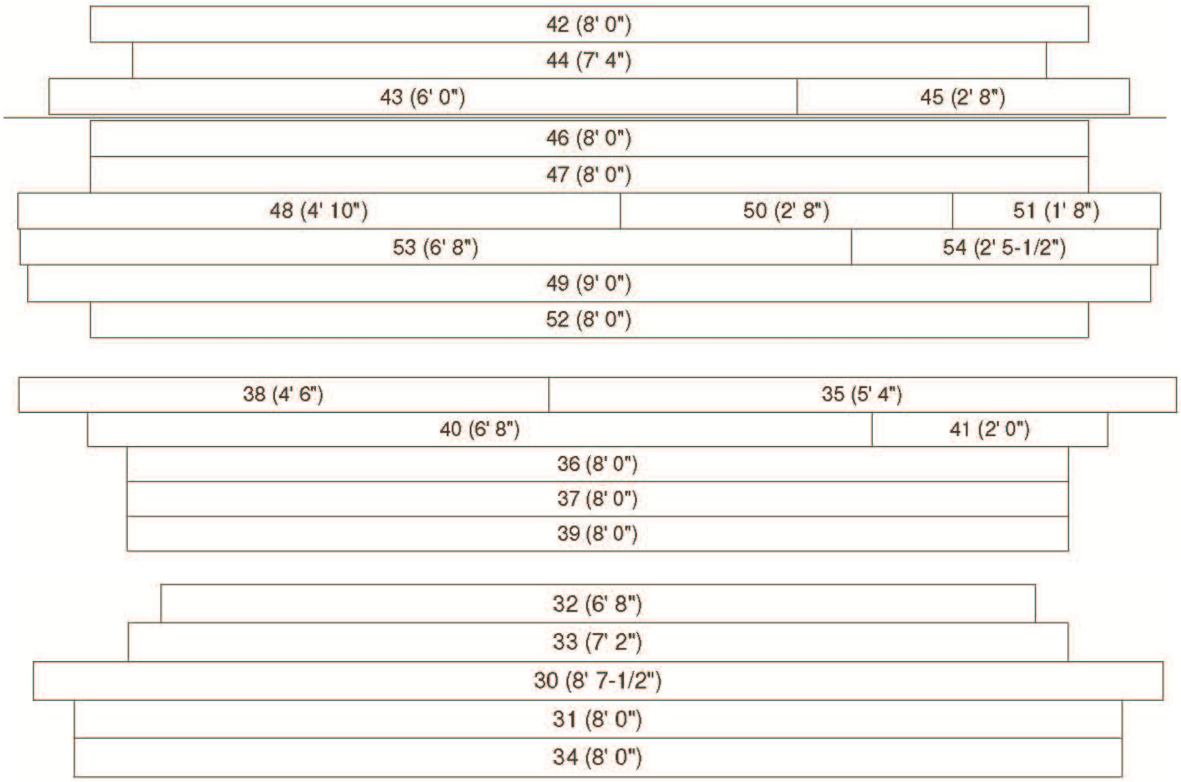
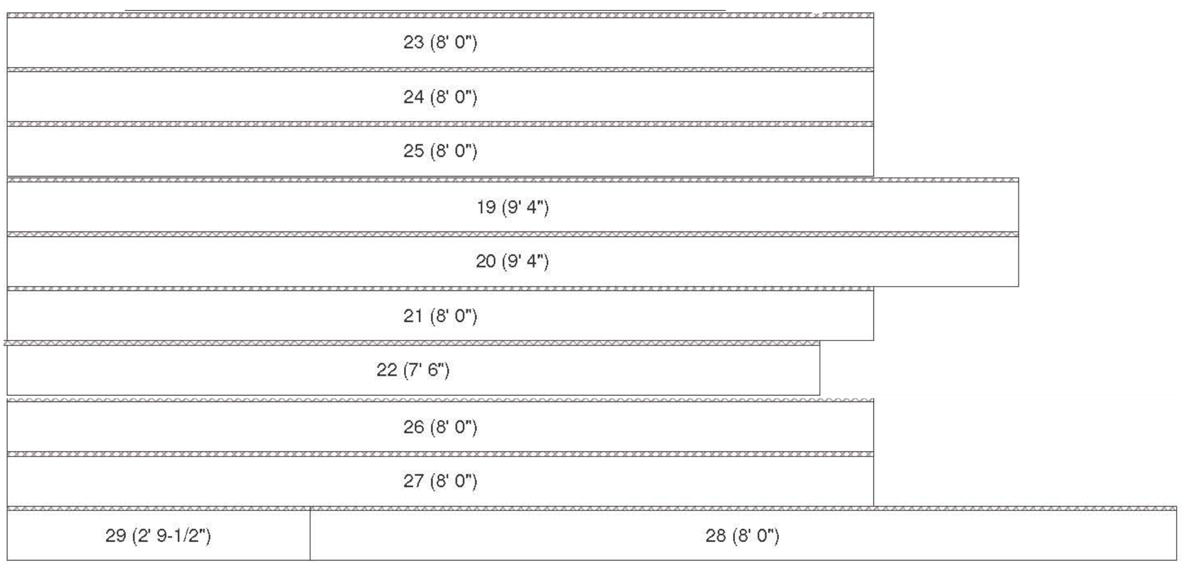
M5-1: Panel Designer



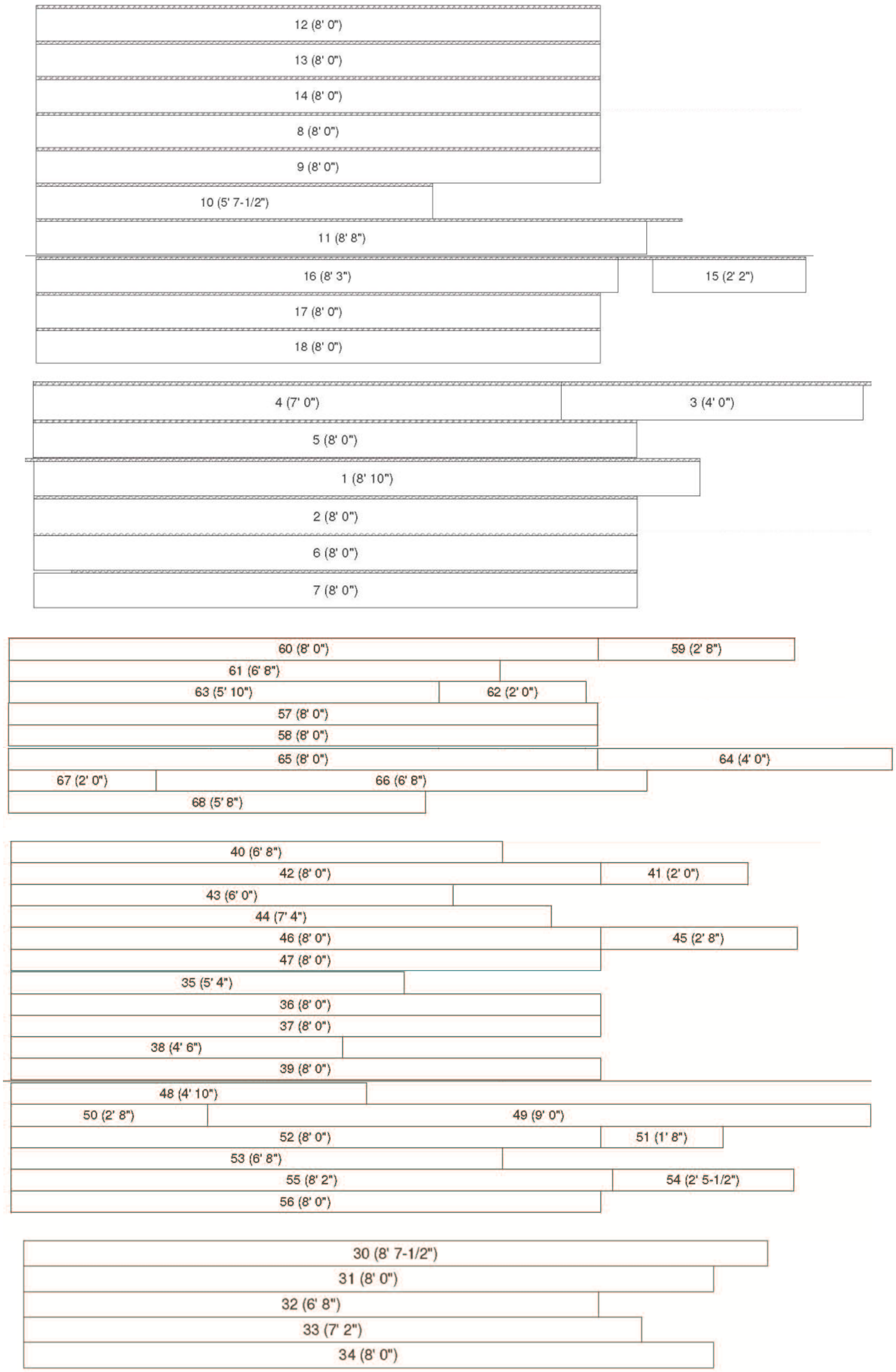
M5-1: Panel Designer



M5-1: IntelliBuild



M5-1: IntelliBuild



M5-1: Proposed algorithm

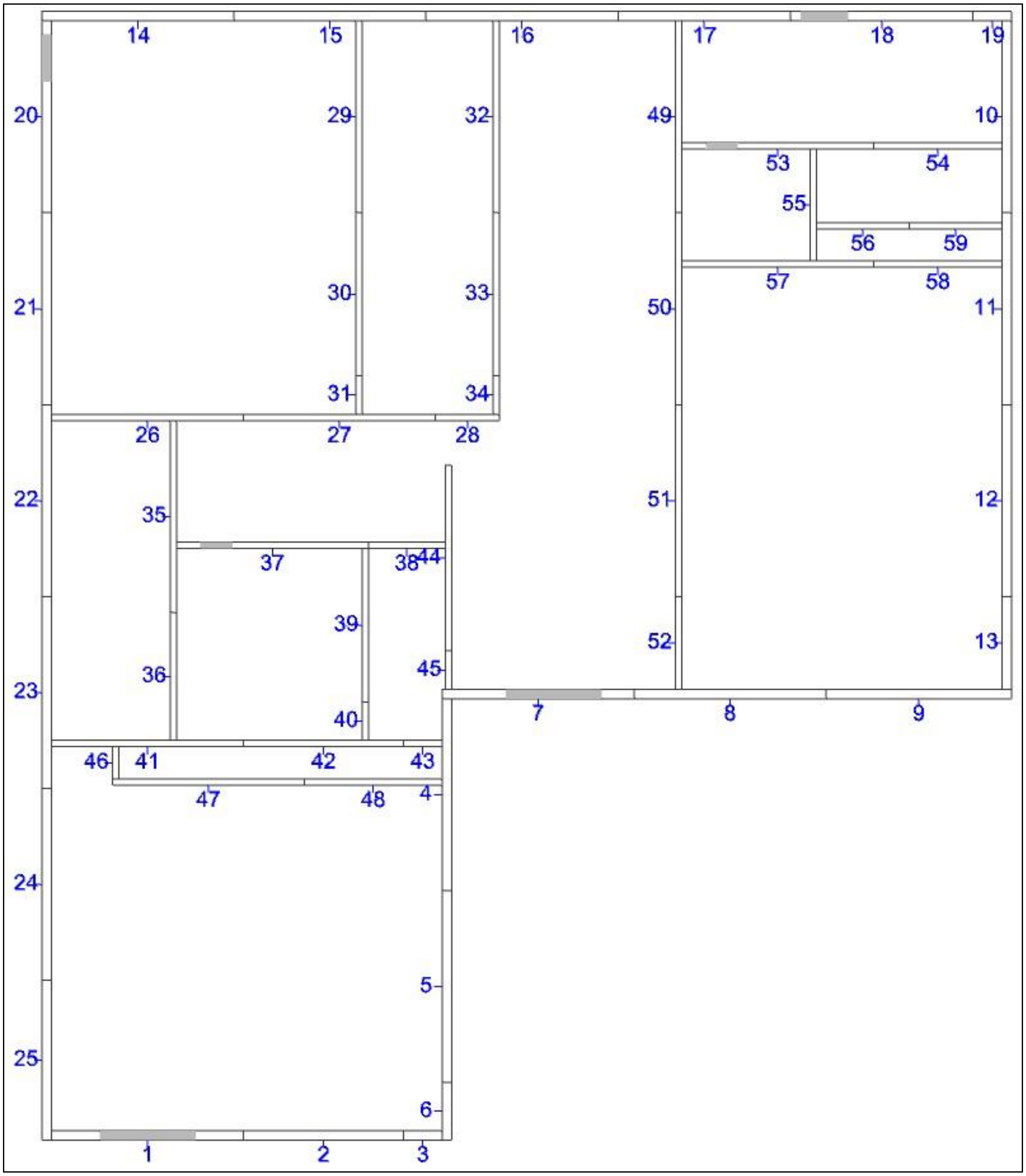
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	222.0
3	384.0

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	52.5	13	1	1	16	2
							2	1	17	2
							3	1	22	1
							4	1	23	1
							5	1	24	1
							6	1	25	1
							7	1	26	1
							8	1	27	1
							9	2	29 28	1 1
							10	1	30	2
							11	1	31	2
							12	1	39	1
							13	1	42	2
2	1	A	RIGHT	114.0	52.5	4	1	2	41 40	1 1
							2	1	46	2
							3	2	51 47	1 2
							4	1	1	3
3	2	A	RIGHT	330.0	52.5	13	1	1	18	2
							2	1	19	2
							3	1	33	1
							4	1	36	1
							5	1	34	1
							6	1	37	1
							7	2	38 35	1 1
							8	1	32	2
							9	1	43	2
							10	1	44	1
							11	2	50 49	1 1
							12	2	45	1
							13	1	48	2
4	2	B	LEFT	330.0	94.5	7	1	1	2	3
							2	1	3	3
							3	1	6	1
							4	1	5	2
							5	1	4	2
							6	1	52	2
							7	2	53 54	1 1
5	3	A	RIGHT	492.0	92.5	17	1	1	20	2
							2	1	21	2
							3	1	11	2
							4	1	12	2
							5	1	13	2
							6	2	15 14	2 2
							7	1	7	2
							8	1	8	2
							9	1	9	2
							10	1	10	2
							11	1	55	2
							12	1	60	2
							13	2	62 61	2 2
							14	1	56	2
							15	2	64 63	2 2
							16	1	68	2
							17	1	65	2
6	3	A	RIGHT	492.0	92.5	3	1	2	67 66	2 2
							2	1	57	1
							3	2	59 58	2 1

M5-2



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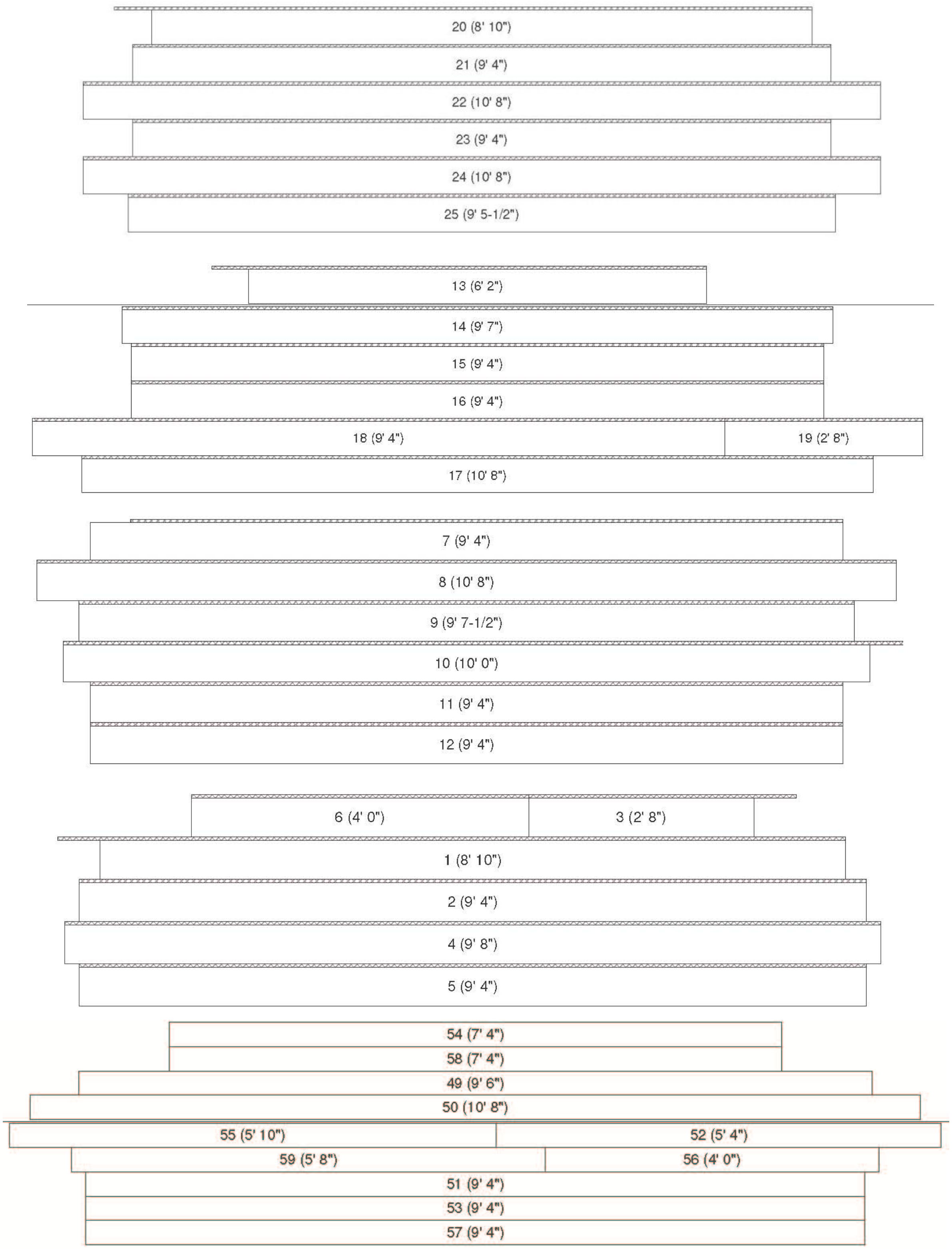
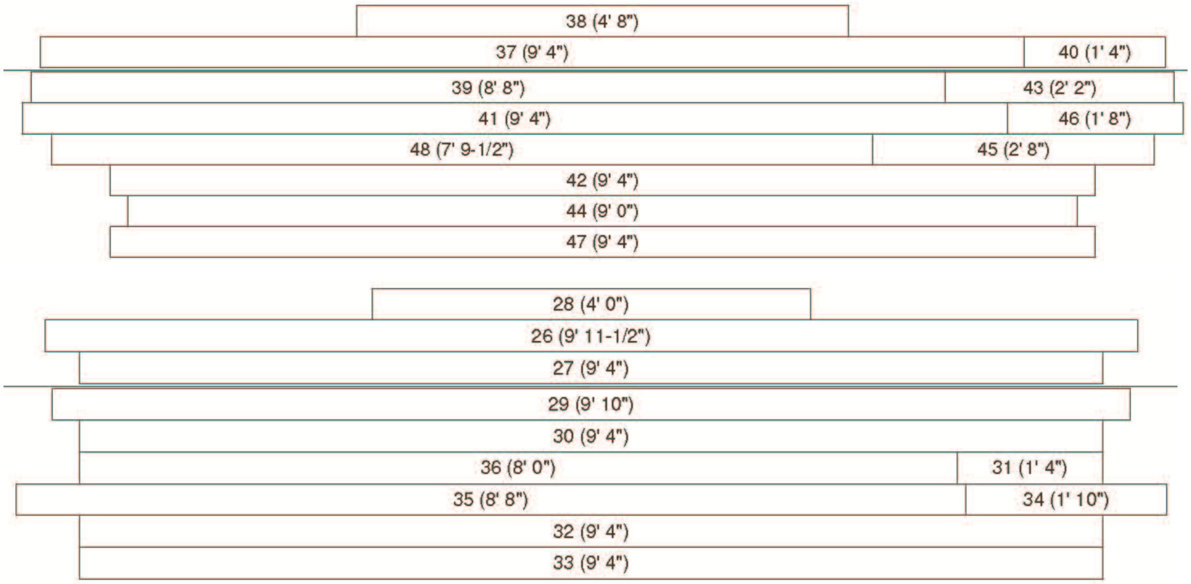
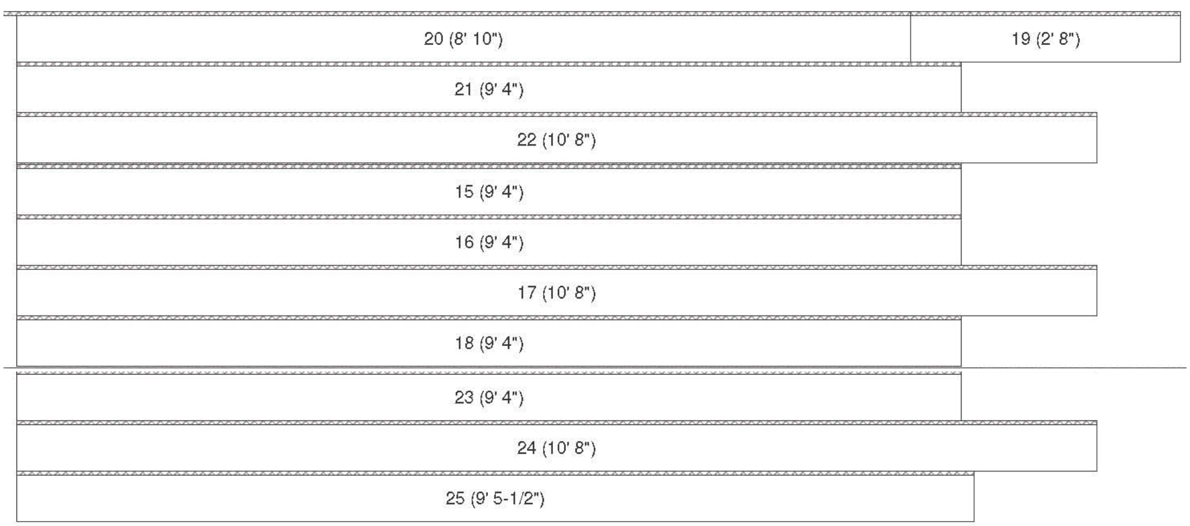
M5-2: Panel Designer



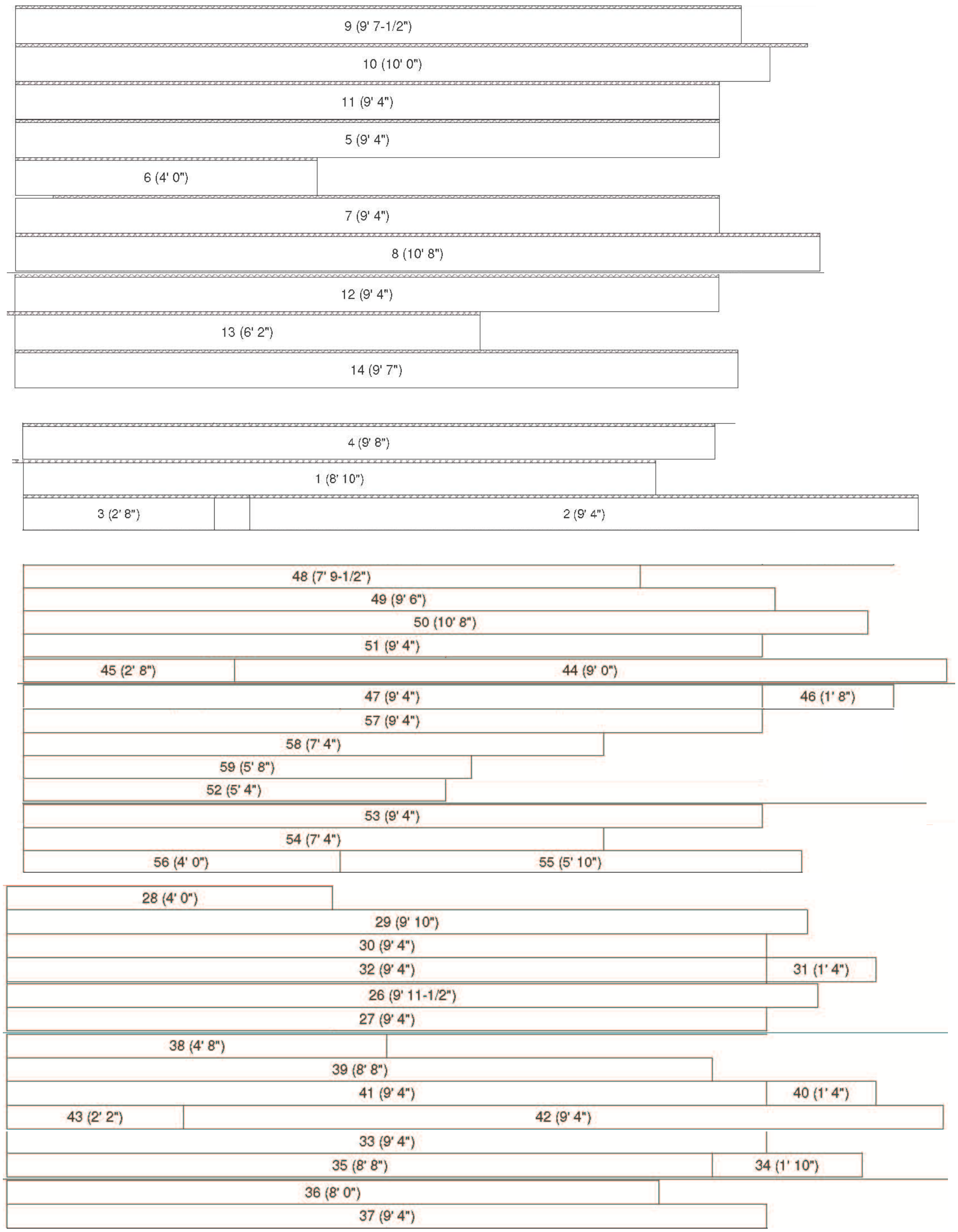
M5-2: Panel Designer



M5-2: IntelliBuild



M5-2: IntelliBuild



M5-2: Proposed algorithm

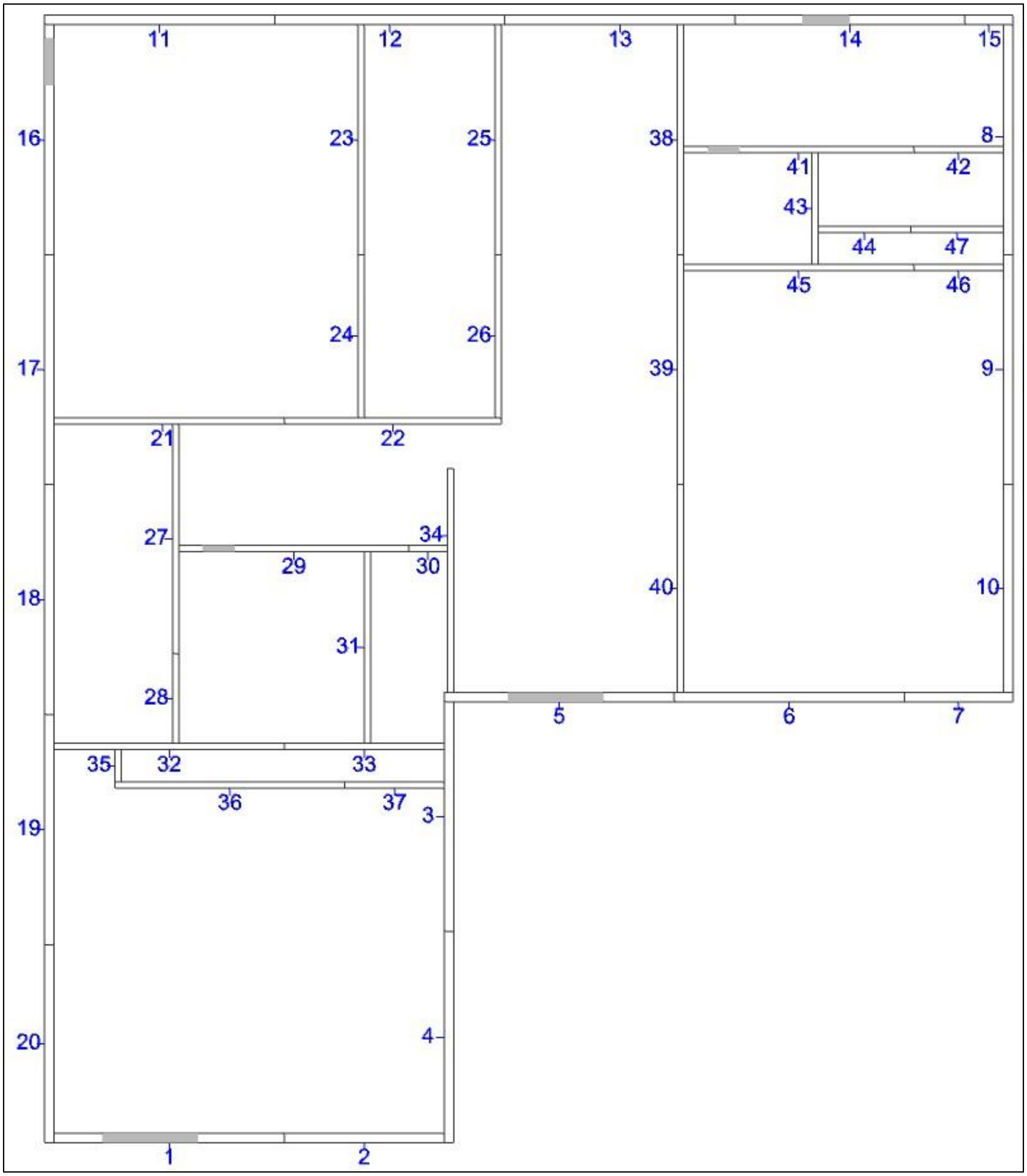
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	212.0
3	384.0

** NStacks
6

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	14	1	1	14	2
							2	1	20	1
							3	1	21	1
							4	1	22	1
							5	1	23	1
							6	1	24	1
							7	1	25	1
							8	1	26	2
							9	1	35	1
							10	1	37	2
							11	1	36	1
							12	2	40 39	1 1
							13	2	46 41	1 2
							14	1	47	2
2	1	A	RIGHT	114.0	48.0	1	1	1	1	3
3	2	A	RIGHT	330.0	98.0	11	1	1	15	2
							2	1	16	2
							3	1	29	1
							4	1	32	1
							5	1	30	1
							6	2	31 33	1 1
							7	2	27 34	2 1
							8	2	38 28	2 2
							9	2	45 44	1 1
							10	2	43 42	2 2
							11	1	48	2
4	2	B	LEFT	330.0	98.0	5	1	2	2 3	3 3
							2	1	6	1
							3	1	5	2
							4	1	4	1
							5	1	7	2
5	3	A	RIGHT	492.0	98.0	15	1	1	17	2
							2	2	19 18	2 2
							3	1	10	2
							4	1	11	2
							5	1	12	2
							6	1	13	2
							7	1	8	2
							8	1	9	2
							9	1	49	2
							10	1	53	2
							11	1	54	2
							12	1	50	2
							13	2	56 55	2 2
							14	1	59	2
							15	1	57	2
6	3	A	RIGHT	492.0	98.0	3	1	1	58	2
							2	1	51	1
							3	1	52	2

M5-3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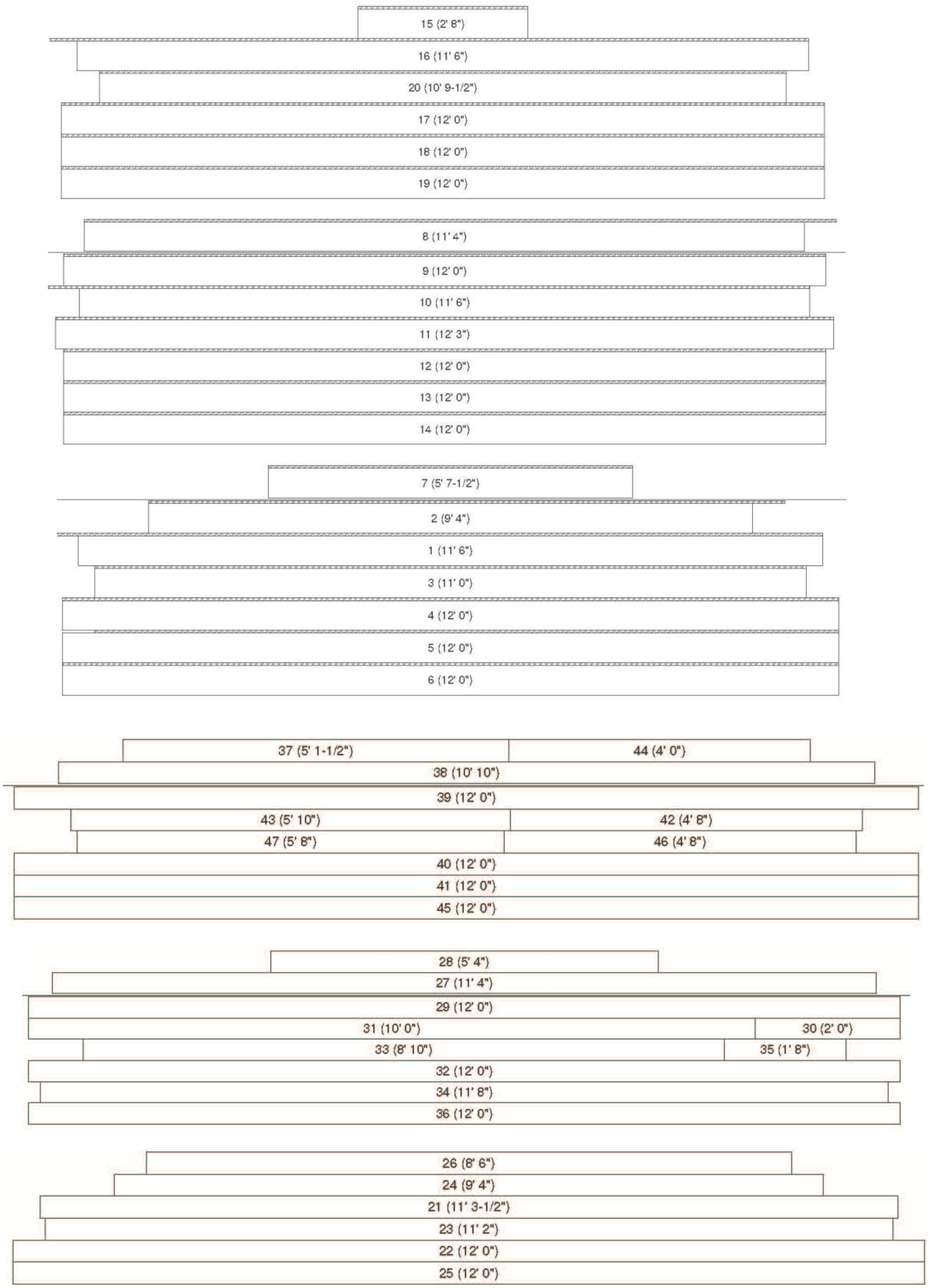
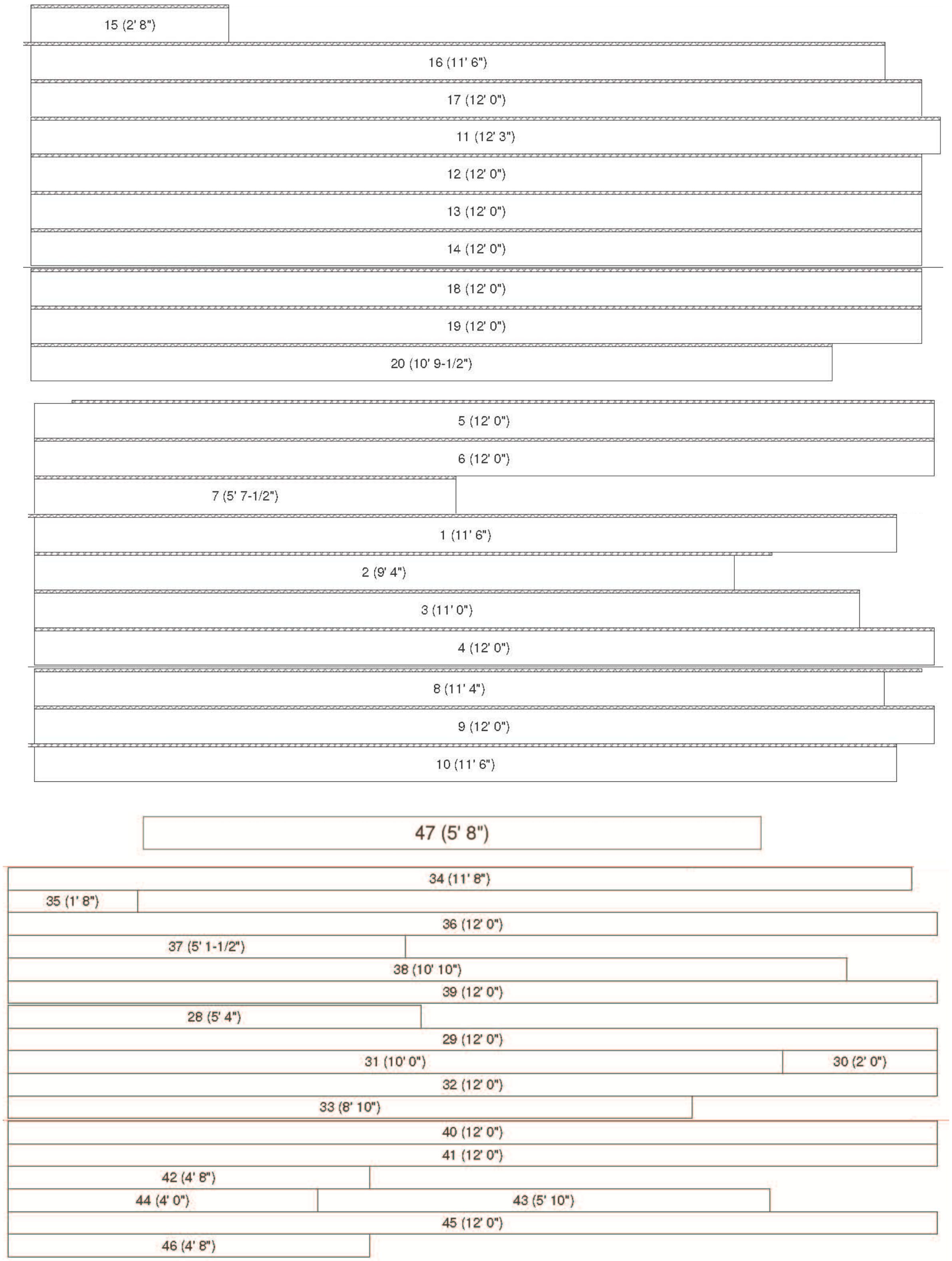
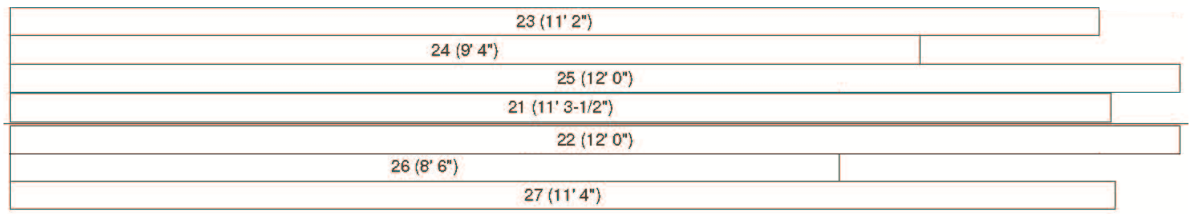
M5-3: Panel Designer



M5-3: IntelliBuild



M5-3: IntelliBuild



M5-3: Proposed algorithm

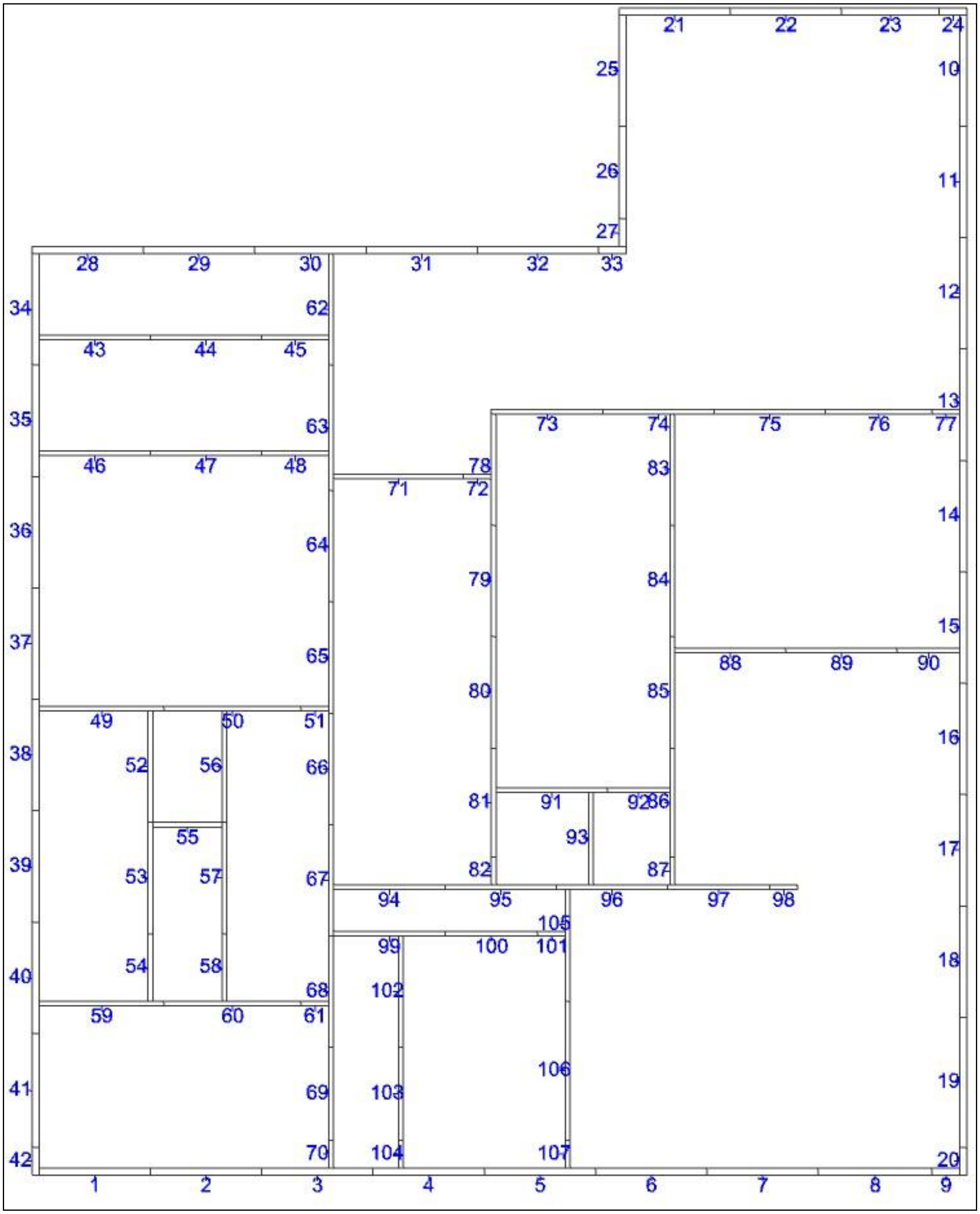
** Nzones
3

**zone	left edge X coordinate
1	6.0
2	226.5
3	379.5

** NStacks
4

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	11	1	1	11	2
							2	1	16	1
							3	1	17	1
							4	1	18	1
							5	1	19	1
							6	1	20	1
							7	1	21	2
							8	1	27	1
							9	1	28	1
							10	1	32	2
							11	1	1	3
2	2	A	RIGHT	336.7	97.3	14	1	1	12	2
							2	1	13	2
							3	1	23	1
							4	1	25	1
							5	1	38	1
							6	1	24	1
							7	1	26	1
							8	1	22	2
							9	1	29	2
							10	2	31 30	1 2
							11	1	34	1
							12	1	39	1
							13	1	40	1
							14	1	33	2
3	2	B	LEFT	336.7	129.3	6	1	1	2	3
							2	1	4	1
							3	1	3	1
							4	2	5 35	2 1
							5	1	36	2
							6	1	37	2
4	3	A	RIGHT	489.8	97.3	12	1	1	14	2
							2	1	15	2
							3	1	8	1
							4	1	9	1
							5	1	10	1
							6	1	6	2
							7	1	7	2
							8	1	41	2
							9	2	43 42	1 2
							10	2	47 44	2 2
							11	1	45	2
							12	1	46	2

L1-1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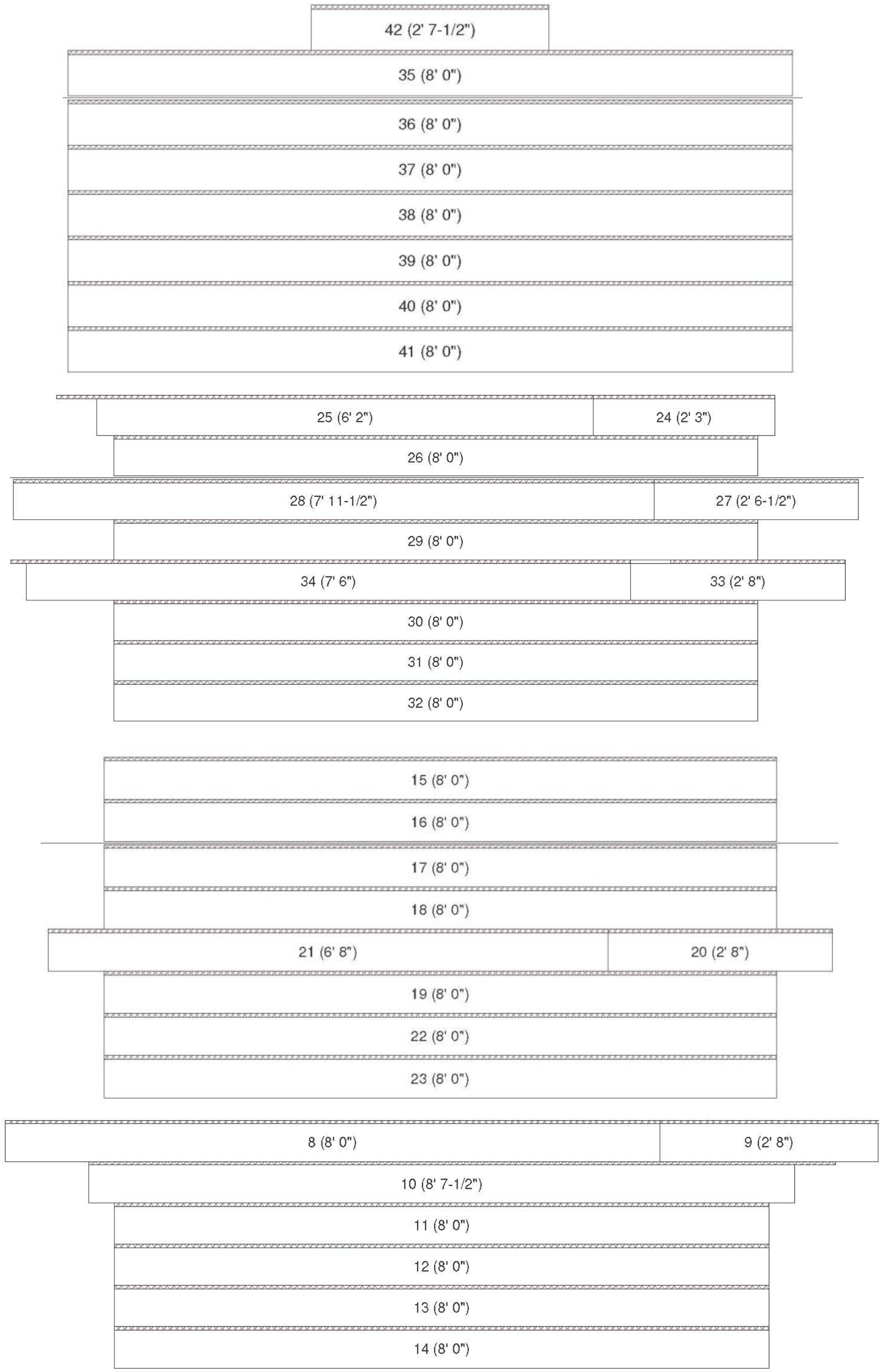
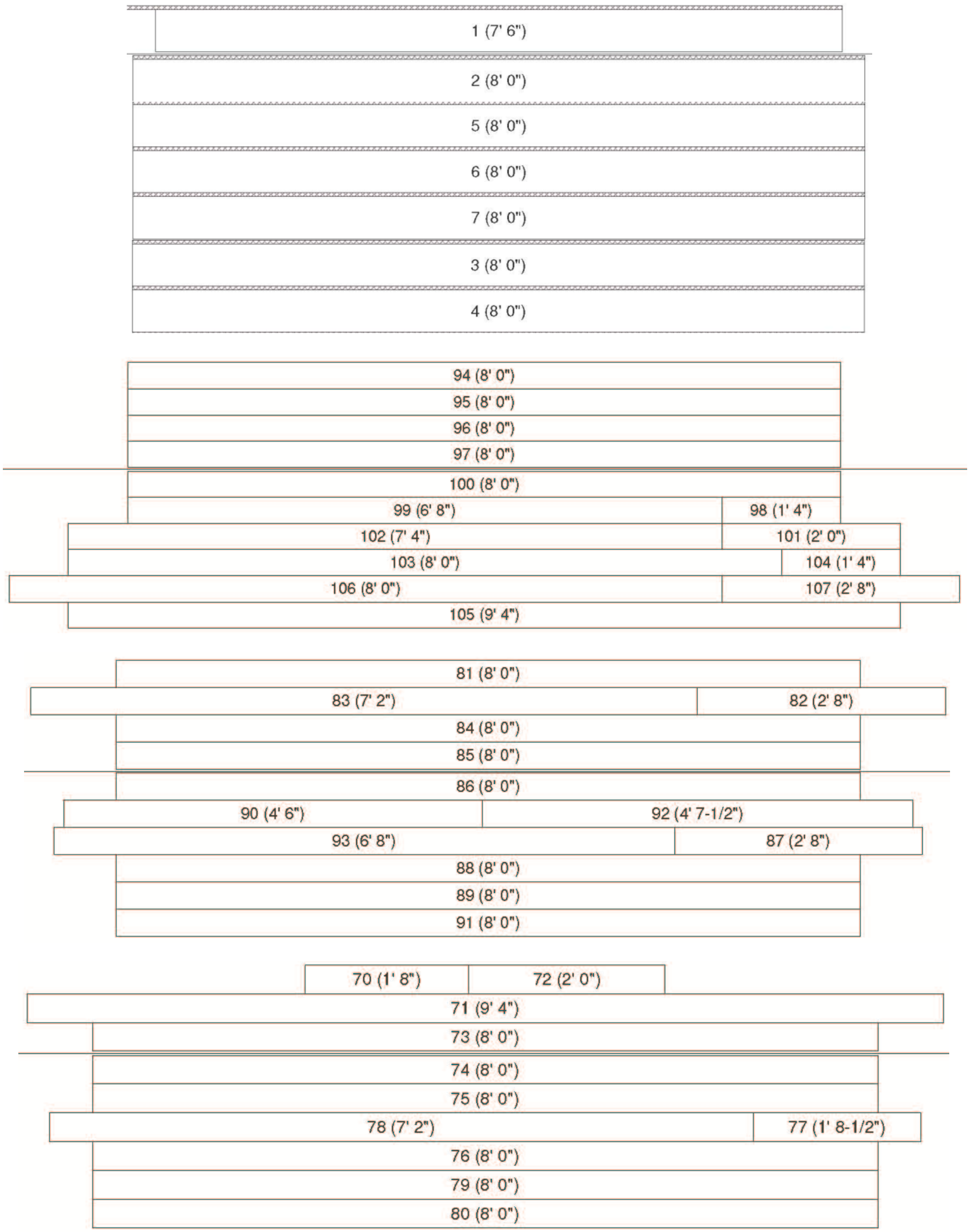
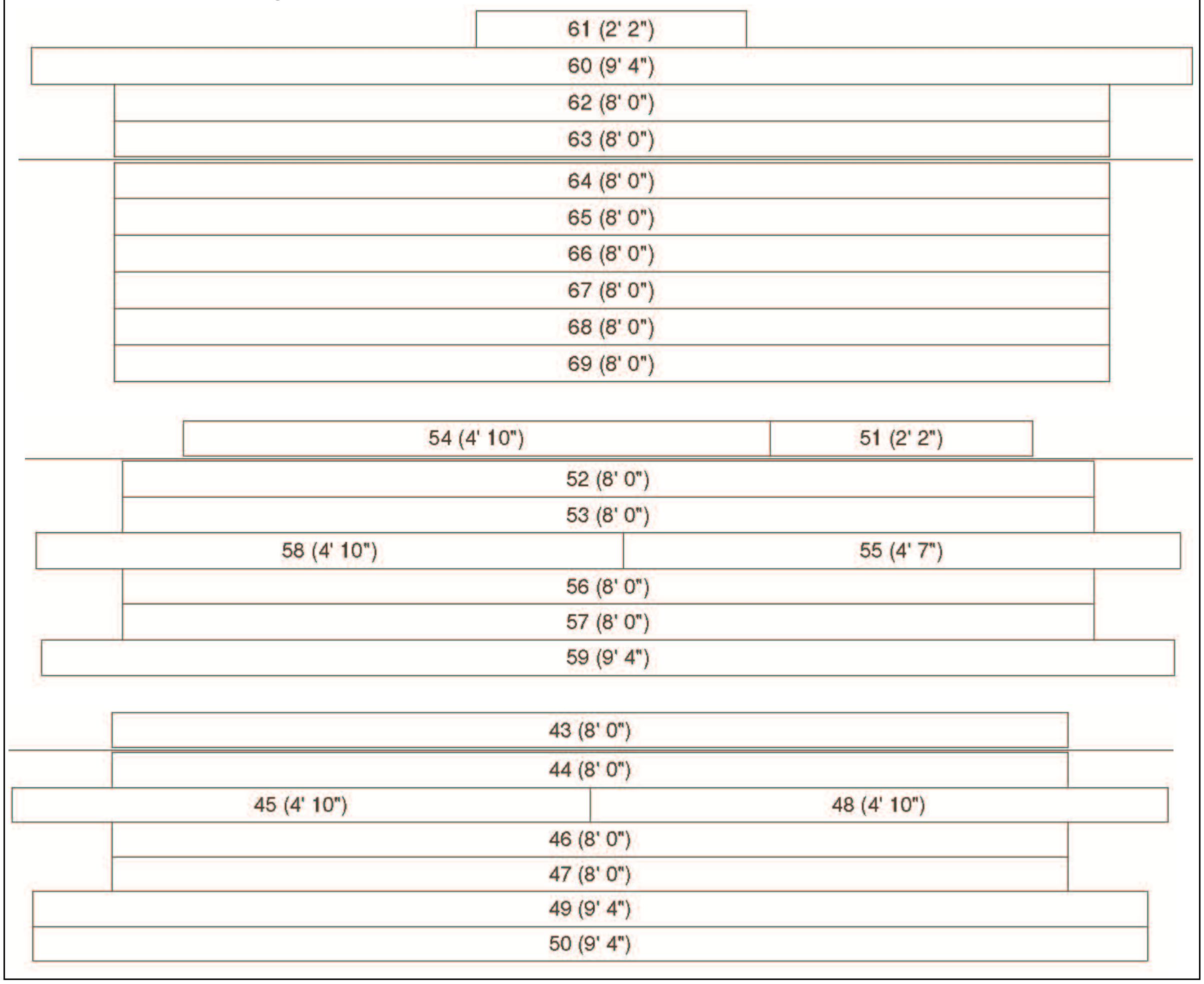
L1-1: Panel Designer



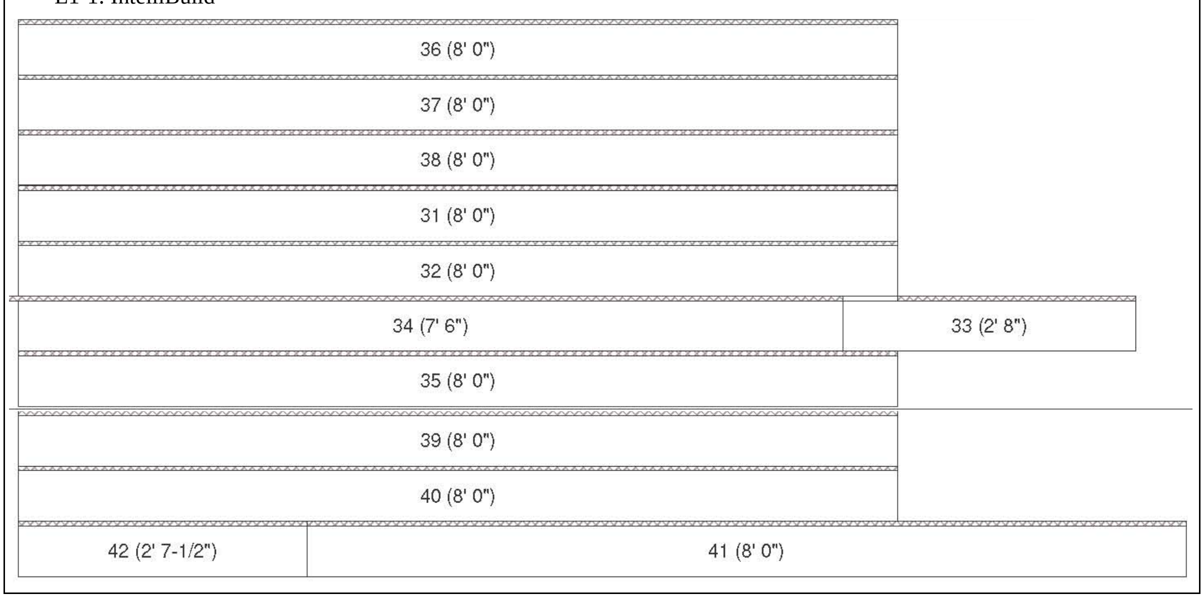
L1-1: Panel Designer



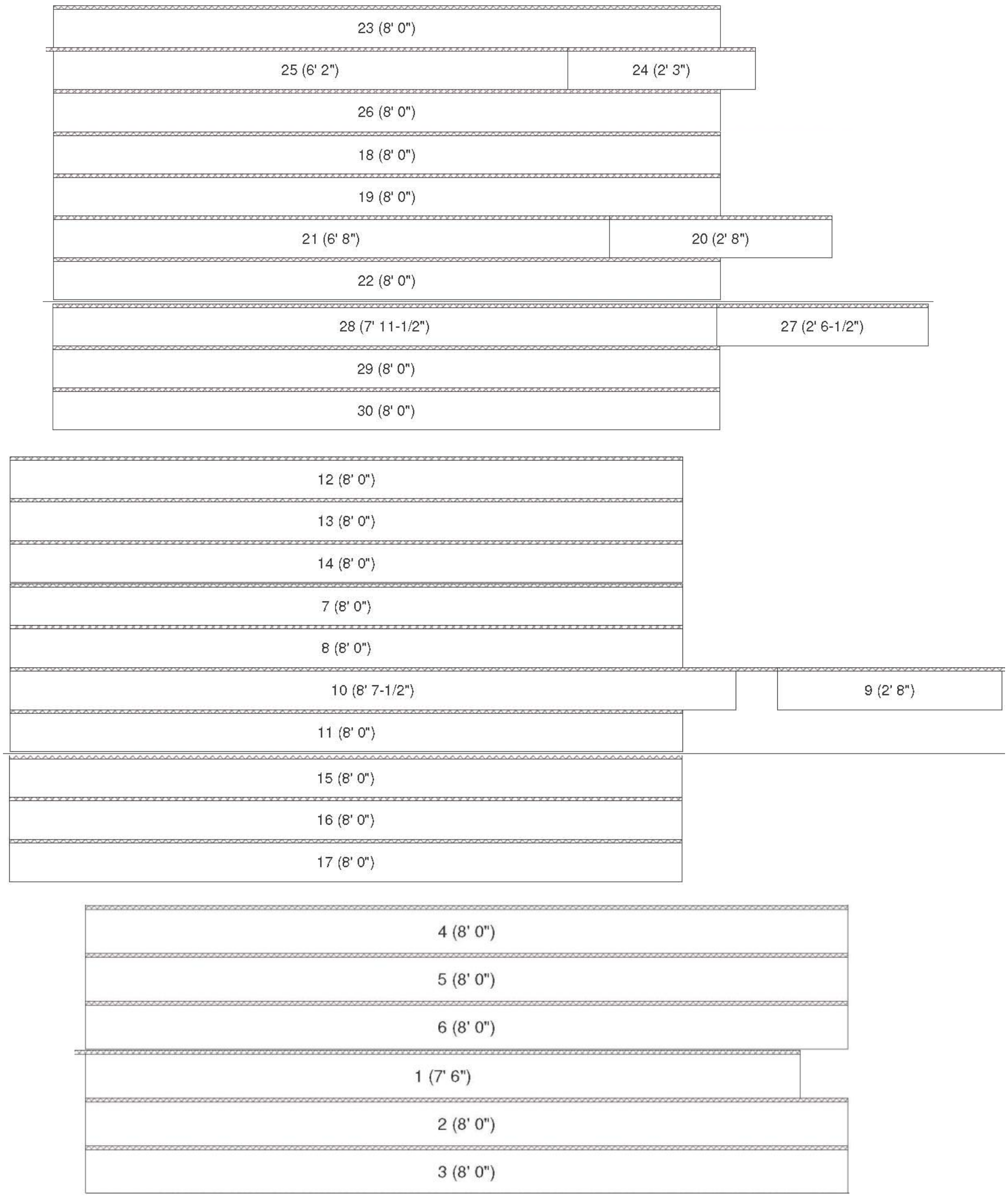
L1-1: Panel Designer



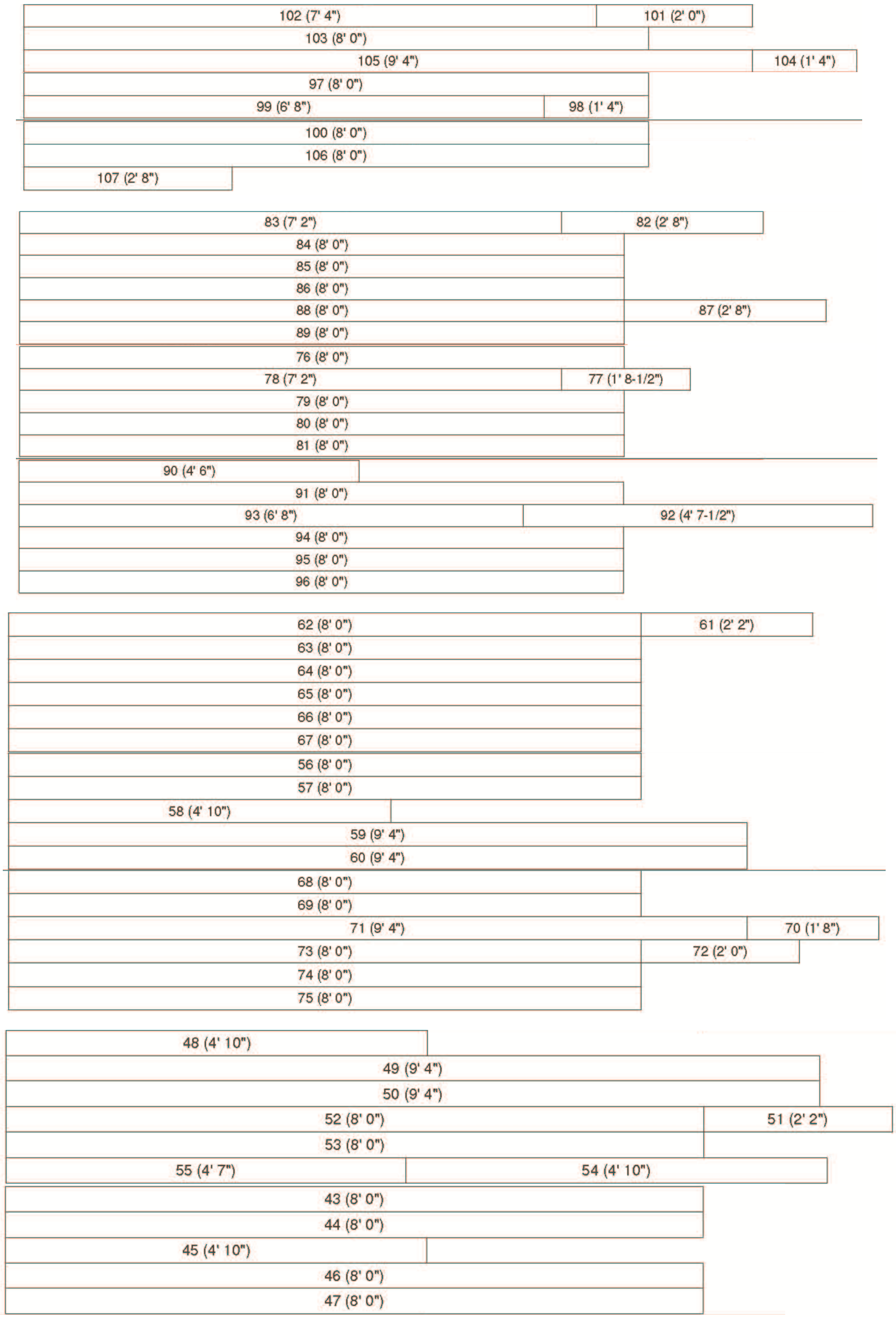
L1-1: IntelliBuild



L1-1: IntelliBuild



L1-1: IntelliBuild

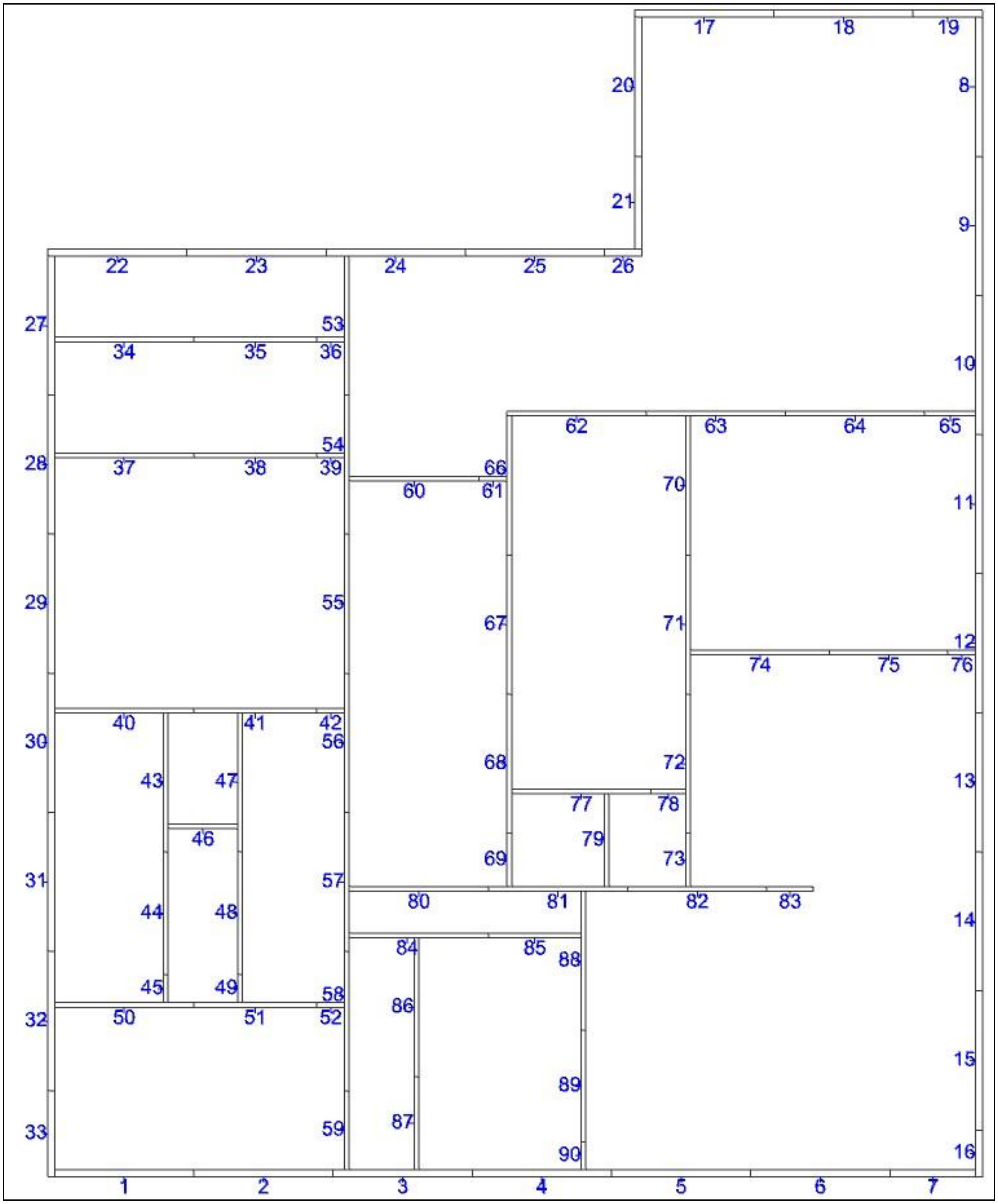


```
L1-1: Proposed algorithm
** Nzones 4
**zone       left edge X coordinate
 1              6.0
 2            212.0
 3            438.0
 4            584.0
** NStacks 8
** stack                  flush
**    #    zone type    edge     xloc    yloc   #layers   j   #panels   panels      orientation
      1     1     A     RIGHT   114.0   48.0      12          1         1    28              2
                                                              2         1    29              2
                                                              3         1    34              1
                                                              4         1    35              1
                                                              5         1    36              1
                                                              6         1    37              1
                                                              7         1    38              1
                                                              8         1    39              1
                                                              9         1    40              1
                                                             10         2    42 41           1 1
                                                             11         1    43              2
                                                             12         1    44              2
      2     1     A     RIGHT   114.0   48.0       6          1         1    46              2
                                                              2         1    47              2
                                                              3         1    49              2
                                                              4         1    52              1
                                                              5         1    55              2
                                                              6         1    1               3
      3     2     A     RIGHT   330.0   48.0      16          1         1    30              2
                                                              2         1    31              2
                                                              3         1    45              2
                                                              4         1    62              1
                                                              5         1    48              2
                                                              6         1    63              1
                                                              7         2    72 71           2 2
                                                              8         1    64              1
                                                              9         1    78              1
                                                             10         2    51 50           2 2
                                                             11         1    56              1
                                                             12         1    65              1
                                                             13         1    79              1
                                                             14         1    66              1
                                                             15         1    80              1
                                                             16         2    82 81           1 1
      4     2     B     LEFT    330.0   90.0       7          1         1    2               3
                                                              2         1    3               3
                                                              3         1    4               3
                                                              4         1    53              1
                                                              5         1    57              1
                                                              6         2    54 58           1 1
                                                              7         1    59              3
      5     3     A     RIGHT   546.0   48.0      13          1         2    33 32           2 2
                                                              2         1    73              2
                                                              3         1    74              2
                                                              4         1    83              1
                                                              5         1    84              1
                                                              6         1    85              1
                                                              7         1    88              2
                                                              8         1    91              2
                                                              9         2    93 92           1 2
                                                             10         2    87 86           1 1
                                                             11         1    95              2
                                                             12         1    96              2
                                                             13         1    97              2
      6     3     B     LEFT    692.0   90.0      14          1         1    5               3
                                                              2         1    6               3
                                                              3         1    67              1
                                                              4         1    94              2
                                                              5         1    99              2
                                                              6         2    100 101         2 2
                                                              7         2    60 61           3 3
                                                              8         1    68              1
                                                              9         1    102             1
                                                             10         1    105             1
                                                             11         1    69              1
                                                             12         1    103             1
                                                             13         2    106 70          1 1
                                                             14         2    104 107         1 1
```

L1-1: Proposed algorithm

7	4	A	RIGHT	692.0	48.0	17	1	2	26 27	2 2
							2	1	25	2
							3	1	21	2
							4	1	22	2
							5	2	24 23	2 2
							6	1	10	2
							7	1	11	2
							8	1	12	2
							9	1	13	2
							10	1	14	2
							11	2	104 107	2 2
							12	1	16	2
							13	1	17	2
							14	1	18	2
							15	2	20 19	2 2
							16	1	7	3
							17	1	9 8	3 3
8	4	A	RIGHT	692.0	48.0	4	1	1	75	2
							2	2	77 76	2 2
							3	1	89	2
							4	2	98 90	2 3

L1-2



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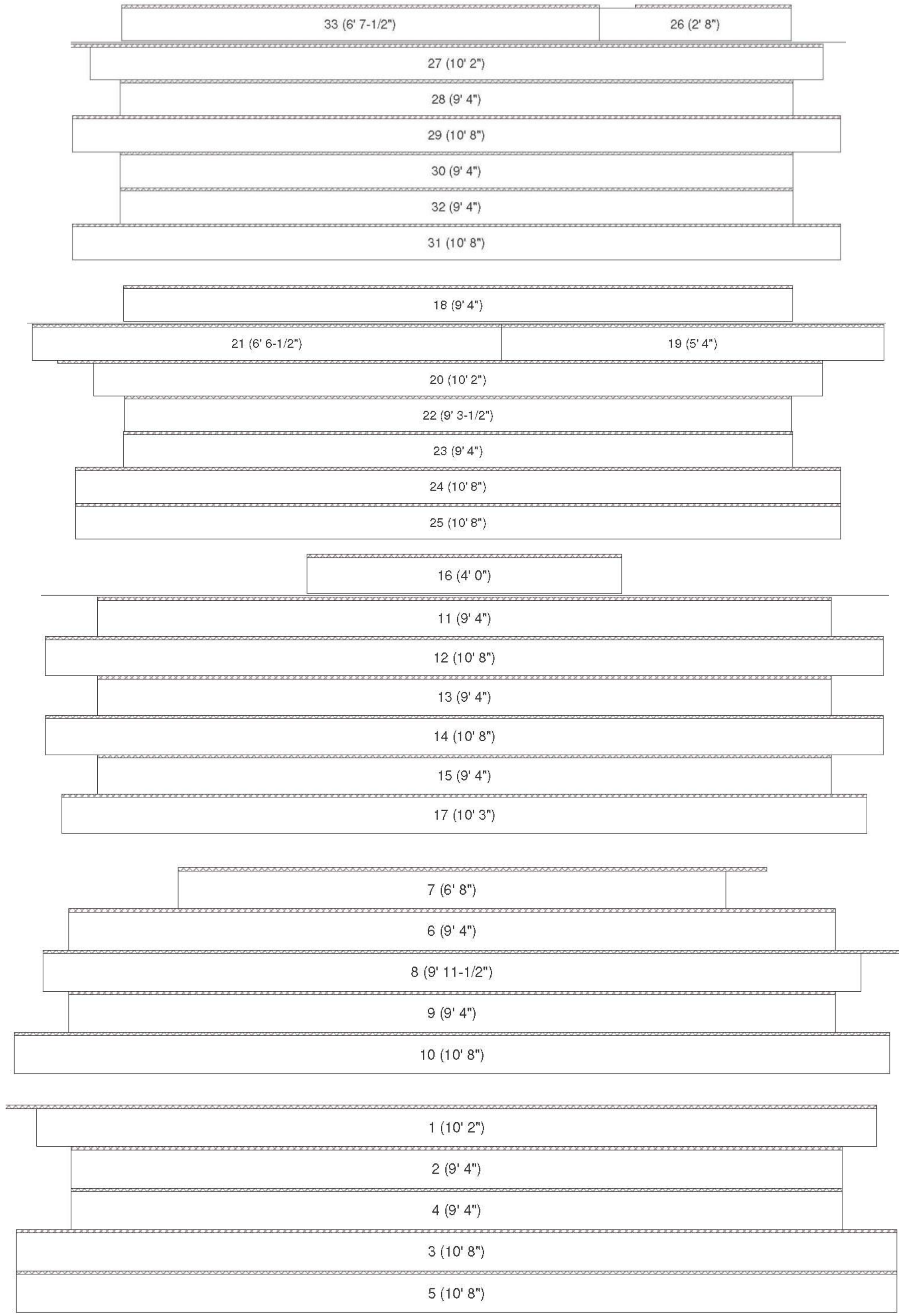
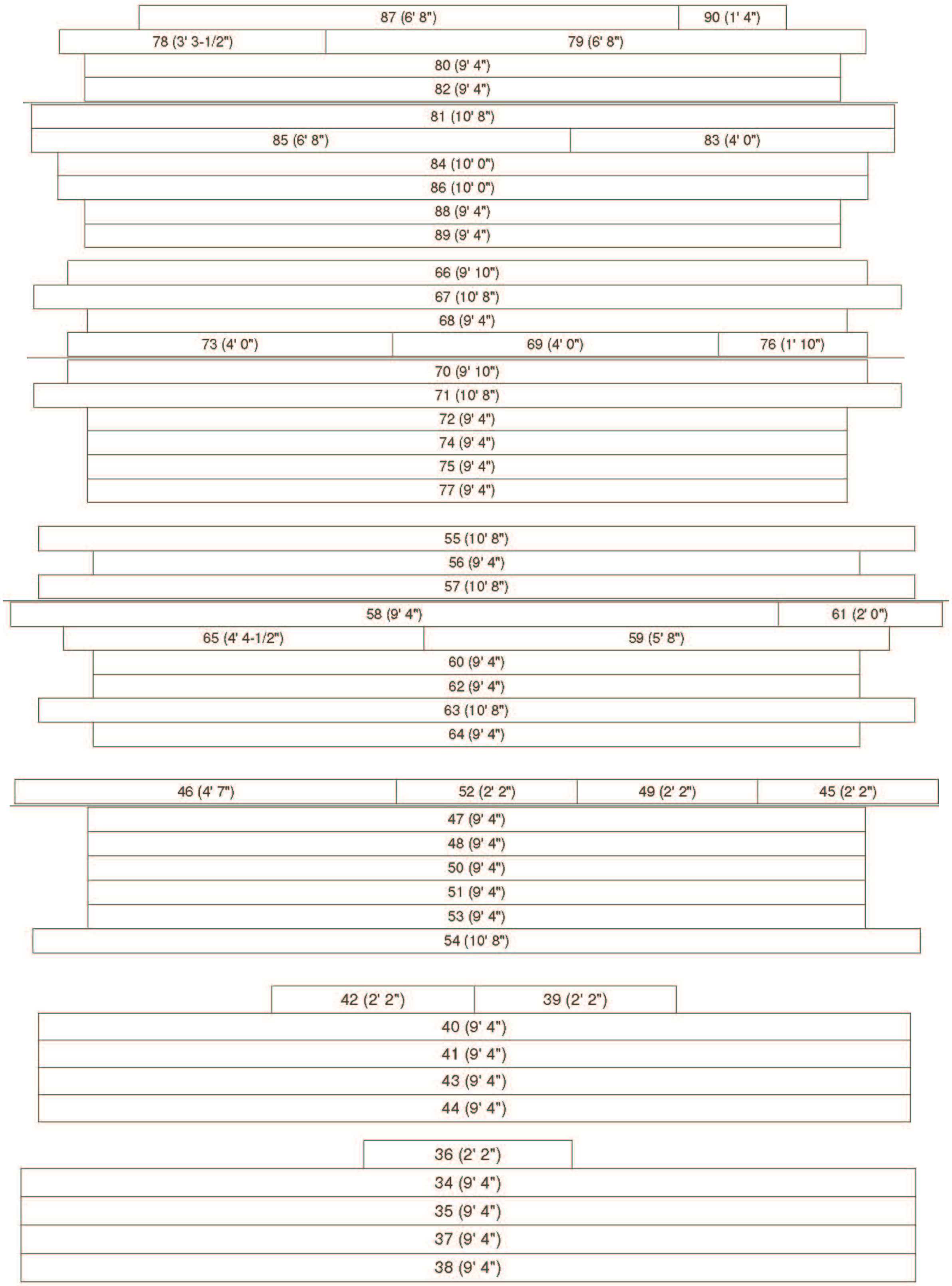
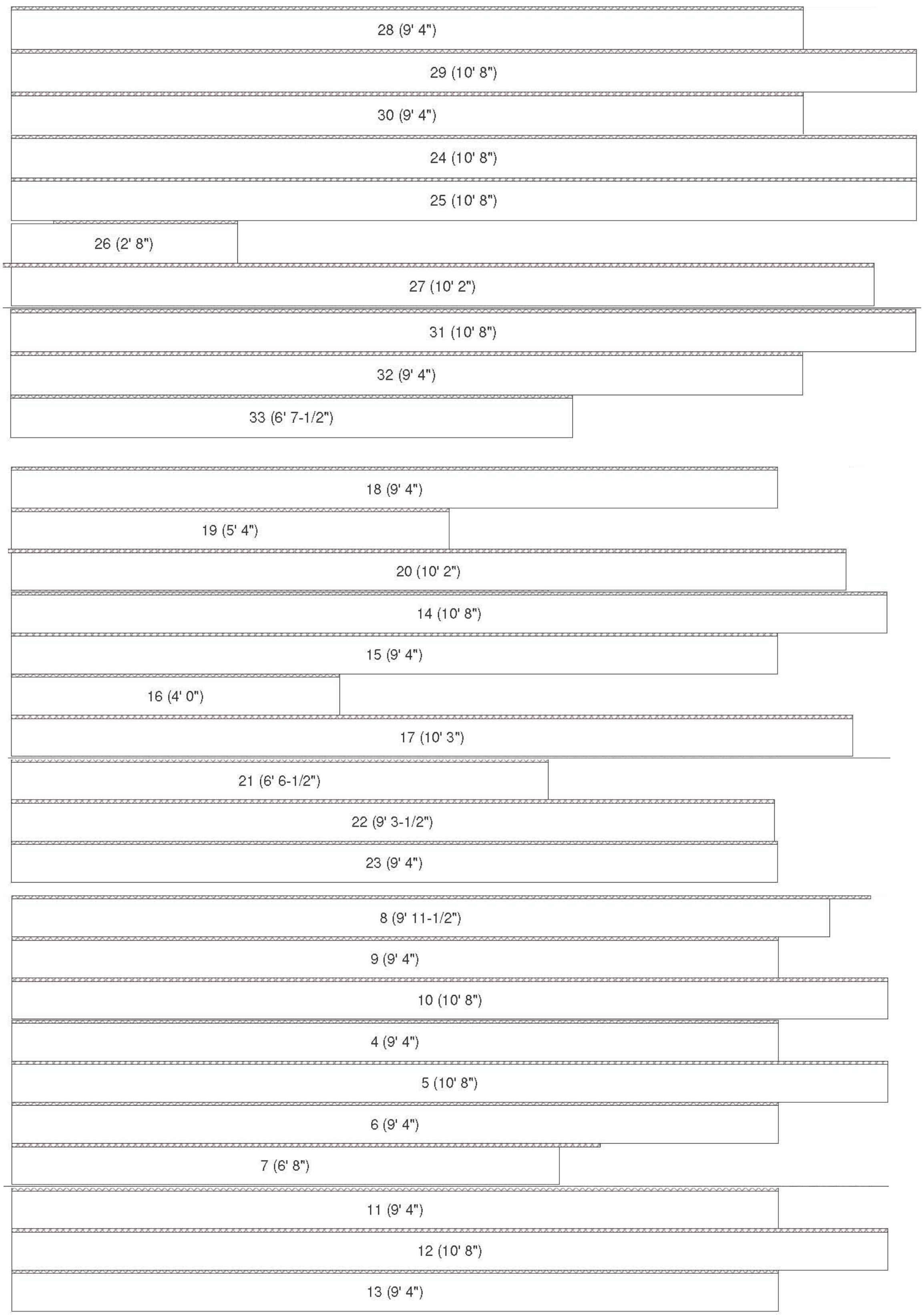
L1-2: Panel Designer



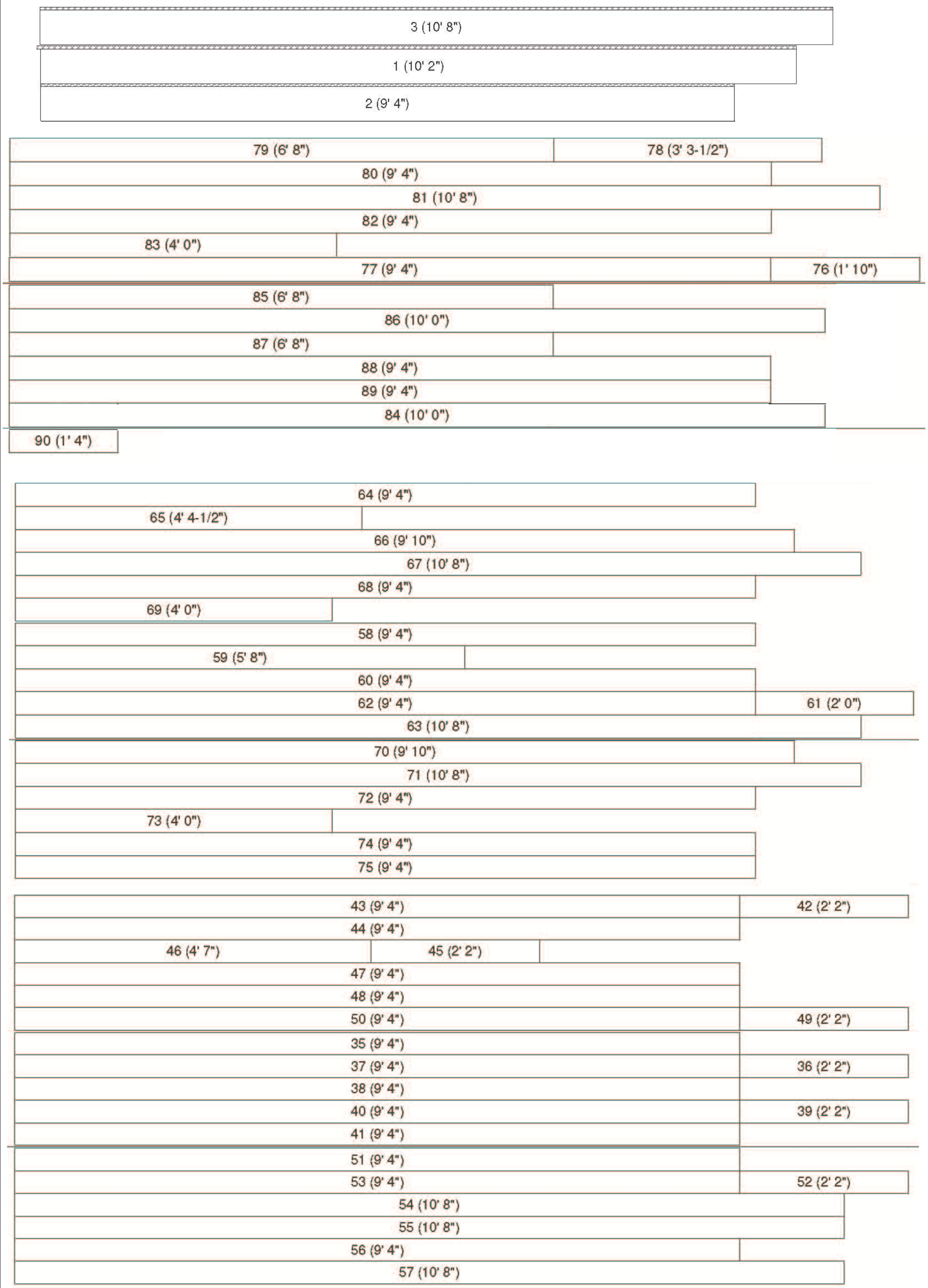
L1-2: Panel Designer



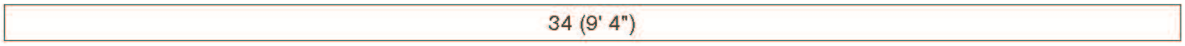
L1-2: IntelliBuild



L1-2: IntelliBuild



L1-2: IntelliBuild



L1-2: Proposed algorithm

** Nzones
4

**zone	left edge X coordinate
1	6.0
2	212.0
3	438.0
4	584.0

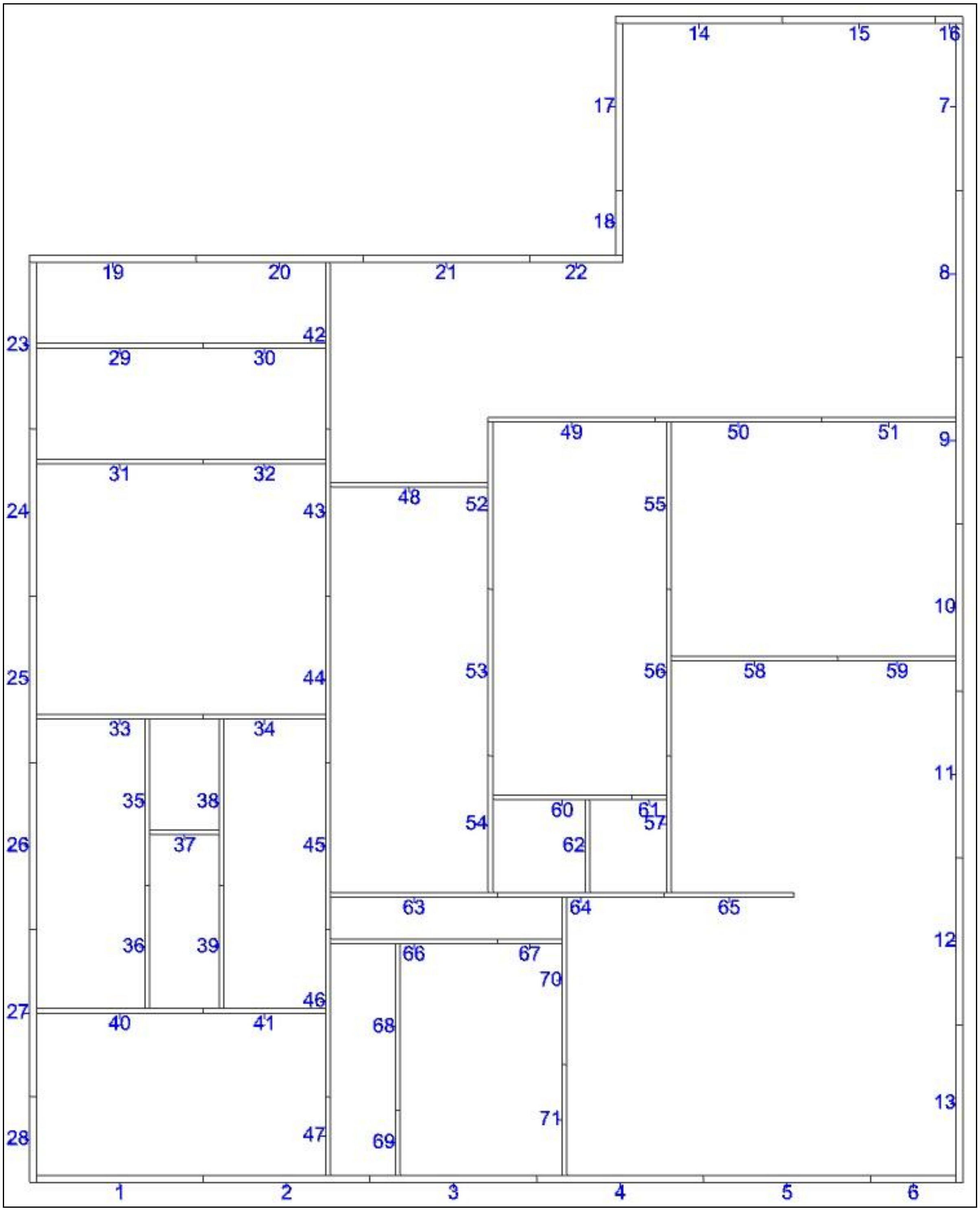
** NStacks
8

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	13	1	1	22	2
							2	1	27	1
							3	1	28	1
							4	1	29	1
							5	1	30	1
							6	1	31	1
							7	1	32	1
							8	1	33	1
							9	1	34	2
							10	1	37	2
							11	1	40	2
							12	1	43	1
							13	1	46	2
2	1	A	RIGHT	114.0	48.0	2	1	1	47	1
							2	1	1	3
3	2	A	RIGHT	330.0	48.0	14	1	1	23	2
							2	1	24	2
							3	2	36 35	2 2
							4	1	53	1
							5	2	39 38	2 2
							6	1	54	1
							7	2	61 60	2 2
							8	1	55	1
							9	1	66	1
							10	2	42 41	2 2
							11	1	56	1
							12	1	67	1
							13	1	68	1
							14	1	69	1
4	2	B	LEFT	330.0	90.0	5	1	1	2	3
							2	1	3	3
							3	1	44	1
							4	2	48 45	1 1
							5	2	49 50	1 3
5	3	A	RIGHT	546.0	48.0	14	1	1	25	2
							2	1	26	2
							3	1	21	1
							4	1	20	2
							5	1	62	2
							6	1	63	2
							7	1	70	1
							8	1	71	1
							9	1	77	2
							10	2	79 78	1 2
							11	1	72	1
							12	1	73	1
							13	1	81	2
							14	1	82	2

L1-2: Proposed algorithm

6	3	B	LEFT	692.0	90.0	13	1	1	4	3
							2	1	5	3
							3	1	57	1
							4	1	80	2
							5	1	84	2
							6	1	85	2
							7	2	51 52	3 3
							8	1	58	1
							9	1	86	1
							10	1	88	1
							11	1	59	1
							12	1	87	1
							13	2	89 90	1 1
7	4	A	RIGHT	692.0	48.0	16	1	1	17	2
							2	1	18	2
							3	1	19	2
							4	1	8	2
							5	1	9	2
							6	1	10	2
							7	1	11	2
							8	1	12	2
							9	1	13	2
							10	1	14	2
							11	1	15	2
							12	1	16	2
							13	1	6	3
							14	1	7	3
							15	1	64	2
							16	1	65	2
8	4	A	RIGHT	692.0	48.0	4	1	1	65	2
							2	1	74	2
							3	2	76 75	2 2
							4	1	83	3

L1-3



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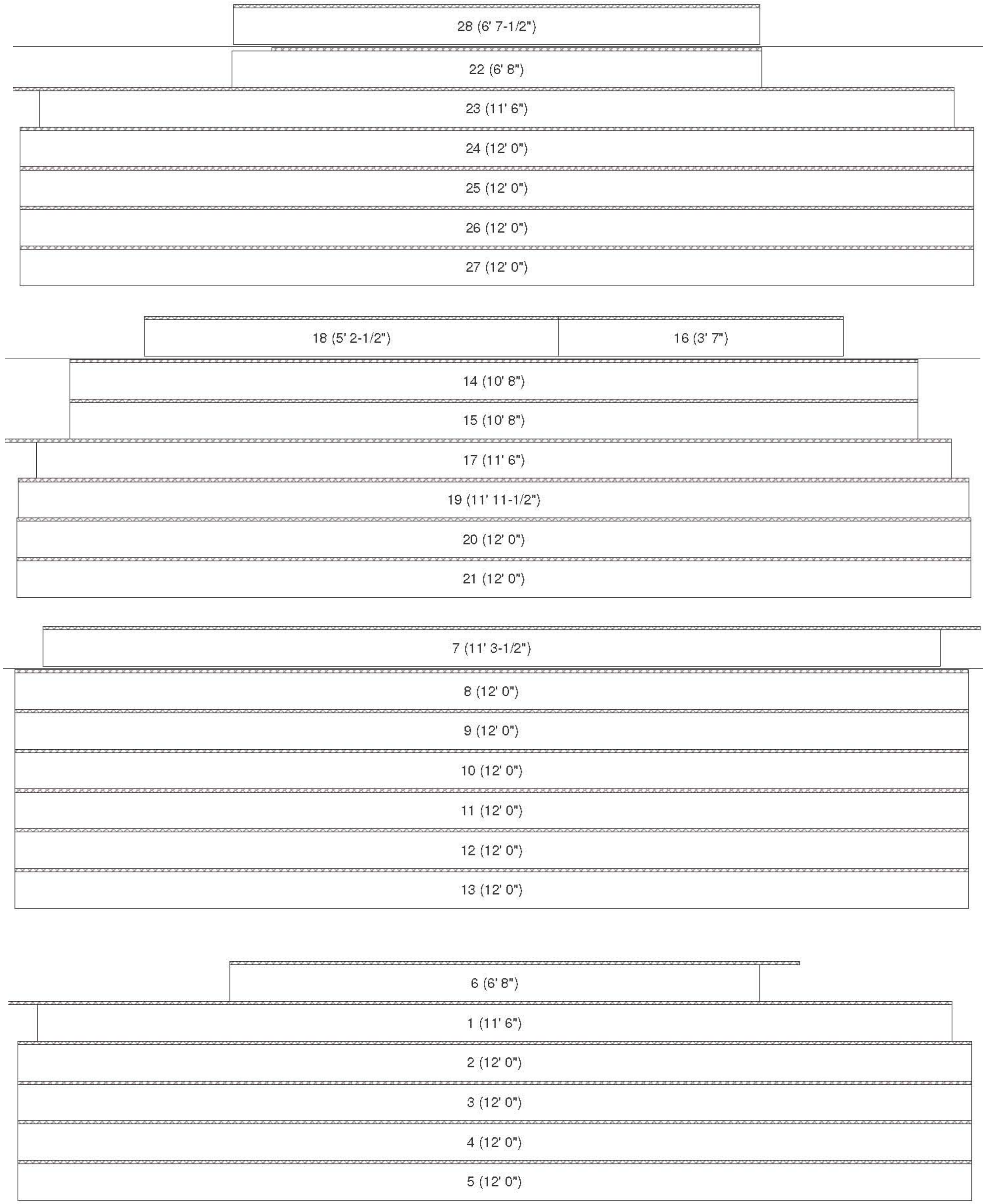
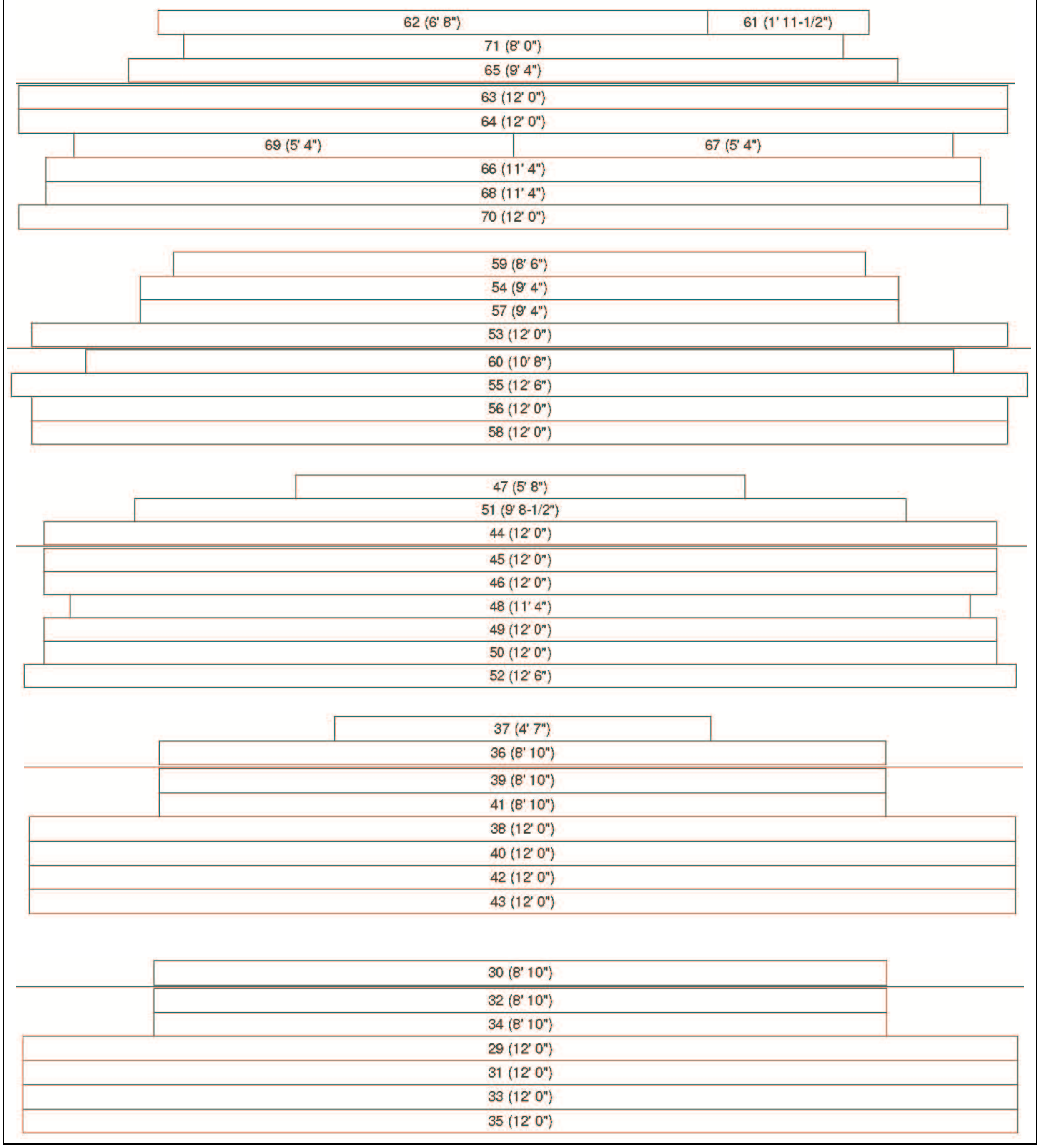
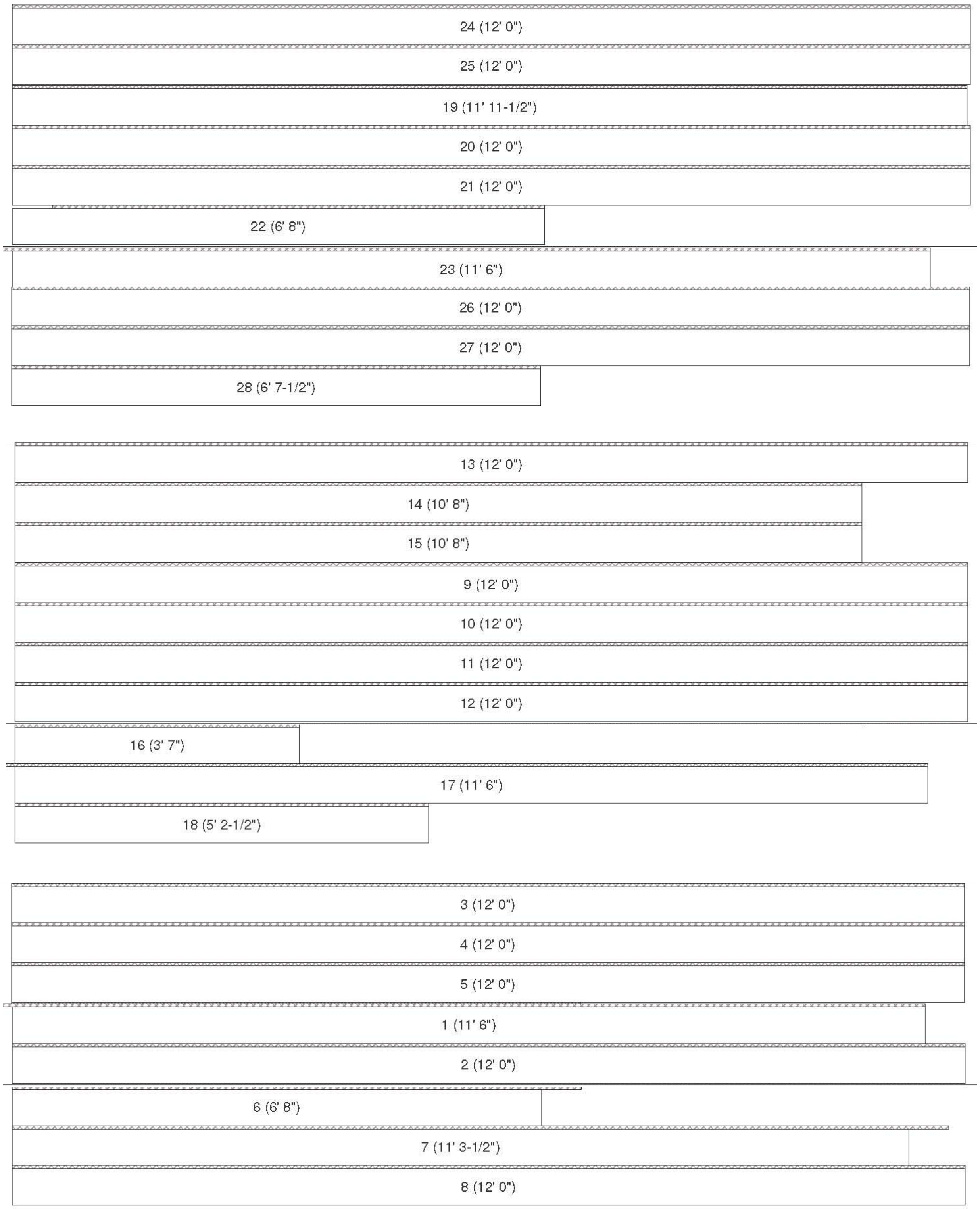
L1-3: Panel Designer



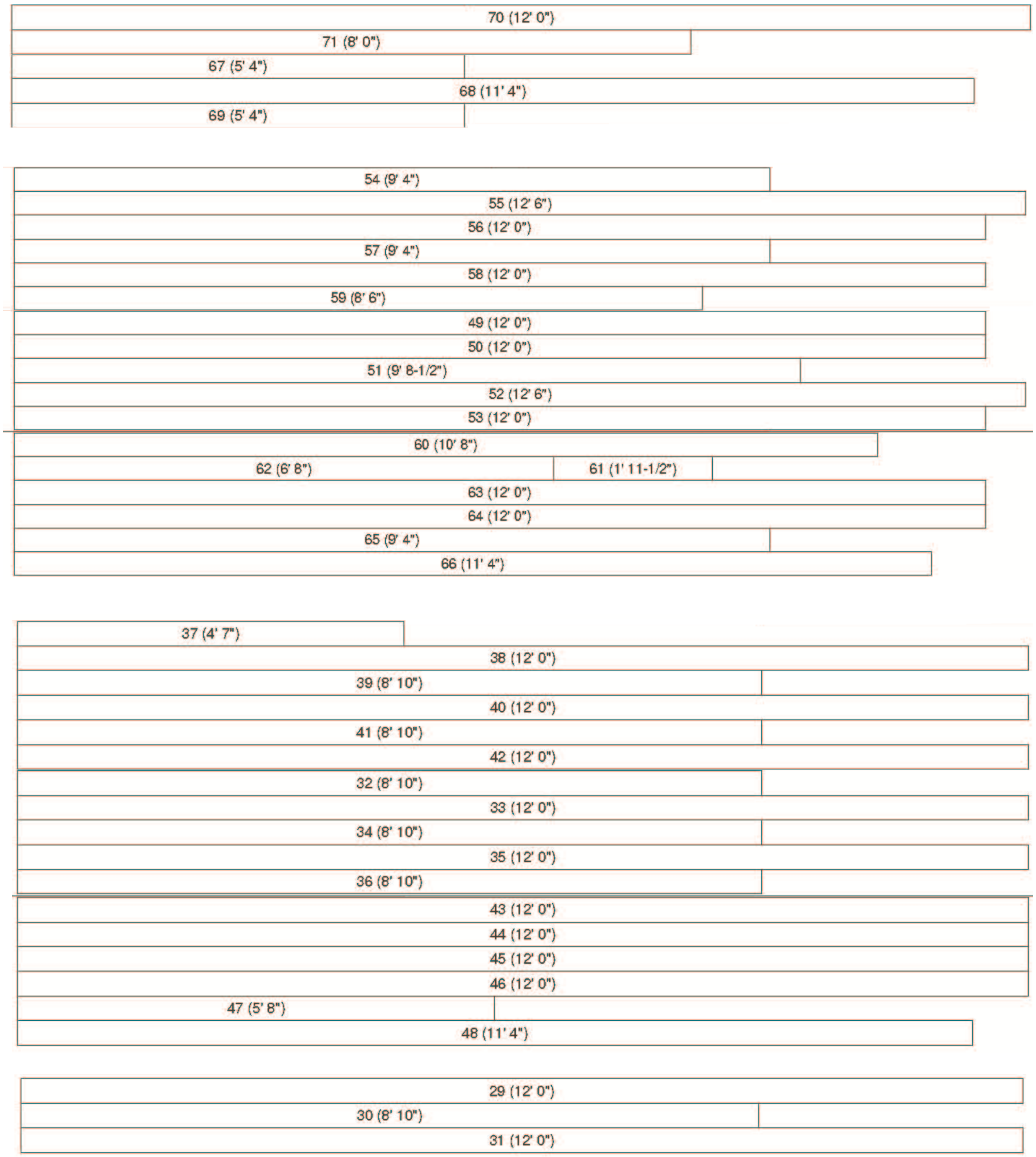
L1-3: Panel Designer



L1-3: IntelliBuild



L1-3: IntelliBuild



L1-3: Proposed algorithm

** Nzones
4

**zone	left edge X coordinate
1	6.0
2	216.5
3	446.9
4	579.5

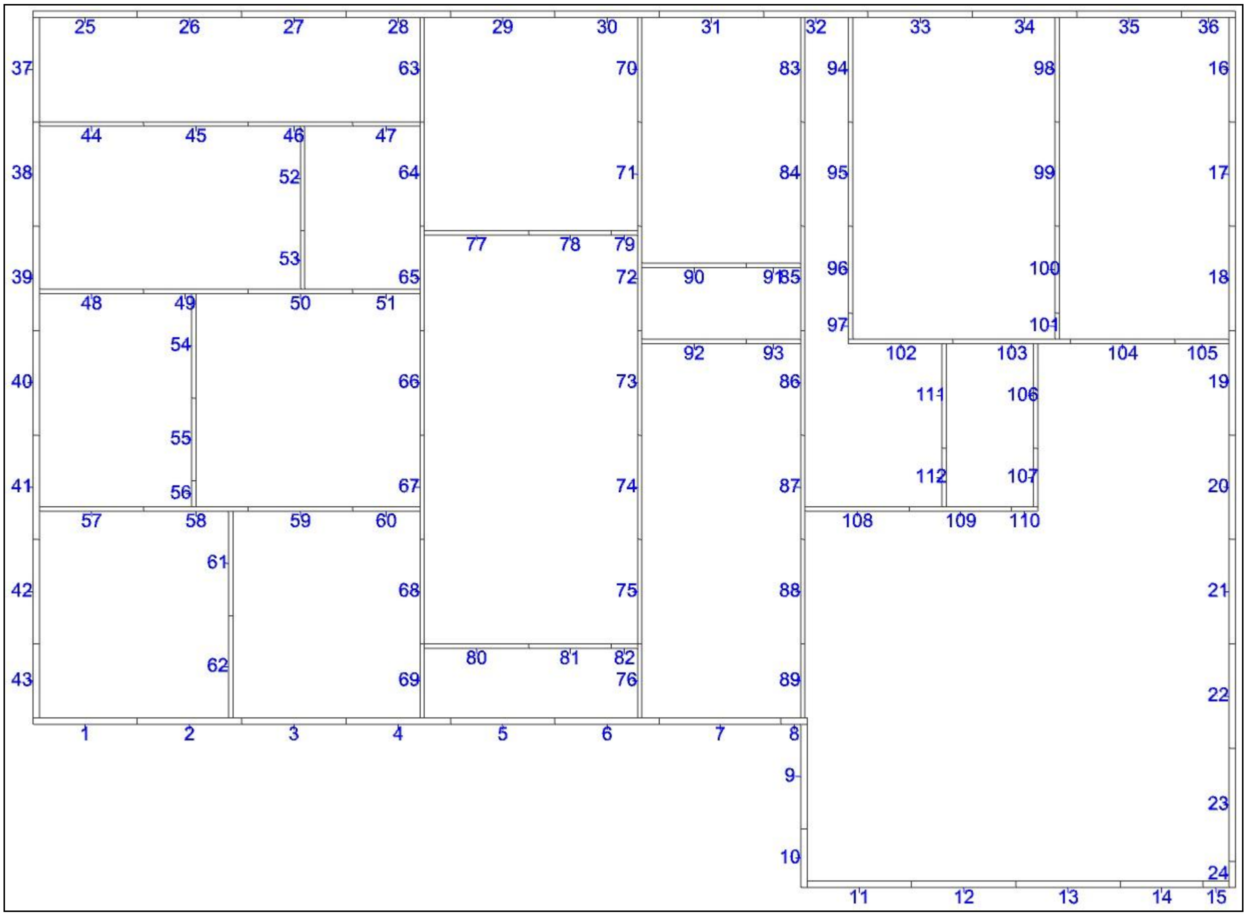
** NStacks
9

** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	13	1	1	19	2
							2	1	23	1
							3	1	24	1
							4	1	25	1
							5	1	26	1
							6	1	27	1
							7	1	28	1
							8	1	29	2
							9	1	31	2
							10	1	33	2
							11	1	35	1
							12	1	37	2
							13	1	38	1
2	1	A	RIGHT	116.2	57.3	1	1	1	1	3
3	2	A	RIGHT	336.7	57.3	13	1	1	20	2
							2	1	21	2
							3	1	30	2
							4	1	42	1
							5	1	32	2
							6	1	43	1
							7	1	48	2
							8	1	52	1
							9	1	34	2
							10	1	44	1
							11	1	53	1
							12	1	54	1
							13	1	63	2
4	2	B	LEFT	336.7	99.3	5	1	1	2	3
							2	1	3	3
							3	1	36	1
							4	1	39	1
							5	1	40	3

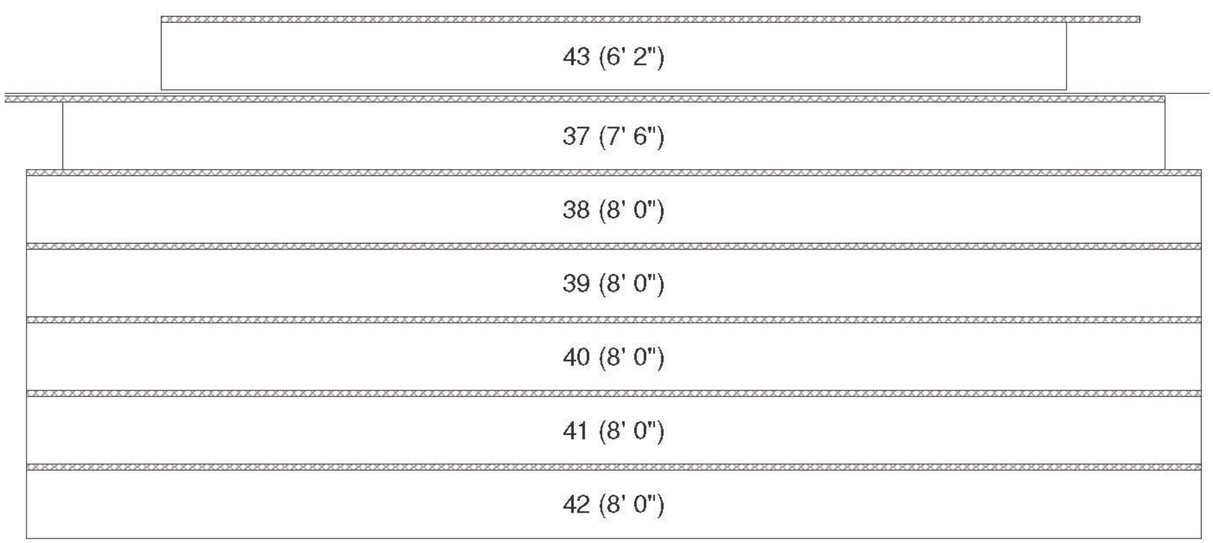
L1-3: Proposed algorithm

5	3	A	RIGHT	557.1	57.3	7	1	1	22	2
							2	1	18	1
							3	1	17	2
							4	1	49	2
							5	1	60	2
							6	2	62 61	1 2
							7	1	57	1
							8	1	64	2
6	3	B	LEFT	689.8	99.3	11	1	1	4	3
							3	1	45	1
							4	1	41	3
							5	1	46	1
							6	1	66	2
							7	2	67 47	2 1
							8	1	68	1
							9	1	70	1
							10	1	69	1
							11	1	71	1
7	4	A	RIGHT	689.8	57.3	15	1	1	14	2
							2	1	15	2
							3	1	16	2
							4	1	7	2
							5	1	8	2
							6	1	9	2
							7	1	10	2
							8	1	11	2
							9	1	12	2
							10	1	13	2
							11	1	5	3
							12	1	6	3
8	4	A	RIGHT	689.8	57.3	4	1	1	50	2
							2	1	51	2
							3	1	55	2
							4	1	56	1
9	4	A	RIGHT	689.8	57.3	3	1	1	58	2
							2	1	59	3
							3	1	65	2

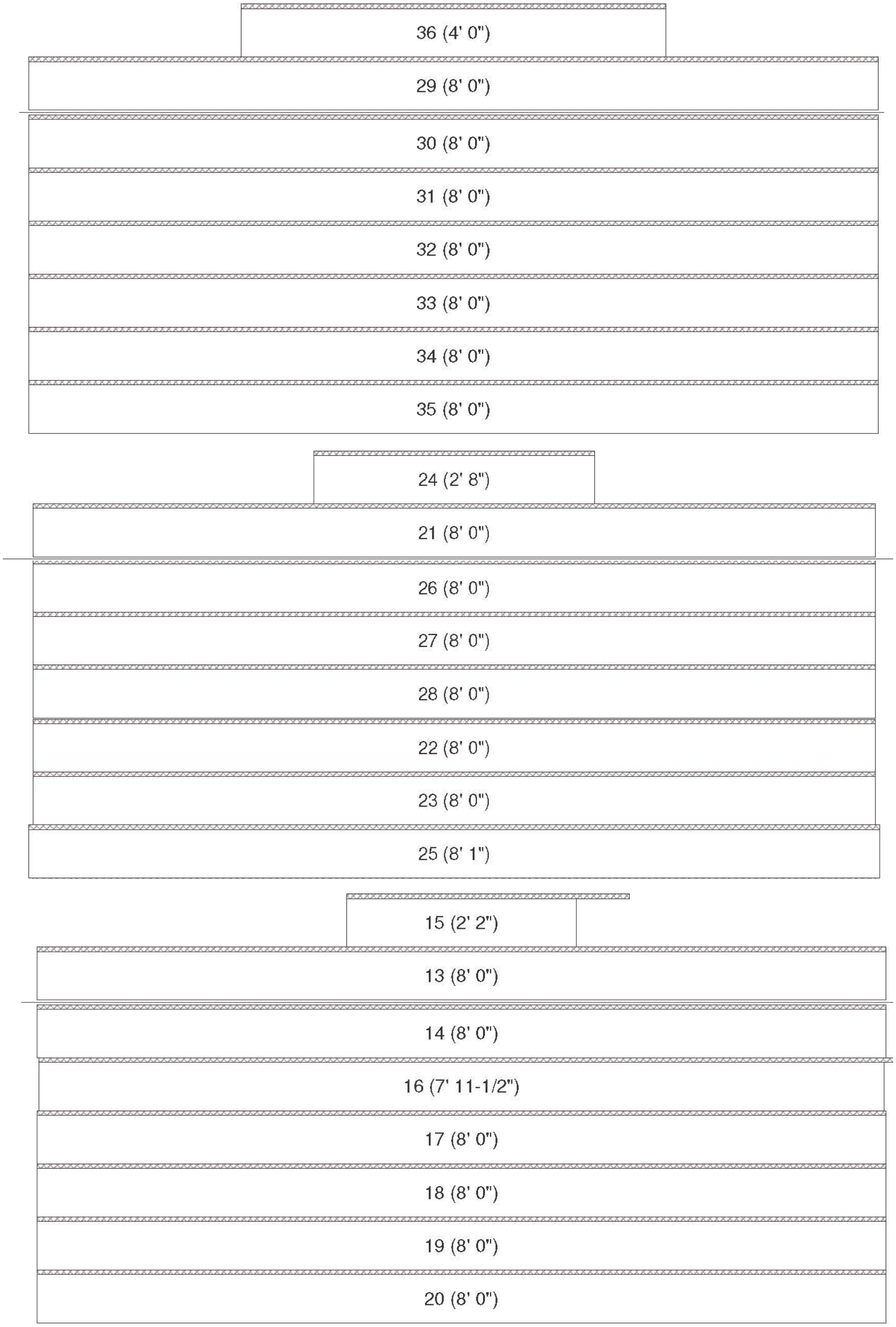
L2-1



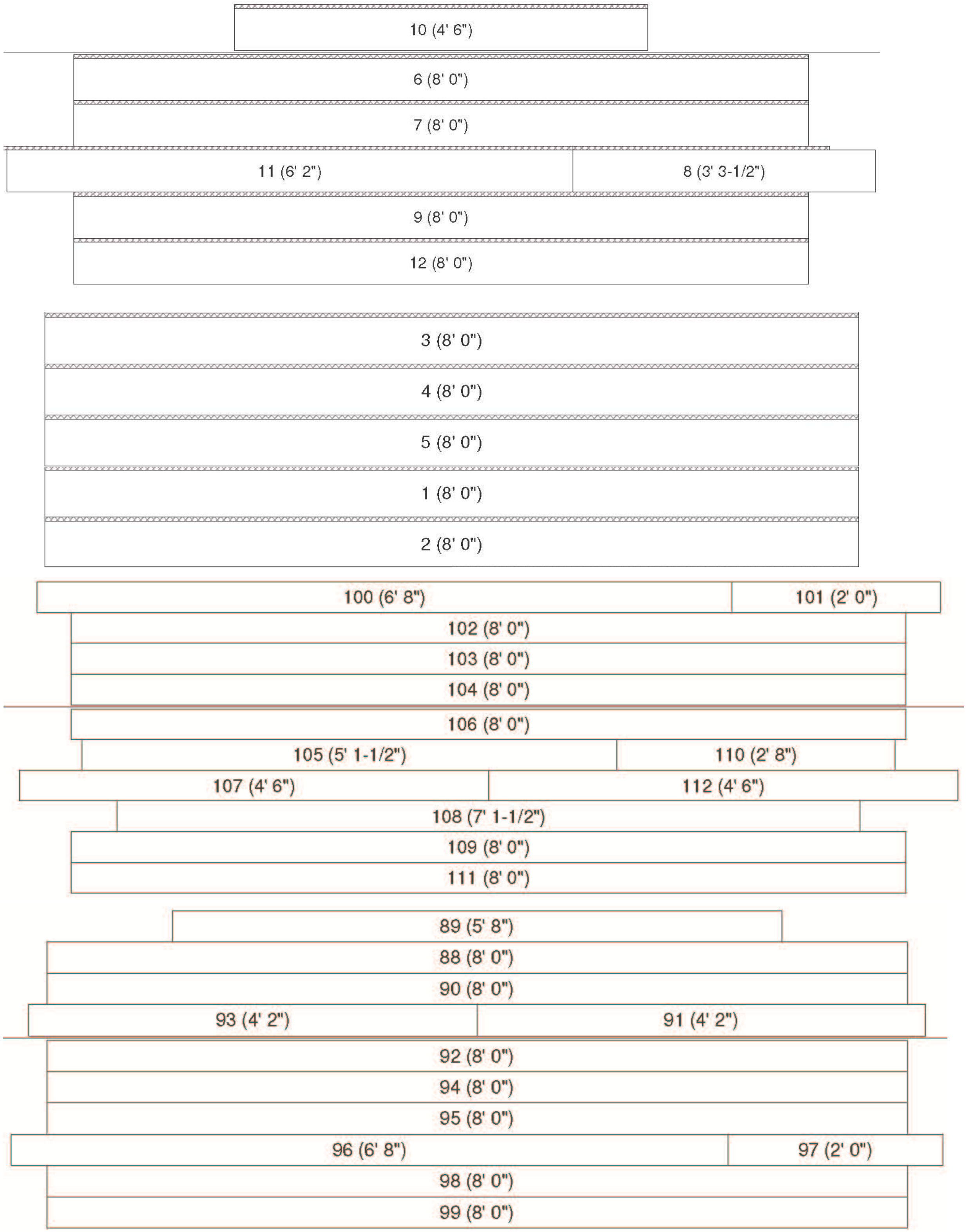
L2-1: Panel Designer



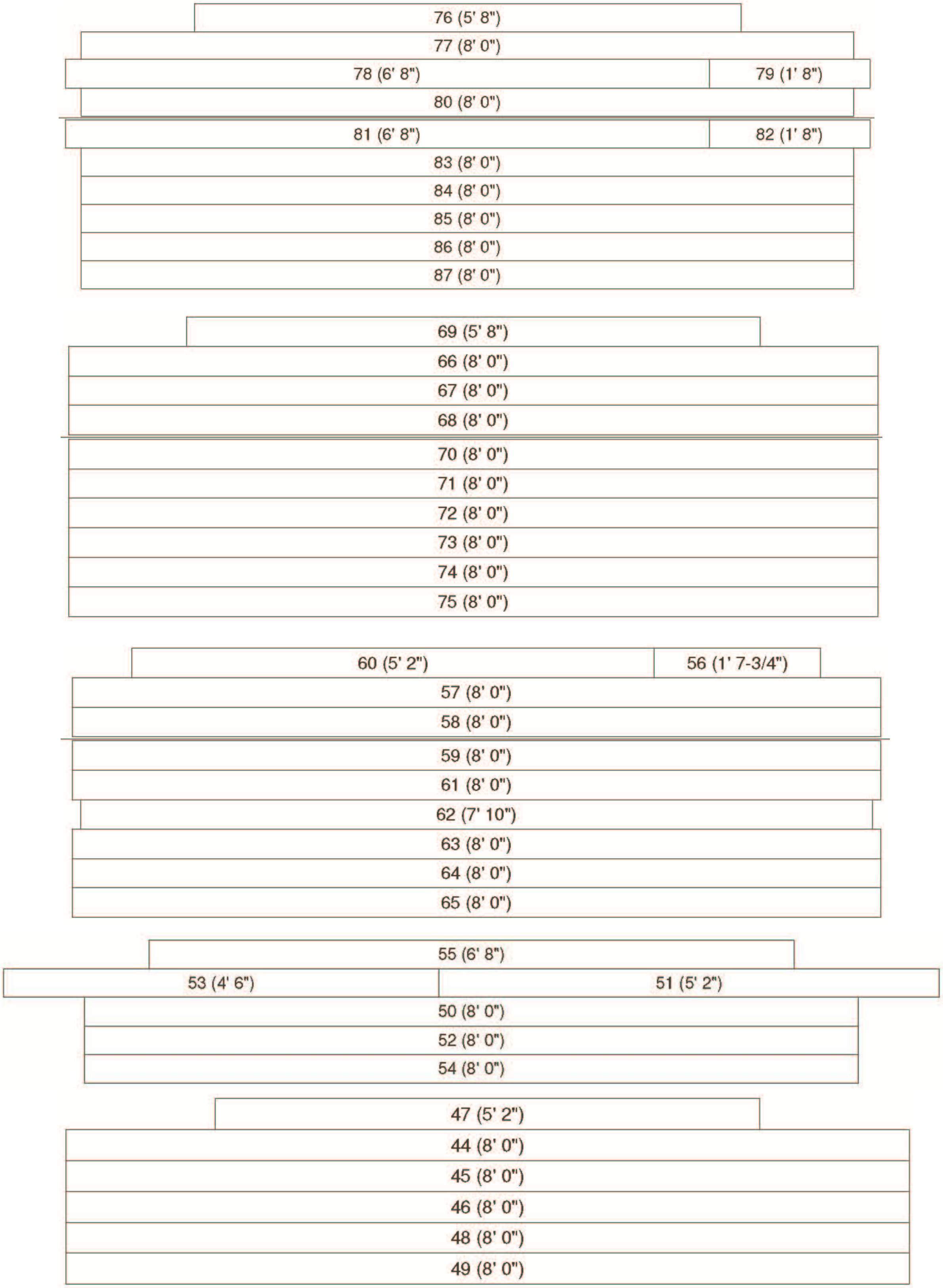
L2-1: Panel Designer



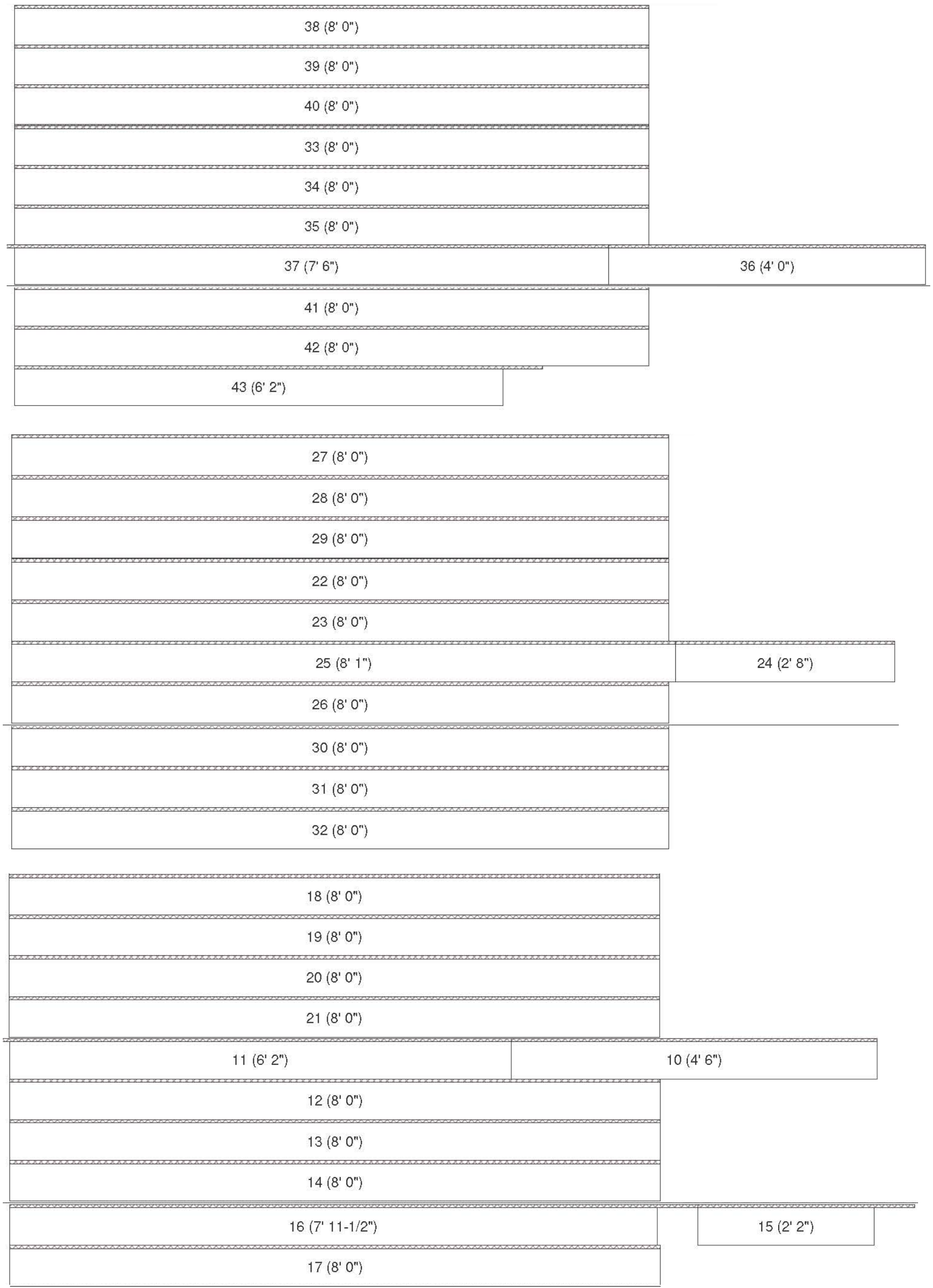
L2-1: Panel Designer



L2-1: Panel Designer

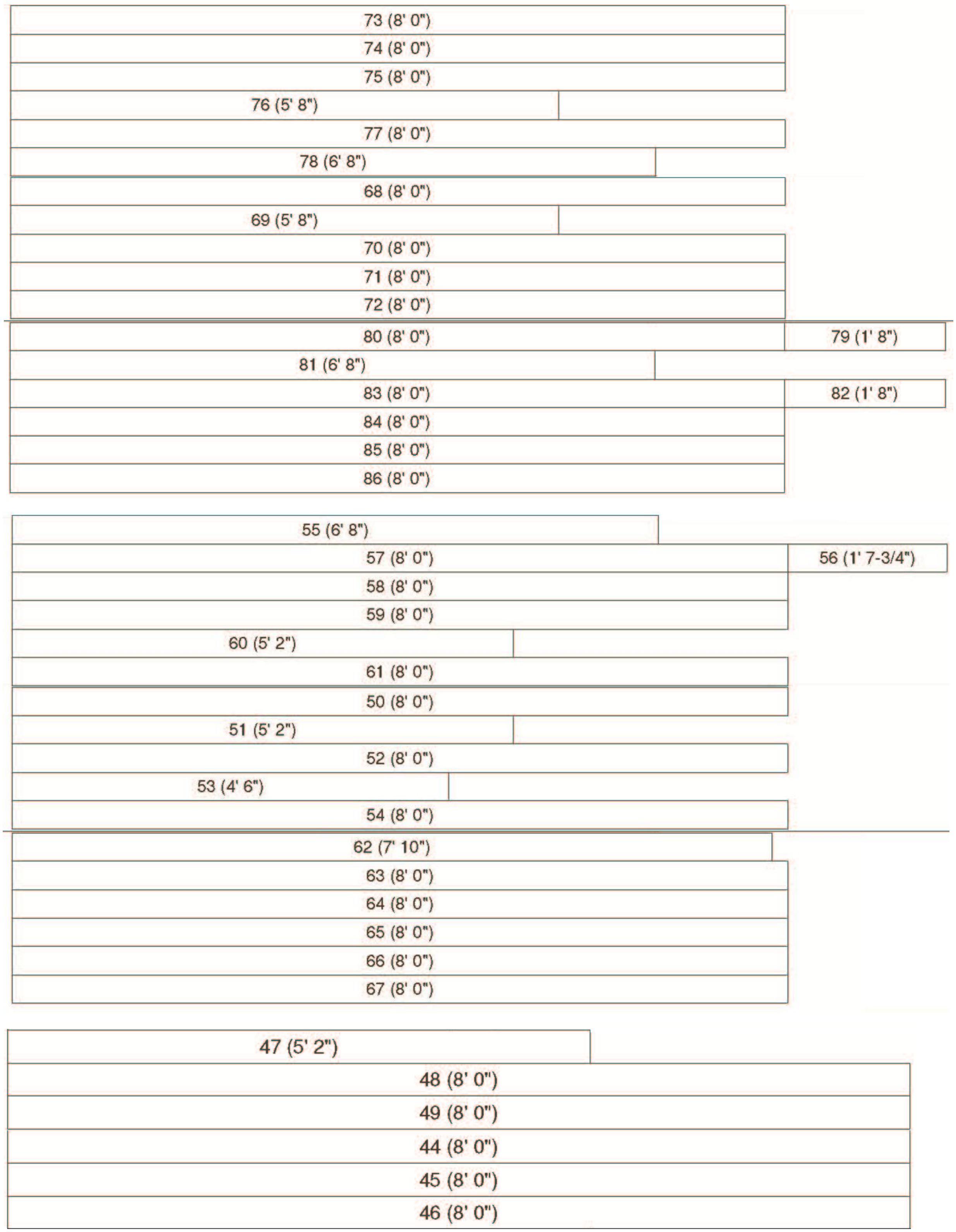


L2-1: IntelliBuild



L2-1: IntelliBuild

L2-1: IntelliBuild



```
L2-1: Proposed algorithm
** Nzones
6

**zone     left edge X coordinate
 1            6.0
 2          212.0
 3          438.0
 4          654.0
 5          870.0
 6          884.0

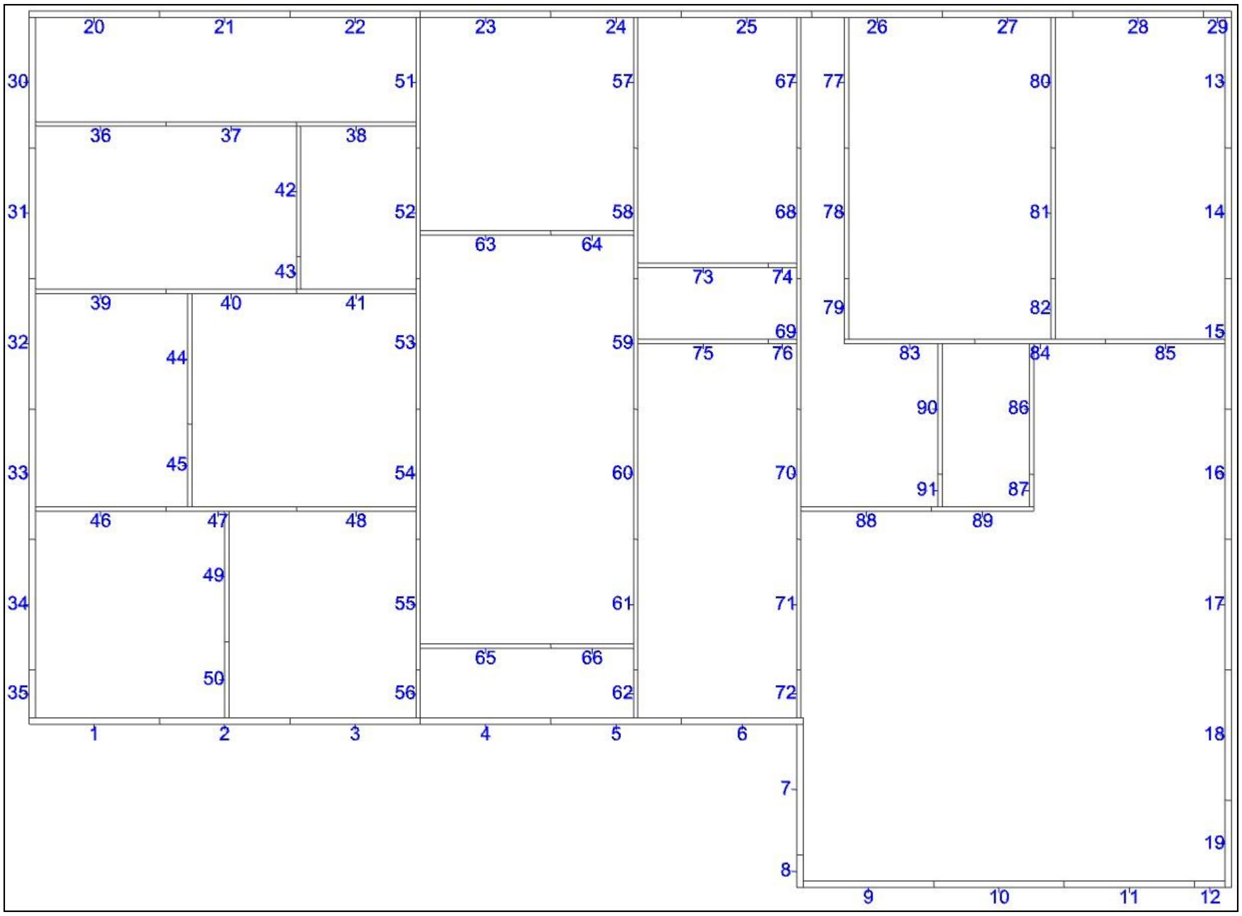
** NStacks
11

** stack              flush
**   #   zone type   edge     xloc   yloc   #layers   j   #panels   panels      orientation
     1     1    A    RIGHT   114.0   48.0     12          1        1    25            2
                                                          2        1    26            2
                                                          3        1    37            1
                                                          4        1    38            1
                                                          5        1    39            1
                                                          6        1    40            1
                                                          7        1    41            1
                                                          8        1    42            1
                                                          9        1    43            1
                                                         10        1    1             2
                                                         11        1    44            2
                                                         12        1    45            2
     2     1    A    RIGHT   114.0   48.0      7          1        1    48            2
                                                          2        1    49            2
                                                          3        1    54            1
                                                          4        2    56 55         1 1
                                                          5        1    57            2
                                                          6        1    58            2
                                                          7        1    61            1
     3     2    A    RIGHT   330.0   48.0     16          1        1    27            2
                                                          2        1    28            2
                                                          3        1    63            1
                                                          4        1    46            2
                                                          5        1    47            2
                                                          6        1    52            1
                                                          7        1    64            1
                                                          8        1    53            1
                                                          9        1    50            2
                                                         10        1    51            2
                                                         11        1    65            1
                                                         12        1    66            1
                                                         13        1    59            2
                                                         14        1    60            2
                                                         15        1    67            1
                                                         16        1    68            1
     4     2    B    LEFT    330.0   90.0      2          1        1    62            1
                                                          2        1    2             3
     5     3    A    RIGHT   546.0   48.0     10          1        1    29            2
                                                          2        1    30            2
                                                          3        1    70            1
                                                          4        1    71            1
                                                          5        1    77            2
                                                          6        2    79 78         2 2
                                                          7        1    72            1
                                                          8        1    73            1
                                                          9        1    74            1
                                                         10        1    75            1
     6     3    B    LEFT    546.0   90.0      8          1        1    69            1
                                                          2        1    80            2
                                                          3        2    81 82         2 2
                                                          4        1    76            1
                                                          5        1    3             3
                                                          6        1    4             3
                                                          7        1    5             3
                                                          8        1    6             3
```

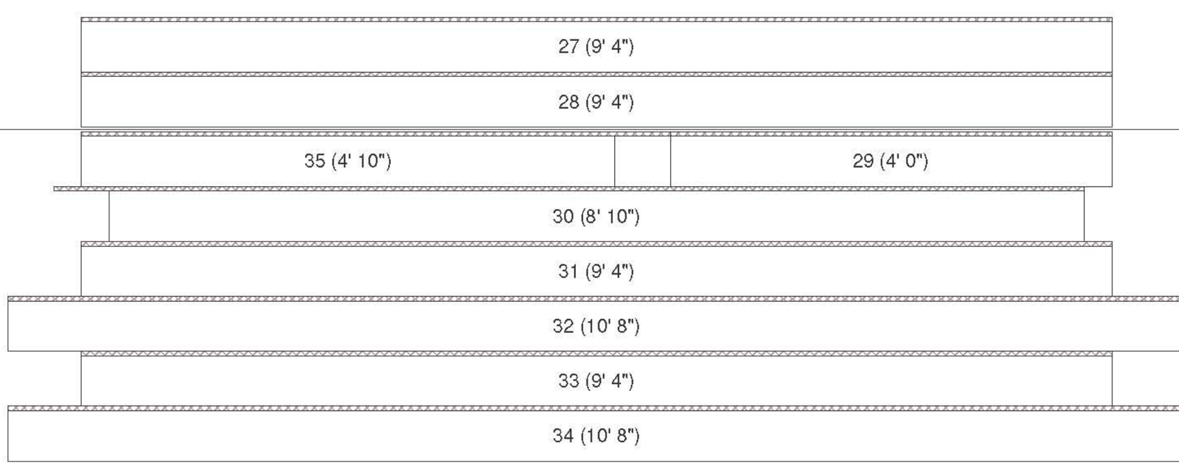
L2-1: Proposed algorithm

7	4	A	RIGHT	762.0	48.0	16	1	1	31	2
							2	1	32	2
							3	1	33	2
							4	1	83	1
							5	1	94	1
							6	1	84	1
							7	1	95	1
							8	1	90	2
							9	1	91	2
							10	1	85	1
							11	1	96	1
							12	1	92	2
							13	1	93	2
							14	2	97 86	1 1
							15	1	102	2
							16	1	87	1
8	5	A	RIGHT	762.0	48.0	4	1	1	111	1
							2	1	112	1
							3	1	108	2
							4	1	88	1
9	5	B	LEFT	762.0	90.0	5	1	1	89	1
							2	2	7 8	3 3
							3	1	9	1
							4	1	10	1
							5	1	11	3
10	6	A	RIGHT	978.0	48.0	14	1	1	34	2
							2	1	35	2
							3	1	36	2
							4	1	16	2
							5	1	17	2
							6	1	18	2
							7	1	19	2
							8	1	20	2
							9	1	21	2
							10	1	22	2
							11	2	24 23	2 2
							12	1	12	3
							13	1	13	3
							14	2	15 14	3 3
11	6	A	RIGHT	978.0	48.0	9	1	1	98	1
							2	1	99	1
							3	2	101 100	1 1
							4	1	103	2
							5	1	104	2
							6	1	106	1
							7	1	107	1
							8	2	110 109	2 2
							9	1	105	2

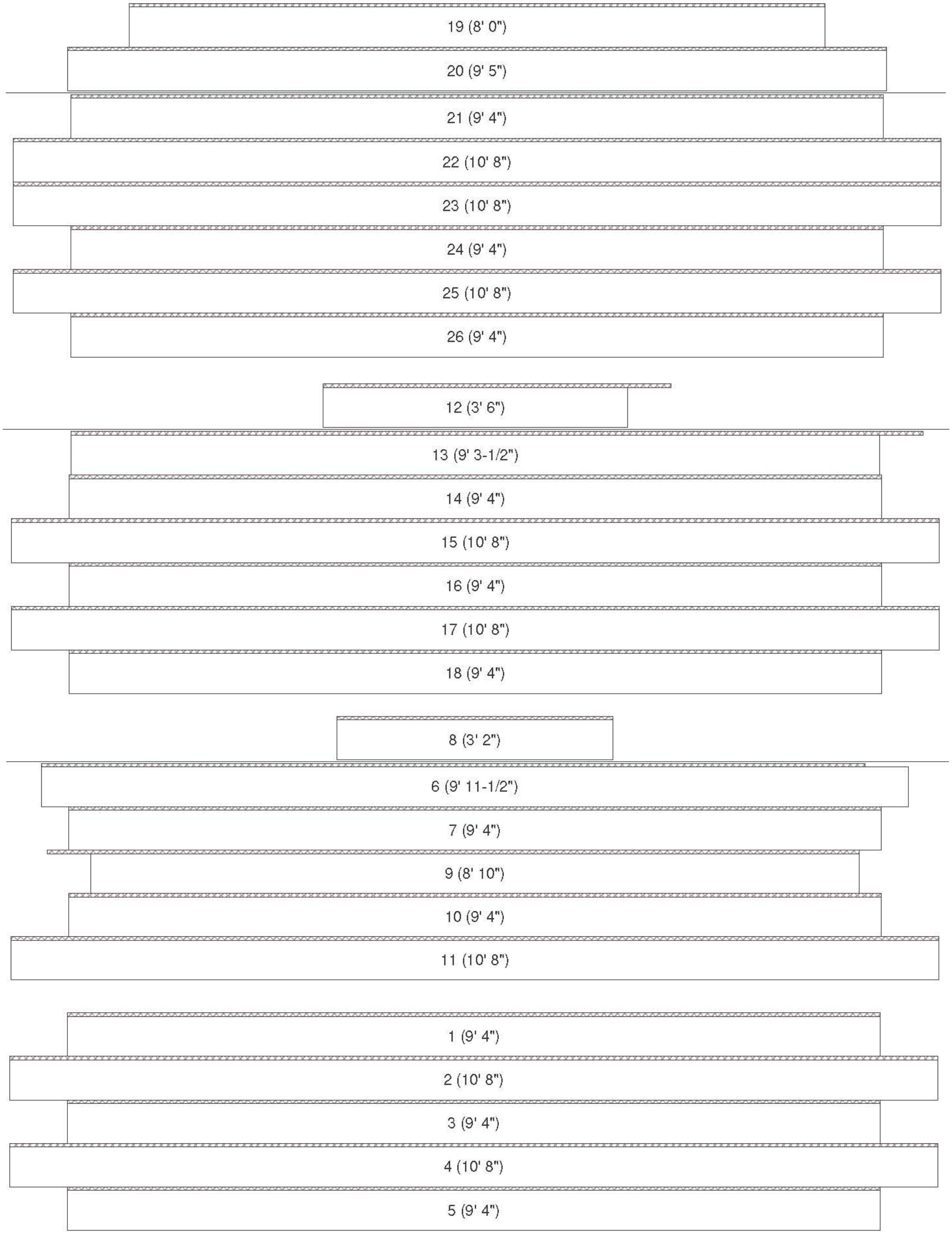
L2-2



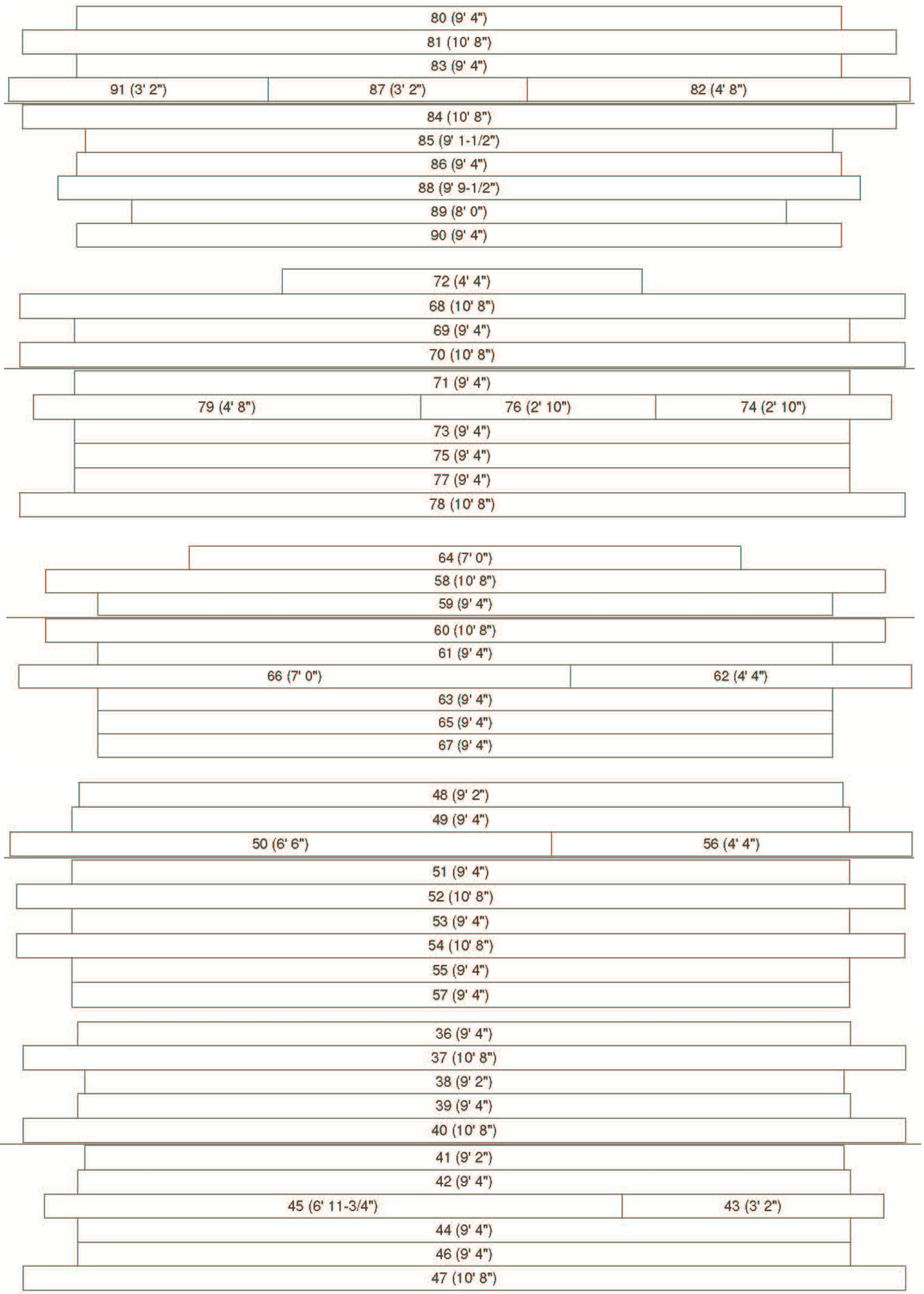
L2-2: Panel Designer



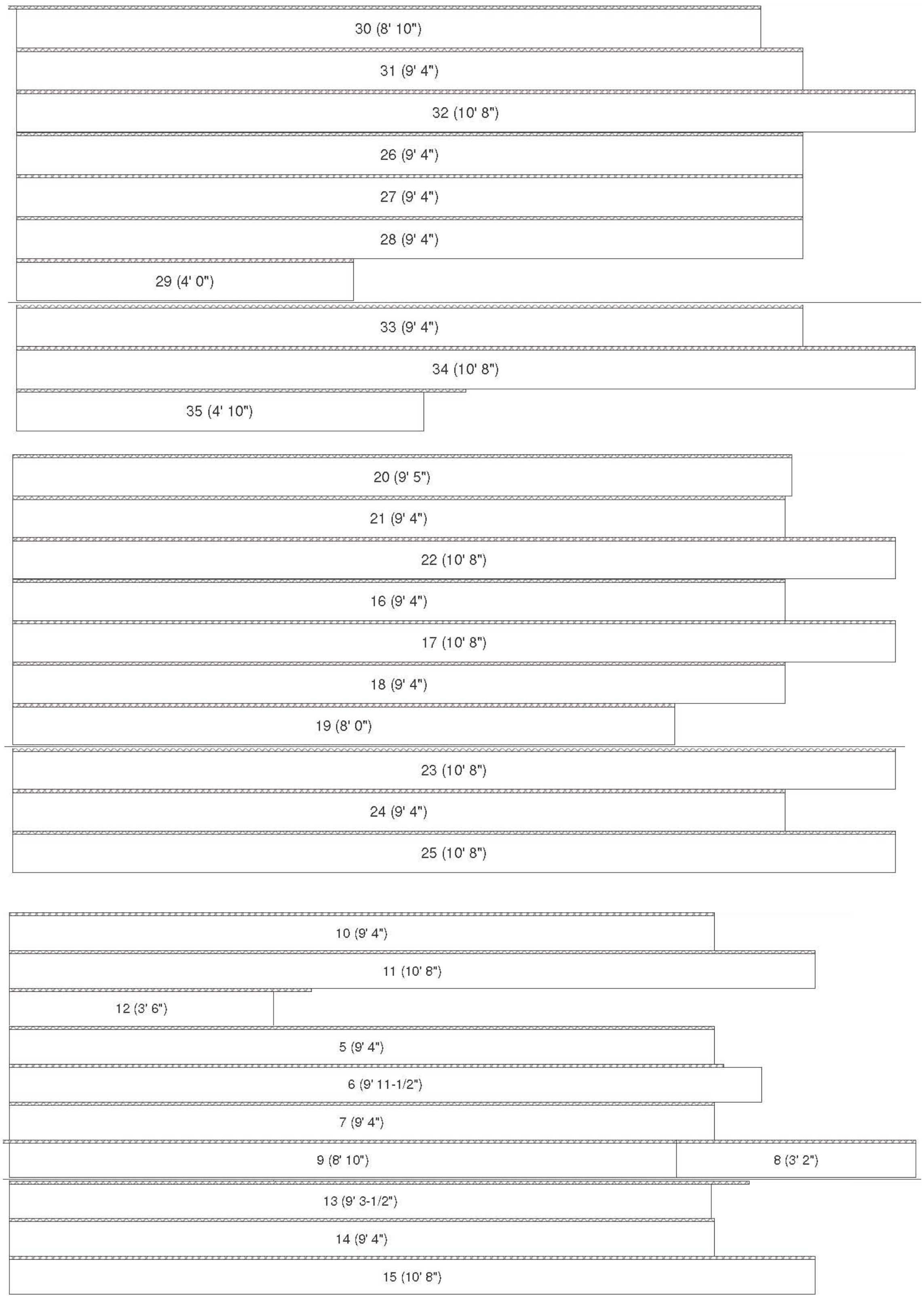
L2-2: Panel Designer



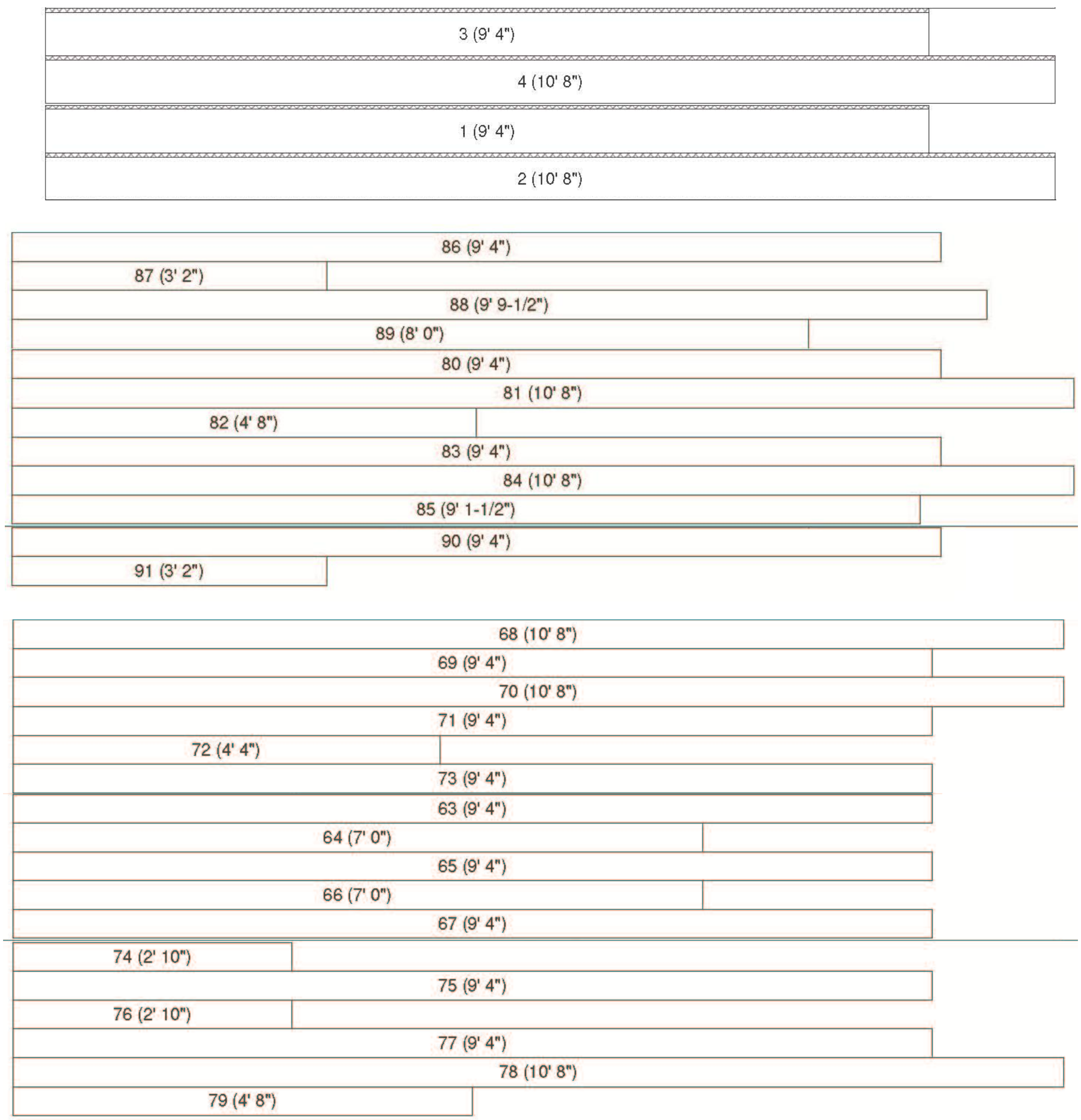
L2-2: Panel Designer



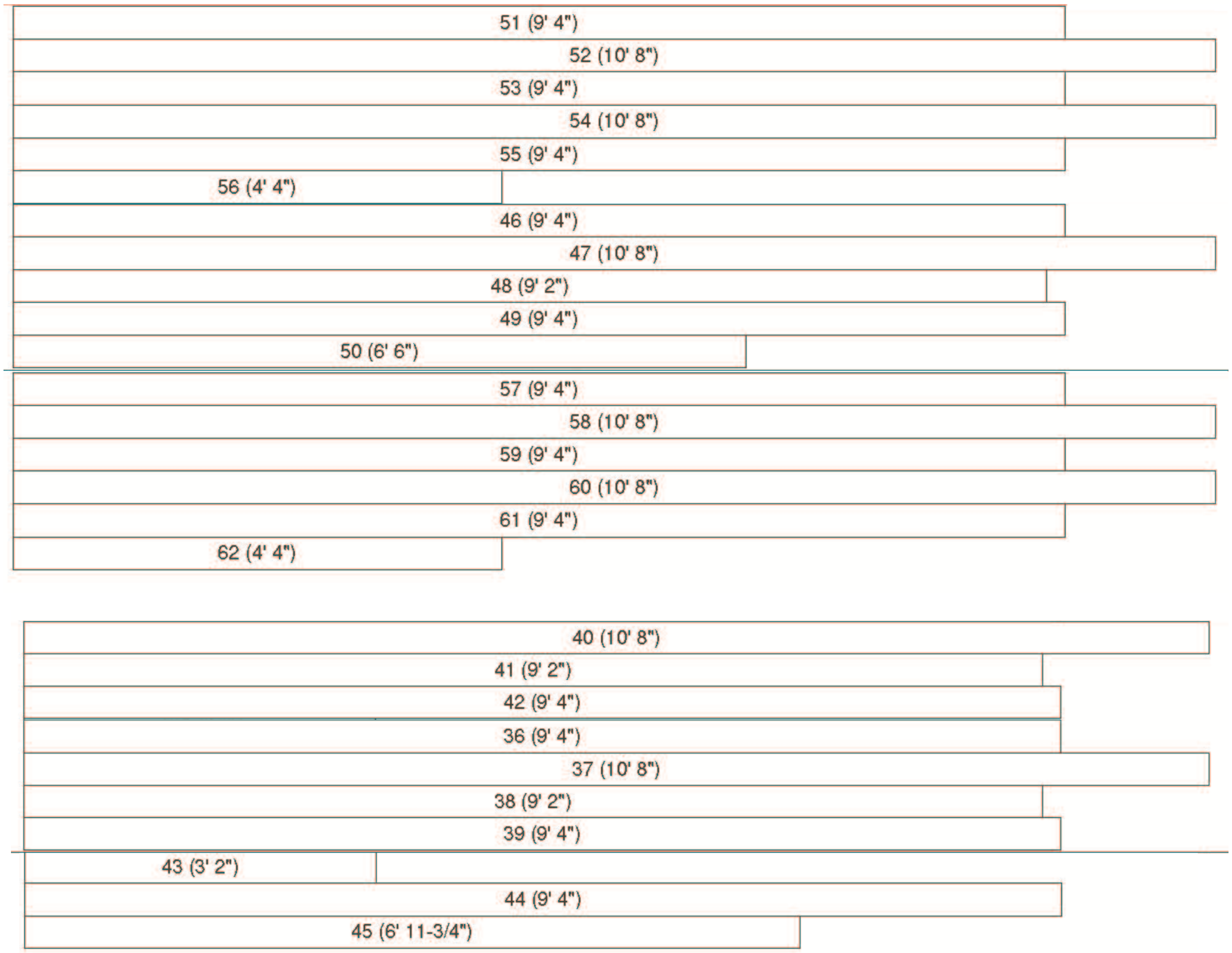
L2-2: IntelliBuild



L2-2: IntelliBuild



L2-2: IntelliBuild



L2-2: Proposed algorithm

** Nzones
6

**zone	left edge X coordinate
1	6.0
2	222.0
3	438.0
4	654.0
5	870.0
6	884.0

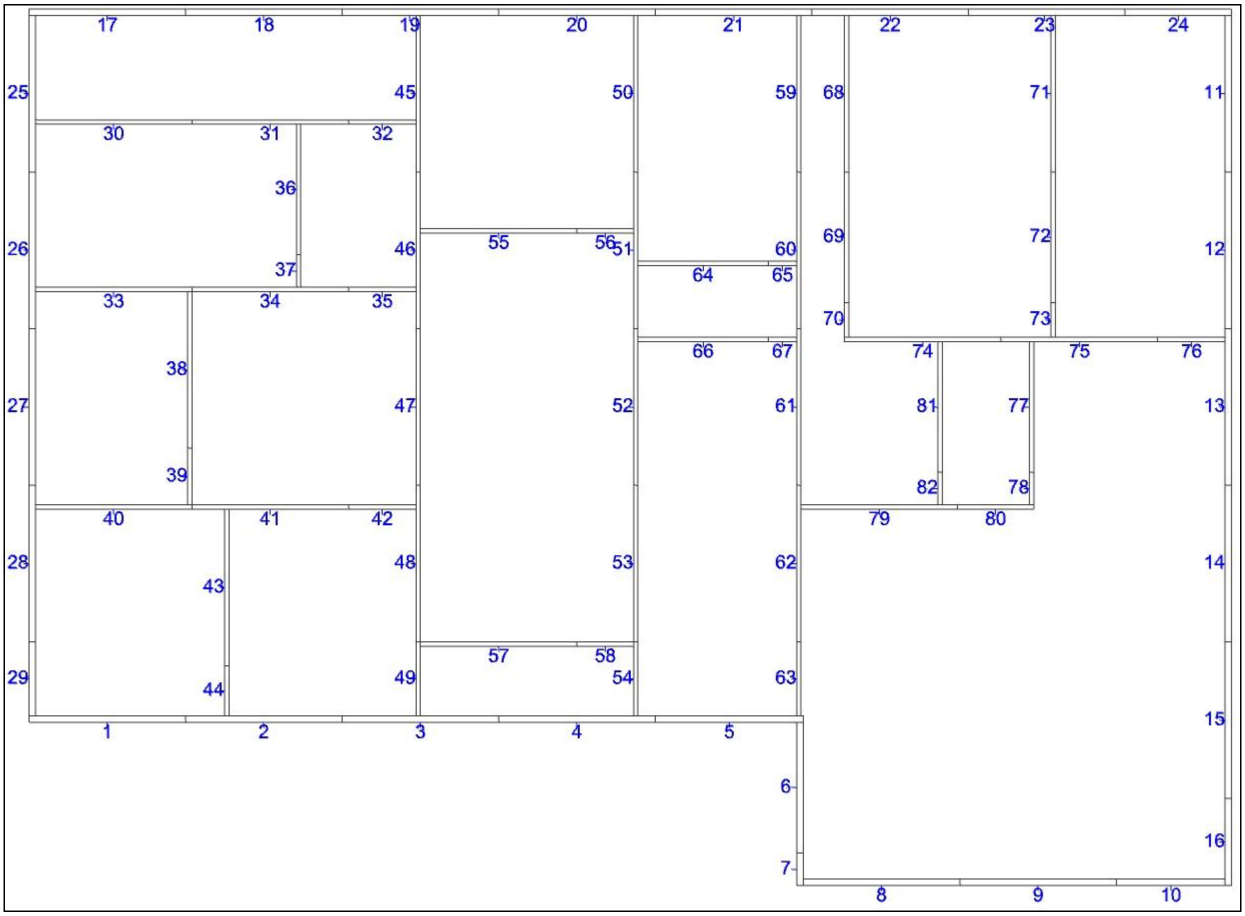
** NStacks
10

** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	48.0	11	1	1	20	2
							2	1	30	1
							3	1	31	1
							4	1	32	1
							5	1	33	1
							6	1	34	1
							7	1	35	1
							8	1	1	2
							9	1	36	2
							10	1	39	2
							11	1	46	2

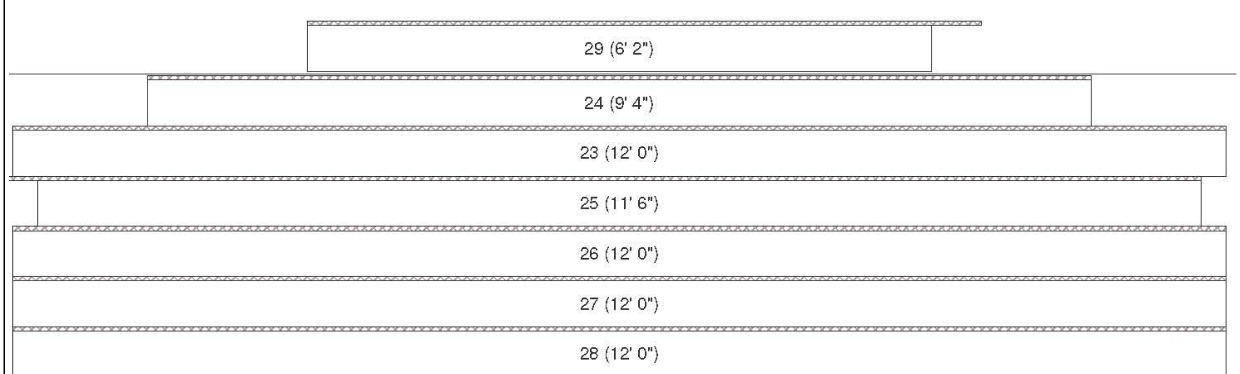
L2-2: Proposed algorithm

2	2	A	RIGHT	330.0	48.0	16	1	1	21	2
							2	1	22	2
							3	1	37	2
							4	1	38	2
							5	1	42	1
							6	1	51	1
							7	1	43	1
							8	1	52	1
							9	1	40	2
							10	1	41	2
							11	1	44	1
							12	1	53	1
							13	1	45	1
							14	1	47	2
							15	1	48	2
							16	1	49	1
3	2	A	RIGHT	330.0	48.0	1	1	1	54	1
4	2	B	LEFT	330.0	90.0	1	1	1	50	1
5	3	A	RIGHT	546.0	48.0	8	1	1	23	2
							2	1	24	2
							3	1	57	1
							4	1	63	2
							5	1	64	2
							6	1	58	1
							7	1	59	1
							8	1	60	1
6	3	B	LEFT	546.0	90.0	9	1	1	55	1
							2	1	65	2
							3	1	66	2
							4	1	61	1
							5	2	56 62	1 1
							6	1	2	3
							7	1	3	3
							8	1	4	3
							9	1	5	3
7	4	A	RIGHT	762.0	48.0	14	1	1	25	2
							2	1	26	2
							3	1	67	1
							4	1	77	1
							5	1	73	2
							6	1	74	2
							7	1	68	1
							8	1	78	1
							9	1	75	2
							10	1	76	2
							11	1	69	1
							12	1	79	1
							13	1	70	1
							14	1	88	2
8	5	B	LEFT	762.0	90.0	9	1	1	83	2
							2	1	90	1
							3	1	91	1
							4	1	71	1
							5	1	72	1
							6	1	6	3
							7	1	7	1
							8	1	8	1
							9	1	9	3
9	6	A	RIGHT	978.0	48.0	13	1	1	27	2
							2	1	28	2
							3	1	29	2
							4	1	13	2
							5	1	14	2
							6	1	15	2
							7	1	16	2
							8	1	17	2
							9	1	18	2
							10	1	19	2
							11	1	10	2
							12	1	11	3
							13	2	85 12	2 3
10	6	A	RIGHT	978.0	90.0	6	1	1	80	1
							2	1	81	1
							3	1	82	1
							4	1	84	2
							5	1	86	1
							6	2	89 87	2 1

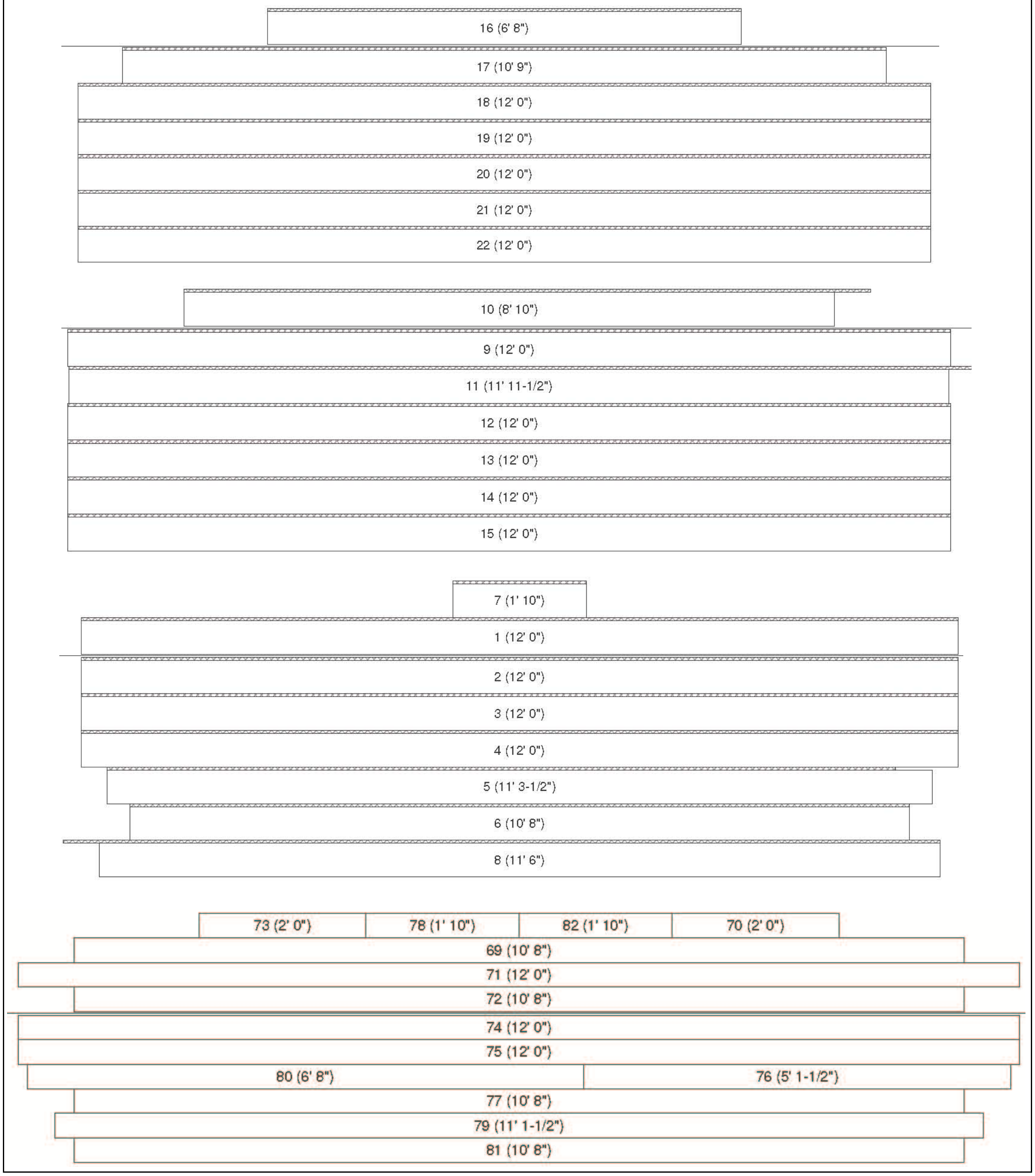
L2-3



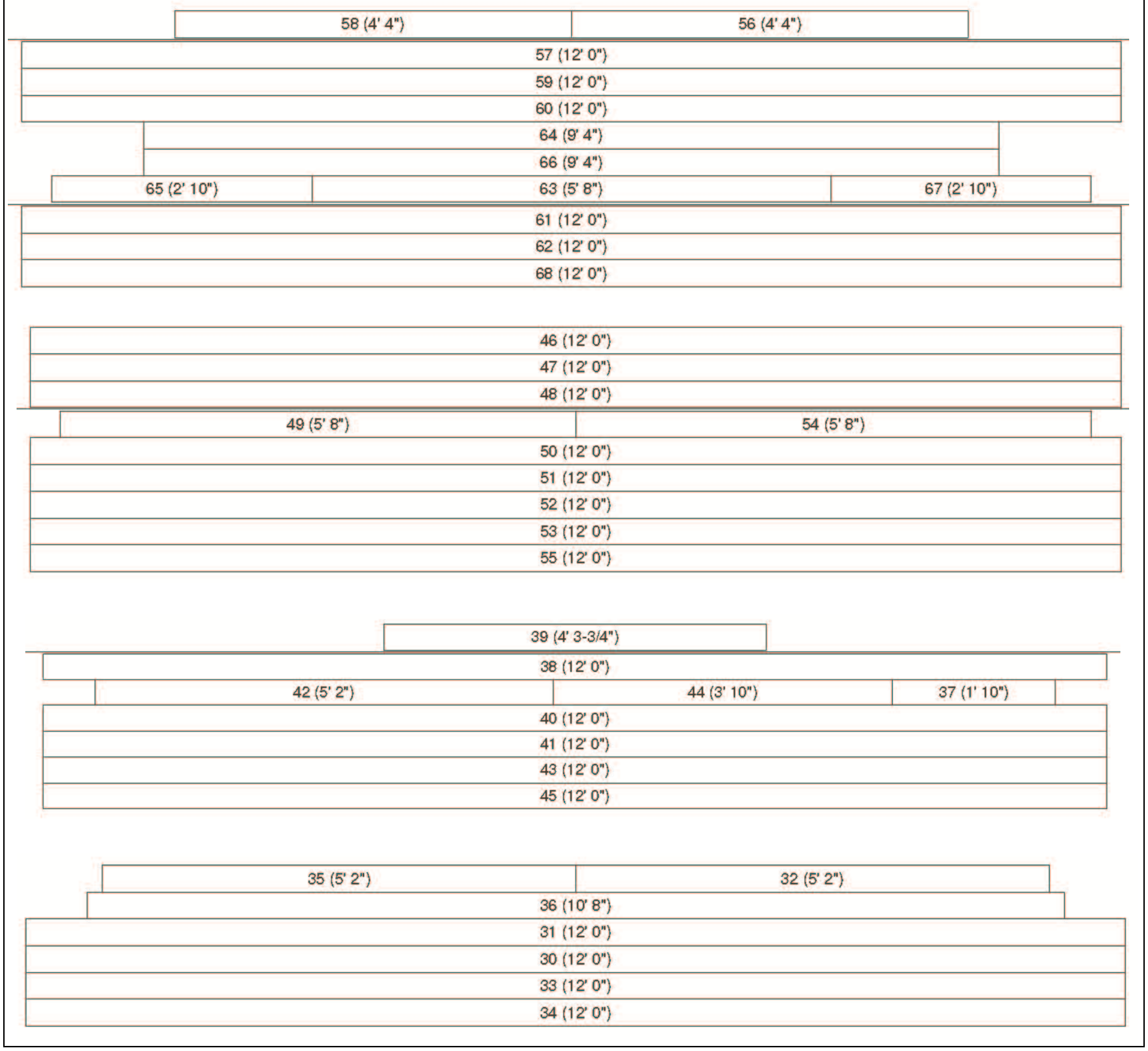
L2-3: Panel Designer



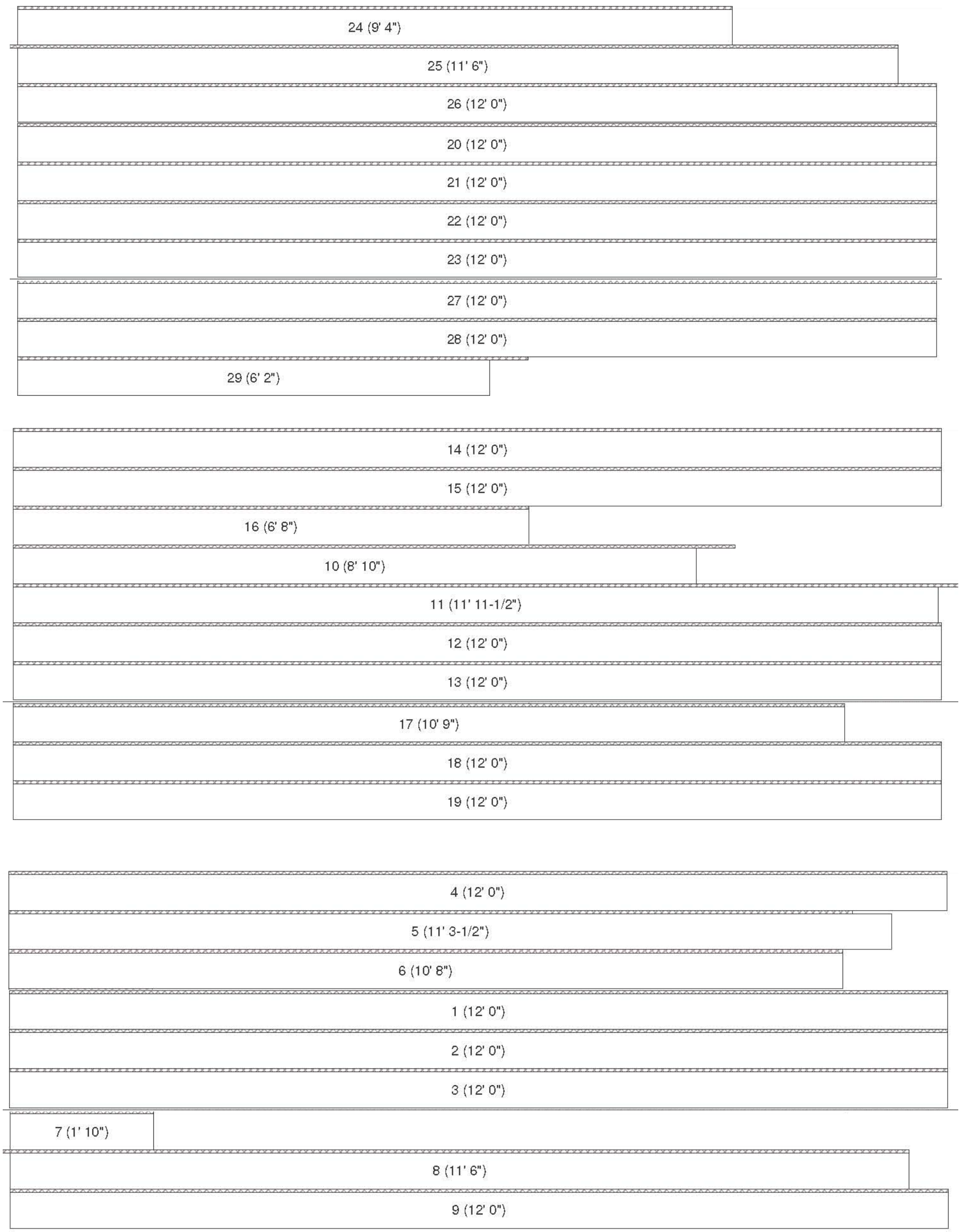
L2-3: Panel Designer



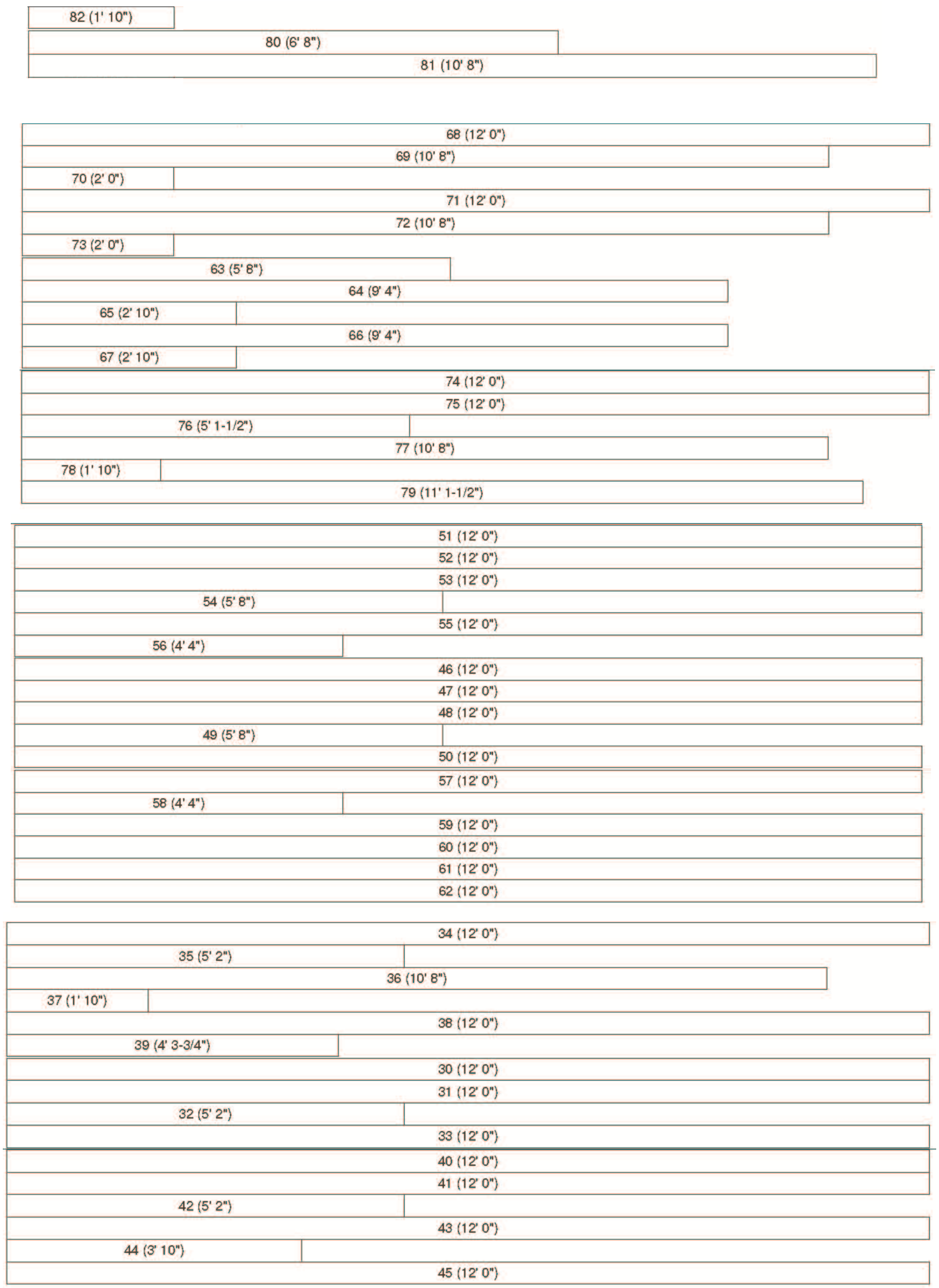
L2-3: Panel Designer



L2-3: IntelliBuild



L2-3: IntelliBuild



L2-3: Proposed algorithm

** Nzones
5

**zone	left edge X coordinate
1	6.0
2	226.5
3	446.9
4	667.4
5	879.5

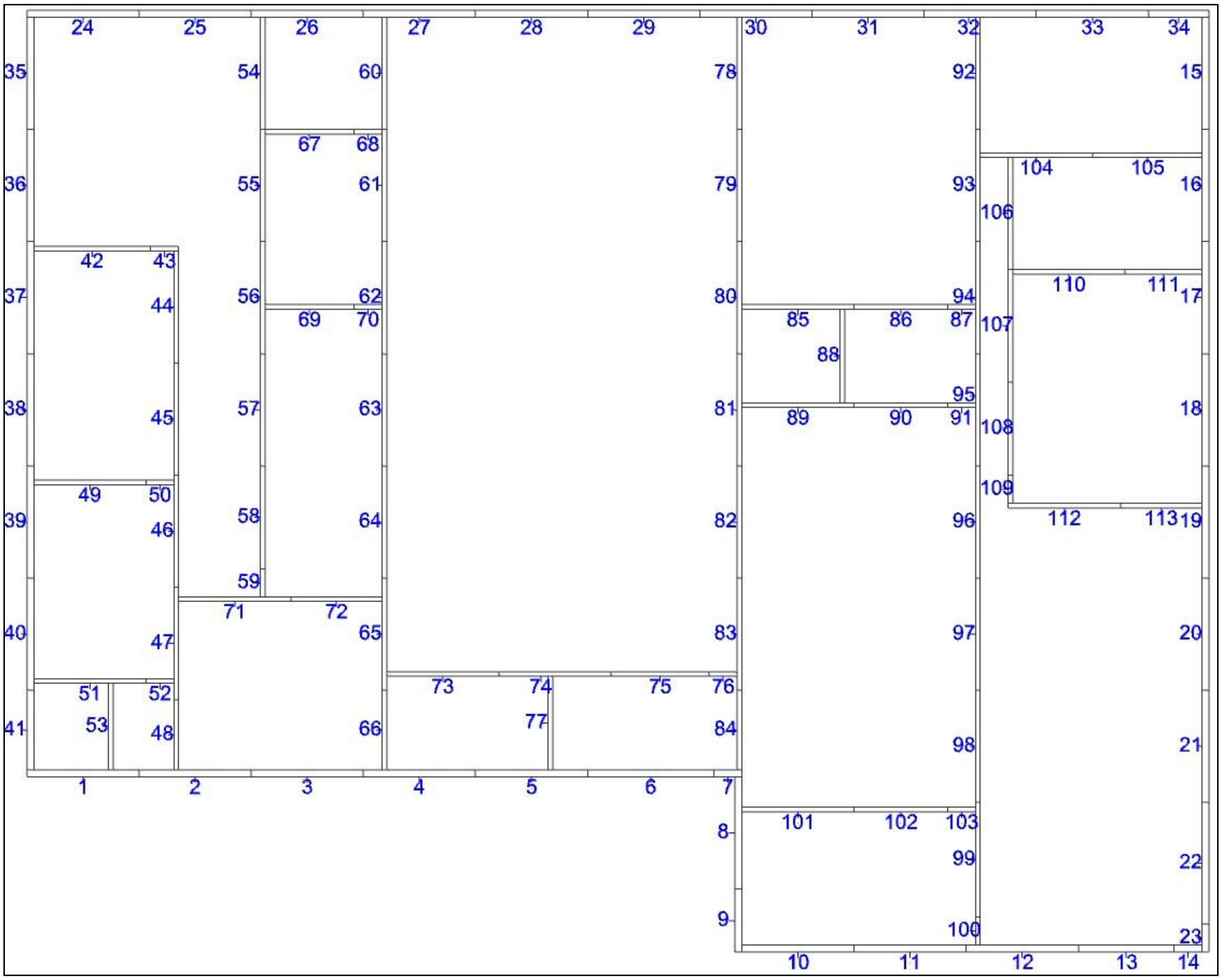
** NStacks
8

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	87.3	12	1	1	17	2
							2	1	25	1
							3	1	26	1
							4	1	27	1
							5	1	28	1
							6	1	29	1
							7	1	1	2
							8	1	30	2
							9	1	33	2
							10	1	38	1
							11	1	39	1
							12	1	40	2
2	2	A	RIGHT	336.7	87.3	13	1	1	18	2
							2	1	19	2
							3	1	31	2
							4	1	32	2
							5	1	36	1
							6	1	45	1
							7	1	37	1
							8	1	34	2
							9	1	35	2
							10	1	46	1
							11	1	47	1
							12	1	41	2
							13	1	42	2
3	2	B	LEFT	336.7	99.3	2	1	1	43	1
							2	1	44	1
4	3	A	RIGHT	557.1	57.3	6	1	1	20	2
							2	1	50	1
							3	1	55	2
							4	1	56	2
							5	1	51	1
							6	1	52	1
5	3	B	LEFT	557.1	99.3	8	1	1	48	1
							2	1	53	1
							3	1	49	1
							4	1	57	2
							5	2	58 54	2 1
							6	1	2	3
							7	1	3	3
							8	1	4	3
6	4	A	RIGHT	777.6	57.3	12	1	1	21	2
							2	1	22	2
							3	1	59	1
							4	1	68	1
							5	1	64	2
							6	1	65	2
							7	1	60	1
							8	1	69	1
							9	1	66	2
							10	1	67	2
							11	1	61	1
							12	1	70	1

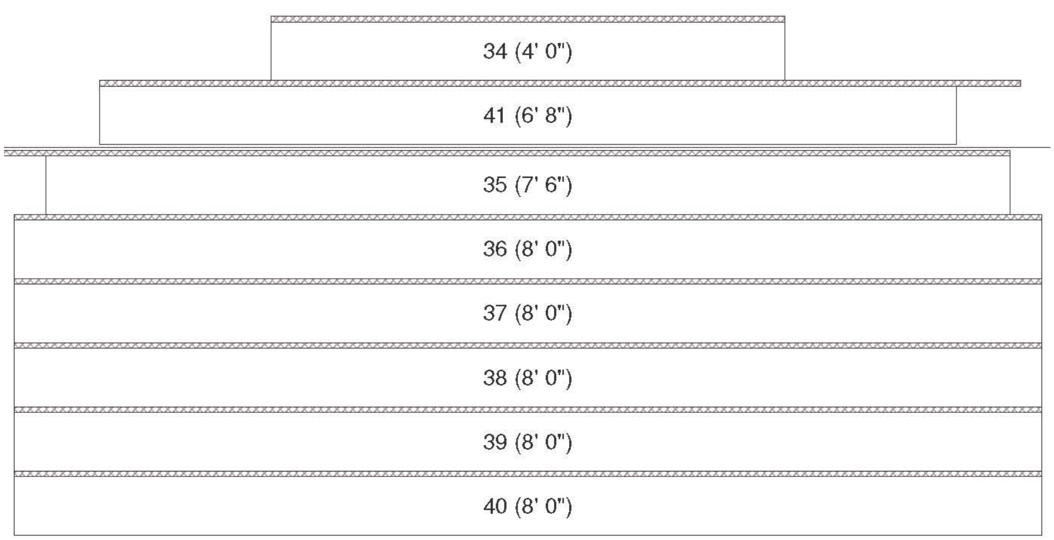
L2-3: Proposed algorithm

7	5	A	RIGHT	989.8	57.3	17	1	1	23	2
							2	1	24	2
							3	1	11	2
							4	1	12	2
							5	1	13	2
							6	1	14	2
							7	1	15	2
							8	1	16	2
							9	1	5	3
							10	1	6	1
							11	1	7	1
							12	1	8	3
							13	1	9	3
							14	1	10	3
							15	1	71	2
							16	1	72	2
							17	1	73	2
8	5	A	RIGHT	989.8	57.3	10	1	1	74	2
							2	1	75	2
							3	1	76	2
							4	1	81	1
							5	1	77	1
							6	2	78 82	1 1
							7	1	79	2
							8	1	80	2
							9	1	62	1
							10	1	63	1

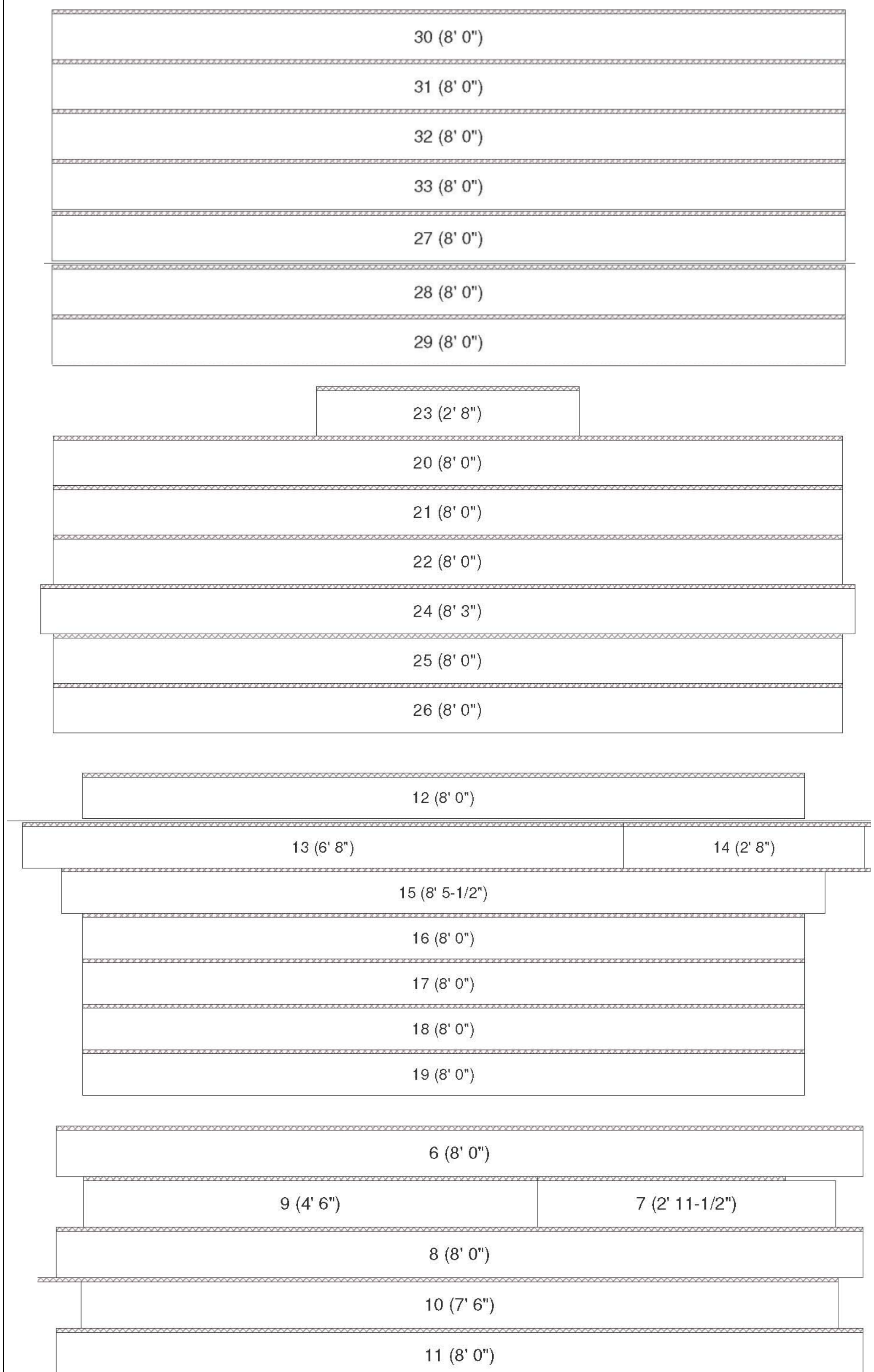
L3-1



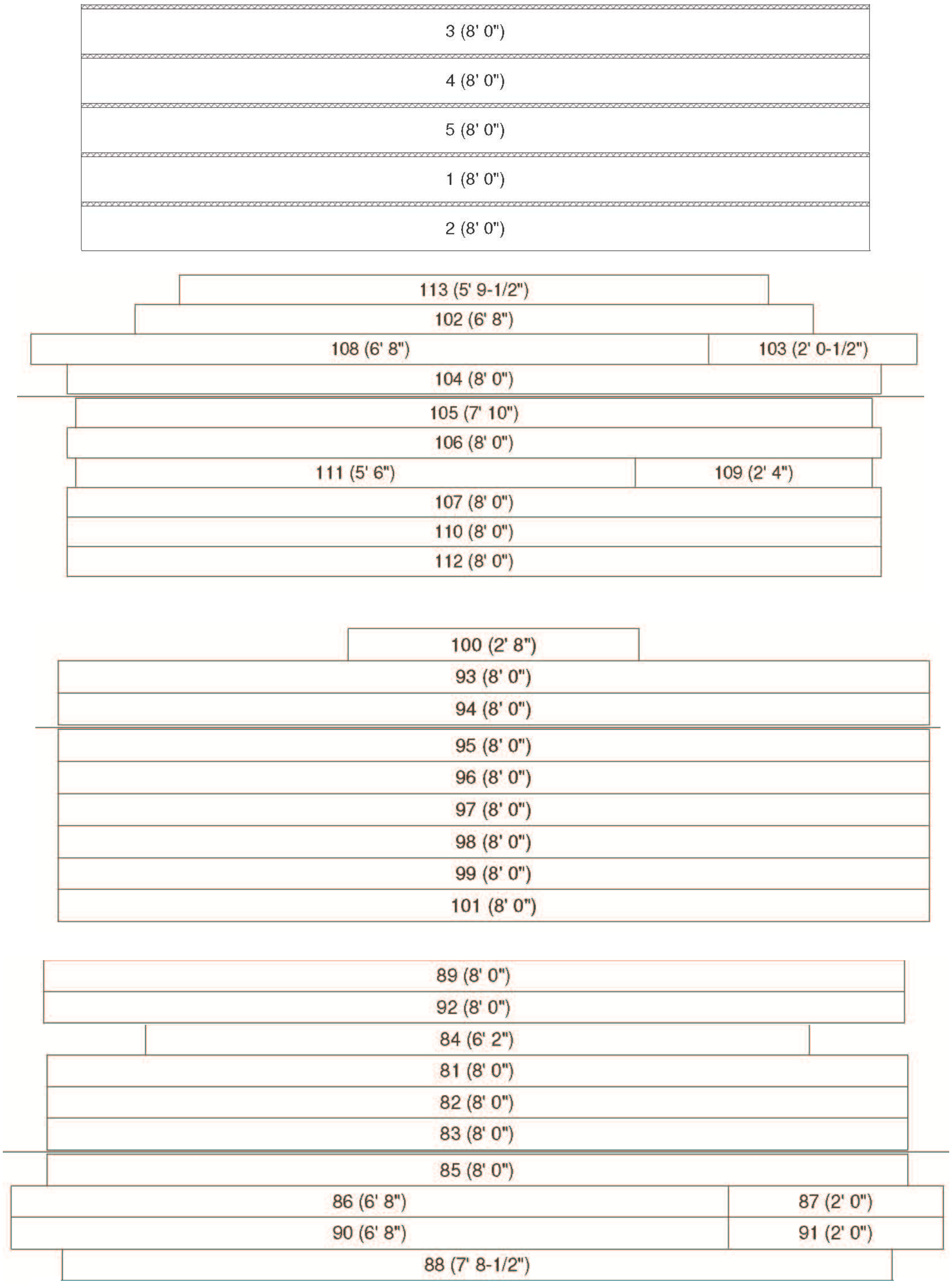
L3-1: Panel Designer



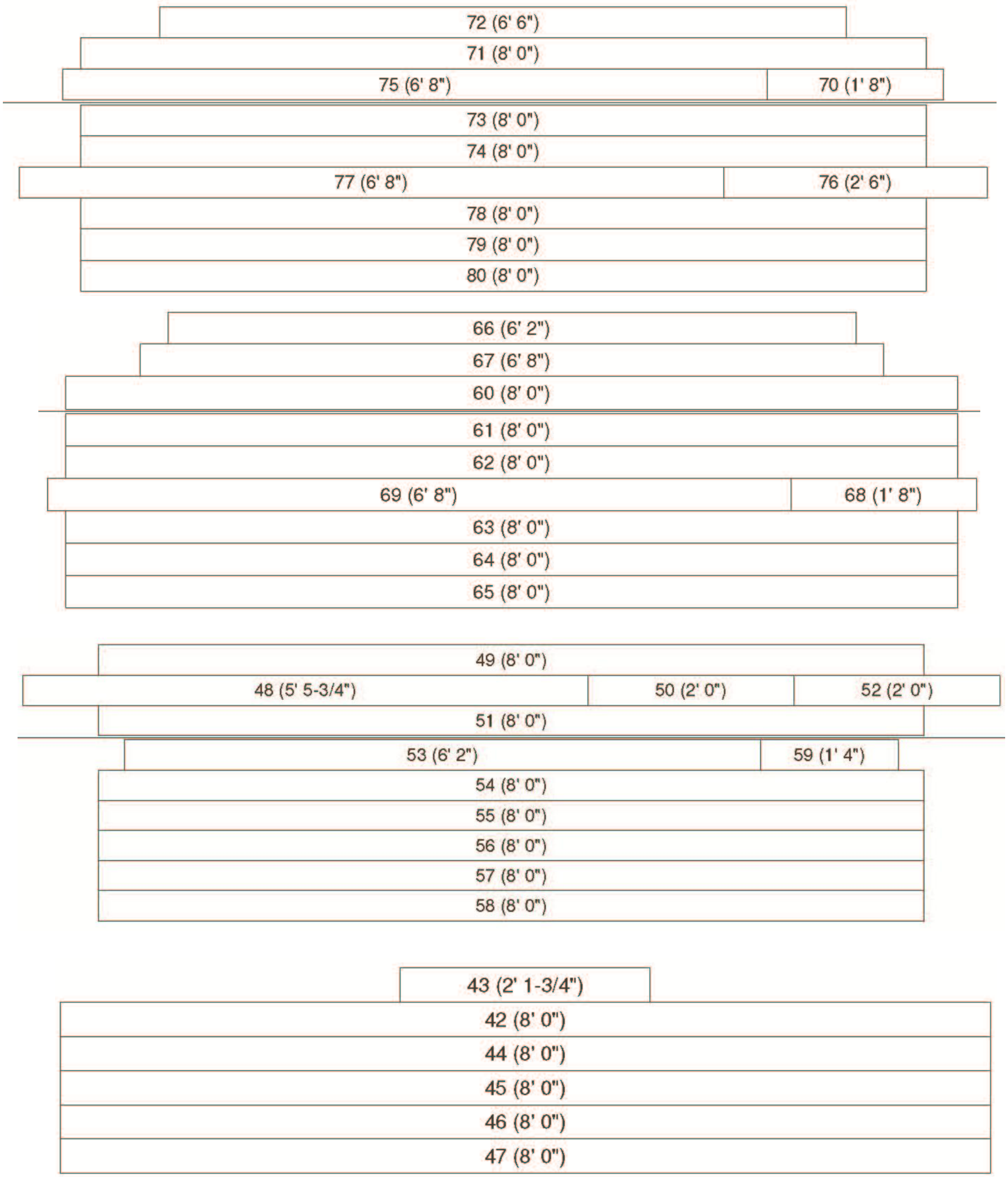
L3-1: Panel Designer



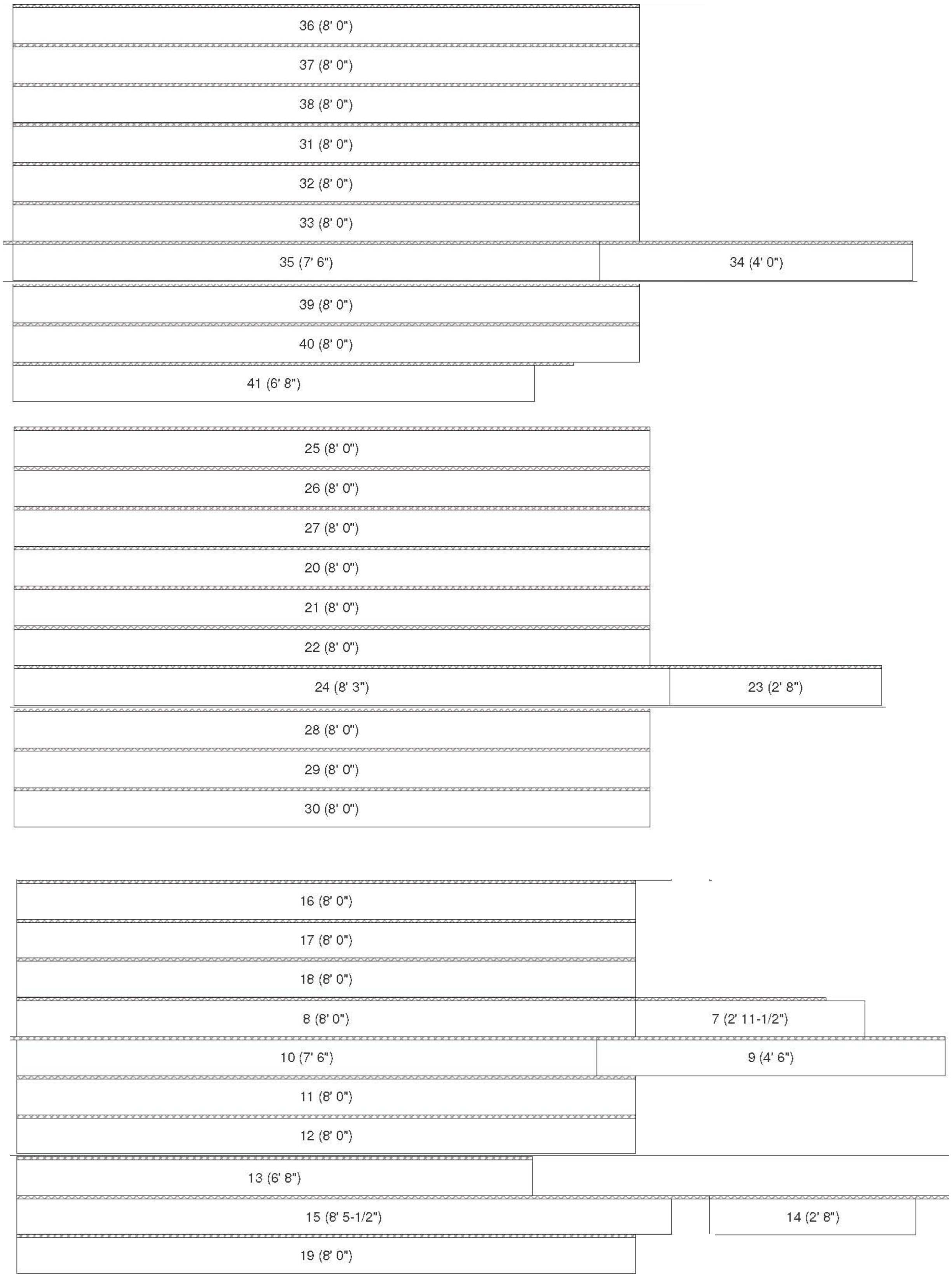
L3-1: Panel Designer



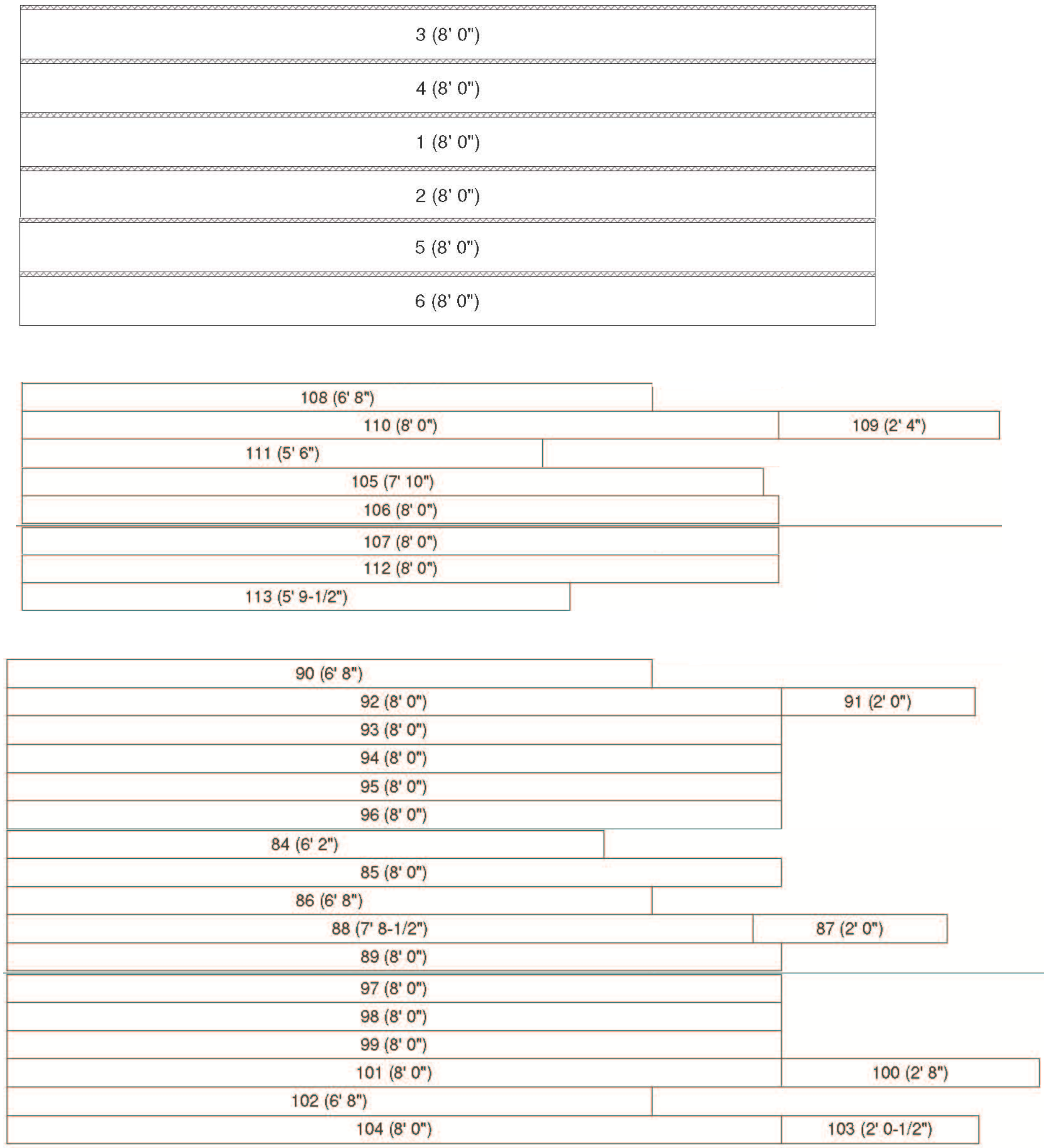
L3-1: Panel Designer



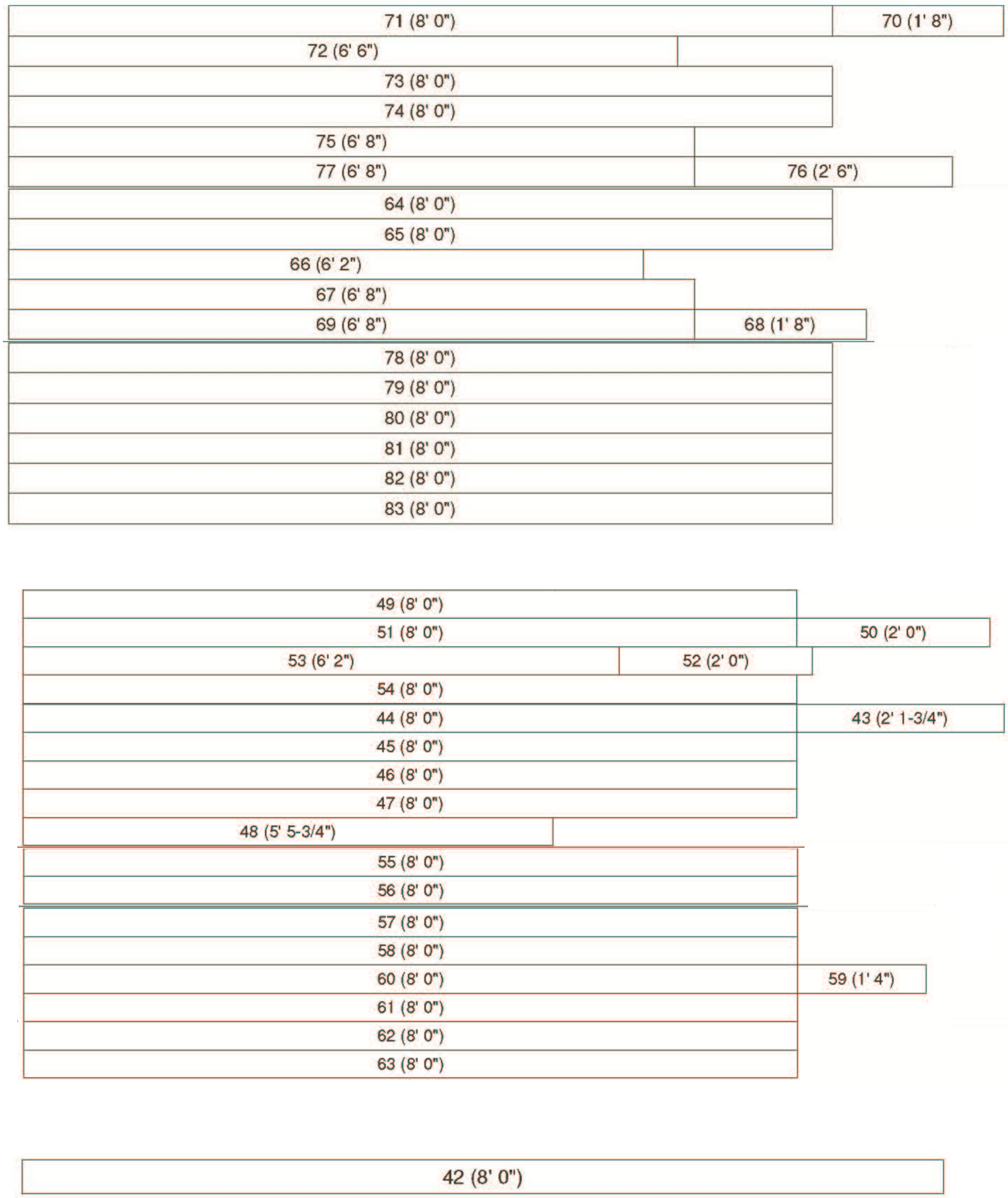
L3-1: IntelliBuild



L3-1: IntelliBuild



L3-1: IntelliBuild



```
L3-1: Proposed algorithm

** Nzones
5

**zone     left edge X coordinate
 1          6.0
 2        210.0
 3        438.0
 4        654.0
 5        790.0

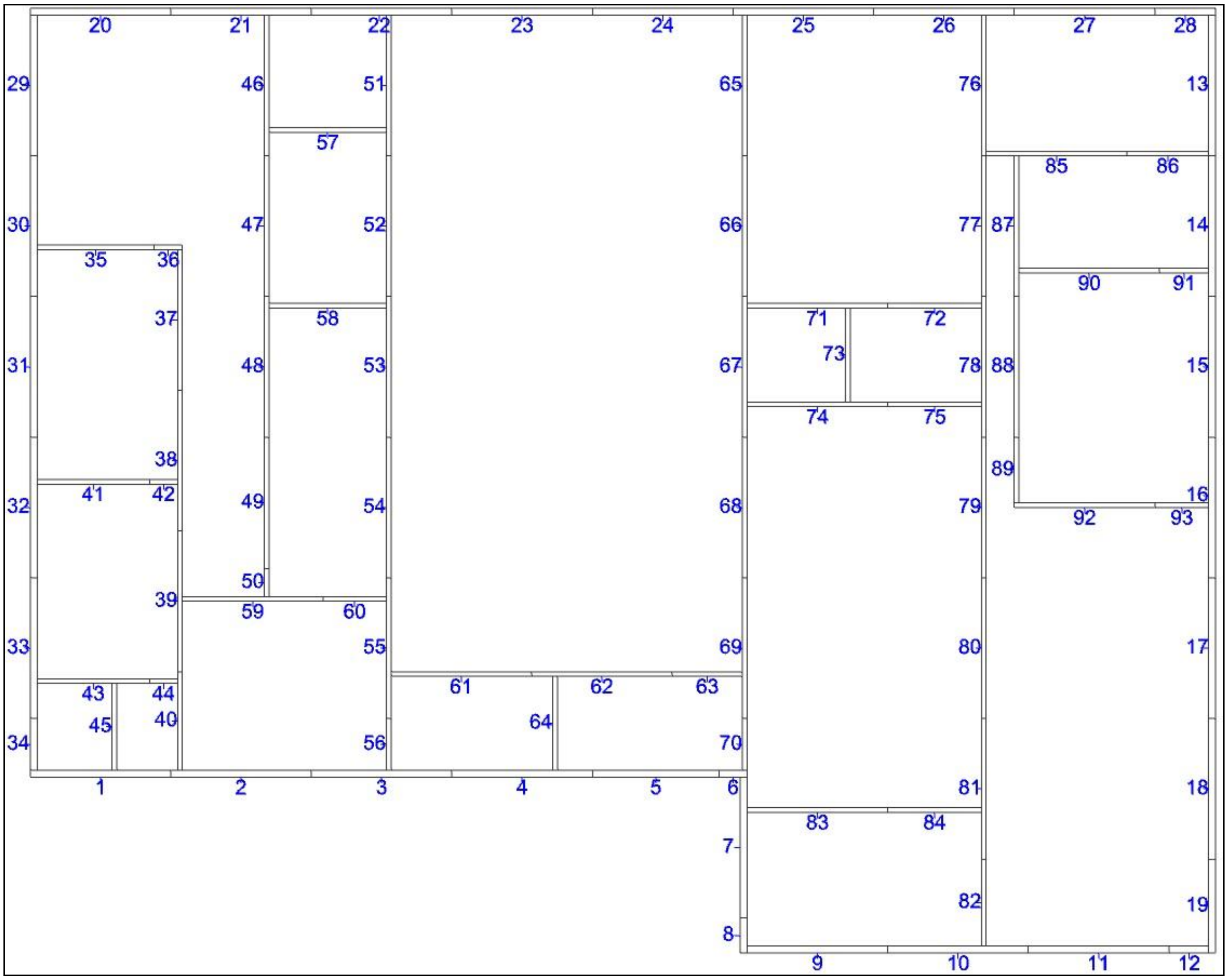
** NStacks
13

** stack              flush
**   #   zone type   edge     xloc    yloc   #layers   j   #panels   panels    orientation
     1     1    A    RIGHT   114.0    78.0     12          1        1      24         2
                                                           2        1      25         2
                                                           3        1      35         1
                                                           4        1      36         1
                                                           5        1      37         1
                                                           6        1      38         1
                                                           7        1      39         1
                                                           8        1      40         1
                                                           9        1      41         1
                                                          10        1      1          2
                                                          11        2      43 42      2 2
                                                          12        1      44         1
     2     1    A    RIGHT   114.0    78.0      4          1        1      45         1
                                                           2        2      50 49      2 2
                                                           3        1      46         1
                                                           4        2      52 51      2 2
     3     2    A    RIGHT   330.0    78.0     16          1        1      26         2
                                                           2        1      27         2
                                                           3        1      54         1
                                                           4        1      60         1
                                                           5        1      55         1
                                                           6        2      68 67      2 2
                                                           7        1      61         1
                                                           8        1      56         1
                                                           9        2      70 69      2 2
                                                          10        1      62         1
                                                          11        1      57         1
                                                          12        1      63         1
                                                          13        2      59 58      1 1
                                                          14        1      64         1
                                                          15        1      71         2
                                                          16        1      72         2
     4     2    A    RIGHT   330.0    78.0      2          1        1      65         1
                                                           2        1      73         2
     5     2    B    LEFT    330.0    90.0      4          1        1      53         1
                                                           2        1      47         1
                                                           3        1      48         1
                                                           4        1      2          3
     6     3    A    RIGHT   546.0    48.0      5          1        1      28         2
                                                           2        1      29         2
                                                           3        1      74         2
                                                           4        2      76 75      2 2
                                                           5        1      83         1
     7     3    B    LEFT    546.0    90.0     10          1        1      3          3
                                                           2        1      4          3
                                                           3        1      5          3
                                                           4        2      6 7        3 3
                                                           5        1      8          1
                                                           6        1      9          1
                                                           7        1      82         1
                                                           8        1      66         1
                                                           9        1      77         1
                                                          10        1      84         1
```

L3-1: Proposed algorithm

8	4	A	RIGHT	762.0	48.0	16	1	1	30	2
							2	1	31	2
							3	1	32	2
							4	1	78	1
							5	1	92	1
							6	1	79	1
							7	1	93	1
							8	1	80	1
							9	1	85	2
							10	2	87 86	2 2
							11	1	81	1
							12	1	88	1
							13	1	94	1
							14	1	89	2
							15	2	91 90	2 2
							16	1	95	1
9	4	A	RIGHT	762.0	48.0	2	1	1	96	1
							2	1	97	1
10	4	B	LEFT	762.0	90.0	2	1	1	10	3
							2	1	11	3
11	5	A	RIGHT	898.0	48.0	14	1	1	33	2
							2	1	34	2
							3	1	15	2
							4	1	16	2
							5	1	17	2
							6	1	18	2
							7	1	19	2
							8	1	20	2
							9	1	21	2
							10	2	23 22	2 2
							11	1	12	3
							12	2	14 13	3 3
							13	1	104	2
							14	1	105	2
12	5	A	RIGHT	898.0	48.0	7	1	1	106	2
							2	1	107	2
							3	1	110	2
							4	1	111	2
							5	2	109 108	2 2
							6	1	112	2
							7	1	113	2
13	5	B	LEFT	898.0	90.0	6	1	1	101	3
							2	1	102	3
							3	1	98	1
							4	1	100	1
							5	1	99	1
							6	1	103	2

L3-2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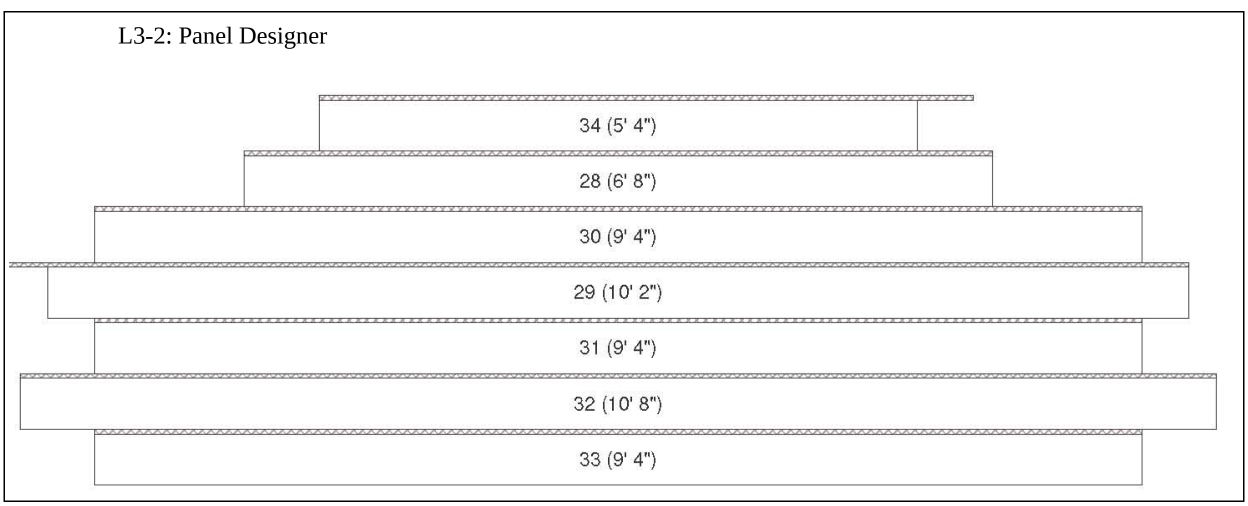
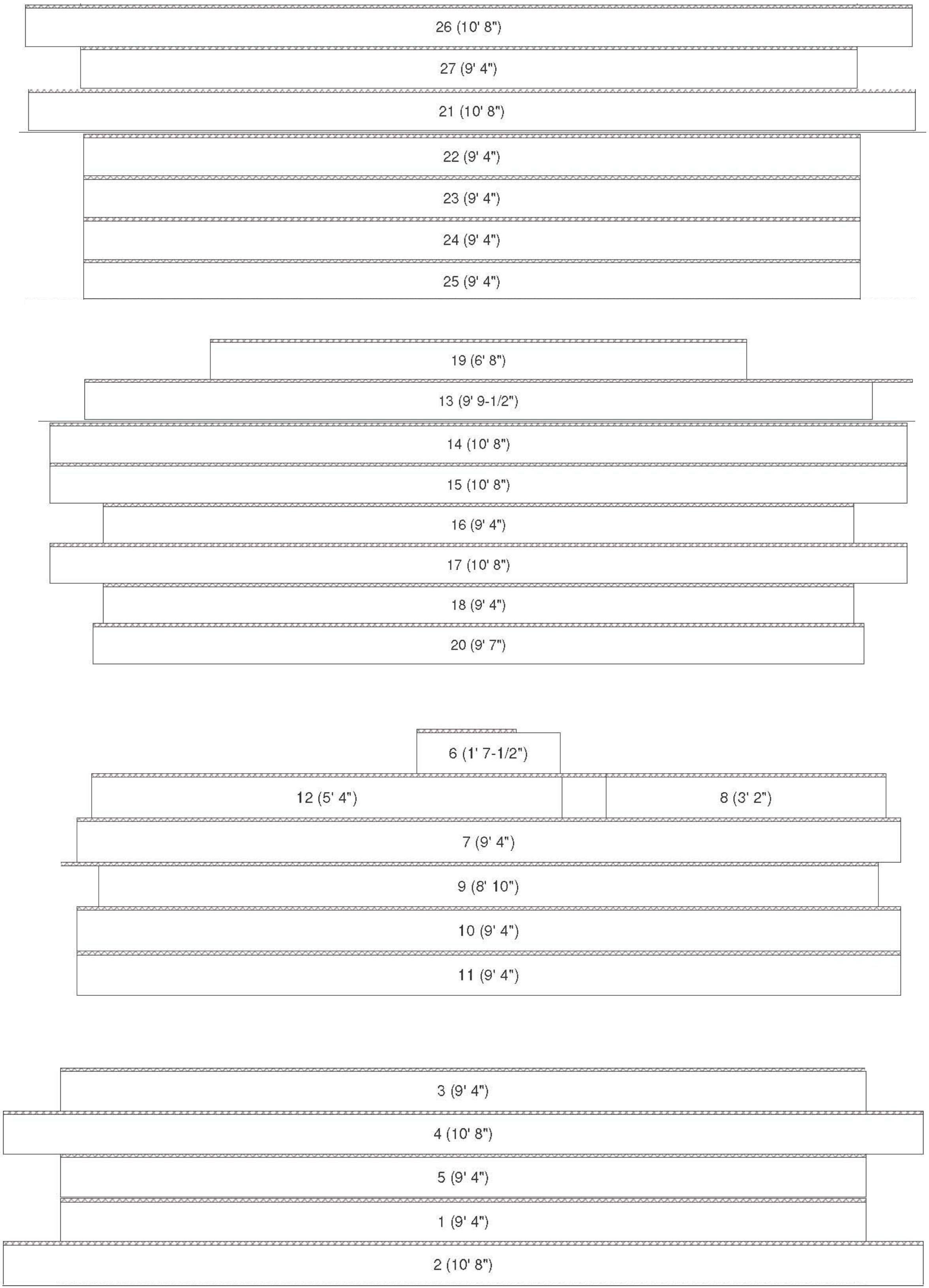
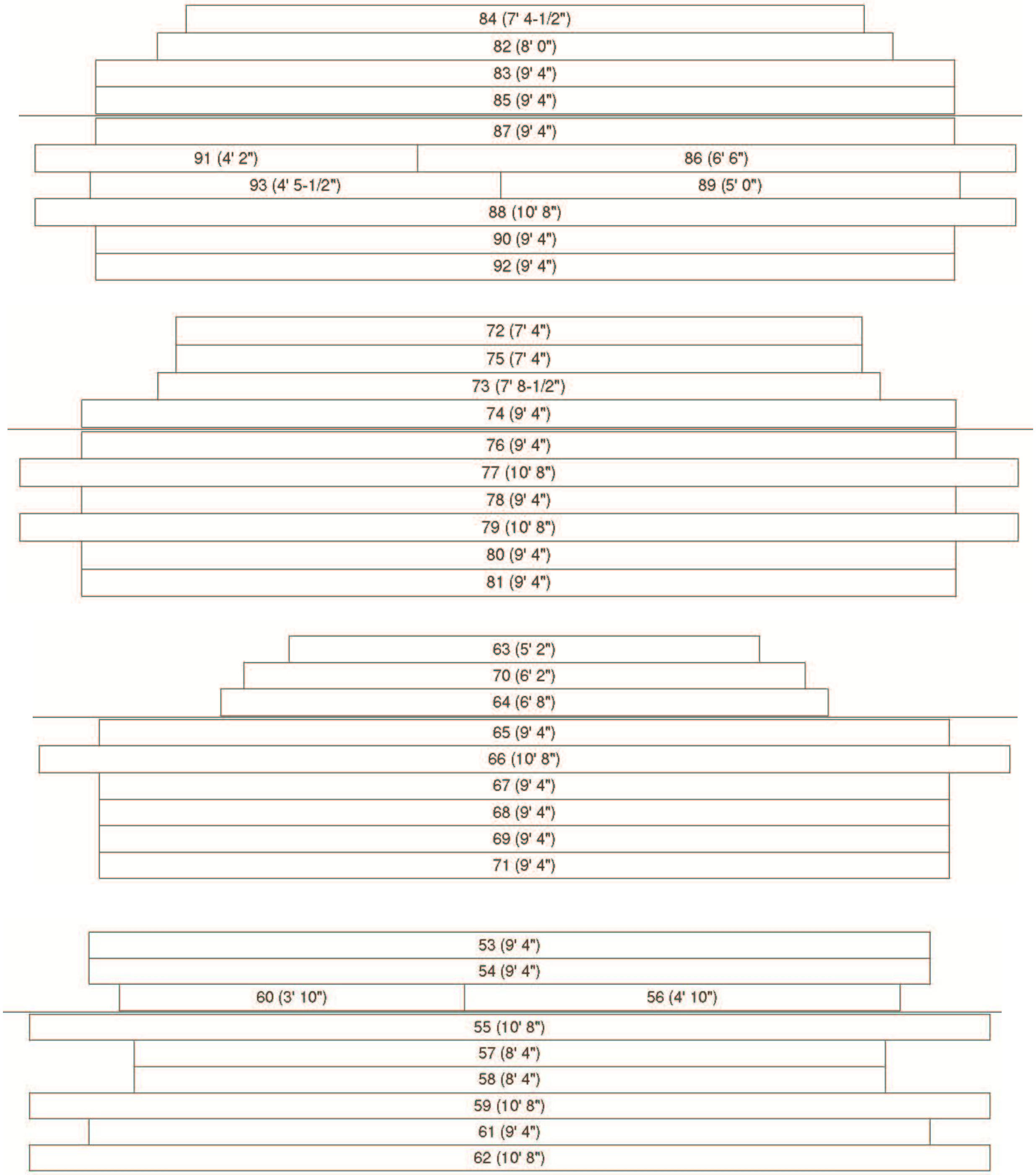

L3-2: Panel Designer
34 (5' 4")
28 (6' 8")
30 (9' 4")
29 (10' 2")
31 (9' 4")
32 (10' 8")
33 (9' 4")

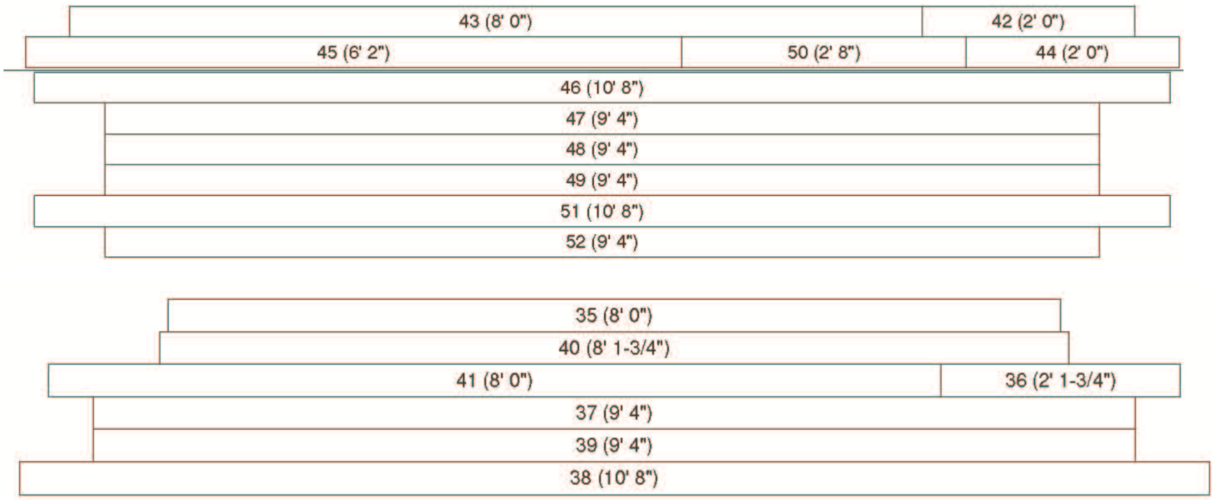
L3-2: Panel Designer



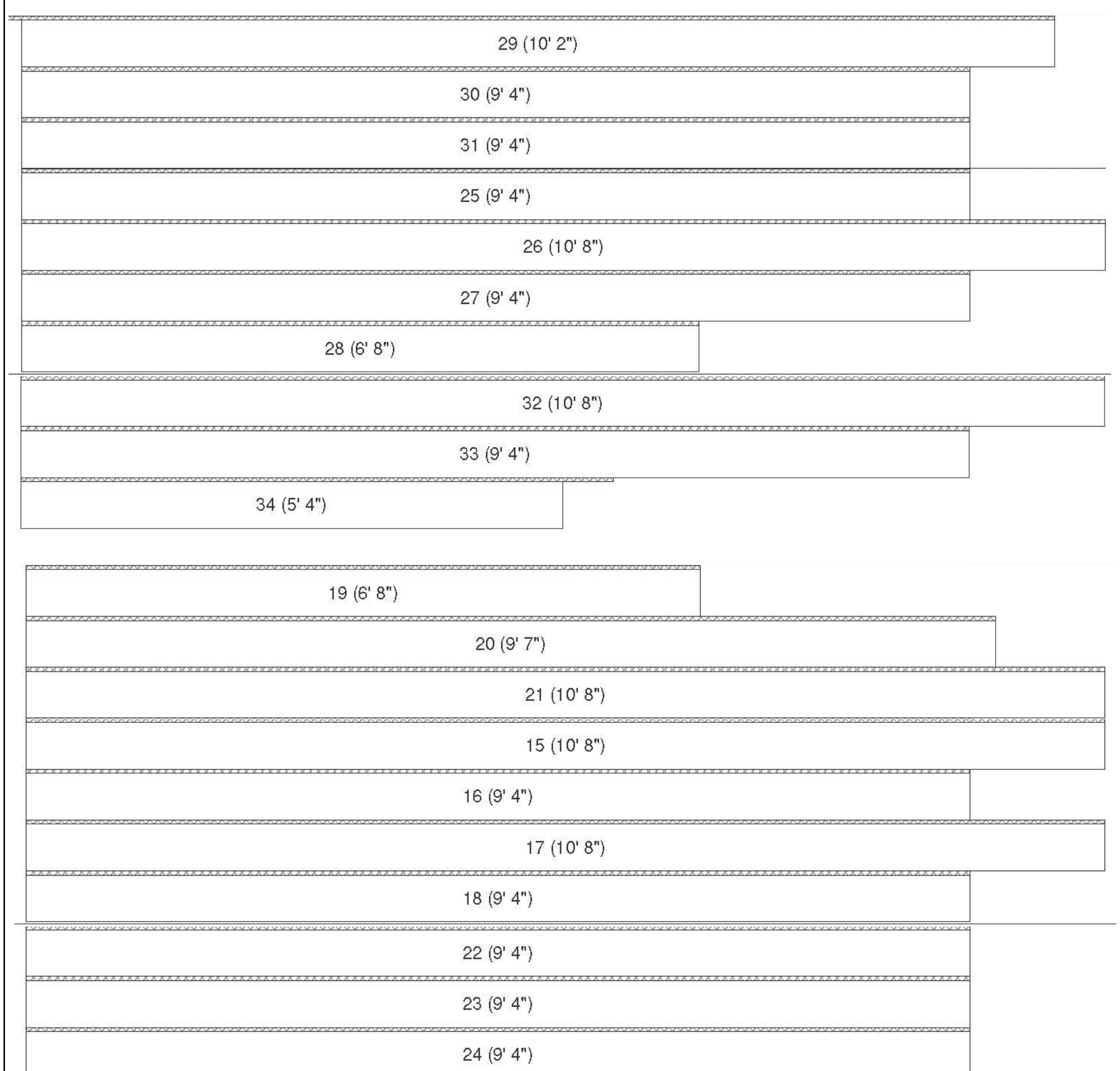
L3-2: Panel Designer



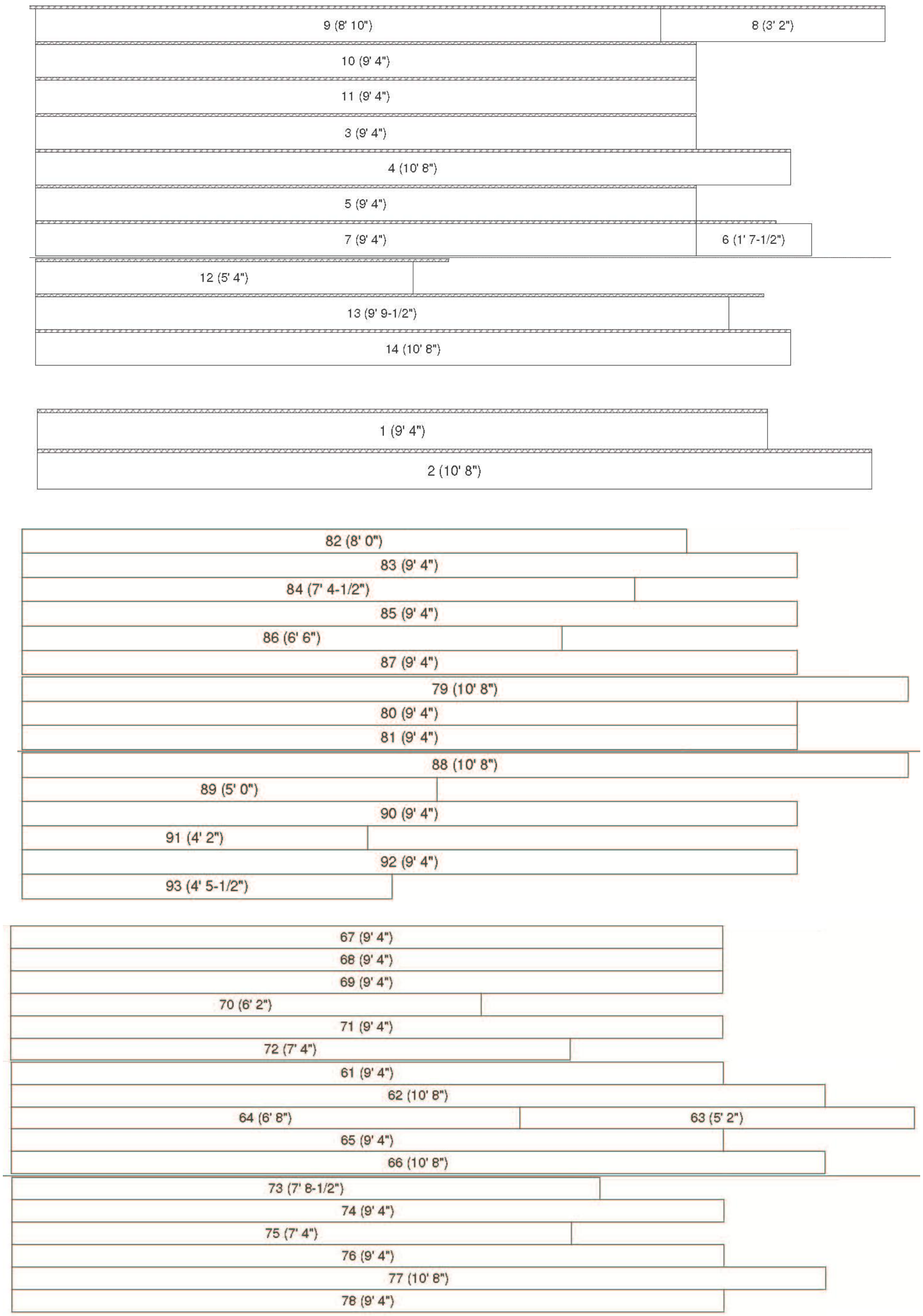
L3-2: Panel Designer



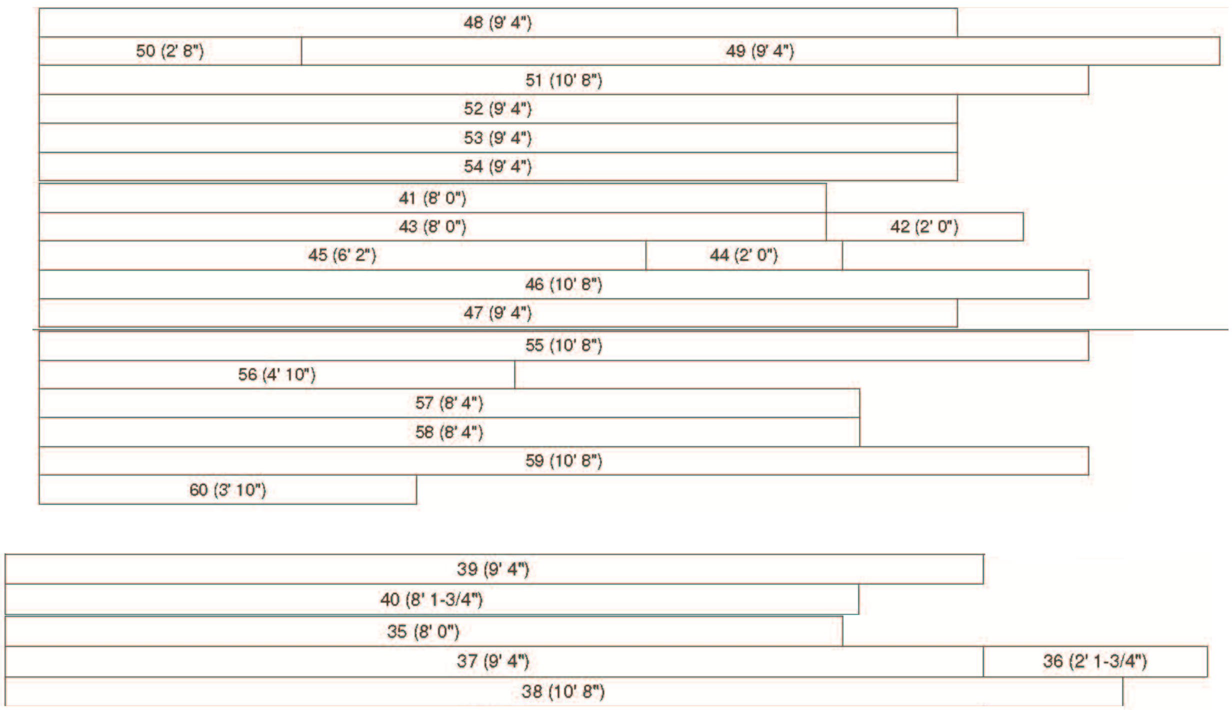
L3-2: IntelliBuild



L3-2: IntelliBuild



L3-2: IntelliBuild



L3-2: Proposed algorithm

```
** Nzones
5

**zone     left edge X coordinate
 1            6.0
 2          211.0
 3          438.0
 4          654.0
 5          790.0

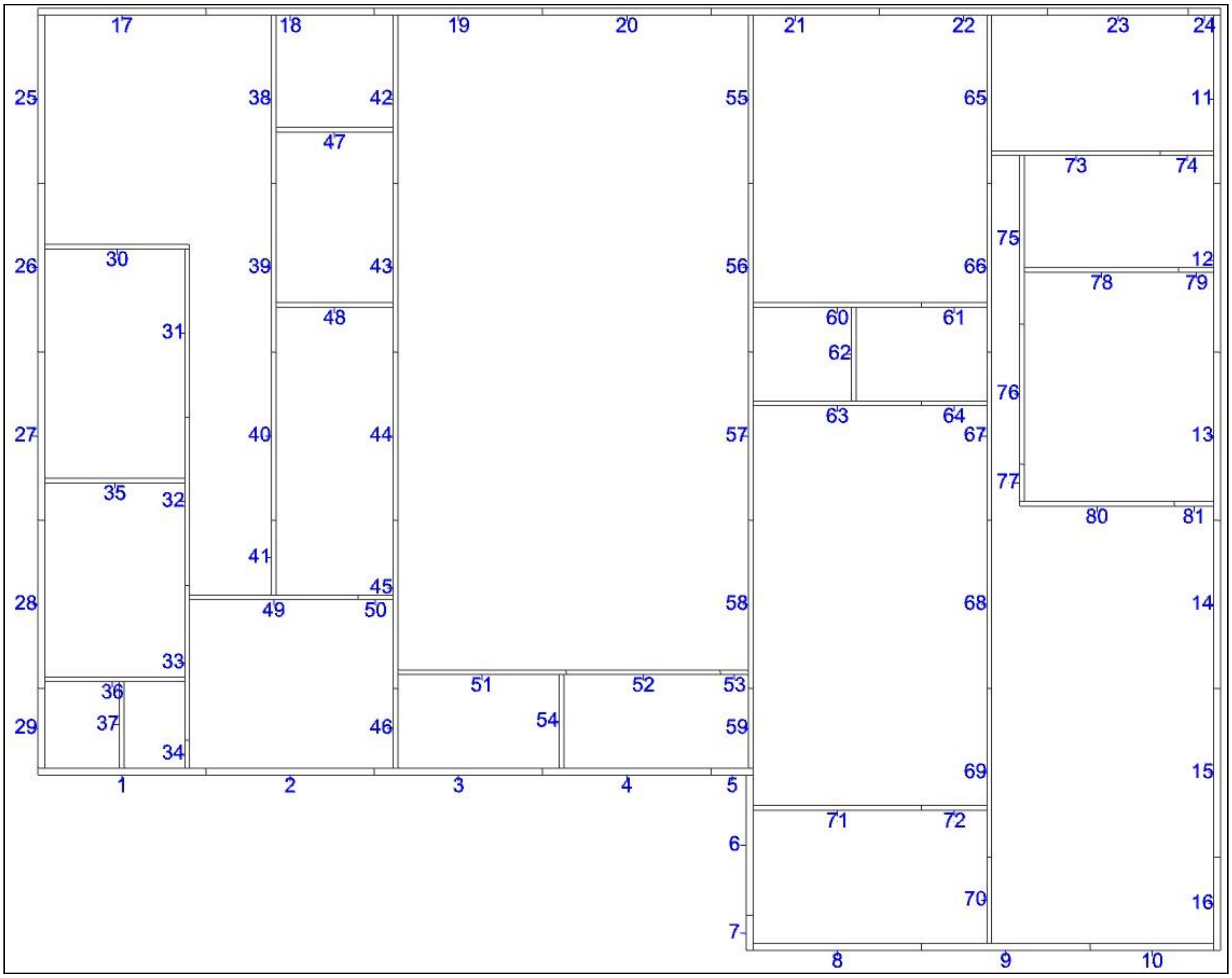
** NStacks
11

** stack               flush
**   #    zone type   edge     xloc   yloc  #layers  j  #panels  panels      orientation
     1     1    A     RIGHT   114.0   78.0     13    1     1     20                 2
                                                     2     1     29                 1
                                                     3     1     30                 1
                                                     4     1     31                 1
                                                     5     1     32                 1
                                                     6     1     33                 1
                                                     7     1     34                 1
                                                     8     1     1                  2
                                                     9     2     36 35              2 2
                                                    10     1     37                 1
                                                    11     2     42 41              2 2
                                                    12     1     38                 1
                                                    13     1     39                 1
     2     1    A     RIGHT   114.0   78.0      1    1     2     44 43              2 2
```

L3-2: Proposed algorithm

3	2	A	RIGHT	330.0	78.0	14	1	1	21	2
							2	1	22	2
							3	1	46	1
							4	1	57	2
							5	1	51	1
							6	1	47	1
							7	1	52	1
							8	1	48	1
							9	1	58	2
							10	1	53	1
							11	2	50 49	1 1
							12	1	54	1
							13	1	59	2
							14	1	60	2
4	2	B	LEFT	330.0	90.0	2	1	1	45	1
							2	1	40	1
5	3	A	RIGHT	546.0	78.0	2	1	1	23	2
							2	1	24	2
6	3	B	LEFT	546.0	90.0	13	1	1	2	3
							2	1	3	3
							3	1	4	3
							4	2	5 6	3 3
							5	1	7	1
							6	1	8	1
							7	1	55	1
							8	1	61	2
							9	1	62	2
							10	2	63 56	2 1
							11	1	64	1
							12	1	69	1
							13	1	70	1
7	4	A	RIGHT	762.0	48.0	15	1	1	25	2
							2	1	26	2
							3	1	65	1
							4	1	76	1
							5	1	66	1
							6	1	77	1
							7	1	67	1
							8	1	71	2
							9	1	72	2
							10	1	73	1
							11	1	74	2
							12	1	75	2
							13	1	78	1
							14	1	68	1
							15	1	79	1
8	4	B	LEFT	762.0	90.0	2	1	1	9	3
							2	1	10	3
9	5	A	RIGHT	898.0	48.0	15	1	1	27	2
							2	1	28	2
							3	1	13	2
							4	1	14	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	19	2
							10	1	11	3
							11	1	12	3
							12	1	85	2
							13	1	86	2
							14	1	87	2
							15	1	90	2
10	5	A	RIGHT	898.0	48.0	5	1	1	91	2
							2	1	88	2
							3	1	89	2
							4	1	92	2
							5	1	93	2
11	5	B	LEFT	898.0	90.0	5	1	1	83	3
							2	1	80	1
							3	1	82	1
							4	1	81	1
							5	1	84	2

L3-3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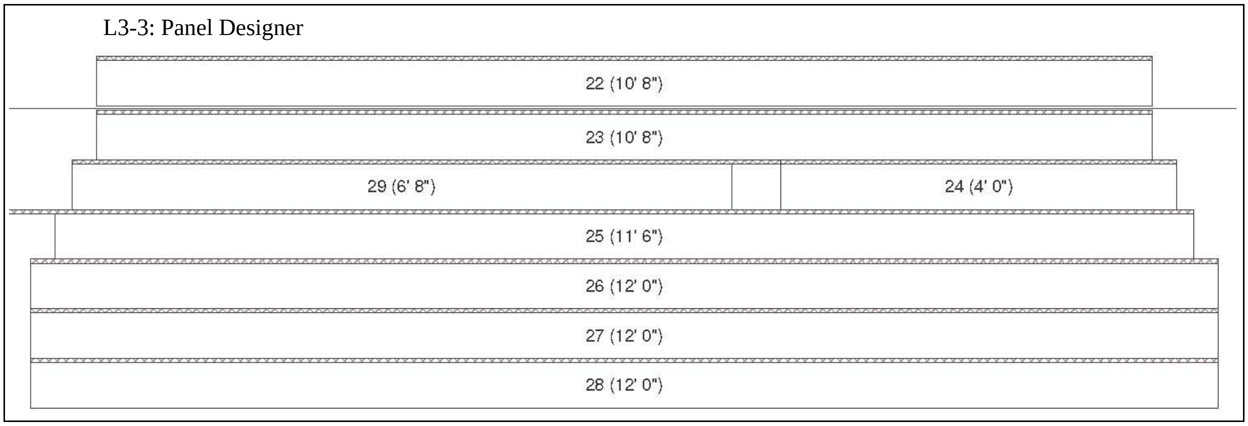
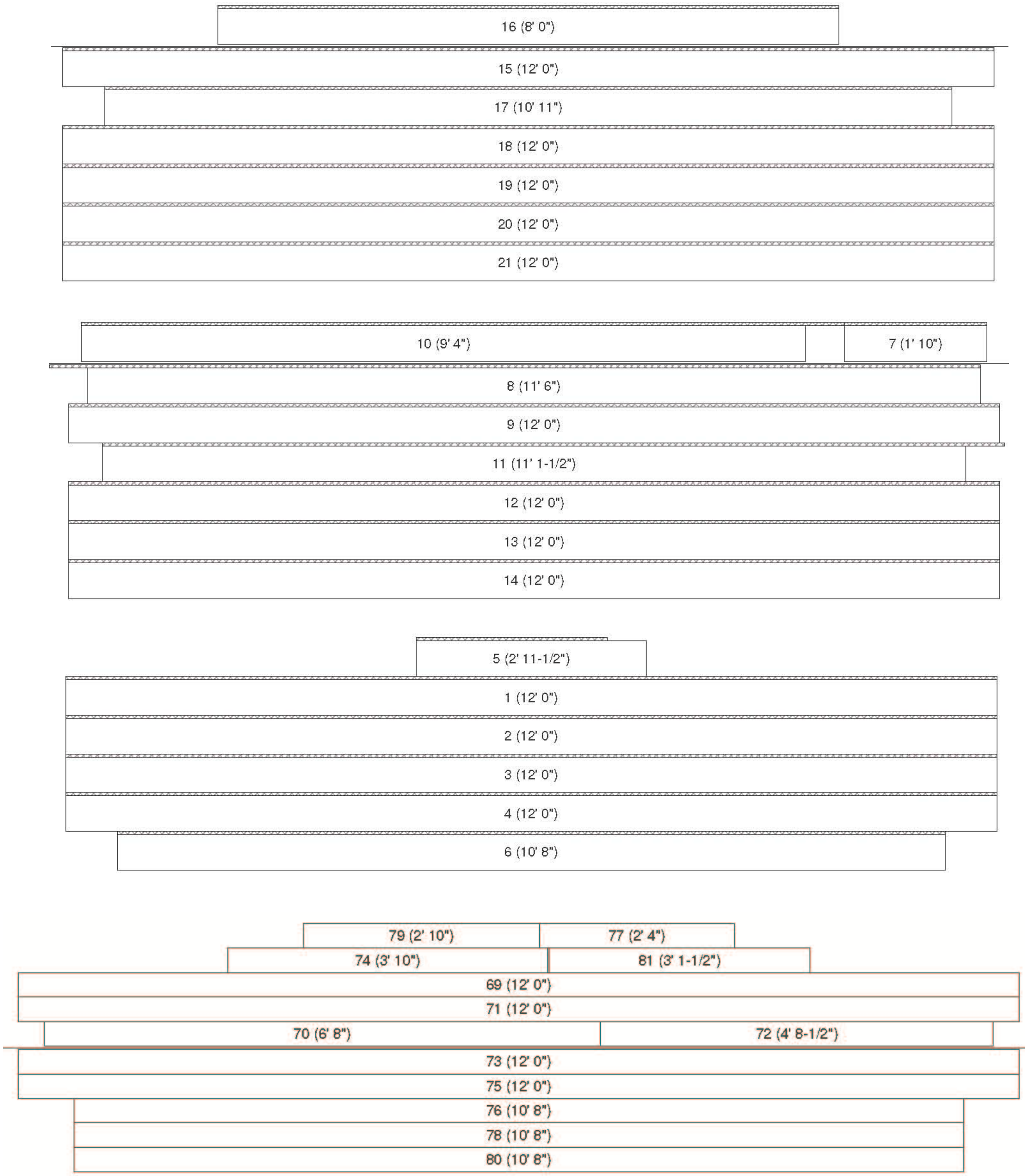
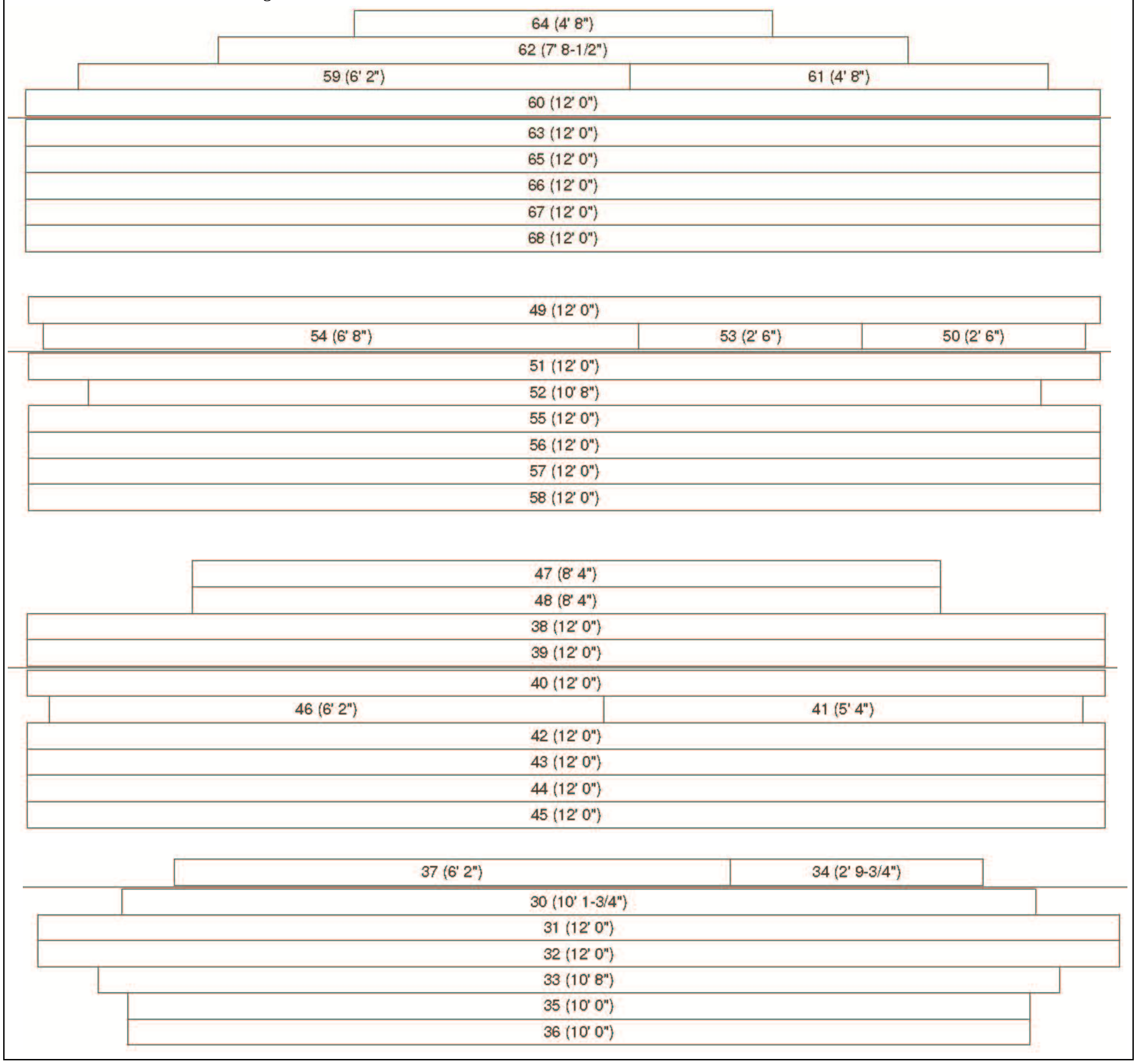

L3-3: Panel Designer
22 (10' 8")
23 (10' 8")
29 (6' 8")
24 (4' 0")
25 (11' 6")
26 (12' 0")
27 (12' 0")
28 (12' 0")

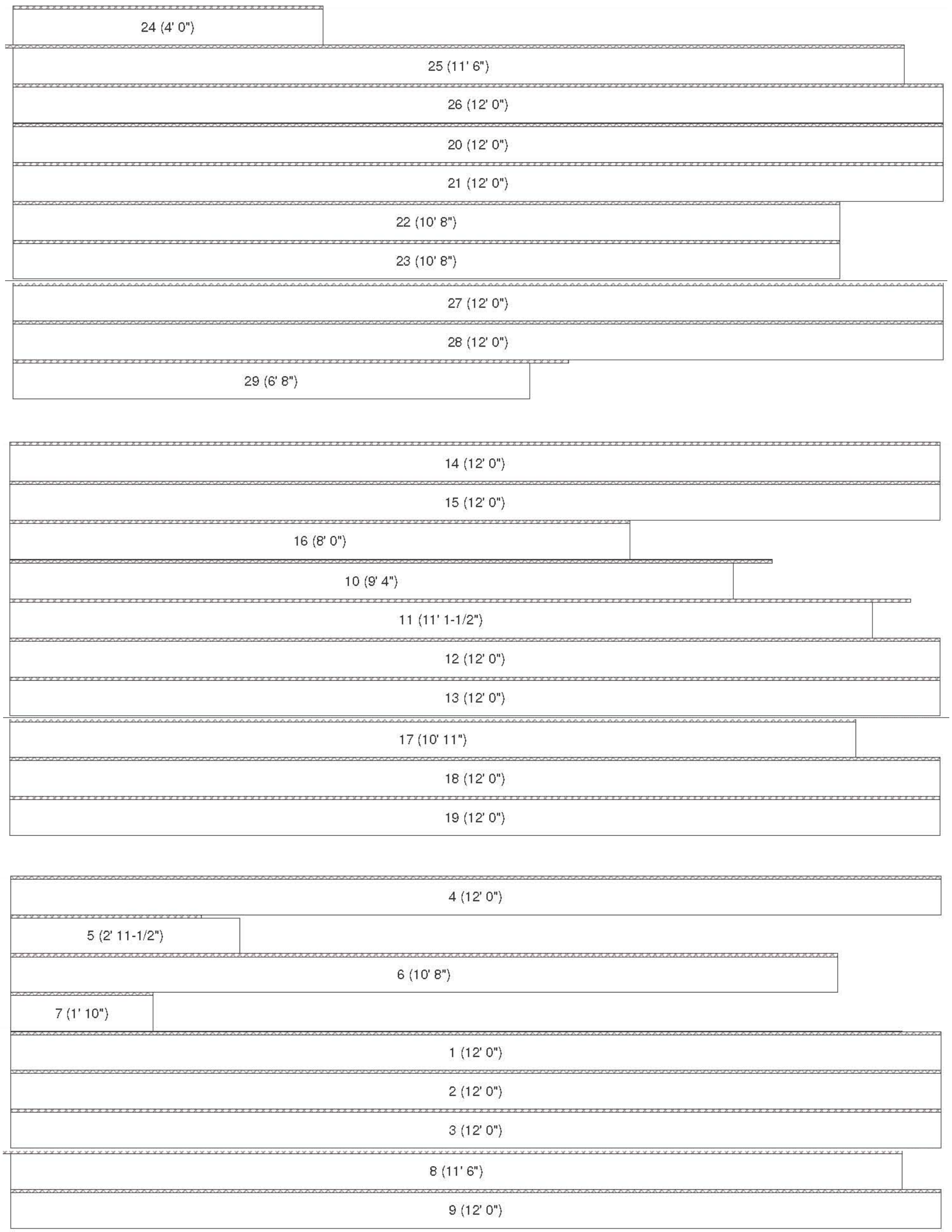
L3-3: Panel Designer



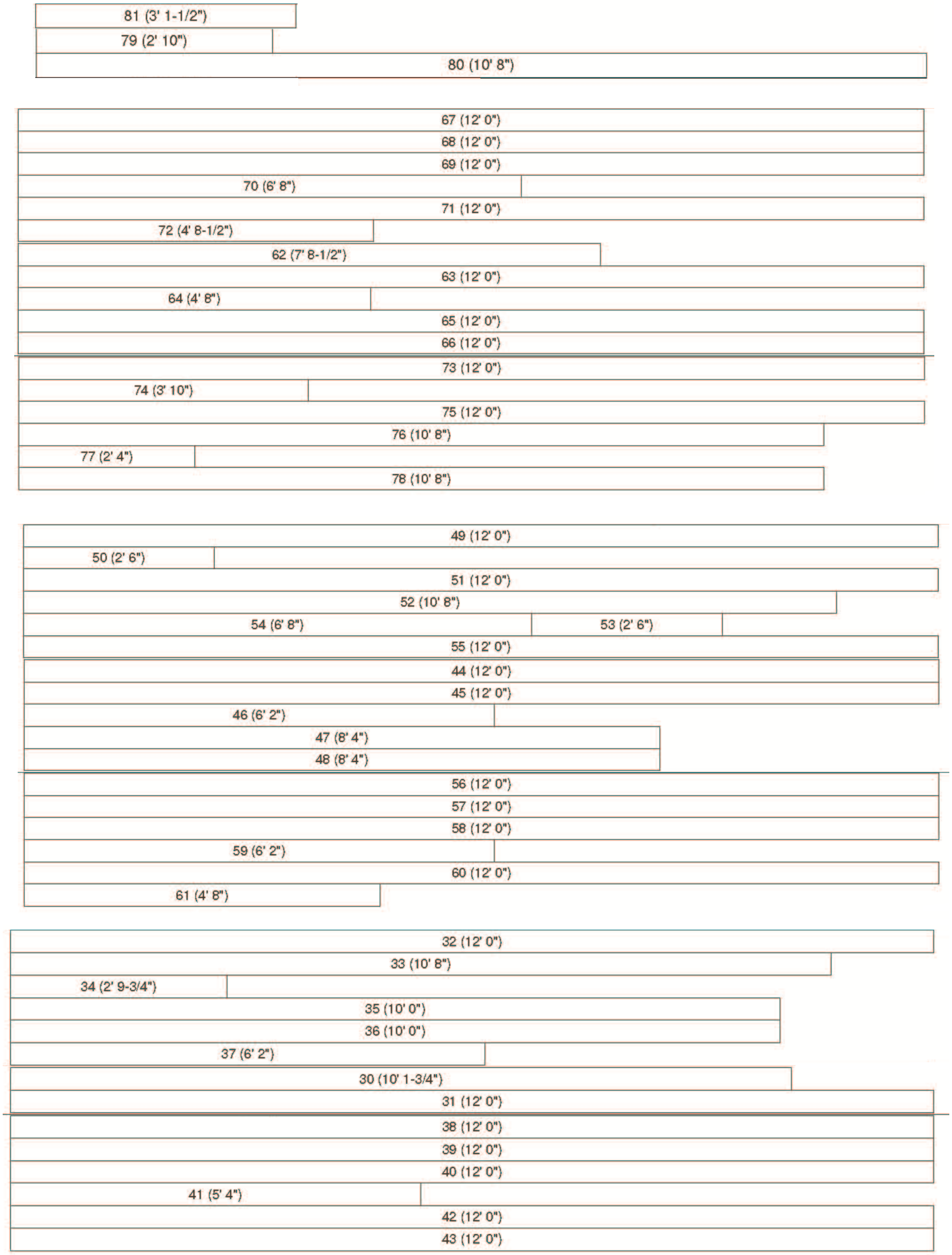
L3-3: Panel Designer



L3-3: IntelliBuild



L3-3: IntelliBuild



L3-3: Proposed algorithm

```
** Nzones
5

**zone    left edge X coordinate
 1          6.0
 2        226.5
 3        446.9
 4        667.4
 5        785.5

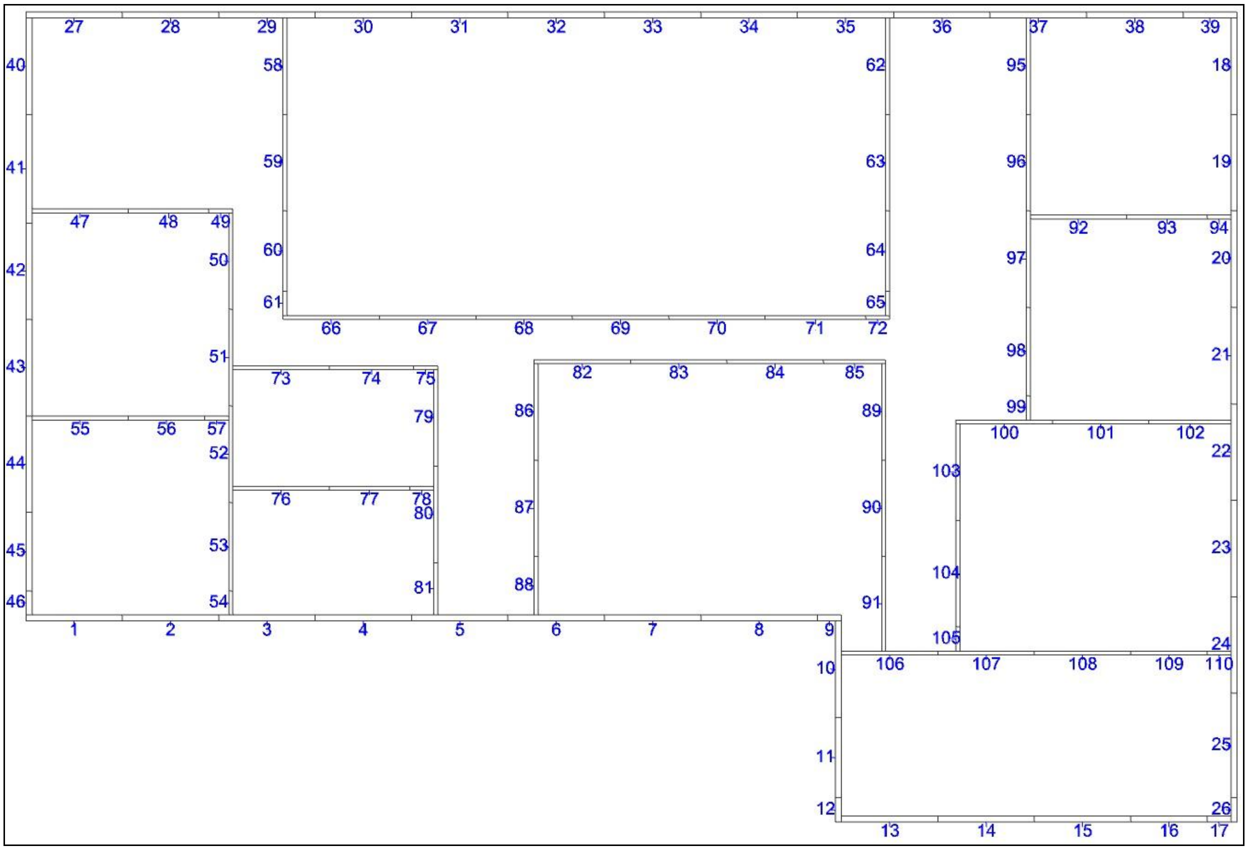
** NStacks
10

** stack              flush
**   #   zone type    edge     xloc   yloc  #layers   j   #panels   panels    orientation
     1     1    A     RIGHT   116.2   87.3     11     1      1       17          2
                                                      2      1       25          1
                                                      3      1       26          1
                                                      4      1       27          1
                                                      5      1       28          1
                                                      6      1       29          1
                                                      7      1       1           2
                                                      8      1       30          2
                                                      9      1       31          1
                                                     10      1       35          2
                                                     11      1       32          1
     2     2    A     RIGHT   336.7   87.3     13     1      1       18          2
                                                      2      1       19          2
                                                      3      1       38          1
                                                      4      1       47          2
                                                      5      1       42          1
                                                      6      1       39          1
                                                      7      1       48          2
                                                      8      1       43          1
                                                      9      1       40          1
                                                     10      1       44          1
                                                     11      1       41          1
                                                     12      1       49          2
                                                     13      1       50          2
     3     2    B     LEFT    336.7   99.3      4     1      1       36          2
                                                      2      1       37          1
                                                      3      1       33          1
                                                      4      1       34          1
     4     3    A     RIGHT   557.1   87.3      1     1      1       20          2
     5     3    B     LEFT    557.1   99.3     13     1      1       2           3
                                                      2      1       3           3
                                                      3      1       4           3
                                                      4      1       5           3
                                                      5      1       6           1
                                                      6      1       7           1
                                                      7      1       45          1
                                                      8      1       51          2
                                                      9      1       52          2
                                                     10      2       53 46       2 1
                                                     11      1       54          1
                                                     12      1       58          1
                                                     13      1       59          1
     6     4    A     RIGHT   777.6   57.3     13     1      1       21          2
                                                      2      1       22          2
                                                      3      1       55          1
                                                      4      1       65          1
                                                      5      1       56          1
                                                      6      1       60          2
                                                      7      1       61          2
                                                      8      1       57          1
                                                      9      1       62          1
                                                     10      1       66          1
                                                     11      1       63          2
                                                     12      1       64          2
                                                     13      1       67          1
     7     4    B     LEFT    777.6   99.3      1     1      1       8           3
```

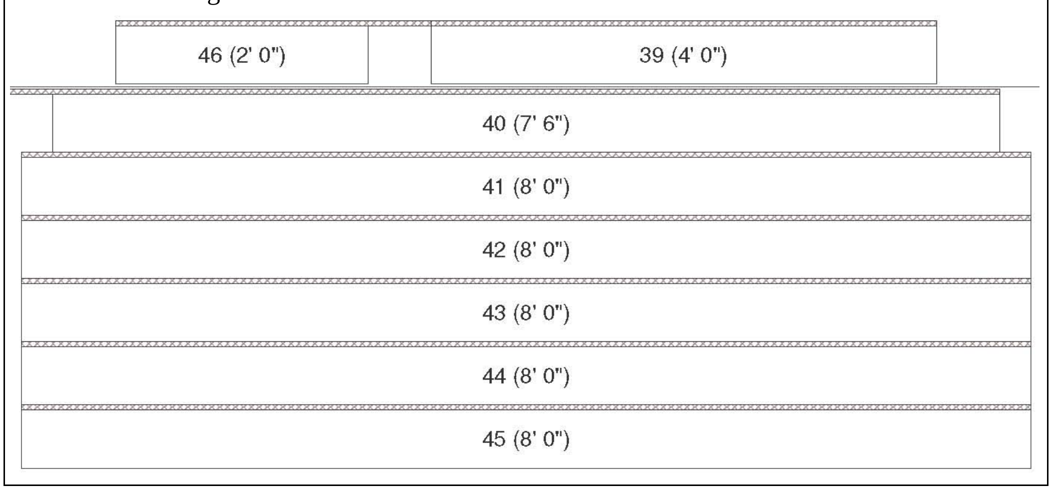
L3-3: Proposed algorithm

8	5	A	RIGHT	895.8	57.3	15	1	1	23	2
							2	1	24	2
							3	1	11	2
							4	1	12	2
							5	1	13	2
							6	1	14	2
							7	1	15	2
							8	1	16	2
							9	1	9	3
							10	1	10	3
							11	1	73	2
							12	1	74	2
							13	1	75	2
							14	1	78	2
							15	1	79	2
9	5	A	RIGHT	895.8	57.3	4	1	1	76	2
							2	1	77	2
							3	1	80	2
							4	1	81	2
10	5	B	LEFT	895.8	99.3	5	1	1	71	3
							2	1	68	1
							3	1	70	1
							4	1	69	1
							5	1	72	2

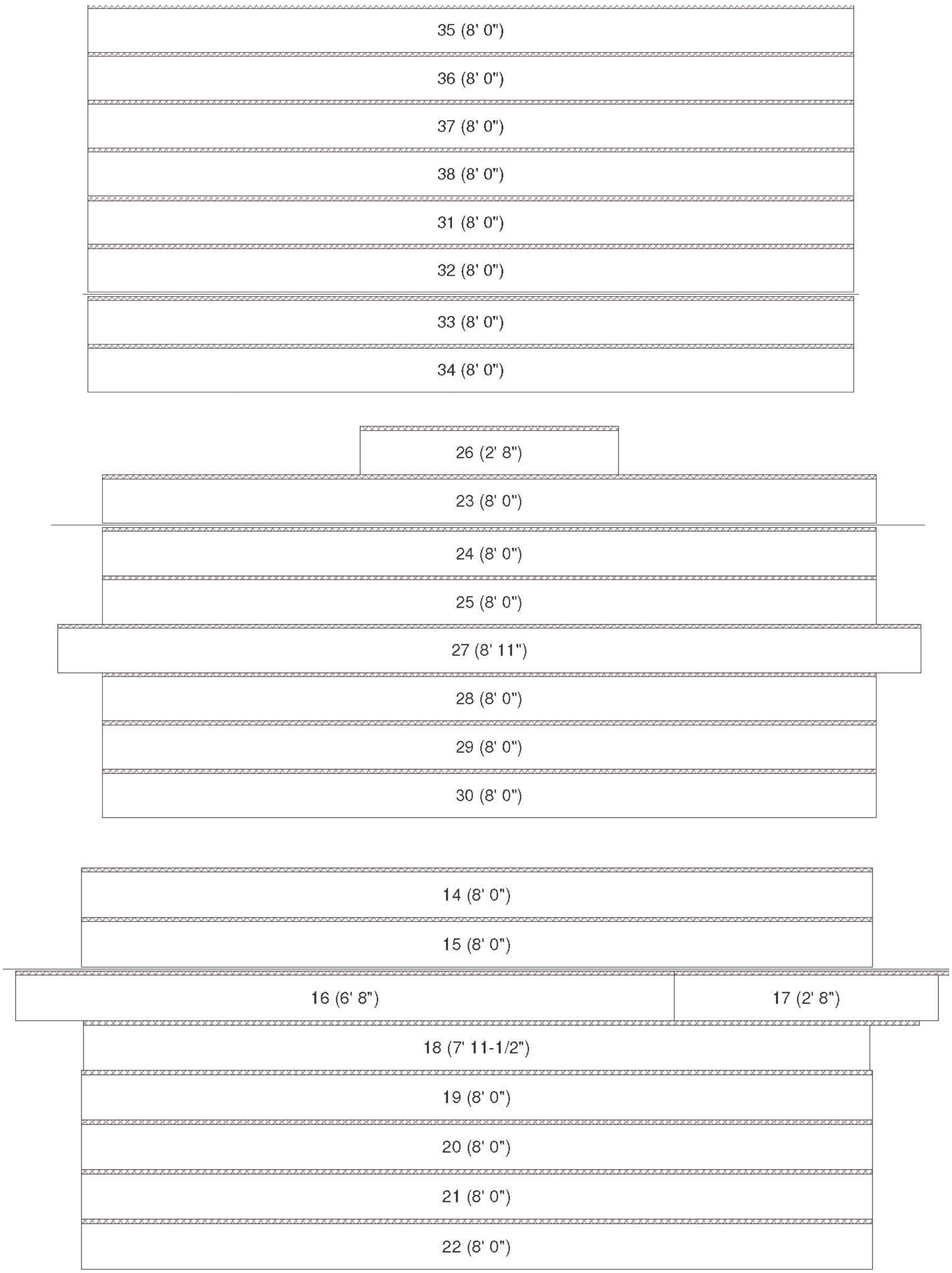
L4-1



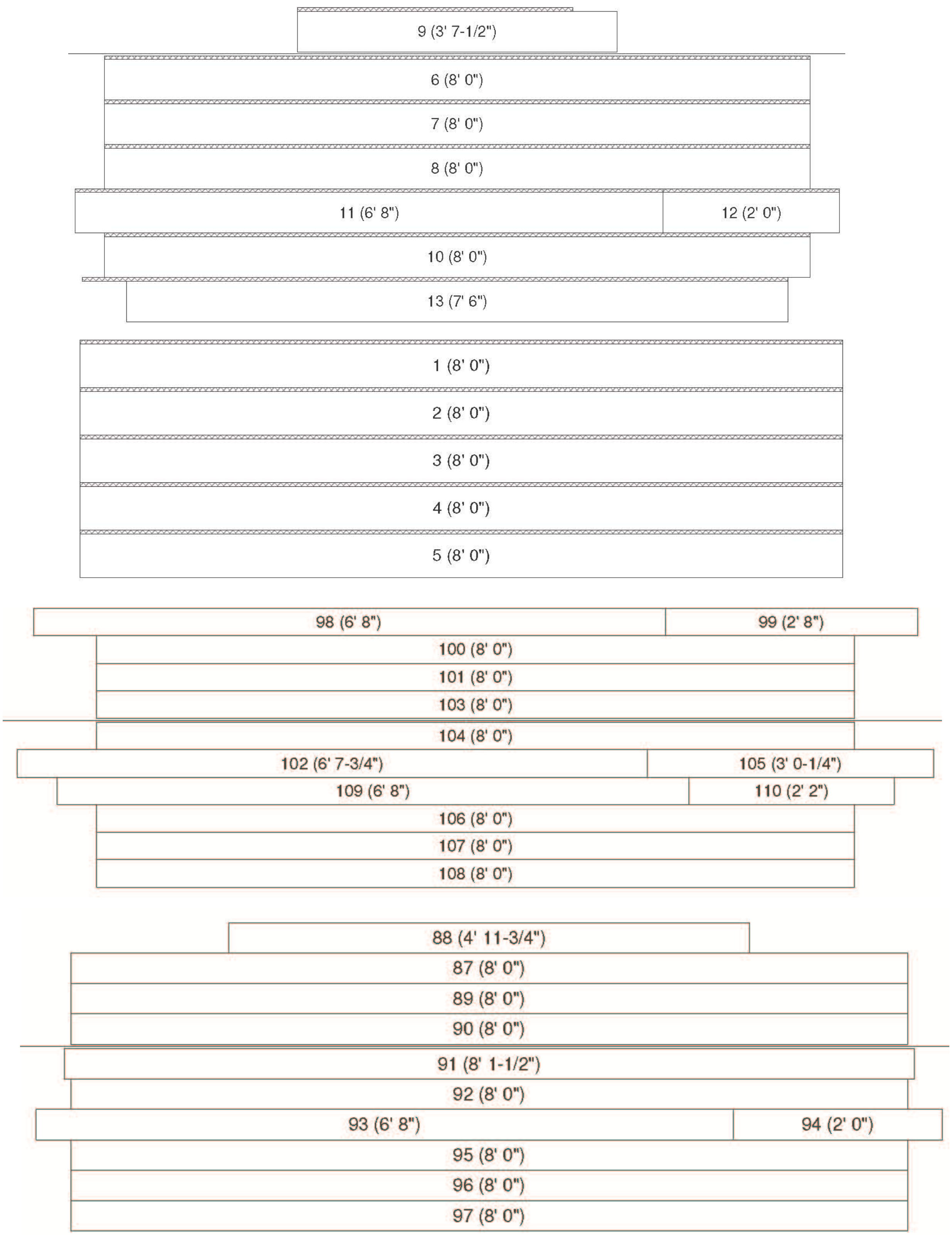
L4-1: Panel Designer



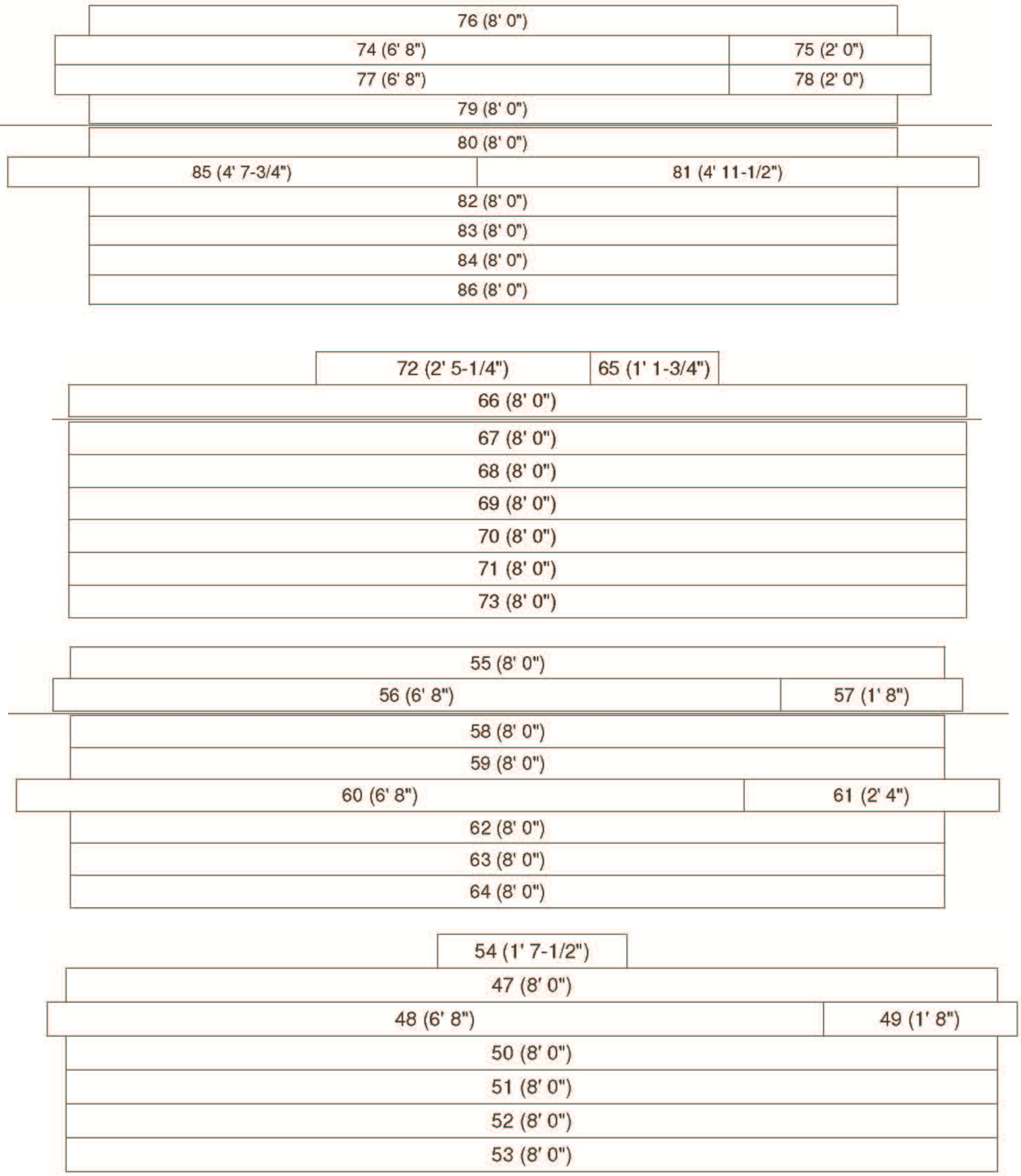
L4-1: Panel Designer



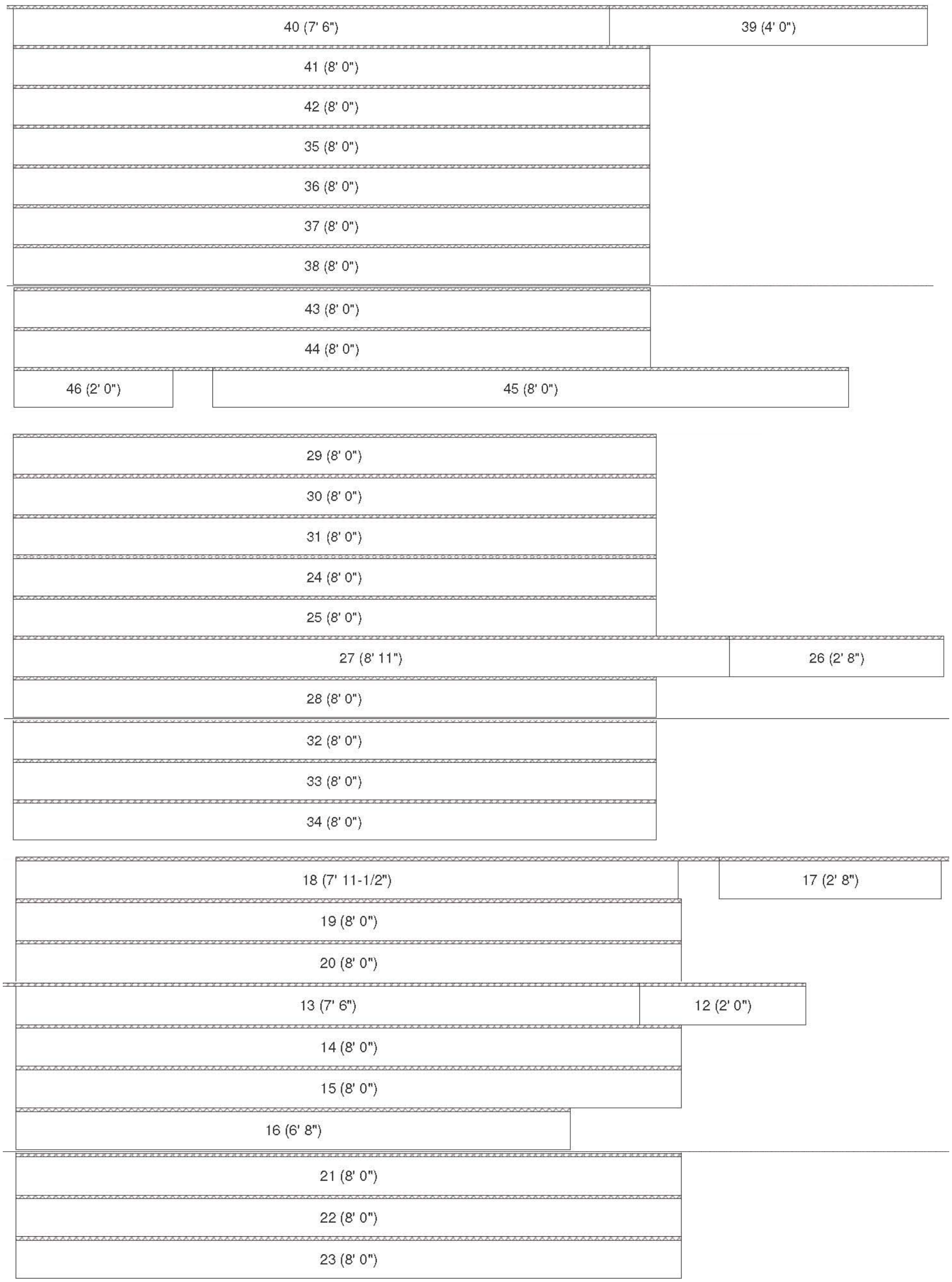
L4-1: Panel Designer



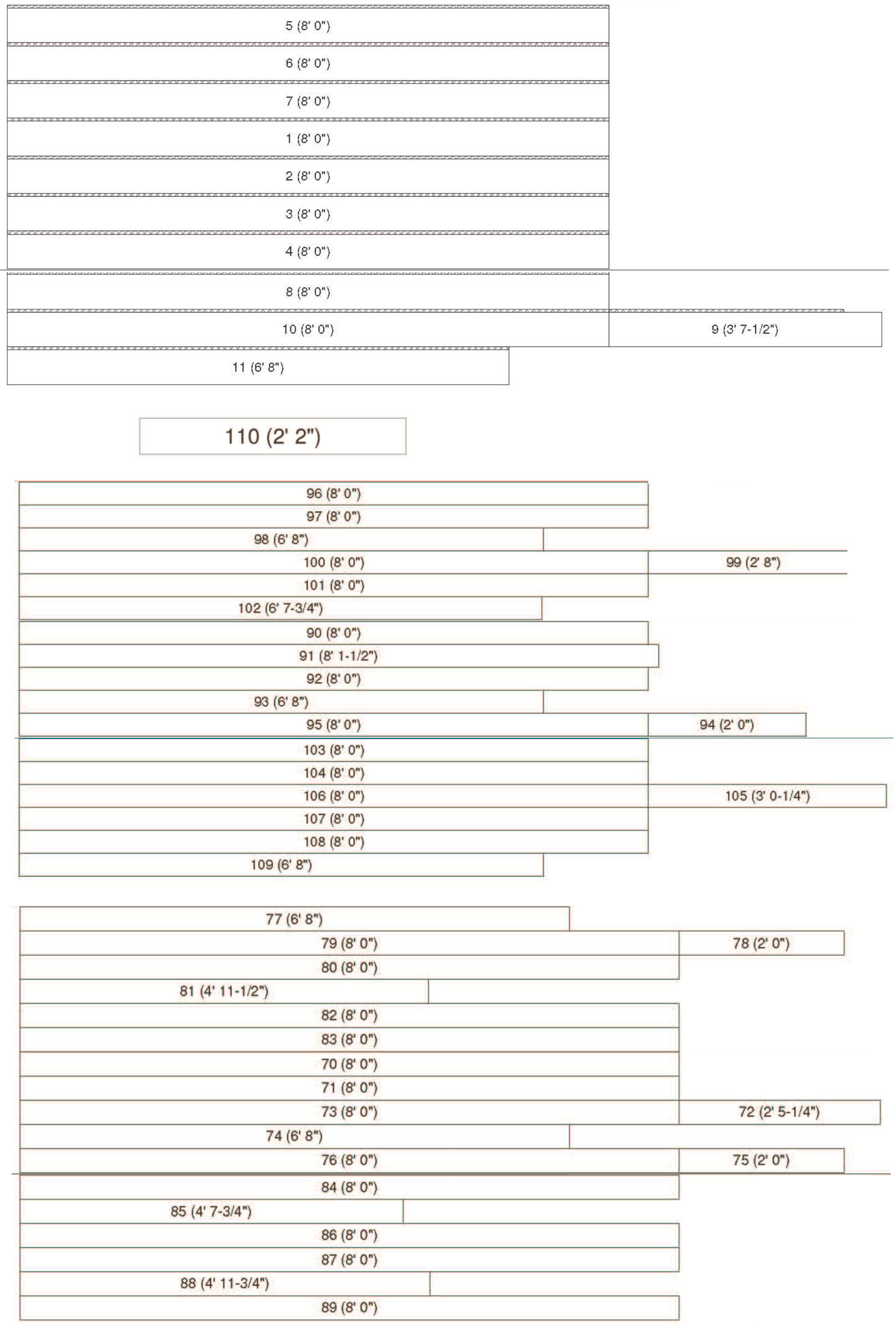
L4-1: Panel Designer



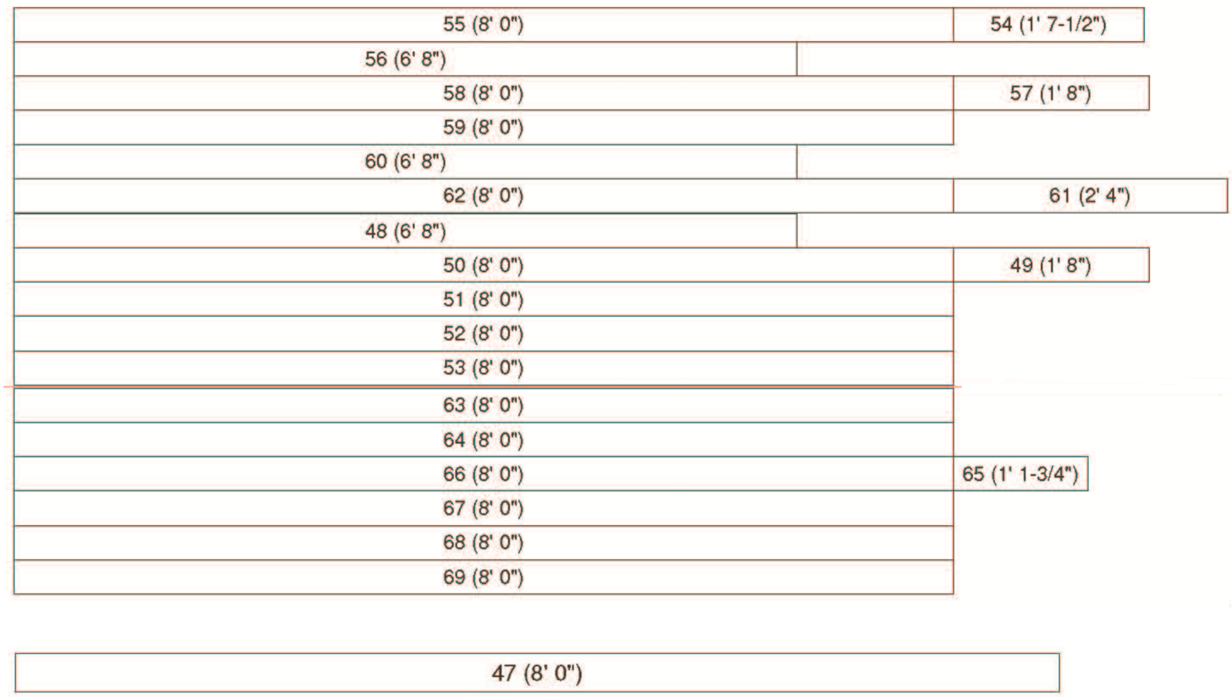
L4-1: IntelliBuild



L4-1: IntelliBuild



L4-1: IntelliBuild



L4-1: Proposed algorithm

** Nzones
6

**zone	left edge X coordinate
1	6.0
2	216.0
3	438.0
4	654.0
5	870.0
6	984.0

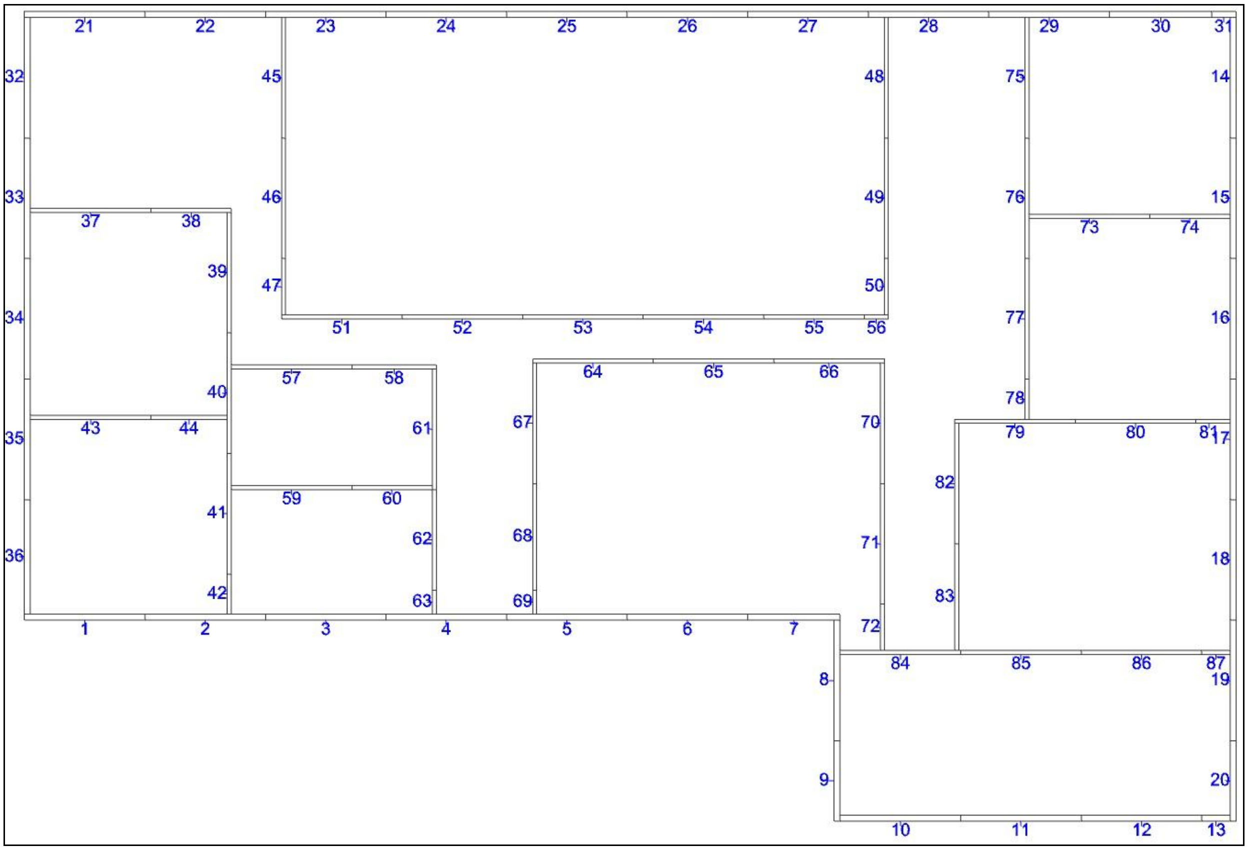
** NStacks
13

** stack ** #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	78.0	13	1	1	27	2
							2	1	28	2
							3	1	40	1
							4	1	41	1
							5	1	42	1
							6	1	43	1
							7	1	44	1
							8	2	46 45	1 1
							9	1	1	2
							10	1	47	2
							11	2	49 48	2 2
							12	1	50	1
							13	1	51	1
2	1	A	RIGHT	114.0	78.0	4	1	1	55	2
							2	2	57 56	2 2
							3	1	52	1
							4	1	53	1

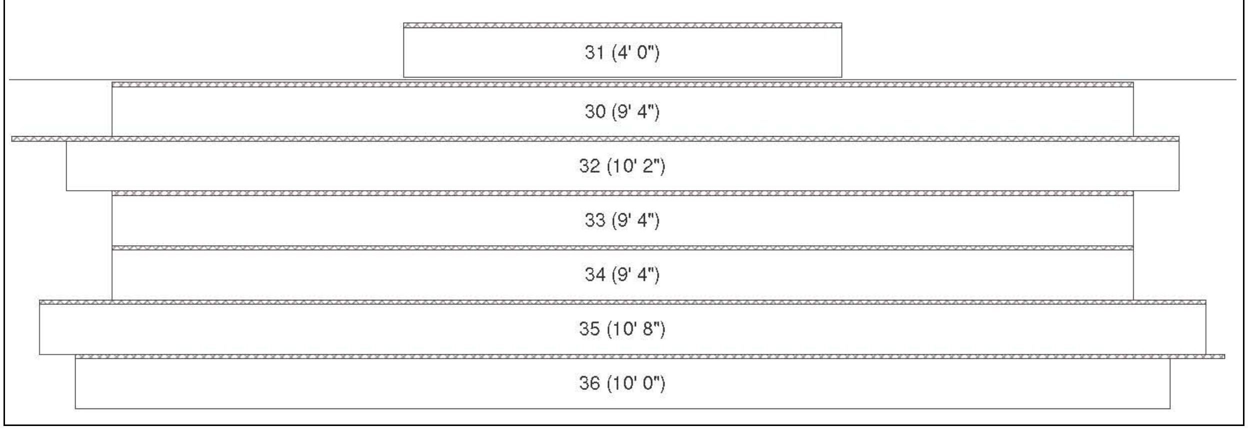
L4-1: Proposed algorithm

3	2	A	RIGHT	330.0	78.0	12	1	1	29	2
							2	1	30	2
							3	1	58	1
							4	1	59	1
							5	2	61 60	1 1
							6	1	66	2
							7	1	73	2
							8	2	75 74	2 2
							9	1	79	1
							10	1	76	2
							11	2	78 77	2 2
							12	1	80	1
4	2	B	LEFT	330.0	90.0	1	1	2	2 54	2 1
5	3	A	RIGHT	546.0	78.0	5	1	1	31	2
							2	1	32	2
							3	1	67	2
							4	1	68	2
							5	1	69	2
6	3	B	LEFT	546.0	90.0	5	1	1	3	2
							2	1	4	2
							3	1	5	2
							4	1	6	2
							5	1	81	1
7	4	A	RIGHT	762.0	78.0	8	1	1	33	2
							2	1	34	2
							3	1	35	2
							4	1	62	1
							5	1	63	1
							6	2	65 64	1 1
							7	1	70	2
							8	2	72 71	2 2
8	4	B	LEFT	762.0	90.0	7	1	1	7	2
							2	2	8 9	2 2
							3	1	10	1
							4	2	11 12	1 1
							5	1	13	3
							6	1	36	2
							7	1	88	1
9	5	A	RIGHT	978.0	78.0	8	1	1	37	2
							2	1	95	1
							3	1	96	1
							4	1	97	1
							5	2	99 98	1 1
							6	1	100	2
							7	1	87	1
							8	1	103	1
10	5	B	LEFT	978.0	90.0	1	1	1	14	3
11	6	A	RIGHT	1092.0	48.0	14	1	1	38	2
							2	1	39	2
							3	1	18	2
							4	1	19	2
							5	1	20	2
							6	1	21	2
							7	1	22	2
							8	1	23	2
							9	1	24	2
							10	2	26 25	2 2
							11	1	15	3
							12	2	17 16	3 3
							13	1	92	2
							14	2	94 93	2 2
12	6	A	RIGHT	1092.0	48.0	9	1	1	82	2
							2	1	83	2
							3	1	84	2
							4	1	85	2
							5	1	86	2
							6	1	89	2
							7	1	101	2
							8	1	102	2
							9	1	90	2
13	6	B	LEFT	1092.0	90.0	7	1	1	91	1
							2	2	104 105	1 1
							3	1	106	3
							4	1	107	2
							5	1	110	2
							6	1	109	2
							7	1	108	2

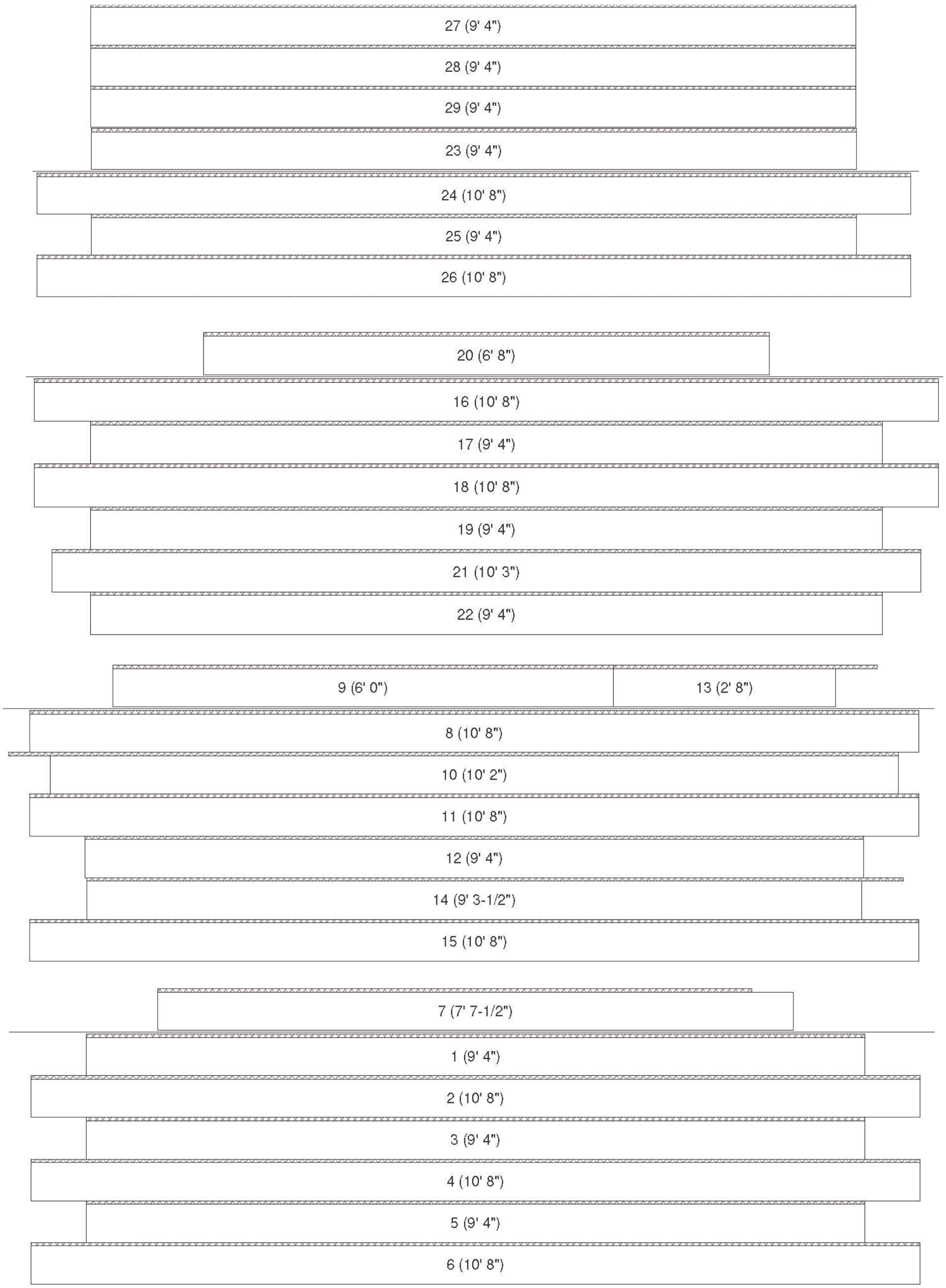
L4-2



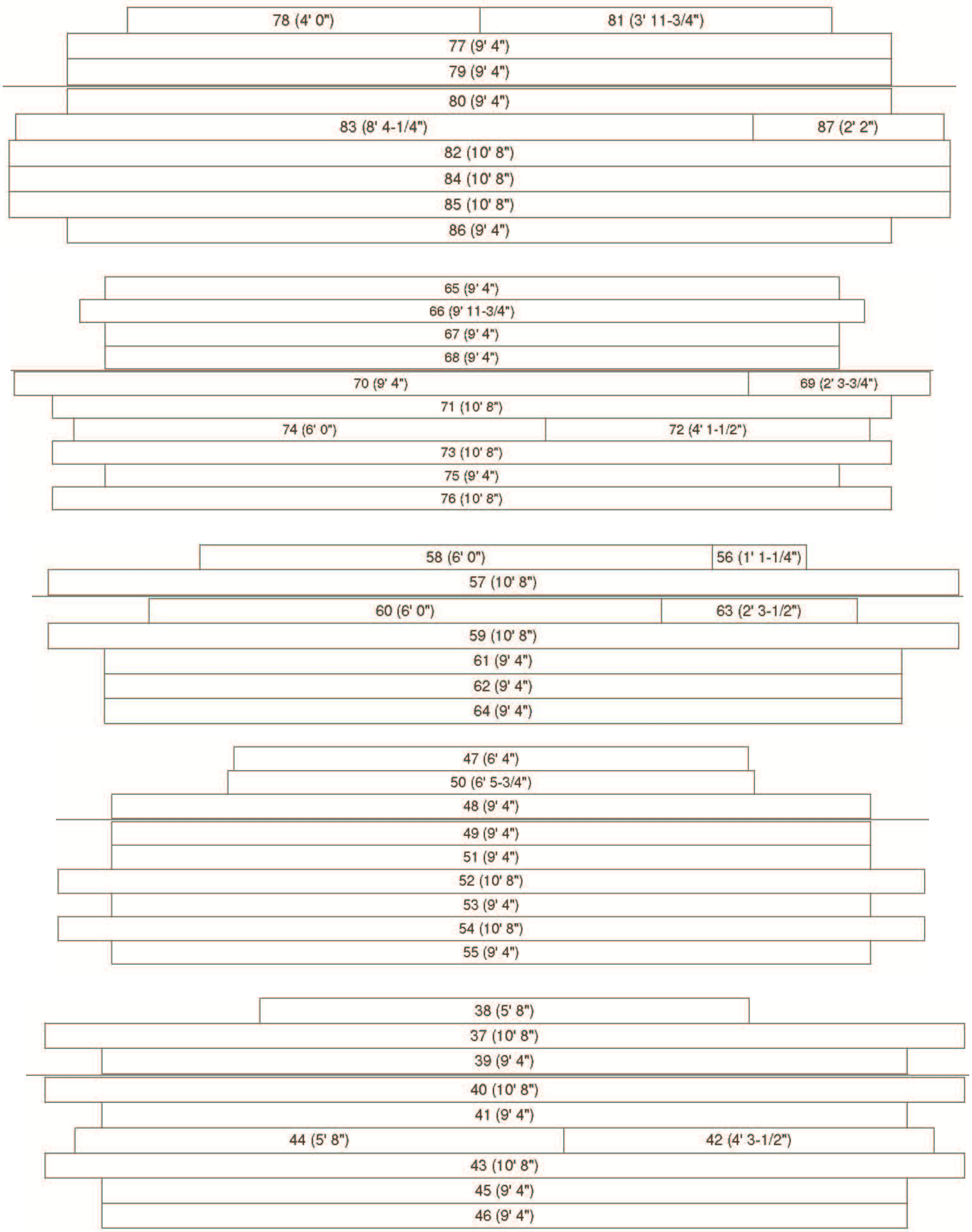
L4-2: Panel Designer



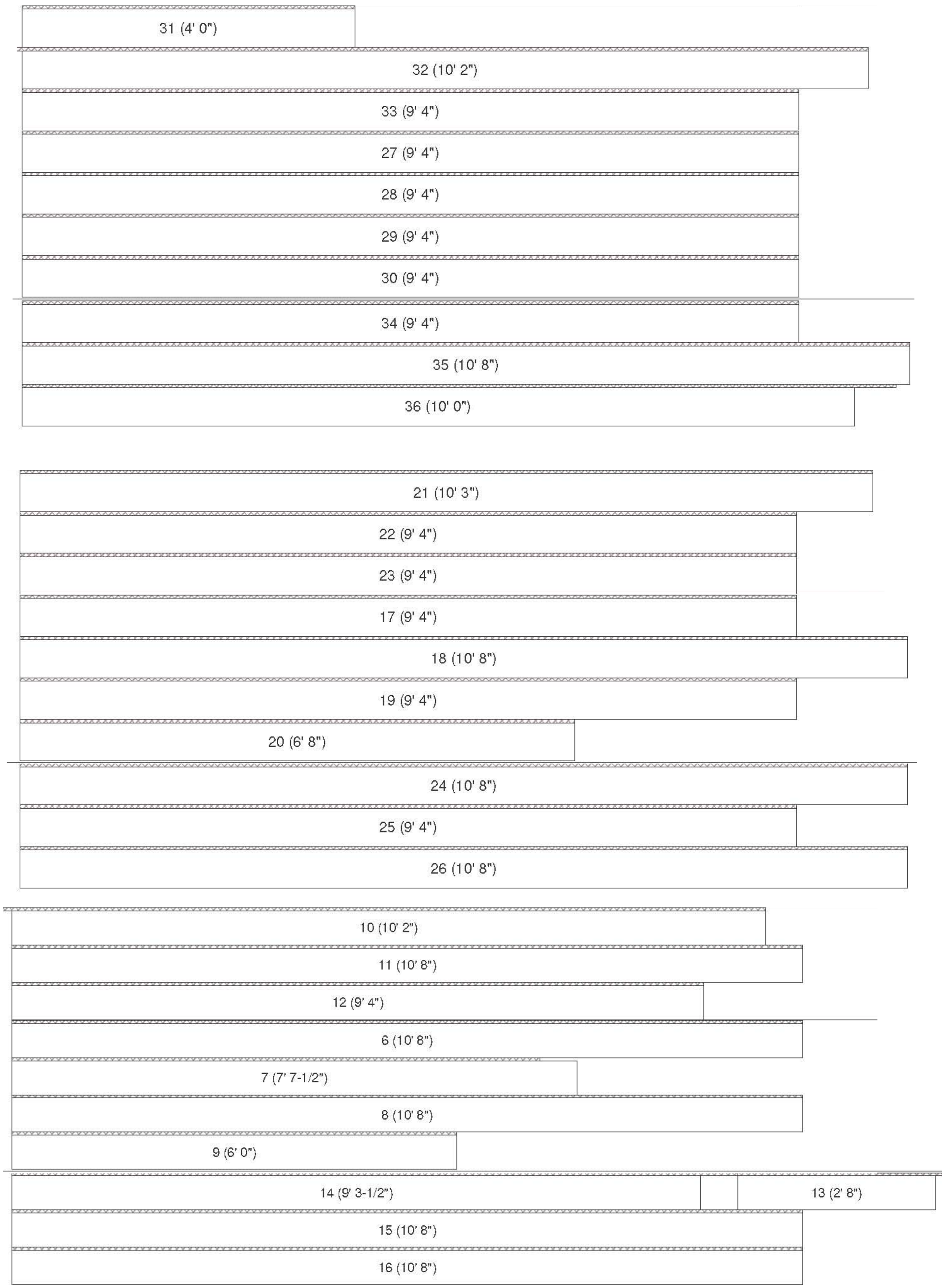
L4-2: Panel Designer



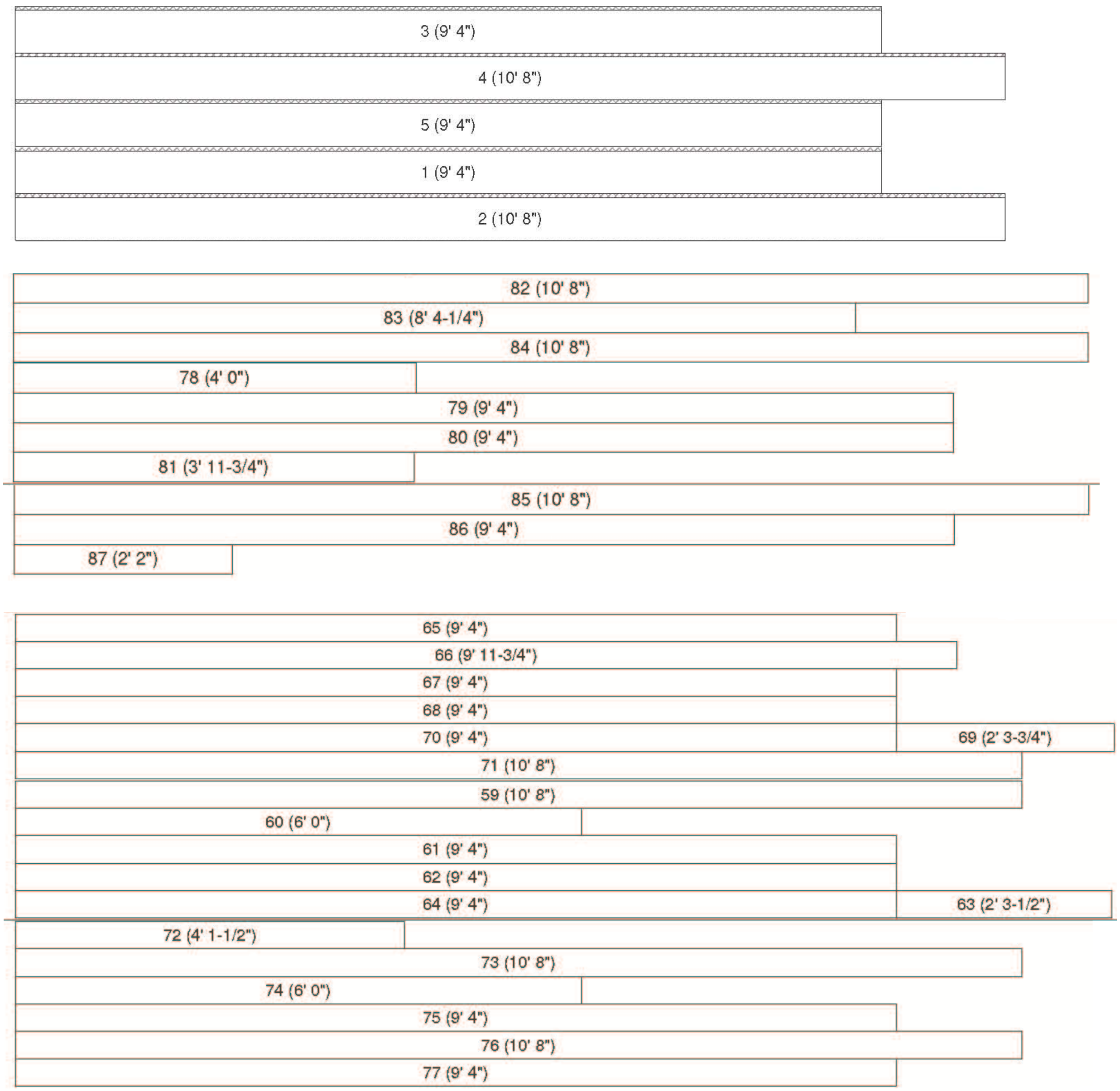
L4-2: Panel Designer



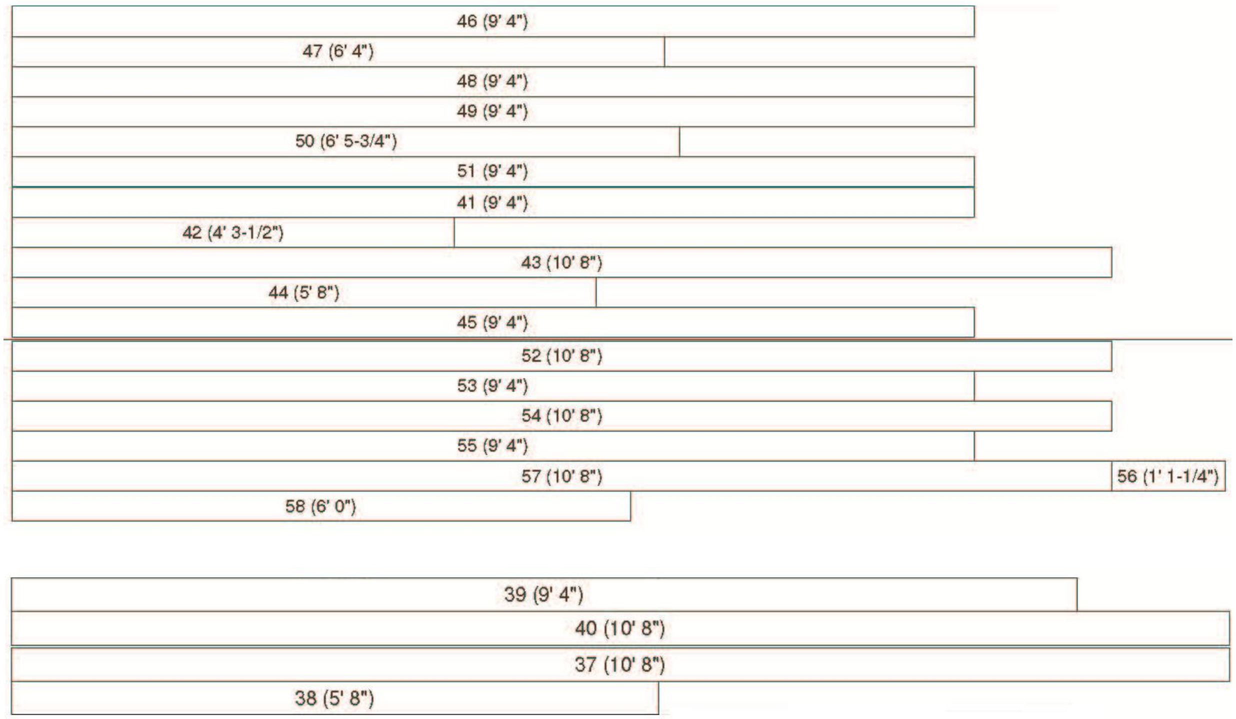
L4-2: IntelliBuild



L4-2: IntelliBuild



L4-2: IntelliBuild



L4-2: Proposed algorithm

** Nzones
6

**zone	left edge X coordinate
1	6.0
2	218.0
3	438.0
4	654.0
5	870.0
6	984.0

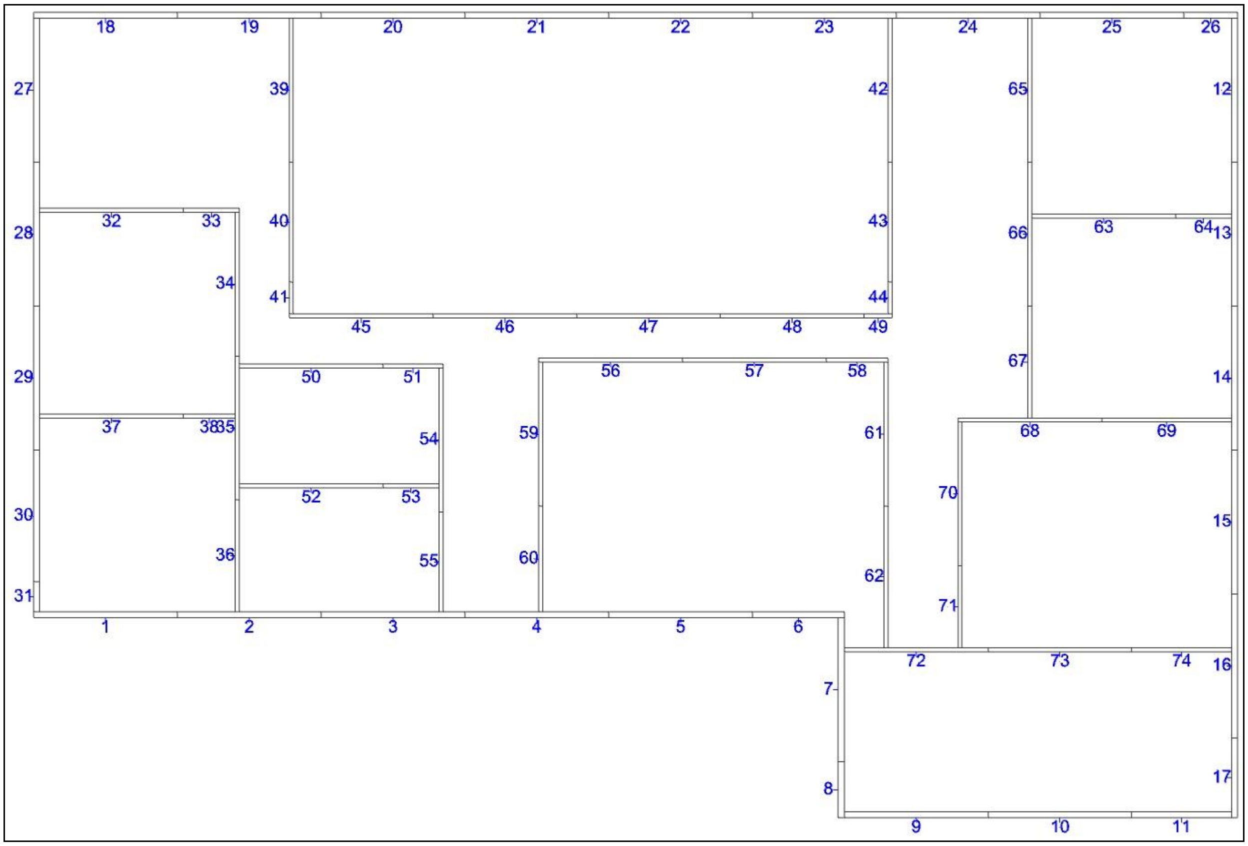
** NStacks
12

** stack			flush							
** #	zone	type	edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	114.0	78.0	14	1	1	21	2
							2	1	32	1
							3	1	33	1
							4	1	34	1
							5	1	35	1
							6	1	36	1
							7	1	1	2
							8	1	37	2
							9	1	38	2
							10	1	39	1
							11	1	43	2
							12	1	44	2
							13	1	40	1
							14	1	41	1

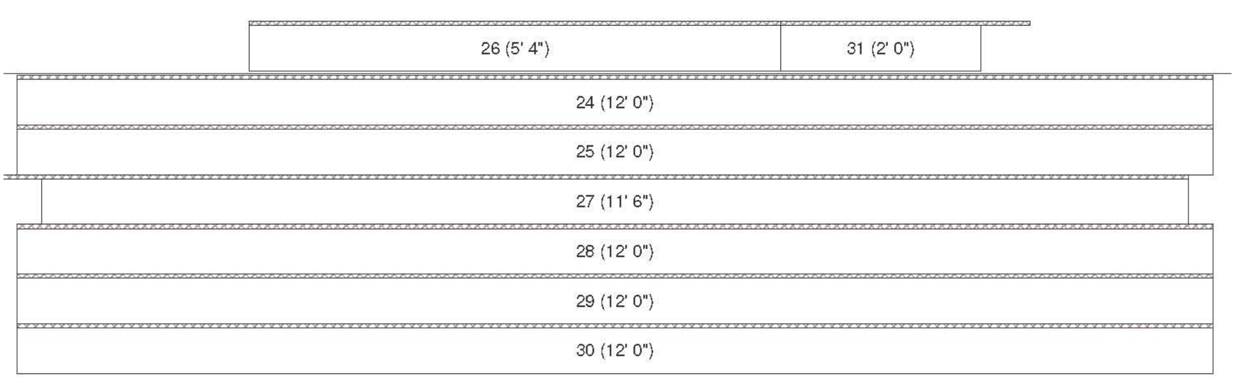
L4-2: Proposed algorithm

2	2	A	RIGHT	330.0	78.0	12	1	1	22	2
							2	1	23	2
							3	1	45	1
							4	1	46	1
							5	1	47	1
							6	1	51	2
							7	1	57	2
							8	1	58	2
							9	1	59	2
							10	1	60	2
							11	1	61	1
							12	1	62	1
3	2	B	LEFT	330.0	110.0	1	1	1	42	1
4	3	A	RIGHT	546.0	78.0	4	1	1	24	2
							2	1	25	2
							3	1	52	2
							4	1	53	2
5	3	B	LEFT	546.0	110.0	4	1	1	2	2
							2	1	3	2
							3	1	4	2
							4	2	5 63	2 1
6	4	A	RIGHT	762.0	78.0	4	1	1	26	2
							2	1	27	2
							3	1	54	2
							4	2	56 55	2 2
7	4	B	LEFT	762.0	110.0	9	1	1	6	2
							2	1	7	2
							3	1	8	1
							4	1	9	1
							5	1	10	3
							6	1	28	2
							7	1	48	1
							8	1	49	1
							9	2	50 69	1 1
8	5	A	RIGHT	978.0	48.0	8	1	1	29	2
							2	1	75	1
							3	1	76	1
							4	1	77	1
							5	1	78	1
							6	1	79	2
							7	1	68	1
							8	1	82	1
9	5	B	LEFT	978.0	90.0	1	1	1	11	3
10	6	A	RIGHT	1092.0	48.0	15	1	2	31 30	2 2
							2	1	14	2
							3	1	15	2
							4	1	16	2
							5	1	17	2
							6	1	18	2
							7	1	19	2
							8	1	20	2
							9	1	12	3
							10	1	13	3
							11	1	73	2
							12	1	74	2
							13	1	64	2
							14	1	65	2
							15	1	66	2
11	6	A	RIGHT	1092.0	48.0	4	1	1	67	2
							2	1	70	2
							3	1	80	2
							4	1	81	2
12	6	B	LEFT	1092.0	90.0	7	1	1	71	1
							2	1	72	1
							3	1	83	1
							4	1	84	3
							5	1	85	2
							6	1	87	2
							7	1	86	2

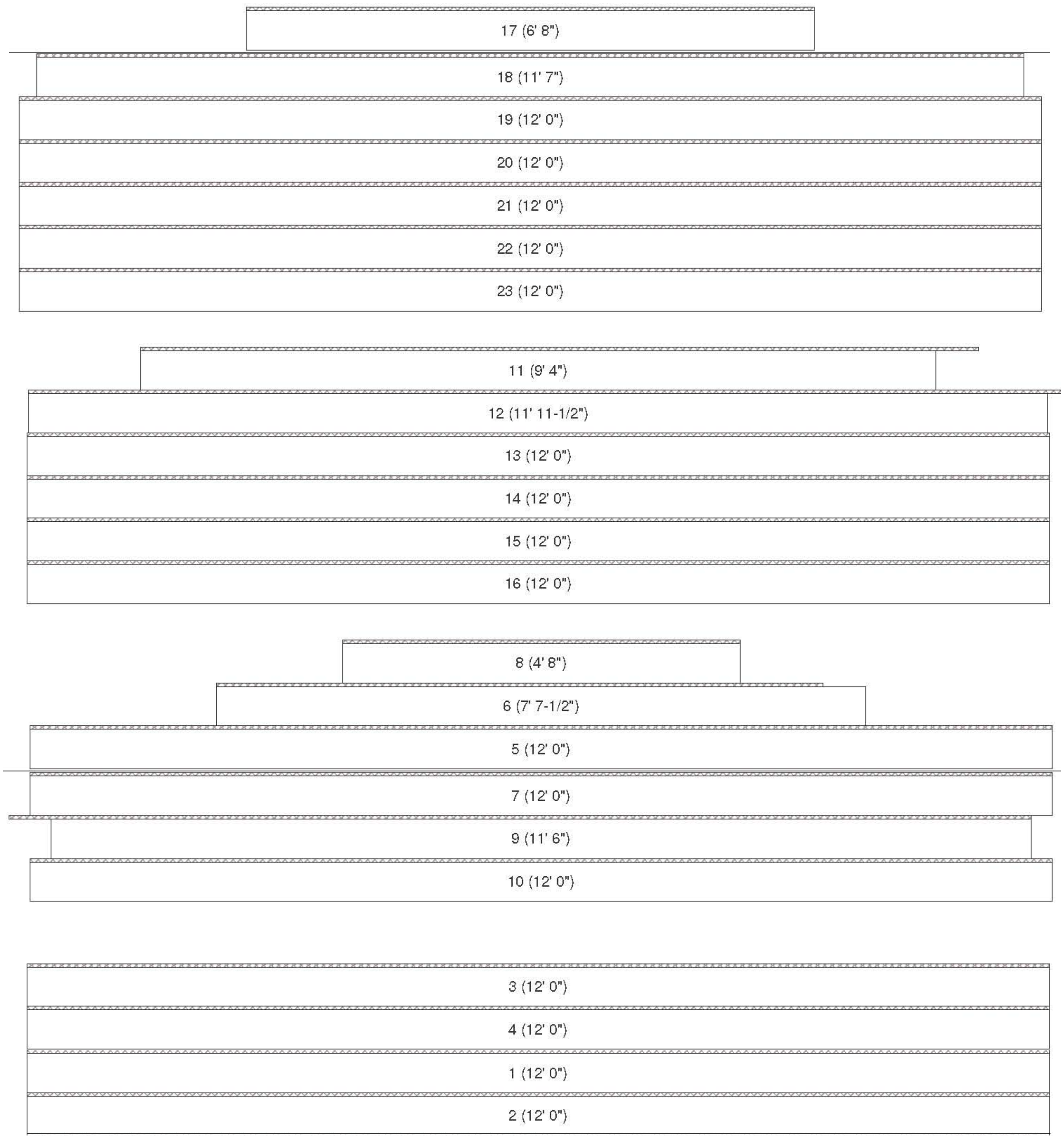
L4-3



L4-3: Panel Designer

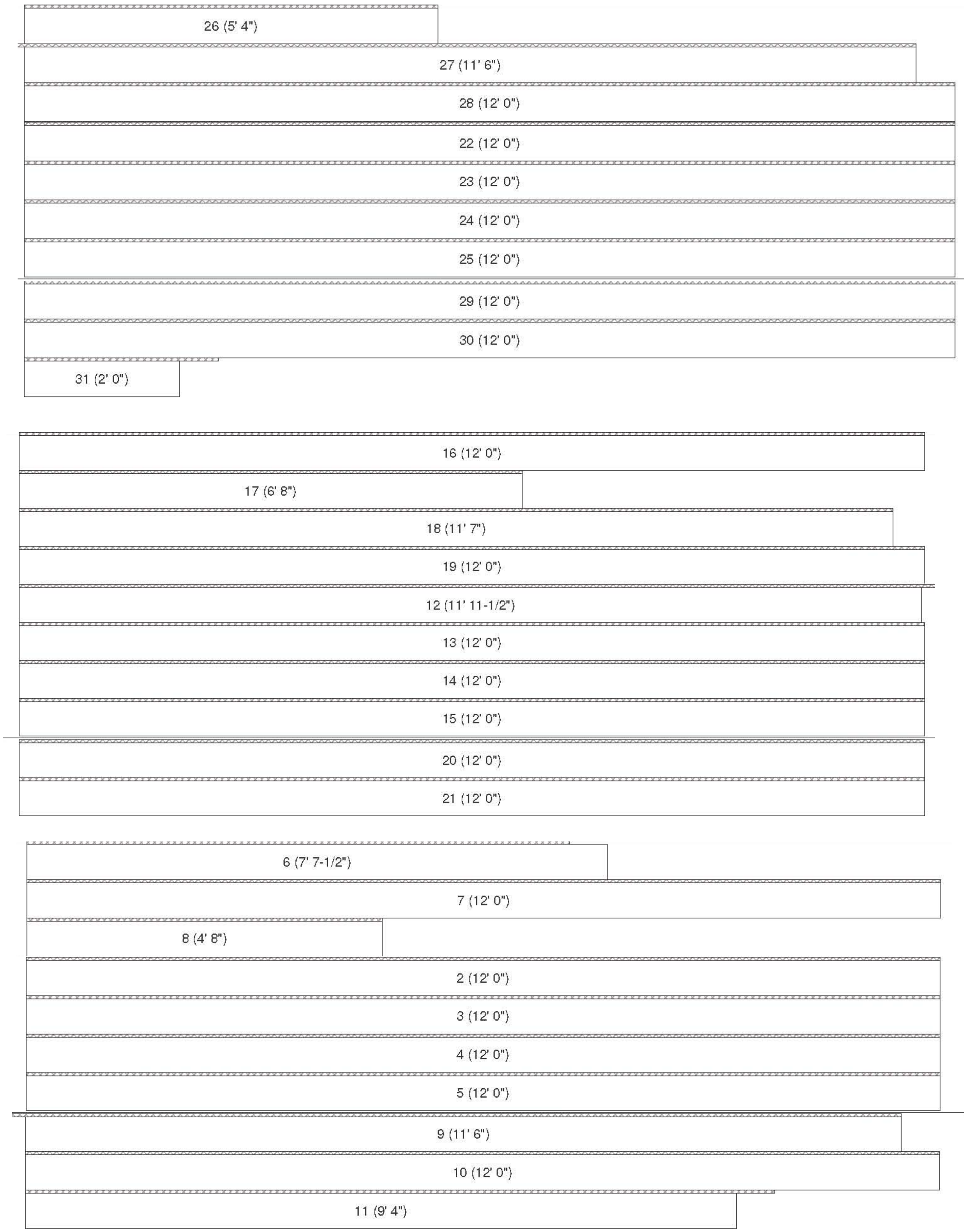


L4-3: Panel Designer

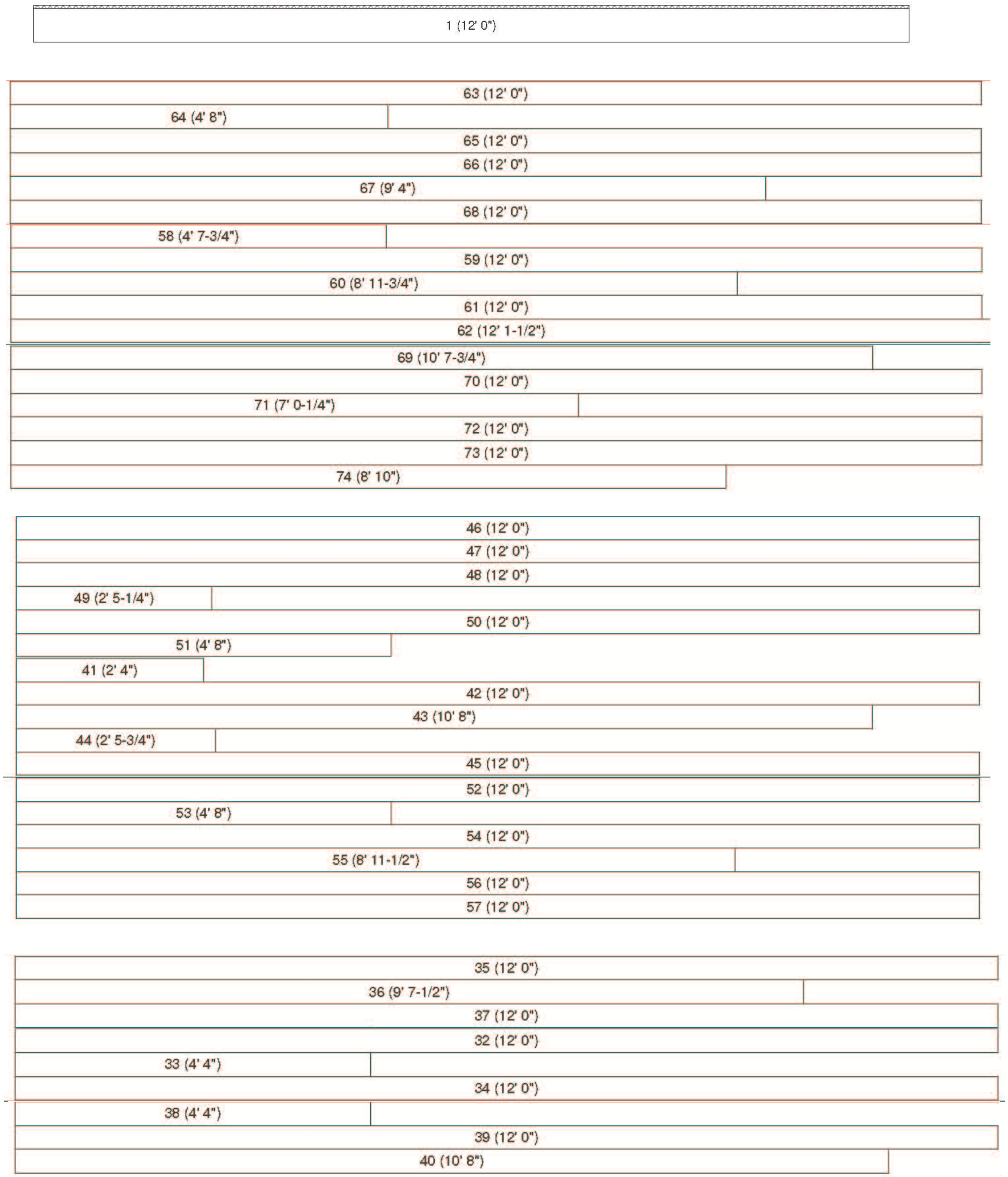


L4-3: Panel Designer

L4-3: IntelliBuild



L4-3: IntelliBuild



L4-3: Proposed algorithm

** Nzones
6

**zone	left edge X coordinate
1	6.0
2	226.5
3	446.9
4	667.4
5	887.8
6	979.5

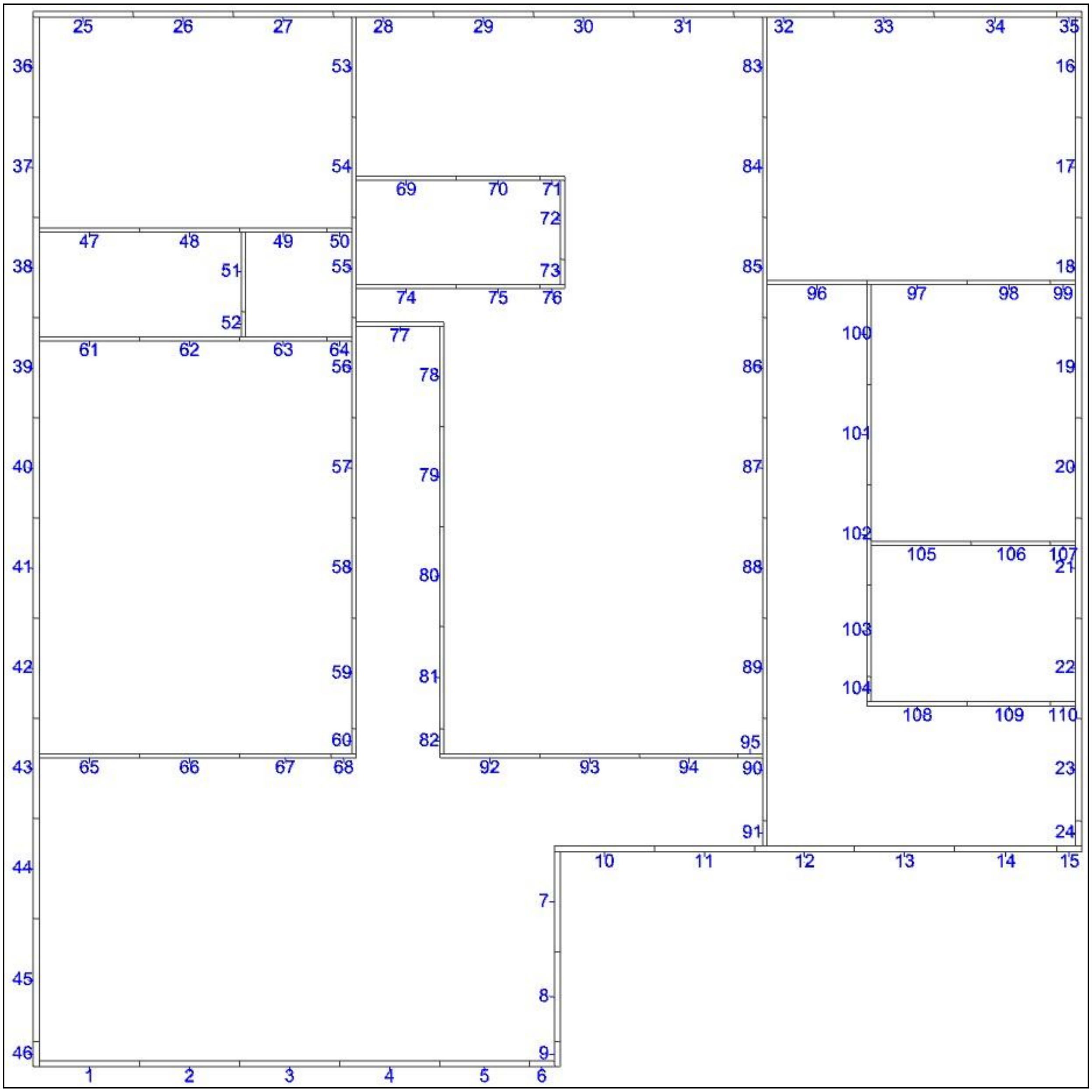
** NStacks
12

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	77.3	13	1	1	18	2
							2	1	27	1
							3	1	28	1
							4	1	29	1
							5	1	30	1
							6	1	31	1
							7	1	1	2
							8	1	32	2
							9	1	33	2
							10	1	34	1
							11	1	37	2
							12	1	38	2
							13	1	35	1
2	2	A	RIGHT	336.7	77.3	11	1	1	19	2
							2	1	20	2
							3	1	39	1
							4	1	40	1
							5	1	41	1
							6	1	45	2
							7	1	50	2
							8	1	51	2
							9	1	52	2
							10	1	53	2
							11	1	54	1
3	2	B	LEFT	336.7	119.3	1	1	1	36	1
4	3	A	RIGHT	557.1	77.3	2	1	1	21	2
							2	1	46	2
5	3	B	LEFT	557.1	119.3	4	1	1	2	2
							2	1	3	2
							3	1	4	2
							4	1	55	1
6	4	A	RIGHT	777.6	77.3	8	1	1	22	2
							2	1	23	2
							3	1	42	1
							4	1	43	1
							5	1	44	1
							6	1	47	2
							7	1	48	2
							8	1	49	2
7	4	B	LEFT	777.6	119.3	6	1	1	5	2
							2	1	6	2
							3	1	7	1
							4	1	8	1
							5	1	9	3
							6	1	60	1
8	5	A	RIGHT	998.1	57.3	7	1	1	24	2
							2	1	65	1
							3	1	66	1
							4	1	59	1
							5	1	67	1
							6	1	68	2
							7	1	70	1
9	5	B	LEFT	998.1	99.3	1	1	1	10	3

L4-3: Proposed algorithm

10	6	A	RIGHT	1089.8	57.3	14	1	1	25	2
							2	1	26	2
							3	1	12	2
							4	1	13	2
							5	1	14	2
							6	1	15	2
							7	1	16	2
							8	1	17	2
							9	1	11	3
							10	1	63	2
							11	1	64	2
							12	1	56	2
							13	1	57	2
							14	1	58	2
11	6	A	RIGHT	1089.8	57.3	2	1	1	61	2
							2	1	69	2
12	6	B	LEFT	1089.8	99.3	5	1	1	62	1
							2	1	71	1
							3	1	72	3
							4	1	73	2
							5	1	74	2

L5-1



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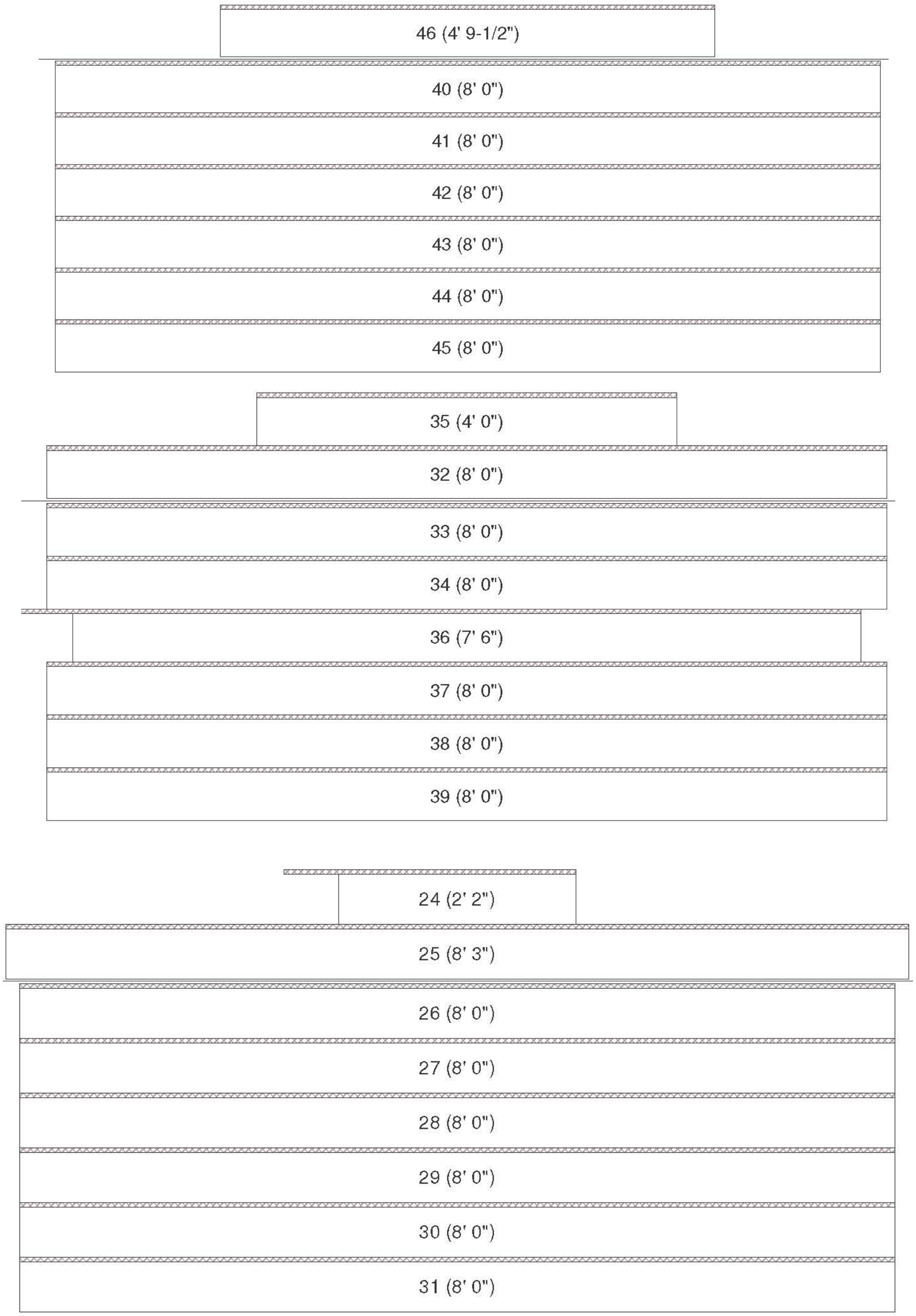
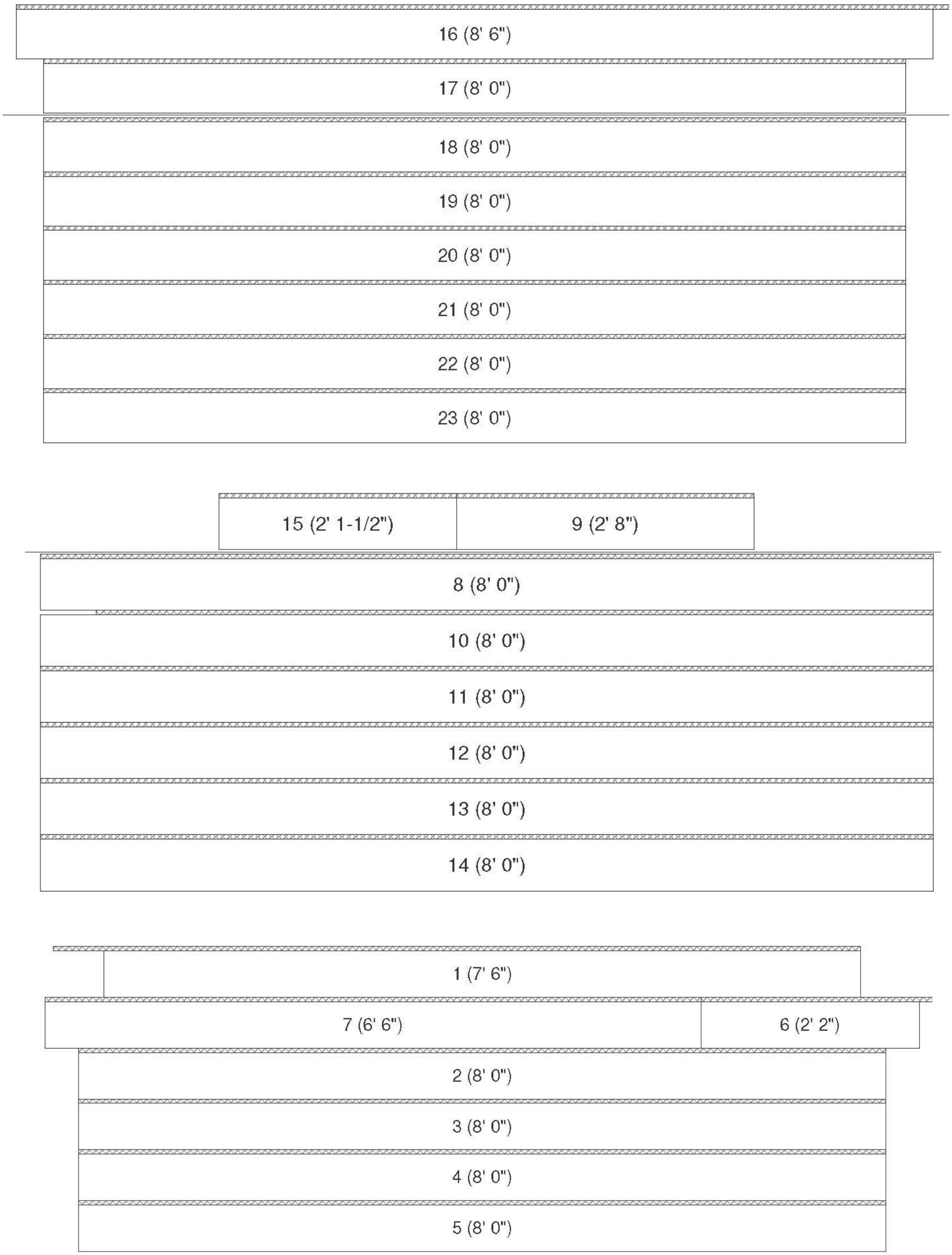
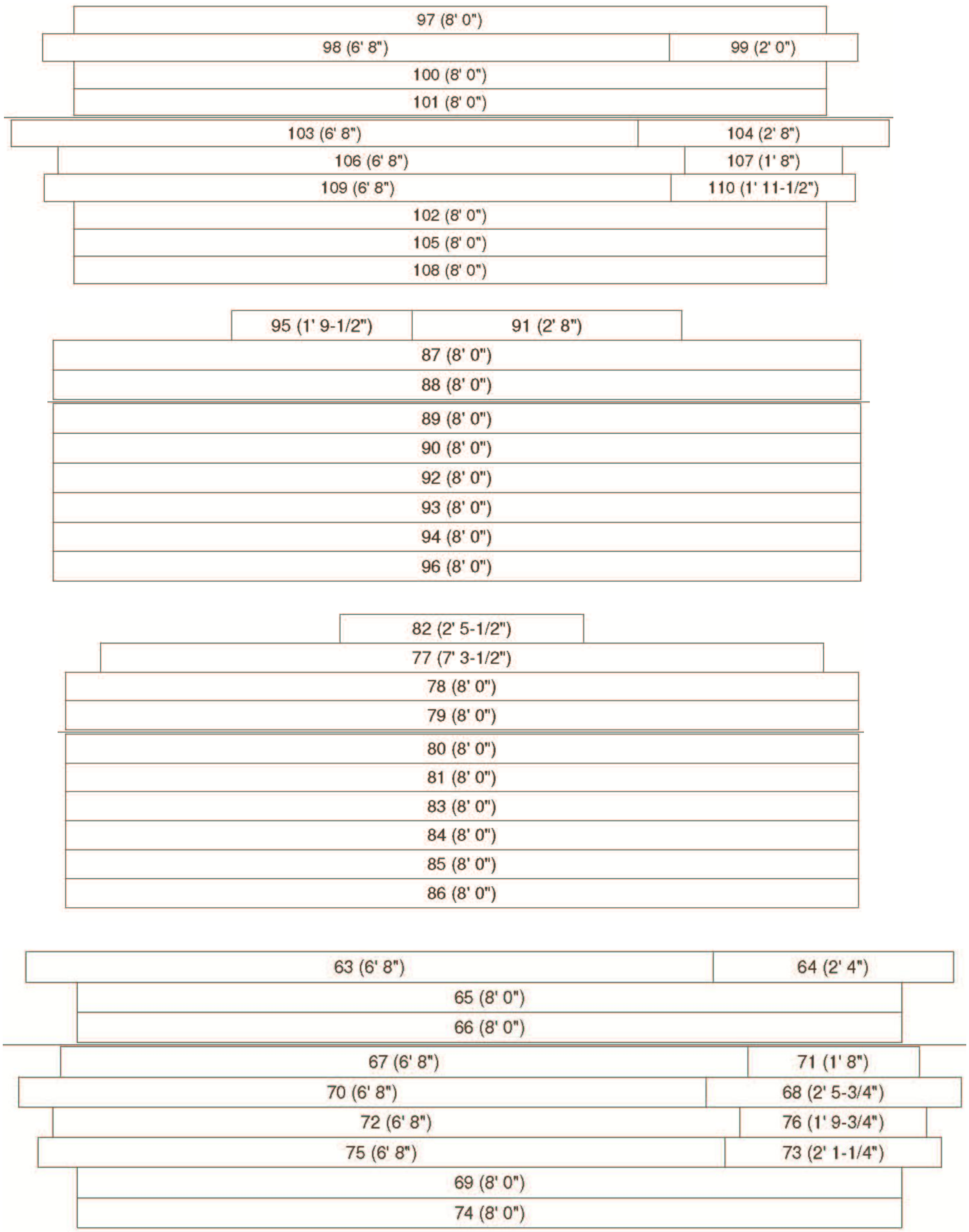
L5-1: Panel Designer



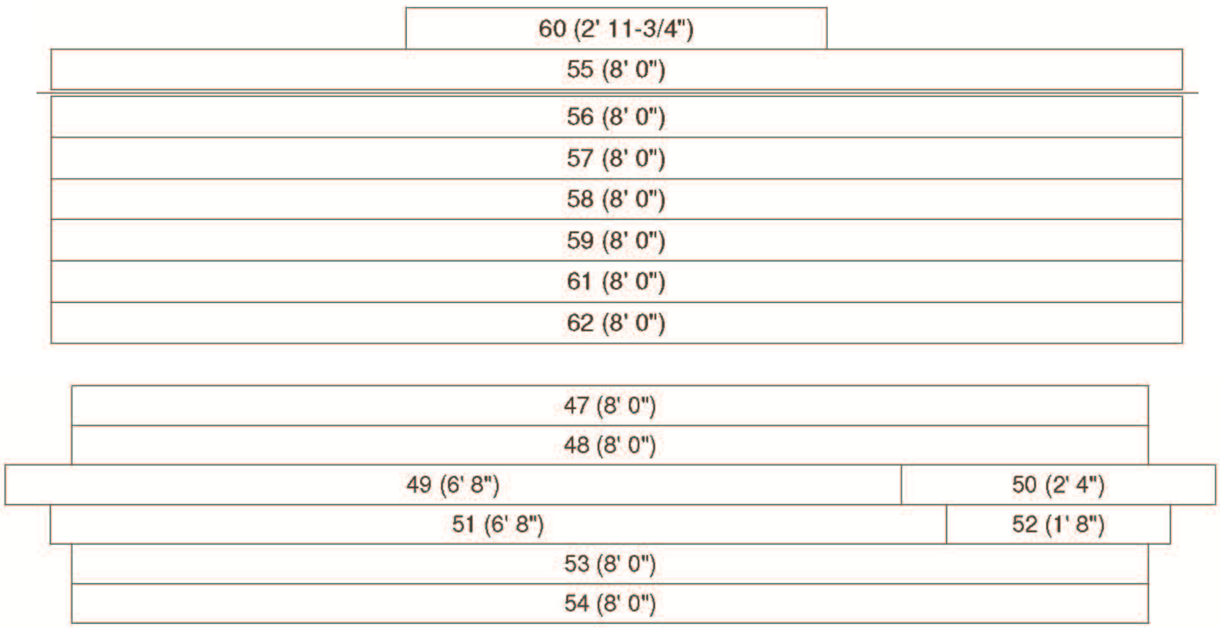
L5-1: Panel Designer



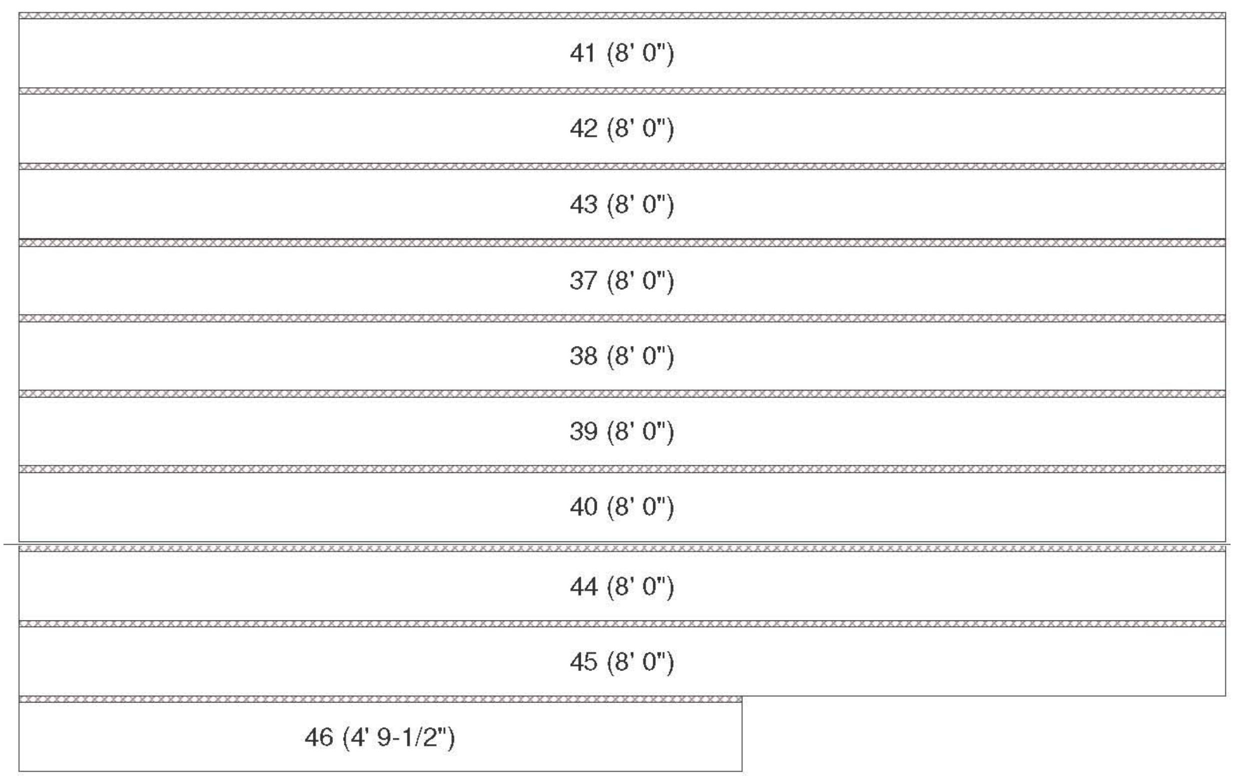
L5-1: Panel Designer



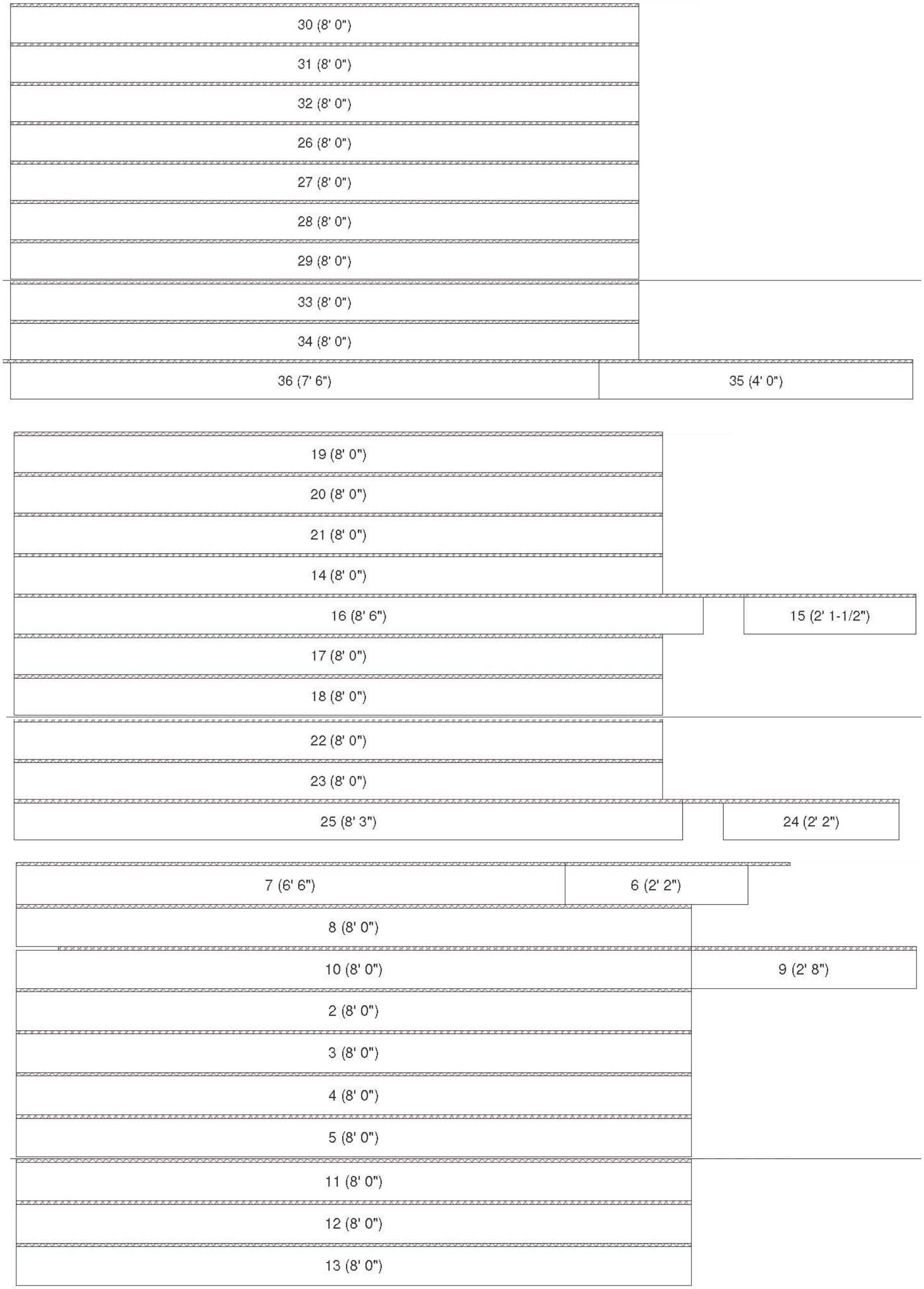
L5-1: Panel Designer



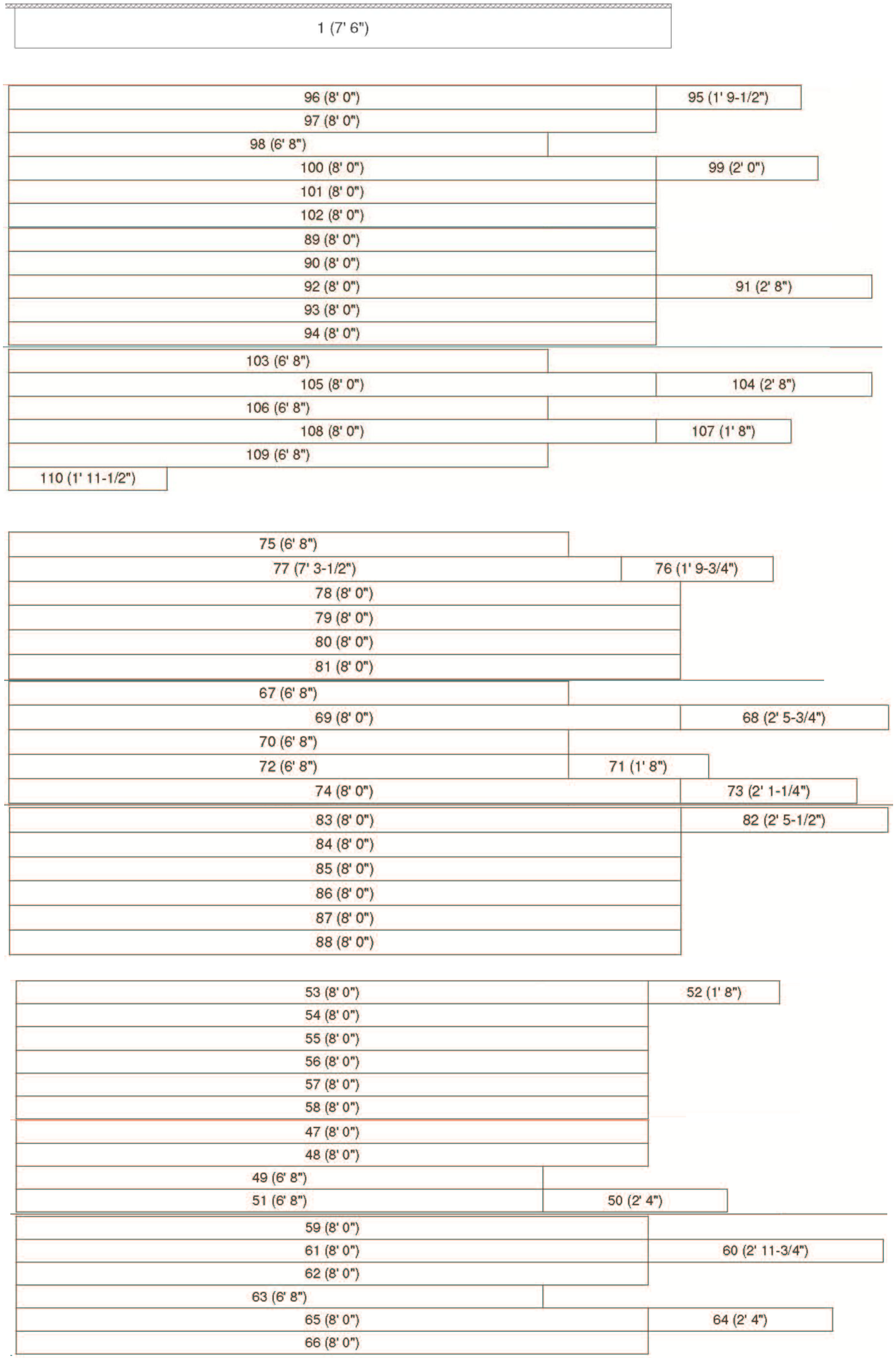
L5-1: IntelliBuild



L5-1: IntelliBuild



L5-1: IntelliBuild



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L5-1: Proposed algorithm

** Nzones
5

**zone     left edge X coordinate
  1          6.0
  2        218.0
  3        438.0
  4        654.0
  5        784.0

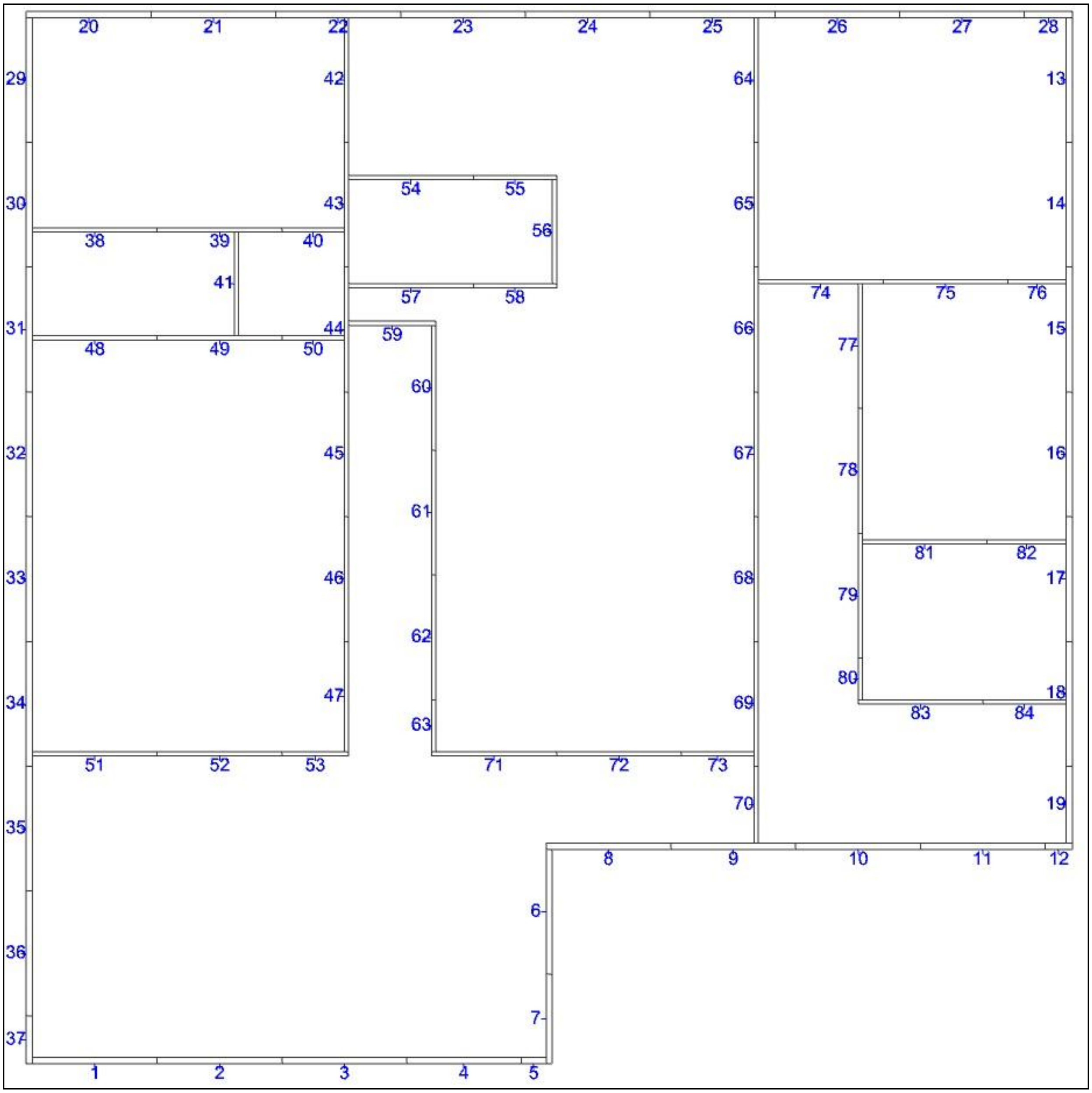
** NStacks
11

** stack               flush
**   #    zone type    edge    xloc   yloc   #layers   j   #panels   panels     orientation
     1     1    A     RIGHT   114.0   48.0      11         1         1     25          2
                                                           2         1     26          2
                                                           3         1     36          1
                                                           4         1     37          1
                                                           5         1     38          1
                                                           6         1     39          1
                                                           7         1     40          1
                                                           8         1     41          1
                                                           9         1     42          1
                                                          10         1     43          1
                                                          11         1     44          1
     2     1    A     RIGHT   114.0   48.0       8         1         2     46 45       1 1
                                                           2         1     47          2
                                                           3         1     48          2
                                                           4         1     61          2
                                                           5         1     62          2
                                                           6         1     65          2
                                                           7         1     66          2
                                                           8         1     1           3
     3     2    A     RIGHT   330.0   48.0      16         1         1     27          2
                                                           2         1     28          2
                                                           3         1     53          1
                                                           4         1     54          1
                                                           5         1     69          2
                                                           6         2     50 49       2 2
                                                           7         2     52 51       1 1
                                                           8         1     55          1
                                                           9         1     74          2
                                                          10         2     64 63       2 2
                                                          11         1     56          1
                                                          12         1     77          2
                                                          13         1     57          1
                                                          14         1     78          1
                                                          15         1     58          1
                                                          16         1     79          1
     4     2    A     RIGHT   330.0   48.0       4         1         1     59          1
                                                           2         1     80          1
                                                           3         2     60 81       1 1
                                                           4         3     68 67 82    2 2 1
     5     2    B     LEFT    330.0   90.0       3         1         1     2           3
                                                           2         1     3           3
                                                           3         1     4           3
     6     3    A     RIGHT   546.0   88.0       7         1         1     29          2
                                                           2         1     30          2
                                                           3         2     71 70       2 2
                                                           4         2     73 72       1 1
                                                           5         2     76 75       2 2
                                                           6         1     92          2
                                                           7         1     93          2
     7     3    B     LEFT    546.0  130.0       3         1         3     5 6 9       3 3 1
                                                           2         1     8           2
                                                           3         1     7           2
```

L5-1: Proposed algorithm

8	4	A	RIGHT	762.0	88.0	16	1	1	31	2
							2	1	32	2
							3	1	33	2
							4	1	83	1
							5	1	84	1
							6	1	85	1
							7	1	96	2
							8	1	86	1
							9	1	100	1
							10	1	87	1
							11	1	101	1
							12	1	88	1
							13	1	102	1
							14	1	89	1
							15	2	104 103	1 1
							16	2	95 94	2 2
9	4	A	RIGHT	762.0	88.0	1	1	1	90	1
10	5	A	RIGHT	892.0	88.0	15	1	2	35 34	2 2
							2	1	16	2
							3	1	17	2
							4	1	18	2
							5	1	19	2
							6	1	20	2
							7	1	21	2
							8	1	22	2
							9	2	24 23	2 2
							10	1	10	2
							11	1	11	2
							12	1	12	2
							13	1	13	2
							14	2	15 14	2 2
							15	1	97	2
11	5	A	RIGHT	892.0	88.0	6	1	2	99 98	2 2
							2	1	105	2
							3	2	107 106	2 2
							4	1	108	2
							5	2	110 109	2 2
							6	1	91	2

L5-2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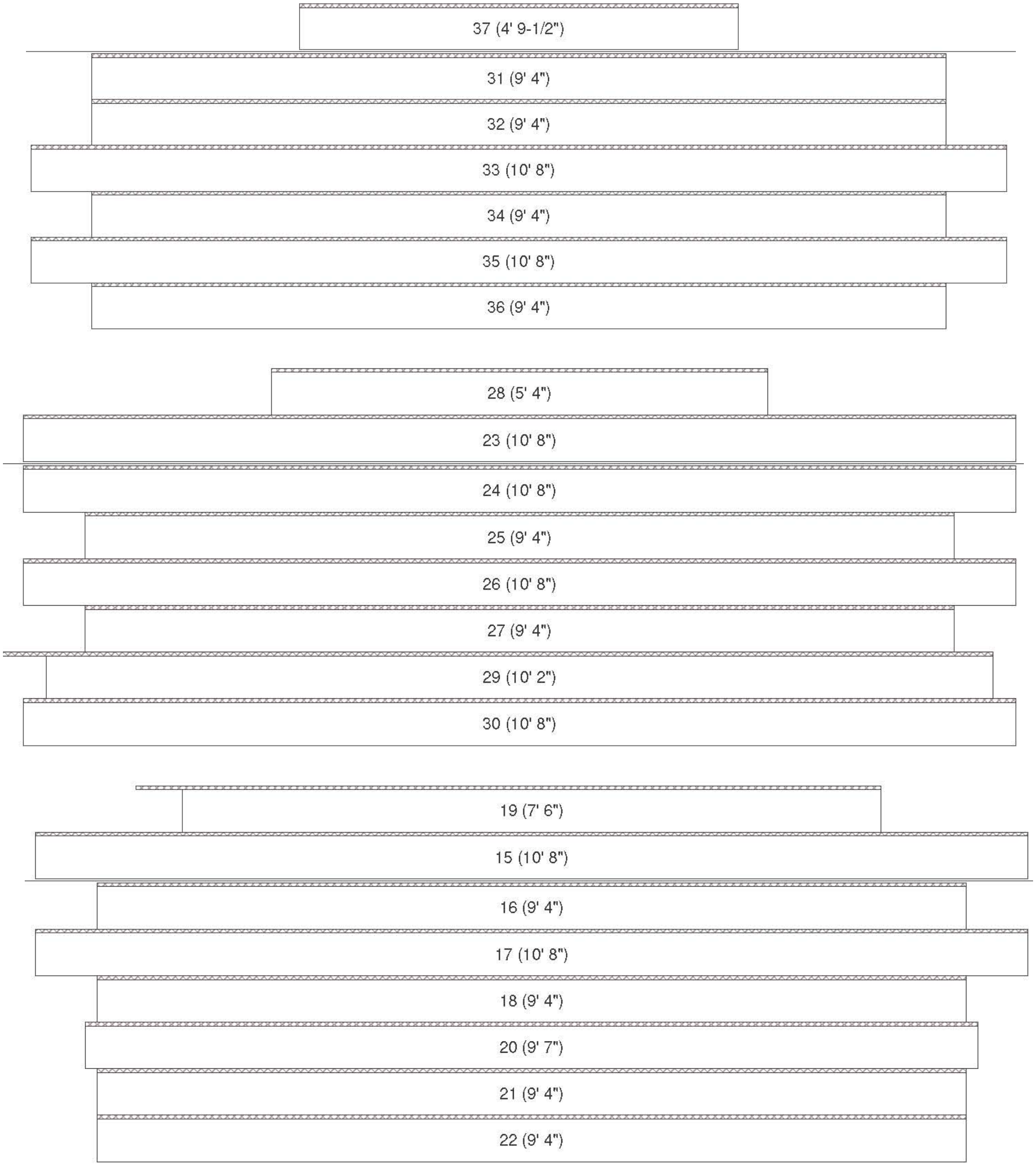
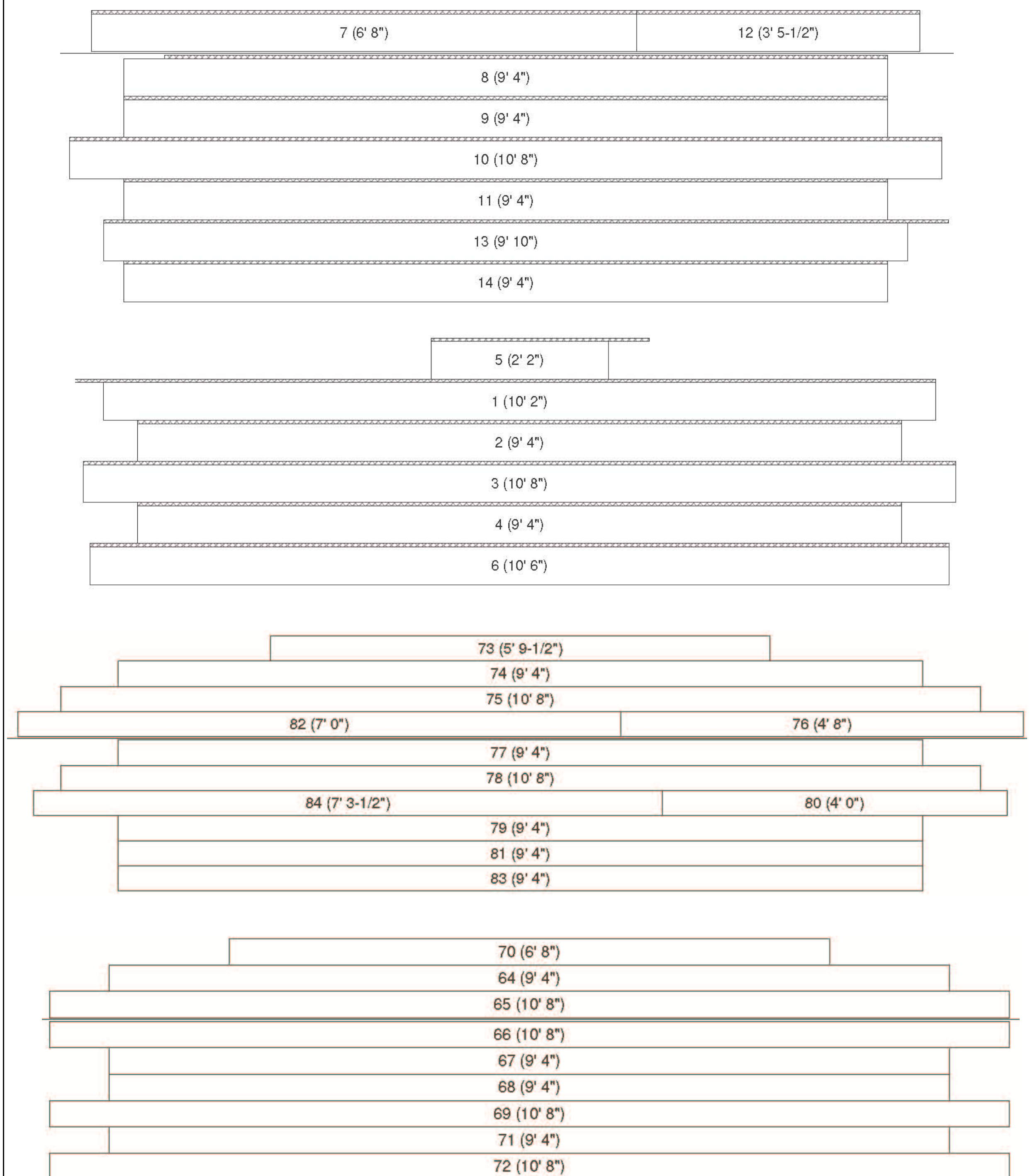
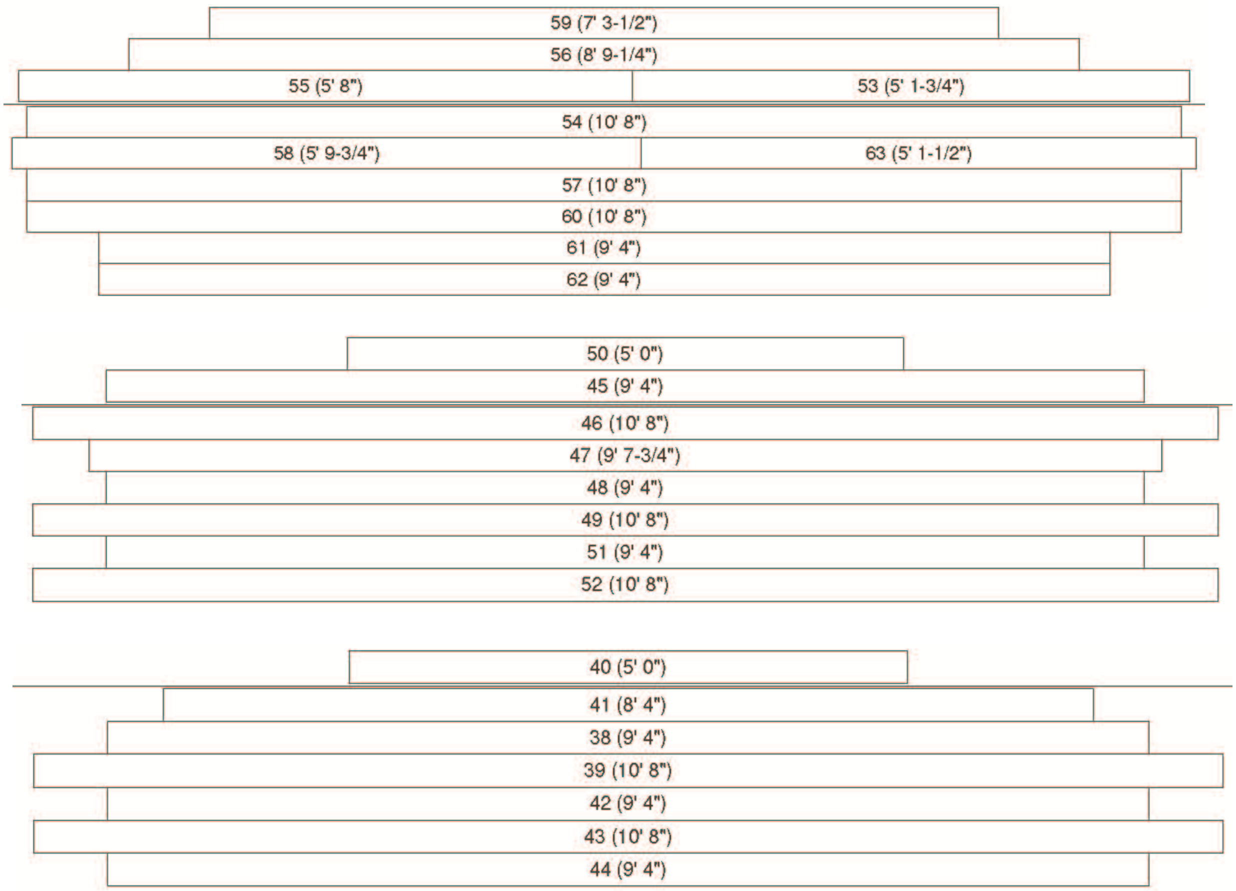
L5-2: Panel Designer



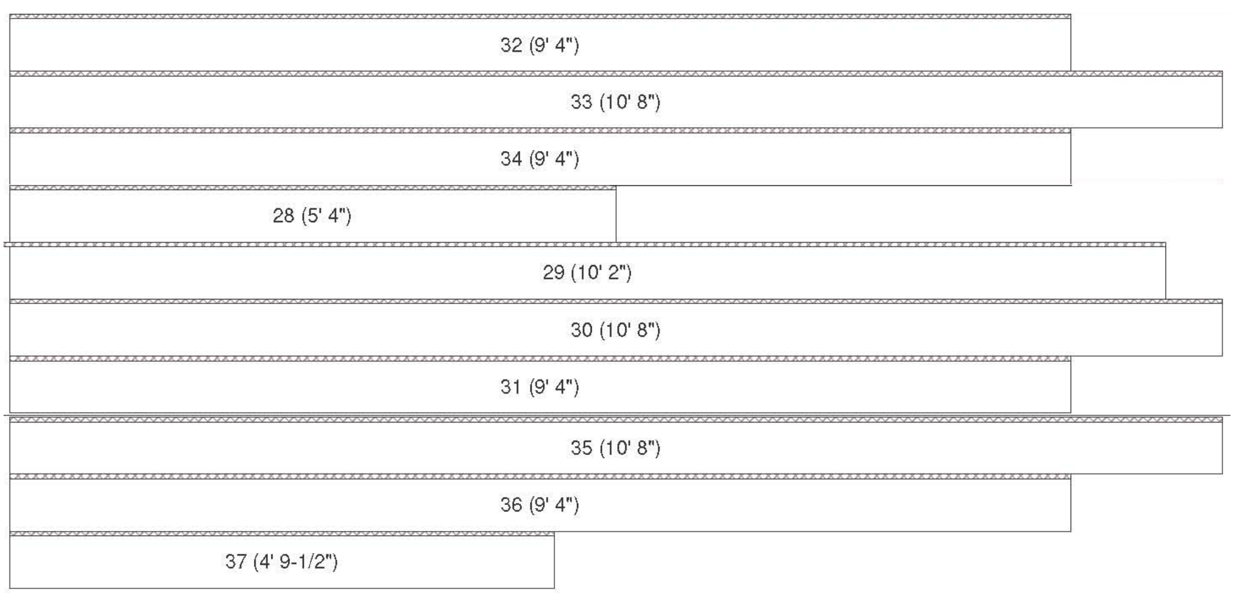
L5-2: Panel Designer



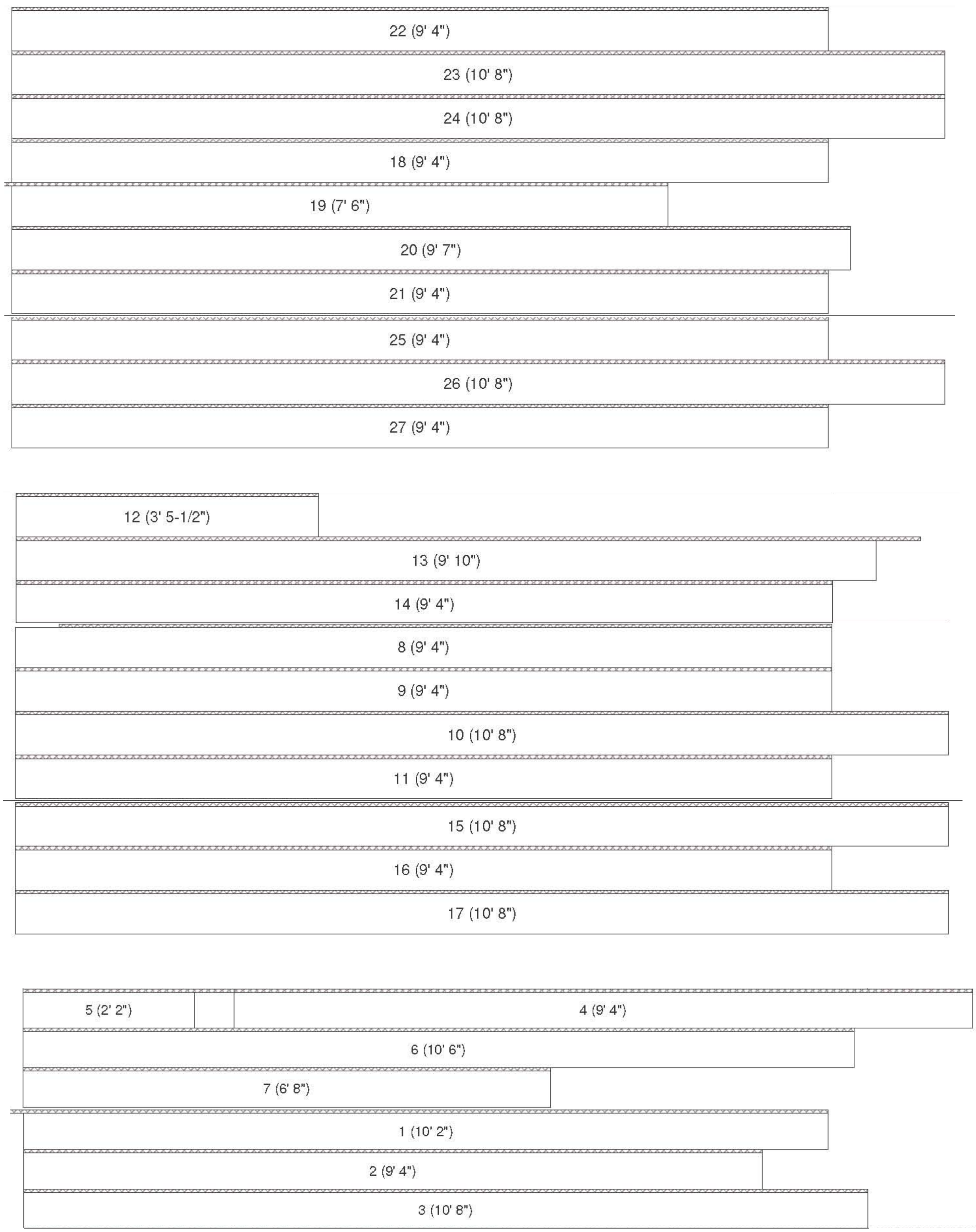
L5-2: Panel Designer



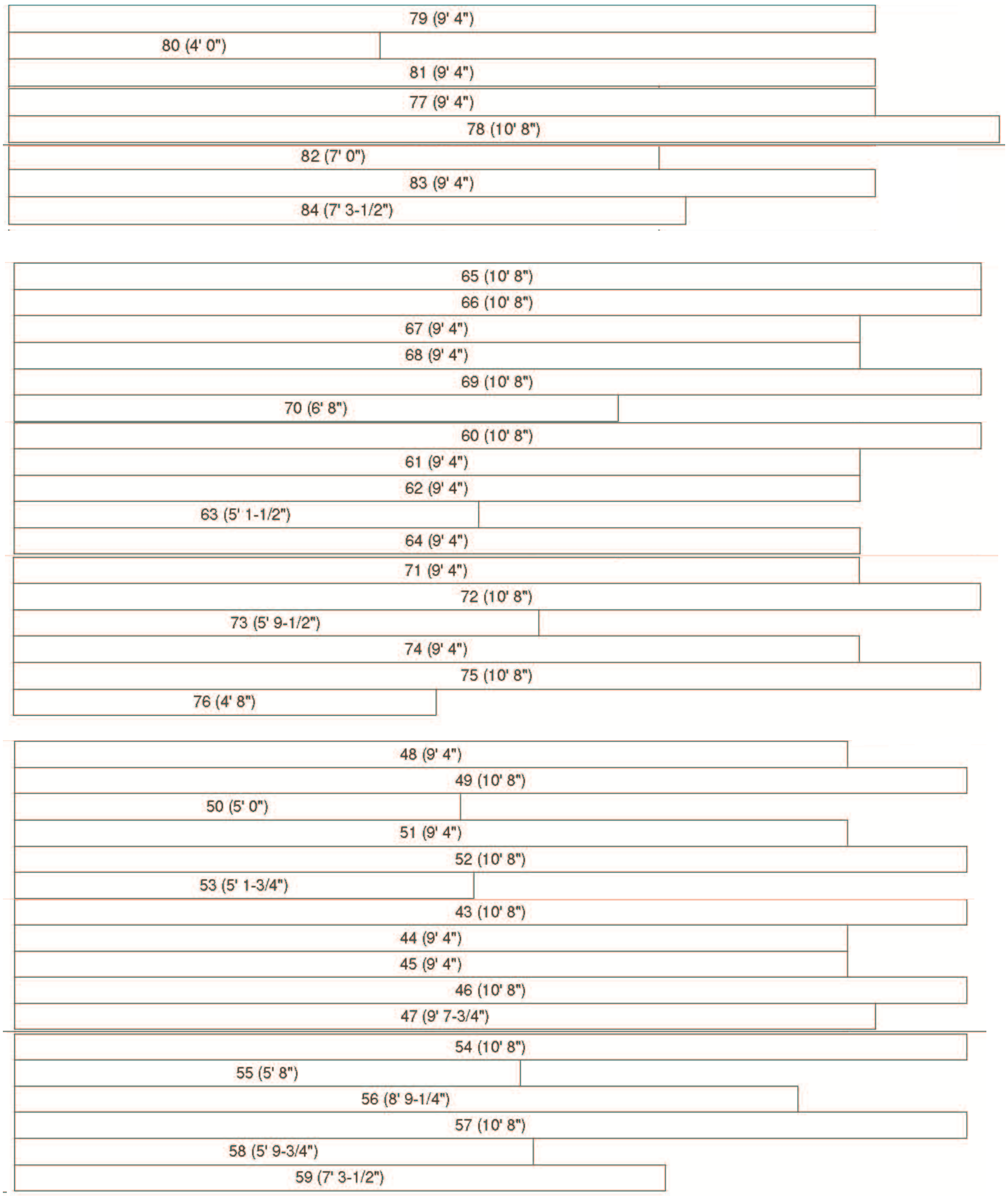
L5-2: IntelliBuild



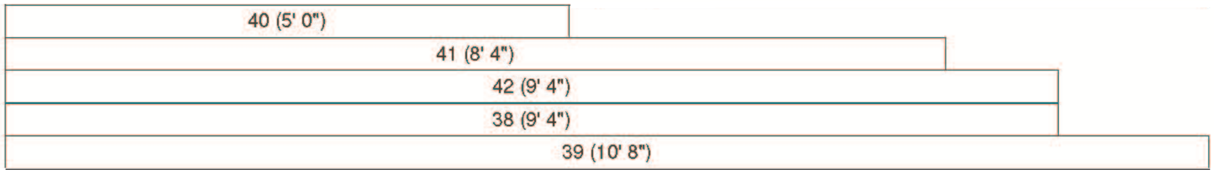
L5-2: IntelliBuild



L5-2: IntelliBuild



L5-2: IntelliBuild




```
L5-2: Proposed algorithm

** Nzones
5

**zone     left edge X coordinate
 1          6.0
 2        214.0
 3        438.0
 4        654.0
 5        784.0

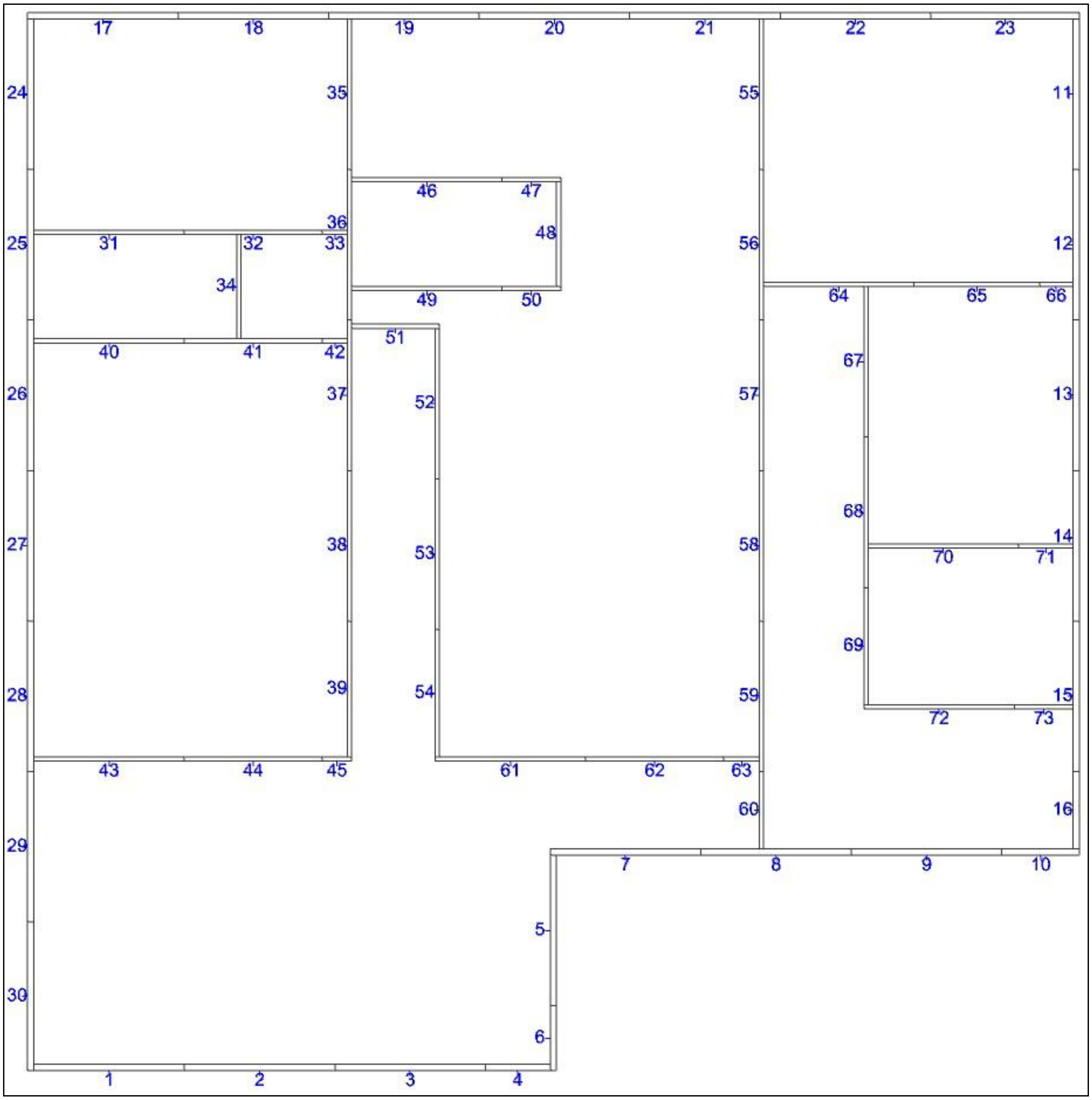
** NStacks
10

** stack                flush
**   #    zone type    edge     xloc    yloc   #layers   j  #panels  panels    orientation
     1     1    A     RIGHT   114.0   48.0      12       1       1     20          2
                                                         2       1     29          1
                                                         3       1     30          1
                                                         4       1     31          1
                                                         5       1     32          1
                                                         6       1     33          1
                                                         7       1     34          1
                                                         8       1     35          1
                                                         9       1     36          1
                                                        10       1     37          1
                                                        11       1     38          2
                                                        12       1     48          2
     2     1    A     RIGHT   114.0   48.0       2       1       1     51          2
                                                         2       1     1           3
     3     2    A     RIGHT   330.0   48.0      16       1       1     21          2
                                                         2       1     22          2
                                                         3       1     42          1
                                                         4       1     39          2
                                                         5       1     40          2
                                                         6       1     41          1
                                                         7       1     43          1
                                                         8       1     54          2
                                                         9       1     49          2
                                                        10       1     50          2
                                                        11       1     44          1
                                                        12       1     57          2
                                                        13       1     59          2
                                                        14       1     45          1
                                                        15       1     60          1
                                                        16       1     46          1
     4     2    A     RIGHT   330.0   48.0       6       1       1     61          1
                                                         2       1     47          1
                                                         3       1     62          1
                                                         4       1     63          1
                                                         5       1     52          2
                                                         6       1     53          2
     5     2    B     LEFT    330.0   90.0       2       1       1     2           3
                                                         2       1     3           3
     6     3    A     RIGHT   546.0   88.0       7       1       1     23          2
                                                         2       1     24          2
                                                         3       1     55          2
                                                         4       1     56          1
                                                         5       1     58          2
                                                         6       1     71          2
                                                         7       1     72          2
```

L5-2: Proposed algorithm

7	3	B	LEFT	546.0	130.0	3	1	2	4 5	3 3
							2	1	7	1
							3	1	6	2
8	4	A	RIGHT	762.0	88.0	14	1	1	25	2
							2	1	26	2
							3	1	64	1
							4	1	65	1
							5	1	66	1
							6	1	74	2
							7	1	67	1
							8	1	77	1
							9	1	68	1
							10	1	78	1
							11	1	73	2
							12	1	69	1
							13	1	79	1
							14	1	80	1
9	5	A	RIGHT	892.0	88.0	14	1	1	27	2
							2	1	28	2
							3	1	13	2
							4	1	14	2
							5	1	15	2
							6	1	16	2
							7	1	17	2
							8	1	18	2
							9	1	19	2
							10	1	8	1
							11	1	9	2
							12	1	10	2
							13	1	12 11	2 2
							14	1	75	2
10	5	A	RIGHT	892.0	88.0	6	1	1	76	2
							2	1	81	2
							3	1	82	2
							4	1	83	1
							5	1	84	2
							6	1	70	2

L5-3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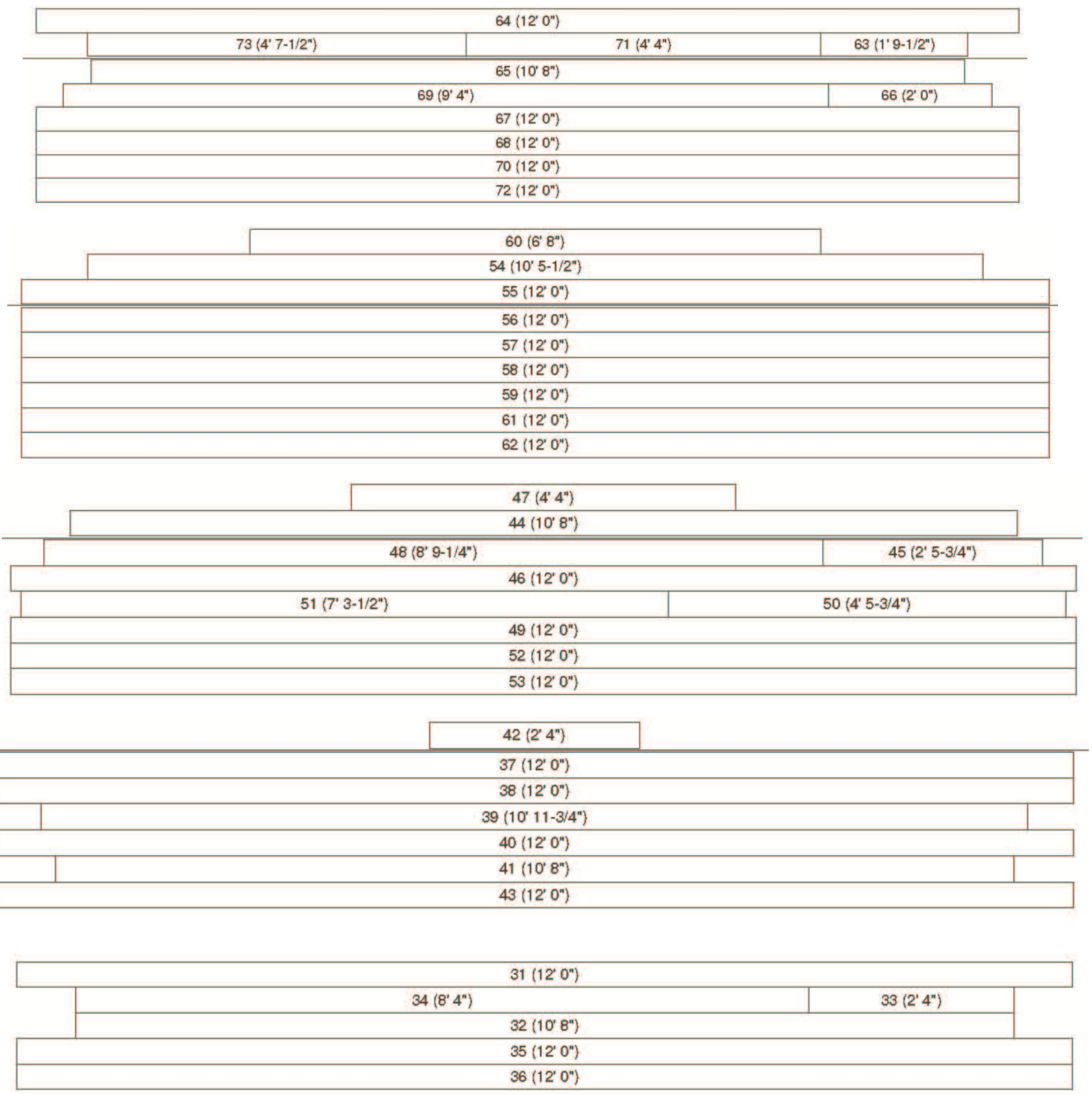
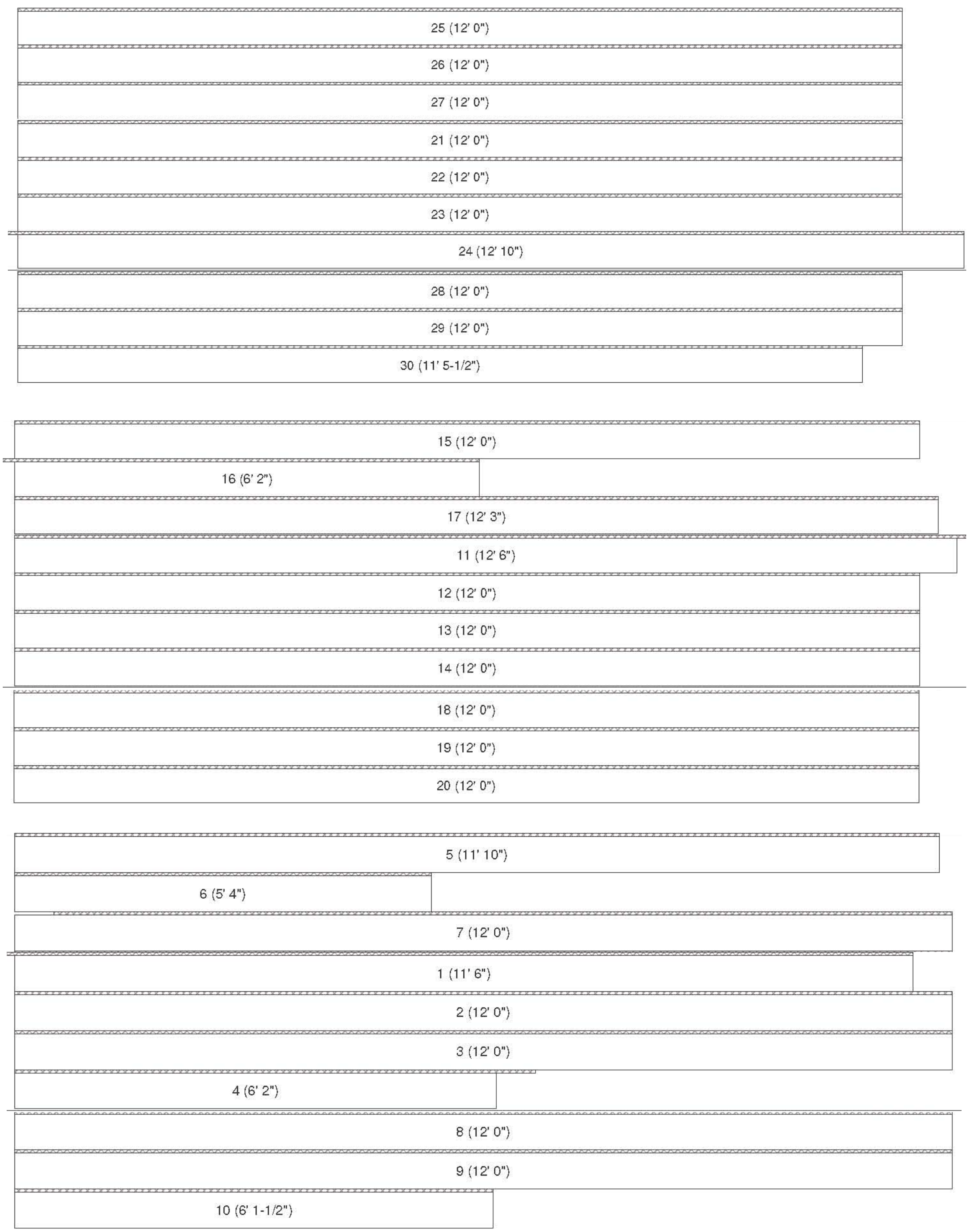
L5-3: Panel Designer

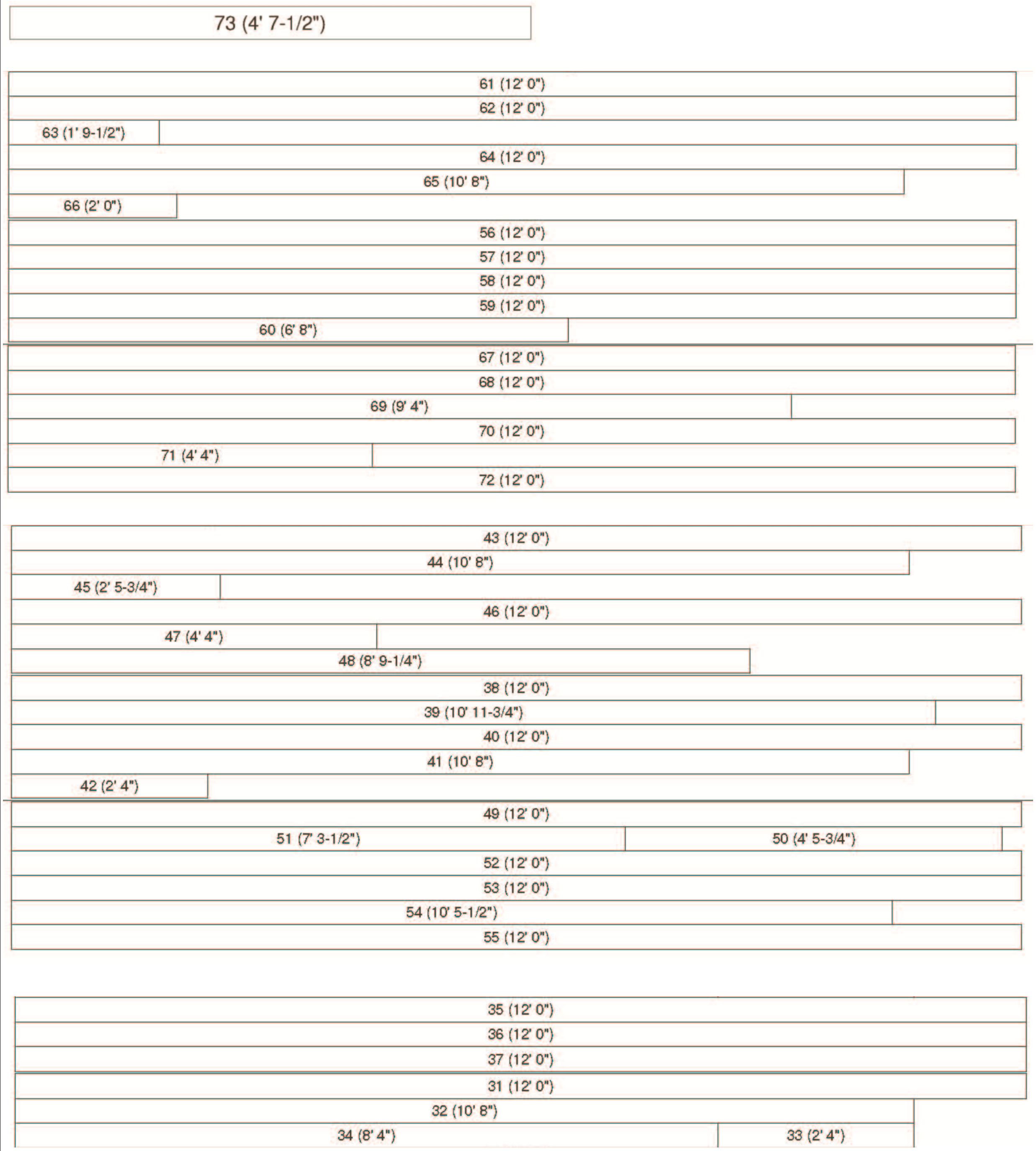
L5-3: Panel Designer



L5-3: IntelliBuild



L5-3: IntelliBuild



L5-3: Proposed algorithm

** Nzones
5

**zone	left edge X coordinate
1	6.0
2	226.5
3	446.9
4	667.4
5	779.5

** NStacks
9

** stack #	zone	type	flush edge	xloc	yloc	#layers	j	#panels	panels	orientation
1	1	A	RIGHT	116.2	57.3	12	1	1	17	2
							2	1	24	1
							3	1	25	1
							4	1	26	1
							5	1	27	1
							6	1	28	1
							7	1	29	1
							8	1	30	1
							9	1	31	2
							10	1	40	2
							11	1	43	2
							12	1	1	3
2	2	A	RIGHT	336.7	57.3	16	1	1	18	2
							2	1	19	2
							3	1	35	1
							4	1	32	2
							5	2	34 33	1 2
							6	1	36	1
							7	1	41	2
							8	1	42	2
							9	1	37	1
							10	1	51	2
							11	1	38	1
							12	1	52	1
							13	1	39	1
							14	1	53	1
							15	1	54	1
							16	1	44	2
3	2	A	RIGHT	336.7	57.3	1	1	1	45	2
4	2	B	LEFT	336.7	99.3	2	1	1	2	3
							2	1	3	3
5	3	A	RIGHT	557.1	87.3	8	1	1	20	2
							2	1	46	2
							3	1	47	2
							4	1	48	1
							5	1	49	2
							6	1	50	2
							7	1	61	2
							8	1	62	2
6	4	B	LEFT	557.1	129.3	2	1	2	4 6	3 1
							2	1	5	2
7	4	A	RIGHT	777.6	87.3	12	1	1	21	2
							2	1	22	2
							3	1	55	1
							4	1	56	1
							5	1	64	2
							6	1	57	1
							7	1	67	1
							8	1	58	1
							9	1	68	1
							10	1	63	2
							11	1	59	1
							12	1	69	1

L5-3: Proposed algorithm

8	5	A	RIGHT	889.8	87.3	13	1	1	23	2
							2	1	11	2
							3	1	12	2
							4	1	13	2
							5	1	14	2
							6	1	15	2
							7	1	16	2
							8	1	7	1
							9	1	8	2
							10	1	9	2
							11	1	10	2
							12	1	65	2
							13	1	66	2
9	5	A	RIGHT	889.8	87.3	5	1	1	70	2
							2	1	71	2
							3	1	72	2
							4	1	73	1
							5	1	60	2

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