Burning Village: Deployable, Scalable, Open Source Camp Infrastructure for Burning Man

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Abstract

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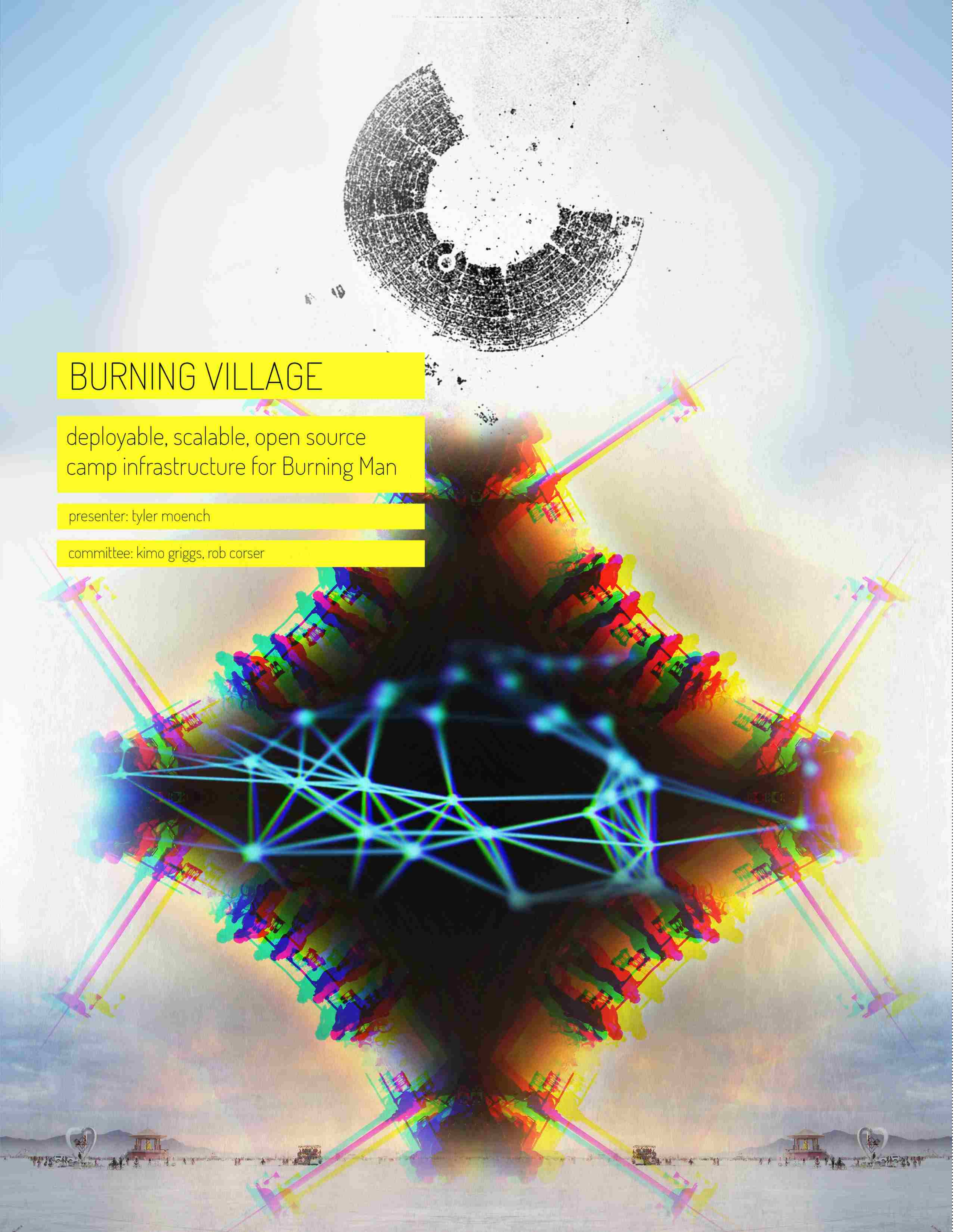
Burning Man Camps are wildly variable, highly unpredictable, and extremely individualized, temporary autonomous communities existing within the larger decentralized network that is Burning Man. However, this chaotic network is built on top of a highly systematized framework – both physical in terms of its location and city planning, and cultural in terms of its ethos & principals. The open framework of Burning Man becomes a venue for the actualization of its participant's creative visions. This semi-modular, decentralized, mosaic relies on its participants to make the event what it is, and ultimately the nuanced layering of the efforts of various disparate camps make Black Rock City the rich, and vibrant city that it is (albeit for only 1 week out of the year). My goal is to design a set of digital tools and a structural framework that can used, co-opted, and expanded on by a group of empowered users to design and fabricate deployable, scalable, open source infrastructural trailers for their Burning Man

camps. Because of the number of radically different programmatic requirements within each camp and the unique physical & cultural environment of the event itself, a top down, one-size-fits-all solution is bound to have limited applicability. However, by utilizing parametric modeling, an open source communal design ethos, and digital fabrication tools it is possible to design flexible, mass customizable, and individualized structures for Burning Man camps which are more closely aligned with the principals of the event. In the way that Burning Man shifts the way we think about society, we can shift the way we think about the design process from a workflow consisting of a top-down visionary delivering a static product to a ground up and communal network of empowered users working within a systematized framework, acting as a canvas for the individual to realize their personal vision through community action.



{0} Abstract

Burning Man Camps are wildly variable, highly unpredictable, and extremely individualized, temporary autonomous communities existing within the larger decentralized network that is Burning Man. However, this chaotic network is built on top of a highly systematized framework – both physical in terms of its location and city planning, and cultural in terms of its ethos & principals. The open framework of Burning Man becomes a venue for the actualization of its participant's creative visions. This semi-modular, decentralized, mosaic relies on its participants to make the event what it is, and ultimately the nuanced layering of the efforts of various disparate camps make Black Rock City the rich, and vibrant city that it is (albeit for only 1 week out of the year). My goal is to design a set of digital tools and a structural framework that can used, co-opted, and expanded on by a group of empowered users to design and fabricate deployable, scalable, open source infrastructural trailers for their Burning Man camps. Because of the number of radically different programmatic requirements within each camp and the unique physical & cultural environment of the event itself, a top down, one-size-fits-all solution is bound to have limited applicability. However, by utilizing parametric modeling, an open source communal design ethos, and digital fabrication tools it is possible to design flexible, mass customizable, and individualized structures for Burning Man camps which are more closely aligned with the principals of the event. In the way that Burning Man shifts the way we think about society, we can shift the way we think about the design process from a workflow consisting of a top-down visionary delivering a static product to a ground up and communal network of empowered users working within a systematized framework, acting as a canvas for the individual to realize their personal vision through community action.

Fig. 0 - Buckminser Fuller's Dymaxion House
Fig. 1 - Prouvé's Demountable House
Fig. 2 - The Man burning

{1} Introduction

There has been a long history of history of Architects experimenting with deployable architecture. Buckminster Fuller, always intrigued with efficiency, designed the Dymaxion House based on the manufacturing process of the car. It used lightweight and easy to assembly structures to reduce cost, construction time, and material usage [1]. Jean Prouvé experimented with deployablilty with his Demountable House. He took advantage of modern steel manufacturing capabilities to produce a modular housing system which could be easily shipped and assembled on site; flat pack housing before flat-packing existed [2]. Prouve's own grandson stated in an interview with Dwell Magazine that to Jean Prouvé, there was "no difference between the structure of a building, and the structure of a table", therefore it should be no surprise that today Ikea is beginning their own foray into deployable architecture [3]. The Swedish furniture company applied their expertise in designing affordable knockdown furniture to the design of a very effective and easily deployed refugee shelter.

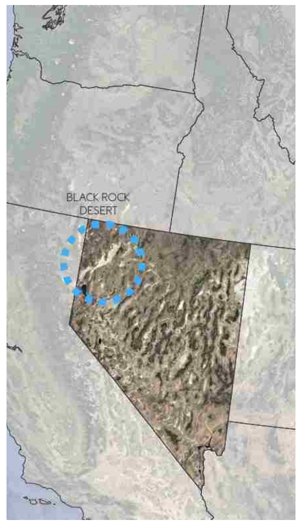
These designs all wrestle with ideas about how to deliver shelter quickly, easily, and affordably to as many people as possible. Deployable architecture could be one solution to housing the multitudes displaced by political turmoil, rising sea levels, and an increasingly hostile environment due to global warming. All the examples put forth here rely on mass production to keep costs down and production efficient but because of the varied circumstances and cultures of their inhabitants, the one-size-fits-all approach of these designs may meet the basic needs of their inhabitants but may ultimately under perform when compared to a solution customized for the environment and culture in which they are being deployed. The remote arts festival Burning Man may be one model that we can use to explore how to design flexible, deployable structures that are mass customized for a variety of situations.

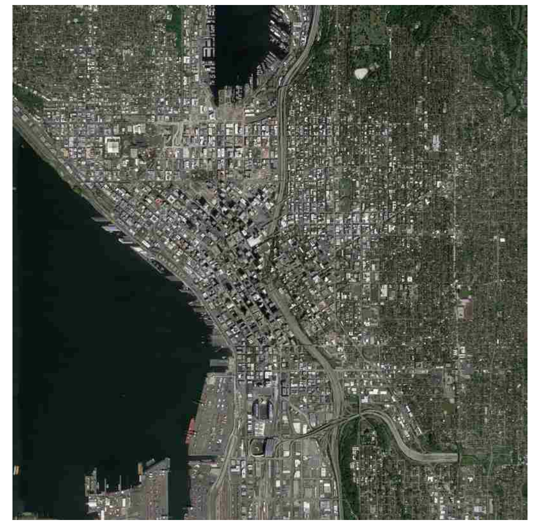
{1;0} Burning Man and Black Rock City

At its core, Burning Man is a week-long arts festival which encourages its participants to make and experience art. The whole event is centered around the burning of a giant effigy (the "Man" in Burning Man) but the event is much larger than that. For that one week a barren patch of remote desert blooms into a pulsating metropolis, a grand experiment of a post-scarcity society built on the layered creative visions of its citizens. And then, as quickly as it arrived, the city vanishes without a trace.

This temporary city is known as Black Rock City (BRC) and is located in the Black Rock Desert, about 100 miles from Reno in North Western Nevada. The size of BRC is hard to imagine but It spans over 7 square miles, and is home to over 70,000 people [5]. For the week that Burning Man is happening, BRC is the 3rd largest city in Nevada. Overlaid onto Seattle, nearly the entire downtown core can fit into the open field which surrounds The Man at the center of the radial plan (fig. 4 and 5).

Black Rock City has a very strong and structured radial plan (fig. 6), acting as the rational and logical framework that this otherwise chaotic city is built on. The most prominent locations on the central axis of the plan are the 3 biggest institutions provided by the Burning Man Organization: Center Camp, The Man, and The Temple. At the center of it all is The Man, the crown jewel after which the event is named; everything radiates from The Man. At 6:00 is Center Camp, which acts as the town hall and is a





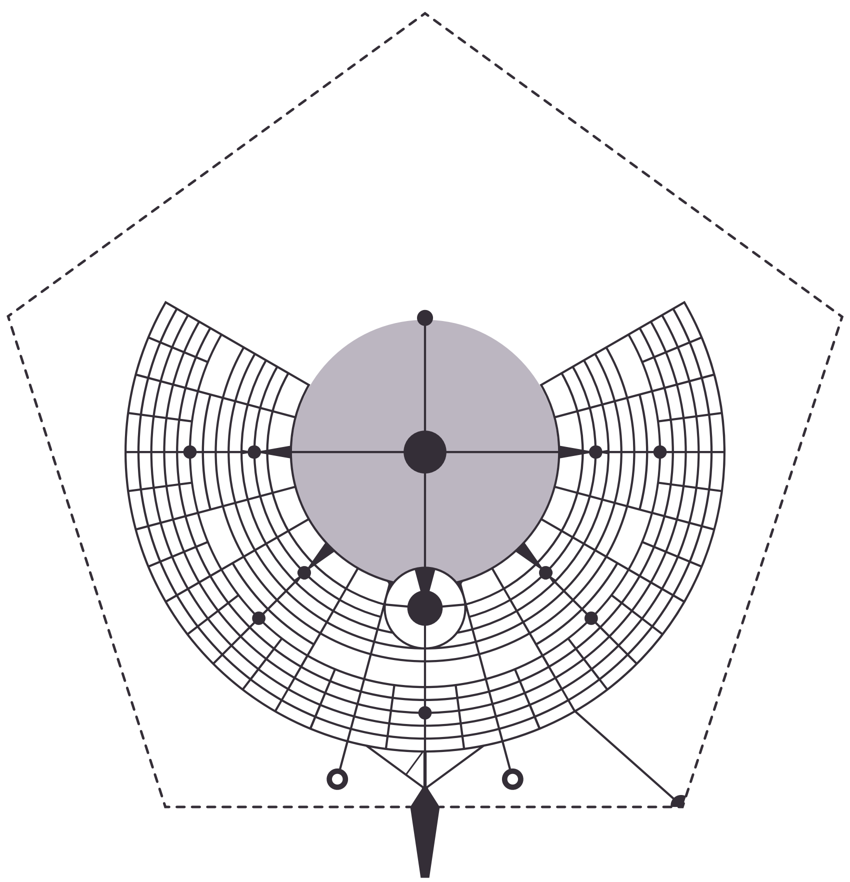


Fig. 3 - Regional Map
Fig. 4 - Black Rock City Satelite View
Fig. 5 - Seattle Satelite View
Fig. 6 - Black Rock City Plan

natural meeting spot. And in relative seclusion, at 12:00 and on the edge of “deep playa” The Temple is the spiritual center of the city. The towering structure of The Temple is different every year and is the quiet and contemplative counter part to The Man. While the burning of The Man is a loud and jubilant celebration, The Temple Burn is almost completely silent, somber, and reflective. The rest of the city is arrayed in a semi-circular arch. Each camp has its own address; radial streets are given times related to their relative position on the clock and concentric streets have a name starting with a corresponding letter of the alphabet, starting with “A” towards the center out to “L”. This system makes navigating the city effortless, without it finding that trapeze show you wanted to see or that camp that makes great grilled cheese sandwiches you’ve been hearing about would be nearly impossible. One’s address might be something like 7:15 and Breath or 5:30 and Fire,

{1;0;0} 10 Principles and the Cultural Site

The heart of burner culture comes down to the 10 Principles. Written by the event’s co-founder Larry Harvey, the principles are a sort of code of ethics which arose organically throughout the early years of the event and continue to be a guiding force in Black Rock City’s cultural landscape [6]. These principals are:

Radical Inclusion – All are welcome at burning man. There are no gatekeepers or in-groups. The stranger is welcomed and encouraged to participate in all Black Rock City has to offer.

Gifting – The act of unconditional gifting with no expectation of compensation or reciprocation. There are no monetary transactions on The Playa, everything is freely gifted. This is central to Burning Man’s gift economy and contributes to the event’s anti-capitalist leanings.

Decommodification – Further separating itself from the capitalist influences of the default world, decommodification “seeks to create social environments that are unmediated by commercial sponsorship, transactions, or advertising.” The organization believes that undue capitalist influence undermines its culture of participation in favor of consumption.

Radical Self-Reliance – Relying on one’s own inner resources and fostering their own autonomy.

Radical Self-Expression – Bringing one’s unique talents and experience to be shared with the wider community

Communal Effort – Collaboration, communal action, and shared information are crucial to making burning man happen for everyone. When Radical-Self Reliance breaks down Communal Effort picks up the slack. Social networks and collaborative environments are forged and amplified through the intersectionality that occurs from radical inclusion and participation.

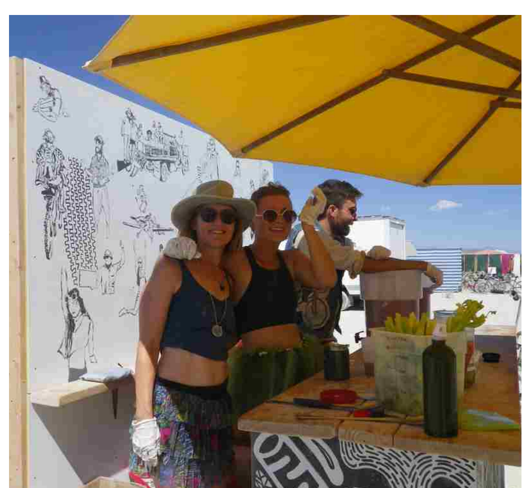


Fig. 7 - Fighting in the Thunderdome
Fig. 8 - "The Christina" - Art Car
Fig. 9 - Art Installation on the Playa
Fig. 10 - Black Rock Roller Disco
Fig. 11 - A Large Sound Camp
Fig. 12 - Bloody Mary Bar at The Lithic Altars Art Support Camp

Civic Responsibility – Being a courteous and responsible citizen of Black Rock City is key to forming a civil society

Leaving No Trace – Being good environmental stewards, and ensuring that the temporary city doesn't leave permanent damage to the fragile environment it exists in.

Participation – No spectators, everyone is a participant. "We achieve being through doing"

Immediacy – Be here now. Experience the moment. Follow your personal desires without impedance from outside pressure. Perhaps the hardest principal to grasp, the BORG (Burning Man Organization) describes it thusly: "Immediate experience is, in many ways, the most important touchstone of value in our culture. We seek to overcome barriers that stand between us and a recognition of our inner selves, the reality of those around us, participation in society, and contact with a natural world exceeding human powers. No idea can substitute for this experience."

Perhaps the most unique and defining feature of the Burning Man experience is that The Burning Man organization doesn't book any talent or provide any content outside of burning The Temple and The Man. In this way, Burning Man is whatever it's participants decide to bring. It's a blank canvas for the people who attend to alter as they see fit. The society is a do-ocracy; if there is something missing, build it yourself. Participation is so ingrained in the culture that along with your ticket you are given a small card that reads:

"We Believe that transformative change, whether in the individual or in society,
can occur only through the medium of deeply personal participation.
We achieve being through doing.
It takes difficult, real work to make Burning Man happen.
There are no spectators. We are all participants. We are all citizens of Black Rock City."

This pervasive attitude of participation over spectatorship is what makes Burning Man special when compared to other large gatherings. Because everyone at the event is a contributor and brings their unique perspective with them, the breadth and richness of possible experiences available on the playa goes far beyond that available anywhere else. Everywhere you look you see people expressing themselves through making art, costuming, art cars, and creative DIY infrastructure, all offering unique experiences.

The difference becomes apparent when we compare it to a similar event like the Bonnaroo music and arts festival. With a larger population at 80,000 [7] but a much smaller geographic footprint, the plans are spatially different while being structurally quite similar; there are areas of the commons which are provided by their respective organizations and a network of streets structuring the camping areas. However, because the camps at Burning Man are expected to be active participants and engage the rest of the city, the whole city becomes activated space, as opposed to the traditional festival format where all the action happens in the common areas and the camping areas are much less activated. Its my belief that

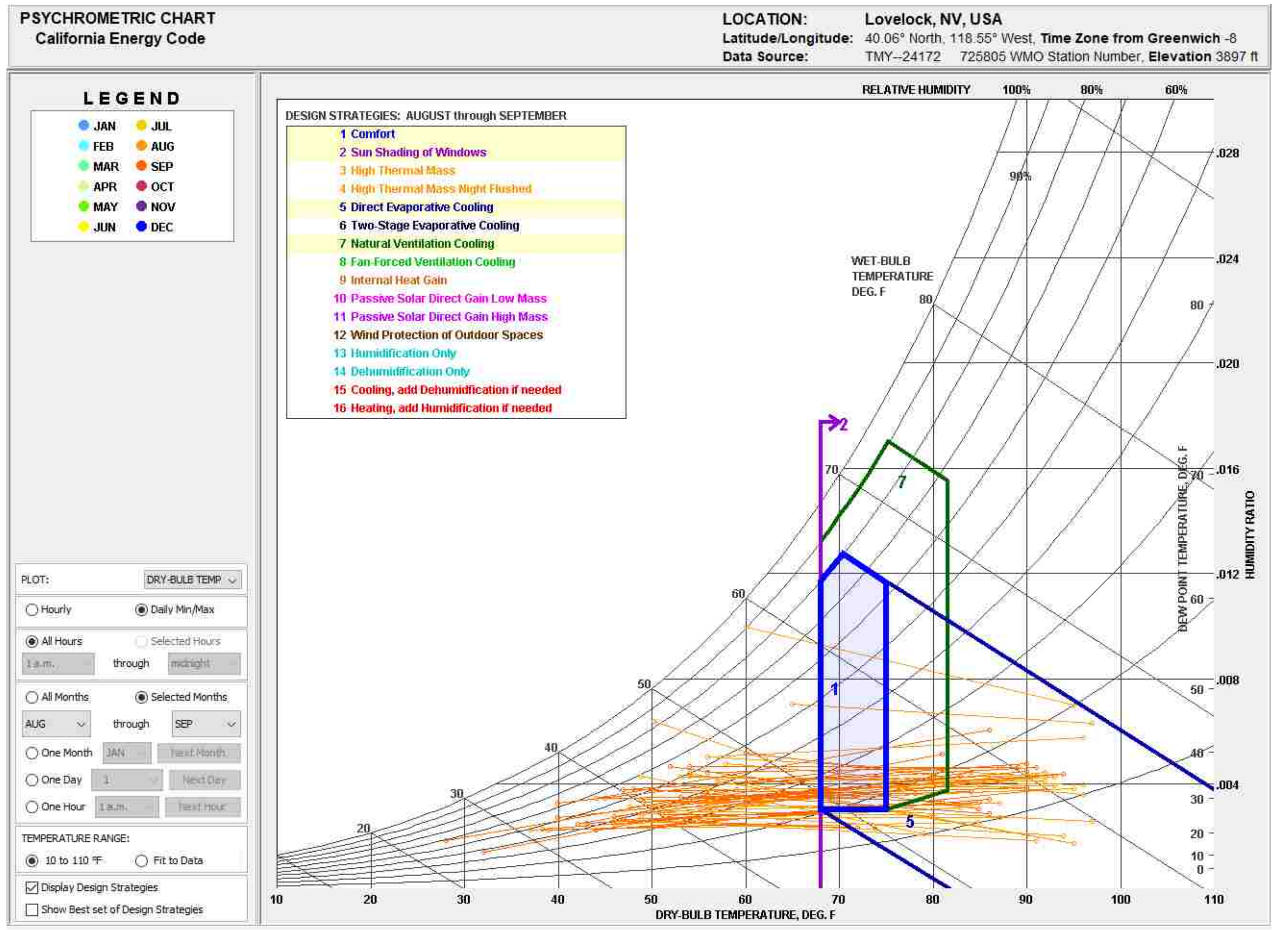


Fig. 13 - Psychometric Chart
Fig. 14 - White-Out Dust Storm
Fig. 15 - Dust Devil Sweeping Through Several Camps

the complex and nuanced layering of people's individual contributions towards the idealized greater whole, makes Black Rock City the vibrant place that it is.

Camps at Burning man vary in size drastically and because of the culture of participation and gifting their programs vary wildly as well (see fig. 7-12). It would not be out of place to see a camp of 5 people who give out pancakes a couple mornings during the week next to a camp of 100 people that has a full bar and a packed music line up. Camps could be offering food and drink, activities (e.g. flag making, gladiator fighting, yoga), services (e.g. bike repair, Buddhist life coaching, fire art safety lessons), Live entertainment (e.g. concerts, DJs, lectures, workshops) or have programmatic needs beyond my imaginative capacity to plan for. Therefore, any solution put forth must be scalable enough to work across many sizes of encampments and flexible enough to accommodate an extreme variety of program types.

{1;0;1} Site Analysis

The physical environment of the Black Rock Desert is impossible to be described as anything but harsh, and the ever-present challenges that this environment produces become a defining characteristic of the event. The site itself is entirely flat and the only natural material there is a super alkaline dried clay known as "Playa". The color pallet of the environment is reduced to the striking light blue of the sky and the tan-white of the playa dust. Wind battered burners, adorned with goggles and facemasks, wear their dust caked clothing with pride; a badge of honor for enduring the inevitable white-out dust storm. By then end of the week everything becomes a uniform tan color and everybody a little darker and crispier from the intense desert sun. Because the event of Burning Man takes place only over the course of one week of the year we can drastically narrow the focus of our climate data to just include late august to early September. A climate model for Black Rock City doesn't exist, so for the sake of this analysis our climate data comes from the Lovelock Municipal Airport in Lovelock, Nevada.

Looking at the psychometric chart (fig.13) for the months of August and September gives us a good idea of what normal conditions on the playa are and which strategies are effective for coping with it. The first things that stands out in the chart is the large diurnal temperature swings. Daytime temperatures in the region are consistently in the 90's or higher, but at night temps can drop down to under 50 degrees F. While nighttime temps are well outside of what we typically consider the human comfort zone, they can easily be mitigated by clothing choice, sleeping bags, or blankets. The daytime temperature extremes are much larger consideration for designing on the playa. The flatness of the terrain and the complete lack of vegetation on the playa offer no natural shade on site so any shade must come from built structures. The transient nature of Black Rock City tends to preclude much truly indoor space to escape the heat, and even with indoor space, the lack of easily accessible electricity makes active cooling like air conditioning impractical and rare. For these reasons overhead shading a key piece of any camp design.

The effectiveness of shading as a design strategy is amplified by the extreme dryness of the Black Rock Desert. The lack of any appreciable humidity makes the shade feel considerably cooler than if the climate was hot and humid. A shade strategy can be implemented effectively with lightweight, tensile shade structures with high air flow and arranging site structures to cast shadows on adjacent structures to keep them cool.

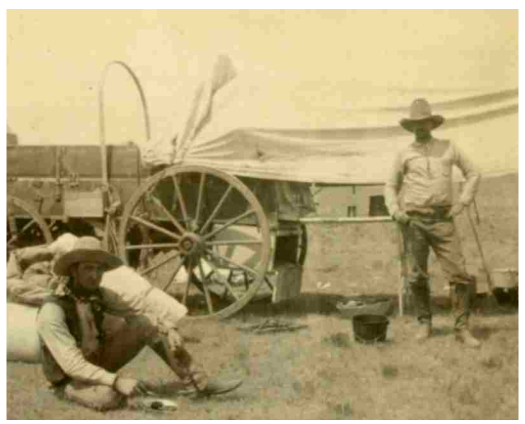
Fig. 16 - The "Bucky Ball Pit" at a Camp
Fig. 17 - Aerial View of BRC Urban Fabric

The design guidelines suggested by the ASHRAE standards for these climate conditions also indicate that building with high thermal mass and night flushing are effective design strategies. While these techniques have effectively been used in very hot and dry climates like the middle east, Saharan Africa, and the Southwestern United States for centuries [8], they are wildly impractical for Black Rock City. The event's transient nature and strong leave-no-trace ethics prevent such monumental building techniques from occurring in Black Rock City.

Another effective design strategy that could be implemented is evaporative cooling. Although not necessarily common place at Burning Man, a portable evaporative cooling system was developed by the burner community [9]. The design uses a 5-gallon bucket, a cheap water pump, and a fan to drastically cool air temperatures through evaporative cooling. Although low tech (a desirable trait for any piece of Burning Man infrastructure) is it not entirely passive, requiring a small amount of electricity, which would need to be factored into the energy plan of camps looking to utilize this strategy. Another downside of evaporative cooling is that the evaporation process inherently wastes water, the most valuable resource on the playa. If those drawbacks can be overcome however, combined with a comprehensive shade strategy, the extreme heat of the site can be mitigated without the need for air conditioning.

{1;1} Design Goals

The intended outcome of this project is to rethink the traditional design process and develop a set of digital tools and a structural framework which can used, co-opted, and expanded on by a group of empowered users to design and fabricate deployable, scalable, open source infrastructural trailers for their Burning Man camps. Because of the number of radically different programmatic requirements within each camp and the unique physical & cultural environment of the event itself, a top down, one-size-fits-all solution is bound to have limited applicability. However, by utilizing parametric modeling, an open source communal design ethos, and digital fabrication tools it is possible to design flexible, mass customizable, and individualized structures for Burning Man camps which are more closely aligned with the principals of the event.



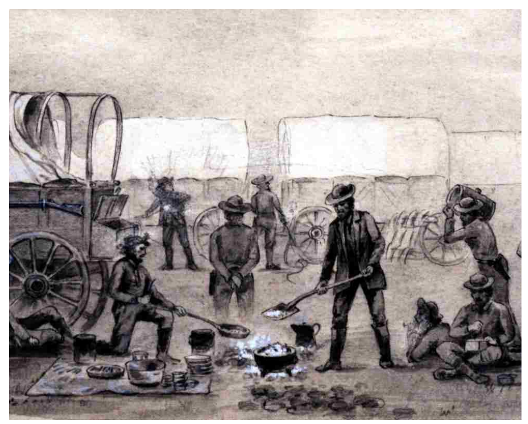


Fig. 18 - Prairie Schooner - Painting
Fig. 19 - Prarie Schooner Set Up as a Chuck Wagon
Fig. 20 - Group of Travelers at Camp - Illustration
Fig. 21 - Wagon Train - Painting
Fig. 22 - "L'Atelier de Wagon" Art Car at Burning Man

{2} Background

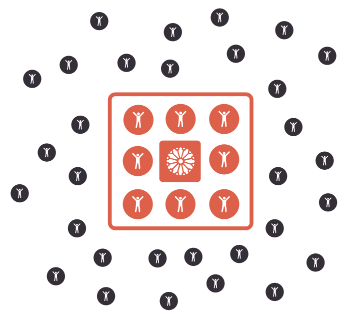
{2;0} The American West

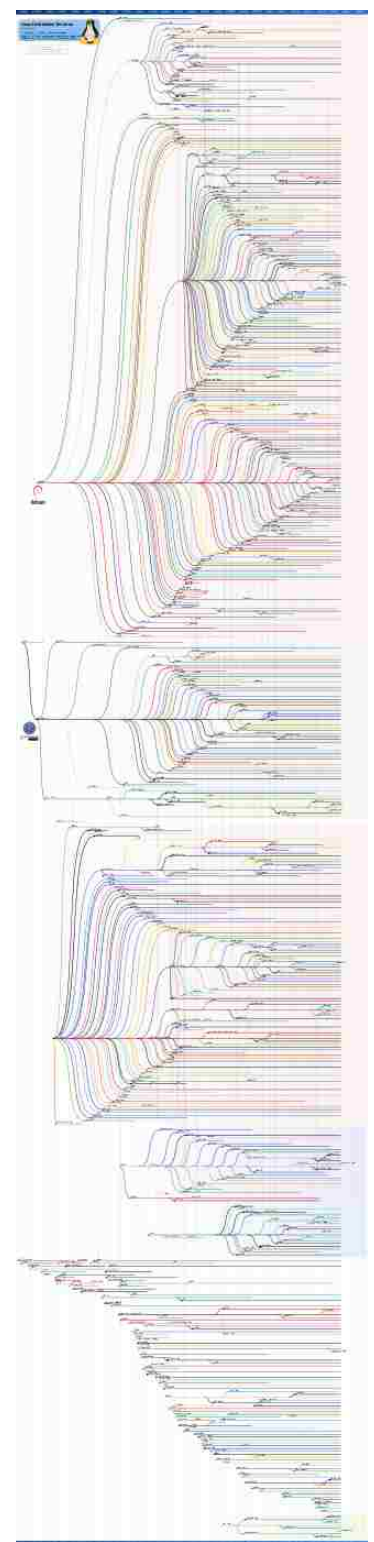
In some ways Burning Man is an extension of a long tradition in the American West of wandering out into the wild and desolate places is search of a freer existence. A sense of rugged individualism drew people from the relative comfort of civilized out into the untamed west. The westward wagon trains of the 1800s share a lot in common with Burning Man. Both parties are looking to break from the pressures and politics of traditional society in search for a more authentic existence and a new way of living. In both cases they find that freedom in the remoteness of the places they are going to and in both cases the distance and hardship of the traveling act as a mechanism for self-selection because only the people who truly want to pursue these things would choose to do so. The Prairie Schooner became symbolic of that western expansion in the 1800s. These iconic wagons carried all the provisions needed for self-reliance on the frontier for many families in search of a new life out west. Named for their characteristic canvas bonnet, which from a distance gave the wagons the appearance of a sailboat adrift in a sea of grass.

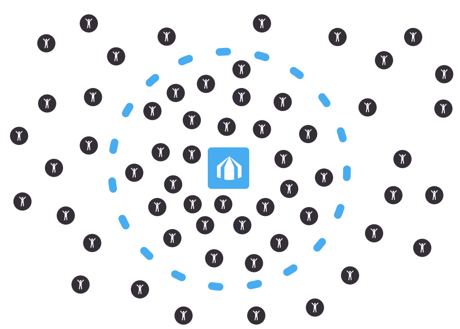
The comparisons of the landscapes of the American West to the open ocean is not lost on the Burning Man crowd. Perhaps amplified by the amount of mental energy devoted to water, or lack thereof, that surrounds the event and the site's history as a dried lake bed, nautical themes are common place in playa art. Mobile party-yachts, cars shaped like angler fishes or sharks, or giant fishing piers constructed on the open playa play off the same nautical imagery as the humble Prairie Schooner evoked while crawling across the great plains.

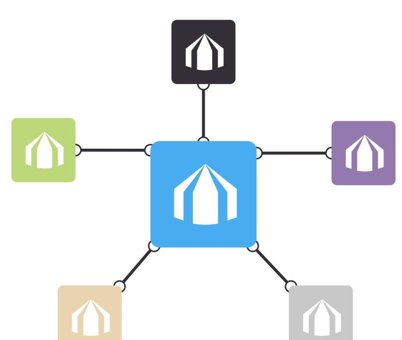
Firsthand accounts of these wild existences in the wagon train focus mainly on the landscape, both the wonder and awe that it inspired and the hardship it caused through inclement conditions [10, 11, 12]. Just like on The Playa, the extreme environment is always at the forefront of your mind. The other commonality amongst the accounts are stories of camp life, particularly involving food and good company. Communal action and a sense of camaraderie was common on the trail, stories often depict strangers coming together to overcome challenges such as getting through a difficult pass and as these individuals gather ad hoc communities form. After a long day of travel, the traveling party gathers around a warm meal and the comforting glow of a fire, bonding over their shared adversity.

The Prairie Schooner at its core was just a box on a frame and a canvas top for weather protection but the design was extremely adaptable and could be configured and customized for the individual need of their users. Chuck boxes were one common programmatic addition to the wagon which transformed it into a mobile kitchen, a welcome sight for ranchers and cowboys tending cattle [13] (fig. 19). Others slung hammocks from under the wagon to make setting up and breaking down camp quicker and easier [12]. This flexibility and the mobility provided by the design are what make the Prairie Schooner worth studying when designing for Burning Man.









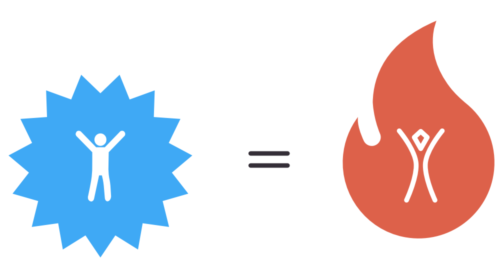


Fig. 23 - The Cathedral Model
Fig. 24 - The Linux Family Tree
Fig. 25 - The Bazaar Model
Fig. 26 - One Piece of Open Software Can Spawn Many New Pieces
Fig. 27 - The Empowered User and The Burner

{2;1} Open Source

In researching how to design for such variability, it was clear that there were two approaches that one could take, "The Cathedral" and "The Bazaar". The idea originates from Eric S. Raymond's book "The Cathedral and The Bazaar: Musings on Linux and Open Source" [14]. The Cathedral is a software design model where a specialized team develops a piece of software cloistered away from the eyes of its user base and will release the finalized product only after extensive development. This closed-wall development style represents the top-down approach that most developers of closed and proprietary software utilize to maintain maximum control over how and why their software is used. The Bazaar approach on the other hand opens the development process to anyone who has something to contribute. This model releases early and often, utilizing its user base as giant pool of beta testers. This methodology brings bugs and other issues to the surface very quickly. However, with this massive pool of people actively developing the software together the solution to these problems are bound to be obvious to someone. Raymond declared this Linus' Law (named after Linus Torvalds, Principal developer of Linux) and states "With enough eyeballs, all bugs are shallow." Essentially, The Bazaar is a recognition that people can be very good at certain things, but nobody is good at everything. Therefore through collaborative action and the development of a body of communal knowledge we can accomplish more than we could on our own, and by expanding that development community as wide as possible we grow the body of communal knowledge.

The open source design ethos is built on the idea of the empowered user [15]. It's about giving over some control to the user and giving them agency to contribute and influence the process in a meaningful way. In exchange for the control that is given up, a richer and more robust product can be produced through community action. The empowered user can also take code that was developed for one use and by modifying it, apply those processes to uses not even considered in its original development. In that way, one piece of software can spawn dozens of unique implementations, filling niche uses that might otherwise never be developed if made from scratch. We see this all over the Linux environment, where there are hundreds of different distributions of Linux all serving unique purposes, but all spawned from a single software kernel (fig. 24). This can have a snowball effect too as these new implementations then get added back into the collective knowledge pool to be further built on and co-opted, which further perpetuates the cycle of creativity. Ubuntu for example, which is a 3rd generation distribution of Linux (based on the Debian distribution) has spawned dozens of unique versions of its own.

In much the same way that Burning Man is a shift away from the modus operandi of conventional society, open source software is an equally radial shift from the status quo. Thousands of individuals working in a decentralized manner, often for no pay, to develop robust freely available tools was thought to be unthinkable before the rise of the open source methodology. This is all possible because software and data can be made and distributed for near zero marginal cost over the internet, shifting from an economy of scarcity where goods and information are protected for personal enrichment, to an economy of abundance where those goods and information are more valuable societally if they are freely available [16].

The open source community and design ethos can be a valuable tool to learn how to design and produce products outside of the typical methodologies. Giving users agency and the tools to build on the collective knowledge of the community allows them to develop highly customized solutions to a variety of problems. This methodology could work very well in the Burning Man environment because the

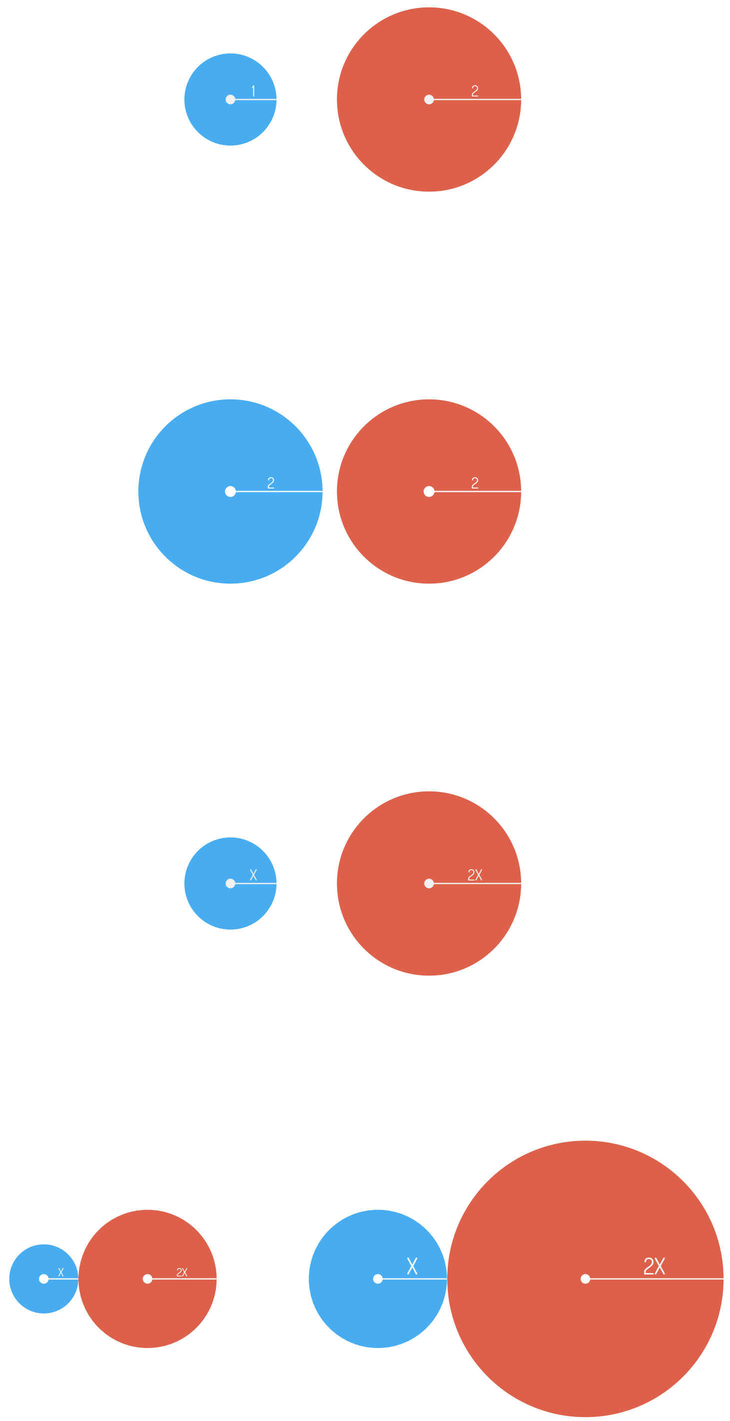


Fig. 30 - Parametric Design Diagram - Pt.1
Fig. 31 - Parametric Design Diagram - Pt.2
Fig. 32 - Parametric Design Diagram - Pt.3
Fig. 33 - Parametric Design Diagram - Pt.4

two communities share many of the same ideals. Radical Inclusion, Gifting, Decommodification, Radical-Self Expression, Communal Effort and Participation are all embedded in the open source model and both communities are applying their unique talents to enrich a larger vision.

{2;2} Parametric Design

Because of the variability in size and program that any widely applicable design for Burning Man would entail, flexibility and scalability are musts. The best way to achieve that flexibility and scalability is with parametric modeling. Parametric modeling is a system of computer modeling in which geometry is generated mathematically from variable inputs. What this means is that a designer can establish a set of relationships which can be manipulated by changing the values of the inputs or parameters. These dynamic and variable ways of generating forms allow designers to manage much higher levels of complexity than traditional design representation techniques.

The explosion in the use of parametric modeling in the design world is due in large part to the free plugin for Rhino 3d, Grasshopper. Grasshopper is a visual programing interface which allows its users to create mathematically defined geometry with limited programing ability. Grasshopper is supported by an entire ecosystem of user-created plugins. These plugins further manipulate data generated by Grasshopper to achieve more sophisticated geometric definitions, often without the requirement of understanding the math behind those definitions [17].

As Grasshopper is a simple programing framework, its users can develop highly specialized modules to perform specific functions, and because they all are made for the same environment they can all interact with each other, eliminating the need to convert data manually between operations. This approach to software design is a radical departure from traditional design software development, in which a centralized group of experts create software which handles all aspects of the digital design environment in a very controlled manner [17].

The way that parametric modeling works differs greatly from traditional CAD programs. Traditional CAD programs are essentially an extension of pen and paper drafting; the designer is drawing lines on a screen creating a 2D representation of a building. It is a relatively 'dumb' system, and does not adapt well to radical changes. With parametric modeling designs become much more flexible and adaptable since the designer is not creating an object but a series of relationships which ultimately define an object. To better visualize this, imagine that there are two circles defined by radius = 1 and 2 respectively. If circle 1 is scaled to radius = 2, it has no impact on circle 2 as it is defined by its size, not its relation to circle 1. However, if the circles are defined by radius = X and 2X, changing the radius of circle 1 will change circle 2 because they are defined as a relationship between the two parts. As the model is defined by relationships any changes to the inputs will propagate downstream, throughout the model, making it very accepting of changes even very late in the design process [18].

The fundamentally fluid and variable nature of parametric modeling make it ideal for generating many iterations of a particular design. By increasing the number of iterations to be performed and examined, a greater proportion of a solution space can be explored potentially informing better design.

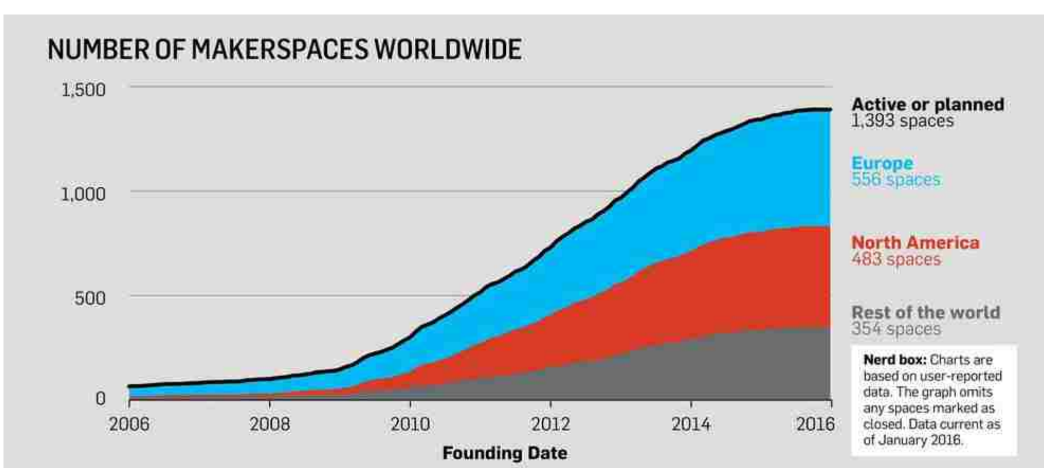


Fig. 34 - Parts for Art Installation Being Milled on a CNC Router
Fig. 35 - CNC Milled Parts Installed on The Playa - Lithic Altars Art Installation
Fig. 36 & 37 - Other CNC Milled parts
Fig. 38 - Number of Maker Spaces World Wide

{2;3} Digital Fabrication

Open source software can offer us a model for how to design, and parametric modeling can help us make flexible and programmable geometries but how can we bring these designs into the physical world? Digital fabrication is the missing factor in this equation. Computer numerically controlled (CNC) tools like CNC routers, laser cutters, 3d printers and water jet cutters use a programing language known as G-code to translate digital linework and models into physical objects. G-code translates the lines in a cad drawing to a series of x y and z coordinates that the tool follows resulting in a custom part. Traditionally additional complexity of parts would result in higher prices but because these tools don't distinguish between straight simple parts and curvy complex parts, complex or unique parts can be made at a cost similar to simple and repetitive ones. Because of this indifference to form digital fabrication is a natural pairing with parametric modeling which is also very adept at handling complexity.

CNC technology has also greatly benefited from the open source movement. Developments by the open source community in both software and hardware around digital fabrication have made these tools much cheaper to build and own, causing rapid expansion in the availability of these tools. Simple 3-axis CNC Routers are common at maker spaces which have also exploded in popularity in recent years. As of 2016 there are around 1400 makerspaces around the globe, 14 times the number 10 years earlier [19]. These makerspaces can act as a decentralized fabrication network to help bring these structures into the physical world. Instead of fabricating them in a centralized factory and shipping them around the planet at a high cost, we can distribute the digital tools at near zero marginal cost through the internet, they can be configured by the end user, and cut files can be generated and then cut at a local maker space using locally available materials. These tools require little user skill to operate and the digital tools that generate the cut files can be embedded with the design knowledge needed to optimize the parts for manufacture with the CNC. This greatly reduces cost as the only thing that needs to be physically shipped is the raw materials (e.g. plywood or other sheet goods) which already have well developed supply chains and efficiency through economies of scale.

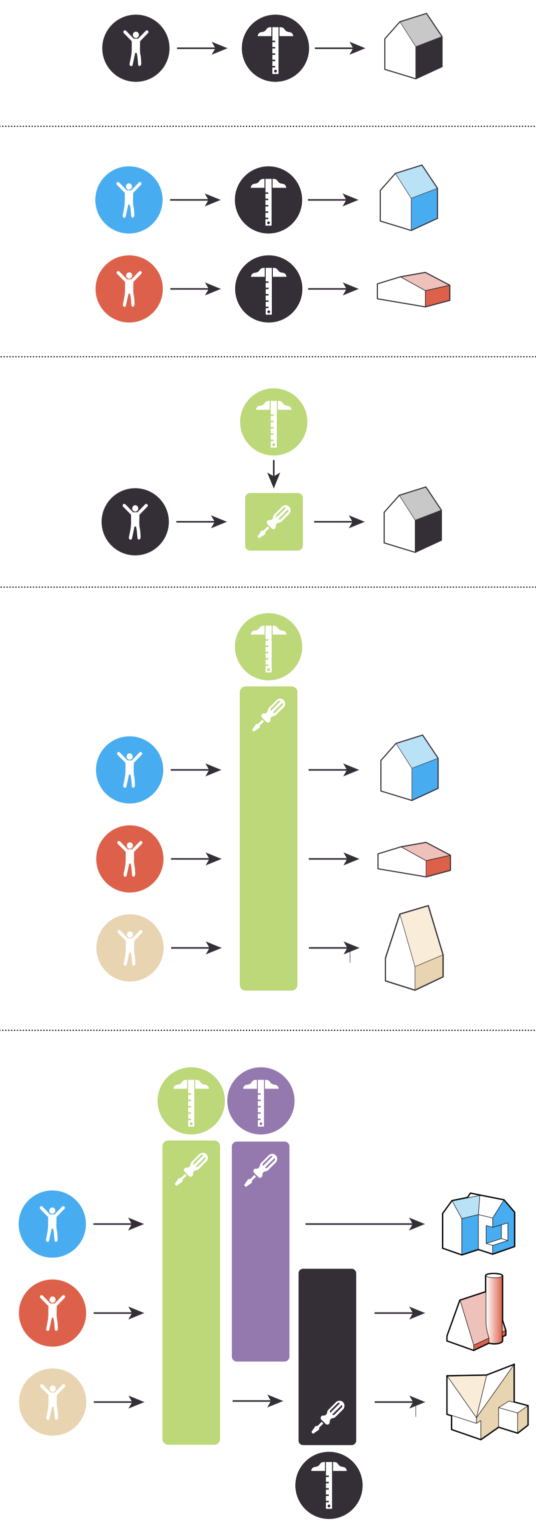


Fig. 39 - The Design Process Diagram - Pt.1
Fig. 40 - The Design Process Diagram - Pt.2
Fig. 41 - The Design Process Diagram - Pt.3
Fig. 42 - The Design Process Diagram - Pt.4
Fig. 43 - The Design Process Diagram - Pt.5

{3} The Project

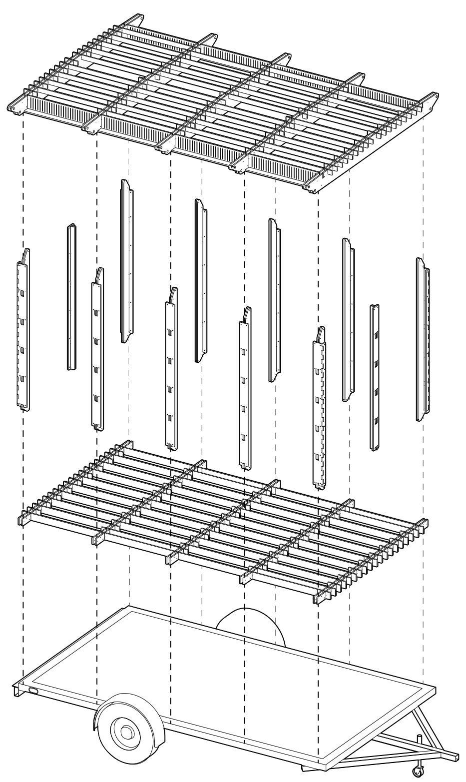
{3;0} Agency and the Design Process

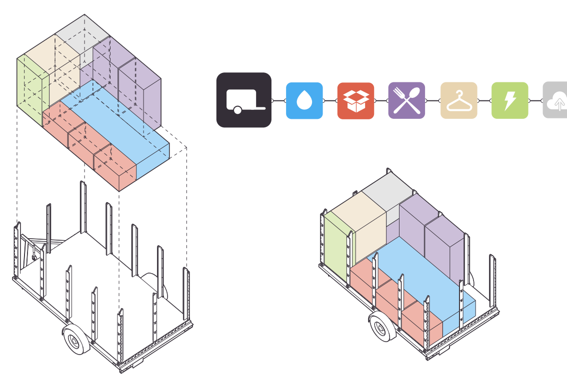
Approaching the design for this project I knew that a top down approach like the typical architectural design process has some inherent incompatibilities with the 10 principles of Burning Man and is bound to offer results with limited applicability. However, by applying an open source software design model to the architectural design process. I could design in a way which more closely follows the ideals of the event.

In the typical architectural design process (fig. 39), a client has an idea or vision that they cannot accomplish on their own, so they contact a designer. That designer then takes the vision of the client and translates the client's thoughts and desires into a product or solution through the lens of the designer's design knowledge. This scenario works and can be very good at producing singular solutions for individual scenarios. However, this method has issues with scalability. Each time a new client wants to make something the designer is heavily involved in that process and therefore the number of things they can help make is limited by the available time of the designer (fig. 40).

The new design process that I am developing represents a radical shift in the relationship between designer, the client and the final product. In this process the designer is embedding their design knowledge into a digital tool to be used by an empowered user. The empowered user is then able to use that tool, embedded with the design knowledge of its maker, to make something on their own (fig. 41). In the end, the user can realize their creative vision thanks to the application of the designer's design knowledge as in the traditional model, but because it's a digital tool it can be widely distributed at near zero marginal cost through the internet and because the designer's direct involvement is not required for each use it has a very strong vector of propagation. This means it can reach larger numbers of people than the typical design Process (fig. 42). By keeping these tools open other designers can start to produce parallel tools to meet other needs by other means, and by layering these tools on top of each other greater degrees of variety can be achieved, widening the available solution space of the system and giving the user a larger repertoire tools to meet their individual desires (fig. 43).

What makes this shift in design thinking so radical is that it gives up some agency over the outcome away the users themselves. This model of design gives up that control in exchange for a more open process and, through increased communal participation, a more robust way to help the maximum number of people possible find highly customized solutions to their problems. By making these tools widely available and easily manipulatable, their utility can be stretched in ways that a designer did not intend or imagine as they are adopted and spun off to better serve other niche applications. With each new iteration the pool of possible solutions grows larger and more varied, thus progressing this cycle of creative expression and widening the potential use cases. So, while the traditional design process struggles to scale, the tool based open source model of design becomes more robust as it grows.





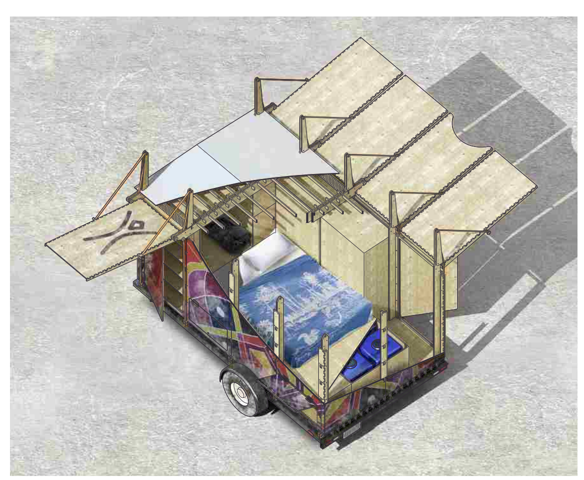


Fig. 44 - Rendering Showing 3 Different Configurations Derived From the Same Parametric Definition
Fig. 45 - Exploded Axon of Structural Members
Fig. 46 - Programatic Plugin Diagram
Fig. 47 - Cut-Away Axon Rendering Showing One Possible Configuration

{3;1} Structural Framework

The system that I developed relies primarily on the generation of a structural framework forming a series of bays (fig. 45). These bays can then be populated by various programmatic elements which can be built out between the structural members (fig. 46). This methodology leaves the program of the trailer open for customization, much like the structure of Burning Man itself. Burning Man from the perspective of the organization is just the structural framework of the city and a few orienting principles but it becomes the rich whole that it is when empowered users come along and begin to plug their creative expressions into the framework of the city. The proposed system works the same way, it's a framework that on its own is not a complete entity but becomes whole when populated by programmatic plug-ins (fig. 51).

The regularized bay system was chosen for several reasons; firstly, it regularizes available space into more predictable chunks, secondly it reduces the unique part count of the system, and finally, it can be generated independently of the program of trailer. The bays are an even division of the length of the trailer and the number of bays is determined by a target bay width parameter that the system tries to get as close to as possible. Bay sizes from one configuration may not match the bays of another configuration, meaning that this is not a fully modular system. However, because of the nature of having a target bay width, its safe to assume that the size of that bay will fall within a relatively narrow range. The system could be described as "para-modular"; it has the configurability of a modular system but with increased flexibility from its parametric design. This para-modular system allows developers of programmatic plugins a degree of regularity to design for, increasing the likelihood of compatibility between programmatic elements. A default bay target has been set in the code but because it's an adjustable parameter built into the structure generator, an intrepid user could change that variable for what ever reason they see fit and the changes would propagate down stream through the work flow.

The decision to keep the bays all the same size within the unit greatly simplifies the system by reducing unique part count. While these parametric systems are very adept at handling the kind of variability that comes with non-uniform bay spacings, ultimately, they need to be assembled by people. By reducing the number of unique parts, we can limit the possibility for human error during assembly. Ease of construction is crucial considering that this project is aiming at helping people who may be under qualified in terms of design and construction ability to tackle a project of this scope on their own.

Defining the programmable space with an independent structural system instead of the inverse was also a conscious part of the design. Doing so simplifies the process from multiple angles. Firstly, it requires much less coding and analysis, making for more elegant code and requiring fewer computational resources. And secondly, it ensures the structure is sufficiently robust without needing to know what program elements are going to be included. Considering that these are meant to be towed to their sites, the structural system needs to be able to withstand the rigorous abuse sustained on the road.

{3;2} Programmatic Plugins

With a structural system established and our spatial modules laid out we can start to assign program and develop the design our trailer. In the work flow being proposed, populating the trailer means

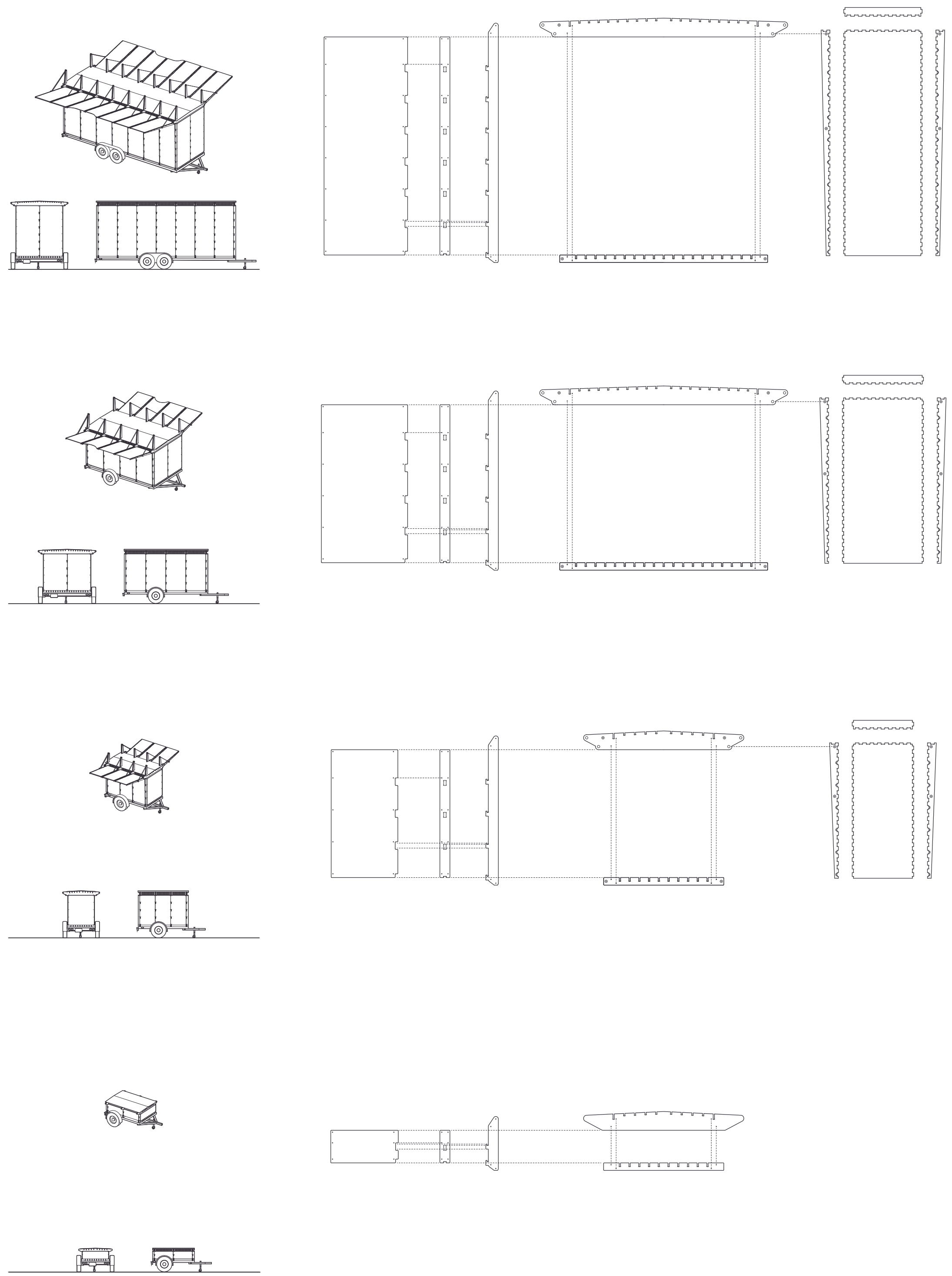


Fig. 48 - Axon and Elevations of 4 Configurations with Coresponding Parts Showing Parametric Scaling

bringing in plugins / clusters of code which populate the trailer with various uses. As a result of how grasshopper (the environment that these digital tools were constructed within) works, data flows downstream in only one direction. Starting with the structural system, data flows into a plugin from the previous one. The incoming data informs the processes within, and then the new data created by the plugin is injected into the upstream data set and the combined data flows downstream to the next plugin, increasing in complexity as more plugins are added. With each plugin placed, the available space in the trailer decreases, meaning that order of operations becomes important for plugins where placement is crucial. A plugin that arranges and places water tanks for example is very location sensitive; depending on the size of the camp It's not unusual to need to carry hundreds of gallons of water weighing thousands of pounds out to the playa, and to haul it safely that weight should sit centered over the middle of the axle. For that reason, the water module should be one of the first plugins in the stream. On the other hand, a simple storage cabinet has significantly fewer placement considerations and therefore, could be placed at almost any point in the data stream.

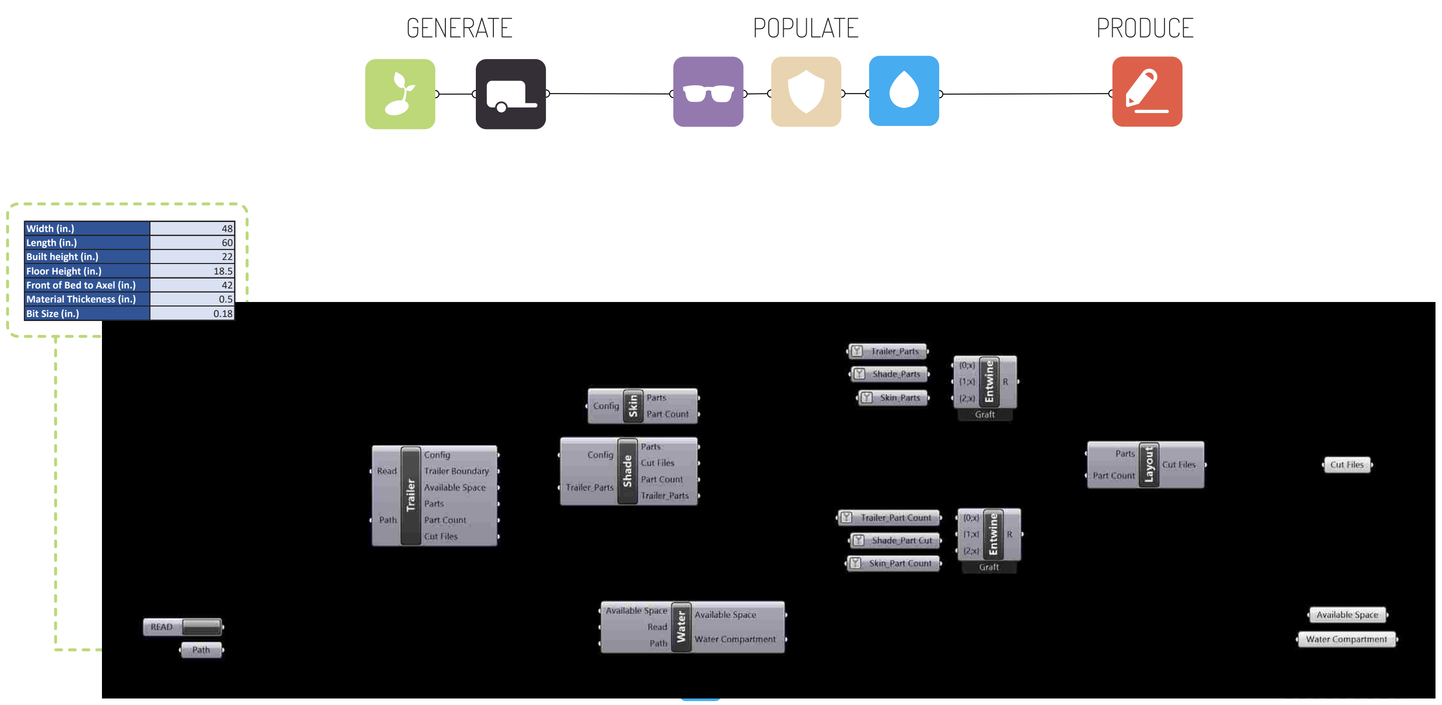
I began to develop a small set of plugins myself (fig. 49), but because it is this area of the design which is most accessible for community development, the pool of programmatic plugins is expected to grow over time. I started with plugins which would address some of the most basic needs one would encounter on the playa to have the widest appeal, these were water shade and shelter (skin) and storage. As more of the low hanging plugins are developed and added to the overall plugin ecosystem they become material that the community can build on and hone for increasingly niche uses.

{3;3} Embedding Design Knowledge in Code

Let's examine how this code actually works. It all takes place in the grasshopper environment, which, as explained earlier, is a visual coding environment that runs on top of Rhinoceros 3D to create parametrically defined objects. Inside the grasshopper environment we can see how data flows downstream from one module to the next by connecting them with "wires". Because data flows in one direction the inputs of a module are always on the left and the outputs are always on the right.

What we see in figure 49 is the definition of one of these trailers at its simplest. Within each of these programmatic plugins is a larger parametric definition which defines all the rules related to how the parts interact with each other. Because each plugin in boiled down to several inputs and several outputs it's easy for a user to mix and match programmatic elements in a modular fashion to configure their structure and if all the modules are drawing from the same original inputs, we can be assured that the parts will all interact as intended. Looking deeper at the code within the "Trailer" module (fig. 50) we can see that the definition looks quite complex but has a relatively simple structure. It begins by collecting the data it needs from upstream / the seed file, then it uses that information to size and shape each of the parts, and then it takes each of those parts and adds joinery to the base shape. Finally, the parts are placed into an organized file structure and a part count for each part is calculated, these figures then become the output for that module.

The nature of this system allows for several layers of involvement by the user depending on their skill level. The most basic level is using a preconfigured set of plugins drawing from an original set of seed information which can be set via a simple spread sheet by the user. The preconfigured grasshopper file then



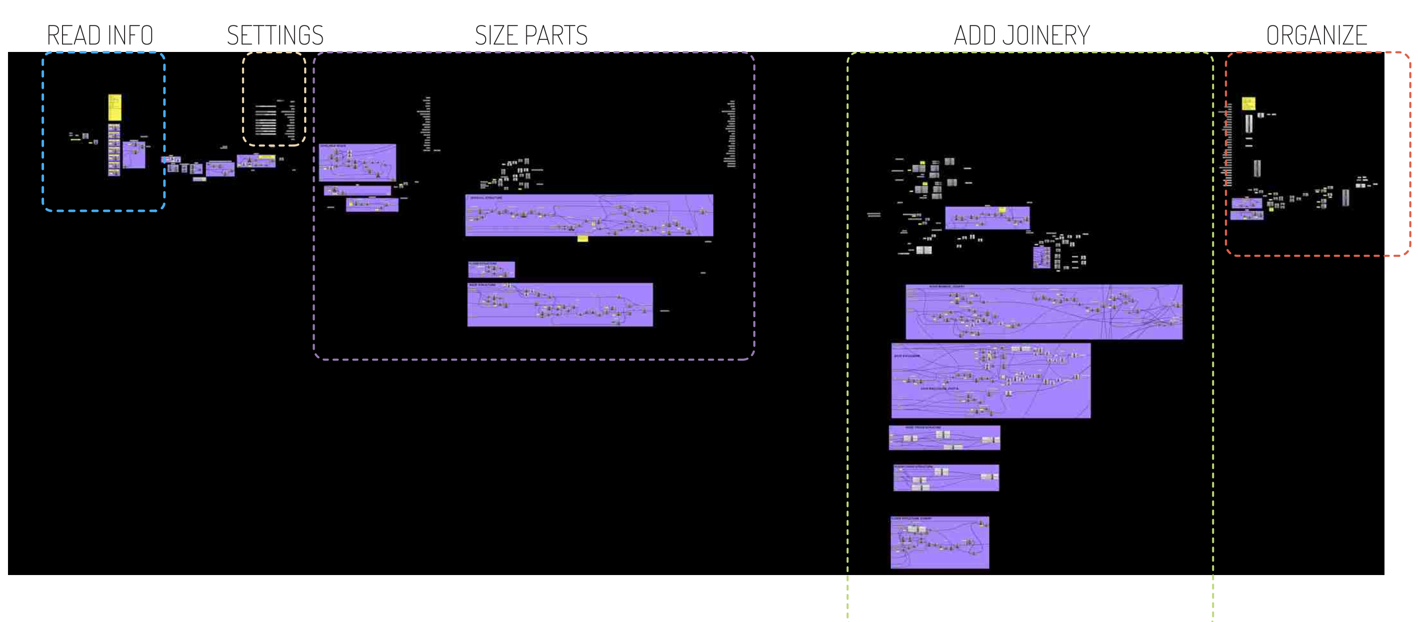
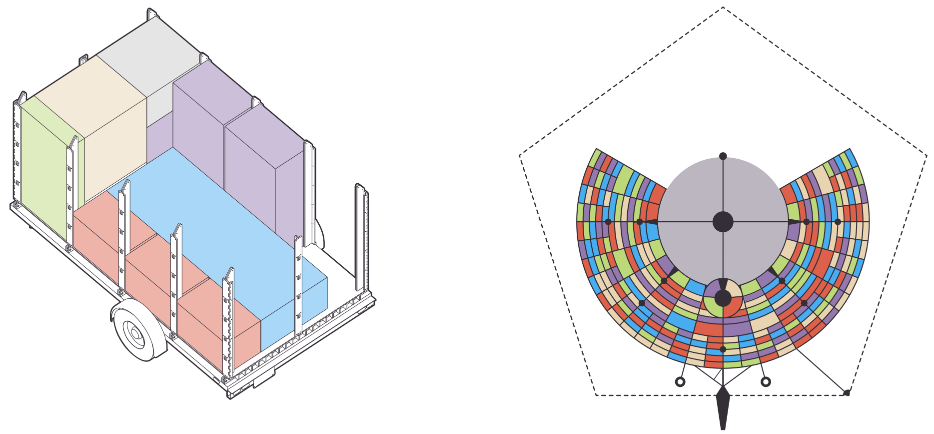
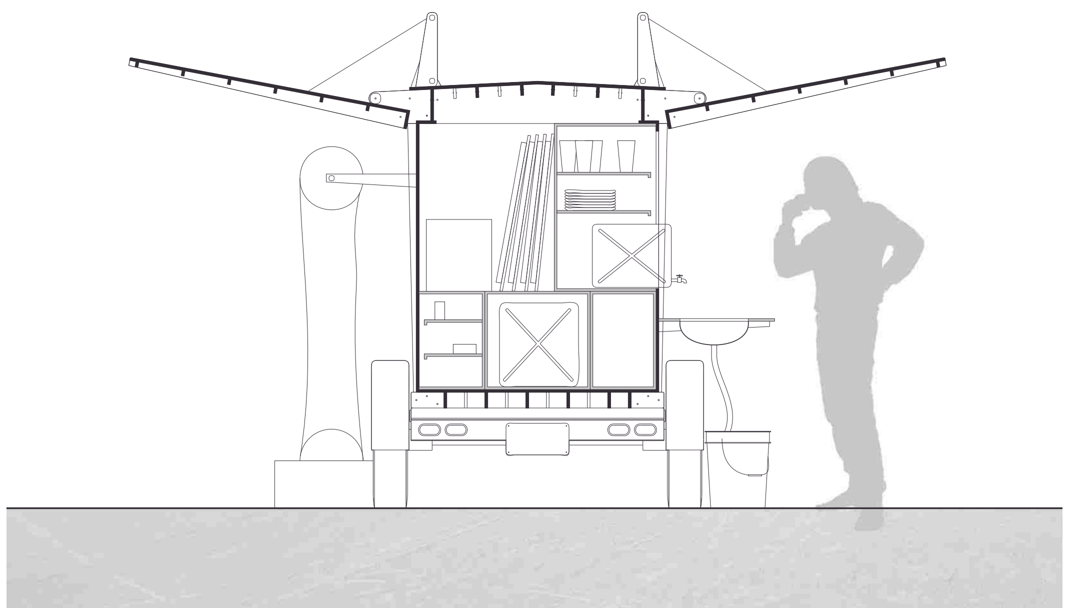


Fig. 49 - Example Trailer Definition Using Programatic Plugins in Grasshopper w/ Diagramatic Overlay
Fig. 50 - Grasshopper Definition of "Trailer" Module w/ Diagramatic Overlay

reads the seed info and outputs a complete set of cut files ready to be cut on a CNC router. This requires no grasshopper work from the user. The next level of involvement is arranging a custom set of programmatic plugins within Grasshopper to generate a custom layout. This allows for greater customization but requires a basic working knowledge of Grasshopper. More advanced users can start to get into each plugin and configure the default parameters within each definition. Changing those parameters doesn't change the structure of the definition itself, but allows for much more granular customization with very little additional Grasshopper knowledge required. Finally, super-advanced users can edit and manipulate the definitions themselves or even develop their own custom plugins from scratch.





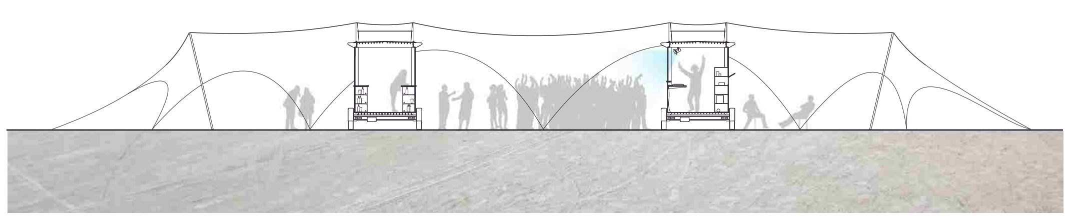


Fig. 51 - Comparison Between Plugin Design Approach and Burning Man
Fig. 52 - Section of a Smaller Trailer Configuration
Fig. 53 - Section of Two Larger Configurations w/ Tensile Shade Structure

{4} Conclusion

Burning Man is a very unique use case for designing flexible and deployable structures through methods outside of the standard design processes. By experimenting with new design ideologies, ideas about agency in design, new methods of delivering designs, and new technologies which change how geometries are drawn and manufactured we can redefine what a designed product is. Utilizing the methodology put forth by this project we can extend the utility of these tools out beyond just Burning Man to cheaply and efficiently deliver highly customizable shelter specially tailored for any environment or culture around the globe.

Extending this method might require a multitude of design solutions to satisfy the different conditions of climate, use and need around the globe, from temporary to semi-permanent, and from weekend accessory to emergency dwelling for populations displaced by natural disasters, or disasters inflicted by man. The overall conception of the multitude solutions might suggest opportunities for formal teams of experts who can guide and oversee the growing design ecology, while recognizing and taking full advantage of the expertise and experience of those contributing through a more dispersed system. While it is useful, productive and exciting to consider a decentralized design process, there may continue to be a need for recognizable expertise.

{4;0} Next steps

The obvious next step is release my code to the wider Burner community in the hopes that a development community will form around it. Short term development goals could include expanding the suite of programmatic plugins to increase the utility of the system. These plugins could be for kitchens, storage, solar arrays, work stations, bars, stages, gray water evaporators, dish washing stations, or any number of programmatic uses. Longer term development goals could include making the plugins smarter by having them report information back to the user to see how well they are meeting their design goals, incorporating genetic algorithms to optimize material usage, incorporating finite element analysis to analyze and optimize structural performance, or analyze weight distribution for increasing tow-ability. Ultimately this is a very rudimentary demonstration of potentiality of this methodology, and with further development could become a very robust design ecosystem with potential to be proliferated around the world for a multitude of uses.

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Fig. 8 – Photo c/o Lithic Altars Art Support Camp
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