

INFORM FORM PERFORM

Nate Holland¹

¹University of Nebraska – Lincoln
Graduate Student MBA/MArch

"Within contemporary architectural design, a significant shift in emphasis can be detected - a move away from an architecture based on purely visual concerns towards an architecture justified by its performance." (Leach) Architects have developed and employed parametric design strategies to both address these performance related concerns and improve their production. Though these strategies have improved architectural design, they are not being used to their full extent in the design process. I propose taking the use of computers in aiding architectural design one step further; information and data should INFORM the project, driving the creation of a building FORM enabling it to PERFORM at higher levels than traditional design.

As architects continue to improve these tools, owners and developers tend to choose an opposing strategy. They often finance cheaply built (and poorly designed) buildings in an effort to reduce the upfront costs of the project. However, in economics reducing costs is only part of a sound financial decision. The other half of the equation is increasing the revenue generated by the project. I further propose that by investing in an informed design/decision making process, investors would be able to fund projects that perform better and sustain significantly higher revenues.

1.0 Information Based Design

The use of computers within architectural design has been fully accepted as a design tool. However, using it only as a tool limits the true power of digital design. As Carlos Marcos described it "Digital consciousness is a design strategy to be found in different degrees among [...] architects or designers that rely on the computer not only as a tool but as part of the team" (Marcos). This type of digital consciousness is growing. Parametric programs such as grasshopper now have a generative potential though the various add-ons such as Galapagos, Kangaroo and Rabbit, which are bringing the power of raw computer code into terms that designers can harness.

As projects become increasingly complex and owners continue to press for higher performance and outcomes, the levels of information integrated into the project grow rapidly. When working through a design process heavily loaded with information organizing and navigating the data can bog down design decisions. Allowing the computer to weigh different options and make proper choices based on optimal solutions and given parameters substantially improves the design work flow.

Working with the computer as opposed to controlling it allows for a unique combination between two entirely different types of rationality. The computer can compute

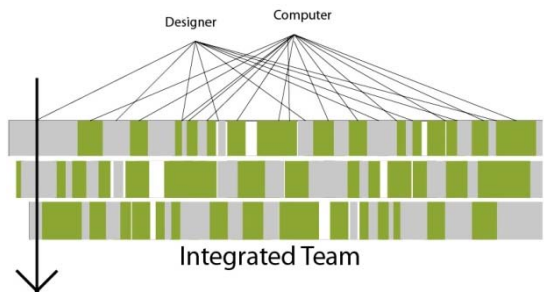


Figure 1. As an integrated team the designer and computer work in parallel. Information and design decisions should be divided and shared both cooperatively and in series.

massive amounts of data extremely quickly but under the restraints set up by the code. Designers, however, can make intuitive judgments and jump from one aspect of the project to another. By sharing design tasks and passing information back and forth they can increase their collective design potential. This “real-time bidirectional exchange of information between the designer and the system is a reciprocal relationship that continuously changes the designer’s understanding of the project as it is being developed, which, in turn, influences the decisions the designer makes” (Verde)

As a case study I am working on a design proposal for a mixed use residential tower in downtown Seattle which strives to fully include the computer as a creative addition

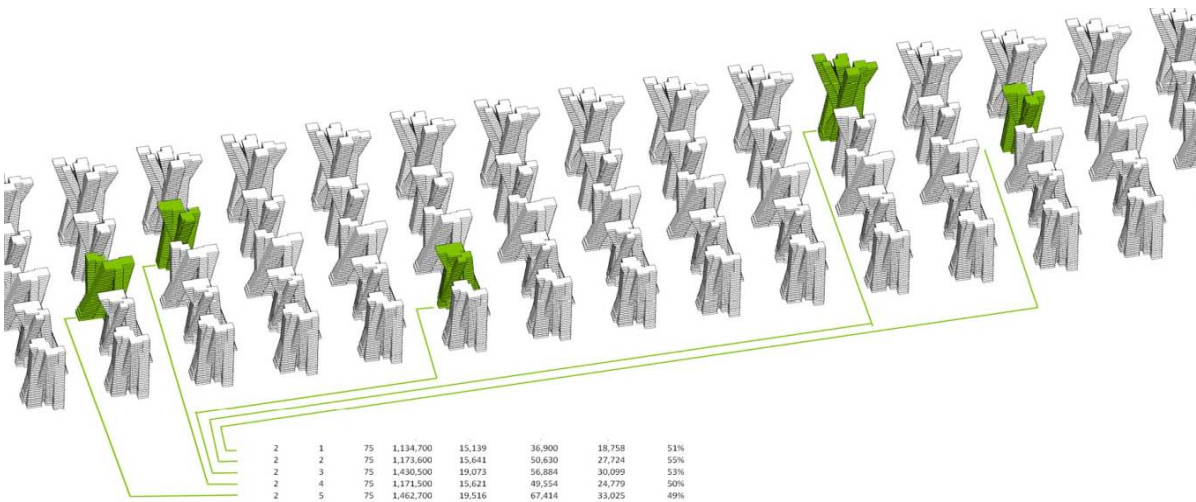


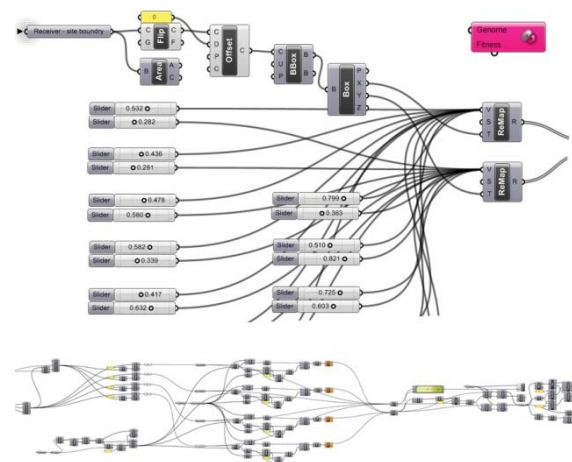
Figure 2. Field of results generated through the information based process showing a digital selection awaiting designer preferences

2.0 Inputs: site, views, values, preferences

In addition to the physical context the information driven process uses preferences from the designer and owners to make appropriate decisions. Programmatic breakdowns, emphasis on particular relationships, and adjacencies, etc. become powerful determinants of how the massing will take shape. Many of these inputs are set as sliders representing the designer preferences. Each quality is ranked on a scale of 1-10 which allows the computer to weight the different resulting outputs to find

2.1 Massing: Lower Floors

The key design strategies for laying the retail base focus on increasing access and proximity to potential customers. The Grasshopper script focuses on four conflicting qualities to achieve these strategies; proximity to public transportation, access to sunny outdoor space (a premium in Seattle), proximity to existing retail, and the distance from existing public plazas. Other more practical design requirements are the area of the footprint, zoning requirements, and maintaining a compact layout with maximum exterior access.



133

ACADIA Regional 2011: Parametricism: (SPC)

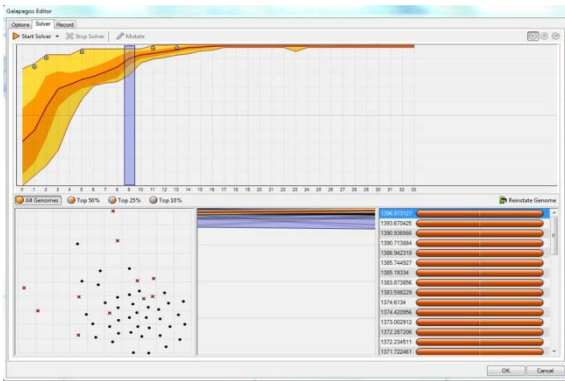


Figure 5. The Galapagos display window showing a graph of the optimization process in the top display, and various statistics about the distribution of test results in the bottom displays.

The integrated team creates the profile of the base level from the intersection of several squares approximately sized from programmatic data. Galapagos, the evolutionary solver within grasshopper, adjusts the location of these squares by moving two sliders for each square, to try and maximize the benefits. Each pair of sliders controls the respective x and y values for the center of the square.

As the primary driver of the form finding process within these Grasshopper scripts Galapagos deserves an explanation of its own. Galapagos optimizes through an evolutionary process which creates and tests one generation of possibilities (by adjusting the input sliders), determines the highest ranking solutions and breeds them together. It takes either matching pairs or contrasting pairs (dependent on user selection) to create the next generation of hybrid solutions. The process continues breeding successful iterations until it narrows in on a maximized result. This type of optimization can lead to a type of inbreeding where Galapagos finds a locally maximized result as opposed to the absolute maximum. This gives designers the opportunity to evaluate multiple optimized solutions from the same input. Though one may perform better, the other results could provide unique characteristics worth considering. What makes the integration between the computer and architects so intriguing is the different ways they view and interpret information. Computers understand

numbers, values and linear logic; in contrast designers look at the problem not as a series of random numbers but as architectural space which has certain intuitive criteria. By stopping the solver occasionally to adjust a piece manually, the designer can seed the system by pointing it in the right direction and starting it again from a more intuitive base point which the computer can optimize.

2.2 Massing: Upper Floors

Within residential real estate there are many value determining factors beyond location which the architects can control. The most directly correlated with value increases are views, balconies and unit sizes. According to Mark Wade a residential unit with a good view (i.e. a luscious green park, Ocean view, or a terrific skyline) can demand twice the sales price as a comparable unit with a bland view (Wade). Similarly, having a useful balcony can add up to 4% to the unit value (Leung).

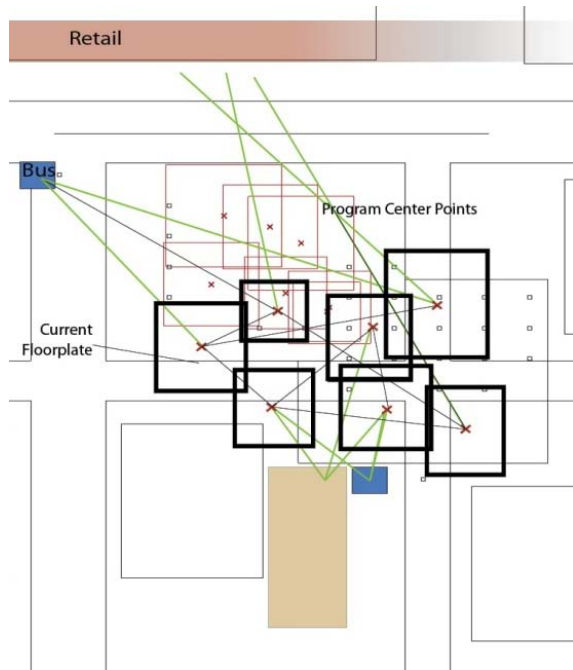


Figure 6. A 2D visualization of the optimization process. Galapagos controls the black squares and measures their distances from nearby points of interest. It Systematically optimizes their locations to generate the ground level floor plan.

This study uses the coastline along the edge of downtown Seattle, as the primary view. The Seattle skyline wasn't included as a valuable view because the three potential site locations are all too close to see more than the nearest adjacent buildings. Using a similar optimization process to control the profile of the top floor, Galapagos adjusts a matching set of squares to maximize the potential the length of the perimeter that has a direct line of sight to the waterfront, thus ensuring that more units have windows oriented towards good views. Other factors influencing the upper profile are the distances between the squares and zoning requirements.

Each time Galapagos runs it becomes an opportunity for the designer to work with the computer in determining the best solutions. For example one might set the geometry in a position that logically works before letting the solver run to further optimize their locations. More specifically in the optimization of the upper floor plate, as the solver narrowed in on a given solution it often leaves small awkward gaps between squares or excludes a square from the primary cluster for whatever reason. The designer can easily stop the script, slide the square into a

more intuitive alignment and restart the Galapagos process, saving both time and processing power.

2.3 Massing: Types

Using these two optimized floor plate profiles Grasshopper creates the massing of each building by blending the two profiles together. Each square from the base floor plate is lofted with its twin on the upper level and then joined together with the other pairs to create the generic form of the building. (See figure 7)

The primary criticism of this massing type is that only two of the floors are truly optimal and that the remaining floors could potentially achieve a higher value. However, optimizing each floor individually becomes overwhelming due to restraints in time and processing power. Because the results of optimizing additional floor plates follow the law of diminishing returns, using only two additional optimal floor plates becomes a viable solution. The floors are chosen by the averages of the different heights of neighboring buildings. This allows the massing to rapidly

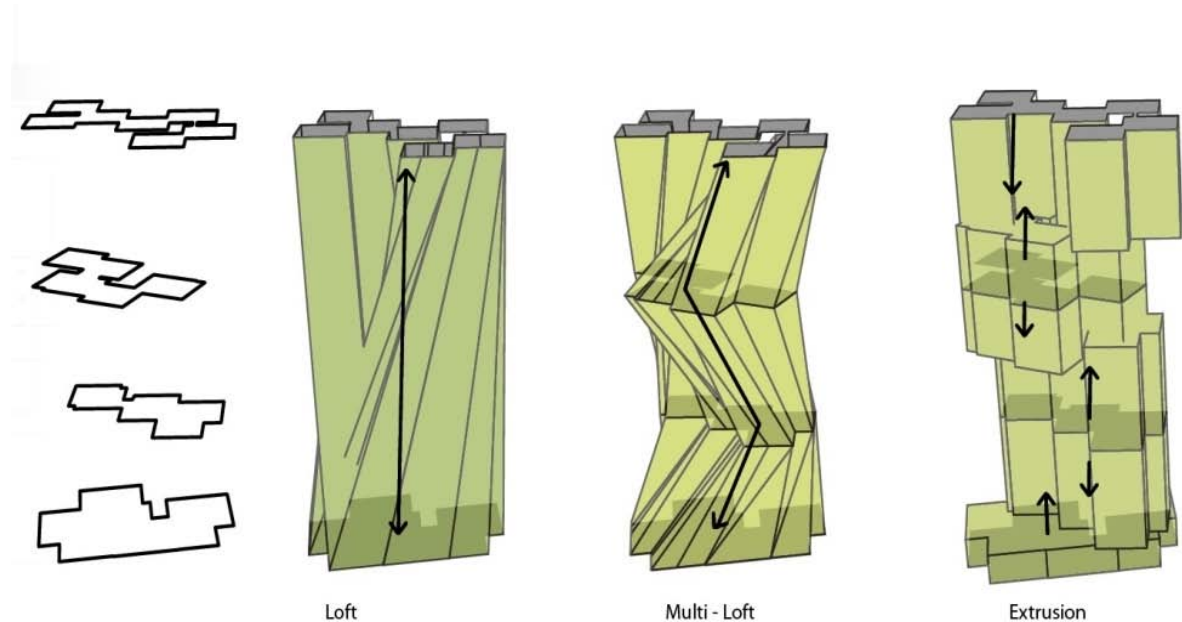


Figure 7. The primary building form is generated from a series of optimized floor plates. The far left image shows the four optimal floor plates stacked above each other. The images on the right show three different formal typologies for generating a building mass from the floor plates.

shift into more profitable configurations once new views became available. With the addition of two more floor plates the multi-loft between matching sets of floor plates generates a significantly different massing type than the single loft. A third typology also exists by extruding these four profiles vertically, resulting in very abrupt shifts in the form of the building at each of these levels.

3.0 Evaluation: Cost, Value, Etc.

The quick speed of this process allows the design team to generate dozens or more study iterations of optimized building masses. Through digital analysis, the computer can sort and present to the designers the top versions for analysis. It also generates 3d printed models and tables of information to accompany each iteration. The design team can narrow down the selection and move forward with only the best options to develop and further analyze.

Before moving forward with any one solution, both additional value and cost increases are calculated in order to determine any potential gain in profit. In some projects this may be the only evaluation criteria. These numbers are calculated using basic valuation techniques in grasshopper and then compared against the results of a similarly sized building consisting of nothing more than an extruded box shape. Using grasshopper to perform these evaluations requires additional information from the designer. The cost of the building is determined by the overall area multiplied by a base cost/s.f. and a variety of cost multipliers to represent the different cost increases in building design and construction; such as height which represents a direct cost increase because both structure and complexity of construction increase as the building grows taller. Cantilevered areas, length of perimeter, complexity of geometry, and building splits are also assigned multiplier values. Similarly the total project value is determined by calculating the cumulative benefits of the optimal floor plates such as significantly

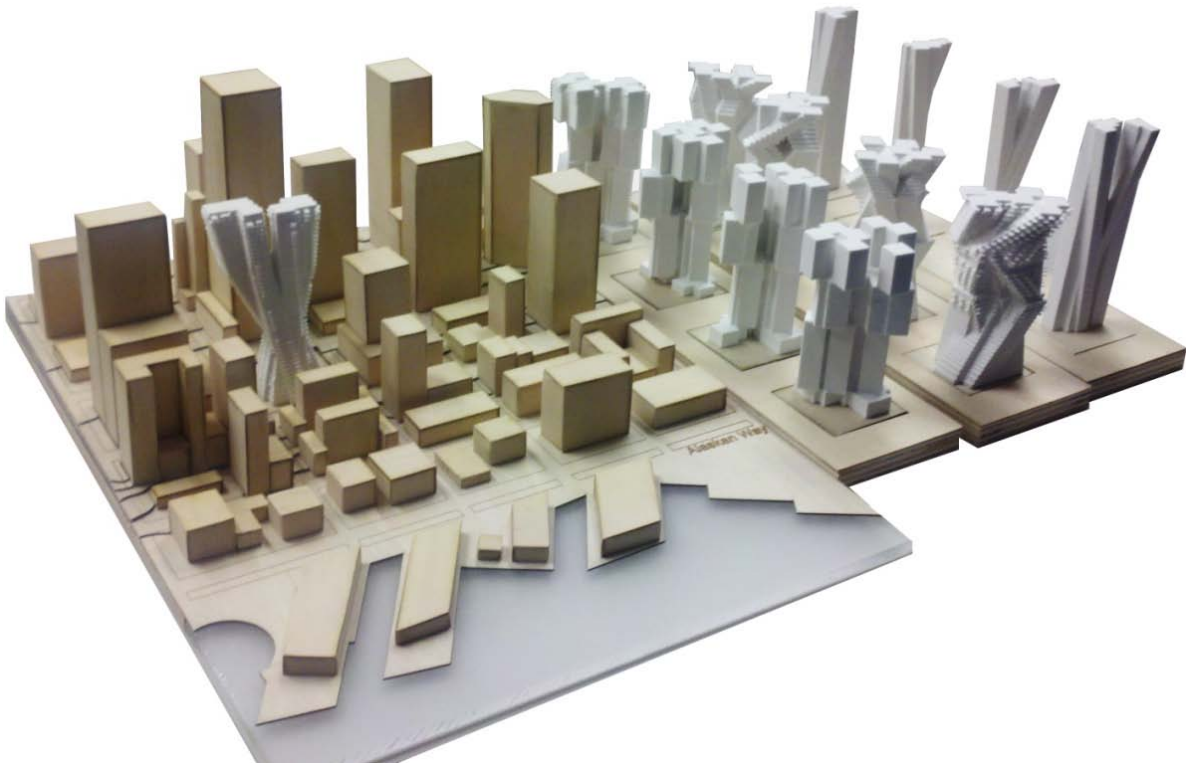


Figure 8. Downtown Seattle site model with interchangeable 3d prints of the optimized building forms.

higher proportions of views, and proximities to attractors at the retail level. Other evaluations such as aesthetic qualities, size, proportion, and core locations can be performed in a similar fashion.

4.0 Floor plate Division

Once a building form has been selected for further development the next step is to sequentially use the massing to generate the intermediate floor plates (see figure 5). Then the design team can work with the computer to build them back up into floor plans and eventually an architectural design. The residential floor plate division process allows the computer and designers to excel as a team. The process starts by creating a hallway between the primary elevator/stair core locations. Then the computer draws a series of division lines through the floor plate radiating out from the centralized hallway and cores delineating the room separations. Galapagos adjusts their locations along the hallway sequentially testing the results against the user input requirements for minimum, maximum and desired room sizes along with the length of exterior windows. Once the designer and the computer derive an appropriate solution Grasshopper separates the rooms into categories based on their size and how many bedrooms their proportions permit to provide feedback through charts and a cumulative spreadsheet.

4.1 Unit Sub-division

A secondary grasshopper script takes a series of flexible room layout prototypes and applies them parametrically to the different sized units, choosing the appropriate style based on the location, size and proportion of the room. This process creates a rough bubble diagram of room layouts within the space that the designers can use to provide drawings/data to the owners and later develop into floor plans.

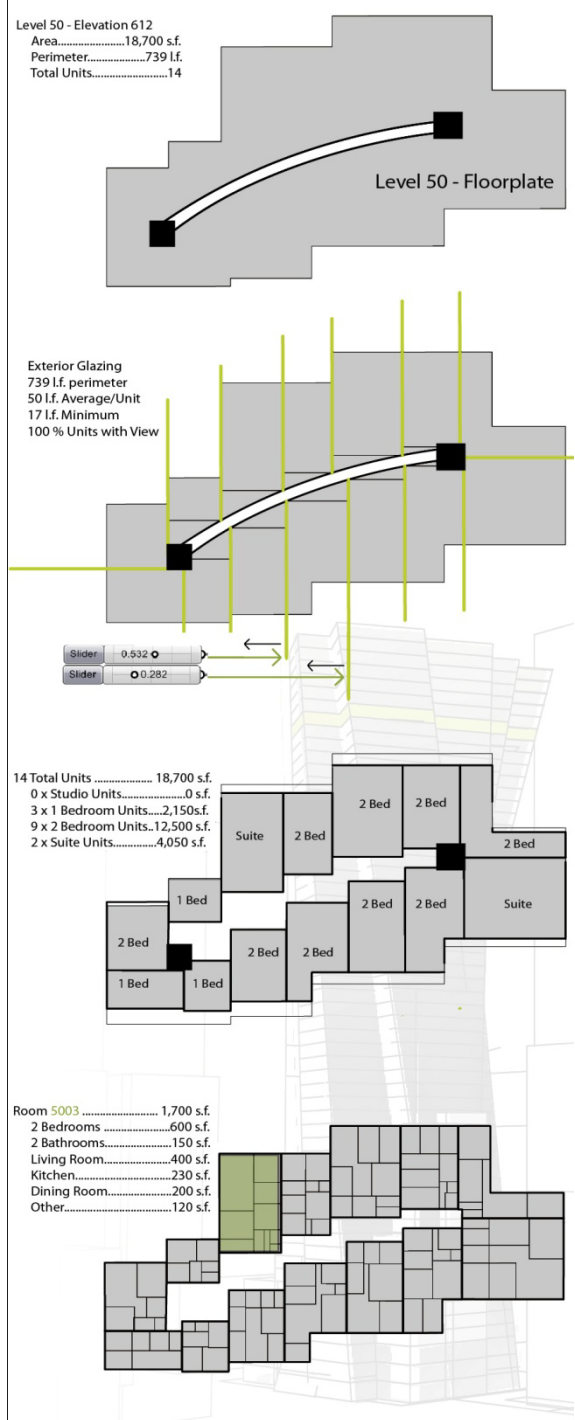


Figure 9. The floor plate division process. From top to bottom: Level selection, Hallway and unit division, Preliminary unit analysis, Parametric bubble diagram

5.0 Results

Through each phase of this design process the integrated effort between the Galapagos solver and the designer produced successful results. Though not every test created optimal conditions, the information based generative process proved viable. According to the values and parameters laid out in the inputs and output criteria, this process produced multiple building forms that each had a higher increase in benefits (Value) than increase in costs, leaving the developer with a higher profit and perhaps a more architecturally significant project.

The case study tested this process on three different sites within downtown Seattle each of different shapes, sizes and zoning restrictions. Two of the three sites generated - mostly successful results, meaning the increase in value surpasses the increase in costs. The site that failed to produce successful results had a lower maximum building

height and thus didn't allow the form to grow tall enough to capture views of the waterfront. In the other two sites all three of the massing types showed positive results, though a clear distinction existed between them (see graph in figure 6). If one looks purely at the number of rooms able to achieve a view of the waterfront through the floor plate division process the benefits of such a system become even greater.

This study also led to the discovery of new typologies or groups of building shapes that maximize views of the waterfront. This type of finding within the generative process allows designers to see different possibilities outside of their preconceived notions. Within this case three distinct types became evident; a wedge shape with the slightly larger end facing the view, the 'W' shape and something more closely resembling a skinny box. (See Figure 11)

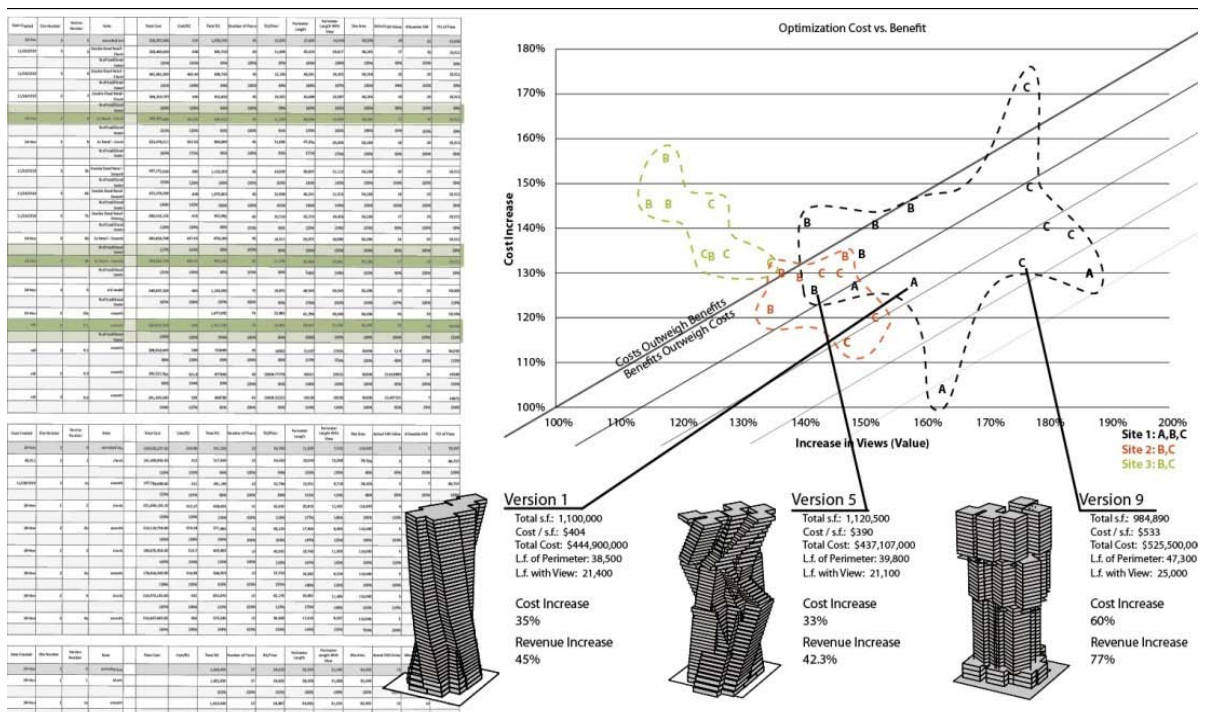


Figure 10. The primary spreadsheet for organizing and charting the results of the different iterations, and a graph representing an increase in value(x axis) vs an increase in cost(y axis). Any result below the diagonal black line represents a positive increase in profit for the developer, the results for the different sites are grouped with dashed lines. Letters A, B, and C represent the Loft, Multi-loft, and Extrusion massing types respectively.

6.0 Conclusion

As a result of the generative information based process the computer in combination with a design team can rapidly produce a wide variety of results optimized towards different input parameters. Each input as either a variable in the larger Grasshopper script or a seed into the Galapagos solver has the ability to drastically affect the output result.

As the computer and designer mesh into an integrated design team Cynthia Ottchen thoughtfully warns: the architect "is still ultimately responsible for design intent and needs to be able to look at the big picture to decide which factors to parameterize, to give limits to the parameters, assign a weight to each factor and determine the order and method of the information modeling process"(Ottchen). This requires a unique new understanding of design, as Marcos called it 'design consciousness.' As the amount of data available to architects continues to grow there is a need for a new generation of designers, those who can not only work with computers but are willing to embrace their generative potential within an informed design process.

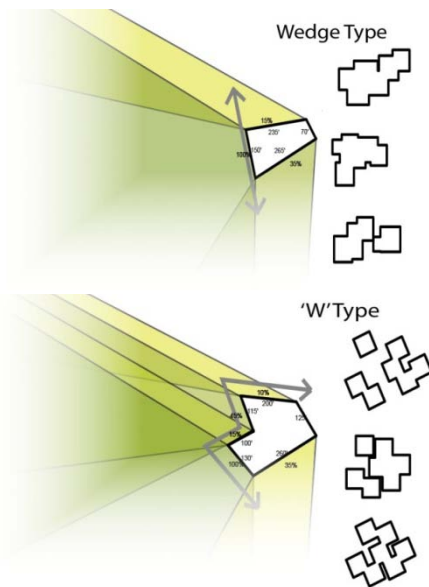


Figure 11. Diagrams showing the different view angles available for different typologies generated through Galapagos.

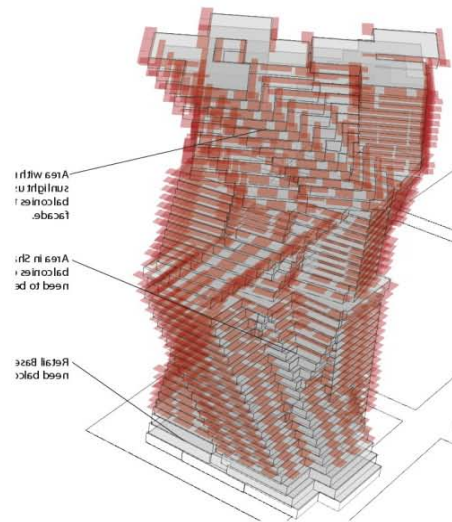
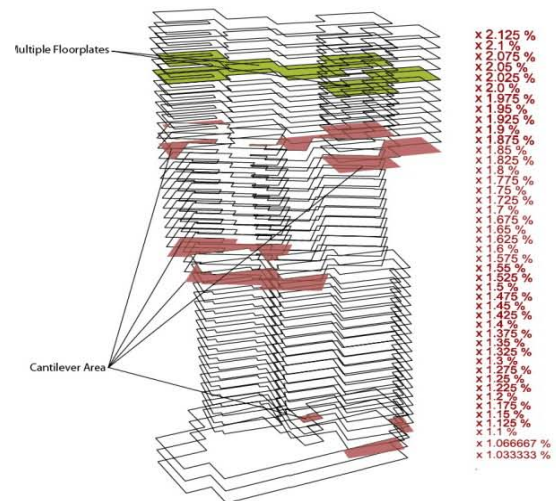
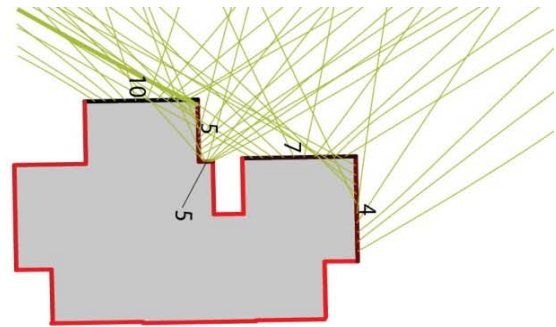


Figure 12. Images showing the view calculation for a particular floor plate, cost evaluation, and balcony optimizations based on solar shading

References

- Leach, Neil. "Digital Morphogenesis." *Architectural Design* 79.1 (2009): 32-37.
- Leung, Wendy. "What Is a Balcony's Value?" Wendy Leung's Seattle Condo Review. Web. 07 Aug. 2010. <<http://www.seattlecondoreview.com/2006/06/post.html>>.
- Marcos, Carlos L. "Complexity, Digital Consciousness and Open Form: A New Design Paradigm." *ACADIA 2010: LIFE In:formation* (2010): 81-87
- Ottchen, Cynthia. "The Future of Information Modeling and the End of Theory: Less Is Limited, More Is Different." *Architectural Design* 79.2 (2009): 22-27.
- Verde, Marco. "Multiperformative Efficient Systems (MES) Towards System Thinking." *ACADIA 09 :reForm* (2009): 248-51.
- Wade, Mark. "Floor Height and View of Philadelphia High Rise Buildings Greatly Affect Value." Web. Aug. 2010.

Figure 13. A 3d visualization of one iteration, showing both structure and mullion patterns, with an enhanced retail base.

