

2015

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Recommended Citation

McDonald, Shannon S. and Shubert, Lucas (2015) "Transportation Conditions and Solutions in Carbondale, Illinois," *Journal of Applied Sciences and Arts*: Vol. 1: Iss. 1, Article 3.

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Transportation Conditions and Solutions in Carbondale, Illinois

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Abstract: This research studies the potential of a new sustainable macro transit system to create sustainable/resilient transportation at the Southern Illinois University (SIU) campus and city of Carbondale, Illinois. The paper is applicable to many small rural University-cities where students do not have access to cars and where the growth pattern has created sprawl. This paper documents the existing transportation systems: train, bus, university campus shuttle, local county transit, automobile, bicycle, and pedestrian traffic. The graduate assistant research and subsequent thesis project explored how full mobility can be provided by creating a multi-modal transportation hub, parking, and new commercial downtown development linking the existing historic downtown and University campus with emerging transportation technology including an automated transit network (ATN), bicycles pathways and car-shared or bike-shared vehicles; all highly sustainable forms of transportation. The research documents how ATN (modern update of PRT) has the potential to replace several of the existing transportation systems, both public and private, to create better mobility for all with a sustainable/resilient, timely and cost-effective system. This system could provide full access without car ownership to the residents of the campus and local community. Environment impacts and new energy sources as part of the final architectural multi-modal transportation design solution creates a complete transportation model for small university-city place-driven ingenuity and research.

Keywords: *Multi-Modal, Automated Transit Network, Car-Share, Sustainable/Resilient*

Carbondale, Illinois and Southern Illinois University General Conditions

1. Introduction

Carbondale is a small university-based city in rural Jackson County, south central Illinois. Since its beginning, transportation has been an integral part of Carbondale's development. Carbondale, Illinois was originally founded as a direct result of adjacency to pre-existing rail lines. The founding of the city was noted in 1852, 96 miles southeast of St. Louis, Missouri, as three men, Daniel Harmon Brush, John Asgill Conner, and Dr. William Richart earmarked 360 acres of railroad land for the founding of a new town. This southern Illinois site, on the northern edge of what is now the Shawnee National Forest, was chosen because of its geographical relationship of highway and rail between the nearby population centers of Marion, Murphysboro, Makanda, and De Soto.

In 1854, the town's first train ran from New Orleans to Chicago on Independence Day. Steady use of this main north-south line would remain constant for the next 159 years to the present. On the other hand, the east-west rail line connecting Marion and Murphysboro (the initial reason for the location of the town) has fallen into disuse over the last century. For most of its first century, though, Carbondale served as a "mercantile and transport center (Explore Carbondale, 2013)." A decade later it became the home of a state-funded school that has since become Southern Illinois University Carbondale (SIUC). Throughout the

twentieth century, SIUC established itself as a research institute, now in the list of the top 100. Forty percent of the student population drives alone. (Corcoran, 2010) Commuter parking is commonly unavailable within half a mile of the destination within campus; and public transportation options are limited to the shuttle system. Bicycle and pedestrian travel are viable methods of connecting downtown Carbondale and SIUC campus, but these modes are inefficient around their less dense periphery. The N/S rail line is still used for freight movement daily and passenger trains, with the major routes to New Orleans and Chicago, although with priority given to freight. However, St. Louis, Paducah and other large nearby populations are only accessible by driving.

Demography, crime, poverty, topography and climate are also factors that create an understanding of Carbondale and its relationship to transportation. The most defining of which is the energy of its college-aged populous. Throughout the last few decades, while SIUC students have gained a reputation for progressive activism, new development in the downtown center of Carbondale has slowed down and stagnated. New retail and commercial areas have sprawled to the east along Highway 13 toward Marion, IL, several miles from the historic downtown and SIUC campus along Route 51. (Figure 1) As typical of urban sprawl this requires increased student and resident dependence on private transportation around the city. It has also contributed to the expanse of parking areas. Currently, reliance on the automobile due to unstable gas costs and cost of vehicle ownership is causing mobility problems for many.

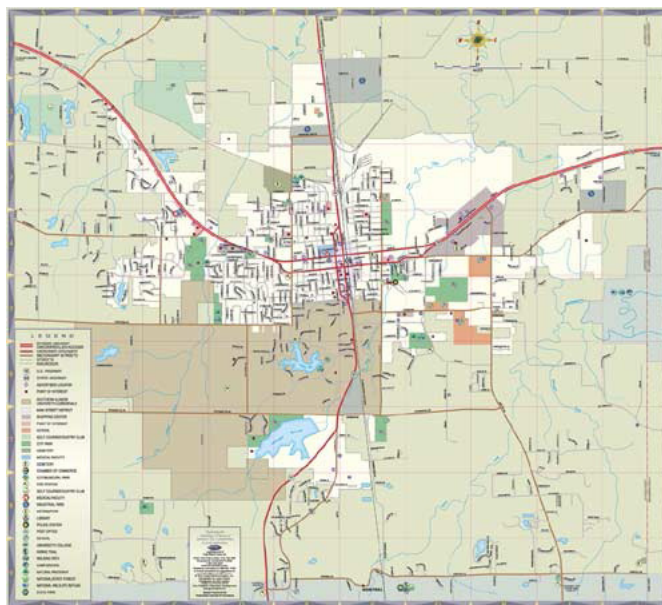


Figure 1. Carbondale, Il (RT 13 is E/W and RT 51 is N/S)

According to the 2010 census, Carbondale has a population of 25,902; and it is the 20th largest city outside of the Chicago metropolitan area in Illinois. There were 1,516 people per square mile spread over 17.09 square acres. It also states that the ethnicities composing that population were mostly white, about one quarter African American, while a much smaller portion is Asian, Native American and Latino. Nearly half the population of Carbondale is individuals.

The rate of crime in Carbondale is very high, compared to other cities. It is only safer than 4 percent of the cities in the U.S. and had 1,721 crimes last year, 286 of which were violent. Every resident of Carbondale has a 1 in 91 chance of being the victim of a crime (Neighborhood Scout, 2013). A heightened sense of danger felt by city residents can easily lead to unwillingness to partake in public transportation. In 2013, 48.2 percent of the population of Carbondale was below the poverty line; and the median income of the majority of the population was slightly above the poverty line. (US Census, 2013) Efficient public

transportation design in sparsely populated low-income cities can be difficult. It is, therefore, not surprising that Carbondale currently has many challenges in this area. Poverty also implies that there are less vehicle owners in the area, making functional transit necessary for this population to access opportunities. Due to Carbondale's moderate topography, walking and biking are both completely viable options for Carbondale residents and SIUC students alike. However, Carbondale has climactic variables that can change from day to day almost as dramatically as season to season in the area. The average temperature shift is approximately from 87 degrees to 20 degrees Fahrenheit, about one third of the days have precipitation, and 45 inches of rain fall. The primary effects on transportation are the possibilities of overwhelming heat and humidity in the summer and freezing rain and snow in the winter impacting pedestrians, bicyclists, and drivers. Southern Illinois also experiences severe weather challenges that can impede travel such as flooding, tornadoes, inland hurricanes, and earthquakes. It is the area of the largest earthquake ever recorded in North America at the New Madrid Fault in 1811-12, that is still active today. Having a sustainable transportation system that could function in multiple disasters defines resiliency.

2. Emerging Transportation Solutions

2.1. Newly Emerging Efficient Transportation Systems

The transportation area is currently experiencing great change with expanding computer technology to create new ways of accessing transportation as well as new forms of transit. These new technologies have the capability to address the challenges of transit in a small city-university community that could not typically be addressed with larger urban transit solutions such as light rail and heavy rail systems. In the most recent, 2001 TCRP Synthesis 39: Transportation on College and University Campuses a survey resulted in a similar condition of multiple transit systems in order to meet mobility needs for college and university campuses. The result of this has encouraged universities and communities to join together to meet the greater challenge of unlimited access and is seen as an important tool for the community. They are seen as "incubators for new approaches to meeting mobility challenges". (Miller, p 48)

2.1.1. Car Share

One means of efficient public transit is a car share system. There are forms of car shares in operation around the world. One such system exists to alleviate peak time commuter traffic around Washington, DC called the Slug Line. This system is essentially a car pool, but the passengers and driver are usually strangers and is similar to peer-to-peer ride share. The potential passengers generally wait in line at a pre-determined location while drivers form of a queue of their own in an effort to gain the number of people needed to travel along the high occupancy vehicle lanes. Another popular form of car share found in dozens of cities and universities throughout the world is administered by a company called Zipcar. This system is designed to relieve traffic in densely populated areas by allowing users to arrive at an intermediate destination by private vehicle, public transit, or pedestrian means and then reserving a vehicle to reach a terminal destination. What makes Zipcar different from a car rental company is its infrastructure, wherein a user pays a monthly rate, giving him or her access to any vehicle at any Zipcar station available by swiping a card over the vehicle's windshield. Basically, Zipcar presents an option for less expensive, need-based vehicle usage. This system could function in a small city like Carbondale, using a few stations to serve the area. Car-sharing is becoming an expanding part of campus transportation plans with peer-to-peer car sharing popular among young people. (Ballus-Armet, 2014). Companies such as UBER and LYFT are now providing transportation in large city areas, while Carbondale struggles with maintaining a cab company. (Hall, 2015) (Zipcar, 2013)

2.1.2. Automated Transit Networks (ATN)

Automated transit networks have a 50 plus year history as a part of transit solutions. From the earliest application still running at West Virginia University to the most up-to-date systems today, their smaller vehicles and point to point service allows for less expensive approach to transit while providing the mobility of a car. The current ideas governing ATN design are the result of decades of development and operational systems starting with PRT.

...in the 1960's, the popularity of the private car and the degree of congestion on the roads in the United States, led the department of Housing and Urban Development (HUD) to seek out alternative ideas for transport, from their research institutions, which would still hold on to the basic idea of using small individual vehicles. (Richards, 2001 p.124)

From that research to William Alden's first attempts at miniature dual-mode cars (road and track capabilities) out of his Massachusetts corporation, the future of efficient transportation systems began heading toward ATN's current state of continual development (Richards, 2001, p.124-125). Alden's most lasting achievement in the early stages of PRT research was that of switching station design and its potential for quickly moving small automated vehicles operating independently within very close proximity to one another (Richards 2001, p.125). Over the course of decades, the idea of PRT has transformed into a functional system constantly being updated and tested as computer capabilities expanded. Versions of ATN systems are currently operational at Heathrow airport: London, Rivium, the Netherlands, Suncheon city: South Korea and Masdar City: Abu Dhabi, United Arab Emirates. A modern ATN ideally consists of a fleet of automated vehicles, powered by a renewable energy source, one system; called PodCars are solar powered, traveling from point-to-point on pre-determined paths separate from vehicular traffic with the capability to go on the road as needed for mobility challenged riders. ATN offers the travel time convenience of private transportation while supporting walkable communities by creating small transit stations within ¼ mile walking distance from any location as developed from its earliest designs in the book, Fundamentals of Personal Rapid Transit. (Irving, 1978) (McDonald, 2011).

The Heathrow airport Ultra ATN system has been fully operational for the public for 4 years and has carried 1.2m passengers, removed over 200,000 bus journeys, vehicles have travelled over 2.5m driverless kilometres, 26066 hours of operation since opening and saves over half a million tonnes of CO₂. (Isles, 2014)

3. Case Studies

3.1. Morgantown

Morgantown is a small West Virginia City with a population of about 30,000, according to the 2010 census, which is similar to that of Carbondale. Both are the economic centers of their respective regions due to the related universities. Morgantown and Carbondale also share similar demographic income levels, with as much as fifteen percent of the population living below the poverty line (City Data, 2013).

WVU has been employing an operational PRT system since 1975; it is currently in a period of continual operation that has lasted for over 30 years (Wright, 2005). It is difficult to derive the effects on economic and population growth, a functioning PRT system has had on the area. WVU's initial demand for a new kind of reliable public transportation was spurred by its expansion, which was complicated by the topography of the mountainous region around Morgantown (Anderson, 1996).

The electric vehicles within the PRT system are pods which are about 15 feet long, with a designed capacity of 20 people (Wolfe, 2005). A fleet of 73 vehicles, which can travel up to 30 miles per hour, carry approximately 15,000 passengers per typical school day (WVU, 2013). While the system is completely automated, the vehicles operate on rails set into separated pathways (WVU 2013). The system is free for Mountaineers (WVU students and personnel), and costs 50 cents per ride for the public (WVU 2013). The system includes only 8.2 miles of track that connect five stations throughout Morgantown and the WVU campuses (WVU, 2013). The system outlined above can potentially lend its principle design characteristics to Carbondale and SIUC. A new system of PRT tracks and stations suggest a considerable capital cost, however not the costs of this historic system due to new technology. Currently according to West Virginia University, PRT present value costs over 20 years is estimated to be \$144.5 million while over the same time period bus present value costs are \$260.2 million. As well:

...Switching to a bus system would increase average time per rider by at least 11.2 minutes. Riders value travel time, and under current conditions, the PRT, in terms of time value, is worth an estimated \$9.1 million per year. Because the PRT is an electric-vehicle system, the PRT produces much less CO₂ than a substitute bus route. Over the course of a year, the PRT is estimated to produce 297 tons of CO₂ while a substitute bus route would produce 2,472 tons of CO₂ – 8.3 times the estimated CO₂ emissions of the PRT service. (West Virginia University, 2010)

3.2. Masdar City

Masdar City, Abu Dhabi, United Arab Emirates was founded in 2006 as a commercial center with a very specific goal in mind—to develop a sustainable technology and renewable energy research center and use the knowledge it creates in its own infrastructure (Masdar City, 2013). In fact, Masdar City translates from Arabic to Source City (Farussi, 2011). The harsh desert climate of the region has taught many lessons to its inhabitants over the centuries, one of which being that sustainable living is not a catch phrase, but a reality. It is for this reason that, even though Abu Dhabi controls eight percent of global oil reserves, it “has enough hydrocarbon reserves at current production levels to last 100 years (Masdar City, 2013).” Masdar City is being developed in one of the wealthiest nations as well as in the world in an environment that rewards sustainable practices, making it a seemingly ideal technology laboratory and its development over the next decade, until 2025 according to the Khaleej Times, integral to the future of energy-related technology. Figure 2 shows a conceptual model for sustainable urban design, one to which Masdar City is attempting to adhere throughout its development and operation (Masdar City, 2013). Each of the six inputs below must be intertwined as shown, including transportation planning and management. Its focus is on being a pedestrian friendly community, can possibly lead to the complete elimination of private vehicles (Masdar City, 2013). Designers are following several strategies, including making “walking and self-propelled transport...the most convenient forms of transportation to many destinations within the city (Masdar City, 2013).” Strategies as simple as shaded walks and pathways and as complex as electric transit systems will be integrated to this end (Masdar City, 2013). For easy travel within the city, personal rapid transit and freight rapid transit that offer the comfort of private transportation with public transit efficiency are operational (deGraaf, 2013).

2getthere was selected to supply the ATN system for Masdar’s first phase, in which it connects the Masdar Institute of Science and Technology. The system features 10 PRT and 2 freight rapid transit (FRT) vehicles operating under the main city above on a 1.2 kilometer track accessing 5 stations. The vehicles are powered by lithium-phosphate batteries, with a range of as much as 60 kilometers that are recharged when the vehicle reaches a station. Even though this system currently only serves 500 people per hour per day, eventually the city plans to have 3,000 ATN vehicles making 130,000 trips per day (2getthere, 2013). A fleet of that size would not be necessary in Carbondale, but the vehicles and their operation methods could readily function there.



Figure 2. Sustainability model for Masdar City (Masdar City 2013).

4. City of Carbondale Comprehensive Plan (CCP)

4.1. Since June of 2010, the Carbondale Comprehensive Plan has been enacted as a...

...framework for guiding future development, redevelopment, and community enhancement in the city and its planning area over the next 20 years and beyond. The purpose of [the plan] is to establish a vision, along with realistic goals and achievable strategies, that residents, business and land owners, major institutions, civic groups, members of advisory committees, and public officials...will support...in the years ahead. (Plan Review Committee (PRC), 2013)

The foci of the plan included an overview of the city and area community, general land use and expansion potential, safety and mobility concerns, housing conditions, economic development, and implementation (PRC, 2013). Of these areas of emphasis, mobility and expansion potential directly pertain to surveying existing and possibly developing new transportation modes. One “Strategic Recommendation” is the creation of a Thoroughfare Plan, which will allot ample right-of-way for vehicular as well as pedestrian modes of travel on a more thoughtful grid (PRC, 2013). This thoroughfare plan could involve the integration of an ATN system.

In 2010, the U.S. Census designated 36 new Urbanized Areas in the United States including the Carbondale/Marion corridor in southern Illinois located along Route 13 which has a total population of 67,821. The Census Bureau identifies “urbanized areas” as 50,000 or more people; this classification allows the creation of a federally funded Metropolitan Planning Organization for Comprehensive Transportation Planning. (SIMPO, 2015) This new designation will allow for further discussions of multi-modal interconnectivity for the Carbondale area. New growth is now occurring in downtown Carbondale with a mixed-use housing project currently under construction on the south end of RT51 within walking distance of campus. A solar field is preparing for construction at the north end of the city limits. Another important item is the development of the Southern Illinois Airport campus northwest of the city in conjunction with a satellite branch of the SIUC campus, seven miles to the west of campus on RT13. Construction of a new SIUC building, the Transportation Education Center, has recently been completed and functions as a new home for the Aviation and Automotive Programs. This forms a complex that recently won a federal grant for the development of a 900 acre area with the intent of creating a new “high-tech zone. In order for the new development in this area, shown in Figure 3 to the far upper left, to reach its full potential, it must be readily accessible by public transit.

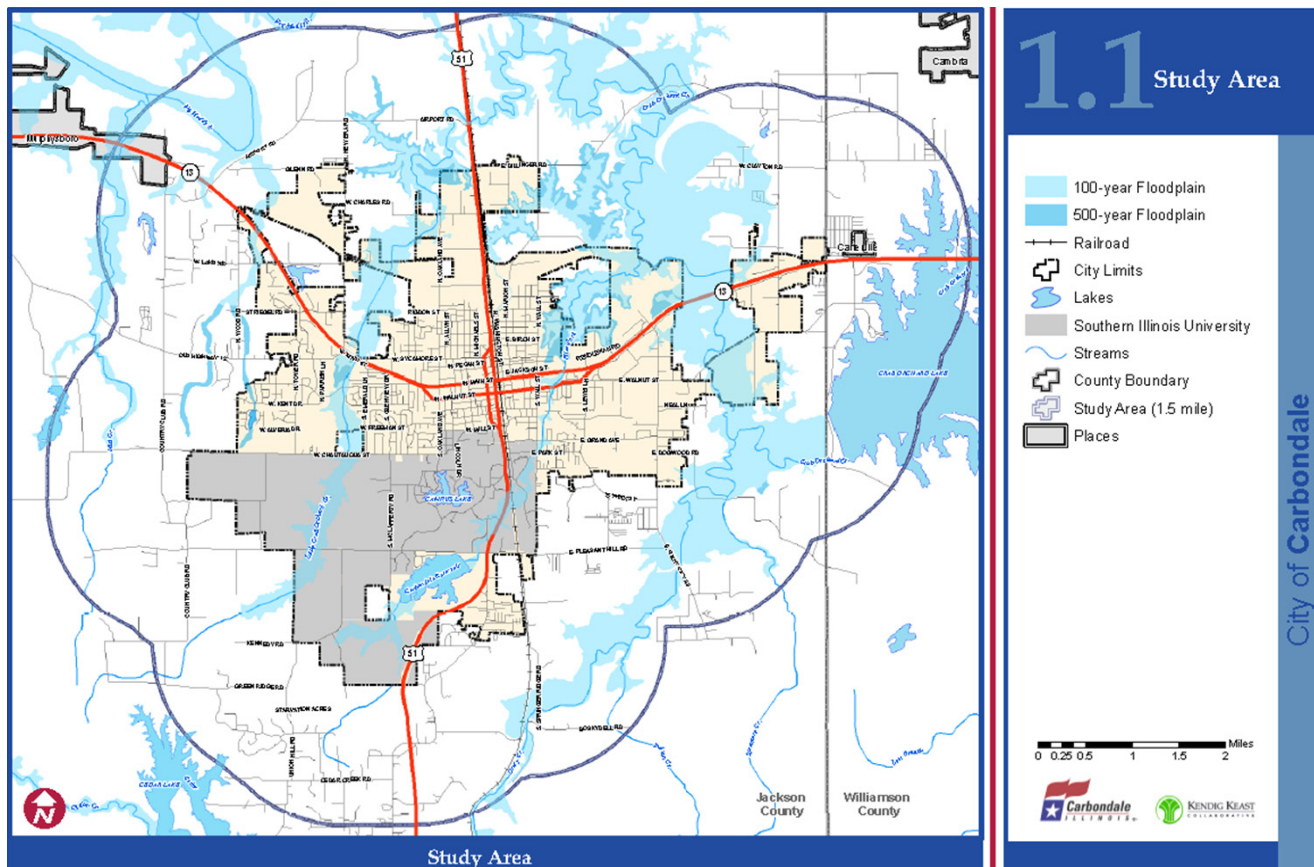


Figure 3. Study area and city limits around Carbondale (CCP 2010).

5. Existing Transportation and ATN Comparisons

5.1. Private Transportation

The private car is clearly the most prevalent form of transportation. The two key issues with being heavily reliant upon private transportation in a university-city are common ones: students without vehicles and students with vehicles and where to park them.

Carbondale has a portion of residents who do not have access to their own vehicle. For example, students from foreign countries may not feel the need for private transportation, having previously lived in an area where it is less common and SIUC students from large metropolitan areas, like Chicago may also be accustomed to readily available public transit. Student transportation modes are: 6.3% bicycle, 34.2% walk, 40.1% drive alone, 6.8% carpool, 11.1% Saluki Express, .6% bicycle, and .9% other (Corcoran, 2010). Parking challenges are handled differently by SIUC campus and the City of Carbondale. SIUC chooses to create desperately high demand for parking within its campus by creating scarcity. It then charges all students and residents for the chance to use it. This policy could potentially be very successful if used in conjunction with efficient public transit. The city handles parking in a completely different way—by supplying drivers with an overwhelming amount of paved area. The results are a city in which there is no shortage of public parking, buildings spread out and a damaged historic downtown, but at the same time little demand for public transit. Parking garages are uncommon in Carbondale; and currently, the only operational one serves Memorial Hospital. The only one existing on the SIUC campus was recently demolished as per the proposed campus master plan.

5.2. Public Transit

Public transit within Carbondale exists in two forms: a public shuttle system called the Saluki Express, and a pay-to-ride shuttle system available to all county residents called Jackson County Mass Transit. Of these two options, the Saluki Express is vastly more popular and can be used by anyone with an SIUC student ID for free. It is the primary component of Carbondale's combined transportation potential. The shuttles themselves range from 40-60 passengers and arrive at specific destinations along pre-determined routes. (Figure 4) The Saluki Express has recently been upgraded both in number of routes and real-time tracking that can be accessed by anyone on the SIUC website (siuc.transloc.com).

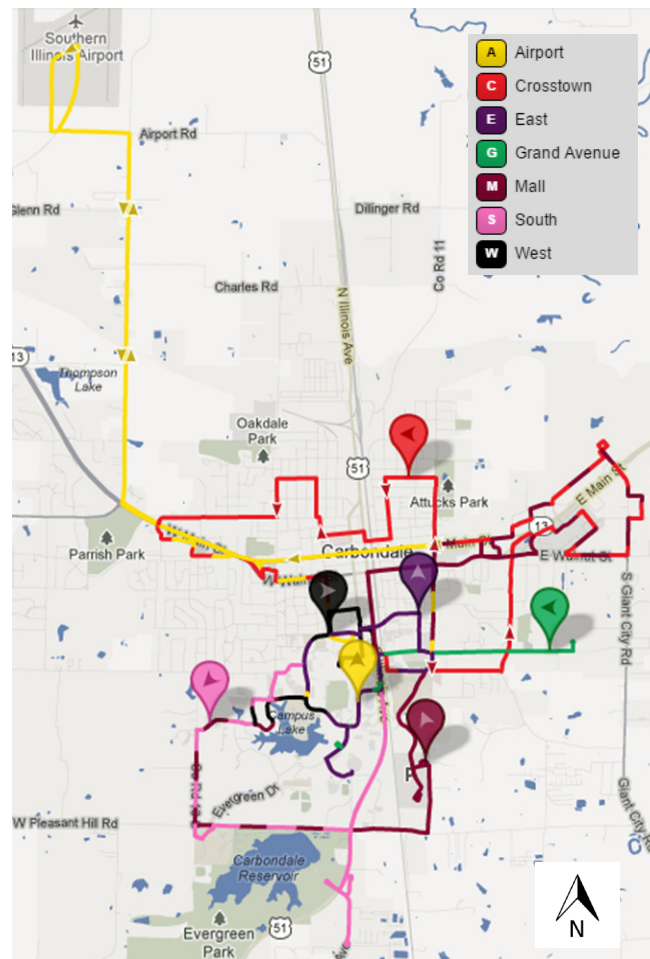


Figure 4. Saluki Express Routes and Stops.

Saluki Express (all routes) is used most of the year by as many as 264.7 riders per hour at peak times from data provided by Bill Bruns at Saluki Express office. Public transit on a regional level also serves Carbondale in the form of 3 Amtrak routes and a daily commuter bus line to St. Louis. The portion of the 21.5% of Carbondale's non-family household population, typically students, according to the 2010 US Census, that is native to Chicago frequently takes advantage of the Amtrak passenger line. This rail line is in many ways the backbone of Carbondale and is positioned for city-funded development within the next few years. Several other options are available for the mobility impaired in medical situations, although this is still quite challenging due to the rural nature and multiple state needs of those seeking non-emergency medical transit.

5.2.1. Saluki Express Ridership

Figure 5 shows ridership data, collected by the author, based on measuring the number of riders along the South route of the Saluki Express at three times of the day. This route only passes through parts of SIUC campus and south of it. Ridership at each selected time was measured on two separate days for a more objective measurement at the given point of the day. An average amount of approximately 20 riders per hour can be calculated from these three times. And, since two of the three times selected are peak commuter times, it is safe to assume that average is higher than the actual number spread across an entire day. Figure 5 gives, albeit a small cross-section of the typical 14 hour per day service schedule of the Saluki Express, a solid indication of when riders use the shuttle most frequently and at what stops along the south route. Travel time was also measured. This data shows some of the imperfections of the SES. For example, one stop along the South route picked up 4 people during stops. Qualitatively, that means that stop is greatly over-serviced and the cost of sending a shuttle there greatly outweighs the convenience benefits of the users getting on and off there. Another form of over-service by the Saluki Express is the placement of overlapping routes arriving at the same destinations at the same times, as can be followed in real time at siuc.transloc.com. While these routes lead different directions away from similar stops, they miss chances to allow riders to transfer between lines and still arrive at their destinations. This kind of change to the routes can lead to a greater time cost for riders. However, it could serve as a compromise between more evenly distributed routes and travel time. Of course, the intention of a shuttle service is to pick up passengers at a somewhat convenient destination. But at what point is the price of operating a shuttle servicing a minimally used station not cost or time effective?

Shuttle Stop	8:35AM-9:05AM (10/29/2012)		9:05AM-9:35AM (10/29/2012)		12:35PM-1:05PM (10/25/2012)		1:05PM-1:35PM (10/25/2012)		5:35PM-6:05PM (10/22/12)		6:05PM-6:35PM (10/22/12)		Total	Minutes from The Reserve	
	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF			
The Reserve at Saluki Pointe	14	3	12	8	6	8	4	6	3	0	0	4	68	-	
Roxanne Mobile Home Park	2	0	0	0	0	0	0	2	0	0	0	0	4	1	
Arnold's Market	4	0	3	0	2	2	0	0	0	4	0	0	15	3	
Student Center West	0	8	0	10	12	10	8	6	16	2	13	1	85	6	
Engineering North	0	1	0	1	0	0	0	3	2	0	4	0	11	9	
Thompson Point North	1	2	0	1	1	2	0	1	0	0	4	0	12	10	
Life Science	0	0	0	0	2	4	0	3	2	0	1	0	12	11	
Oakland & Douglas	0	1	0	0	0	0	0	0	0	0	2	0	3	12	
Law School	0	2	0	4	3	4	3	4	2	0	0	0	18	13	
Beimfohr Hall	0	0	2	0	1	0	0	0	0	3	0	0	6	14	
McLafferty Annex West	0	0	0	0	0	1	0	3	0	0	0	0	4	15	
Evergreen Terrace West	6	0	4	0	0	6	5	0	0	8	0	6	35	17	
Evergreen Terrace East	2	0	7	0	0	4	3	1	0	3	0	2	22	18	
Westwood Apartments	0	0	1	0	0	0	1	0	0	2	0	1	5	19	
Total	29	17	29	24	27	41	24	29	25	22	24	14			
Shuttle + Walking Time															
Quigley Hall															22
Morris Library															19.5
Engineering															20
Blue Barracks															24
Fanner Hall															18

Shuttle Stop (30 Min. Int.)	8:35AM-9:05AM		9:05AM-9:35AM		12:35PM-1:05PM		1:05PM-1:35PM		5:35PM-6:05PM		6:05PM-6:35PM		Total	Minutes from The Reserve (Add 0-30 Min. Wait Time)	
	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF			
The Reserve at Saluki Pointe	14	3	12	8	6	8	4	6	3	0	0	4	68	-	
Roxanne Mobile Home Park	2	0	0	0	0	0	0	2	0	0	0	0	4	1	
Arnold's Market	4	0	3	0	2	2	0	0	0	4	0	0	15	3	
Student Center West	0	8	0	10	12	10	8	6	16	2	13	1	85	6	
Engineering North	0	1	0	1	0	0	0	3	2	0	4	0	11	9	
Thompson Point North	1	2	0	1	1	2	0	1	0	0	4	0	12	10	
Life Science	0	0	0	0	2	4	0	3	2	0	1	0	12	11	
Oakland & Douglas	0	1	0	0	0	0	0	0	0	0	2	0	3	12	
Law School	0	2	0	4	3	4	3	4	2	0	0	0	18	13	
Beimfohr Hall	0	0	2	0	1	0	0	0	0	3	0	0	6	14	
McLafferty Annex West	0	0	0	0	0	1	0	3	0	0	0	0	4	15	
Evergreen Terrace West	6	0	4	0	0	6	5	0	0	8	0	6	35	17	
Evergreen Terrace East	2	0	7	0	0	4	3	1	0	3	0	2	22	18	
Westwood Apartments	0	0	1	0	0	0	1	0	0	2	0	1	5	19	
Total	29	17	29	24	27	41	24	29	25	22	24	14			
Shuttle + Walking Time															
Quigley Hall															12
Morris Library															9.5
Engineering															10
Blue Barracks															14
Fanner Hall															8

Figure 5. Collected ridership & drive time data.

Figure 6 shows detailed SES ridership data over a twelve month period in riders per hour provided by Bill Bruns, representing the Office of the Saluki Express. The peak number of riders per hour during the 2011

Southern Illinois, a generally sparsely populated region, has established dependency upon private vehicular transportation as a response by its inhabitants to the sprawling nature of rural development. Over time, this reliance has led to a general distaste for public transit, as can be inferred from the information gathered by a campus transportation survey. The overwhelming majority of survey-takers drove alone, while less than 10 percent of the over 4,000 responding student, faculty, and staff admitted to commuting on the Saluki Express (Corcoran, 2010). Figure 8 shows the beginning point of the commutes of the participants of an SIUC 2010 transportation survey, where a great deal of the land is outside of the range of a hypothetical PRT system within Carbondale (Corcoran, 2010). Therefore, an ATN system would only serve them if an intermediate parking area were provided.

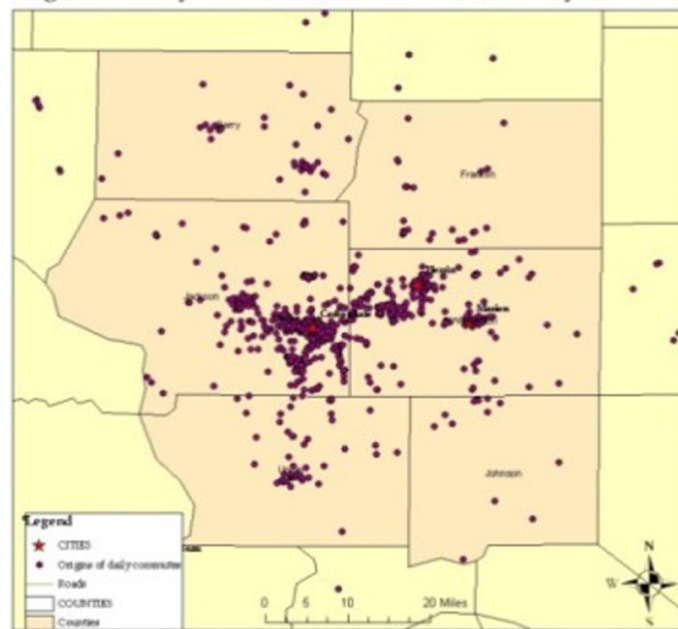


Figure 8. Origins of daily commuters for student, faculty, and staff (Corcoran 2010).

A functioning ATN system in Carbondale, such as the one in Morgantown, West Virginia could connect the disjointed small city back together. Ideally, it would have a substantially lower operating cost while moving a far greater capacity of riders more quickly than the existing public transit systems. It could also serve as a research model for sustainable energy in transportation that could be reproduced in similar small university cities.

5.4. Pedestrian & Bicycle

Walking and biking are two very popular ways to get around the city. Raised walkways over Route 51 connect the SIUC dormitory and cafeteria buildings with the central campus. Existing designated bicycle paths are noted on Figure 9. “Based on community input received, there is a call...for improved pedestrian connections citywide (CCP, 2010).” These methods of travel are perhaps the least demanding, economically, for which to create safe pathways. Therefore, the proposed campus master plan, shown in Figure 9, within the CCP has included several new pedestrian pathways.

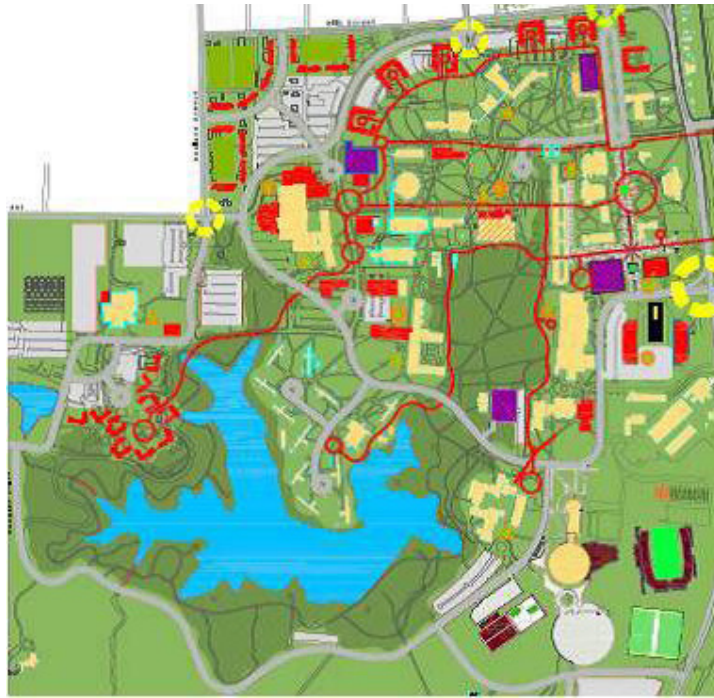


Figure 9. Proposed new pedestrian pathways, SIUC campus master plan (CCP, 2010).

5.5. Travel Time

Based on Figures 6 and 7, routes used by Saluki Express and commuters do not serve their destinations. Figure 10 shows walking times to major buildings on campus measured from the SIUC Student Center, the hub for the Saluki Express. When these are compared to the time to travel the same distance by Saluki Express, typically the choice is to walk.

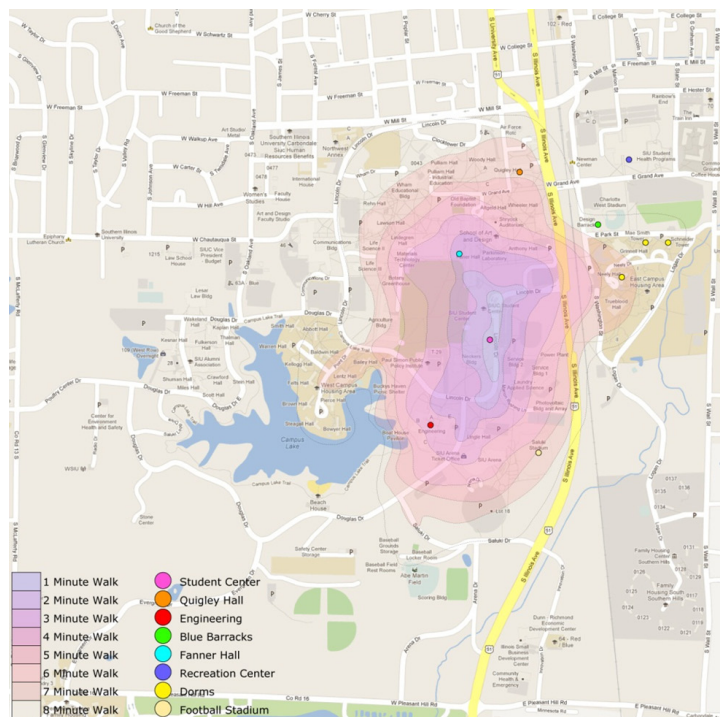


Figure 10. Travel times from the Student Center on SIUC campus.

5.6. Handicapped Accessibility

The SIUC campus itself is almost completely accessible, however spread out over a large area comprised of 8,588.63 acres, 500 buildings, and 8,932,994 building square footage. The city is less accommodating to wheelchairs due to a number of factors. Much of the paved parking area off of the SIUC campus is uneven or its primary access includes stairs. Also, due to the nature of Carbondale's growth, slowly and outwardly from the historic city center, much of the older development remains noncompliant with ADA standards. However, SIUC and Carbondale have a long and early history of accessibility as one of the first Universities to address accessibility. (SIU Library Overview, 2015) Accessibility is handled by the Saluki Express with wheelchair accessible entrances on all the shuttles. Also, the stops along its routes are at locations where disabled persons can easily reach them.

5.7. Inter-Connectivity

Connection between transportation systems within a city is vital to successful and efficient use by commuters, students, employees, and residents alike. Modal connections between private vehicles and Saluki Express shuttle routes are very limited within the SIUC campus. Outside the campus, only a few routes have stops within or near parking areas. Inter-connectivity between Carbondale's existing transportation systems could hypothetically allow a commuter to travel to Carbondale, either by train, bus, or private vehicle, and then transfer to a Saluki Express shuttle, Jackson County Mass Transit shuttle, or car pool before reaching a terminal destination. However, without dramatic redesign of these systems' routes and time tables, this kind of commuter usage would be an inefficient use of time.

If the PRT system throughout Carbondale were further connected to surrounding population centers by larger scale transportation systems, it could possibly spur a revitalization of the currently economically depressed Southern Illinois region and provide access to more opportunities. The addition of a completely new mode of public transit would undoubtedly require a concentrated effort by the Carbondale City Council, SIUC administration, and Carbondale's citizens together to ever be realized.

5.8. Major Activity Areas

The greater Carbondale area can be simplified into three major destination areas: the historic downtown 'strip,' the sprawling corridor along Highway 13 that connects with Marion, IL, and the SIUC campus. The historic downtown is the center of the city. The Carbondale Civic Center, City Hall, and Amtrak station are located on adjacent blocks along with a string of small businesses along Route 51, forming the 'strip.' The land along Highway 13 through Carbondale has almost completely become, as commercial interests have developed throughout the years, a string of strip malls, big box stores, and franchise restaurants. Its resultant current state is approximately two miles of unlinked destinations which are only realistically accessible by vehicle. This entire corridor could be serviced by two PRT lines following Highway 13 on its north and south. There is typically ample space on both sides of the highway for the addition of new PRT lines. However, due to the number of intersections these lines would encounter, it would be more efficient to remove them from grade to prevent liability, as Robbert Lohmann has stated. Using the figures of 10 vehicles transporting 500 people per hour per day by Masdar City's current PRT system, it can be stated that a similar system could hypothetically handle the peak monthly ridership per hour of approximately 264 on the Saluki Express (Masdar City, 2013).

5.9. Energy Challenges

Energy conservation relating to transportation is something that has yet to be addressed in Carbondale. Saluki Express transit fuel costs include diesel fuel and coal. Diesel fuel must be supplied to operate the shuttles

day to day. Coal is burned at a plant within the SIUC campus to supply heat and electricity for operations, maintenance, and lighting at stops along the routes. SIUC's power plant has employed a circulating fluidized bed combustion boiler for the last sixteen years; and it is currently conducting research concerning alternative energy resources like biomass for heating campus boilers (Coal Research Center, 2013). These traditional energy production systems are common throughout Southern Illinois. However, according to Robbert Lohmann of 2getthere, a personal rapid transit design company, they result in a higher operational cost than automated systems which also produce some of the energy they consume.

This project is designed in the interest of balancing energy production and consumption as much as possible, while maintaining its original goals. This project includes two systems that convert a form of energy into electricity. The first system converts light into electricity through a massive array of 750 polycrystalline photovoltaic (PV) panels. They cover the long, narrow north-to-south roof of the parking garage on the proposed downtown multi-modal master plan. The other power production system in this project converts kinetic energy into electricity through a series of devices in along the rail line. Invented by researchers from Stony Brook University in New York, this device can reliably convert railway vibrations into Watts of electrical power (Ridden 2012). Over the course of this multi-modal station's life, that power will supplant a tremendous amount of energy load.

6. New Synergies

6.1 Simulations

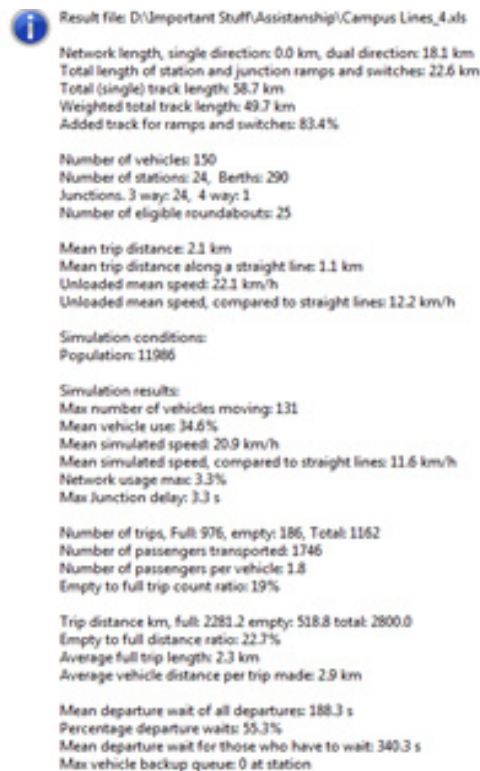


Figure 11-A. Data and Map of Beamways Simulation and campus station locations.

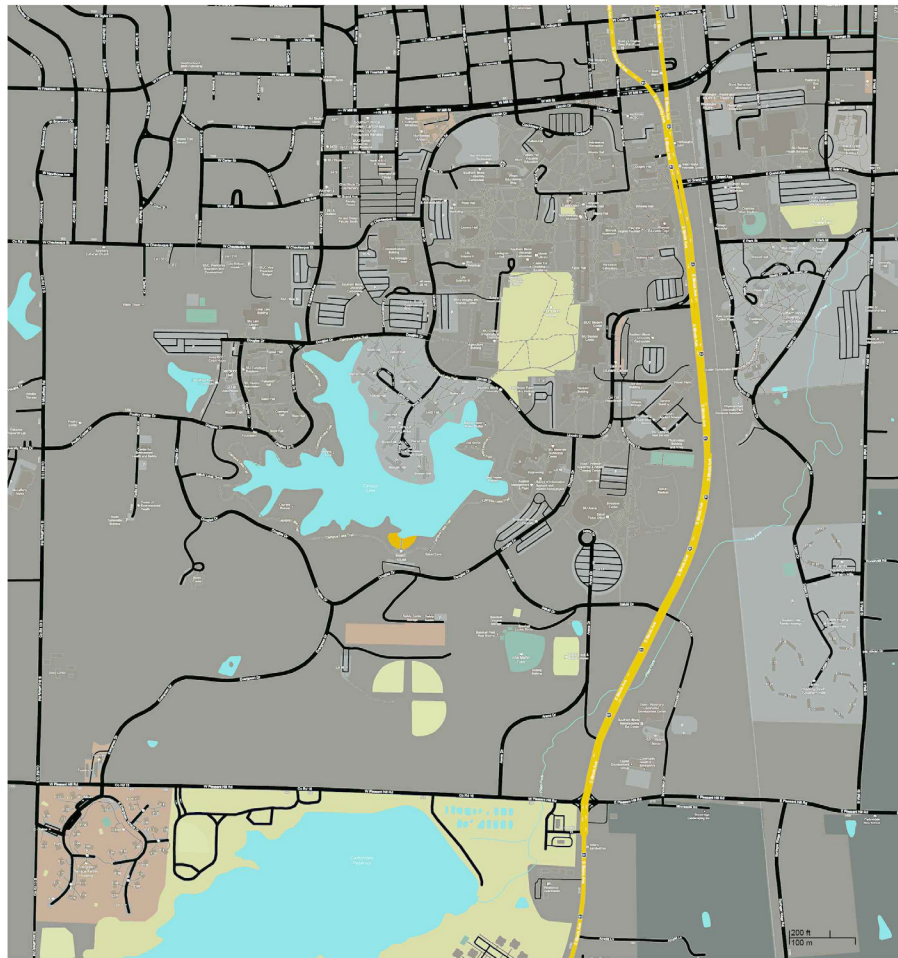


Figure 11-B. Data and Map of Beamways Simulation and campus station locations.

A simulation model was created in BeamEd software of a SIUC campus ATN system, this includes 25 stations on 50.5 miles of guideway (81.3 km). (Figure 11) That distance accounts for 2-way traffic, ramps, and switches. This simulation, after running for 1 hour, estimates that 44.7% of users who arrive at a station will have no wait. The rest of the users will have to wait an average of 5.6 minutes, assuming that 150 vehicles are operating in the system. The high cost factors of this system are multiple stations per mile of guideway and elevated crossing points. The cost effective items are: 10 miles of guideway, high percentage of at-grade guideway, simple stations, lower regional construction costs, and high use of standard components. This system could be optimized with further study.

6.2. Campus Connections

Connection between the major (and minor) destinations could be improved greatly by a series of PRT lines. Figure 12 conceptually shows where these new lines could be placed within the SIUC campus. Most of the proposed PRT lines follow existing roads and paths, in an effort to limit potential capital costs. In areas where a series of intersections are unavoidable, the proposed lines would either be raised off the ground or travel beneath the grade (depending on the cost). Beyond the campus the city could be connected with the ATN system linking the parks and green spaces of Carbondale.

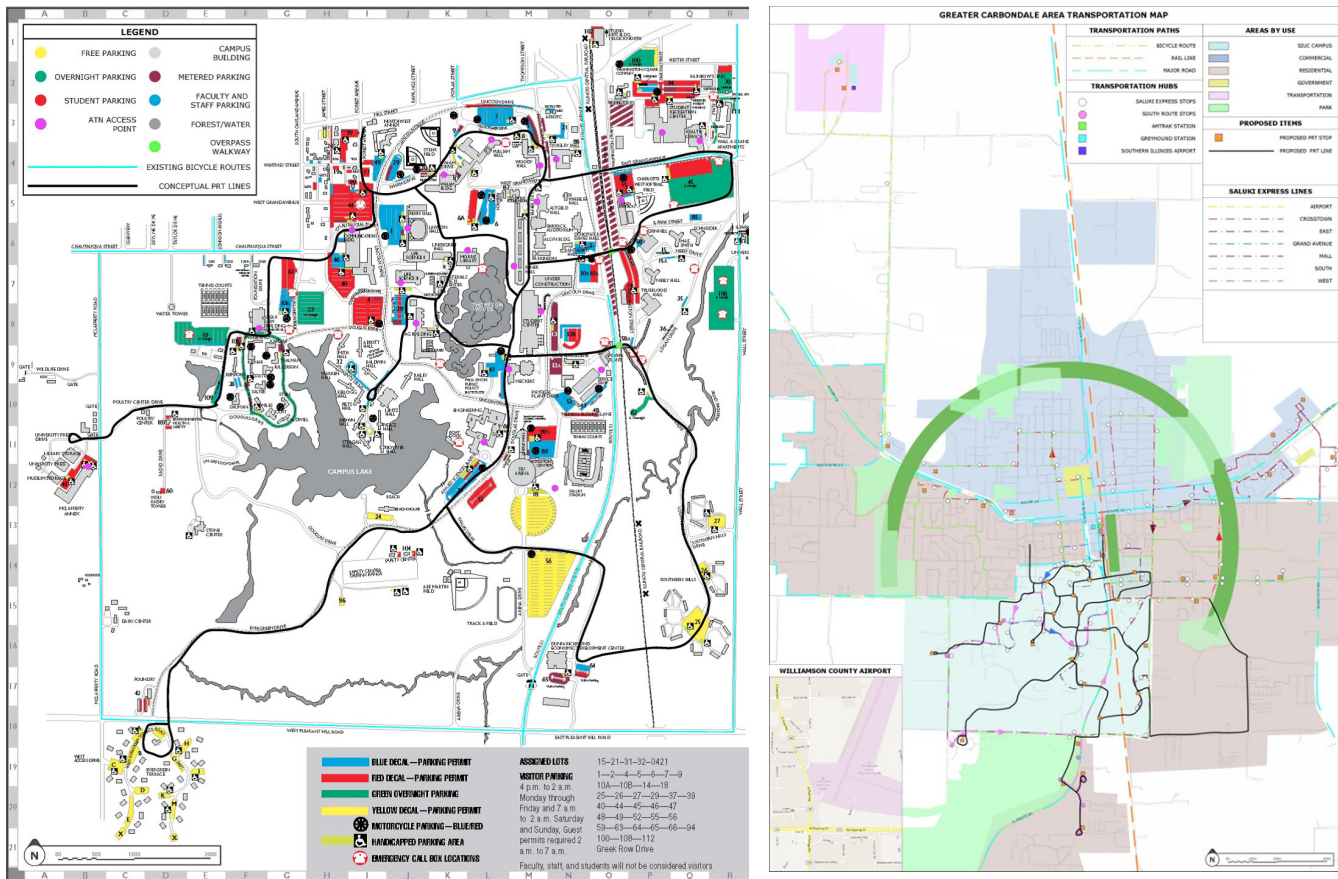


Figure 12. Connections between activity centers within the SIUC campus, provided by SIUC parking division.

6.3 Multi-Modal Transit HUB

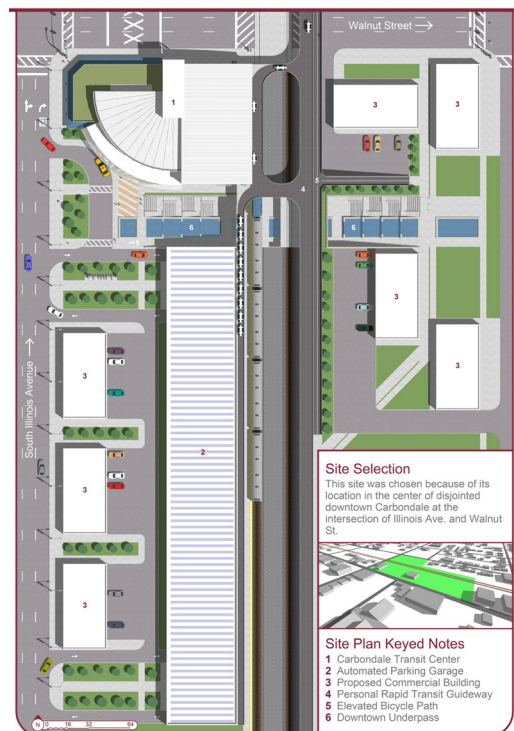


Figure 13-A. Downtown Plan and section through Multi-modal station.

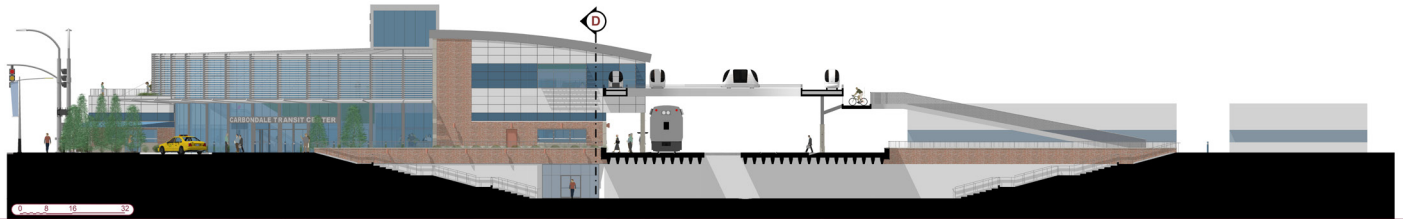


Figure 13-B. Downtown Plan and section through Multi-modal station.

7. Conclusions

7.1 Community

In the recent Beyond Traffic Report it was reported that:

“Transportation plays a major role in promoting economic growth and livability in communities across America. Transportation projects create new jobs, expand the gross regional product, increase property values and tax bases, and improve the overall quality of life. Transportation supports economic growth through short-term stimulus impacts and longer-term impacts on economic productivity. In assessing the economic development impacts of transportation, economists at University of Minnesota’s Center for Transportation Studies have demonstrated that careful investments and well-designed transportation projects can yield substantial economic benefits that greatly exceed overall project costs.

Consider, for example, the case of East St. Louis, Illinois—an industrial suburb. For decades, the city’s economic and demographic situation has been bleak; the city lost more than two-thirds of its population between 1950 and 2010 as a result of deindustrialization and economic decline. Despite these challenges, in the early 2000s planners and citizens were able to capitalize on the eastward expansion of the St. Louis light rail system—MetroLink—to enact a transportation vision that promised a brighter future for the area. The construction of a MetroLink station in the Emerson Park neighborhood helped link low-income residents with job opportunities in the Greater St. Louis area and spurred a series of transit-oriented affordable housing projects for local residents. The rail station also helped persuade lenders to finance mortgages and began to attract developers, retailers, and employers to the area. More than ten years later, the station is still spurring economic development, including a recently-opened \$22 million mixed-use apartment complex (Foxx, p.179).

This paper discusses how an automated transit network (ATN) can alleviate the transportation problems in the Carbondale area by comparing the benefits and detriments of ATN and traditional transportation modes. By simulating the ridership per hour potential and comparing resultant efficiency based on travel time, ATN can move a person from point A to B much more effectively than car, bus or shuttle. On a small city university scale, ATN holds the potential to address an entire small rural community’s transportation problems and provide a viable option to private automobile use within its city limits.

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