

Network Dynamics and Fluctuating Architectural Typology: Flux

by

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Ryan Donald Schumacher

April 2009

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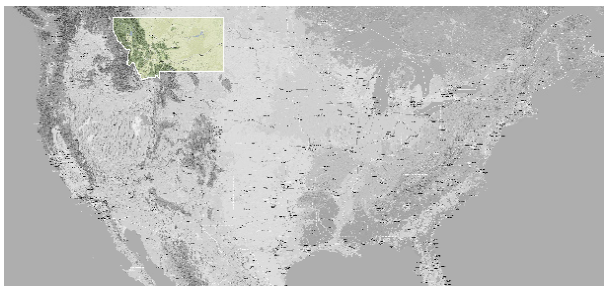
ABSTRACT

Located in the northern United States, along the Rocky Mountains, lies the state of Montana. Traditionally rural, Montana is experiencing significant growth in its urban and destination areas. With growth comes obstacles and opportunities. The majority of the state is sufficiently connected to the global transportation network for the movement of goods, but lacks diverse people moving systems. While goods have the benefit of being transported at high speeds via road, rail, and air, the majority of people do not. Roadways near urban areas are frequent victims of congestion, the vitality of many airports is in question, and rail is minimized to a northern Amtrak route that neglects most population centers. The lack of passenger transit systems effectively cuts travel possibilities in half for hundreds of thousands people. Montanans deserve an option for the future that streamlines their transportation infrastructure, integrates them with the rest of the world, and provides an example of positive development.

The intent of this thesis is to analyze the current network of people moving systems in Montana in order to determine how a better understanding of network dynamics and transportation architecture can help create connections to the global transportation network and foster positive growth. Information will be presented in graphic and literary form starting with the economic and transportation infrastructure in the region. Precedents are used to gain insight on existing and proposed architectural solutions to facilitate a proposal for an integrated transportation network in Montana, using architecture that utilizes continuous change, passage, and movement as active support.

HISTORICAL CONTEXT

In 1889, the state of Montana was officially created from the Montana territory. It became the 41st state of the United States of America. Five years later Helena was named the capitol. Montana's name is derived from Latin roots meaning "mountainous region". Although this describes the western half of the state well, it poorly defines the eastern portion. Western Montana is comprised of over 50 mountain chains, while eastern Montana is made of rolling hills and sprawling plains.²



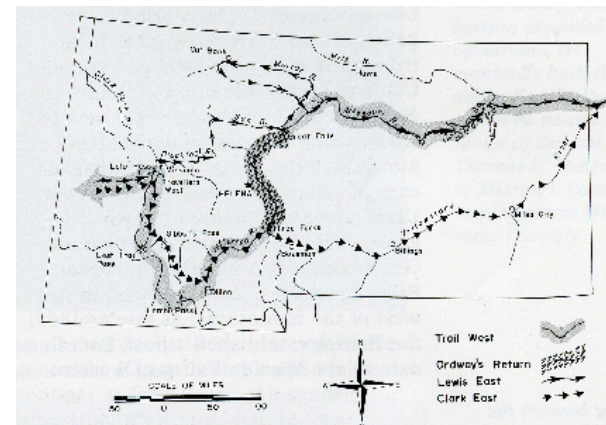
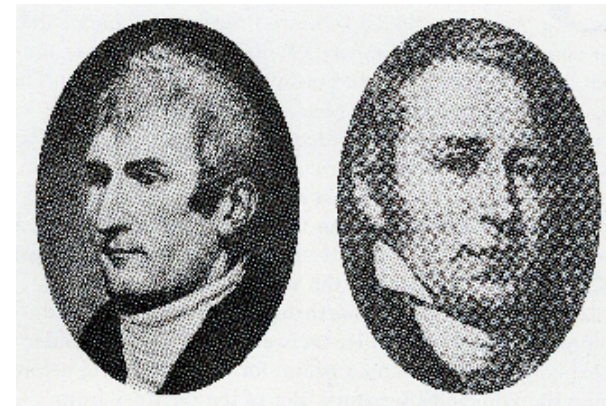
ECONOMY

Montana's first human inhabitation began when Native Americans entered the territory 13,000 years ago.³ Because of the regions dry climate, short growing season, and abundance of big game, Native Americans developed an economy base on hunting and gathering. Evidence of campsites shows that despite a semi-nomadic lifestyle, they were well fed and lived comfortably. It wasn't until the decline of big game numbers due to over hunting, and their encounter with Europeans, that their economy began to weaken.⁴

On April 25th, 1805, under orders from United States president Thomas Jefferson the U.S. Corps of Discovery crossed the 104th degree of longitude entering modern day Montana. The expedition, led by Captains Meriwether Lewis and William Clark, was to travel up the Missouri river to investigate the newly purchased Louisiana Territory in order to find a water route to the Pacific Ocean. Lewis & Clark spent much of their time in Montana mapping and documenting. Their travels took them all over the state, including the modern day urban centers of Great Falls, Helena, Billings, Bozeman, and Missoula. Travelers Rest near Lolo, Montana marks the spot where the explorers split up into two groups

on their way back from the Pacific Ocean. Clark went south to explore the Yellowstone river, while Lewis headed north up the Blackfoot river. The expedition was very important for the United States of America, but equally significant for Montana. It made dozens of new scientific discoveries, named the rivers of modern day Montana, mapped the state, and was a catalyst for a new economy in the region. Two years after Lewis and Clark stepped foot in the territory, Montana's first corporate enterprise was established, leading to the regions second economic phase; fur trapping and trading.⁵

Trappers quickly came to Montana after news of the abundance of game. Otter became a prime target because of their widely appreciated pelts. Individuals known as mountain men worked in tandem with companies trapping otters and selling their fur. Most of the time, the two parties would gather once a year to trade for supplies.⁶ The business was lucrative at first, but after over-trapping much of the land, it gave way to Montana's third economy; resource extraction.



HISTORICAL CONTEXT

Separate geographies have developed different economies in Montana. Mining, agriculture, and timber have historically been the principal industrial businesses. For most of the 20th century, the Anaconda Copper Mining Company developed all three. Owner Marcus Daly's interests were heavily invested in mines. "In two years he built the most elaborate copper mining and smelting facilities in America...by 1887 the Anaconda Copper Mining Company was the largest producer in the world."⁷ This drew in a large workforce. Wood was needed for mines, and food was needed for workers, so large timber and agriculture operations were established throughout the state.



In the early 21st century, Montana is beginning an economic shift. Industrial businesses (mining, timber, agriculture,) are declining, and technologically based ones (telecommunications, e-commerce, streaming solutions, fiber optics) are beginning to take hold. One reason for the industrial decline is Montana's isolation; competitors have an advantage because of their closer proximity to buyers. Another reason is Montana's climate; the short growing season makes it difficult to harvest large crop yields. Montana has yet to develop a sound technological based economy. An example of current failure is Montana Power's transformation from an energy supplier (industrial) to Touch America, a telecommunications company (technological). In lieu of this, places like Hamilton, and Kalispell are becoming centers for successful technologically based companies. Rocky Mountain Laboratories in Hamilton is a state of the art biomedical research facility. Semitool in Kalispell, designs, manufactures, and supports equipment used in the fabrication of semiconductor devices.⁸ In addition to the emerging technological economy, retail trade, healthcare, and tourism are already abundant and growing. Montana contains two national parks, many world class ski resorts, and a wealth of outdoor recreation areas. In 2006, 10.68 million visitors came to Montana, spending

3.08 billion dollars.⁹



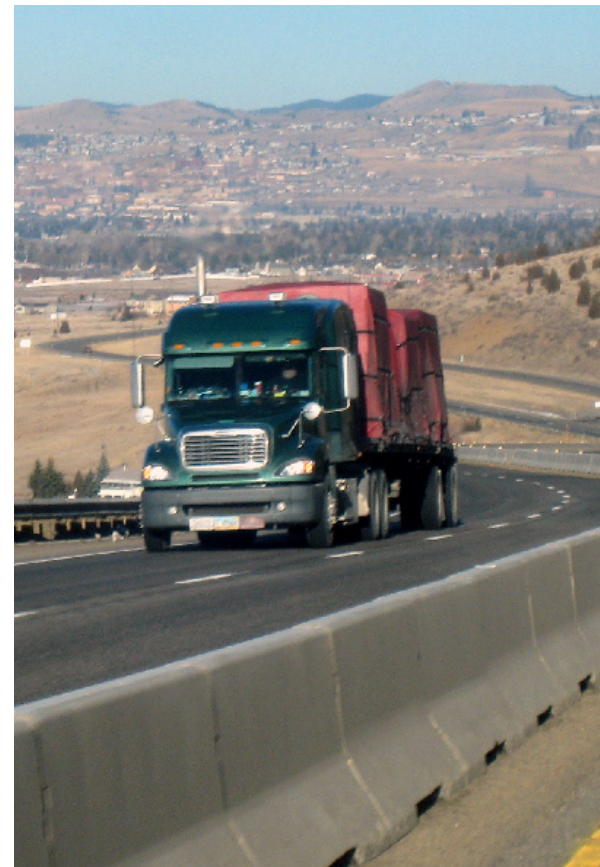
HISTORICAL CONTEXT

TRANSPORTATION INFRASTRUCTURE

The development of Montana's transportation infrastructure began with the industrial revolution. In 1859, ships traveling up the Missouri to Fort Benton brought people and supplies to the region while creating an opportunity for efficient export. Shortly after the steam engine's arrival, appropriation was secured for the first wagon route across the Rocky Mountains. Lieutenant John Mullan was given the job of building the road through Montana in order to link Fort Benton to Fort Walla Walla, connecting "the Columbia watershed to the head of navigation on the Missouri".¹⁰ It was constructed in the state from the late 1850's to 1861, and portions have turned into Interstate 90. During World War I three major railroad lines were run East-West through Montana. The Northern Pacific was built in the south, the Milwaukee Road was built through the middle, and the Great Northern was built in the north. Railroads sought settlers and sold land in order to pay for construction. Starting in the 1920's, highways, roads, and air transportation were introduced. Although they were used to patch up breaks in Montana's transportation network, the state remained relatively landlocked from major markets. In the 1950's the Eisenhower administration supported the Federal Interstate Highway Act. This radical program

changed the way most Americans lived and worked. It provided new opportunity for jobs, housing, and business, while establishing vital connections for national defense. "It was simply the largest public-works project in the history of the world."¹¹

Montana has more than 1,000 miles of interstate highway, spanning East-West through Urban areas such as Billings, Bozeman, and Missoula, and North-South through urban areas such as, Helena, and Great falls. Currently the road system is the most highly developed transportation system in the state. Traffic on roads is greatest near major urban corridors (Billings, Bozeman, and Missoula), and dominated by privately owned cars. These areas often experience congestion because of a lack of alternative transport. Commercial air travel in Montana runs through fifteen Federal Aviation Administration certified airports, boarding about 1.5 million people per year. Of those fifteen airports, six (Billings, Bozeman, Missoula, Kalispell, Great Falls, and Helena) reported annual boarding's over 50,000 for 2007, giving them a 96.8% share of the air transportation market. Eight airports reported annual passenger boarding's of 3,800 and lower.¹² Although 69% of all cargo tonnage is moved by way of train, opposed to only 29% by way of truck, passenger rail in Montana is minimal.¹³ The current Amtrak route runs along the northern part of the state, neglecting all major urban areas.



PROJECT: **PUBLIC TRANSPORT**
CITY: **JOHANNESBURG**
COUNTRY: **SOUTH AFRICA**

During most of the twentieth century, South Africa was ruled by the white minority through a system known as apartheid. Apartheid created a distinct separateness between races in the country, and was used to reinforce the superiority of the ruling whites over the native Africans. This separateness affected everything from lifestyles to city layouts. Outlying suburbs, populated mostly by the repressed majority were purposely left unconnected to the core by public transportation, leading to sprawling single story edge cities. In recent years Johannesburg has been attempting to reinvent itself through a collective self identity. This shared self image has created opportunities to reorganize public transport. Daily thousands of people travel to downtown Johannesburg from the suburbs by way of taxi. In response, the Johannesburg development agency has created a new multimodal public transportation system that links outlying neighborhoods to the centralized downtown by way of bus, train, and taxi. Stations at both ends of the new commute are used to remember history and create opportunities for economic development. Every new station creates

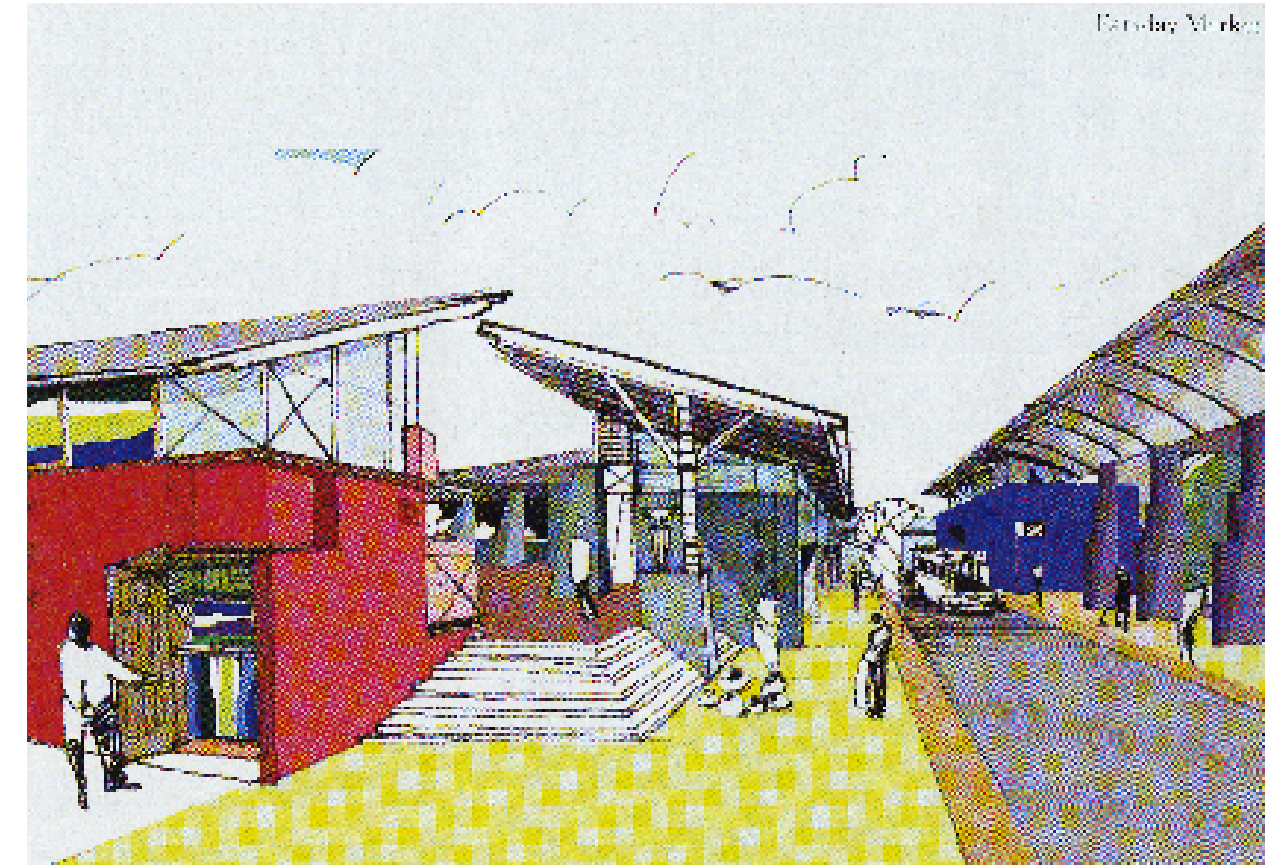
a shared space that is used daily. One station, the Faraday Market & transportation interchange by Mzumara & MMA “belongs to a new generation of mixed-use infrastructure projects in Johannesburg. The complex connects private taxi services and an existing transit system. It also provides improved facilities for the local trade in traditional medicine, incorporating a healers’ herb market. The project, say the architects, “elevates a previously informal market to a position in the city where surviving traditions may be celebrated through the application of handcrafted elements such as woven wire sunscreens, among others.”¹⁴ The forms of the new transportation hubs are simple and cheap. “South Africa is developing a modern vernacular of concrete frames and brick infill panels, of thin shed structures and open spaces, and of compound forms that look back to the historical roots of both African and European structures, including farm sheds and village groupings.”¹⁵

SIGNIFICANCE:

Transportation hubs create opportunities for multi-cultural centers that can be used to remember history, and encourage economic development.

Modern architectural design can be unique while

still paying homage to historical roots.



PROJECT: **PUBLIC TRANSPORT**
 CITY: **CORITIBA**
 COUNTRY: **BRAZIL**
 ARCHITECT: **JAIME LERNER**

In the mid 1960s the city of Curitiba, Brazil began the design of its master plan. At that time, Curitiba's population was about 500,000, up from 140,00 in 1943.¹⁶ To accommodate this fast growth rate, Curitiba needed a transportation system with the performance of a subway. The city did not have the financial resources to implement such a system, so a less expensive option had to be developed. Curitiba's response was to use double articulated buses that could load and unload at plexiglass bus tubes. "The tube...gives the buses of Curitiba the same performance as a subway..." They allow payment before riding, and boarding at the same level as the bus.¹⁷ With this system in place "... you can transport 300 passengers every minute very easily, which is 18,000 passengers per hour in one direction. In thirty seconds, this is 36,000 people per hour, which is a subway statistic..."¹⁸ The system travels at 90% the rate of cars, only 3mph slower.¹⁹ With leadership from Jaime Lerner (architect and former mayor), Curitiba has become a model of successful public transportation for the

world. "Curitiba has more private cars than any Brazilian city except Brasilia (500,000), yet 75% of commuters take the bus and Curitibaanos spend only 10% of their income on transport."²⁰ Worldwide, 83 cities are mimicking the Curitiba model.²¹

SIGNIFICANCE:

Inexpensive alternatives to traditional transportation systems can be designed to perform at high standards.

Payment before riding, and boarding at the same level increases performance.

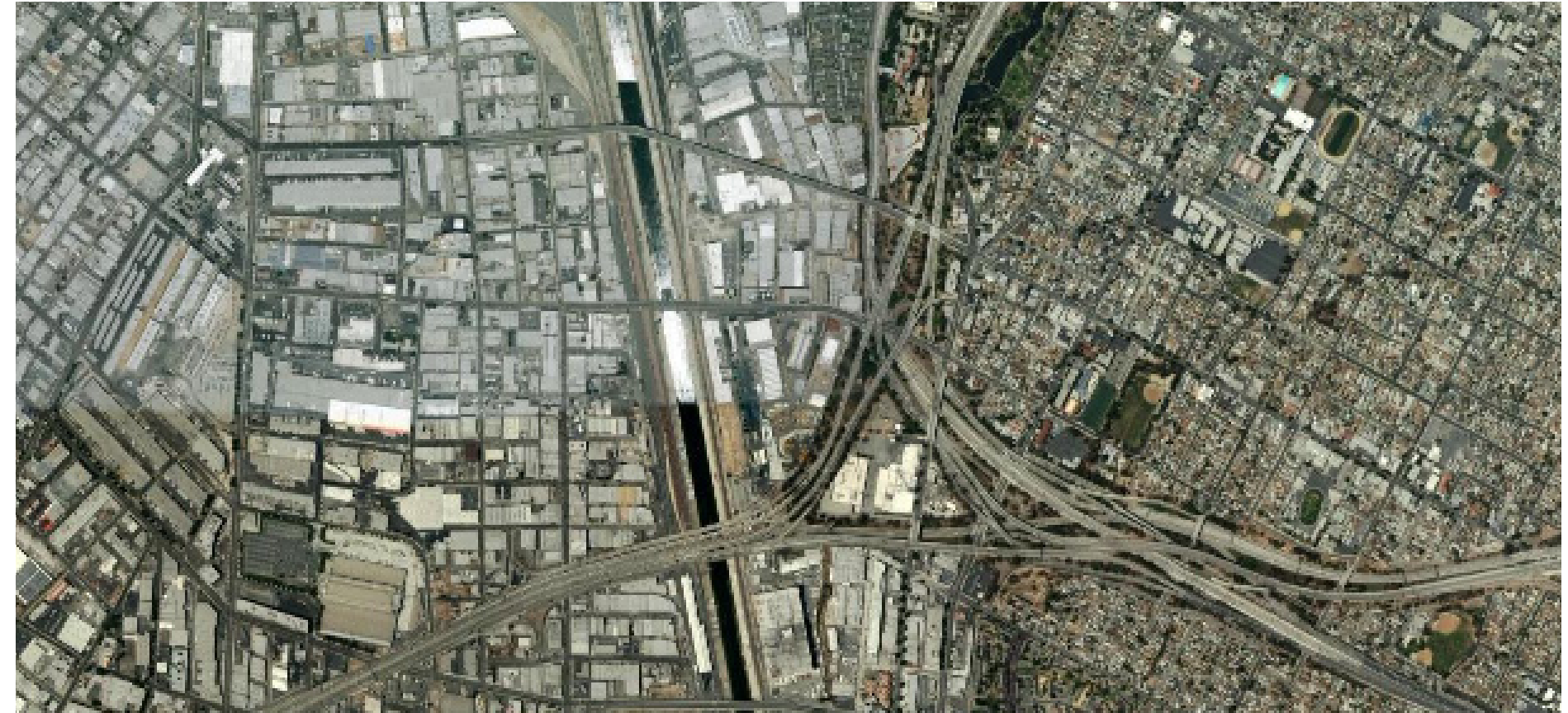
If a good alternative to private car is offered, people will take advantage of it.



PROJECT: **TRANSPORT NETWORK**
CITY: **LOS ANGELES**
COUNTRY: **UNITED STATES OF AMERICA**

“For in L.A. they have built a metropolitan system so physically enormous and so enormously susceptible to sudden ruin that anyone who took a long term view of the cities problems would have to go crazy.”²² Los Angeles never established a dominant center due to growth generated by the incorporation of small spread apart towns. Its development was initially along train line nodes. With the advent of the automobile, trains began to suffer, and were replaced by freeways that still follow the original train routes. Nodes created by train stops have since become consumed by sprawling strip developments. The Los Angeles metropolitan area covers 5 counties housing 16 million people.²³ Each year it becomes increasingly reliant on the road network because sufficient alternative transport is not in place. “On any given day 100 million vehicle miles are driven in Los Angeles County on 915 miles of highways and freeways”.²⁴ The average commuter spends 72 hours per year idling in traffic; giving Los Angeles the worst congestion in the country.²⁵

SIGNIFICANCE:
Relying on a single mode of transportation can cripple a community.



PRECEDENTS

PROJECT: **TRANSBAY TRANSIT CENTER AND TOWER**
CITY: **SAN FRANCISCO**
COUNTRY: **UNITED STATES OF AMERICA**
ARCHITECT: **PELLI ARCHITECTS**

In March 2008, the city of San Francisco chose Pelli Architects as winners of the design competition for the Transbay Transit Center and Tower. This project, located in the center of downtown San Francisco will connect the state of California and the San Francisco bay area. It will centralize the city by harboring 8 different forms of transit under one roof. AC Transit, Caltrain, MUNI, Golden Gate Transit, SamTrans, Greyhound, BART, WestCAT, and future California High-Speed Rail will find a place in the hub. Sustainability was a major driving force in the proposal by Pelli Architects. The roof of the new transit center will be a 5.4 acre park, used to absorb pollution, treat and recycle water, provide a habitat for local wildlife, and support outdoor activities. Light shafts are used to reduce artificial lighting in the interior spaces as well as create natural ventilation. Program within the proposed project includes residential housing, and retail, along with necessities for transit. The form of the project is organic in nature, the structural

components are abstract representations of trees. Major materials include glass, steel, and concrete. In the words of Pelli Architects, "...Transbay Transit Center aspires to become one of San Francisco's great civic places."²⁶

SIGNIFICANCE:

Civic projects can be used as examples of sustainable architecture that combats pollution and energy consumption.

Linking multiple forms of transportation can centralize a city.



PROJECT: **KAMPPI CENTER**
 CITY: **HELSINKI**
 COUNTRY: **FINLAND**
 ARCHITECT: **JUHANI PALLASMAA**

Opened in March of 2006, the Kamppi Center is one of the first mixed use, multimodal transportation hubs in Europe. It houses transit stations, residences, restaurants, offices, and a shopping center. It is one of two commercial centers that the city of Helsinki is developing in anticipation of 40,000 new residents by the year 2020.²⁷ As well as being infill development, “It’s the largest construction project in Finland’s history...”²⁸ Due to tight quarters, designers had to develop new ways of handling traditional modes of transportation. The bus terminal works much like an airport – passengers wait inside behind a glass wall for busses that are assigned gates as they arrive. The terminal is open and light filled, bustling with the movement of business people, kids, recreational shoppers, and tourists. It is the center of activity in the Kamppi neighborhood, and is solidifying the area as a destination place within Helsinki. Its position on its site has created an outdoor space that can be used for everything from street hockey to congregation.

SIGNIFICANCE:
 Mixed use buildings promote diversity.

Architecture that anticipates growth can be highly successful.

Traditional transportation modes do not have to be handled traditionally in order to operate efficiently.



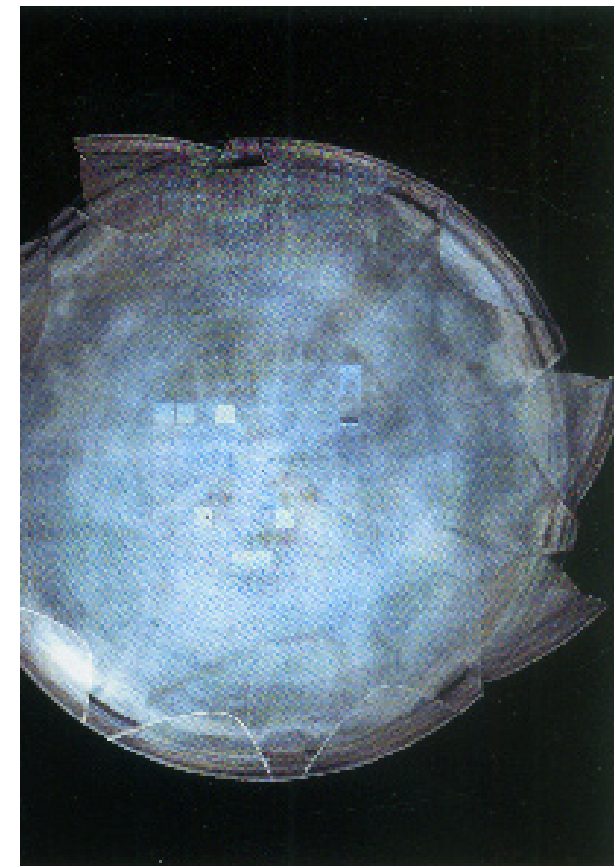
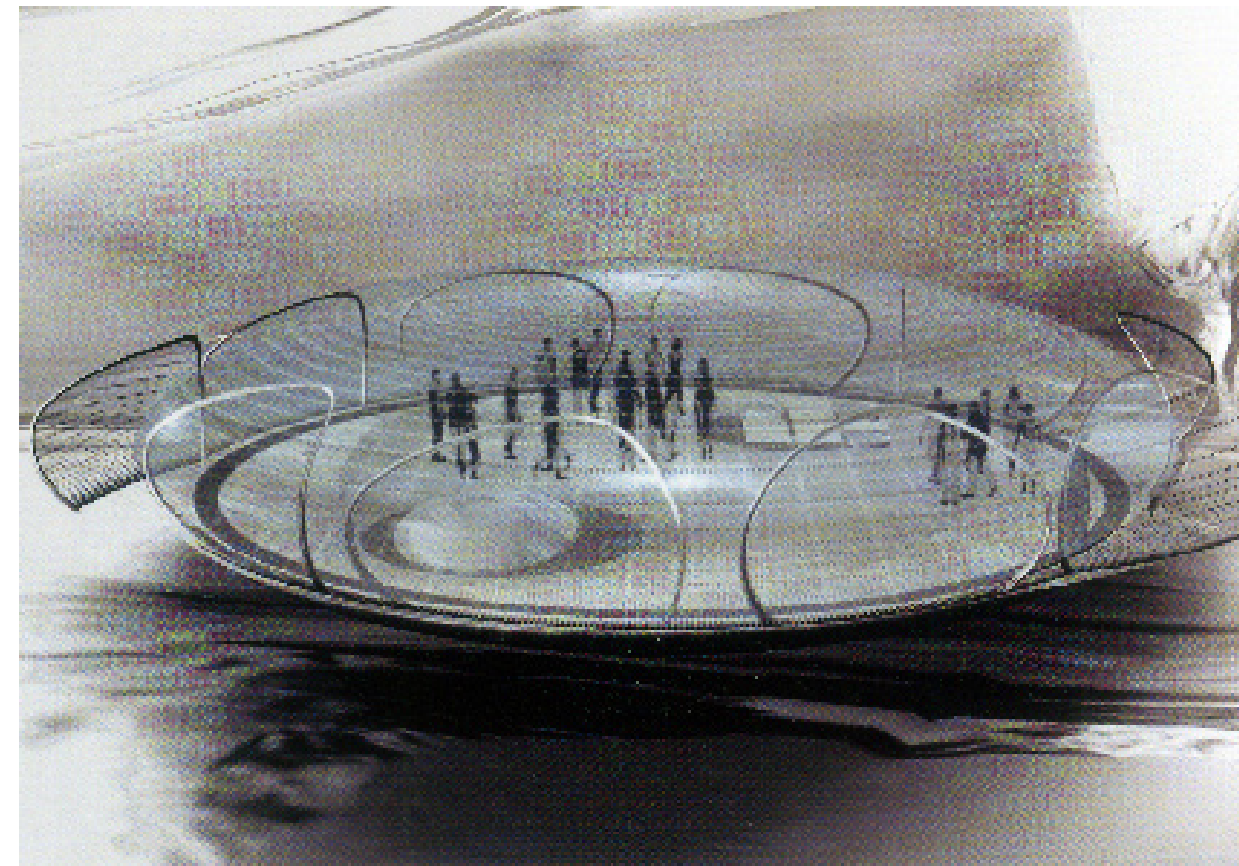
PROJECT: **R129 PROTOTYPE**
 CITY: **STUTTGART**
 COUNTRY: **GERMANY**
 ARCHITECT: **WERNER SOBEK**

"In R129 Sobek explores the idea of living completely off the grid and in harmony with nature."²⁹ The R129 utilizes inventive strategies that are integrated through different steps in design. Currently, Dr. Sobek has completed step one, which is to design a way to use less material for structure without decreasing spans. This is important, because it allows the use of less energy in the creation of the building. The roof is the first application of load bearing glues in a large dimension, allowing it to be the thinnest glass shell ever built. In the shape of a sphere, it is 10mm thick and spans 8 meter 50, making it proportionally a 10th of an eggshell.³⁰ Step two is to design a mono-space, where the entire interior of the building is adaptable to user needs. This is accomplished by making multifunctional furniture that can fold and unfold out of the floor or ceiling when needed. Step three is to make the building independent of exterior public systems by providing the means to supply its own clean air and water, and manage its own waste.

SIGNIFICANCE:

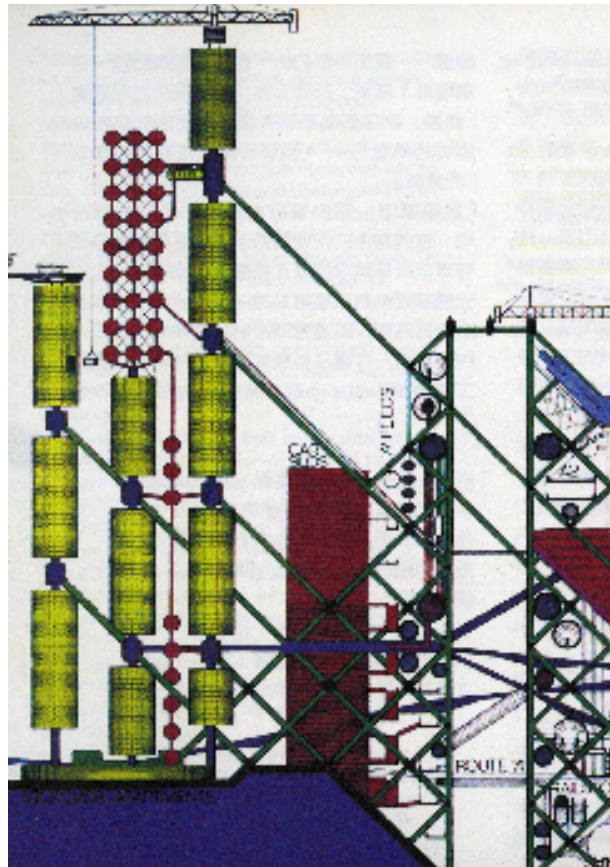
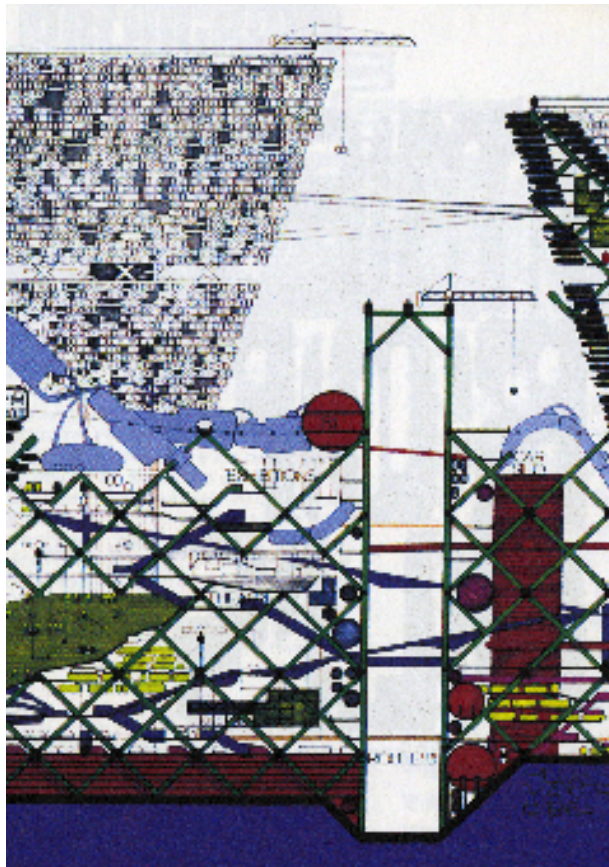
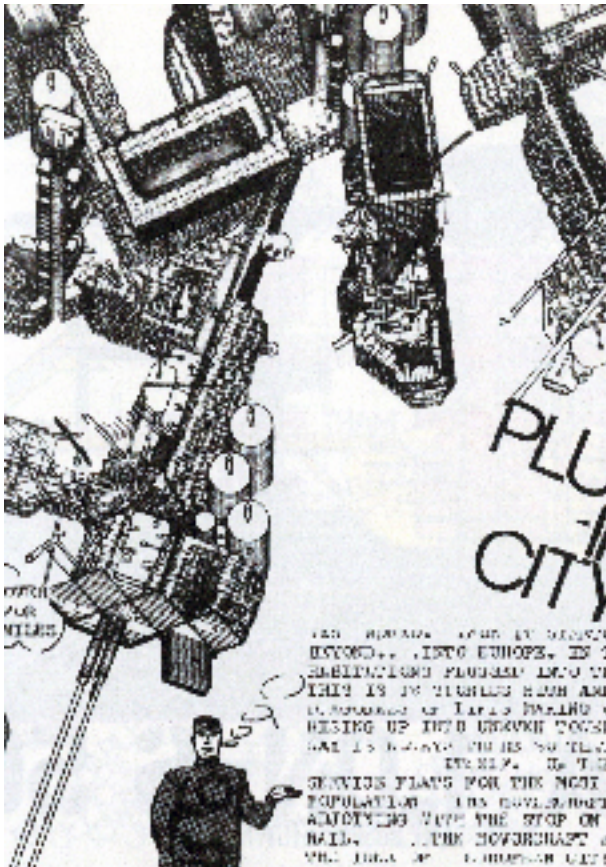
Moveable, multifunctional parts can create adaptable space that responds to user needs.

Application of materials in new ways can create energy saving opportunities.



The 1960's saw an outpouring of young avant-garde architectural groups such as Archigram, who challenged the traditional practice of architecture by experimenting with building types, materials, ideas, and techniques from other industries. Plug-In City is an excellent example of a project whose very essence is experimental. It is flexible and adaptable. It is a materialistic parallel to ideological notions regarding the quality of city life such as symbolism, dynamics, and dependence on situation as much as established form. It is an investigation as to what happens if the whole urban environment can be programmed and structured for change through interchangeable parts. "The Plug-In City is set up by applying a large scale network structure containing access ways and essential services to any terrain. Into this network are placed units which cater for all needs. These units are planned for obsolescence. The units are served and maneuvered by means of cranes operating from a railway at the apex of the structure."³¹

Interchangeable units allow active response to physical and psychological forces such as weather and social conditions.



NETWORKS

The study of networks is important to the advancement of transportation throughout Montana. Society is globally connected through different types of networks such as; the Internet, human social groups, human cell, and economy. Networks are comprised of nodes and links. Nodes provide an opportunity to change speed and direction by connecting various links that make up the paths between them. In some networks, a few nodes develop a disproportionately large amount of links. These nodes are known as hubs, "they are the thread of society, smoothly bringing together different races, levels of education, and pedigrees."³² The major people moving systems in Montana can be broken down into two different network forms: random and scale free.

Montana's primary transportation system is the road, which is part of the national highway system. America's highways have a distributed organization. They create a random network made of static connections between non hierarchical nodes. Nodes are cities and towns, while links are the roads connecting them. "The degree distribution of a random network follows a bell curve, telling us that most nodes have the same number of links..."³³ When the national highway system was conceived, planners knew what the final outcome would be. It's arranged as a "fixed number of nodes and links such that the final web conforms to the network being modeled".³⁴ Large cities such as Albuquerque, New Mexico have the same number of links as small towns like Butte, Montana. A random network dismisses growth by treating all nodes equally. Potential failure in a random network is greater than it is in a scale free network, because dynamic adaptation is not possible.

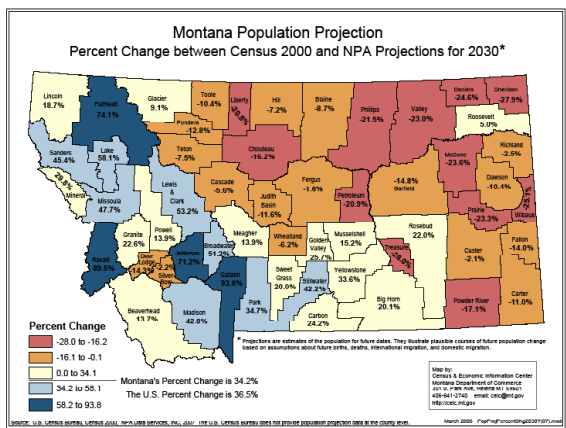
The air and rail transportation systems are examples of scale free networks. They are constantly changing due to the addition and subtraction of nodes and links. Nodes are always in battle for links. In other words, airports and rail stations are always battling for more carriers and connections to new destinations.

Sizes of nodes are in flux due to the amount of links they provide, creating a hierarchy where dynamic growth and decay may occur. Resources in scale free networks are allocated according to varying degrees of demand. Scale free networks follow a power law degree distribution curve. Most nodes only have a small amount of links, while a few highly connected hubs hold the network together.³⁵ Examples of hubs include Denver, Colorado and New York, New York. Nodes are classified as smaller terminals that have to link up with larger hubs to make most connections. Examples include Missoula, Montana and Bozeman, Montana. Scale free networks are prevalent in living systems, such as the internet and biological cell.³⁶

As humans progress and expand, new demands will increase the importance of transportation. In Montana, the potential for a prosperous future is good, but a change in attitude is needed. People must care about the vitality of their community and take initiative to improve it. Many jurisdictions and developers have failed to provide a positive public amenity by isolating development from destination places. Most people are unwilling to travel in places that are uncomfortable and unappealing. These include areas without sidewalks, and those that limit circulation choices through unwalkable distance, and unavailable or congested transportation. In a study of pedestrian movement in New York City, Boris Pushkarev found that 94% of people would not walk more than 1 mile (5,280 ft) in a single trip.³⁸ Isolated suburbs, airports, community centers, shopping areas, and towns take away opportunity from those who cannot drive. "In almost all communities designed since 1950, it is a practical impossibility to go about the ordinary business of living without a car."³⁹ As Montana continues to grow, new development is located farther away from destination places, and once sufficiently connected parts become more

Montana's transportation infrastructure must be well thought out in order to operate smoothly. Montana should maintain its current road system while increasing rail and streamlining air. The road is a lifeline for small communities that do not have the population to require other forms of

Passenger rail in Montana is underdeveloped. It needs to be expanded in order to be used as a compliment to the already established air and road networks. Two new high speed passenger rail services utilizing existing rail lines should be added. The first proposed route is a connection between Denver, Colorado and Spokane, Washington. This would link the Rocky Mountain region to the Pacific coast. By doing so, it would pass through five of the six urban areas of Montana (Billings, Bozeman, Helena, and Missoula), and service Yellowstone National Park, Big Sky Ski Resort, Bridger Ski Resort, and the state Capitol. The high speed train would establish the new passenger service as an alternative travel mode to air and automobile because of its fast travel rate. This would not be the first passenger rail service to operate in Southern Montana, but would be the first service efficient enough to satisfy the needs of both business and recreational travelers. The second proposed route is a connection between Phoenix, Arizona and



Calgary, British Columbia, effectively connecting the southern United States to Canada. This route would run through Western Montana, one of the fastest growing regions in the country (Flathead, Lake, Missoula, and Ravalli County are projected to grow 74.1%, 58.1%, 47.7%, and 89.5% respectively by 2030).⁴⁰ Along with servicing the urban areas of Missoula, and Kalispell, it would connect destination places such as Lost Trail Ski Resort, the Bitterroot Valley, Flathead Lake, and Glacier National Park. It would also stitch the proposed southern route to the existing Amtrak Empire Builder Route that runs between Libby and Wolf Point in Northern Montana. The new rail system of Montana should be hierarchical in nature. It must be integrated with all forms of transportation and adaptable to new demands. While many skeptics maintain that low population densities do not support rail, Montana would be a counter example. Major destination places and urban areas would be connected, giving the nearly 10.7 million annual visitors and 1 million residents reasons to ride.

There are more than enough airports to satisfy the long distance travel needs of Montana. Airports with boarding numbers under 50,000 passengers per year should be abandoned. This would cut the number of airports in the state by more than half while maintaining the six airports that control 96.8% of the air transportation market: Billings, Bozeman, Missoula, Kalispell, Great Falls, and Helena. Billings, Bozeman, Missoula, Kalispell, and Helena are located along the proposed rail routes, and all are located along major highways.

Financing for the new transportation network should come from all modes of transport. The road system has the opportunity to be a major funding source for other forms of transportation because of its high user rate. New possible financing could come from highway and corridor access tolls. In a recent study, the Hudson Institute suggests fees should be collected for miles traveled, type of vehicle driven, pollution generated, and traffic demand in effect when a trip is made.⁴¹ New technology is available that can collect fees without affecting traffic.⁴² Results of user-fee highways include decreased congestion, decreased pollution, supplemental financing, and increased participation in alternative forms of transportation. Another possible way of financing Montana's transportation system could come from the use of multiple stake holders. The new transportation system could allow the public and private sector to enter the market. Interested parties would be able to adopt transport carriers. By doing so, they would be required to supply financing to maintain the car they purchased, but would be able to display advertising to a fluctuating user group. In return the system would be cheaper to maintain, allowing it to reach an expanded customer base, and run more frequently.

Different areas of the Montana will require more system energy at different times of the year and at different points in the future. Montana's greatest attraction to visitors is its Mountains. Glacier and Yellowstone National Parks are the top two tourist destinations in the state. They receive most of their visitors during the summer months. In the winter, Ski resorts also become important. Montana's weather has the potential to vary from summer highs that reach into the 100's to winter lows that fall in the negative degrees Fahrenheit. The state experiences winter, summer, fall, and spring seasons. Business activity is highly centered in urban areas, but rural destination places and resource extraction companies that scatter the landscape are high priorities. By cross-referencing monthly attractions and annual business necessities with predicted growth and climatic change, demand for resources at different times can be determined. The transportation network will address the distribution of resources by maintaining a constant state of flux. Nodes and links of all transportation possibilities will adapt to regional demand by allocating connections and program based on nodal requirements for space and communication.

Users of the new transportation network will experience increased performance and reliability, along with decreased travel times. Dispersing network users among multiple systems, and responding to necessities of place, will decrease the burden that would be put on a single aspect of transportation. New rail connections to places otherwise only accessible by car offer more opportunities, and generate new economic possibilities. Land near transportation nodes enjoys premium value, because they maintain a constant flux of diverse people. Those who take advantage of the new multimodal transportation system will experience decreased commuting costs. A person working 5 days a week, driving 30 miles round trip will spend on average \$4430.00 per year commuting. Average annual costs of public transportation range from \$200 to \$2600 depending on travel factors, such as distance and time of day.⁴³ Transportation systems swell the consumer market, thereby benefiting growing economies. They provide access to jobs and enhance employee reliability. Public transportation also increases personal mobility for elderly and teenage populations. Currently, those unable to drive in Montana become dependent on those who can.

As new connections are established throughout Montana, opportunities for exchange between disparate communities will become more feasible. Montanans that were once isolated in rural communities will have the opportunity to engage in global dialogue via hierarchical branches of the new system. The design will respond to necessities of place. It will be adaptable to the fluctuating demand of nodes, thus performing more efficiently for Montana's visiting and residing populations.

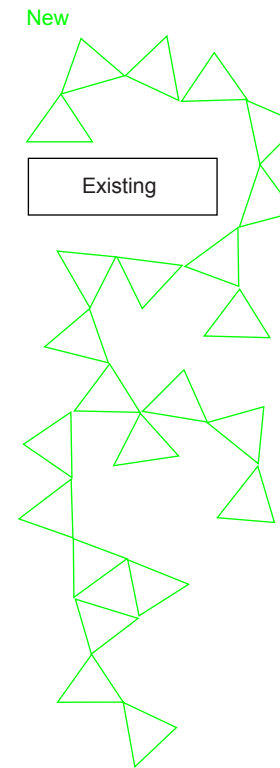
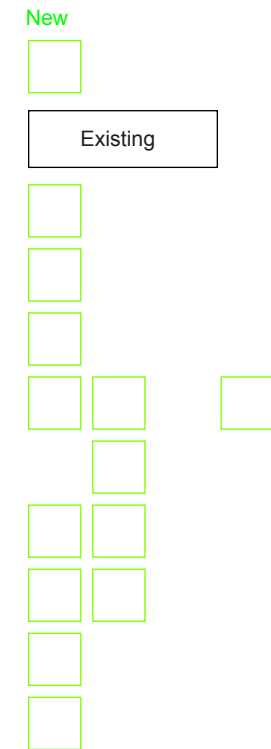
THEORETICAL POSITION

The architecture of the nodes in the new transportation system must reflect the benefits of the network. Nodes must be multimodal by addressing all forms of transportation in the region. They must integrate with established systems, connecting all forms of travel. Nodes must function as gateways between different modes of transport and multiple communities. They should act as a bridge, connecting pedestrians, bicyclists, drivers, and transit vehicles. Because of the importance of transportation in everyday life, nodes have the opportunity to function as destination places by becoming civic centers and symbols of community ideals. They should not be strictly transportation stations, but should be multi-use buildings that provide the diversity, hierarchy, and communication that the network they are apart of promotes. As nodal demands change, the architecture of the node should as well. In the past architecture has been about wholeness and completeness, this thesis rejects that. The mentality of wholeness and completeness has brought about architecture that is fixed and unable to adapt. This thesis proposes a paradigm shift where the parts of architecture are just as important as the whole. Architecture should challenge the conventional view of buildings as stagnant by maintaining a constant state of

flux, allowing it to be dynamically responsive to surrounding requirements. Architecture of the new millennia must be able to adapt. When program, climate, technologies, and social characteristics change, buildings should respond. Architecture in flux is not only better suited for the ever changing modern day man, but also more capable of living in harmony with the shifting character of the environment. It fits its purpose better and has a greater potential to remain relevant. In the past, the “general understanding was that flexible buildings had their uses, but they were also quite limited – this sort of design was seen as less important than permanent, fixed architecture”.⁴⁴ Fluctuating architecture is capable of solving a wide range of problems better than conventional architecture because of its ability to respond in real time. By establishing it as a major civic element such as a transportation node and community center, prior understandings of movable architecture as limited, and unimportant, will be obsolete.

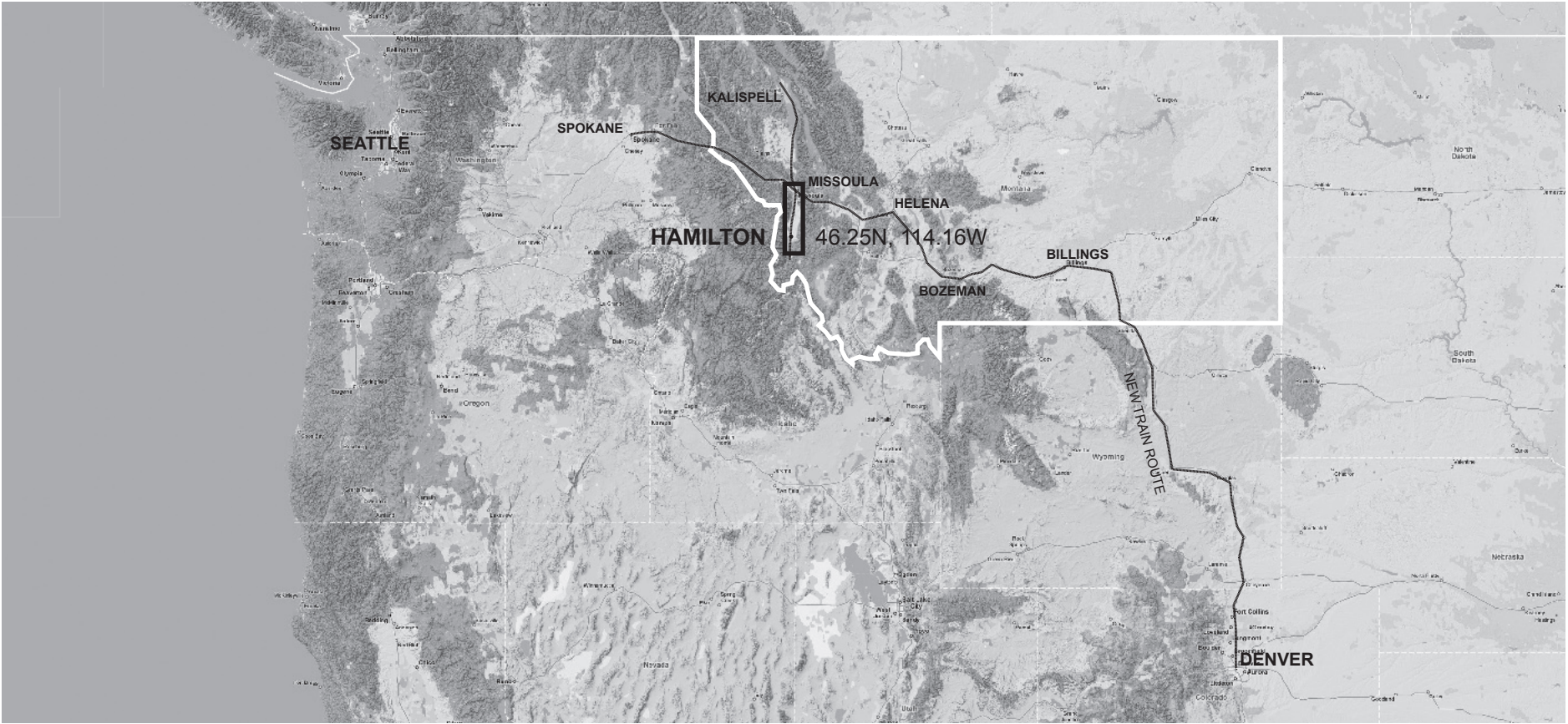
Modular construction is the most applicable building technique for the nodes of the new transportation system. It's very nature allows for fluctuating demands. Interchangeable building components can be gathered and partially assembled off site,

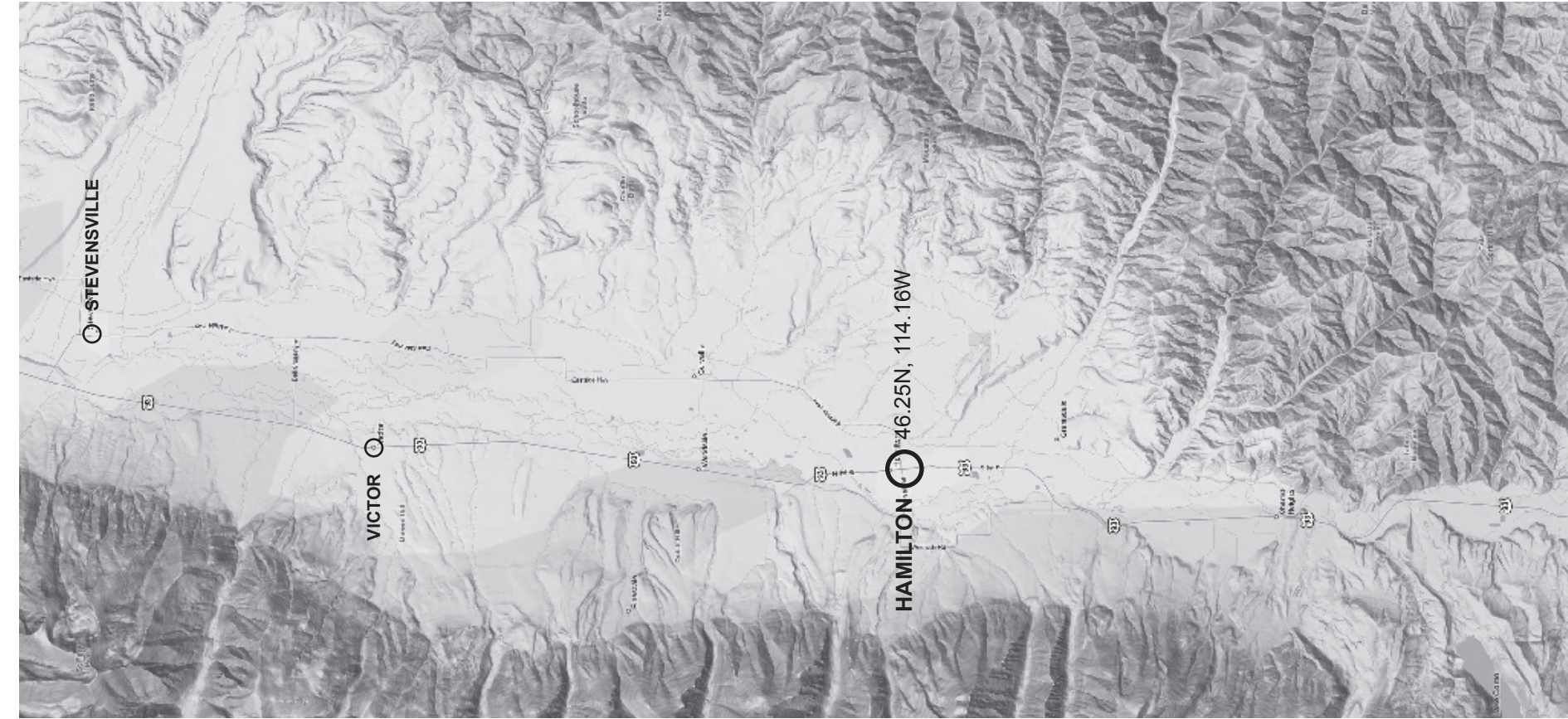
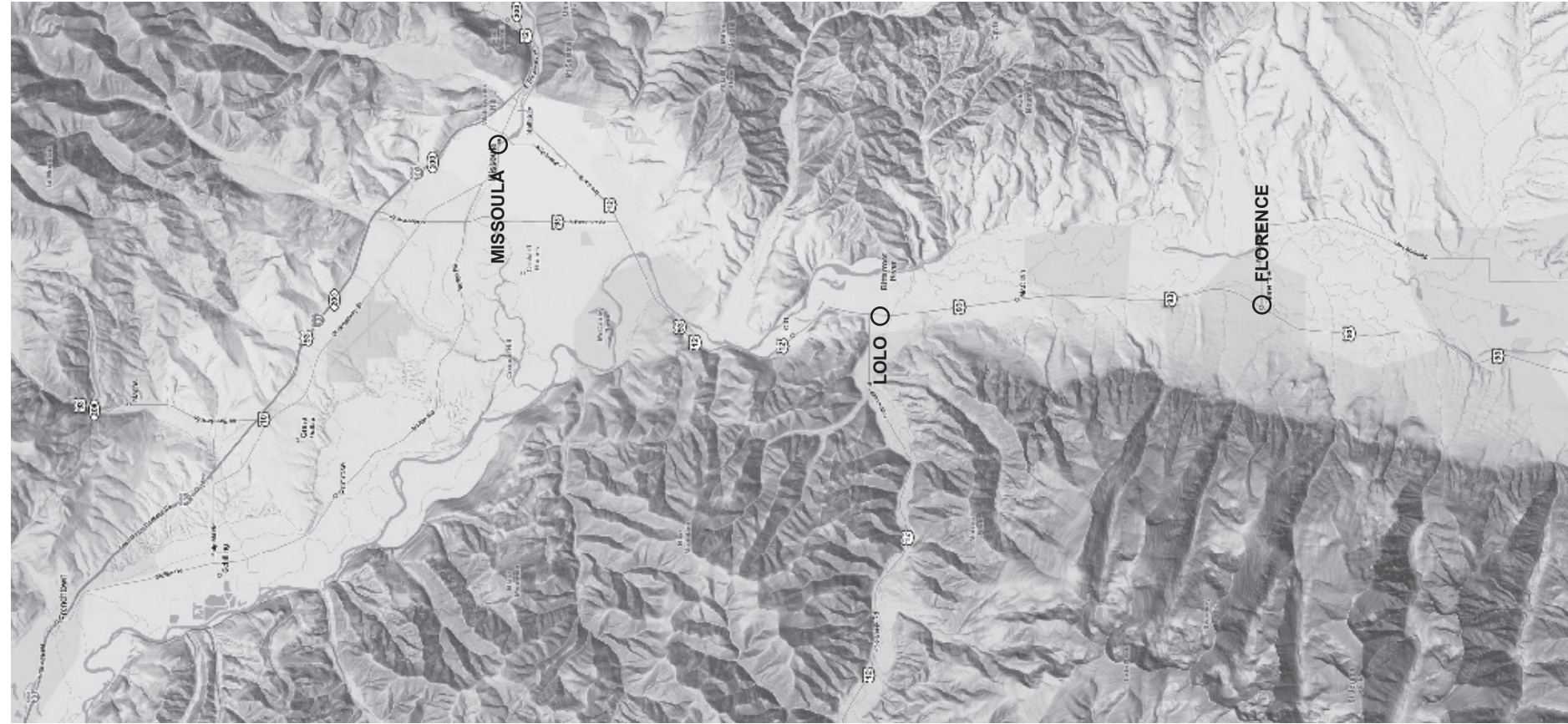
then transported to the site when needed. If they are designed in a way that allows them to be built up and dismantled quickly, the building will have less impact on the surrounding neighborhood, increased flexibility, and more potential to be reused elsewhere if needed. Since each node in the transportation system will be connected by road, and the majority of highly active nodes will be connected by rail, building components should be sized to fit both semi truck and rail cars.



LOCATION

The city of Hamilton is located in Southwestern Montana between the Sapphire and Bitterroot Mountains at latitude 46.25 N, and longitude 114.16 W.⁴⁵ It has a population of 4,691 people.





HISTORY

Copper King Marcus Daly founded Hamilton in 1890 as a planned company town to fuel Anaconda Mining Company's need for lumber. As a result, it is situated next to the Company's Big (lumber) Mill. Hamilton was named after its designer, engineer James Hamilton. James designed the town with 80 foot wide streets on 160 acres of land.⁴⁶ In its early years, Hamilton's most significant building was the Missoula & Bitterroot Valley Rail Road Depot. Its position perpendicular to Main Street gave it prominence in the built environment. As a node on the Northern Pacific branch line, it connected residents and cargo from Hamilton to the rest of the world.

In the 21st century, Hamilton's economy continues to be based in agriculture and lumber extraction. Log home building kits are a major business in the region; models ship around the world, and the construction and manufacturing industries employ nearly 19% of the population.⁴⁷ The agriculture industry provides 2.7% of the population with jobs.⁴⁸ Dairy and poultry farms that sell to the nearby urban center of Missoula dominate the farming economy. Technological industries are beginning to take hold. In the southwest part of town, Rocky Mountain



Laboratories leads the way. Best known for research in diseases such as, Rocky Mountain spotted fever, and lyme disease, Rocky Mountain Laboratories is a key component of the National Institute of Infectious Diseases. Employing approximately 350 people, it occupies 30 buildings on 33 acres of land, and has a new integrated research lab under construction.⁴⁹ In addition to being located between destination places such as Glacier National Park and Lost Trail Ski Resort, Hamilton is a destination place in itself. Many people come to the city because of its beautiful natural surroundings that are attractive to hunting, fishing, and vacationing.⁵⁰

The Bitterroot Valley is an ecologically valuable resource. Open land is essential because activities like logging, agriculture, hunting, fishing, and hiking require it. When growth is expected, large roads and suburban developments that are underutilized and environmentally harmful are added in a distributed manner that forgets the importance of the natural landscape. A hierarchical transportation system would support infill and dense development, creating cores of human inhabitation that will allow the surrounding areas to remain undisturbed and large enough to support the economy in the region.

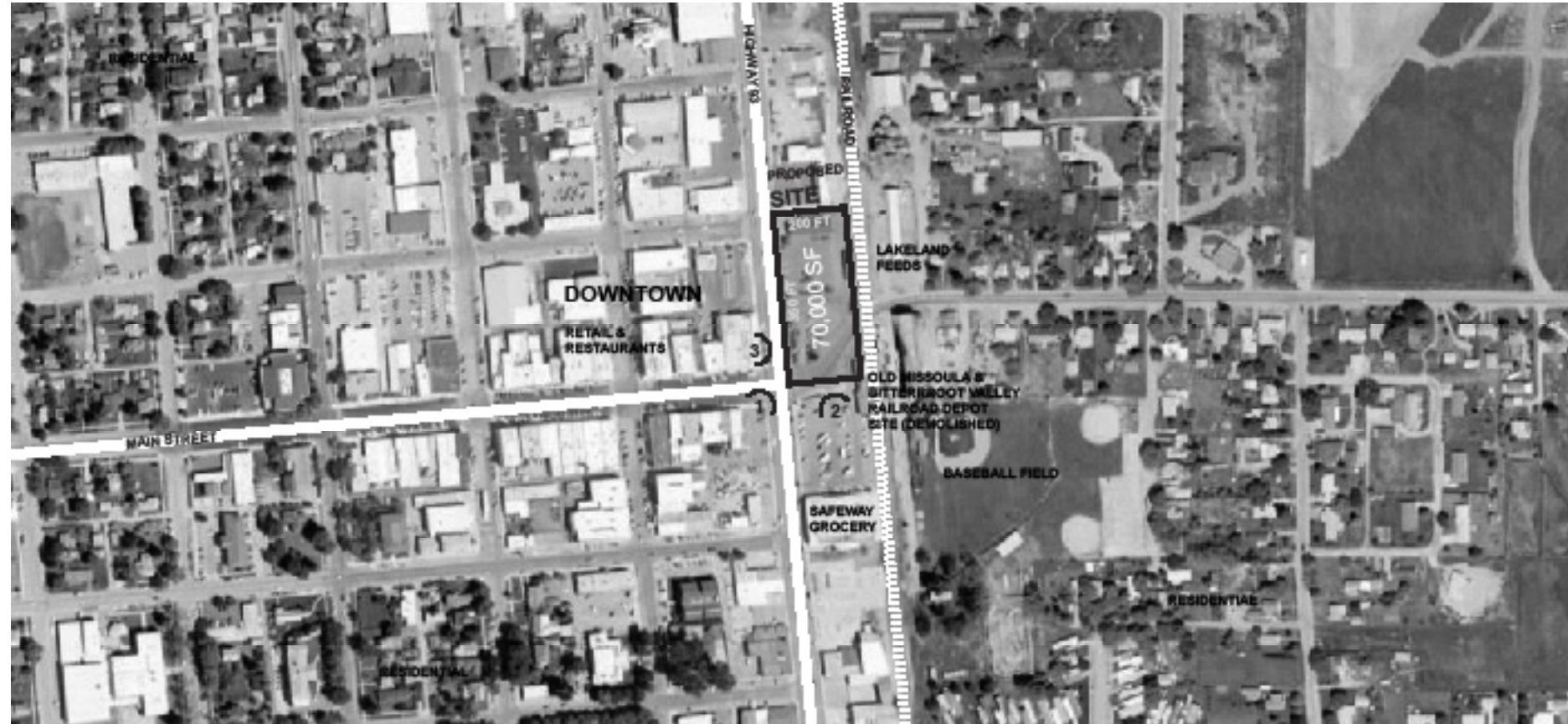
Hamilton is the county seat of Ravalli County, which is projected to grow by 89.5% by 2030, making it the 2nd fastest growing county in Montana.⁵¹ Architectural proposals should prepare, and be able to respond to growth because of this fast growth rate. Hamilton's location 45 miles south of western Montana's most populated urban center, Missoula, guarantees that it is undergoing interdependent co-evolution with the city. Their futures are intertwined due to the symbiotic relationship they are developing. Hamilton is becoming home to a growing commuter population that supplies Missoula businesses with employees and consumers. Missoula's size makes it capable of providing a large user group that includes Hamilton with amenities associated with urban cities like sporting venues, a University, diverse restaurants, and an International Airport. Although thousands of people travel back and forth between Hamilton and Missoula, they are not yet connected by a satisfactory highway or rail system. Highway 93 cannot adequately carry the loads necessary for efficient travel since 69.7% of Ravalli county residents drive alone to work.⁵² In the morning between 6am and 9am, and then at night between 4pm and 7pm traffic backs up considerably along Highway 93. The average travel time is 23 minutes, which is comparable to major cities like

Seattle and San Francisco who average in the upper 20's.⁵³ Many believe adding lanes to create less congestion is the best option for Highway 93. History time and again shows that building larger roadways only creates more traffic.⁵⁴ At the height of the Great Depression the Triborough Bridge and Tunnel Authority was building major road systems throughout the Eastern United States to generate jobs and alleviate congestion. Their own projects proved "...the principle of traffic generation, the mathematical rule that any highway built to alleviate congestion on an earlier existing road, would only succeed in generating a larger aggregate amount of traffic for all roads."⁵⁵

ACTIVITIES AND USE

Activities and use within walking distance of the core of Hamilton include: Baseball fields, residential neighborhoods, a supermarket, and downtown Hamilton – which includes restaurants, retail, and convenience stores. Pathways in the form of sidewalks and dirt paths cross the area, connecting various activities and uses. Long distance transportation is limited to automobiles which travel in the north-south and east-west directions. A good location for the proposed transportation node would be centrally located at the intersection of Main Street and Highway 93. This would put it near existing transportation infrastructure (Highway 93, railroad), and within walking distance of commercial and residential areas, while supporting a centering of city development.





DEMOGRAPHICS

⁵⁶Demographically, the population of Hamilton is composed of 45% males, and 55% females. White Caucasians, people of two or more races, Latin Americans, and Native Americans make up 96.2%, 1.8%, 1.6%, and .9% of the population respectively. At 82%, the percentage of people with High School education is two percentage points above the national average. An interesting statistic to note is the percentage of people with disabilities. Nearly one third (26.9%) of residents in Hamilton over 5 years old are disabled, this is well over the US average of 19.3% (the city's large population of elderly people (28.3%) could be a significant factor). In response to Hamilton's considerable number of disabled citizens, the transportation node must be easy to find, accessible, and simple to navigate.

CLIMATE

⁵⁷Average **temperatures** in Hamilton range from 83°F in the summer to 17°F in the winter. July is generally the warmest month, with an average high of 83°F and average low of 49°F. December is generally the coolest month, with an average high of 34°F and average low of 17°F. The record high temperature was 105°F in July of 1895. The record low temperature was -39°F in February 1899. Since temperatures in Hamilton have the possibility to fluctuate over 130° throughout the year, the transportation node must be able to handle a wide range of weather patterns.

⁵⁸Average annual **precipitation** in Hamilton is 13.54 in., peaking in late spring and early summer. May is the wettest month, with an average precipitation of 1.75 in. October is the driest month, with an average precipitation of .78 in.

⁵⁹Average annual **wind** speed in Hamilton is 6 mph. April receives the highest wind speeds, averaging 7.6 mph, while December receives the lowest wind speeds, averaging 4.7 mph. The nearest city reporting wind direction is Missoula (45 miles north), prevalent winds there are to the NW year-round with the exception of December and January when wind

direction is ESE.

⁶⁰Yearly **sky cover** conditions in Hamilton involve a 1/3-1/3-1/3 split with peak clear sky periods in the summer, and peak cloudy days in the winter. July is 18% cloudy, making it the clearest month, while January and December are 80% cloudy, making them the cloudiest months.

⁶¹Solar **altitude** and **azimuth** conditions in Hamilton change greatly depending on the time of year. In June, the sun is at an altitude of 40.9° and an azimuth of 98.3° at 9am, an altitude of 65.9° and an azimuth of 157.9° at 12pm, and an altitude of 53.6° and an azimuth of 243.4° at 3pm. In December, the sun reaches an altitude of 5.2° and an azimuth of 132° at 9am, an altitude of 19.9° and an azimuth of 171.5° at 12pm, and an altitude of 13° and an azimuth of 213.8° at 3pm.



Program for the proposed transportation node will fluctuate, so concrete programmatic elements should not be determined. Instead, current requirements will be given. These elements should not be seen as the only possible parts of the facility. Future needs may change and make the current proposed elements obsolete or establish new program not currently needed for the space. Currently, Hamilton is a freestanding community outside of a larger urban center, this suggests that the transit program should provide a commuter population with a service that is responsive to peak demand. It should also offer a mix of uses that includes offices, residential areas, neighborhood retail, and area for local activities. Programmatic elements added that are not specifically needed for the operation of existing business or the transit node are needed in order create a mixed use building that supports activities at all times of the day.

Requirements as of April 2009

(Existing) Offices, Restrooms, Storage, Employee Facilities, Retail	(New) Total Gross Square Feet
21,600 SF	31,250 SF
(New) Ticketing, Information, Waiting & Queuing, Restaurants, Retail	(New + Existing) Total Gross Square Feet
10,000 SF	52,850 SF
(New) Residential	Parking
15,000 SF	SF
	Outdoor Space
	SF
(New) Total Net Square Feet	
25,000 SF	
Mechanical, Structural, & Circulation (Plus 25%)	
6,250 SF	

Based on 2003 IBC

1. OCCUPANCY GROUP CLASSIFICATIONS (Chapter 3)

A-2	Restaurant
A-3	Community Space/ Waiting & Queuing Areas
B	Business’/Offices
R-2	Residential
S-2	Low-Hazard Storage

2. Required Occupancy Separations (Table 302.3.2)

A-2 and A-3	2 hour*
A-2 and B	2 hour*
A-2 and S-2	2 hour*
A-2 and R-2	2 hour*a
A-3 and B	2 hour*
A-3 and S-2	2 hour*
A-3 and R-2	2 hour*
B and R-2	2 hour*
B and S-2	2 hour*

*Note: Reduce the required separation by 1 hour, but not less than 1 hour (if assumed fire sprinklered) except Group H and –I occupancies per section 302.3.2 exception. Doesn’t modify required floor construction rating.

^a Commercial kitchens need not be separated from the restaurant seating areas that they serve.

3. Allowable Height and Building Areas (Table 503)

Allowable Max Height: 65 FT
Allowable Area: A-2: 15,500 SF, A-3: 15,500 SF, B: 37,500 SF, R-2: 24,000 SF, S- 2: 39,000 SF

Height Modification (Section 504.2)-If assume building is fire sprinklered, increase height value specified in Table 503 by 20’.

Area Modification (Section 506.3)-If assume building is fire sprinklered, increase area value specified in Table 503 by 200% for multistory buildings and 300% for single-story buildings.

4. Types of Construction (Table 601)

Fire Resistive Requirements for Building: Type IIA; Structural Frame, Including Columns, Girders, Trusses: 1 Hours, Bearing Walls (Exterior & Interior): 1 Hours, Floor Construction: 1 Hours, Roof Construction: 1 Hours

5. Accessible Means of Egress (Section 1007)

One accessible means of egress is required.

5. Occupant Load Factors (Table 1004.1.2)

Occupancy	Program Space	Sq. Ftg.	OLF	OL
A-2	Restaurants	2,000	15	134
A-3	Waiting & Queuing	11,200	100	112
A-3	Community Space	5,000	15	334
A-3	Commercial	5,000	60	100
B	Office Space	4,500	100	45
R-2	Residential	5,000	200	25
S-2	Storage	1,000	300	2
Total Occupant Load				752

*Note: Verify OLF for your specific use as applies to A occupancies.

6. Egress Width per Occupant Served (Table 1005.1)
Stair width .2 inches per occupant, 12 feet 7 inches minimum in total occupant load areas.

Egress width .15 inches per occupant. 9 feet 5 inches minimum in total occupant load areas.

*Note: Widths assume fire sprinkler use.
7. Stair Headroom (Section 1009.2)
Minimum of 80 inches (6'-8") measured vertically from a line connecting the edges of stair nosings.
8. Stair Treads and Risers (Section 1009.3)

Stair heights shall be 7 inches maximum and 4 inches minimum.
Stair tread depths shall be 11 inches minimum.

9. Stairs Vertical Rise (Section 1009.6)
A flight of stairs shall not have a vertical rise greater than 12 feet between floor levels or landings.
10. Ramps (Section 1010)
Slope: not greater than 1:12 (8% slope) if used as a means of egress. Note: if slope of 1:20 or greater, handrail not required. See section 1024.11 for specific requirements for Group A occupancies.

Vertical Rise: Shall not be greater than 30" (if ramp continues from that point, must have a landing that is 60 inches minimum per Section 101.6.3).

Width: minimum width shall not be less than that required for corridors
11. Exits Access Arrangement (Section 1014.2)
Where two exits are required (occupant load of a given space is greater than or equal to 50), they shall be placed a minimum of one-half the maximum diagonal dimension of the room/building measured in a straight line.
12. Exit Access Travel Distance (Section 1015.1)
Group A occupancies shall have no greater than 250 feet maximum travel distance to the nearest exit if sprinklered, 200 feet if not.

Group B occupancies shall have no greater than 300 feet maximum travel distance to the nearest exit if sprinklered, 200 feet if not.
13. Corridor Width (Section 1016.2)
Minimum corridor width as determined by this section, but not less than 44 inches. Note: The same applies for stair widths.
14. Dead End Corridors (Section 1016.3)

20 foot maximum length.

15. Minimum Number of Exits for Occupant Load (Table 1018.1)

Occupant loads more than 501, but less than 1,000 are required to have 3 exits.

17. Vertical Exit Enclosures (Section 1019.1)

Exit enclosures shall have a fire-resistance rating of not less than 2 hours where connecting four stories or more and not less than 1 hour where connecting less than four stories.

18. Exit Passageways (Section 1020.2)

The width of exit passageways shall be determined as specified in Section 1005.1 but such width shall not be less than 44 inches.

19. Assembly (Section 1024.2)

Group A occupancies that have an occupant load of greater than 300 shall be provided with a main exit. The main exit shall be of sufficient width to accommodate not less than one-half of the occupant load, but such width shall not be less than the total required width of all means of egress leading to the exit. Where the building is classified as a Group A occupancy, the main exit shall front on at least one street or an unoccupied space of not less than 10 feet (3048 mm) in width that adjoins a street or public way.

16. Accessibility (Chapter 11)

Buildings and facilities shall be designed and constructed to be accessible in accordance with Chapter 11 IBC and ICC A117.1.

Accessible routes within the site shall be provided from public transportation stops, accessible parking and accessible passenger loading zones and public streets or sidewalks to the accessible building entrance served.

At least 50 percent of public entrances shall be accessible.

Accessible parking spaces shall not be less than 1, if number of spaces exceeds 25, additional accessible parking spaces shall be in accordance with Table 1106.1.

17. Plumbing Fixture Requirements (Chapter 29)

Occupancy	W C	Lavs	DF's	Service	Sinks
	M/F	M/F		Showers	
A-2 (134/2=67)	1 / 1	1 / 1	1	-	1
A-3 (546/2=273)	1 / 1	1 / 1	1	-	1
B (45/2=23)	1 / 1	1 / 1	1	-	1
R-2 (25/2=13)	5	5	-	5	5
S-2 (2/2=1)	1 / 1	1 / 1	1	-	1
Totals	9 / 9	9 / 9	4		9

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