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EVALUATING TRANSIT SYSTEMS IN A UNIVERSITY ENVIRONMENT THE CLEMSON UNIVERSITY CASE STUDY

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EVALUATING TRANSIT SYSTEMS IN A UNIVERSITY ENVIRONMENT
THE CLEMSON UNIVERSITY CASE STUDY

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ABSTRACT

With the economy in a slow recovery, enrollment in higher education is increasing. This means that universities across the country must accommodate these new students, their vehicles, and local transportation needs. Campus setting and ambiance is a treasured quality on a university campus resulting in the approval of additional surface lots and parking garages being difficult or restricted. To combat the increased number of single occupancy vehicles, universities are developing and encouraging the use of multi-modal transportation by providing pedestrian, bicycle, and public transportation facilities along with providing users with the information necessary to make the optimal modal choice (Boyles, 2006).

This research developed a framework to evaluate transit in the context of mobility currently on a university campus. The framework includes a process that any university can utilize to evaluate its current and future transit efficiency levels and identify solutions through an integrated process of planning, operations, and performance monitoring. Clemson University's campus in Clemson, South Carolina serves as a case study for the test application of this process. This study evaluates Clemson University's performance in providing adequate transportation options to the university community in comparison with similar universities. Customer satisfaction surveys are used to determine deficiencies from the user's perspective. Traffic simulations and a matrix alternative analysis have evaluated several alternatives developed through integrating the results of transit capacity surveys, user surveys, and considerations for pedestrian and bicycle

traffic to create seamless operations and optimal function of all transportation modes available.

The case study presented in this thesis can serve as a guide to university campuses beginning to have significant mobility problems. It also provides an insight into the institutional or organizational structures that facilitate efficient, high-quality transportation services, which can guide universities to pursue structural or policy changes to improve mobility. Although the process is tailored for small- or medium-sized universities outside of urban areas, the evaluation framework can be customized for use at any university regardless of its size or location.

DEDICATION

This work is dedicated to my mom and tato for supporting me and pushing me to always strive for the best. It is also dedicated to my fiancé for his patience and willingness to read anything I write. Thanks for everything.

ACKNOWLEDGMENTS

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CHAPTER ONE

INTRODUCTION

With the economy in a slow recovery, enrollment in higher education is increasing (Census, 2009). This means that universities across the country must accommodate these new students, their vehicles, and local transportation needs. Campus setting and ambiance is a treasured quality on a university campus resulting in the approval of additional surface lots and parking garages being difficult or restricted. To combat the increased number of single occupancy vehicles, universities are developing and encouraging the use of multi-modal transportation by providing pedestrian, bicycle, and public transportation facilities along with providing users with the information necessary to make the optimal modal choice (Boyles, 2006).

Transportation requirements vary based on a number of factors including setting, existing transportation infrastructure, and the needs of the users. For instance, if a satellite campus is located 30 minutes from a university's main campus a shuttle might be required or if it takes an average person 15 minutes to walk across the main campus a form of transit may be necessary. The transportation needs of a campus are different at every location.

No two universities are exactly alike; however, many school administrators believe institutions need to grow in order to survive or stay competitive with other schools (Toor, 2004). In a society stressing the need for economic and environmental sustainability, growth in the realm of transportation is necessary. For decades, the automobile has been the primary mode of transportation for the nation (U of Michigan, 2009). Transportation problems on university campuses traditionally have been solved by expansion of surface parking lots (Boyles, 2006). Currently, campus transportation systems must adapt and compete with an increase in student enrollment and accompanying vehicles, “a growth that strains parking and claims space for new educational facilities while increasing traffic and congestion” (Miller, 2001). The conflict over the diminishing available space on university campuses has led many planners and administrators to implement transportation demand management (TDM) techniques. These techniques include carpool programs, car share programs, transit systems, and bicycle share programs. All these programs are aimed at reducing the dependency on single occupancy automobiles, therefore creating a more economically and environmentally sustainable transportation system that will help a university grow. The question lies in which of these programs are appropriate for a particular campus.

Transit systems are an integral part of many universities’ transportation plans to control traffic on campus. Many universities have either implemented their own transit systems or contracted with local transit providers to operate transit on their campuses. Traditionally, an objective of transit systems has been to increase ridership; this mentality can prove at odds with a multi-modal university transportation goal. In a survey released to 94 transit agencies that serve university and college campuses and communities in *TCRP Synthesis 78*, most systems “reported an overall aim to increased transit ridership, yet many respondents indicated that an ultimate goal is to shift away from single occupancy vehicle trips to other modes, regardless of what actual alternative mode is used” (Krueger, 2008). It is this recognition by transit agencies that creates the unifying mission to improve a transportation system at a university and within a community.

The objective of this research is to develop a process for evaluating a campus transit system. Additionally, this project develops a case study to assess the process developed for evaluating a campus transit system. The findings from this research should support university administrators and planners in meeting their campus-wide mobility goals.

Clemson University is located in the fringe city of Clemson, SC. Clemson University's transit system, operated by Clemson Area Transit, was chosen as the case study to test the effectiveness of the evaluation process. Currently, the university is undergoing expansion of its academic facilities on sites of existing surface parking. Due to state legislation, the university is not allowed to use construction funds to recreate those parking spaces elsewhere; thus, causing a shortage in faculty, staff, and student parking. Therefore, transportation planning and campus mobility have moved to the forefront of conversation at the university, which serves as a prime location to test such an evaluation process.

The following chapters describe the evolution and performance of the evaluation process. Chapter 2 describes what is currently published about the culture of a university, the evaluation of transit systems, and decision making approaches. Chapter 3 states the methodology used to develop the transit system evaluation process and the case study at Clemson University. The evaluation process and results of the case study are presented in Chapter 4 followed by the conclusions in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW

Mass transportation by bus, from an omnibus to an articulated double-decker, is one of the oldest methods of moving people. Bus transportation is increasingly being utilized around the world, and particularly in university settings. This review of literature explores the unique characteristics of a university campus environment, the parking requirements at universities, and what methods and techniques are currently employed by transportation planners and evaluators to plan and assess transportation services.

Unique Characteristics of a University Campus

Universities are defined by different attributes depending on the demographic speaking. Students might define a university by its school spirit, athletics, or degrees offered while an administrator defines the university by its retention rates, services offered, and national ranking. Rarely do two people evaluate an entire university on the exact same criteria so it is expected that the transportation system at a particular university would also be viewed with varying criteria. “The high degree of variability makes each academic institution an individual case for planning; however, [they] are more likely to operate under centralized management, providing greater leverage for implementing transportation policies and options” (ITE 2009). A survey released to 71 transit agencies serving a university and/or its surrounding community reported that 70 percent have had an impact on transit cost, service, and/or effectiveness as a result of changes in campus demographics, student body composition, or student residential locations (Krueger, 2008). Transit systems operating in a university setting are challenged with assured turnover as students are entering and graduating every term – all of them coming from different communities and transit experiences. For many students, going to a university will "be their first real experience with pedestrian- and bicycle-friendly design, or with accessible transit" (Toor, 2004). It is essential that a university recognizes and embraces this reality. A university can produce a generation of alternative mode users, such as transit, bicycling, or walking, or it can produce a generation further rooted in auto-dependency. "University policies towards transportation on and off campus including student auto ownership; parking availability and financing; transit availability and financing; and parking priorities" will shape the travel patterns and mode choices of its students while at the school and into the future (ITE, 2009). Thus, universities have a tremendous responsibility for educating and training new generations of sustainable transportation system users.

Parking Dependencies at Universities

All universities, large or small, urban or rural, must accommodate parking. There are a myriad of options and systems that can be used to control parking throughout a campus. Across the United States, two dominating parking management models are used at universities – the economic model and the political model (Shoup, 2007). The economic model relates parking prices with the cost of supplying parking and/or the convenience of the space obtained. The political model ranks parking permits and defines which spaces or zones where drivers are eligible to park based on their positions (i.e., student, faculty, staff) and sometimes ranks (i.e., freshman vs. senior; assistant professor vs. full professor) in the university. Parking availability is rapidly becoming a heated issue with university administrators finding themselves "in the difficult position of deciding between the construction of expensive parking structures or searching for ways (which can be politically unpopular) to substantially reduce parking demand" (Balsas, 2003). In 2003, a university could initially expect to pay between $15,000 and $30,000 per net new parking space constructed within a parking structure (Toor, 2004). The expansion of parking through structures intensifies the debate over land use: is the expansion of academic facilities or the transportation system more important? As Hoel (2004) notes, "most development is [occurring] on previously used land – often surface parking lots – in the central campus."

Parking demand is influenced by a number of factors including city and campus transit services, student to staff ratios, parking policies, class schedules, and on-street parking in nearby neighborhoods. As parking demand exceeds availability, "determining an appropriate pricing rather than quantity of spaces is the issue" (Shoup, 2007). 95% of campuses surveyed in *TCRP Synthesis 78* charged a fee for parking; however, the majority of universities and government/transit agencies agree that their parking fees do not deter people from driving (Krueger, 2008). Universities are faced with the challenge of balancing pricing and supply with the availability of limited or remote parking facilities. As parking is forced outward and universities are running out of space to build more parking facilities, transit is becoming an attractive alternative.

Necessity of Transit and Innovation

The most successful services are well targeted to serve an identifiable transportation need or opportunity (Pratt, 2004). The connection between central campus and its parking facilities (campus circulation) and the connection between a university and its community could not be a more identifiable transportation need and an opportunity for growth for the university and the community. At universities with transit, and those developing a system, two questions must be answered to determine if the system in place is the best for the university and the community:

1) Is the system meeting all of the needs in the service area?
2) Is the system perfect in every way? (KFH Group Inc, 2001)

If the transit planners can confidently say yes to these questions, then the system created should service the needs of all users and be an attractive alternative mode of transportation. If a confident yes cannot be mustered, then change specific to the needs of the university and/or the community is necessary - change through innovation. Innovation is a locally driven process that succeeds where organizational conditions foster the transformation of knowledge into products, processes, systems, and service (Hikichi, 2008). Nowhere better can innovation be fostered than at a university where students are challenged daily to think critically and encouraged to explore new ideas. For transit agencies to capture the innovative potential of a university, a culture of innovation must be established. A culture of innovation suggests that an organization is able and willing to change and improve when necessary (KFH Group Inc, 2001). For a transit agency not to capture this innovation reduces its responsiveness to its riders and it can become a prisoner to the past.

As transit organizations look to evolve and adapt to the wants and needs of universities, a focus on quality is imperative. Quality is important to gain community standing and credibility, which then offers leverage to try new and different things (KFH Group Inc, 2001). Universities shape the mode choices of thousands of people throughout the world and pose a unique opportunity to experiment with a transit system to find out what methods and technologies are effective. As Krueger (2008) states, "systems hope to appeal strongly to college students, who are often more tech savvy and are also more likely to use transit to get around than other groups, and who are perceived as the "next generation" of riders that transit systems aim to attract to habitual use." The opportunity to experiment is present, but there are many other factors that might restrict those opportunities. In the 2008 study performed by Hikichi, the two most prevalent limiting factors in innovation were cost and a champion. Without a person dedicated to the improvement of a system and the financial resources available to try something new; innovation can be unfruitful.

Potential Partnerships

Universities and government agencies have different funding opportunities afforded to them. Government agencies are able to leverage taxes, appropriations, and state and federal grants to operate their transit systems while universities predominantly use student fees, school general funds, parking fees, and advertising revenue (Krueger, 2008). It is customary that to receive a federal or state grant, a local match ranging from

20% to 50% must be made in order to receive the funds. An effective partnership between a university and a transit agency can create leveraging opportunities that alone neither entity could attain. In a study published in 1999 by Cambridge Systematics Inc, "many universities rethought both parking and transportation policies and have either abandoned their own separate transit operations or successfully downsized and integrated them with local public transportation services." Effective partnerships can help leverage federal money otherwise unavailable to a university and community in order to create the most effective transit system possible.

Universities can also provide another benefit to a transit agency – consistent ridership. In an article entitled *Effects of Bus Stop Consolidation on Passenger Activity and Transit Operations*, "optimal transit service can be characterized by a limited number of stops with high and predictable passenger activity and few service reliability problems" (El-Geneidy et al, 2008). Through appropriate planning and policy making, bus stops on a campus can be limited to specific locations based on the needs of the students who in turn will likely provide the high and predictable passenger activity required. Service reliability must be continually managed in order to maintain optimal service. Capacity problems and service frequency at peak class times are generally the most common reliability problem on a university campus. In 2007, 100 public transit agencies reviewed cited partnering with a university and other schools as the most frequently used specific strategy for increasing ridership (TranSystems et al, 2007). Increasing ridership levels is essential when competing for appropriations as it is a common metric in funding formulas across the nation. Partnering with a university can open many opportunities financially for a transit agency and a university can benefit from a transit agency by providing greater mobility to its students. “An atmosphere of coordination and cooperation between a university and its surrounding community will help to produce mutually beneficial short- and long-term transportation plans” (Boyles, 2006).

An Effective Transit System

The goal of transportation professionals in all areas of transportation, including transit, is to create a sustainable transportation system. A sustainable transportation system can be defined as one that (Vuchic, 1999):

- Allows the basic needs of individuals and societies to be met with safety, in a manner consistent with human and ecosystem health, and with equity within and between generations;
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy, and
- Limits emissions and waste within the planet’s ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

To make a more sustainable transportation system at a university, alternative modes such as walking, bicycling, ridesharing, and taking mass transit must be encouraged. Pratt (2004) states “for patronage to be attracted to a bus route or system, the operation must first and foremost connect points between which there is a significant demand for travel.”

On a university campus, origins and destinations can be easily determined through the examination of travel patterns or campus activity levels. For many schools, the connection of remote parking facilities and the core of campus serve as very viable transit possibilities. In developing a route total travel time must be minimized. “Passengers seek to minimize their combined in-vehicle and out-of-vehicle travel times, with the latter carrying a higher implicit monetary penalty” (El-Geneidy et al, 2008). Out-of-vehicle travel time includes walk time to a bus stop, wait time for a bus to arrive, walk and wait times related to transfers, and the walk time to the final destination. All these factors contribute to the user’s perception of convenience and quality. If a system is not perceived as convenient and easy to use, it will not be considered attractive and it will not reach its ridership potential. Pratt (2004) identified several characteristics, which when used in a majority on a route, can lead to greater operating efficiencies and ridership growth:

1) Emphasis on high service level core routes,
2) Consistency in scheduling,
3) Enhancement of direct travel and decrease of transferring,
4) Service design based on quantitative investigation of travel patterns,
5) and Favorable ambient economic conditions.

A focus on these core areas can lead to a better transit system and increased ridership. One notable area not mentioned in Pratt’s list is the use of fares. Fare integration, that is allowing a passenger to use one form of payment regardless of the system or route used, is further enticing more riders to transit systems because of its ease of use. There is a growing trend among universities who are partnering with local transit agencies to provide unlimited access passes (U-Pass) to students, faculty, and staff. These passes are provided when a “fee is paid by the university (and often passed on to students and/or staff, explicitly or indirectly) to purchase or reduce the price for unlimited-ride transit passes on a local transit system” (Krueger, 2008). U-Passes are increasing operating efficiencies on university campus by reducing or eliminating the need to collect fares at transit stops, thereby reducing dwell times at stops and overall in-vehicle travel times. U-Passes, service expansions, and restructuring of routes have led to a tripling of system wide ridership in several university towns (Pratt, 2004). Finding the optimal transit route on a campus might take several iterations and a solution that works one year might not be the best one three years later. Changes to class schedules, new academic buildings, the location of residential housing on and off campus, parking policies and lot designations, and the demographics of the university all affect where students, the primary users, need and want to go. The dynamic transportation system at a university necessitates constant investigation and evaluation of its transit system to ensure that the highest quality service is provided.

Evaluating a Transit System

Throughout the nation’s history there have been many different approaches to transportation planning and evaluation. In the 1960s and 1970s when the baby boomers went to college, mobility problems were solved by adding infrastructure – more roads and more parking lots. This limited approach to transportation planning brought (Balsas, 2003):

- An almost exclusively auto-oriented approach,
- Ineffective solutions to modern transportation problems,
- “Built-out” urban areas, and
- Severe constraints on financial resources.

When this system was evaluated in its time, it was deemed to be effective and solved the problem. To evaluate a system without planning for the future is like a dog chasing its tail; it is entertained but it is not accomplishing anything. It also must be recognized that “a transportation system is usually planned, designed, built, operated, and maintained by organizations and individuals with different objectives, mandates, constituencies, and problem definitions” (Meyer & Miller, 2001). In the development of an evaluation process, all stakeholders and constituencies must be considered. To favor only one party’s objectives will lead to a rejection of the results and animosity between the stakeholders. Ryus (2003) identifies four points of view that transit performance should be addressed from:

1) Customer = passenger perceptions and quality of service
2) Community = impact on community and role in meeting broad community objectives
3) Agency = efficiency and effectiveness of the service
4) Driver/Vehicle = performance measures predominately used by traffic engineers such as average travel speed and delay.

Safety can be considered another perspective; however, safety is also an issue in which each perspective should agree is priority but might have different methods of addressing it. Transit performances from these perspectives need to be evaluated for current conditions and expected future conditions. The demographics of university might change in an unpredictable manner but the growth of the university and the surrounding community is traditionally based off a plan. That land use plan should be tied to the transportation plan and the evaluation of the transit system while considering the points of view above.

A performance measurement system can be structured in a myriad of ways to fit a particular community, agency, or university. In a performance measurement model developed by Nakanishi and List (2000), some key characteristics that must be present, no matter the form, for a performance measurement system to be effective:

- Stakeholder acceptance,
- Linkage to goals,
- Clarity,
- Reliability and credibility,
- Variety of measures,
- Number of measures,
- Level of detail,
- Flexibility, and
- Realism of goals and targets.

All of these characteristics are reflected in the programs to establish a performance measurement system found in such references as *NTCRP Report 8* released in 1984, *TCRP Report 88* released in 2003 and *Transportation Planning Handbook, 3rd* *ed.* released in 2009. The premise behind a performance measurement system has been the same for decades, but the value of such systems has been lacking throughout agencies across the country. With passing of Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users [SAFETEA-LU (Public Law 109–59, 109th Cong., August 10, 2005] making grant money dependent on a performance measurement system, universities and transit agencies will need to work ever closer together to achieve greater mobility on campus and around the community.

Before a process that integrates planning, operations, and performance management into one process, a review of existing process was necessary. Frameworks available in transportation planning were the first subject investigated as possible alternatives to include in the process being developed. The Transportation Planning Handbook offered a planning framework for large institutions which included colleges and universities. This framework is shown in Figure 1 and served as a foundation for the planning aspects of the framework developed. A performance based framework developed for the Federal Highway Administration Highway for LIFE program, a program that represents longer-lasting highway infrastructure using innovations to accomplish fast construction of efficient and safe highways and bridges, demonstrates the importance of bringing stakeholders together and fostering innovation (See Figure 2).

Managing operations involves not only the management of the labor performing an operation as it is managing the assets that are needed. Multiple processes have been developed for transportation asset management all over the world which directly impacts the operations of a system. The FHWA described transportation asset management as a “systematic, fact-based, and reproducible decision-making approach to analyzing the tradeoffs between investments and improvement decisions at the system and project level” (Cambridge Systematics, 2002). It is that belief that led to the creation of the process shown in Figure 3 and one that universities should embrace because it removes the personal beliefs and can bring transparency to decision making. In Victoria, Australia, an integrated approach to asset management and service delivery is utilized across all assets and government departments. The Australian approach emphasizes the examination of an entire asset base instead of individual asset during a decision making process. That same approach is essential in when evaluating a transit system on a university campus because it is not the transit system that must be evaluated rather it is the entire transportation network. An illustration of the Australian approach can be seen in Figure 4.

Several frameworks found were designed to customizable to meet the needs of organizations in “different policy, institutional, organizational, technological, and financial settings” (Cambridge Systematics, 2002). One such framework was designed by Cambridge Systematic (2002) for the American Association of State Highway and Transportation Officials (AASHTO) in order to provide a framework that could be utilized with a broad view or narrowed down to fit a more manageable scope (see figure 5).

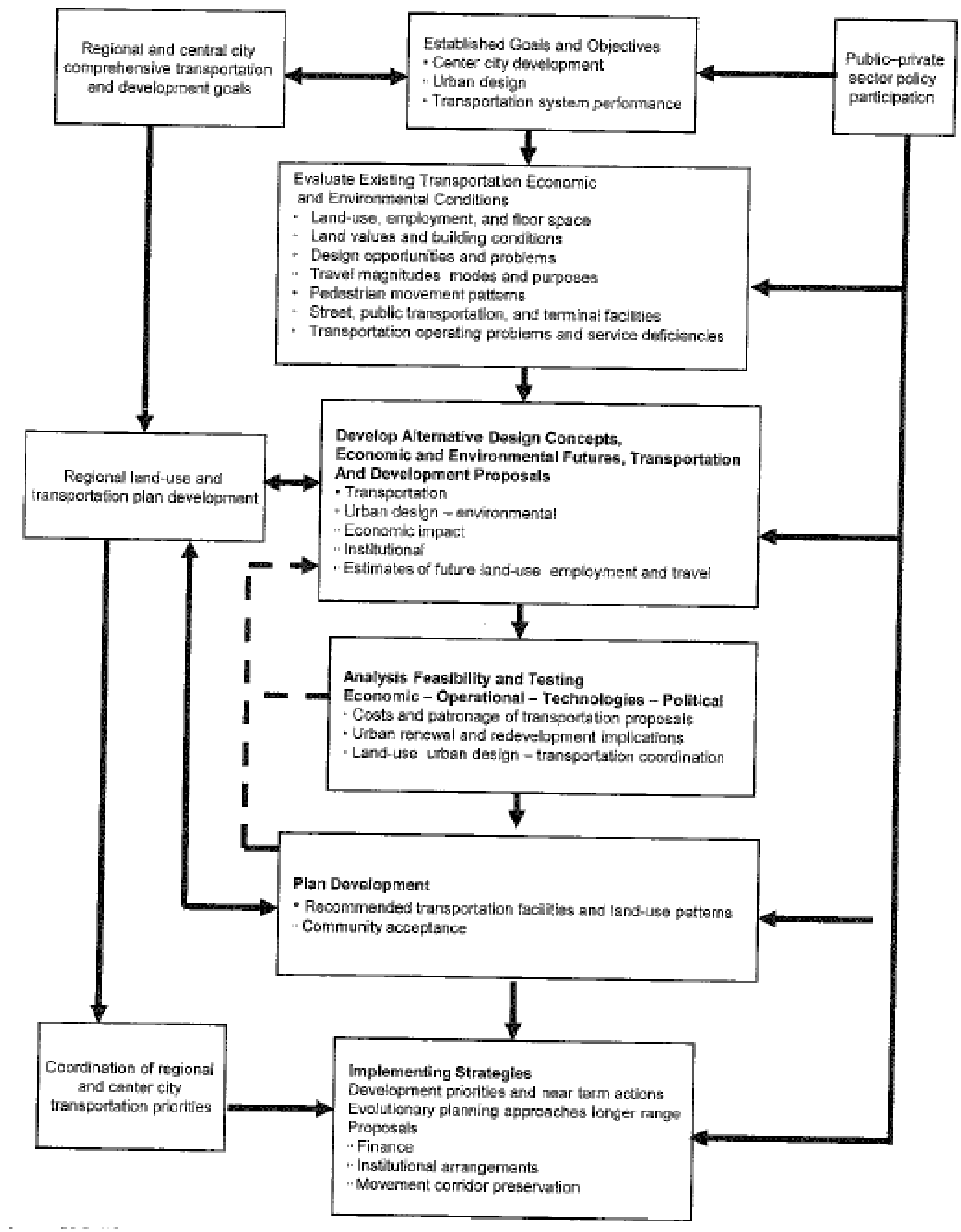

Figure 1: Planning Framework for Large Institutions (Source: ITE, © 2009)

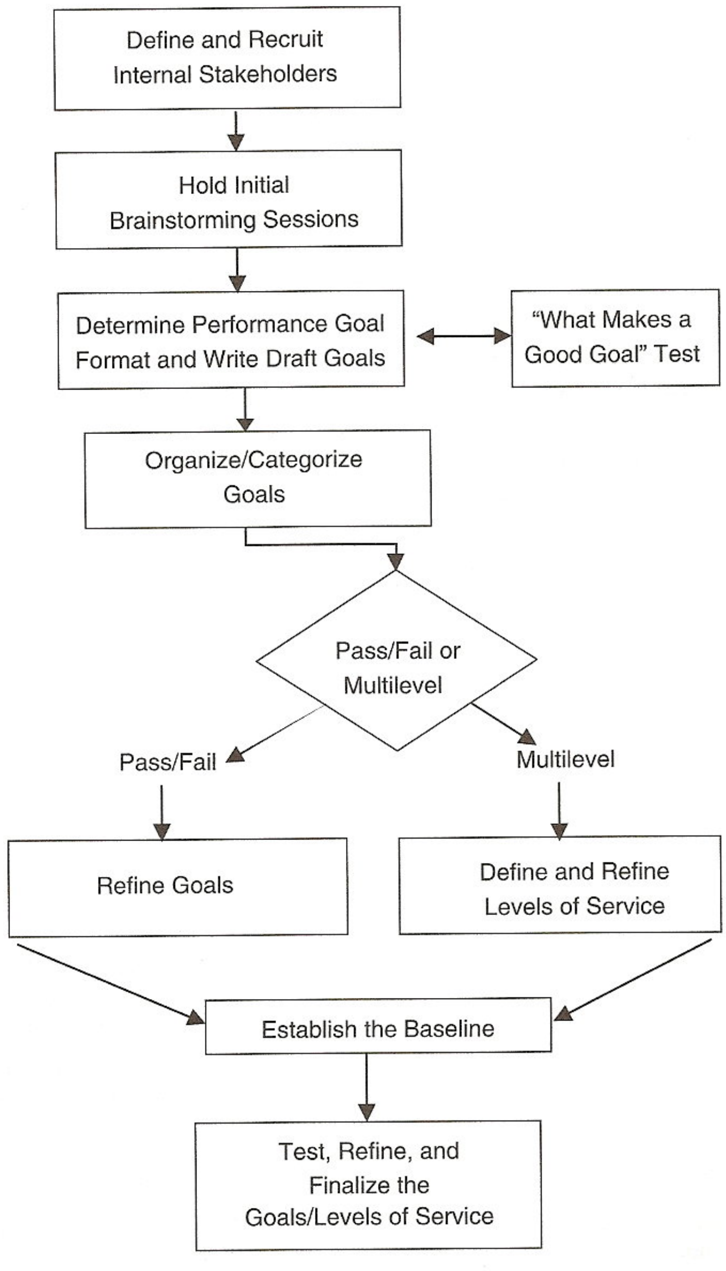

Figure 2: FHWA Highways for Life Performance Framework (Source: Scott, 2008)

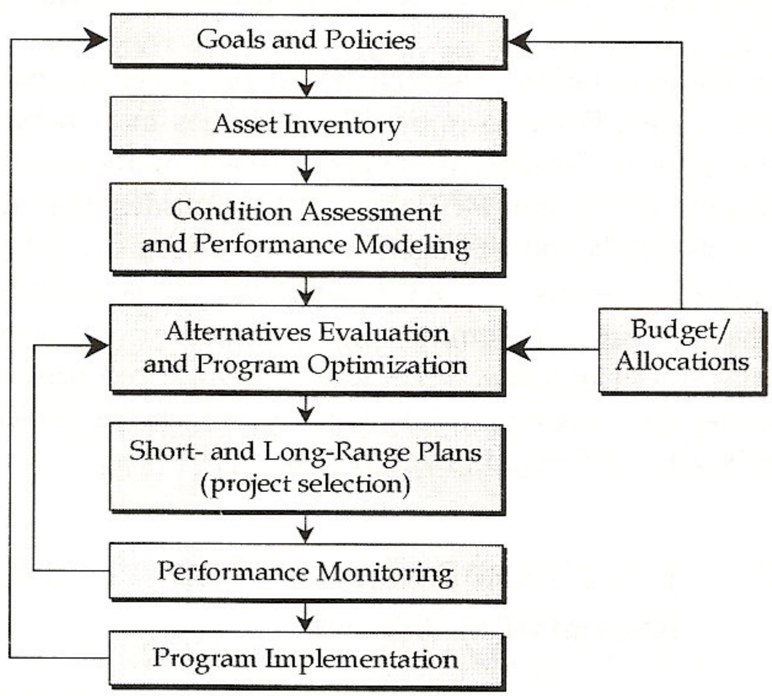

Figure 3: FHWA's Overview of Transportation Asset Management (Source: Cambridge Systematic, 2002)

Figure 4: Australian Approach to Asset Management (Geiger et al, 2005)

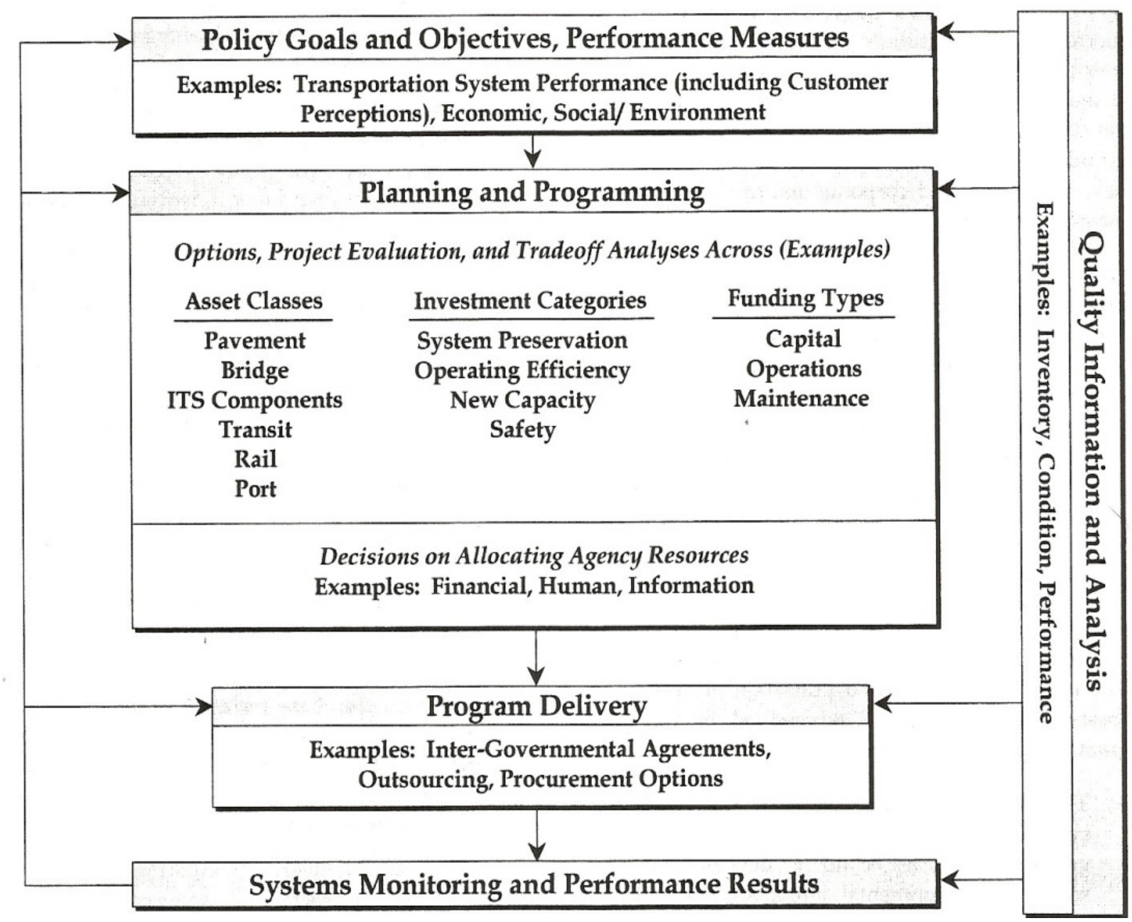

Figure 5: Example Resource Allocation and Utilization Process (Source: Cambridge Systematics, 2002)

Similar to other processes investigated, performance measurement plays a significant role in an evaluation or decision making framework. The process to create a performance monitoring system was the last area of investigation. Ryus (2003) offers an eight step process for establishing a performance measurement program which goes as follows:

1) Define goals and objectives.

2) Generate management support.

3) Identify users, stakeholders, and constraints.

4) Select performance measures and develop consensus.

5) Test and implement the program.

6) Monitor and report performance.

7) Integrate results into agency decision making.

8) Review and update the program.

This process contains many of the same elements found in the other model such as identifying stakeholders and defining goals and objectives, and monitoring performance. From the frameworks reviewed, the more broadly defined the process steps are the more customizable the process is meant to be. Although there is overlap between the various frameworks, each offers a slightly different perspective and goal that should be incorporated into a transit evaluation process.

Decision Making

Thousands of metrics are available for the evaluation of a transit system. A similar number exists in the realm of traffic engineering. In the evaluation of a roadway it is essential to pick "a few good measures" (NTOC, 2005). The same concept applies to public transit. By a selecting a few meaningful performance metrics, the value of them is not degraded or lost in a mass of data. Ryus (2003) recommends 8 primary categories of performance measures that addresses each of the essential points of views and can be customized to fit the needs of the transit agency and the university:

1) Safety and security,
2) Availability,
3) Service delivery,
4) Maintenance and construction,
5) Economic,
6) Community,
7) Capacity,
8) And travel time.

Some of the performance measures such as capacity can be time sensitive. Pratt (2004) notes that a new bus route can take between 1 and 3 years to reach its full patronage potential. In a university setting, most of the potential ridership should be attained within the first year as students determine their schedule and travel patterns within the first month of a semester. Care is needed to ensure that metrics are collected at an appropriate time as they could be affected by the university vacation schedule, examination periods, or by an entire semester as spring semesters traditionally have lower enrollment than fall semesters.

Performance measurements alone are not enough to provide decision makers with the information necessary to confidently make changes at a university or a transit agency. In the construction industry, baselines are created and continually updated to compare a current construction schedule with a target schedule (Newitt, 2009). In cost accounting, comparisons between actual expenditures and budgets are done anywhere between daily to yearly with variances used to explain why there are differences (Berry, 2009). Transit agencies and university transit systems should operate no differently. Several methods for determining comparisons include (Ryus, 2003):

- Route design standards = compare against the design values used to make a route
- Comparison with annual average = compare routes values with a system average
- Comparison with baseline = use prior year metrics as a baseline for comparison
- Trend analysis = record a particular metric at set intervals to view a trend
- Self-identify standards = set targets either for a route or the system
- Indentify typical industry standards = use industry standards for comparison
- Benchmark with peer systems = compare system metrics with those of a similar system
- Or combination of above.

Each method described above has its strengths and weaknesses. A comparison with a baseline is only effective if the baseline is considered reasonable data. Self-identify standards can either be set too high, which can be discouraging or set to low creating a false sense of success. A combination of multiple methods can create a lot of data and can be taxing on an agency to collect. The positive of all of these methods is that comparisons across time and organizational boundaries can be achieved and accountability can be established.

Another method used heavily in the transportation industry is a multi-objective approach. Using this approach, items which might not be easily quantifiable can be included in the analysis of the current system and an alternative. “This method evaluates alternatives easily; each objective’s weights receive explicit definition; and the decision maker expresses preferences directly for each alternative" (Chowdhury, 2002). The ability to weight each factor individually allows for each stakeholder to express their opinions and concerns and allows for the "best-comprise solution" to be reached based on which alternative receives the highest score. In transit, any service change "is deserving of analysis designed to identify winners and losers among existing riders, as insurance that the alterations will be beneficial overall" (Pratt 2004). It is through proper planning, performance monitoring, innovation, and systematic evaluation of alternatives that an agency, whether a university or a city transit agency, can confidently save and prove that the service offered is the best. It is then that accountability and transparency can be attained and customer satisfaction and trust between stakeholders can be strengthened.

Summary

When an agency states it is evaluating its transit service it means a lot more than just determining how many riders are using the system. As seen from the literature, evaluation of transit system, especially one at a university, requires an examination of more than just a single route or even the entire transit system; rather, it is an examination of the culture, politics, goals, relationships, financing, and performance of the route from the perspective of the university community, the community around the university, the transit agency and the drivers. Only when the views of each stakeholder are considered and alternatives weighed systematically against one another can a transit system, whether in operation or to be operated in the future, be truly evaluated.

This research expands on what was found in the literature to forge a process that ties planning, performance measurement, and alternative evaluation into one process.

Transit systems on a university campus are becoming an essential component of its transportation system. It is vital for the system to operate efficiently and serve its users, typically a dynamic community of students, in order to make it an attractive alternative to the automobile. As the literature states, for many students college is their first experience with transit and it is the duty of university to ensure it is the best experience possible.

CHAPTER 3

METHODOLOGY

Transit System Evaluation Process

Information used in the development of the evaluation process came from a synthesis of published literature and methodologies of transit evaluation conducted at other universities in the United States. A review of relevant literature was conducted to identify trends and methodologies in planning, operating, and performance monitoring of transit service. It also focused on the key planning and organizational issues that make college and university transit systems unique. Materials examined included articles published in peer-review journals and texts on campus and transportation planning.

Interviews were also an essential method of data collection. Interviews with industry professionals in the fields of traffic engineering and transit consulting were conducted to determine what the state of practice was for conducting an evaluation at a college or university. Campus planners and administrators were also interviewed to reveal the organizational structure at a university. The colleges and universities interviewed were small urban and rural institutions in turn making the use of the evaluation process developed more fitting for use at colleges and universities in a similar setting.

The final source of information for this research was an in depth case study of Clemson University. In 2008, the university restructured its transit routes to align with the current goals and desires of the student population. In light of budget shortfalls, academic expansions, and a change in student desires, Clemson University needed to evaluate its current transportation system and select the “best-compromise solution” for the university.

Since an objective for the framework was to combine planning, operations, and performance measurement into one process an examination of current frameworks in each of those areas was conducted in the literature review. The elements in each framework were compared against each other to determine which elements should be included in the transit evaluation process. Table 1 depicts which elements were included in each of the frameworks. Elements present in two or more processes were incorporated into the framework. Not all elements were included as listed in the original frameworks; some of the elements were incorporated into the transit evaluation process by iteration arrows. From the elements appearing in multiple frameworks, a transit evaluation process for a university campus emerged.

Table 1: Elements of Published Frameworks

Evaluation Step \ Method of Evaluation	Transportation Planning Handbook	Highways for LIFE Performance Framework	Overview of Asset Management	Australian Asset Management	Resource Allocation and Utilization Process	Performance Measurement Program
Define and Recruit Internal Stakeholders		x				x
Hold initial brainstorming sessions		x				
Review and coordinate with regional and city transportation and development goals	x					
Establish goals and objectives	x	x	x		x	x
Evaluate existing transportation conditions	x		x		x	
Evaluate existing economic conditions	x		x		x	
Evaluate existing environmental conditions	x					
Develop Alternatives	x		x	x		
Analysis, Feasibility, and Testing	x	x	x	x	x	
Refine Goals		x				
Plan Development	x		x		x	
Develop Consensus						x
Implementing Strategies	x		x			x
Establish baseline		x				
Performance monitoring			x		x	x
Establish, communicate, and implement requirements for ownership, accountability, and responsibility				x		x
Integrate asset planning and management into plans, and budgetary and evaluation processes				x		x
Review and update the program						x

Clemson University Case Study

The case study of Clemson University began in July 2009 which corresponded to beginning of the university fiscal year and the beginning of Clemson's second summer session. The case study lasted one full year ending in June 2010. During this time, the following studies were conducted as part of the evaluation process.

Visioning Sessions

As seen in all of the frameworks investigated in the development of transit evaluation process, the initial step in proceeding in the process is the identification of stakeholders. For the Clemson University case study, a Visioning Committee was formed to ensure that all stakeholders of the university were identified and additional members could be invited throughout the process. The Visioning Committee was comprised of 12 voting members with 4 votes given to undergraduate students, 2 votes to graduate students, 2 to faculty senate representatives, 2 to staff senate representatives, and 1 vote given to a collaborative effect between athletics and major events. Other campus stakeholders including members from parking services, campus housing, university financing, campus planning, university administrators were invited to session and were able to express their opinions and concerns but were not given a vote in the proceedings.

Upon the identification of stakeholders, an examination of the transportation goals and objectives was necessary. Guidance for the transportation system at Clemson University was found in the parking principles. Nearly every university has a different name for these goals and objectives, but each university has some form. Before the system could be reformed to meet the needs of its users, the goals had to be refined. The task of this committee was to expand the parking principles from such a narrow focus into the transportation principles of Clemson University encompassing all modes of travel into and around campus.

Ride Check Surveys

A manual method of data collection was used for this research. The method consisted of preparing packets of forms for surveyors to record boardings and alightings by stop and the time the bus departed timed locations. Surveyors also recorded the number of people left behind at a stop in the event that the bus was at capacity. This information was then input into a spreadsheet for analysis and reporting. The development of the ride check survey followed the 8 steps described below.

1. Conduct planning sessions

Planning sessions were conducted involving members from Clemson Area Transit (CAT), Clemson University Departments of Student Affairs and Campus Planning, and Tiger Paw Productions. These sessions were conducted for both the summer and fall semester ride check surveys. In discussions with members from Clemson University, it was determined that the most appropriate weeks to conduct the ride check surveys would be from Monday, July 27 to Thursday July 30, 2009 for the summer session and from Monday, September 28 to Sunday, October 4 in the fall. The week in the summer was chosen because no holidays are present and it falls within regularly scheduled class. The fall ride check week was chosen because it did not coincide with a home football game and the effects of Clemson University's fall break or Thanksgiving holiday should not have affected the student's riding behavior yet. By choosing a week not ever to be affected by the presence of an impending holiday enhances comparability for future years. The principal investigator rode the routes to ensure that all bus locations were included and in the right order. The locations were further confirmed by the operator run assignments provided by CAT listing the departure times for each vehicle at key locations and the public timetables. The logistics of the ride check survey were reviewed and explained to the representative from CAT. Prior to the survey, CAT informed its dispatchers, route supervisors, and drivers of the survey effort to ensure their cooperation.

2. Develop surveyor assignments

Utilizing the operator run assignments, surveyor assignments were developed by TigerPaw Productions using people on its staff. The assignments were then shared with the principal investigator daily for use in quality control. The two principal transfer locations were East Library Circle and Littlejohn Coliseum. Each surveyor was scheduled to arrive 10 minutes prior to the start of their shift to allow time to convey any additional instructions or announcements and to ensure that they were ready when the bus arrived. Survey assignments were made in such a way that two surveyors were supposed to be on the bus at a time, one watching the front door and one watching back door. This double coverage was also utilized to minimize the possibility that a bus would not have a surveyor on board.

3. Prepare survey packets

Survey packets were prepared for each surveyor position and for each day. Two surveyor packets were provided per bus and were labeled with front and back door designations. The surveyors were asked to make a note on the survey forms if they were recording both front and back doors. There was a survey form for each run of the bus while it was in service. The survey forms consisted of the list bus stops, the scheduled time of arrival for stops based on the operator run assignments, columns for recording the actual bus departure times, the number of boardings (ons) and alightings (offs), the total number of passengers the bus was carrying (load) going into each stop, and the number of people left behind due to a full bus. Included in the packets were also an instructions letter and a timesheet for surveyors to sign in and out.

4. Train surveyors

Prior to the start of the survey, each surveyor was asked to go through a training session. Due to the enormity of the survey staff, it was deemed that a virtual training session would the most appropriate and accessible method of training. A training video was created which covered the dress code, etiquette on the bus, the survey sheets, and an example using video clips taken from on the bus showing ons, offs, and how to record load. The training video was then published on YouTube.com to minimize the possibilities of technical difficulties. The web address for the training video is http://www.youtube.com/watch?v=qMZA2WwlAGk. Further clarification of the surveyor instructions were conducted informally prior to the start his/her shift.

5. Conduct ride check survey

The survey was conducted from Monday, July 27 to Thursday, July 30, 2009 and Monday, September 28 to Sunday, October 4, 2009. The surveyors met the bus at their first official stops according to the operator run assignments on Clemson's campus. The surveyors were met by one of two supervisors who gave each surveyor that day's survey packet which would remain on the bus until end of the day and two pens. The surveyors were instructed to bring a cell phone with them and given the supervisor's cell phone number in case of any emergencies. At the end of their assignments, the surveyors were instructed to either hand their notebook to the next or remaining surveyor on the bus or leave the notebooks on the bus's baggage storage area so that the survey packets did not leave the bus until the end of the day. At the end of the day, one of the supervisors met the surveyors when they got off to collect their packets and pens and to debrief them on any problems encountered during the assignment.

6. Implement quality control

Quality control procedures were necessary to ensure that all surveyors were completing their assignments properly. Procedures such as checking the surveyor packets for completeness, conducting on-board spot checks, and correcting any incorrect methods of collections were taken to ensure the quality of the results. Surveyors who were blatant in not performing their duties or those who were chronically deficient were dismissed from future duties and replaced. After reviewing the data, the summer semester had all times reported while several gaps were identified in the fall semester ride check results. These gaps were not resurveyed because it was not felt that the overall ridership would increase significantly. The following table delineates all gaps that were discovered in the fall data due to missed assignments.

Table 2: Survey Times Not Captured in Fall 2010 Semester

	Bus #	Time	Duration
9/28/2009	Tiger 4	7:31 AM – 7:58 AM	27 min
9/28/2009	Tiger 7	7:37 AM – 7:49 AM	12 min
9/29/2009	Tiger 1	10:22 AM – 10:56 AM	34 min
9/29/2009	Tiger 4	2:30 AM – 3:15 AM	45 min
9/29/2009	Tiger 5	7:39 AM – 8:52 AM	73 min
9/30/2009	Tiger 4	7:55 PM – 10:53 PM	178 min
9/30/2009	Tiger 4	12:21 PM – 1:57 PM	96 min

7. Enter data

Following the survey, the completed survey forms were batched by day and by bus designation. The forms were then keyed into an Excel file for processing and editing. The principal investigator was responsible for the data entry from the Tiger Route.

8. Correct, analyze, and report data

The keyed data was reviewed to determine if recorded data was reasonable. Rational data adjustments were instituted where appropriate based on the judgment of the principal investigator using the guidelines set forth by Ryus (2003). Daily counts for the survey week were requested from Clemson Area Transit to check the accuracy of the data collected but only received daily totals for the fall survey week. A sample ride check survey form is included in Appendix A.

Peer University Benchmark Survey

The initial step in the peer university benchmark survey was to identify potential peer colleges and universities. There are 4,146 non-profit public and private college campuses in the United States as reported by the Department of Education's Institute of

Education Sciences' Integrated Postsecondary Education Data System (IPEDS). Naturally, not all of these campuses were peers to Clemson University for various reasons. Several characteristics were selected to filter through the college campuses in order to determine who suitable peers for Clemson University are. The metrics chosen for the filter are as follows:

- Public university
- Large 4 year, primarily residential university
- Enrollment between 10,000 – 20,000
- High undergraduate enrollment
- Dorm capacity
- High research activity
- Town setting

Colleges and universities were filtered using IPEDS and the Carnegie Classification system, maintained by the Carnegie Foundation for the Advancement of Teaching, using the metrics above. The results of the filters were also cross referenced against a list of suggested peers generated using the Executive Peer Tool (ExPT) sponsored by IPEDS and the Similar Institution tool sponsored by Carnegie. All Clemson University identified peer institutions were included in the list of potential peers along with recommendations made by the Clemson's parking and transportation consultant, Connetics Transportation Group. The following universities and colleges were identified as potential transportation peers.

Table 3: Potential Transportation Peers

*Auburn University**	**Oklahoma State University – Main Campus**
Ball State University	*Purdue University**
Bowling Green State University – Main Campus	Southern Illinois University – Carbondale
*Georgia Institute of Technology**	***Texas A & M University****
Iowa State University*	Texas State University – San Marcos
James Madison University	University of Alabama
Kansas State University	University of Arkansas – Main Campus
Kent State University – Main Campus	**University of Idaho**
Miami University – Oxford Campus	University of Mississippi – Main Campus
*Michigan State University**	**University of Montana**
Mississippi State University*	***University of Nebraska – Lincoln Campus****
*North Carolina State University**	University of Rhode Island
Northern Arizona University	**University of South Carolina**
Northern Illinois University	University of Southern Mississippi
Ohio University – Main Campus	University of West Georgia
Virginia Polytechnic Institute and State University* (Virginia Tech)	

* *Clemson University identified peer institution*
Bold denotes responsive institutions

The transportation directors at each of the institutions above were mailed an initial fact finding survey in both paper and electronic formats to gather some basic information about the operations and management of the parking and transportation services provided on each campus. Information from the surveys was supplemented with data gathered from the institutional profiles published in IPEDS to gain a more comprehensive picture of the institution. Of the 31 schools that were mailed surveys, the 12 schools who responded are in bold print above. That is a survey response rate of 38.7%. These institutions formed the pool in which the official transportation peers would be selected.

Selection of Transportation Peer Institutions

The information gathered from the initial fact finding survey, the institutional profiles, and census data was compiled and organized into a summary comparison spreadsheet and distributed to the Visioning Committee for review (see Appendix B). The summary comparison sheet was distributed to each member, and they were asked to rank the top four institutions they felt best resembled Clemson University as a transportation peer. The votes were then tallied and a weight applied to each ranking. To calculate the score, the first choice received a weight of 4; the second choice received a weight of 3 and so on. The summary of votes is shown in Table 4. The top four ranking institutions, in bold, were considered the transportation peer institutions to Clemson University. Further questions about policy and management of transportation systems were directed to these four institutions (see Appendix C).

Walking Time Study

Currently, Clemson University schedules a 15 minute break between class periods for students and faculty to change classrooms. A 2007 survey released at Clemson University found that walking was the predominant mode students chose to get from one class to another. As the university redevelops parking lots surrounding the core campus into academic facilities, a concern was raised that a 15 minutes break between classes is

Table 4: Transportation Peer Institution Selection Matrix

Choice	1st	2nd	3rd	4th	
Weight	4	3	2	1	
School	Votes				SCORE
MS State U	3	5	1	2	**31**
Bowling Green State U	3	1	2	2	**21**
Miami U	3	0	4	1	**21**
Texas A & M U	3	0	0	0	**12**
Iowa State U		3	1	0	11
Virginia Tech		1	2	1	8
U of South Carolina		0	1	3	5
U of Nebraska		1	0	1	4
Ohio U		1	0	0	3
U of Montana		0	1	0	2
U Idaho		0	0	1	**1**
OK State U		0	0	1	**1**

not adequate for students to walk from one outlying building to another. To determine if students were able to walk these distances in the allotted 15 minutes, the average walking speed of students was needed. A cluster sample of 62 students in the civil engineering program was used in the study. The study was administered as a homework assignment for the CE 311 – Introduction to Transportation Engineering class the students were enrolled in. Each student was required to complete a walking time study from three different origin-destination pairs in order to receive full credit. For the convenience of the students and to help ensure more accurate results, the origin-destination pairs were grouped so that a destination would be on the same side of campus as the next origin.

Students were provided with an instruction sheet and a map of campus with the origin-destination pairs defined by different colors. The students were asked to walk at a comfortable pace from the origin location to the destination location using whatever path they thought would be most efficient and time how long it took. Upon arriving at the destination, students were asked to draw the path they had just taken on the provided map. After timing their walk, students were asked to check out a measuring wheel and trace the path they had initially walked for each origin-destination pair. 165 walking times were collected from the sample group with 88 of those times having an accompanying distance measurement. Only the complete data sets were used in determining the average walking speed of students.

Preliminary Alternative Analysis

Clemson University was very interested in what transit route alignment students felt would be serve their needs. To find this out, the Clemson Transportation Continuity Council, a council of 10 students consisting of 2 from each class standing, was convened. The revised parking principles as set forth by the Visioning Committee, the planned expansions for Clemson's campus, and results of the Fall ride check survey were presented to the council. Upon the completion of the presentation, each member was given several blank maps and multiple colored markers and was asked to draw one or multiple transit routes they felt would best suit the needs of Clemson students. The members were given 30 minutes to devise their route during which time they could converse with the other members.

Alternative Analysis

Upon completion of the 30 minutes, each member of the council was asked to present their design and explain why he/she felt it would best serve the needs of Clemson's students. The pros and cons given by the council members were recorded and incorporated into an analysis matrix. Concerns expressed by the students included trip directness, length of route, operating efficiency measured by the number of left hand turns, noise contributions to core campus, and number of destinations served. The alternatives were also evaluated by university planners and administrators and Clemson Area Transit. Other evaluation criteria added to the analysis matrix after these evaluations included driver break locations, number of relief drivers necessary, and cumulative passenger boarding based on the number of parking lots served in succession before heading to the inner campus. The routes were assigned scores by criteria and totaled to determine which route was the best alternative developed.

Transit Route Simulations

The best alternative developed from the alternative analysis was chosen for comparison with the current Tiger Route by simulation. The primary parameter needed from the simulation results was the average travel speed of a bus in the network. The average travel speed was needed in order to determine the headway possible on the route and to create accurate, useable, and safe operating time tables for Clemson Area Transit. Through concerns expressed by Clemson Area Transit the simulation would produce to results in too ideal of conditions, the bus operations were simulated in the worst case scenario.

The simulation was accomplished using a model of Clemson University's campus developed by Dr. Ryan Fries. Dr. Ryan Fries conducted an extensive traffic study in 2006 and 2007 on Clemson's campus in order to be able to simulate increase traffic demands on campus. In Dr. Fries' study, it was found that the peak traffic occurred between 10 am and 2 pm. Based on the fall ride check survey and statements made by Clemson Area Transit, the peak transit ridership was found to occur from 8 am to 12 pm. By simulating peak transit travel in peak traffic periods, the worst case scenario, excluding days with major campus events, is achieved.

The base simulation model used in this research was created by Dr. Ryan Fries and calibrated to simulate peak vehicle traffic on Clemson's campus. The model was created in a microscopic simulation program, Vissim 5.10-03 created by PTV America. Upon Dr. Fries' completion of the base model which simulated vehicles and transit conditions on campus, he validated his findings by comparing the results of the simulation with that of observed results. No significant changes in parking policies, campus population, or roadway network have occurred since the completion of the original study and validation of the model. Since no significant changes have occurred after the validation of the model, the model was deemed validated even after the alterations to the transit route alignments.

One slight adjustment had to be made to the simulation model. In the summer of 2009, Nu St was opened connecting Centennial Blvd with Williamson Rd. This connection was not present in the base model so the necessary links had to be added and path files recreated. With this addition, the model was ready for use.

Before the simulation of the transit alternative could be performed, the creation of new bus stops and the input of passenger boarding and alighting information was required. A majority of the bus stop locations on the alternative route were aligned with the existing bus stop locations in the model because the same origins and destinations were still being served. Boarding information was generated based on the maximum 15 minute boarding period for the week by stop in fall ride check survey findings. Hourly volumes could not be used in the simulation because the peak boardings 15 minutes prior to the start of a class period were not accurately portrayed. The percentage of passengers alighting at each stop was calculated by summing the maximum 15 minute alighting periods for the survey week by stop and normalizing the data so that the cumulative percentage equaled 100%.

After alignment was complete, boarding and alighting information was put in the model. The final task was to select vehicle information that was necessary. The parameters collected in the simulation model include the following:

- Simulation time [s]
- Active link number
- Line number
- Occupancy (number of passengers)
- Current transit stop number
- Number of passengers alighting at current stop
- Number of boarding passengers at current stop
- Total time in network [s]
- Total distance traveled in the network [ft]

In the model, transit vehicles that had completed their run were unable to leave the network which caused them to circulate in a parking lot until the end of the simulation. The last link of the route alignment was identified and all vehicle records after that link were deleted because the vehicles were not running productive miles. The passenger boarding, alighting, and occupancy information and transit stop data was collected to provide a check that the transit vehicles were transporting passengers as programmed. To simulate the worst case scenario as requested by Clemson Area Transit, all transit vehicles were required to stop at each transit stop whether or not passengers were waiting. The dwell time was based on a regression equation generated from a sample of 32 dwell times captured on the current transit system.

With the data cleaned of unproductive time and miles and checked to ensure that passenger activity was reasonable, the average travel speed of that run was calculated. The average travel speed was calculated by dividing total distance traveled in the network in miles by the total time in the network in hours. The average travel speed of the buses in the network was found by averaging the travel speeds of the individual runs. The average travel speed was then compared with actual travel speeds calculated from the ride check survey results. The average travel speed for the transit alternative was then provided to the consultant hired by Clemson University, Connetics Transportation Group, to finish the bus scheduling.

CHAPTER 4

ANALYSIS

Transit Evaluation Process

From the elements identified in existing evaluation frameworks, a transit evaluation process emerged. Seen in Figure 6, this process integrated planning, operations, and performance monitoring to help administrators and planners evaluate transit options on a college or university campus. It was designed to be adaptable to any university or college settings since no two institutions are exactly alike.

The first step in the process was to identify the users of the transportation system and all stakeholders that have an interest in the system. The users of the system included groups such as students, faculty, staff, visitors, and vendors. The stakeholders identified should be specific individuals or from specific university groups and agencies. Examples of possible stakeholders are members of undergraduate student government, graduate student government, campus housing, campus planning, parking and transportation services, campus police, athletics, and campus major events. To ensure acceptance of the alternatives chosen by the coalition formed, it was essential that all major interest groups were identified and engaged before the process proceeded.

Before setting the transportation goals and objectives for the university, it was important to know where the university is heading the in future organizationally, academically, and financially. Planned expansions and expansions of the university can range from where resident housing will be placed in the coming years to where new academic buildings are to be placed. It might also include plans for the expansion of the

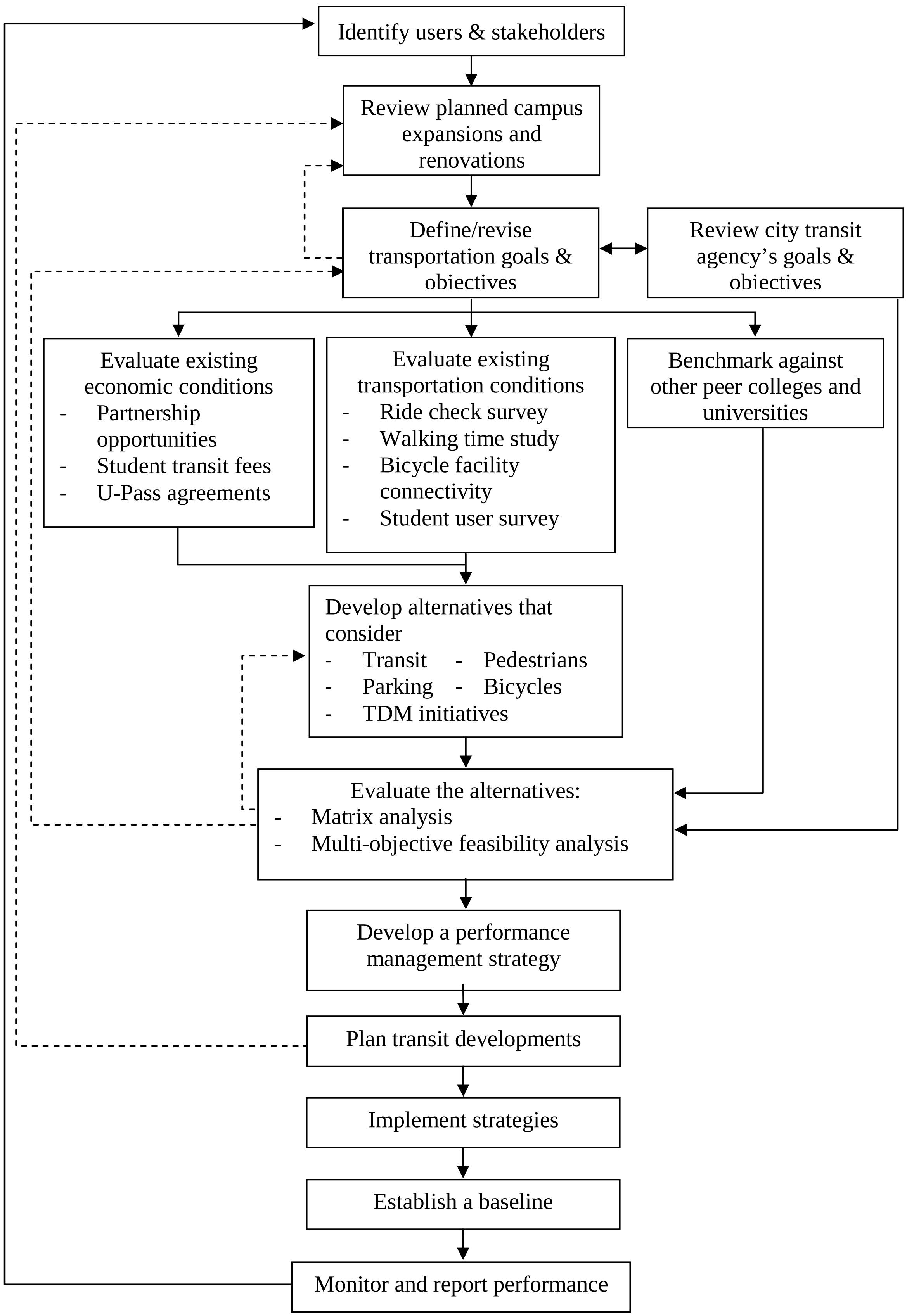

Figure 6: Transit Evaluation Process

transportation system in terms of roadway, bicycle or pedestrian improvements. By knowing what the university had already begun planning for, the stakeholders were able to think critically and creativity to further enhance the transportation system.

When defining the transportation goals and objectives, it was important to keep a multi-modal perspective. For decades, the only transportation mode that was considered was the automobile, but now universities must plan for pedestrians, bicyclists, motorists, bus riders, rail riders, light rail riders, etc. For many universities, the transit system operating on its campus was contracted out to an external agency. In creating the goals of the university, it is a good idea to learn about the goals of the operator. Not only did the goals illustrate the level of quality that transit agency strived to achieve, but also where that agency liked to expand in the future. Similar to transportation plans required by the state and federal departments of transportation, creating short term and long term goals helps guide the university's transportation system throughout the future.

Once the goals and objectives of the transportation system were complete, an evaluation of the current system commenced. Economic sustainability in parking and transportation accounts was required by many universities. It was for this reason that universities strived to extend their money either through federal grants or partnerships with local transit agencies. Although generally considered an unfavorable option, the opportunity to levee a student transit fee was becoming a trend throughout many college and universities. The funding opportunities were dependent on the rules governing a particular college or university; however, innovation in this area can be encouraged no matter what system is being discussed.

The evaluation of the existing transportation system was where most of the numerical data is generated. A ride check survey, either done manually or through use of an automatic passenger counter technology, was a primary tool in determining the travel patterns on a transit line. It also revealed where and when a transit line is at capacity and what routes were underutilized. Campus administrators must be cautious not to make hasty decisions. If one route received low ridership, it must not be assumed that route should be immediately cut from service. There might be other underlying issues such as frequency or alignment that made that route unfavorable. Making decisions based on the numbers alone can lead to changes which further detract from transit's attractiveness.

Transportation improvement programs did not have to be like reinventing the wheel. By conducting a benchmark survey of academic institutions with similar transportation systems, one university can learn from the others mistakes without trying them on their own. Similarly, the successes of one university might benefit many more if it was known that a particular program worked well. Teachers encourage students to learn through peer learning and universities should follow that same advice.

After gaining a perspective on the financial situation and the transportation system at a university and what similar universities were doing for their transportation system, it was time for innovation to flourish. Although this evaluation process was geared towards the evaluation of a transit system, the alternatives generated should not be limited to just changes to the transit system. The transportation system was an interconnected web consisting of the transit system, roadway network, parking facilities, pedestrian facilities, bicycle facilities, and demand management techniques. A small change in any one of these areas could prove to have major changes on the transit system. In developing alternatives, it was important to think multi-modally and in terms of the system not the component. Innovation can come from anyone so this was great opportunity to engage the users and stakeholders of the system.

After developing alternatives, each alternative needed to be evaluated critically and objectively. A matrix analysis, a method commonly used to evaluate roadway projects, is one of the methods for evaluating the transit alternatives. A matrix analysis allowed for each stakeholder or user to express topics in which they were most concerned. A weight was then applied to each of the topics by which all the alternatives were measured against. Each alternative was then rated on a set scale by topic, weights applied, and a total score given. The alternative with the highest score represented the "best-compromise solution." A multi-objective analysis follows a similar process but allows for a more in depth and mathematical analysis. A utility function is created for each of the concerns raised by stakeholders. The functions are solved simultaneously to determine the overall score of a particular alternative. The alternative receiving highest score is deemed the "best-compromise solution." All alternatives, regardless of the analysis method used, should be in line with the transportation goals and objectives set earlier in the process. If they were not compatible, more alternatives needed to be generated.

Following the selection of a "best-compromise solution," a performance management plan needed to be considered. The metrics chosen were dependent on the information desires of the administration and the available technology of the system. In the thousands of possible metrics, it was important to choose a few good measures which were meaningful and easily understandable by university administrators and users. Choosing metrics that satisfied the four points of view in the transportation system (customer, community, agency, and driver) ensured that all stakeholders have at least some data of which they care about. These metrics should again go back to the transportation goals and objectives of the university.

After a performance measurement system was agreed upon, the creation of an implementation plan was necessary. This plan described what transportation improvements were desired for the university campus and a reasonable time frame for the completion of the projects. It was here that the short term and long term goals were addressed. Once the plan was created and all stakeholders and the administration approved, it was time to implement the strategies outlined. The final step proved to be the most important. Continual monitoring and reporting of the performance of the system was essential in staying ahead of any potential problems. Similar to the construction industry, the sooner a work order change is given, the less it will cost. For the transportation system, the faster a problem is dealt with, the fewer customers are affected. In the continual monitoring of the system, it was important to periodically review the planned expansions and renovations for campus and ensure that the transportation system was expanding alongside the university.

Clemson University Case Study

The Clemson University Case Study followed the process set forth in the previous section to evaluate its transit system. Some of the names used for the various elements of the process were changed based on the customization Clemson University administrators wished to see. The entire evaluation process was not completed at Clemson University. Alternative transit routes were developed and the best compromise solution. When this research was concluded, Clemson University was in the process of defining its performance measurement strategies with Clemson Area Transit. The following sections review the results of the completed portions of the process.

Visioning Sessions

Clemson University combined the identification of stakeholders and users and the definition of goals and objectives into the creation of vision sessions. The Visioning Committee was comprised of both voting and non-voting members from a variety of users across campus. The committee formed was tasked with revising the Clemson University Parking Principles. At the onset of the case study, Clemson University had 12 parking principles. After extensive discussion and voting, the Visioning Committee agreed on 12 major parking principles with many sub-principles present. The parking principles were written and revised by the transportation consultant Carl Walker, Inc. Prior to the revision of the parking principles, there was an emphasis on the success of the parking system. After revisions, there was realization that the "transportation system includes all mobility elements related to campus access, including parking, transit, pedestrian movement, and other alternate travel modes and should be planned and managed to support broader university goals expressed in the campus master plan, goals for achieving a pedestrian friendly campus, campus housing objectives, promotion of healthy lifestyles, and environmental sustainability." The new parking principles also states that "the campus master planning process should anticipate, assess and plan for any impacts on parking sufficiency." A full comparison of the old principles and the new parking principals can be viewed in Appendix D.

Summer Ride Check Survey

The ride check survey was intended to provide a 100 percent sample of weekday trips spanning from Monday, July 27 to Thursday, July 30 during summer session II. Data was collected from 7:30 am to 5:00 pm each day. Two buses were operating at 30 minute headways and completed 20 runs each day. Based on an examination of the survey sheets, a 100 percent sample was achieved. Daily ridership counts from Clemson Area Transit have yet to be received to compare with the survey results to test its accuracy.

Figure 7 presents the ten bus stops with the greatest number of combined boardings and alightings for the Tiger Route. Ridership activity was combined for locations where stops are located on both sides of the streets (i.e. Edwards Hall or Hendrix Center) and stops that both the East and West routes use (i.e. Library Circle). At P-3, however, the ridership activity was reported separately for the two stops serving this lot. The top ten stops based on activity were graphed above. The remaining stops all have ten or less riders for the study week. The graph clearly depicts that the Breezeway and

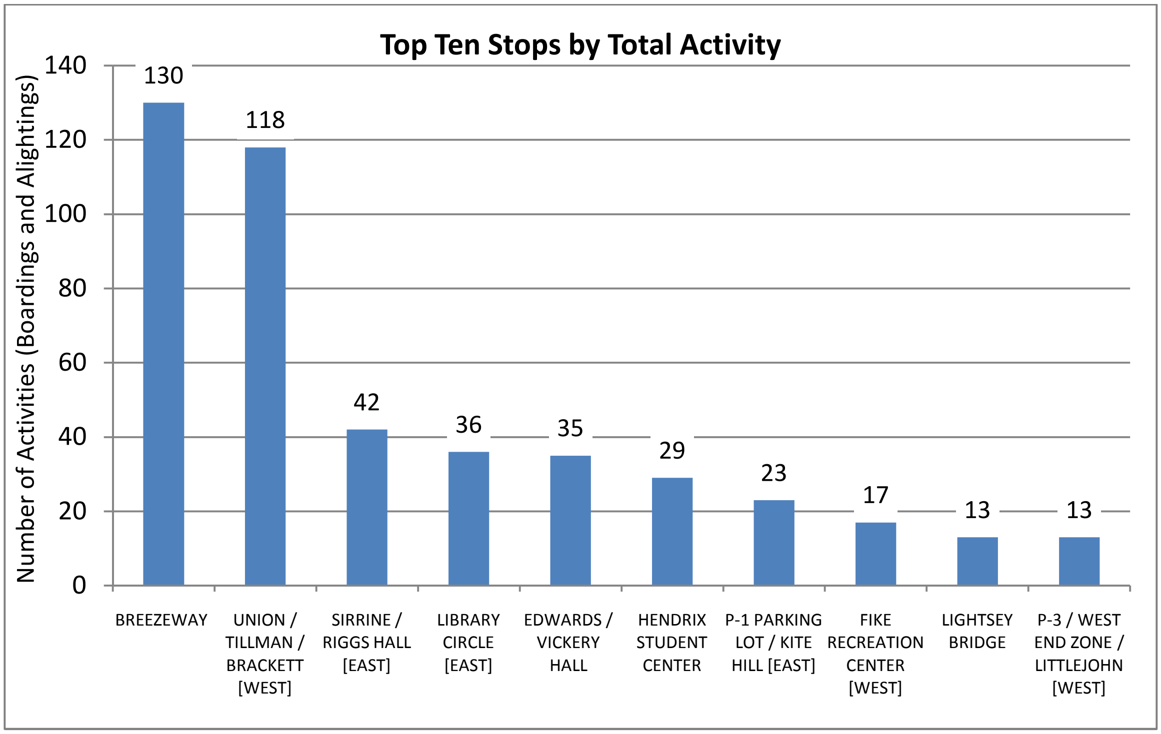

Figure 7: Total Activity for the Summer Survey Week

Union/Tillman/Brackett stops have the highest activity on campus. There were 76 more riders at these stops than the next highest.

Tables 5 and 6 depict top ten boarding and alighting locations on campus, respectively. This information was important to take note of because in the top ten boarding locations, bus stop amenities and space is needed to make people comfortable. In relation to the top ten alighting locations, traffic control and adequate pedestrian safety measures must be taken since passengers getting off the bus are likely to cross the street in a group. Not surprisingly, the top ten locations for boardings and alightings mirrored the top ten stops based on activity. Based on the stops listed, one can see that the most activity was from parking lots on the West side of campus into core campus. If students were returning to their cars using the CAT bus, one would see higher boarding numbers for Union and alightings at the Breezeway. It was concluded that students are riding into campus using the bus, but find it better to walk back to their cars instead of waiting for the bus. For a complete look at boardings and alightings, see Figure 8.

Table 5: Top Ten Boarding Locations for Summer Survey Week

Rank	Stop Location	Total
1	BREEZEWAY [WEST]	99
2	UNION / TILLMAN / BRACKETT [WEST]	23
3	P-1 PARKING LOT / KITE HILL [EAST]	13
4	FIKE RECREATION CENTER [WEST]	13
5	SIRRINE / RIGGS HALL [EAST]	13
6	LIBRARY CIRCLE [WEST]	11
7	LIBRARY CIRCLE [EAST]	10
8	AVE. OF CHAMPIONS @ CENTENNIAL BLVD [WEST]	10
9	LIGHTSEY BRIDGE	9
10	HENDRIX STUDENT CENTER [EAST]	8

Table 6: Top Ten Alighting Locations for Summer Survey Week

Rank	Stop Location	Total
1	UNION / TILLMAN / BRACKETT [WEST]	95
2	SIRRINE / RIGGS HALL [EAST]	29
3	BREEZEWAY [EAST]	27
4	EDWARDS / VICKERY HALL [WEST]	18
5	LIBRARY CIRCLE [WEST]	14
6	P-1 PARKING LOT / KITE HILL [EAST]	10
7	HENDRIX STUDENT CENTER [WEST]	7
8	P-3 / WEST END ZONE / LITTLEJOHN [WEST]	7
9	HENDRIX STUDENT CENTER [EAST]	7
10	FLUOR DANIEL / HUNTER [EAST]	6

Total ridership by day was shown in Figure 9. Ridership throughout the week was approximately constant with only a difference in ten riders between the highest days, Monday and Tuesday, and the lowest day, Thursday. On initial inspection, ridership was low during the summer months. These low numbers resulted from a lower student population on campus, a decreased need to ride transit since parking was readily available

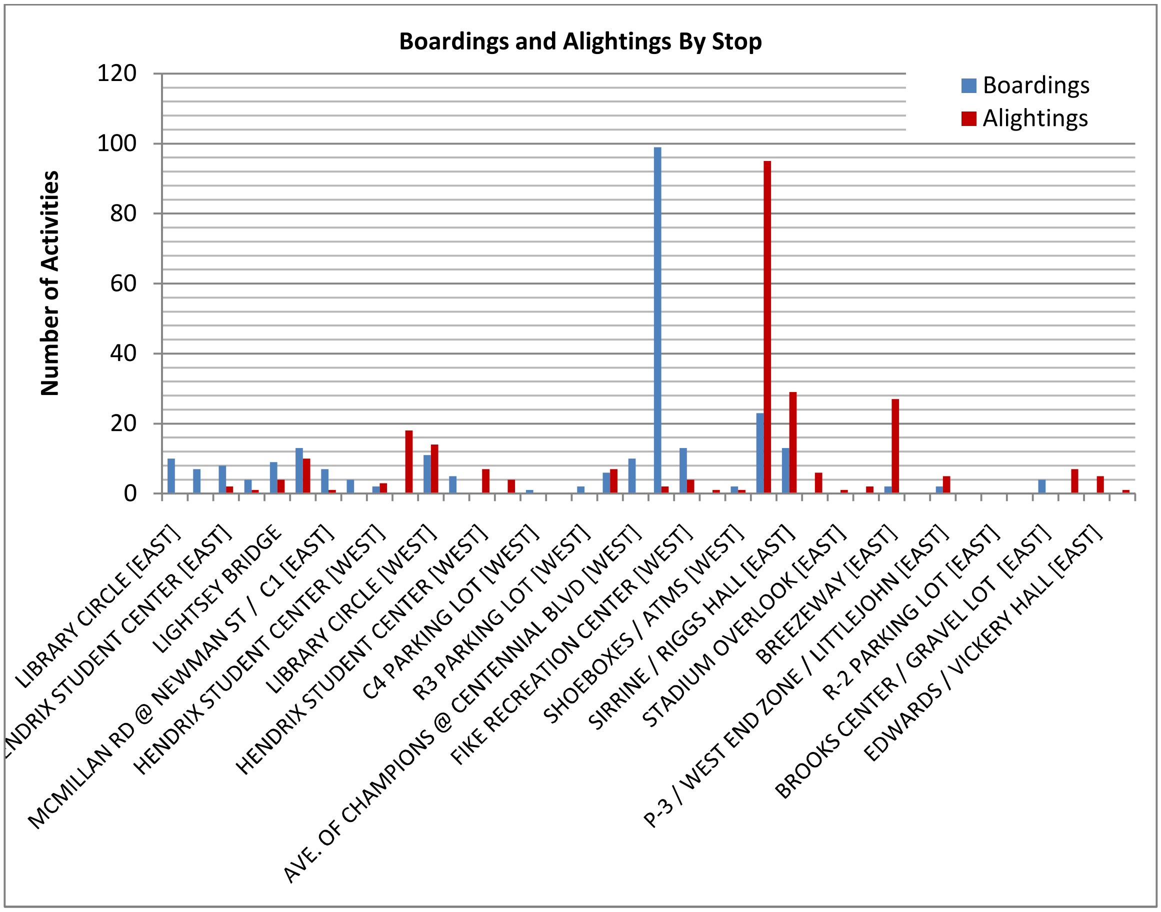

Figure 8: Boardings and Alightings by Stop for Summer Survey Week

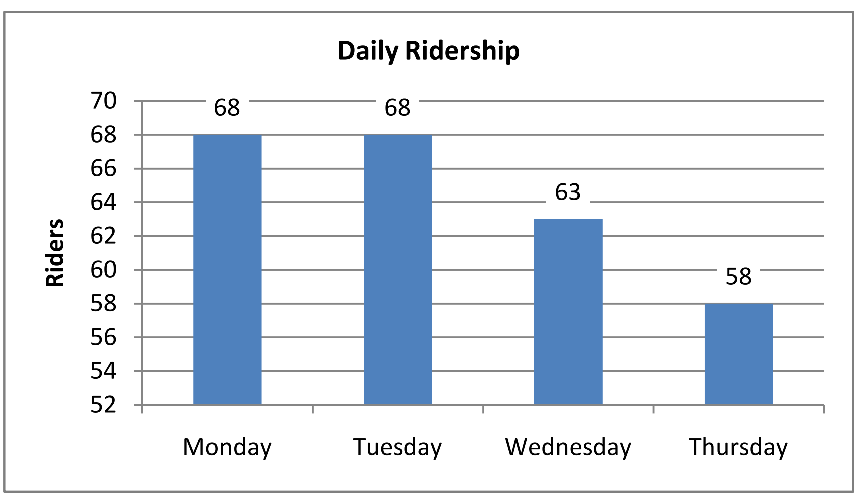

Figure 9: Ridership by Day for Summer Survey Week

in most preferred lots, and walking was common practice in the summer. Also, the low frequency of the route likely discouraged many choice riders.

By examining the total boardings by the hour, the peak hour of service was identified. Figure 10 depicts the total boardings by the hour for the survey period. By examining this graph, the peak hour was the 9:00am hour. To truly define the peak hour, one needed to narrow down the time frames to see the fluctuations in boardings. By examining the boardings based on a 15 minute time frame, a peak hour factor (PHF) was calculated. The PHF was calculated using the following equation:

$$PHF = \frac{Total\ Boardings\ in\ an\ Hour}{4 \times Boardings_{15\,\min max}}$$

The peak hour factor related the total boardings in an hour with the theoretical maximum determined by multiplying the number of boardings in the peak 15 minutes by 4 to convert it into boardings per hour. Generally, this equation is used in traffic engineering,

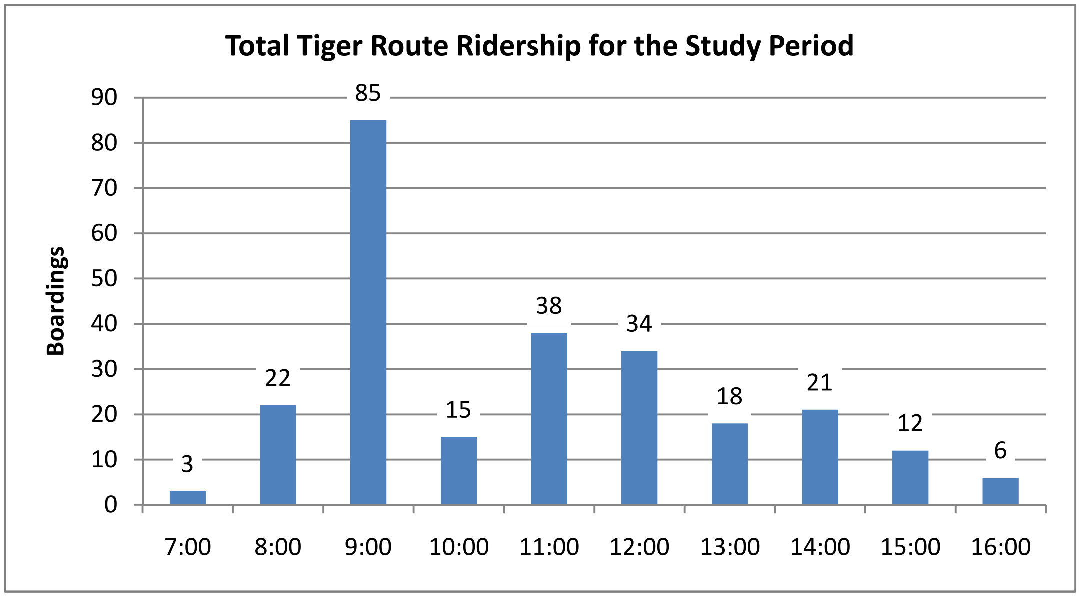

Figure 10: Total Boarding by the Hour for Summer Survey Week

expressed in vehicles per hour, to evaluate the volume of cars and the level of congestion on the roadway. This same principle was applied to the CAT bus system to determine the volume of passengers boarding the system. The maximum boarding in 15 minutes occurred at 9:15 am with a total of 62 boardings. Since the number of boardings in the peak time was 3 times larger than any other time in the system, the second highest 15 minute boarding period was used to calculate the PHF. The next highest boarding period occurred at 11:15 am with 20 boardings. A peak hour for this study is defined as any hour of time in which the PHF exceeds 0.6. Based on the peak hour factors, the peak time occurred from 8:30 am – 10:15 am with the worst hour occurring between 8:45am - 9:45 am. This time period was the only instance in which the peak hour factors were greater than 0.6 with an average of 1.05. The peak hour factor was greater than one because the second highest 15 minute volume was used to determine the factors. Capacity of the system was not an issue in the summer due to the lower ridership. Figure 11 depicts the worst hourly ridership for the study period which represented the maximum number of observed riders that were served during the study period. It was likely that if a greater frequency of service was provided it would attract more riders to the system. If the Tiger Route continued to operate at the 30 minute headway, it was likely that students will use the bus to get to class but will continue to walk back to their vehicles in the evening and low ridership will be maintained.

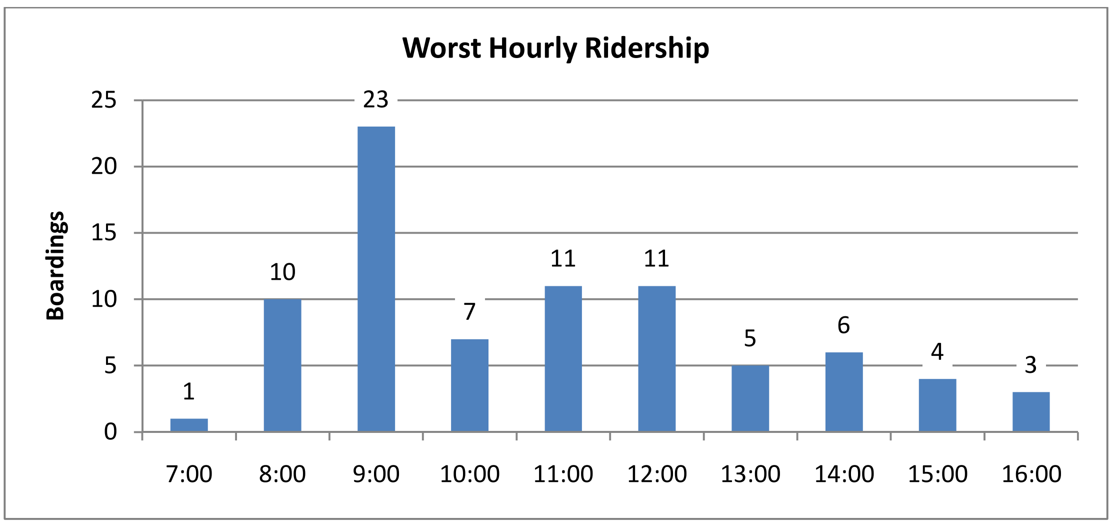

Figure 11: Worst Hourly Ridership for Summer Survey Week

The Tiger Route provides consistent service in a "figure 8" pattern across campus, servicing primarily the commuter lots. During Summer I and II sessions, the bus operated on a 30 minute schedule from 7:30 am to 5:00 pm. Although this schedule seems adequate, students are finding that it was neither convenient nor attractive for use. Average ridership on the system during the peak hours, 8:30am – 10:15am, is striking –

an average of 9 riders/hour except from 9:15-9:30 when 15 riders board the bus. One needs to remember that the student population, the primary riders in the fall and spring semesters is significantly decreased in the summer sessions. The ridership data is representative of the Summer II session. It is unlikely that ridership between Summer I and Summer II sessions will vary significantly because the class times are consistent across the two sessions and students are restricted to 6 credit hours maximum in either session, equaling 2 or fewer classes. Examining the ridership numbers, one should be concerned that money was allocated to a service that a select few is using.

At no point during the survey period was a seat not available to a rider. Capacity was not a problem for the Tiger Route in the summer, frequency was. With parking readily available across campus and students taking a maximum of two classes, the need to provide a cross campus connection was not present, yet the Tiger Route still provided one. Route alterations should be considered to reduce the number of unused miles and increase the frequency from outlying parking lots to the inner campus. An investigation into the feasibility and resource requirements needed to reduce the frequency of the route from 30 minutes to 15 minutes through a combination of route alterations and scheduling was needed to improve services.

Most ridership activity occurred on the West side of campus. Of the 257 riders who used the system during the study period, 65 % of them made trips contained to the West side of campus. A fixed route at a higher frequency on the West side of campus would likely increase ridership on that side of campus. An alternative to a fixed route system utilizing CAT buses might be considered on the East side of campus since ridership is much lower. A demand response system utilizing smaller vehicles might be sufficient to serve the student population during the summer sessions. A demand response system provides for flexibility in both route and schedule; however, further research was needed to determine the adequacy of this system.

Fall Ride Check Survey

The fall ride check survey was conducted from Monday, September 28 to Sunday, October 4, 2010. 7 buses operate from 7:30 am to 6:00 pm at 8 minute headways and complete The ride check survey was intended to provide a 100 percent sample of both weekday and weekend bus trips. Weekday trips that were not surveyed were missed because a surveyor failed to complete a portion of their assignment. Overall, 98.4 percent of the weekday trips were counted corresponding to 26,845 minutes out of 27,310 minutes in operations. 100 percent of the weekend trips, corresponding to the 2,100 minutes of operation, were surveyed. A comparison of the ridership numbers recorded by the surveyors and those recorded by the CAT bus drivers is seen in Table 6. A standard deviation of 149.4 riders was found for the Monday through Thursday counts resulting in a 95% confidence of 4,003 to 4,589 riders. Each of the weekday ride check counts fall within this range, thus ensuring the relevance of the data. Friday was not included in this analysis as it was not representative of true school day as seen in the reduction of ridership on that day. A similar statistical procedure was conducted for the weekend resulting in a standard deviation of 10.1 and 95% confidence range of 1 to 40 riders. Although the weekend numbers fall within this range, it was preferred that any statistical analyses have samples greater than 30. Neither the Saturday nor Sunday counts were greater than this threshold, thus making any statistical analysis or comparison between the two samples questionable. Another possible reason for differences in the ridership counts was the understanding that anyone who steps on the bus, regardless if they travel on the bus, is counted as a passenger to the bus driver, but might not have been considered a rider to the surveyor. It might also be that a surveyor was signed in for entire shift, but did not fulfill the requirements of that entire shift.

Table 7: Ridership Count Comparison for Fall Survey Week

Date	Day of Week	Ride check Counts	CAT Counts	Percent Recorded
9/28/09	Monday	4,230	4,436	95.4%
9/29/09	Tuesday	4,230	4,336	97.6%
9/30/09	Wednesday	4,119	4,173	98.7%
10/1/09	Thursday	4,074	4,239	96.1%
10/2/09	Friday	2,608	2,829	92.2%
10/3/09	Saturday	7	15	46.7%
10/4/09	Sunday	16	26	61.5%
	TOTAL	19,284	20,054	96.2%

Figure 12 presents the bus stops with the greatest number of boardings and alightings for the Tiger Route. Ridership activity was combined for locations where stops are located on both sides of the streets (Edwards Hall or Hendrix Center) and stops that both East and West routes use (Library Circle). At P-3, however, the ridership activity was reported separately for the two stops serving this lot since the waiting areas are separated and it served as a hub for the route. The top eleven stops based on activity are graphed below because they all fall above 1,300 activities while the next highest stop, Lightsey Bridge Apartments, falls below 1,000 at 987. The graph clearly depicts that the Union/Tillman/Brackett stop had the highest activity on campus. There were 1,400 more boardings or alighting occurring at this stop than the next highest, but received minimal attention in terms bus stop amenities.

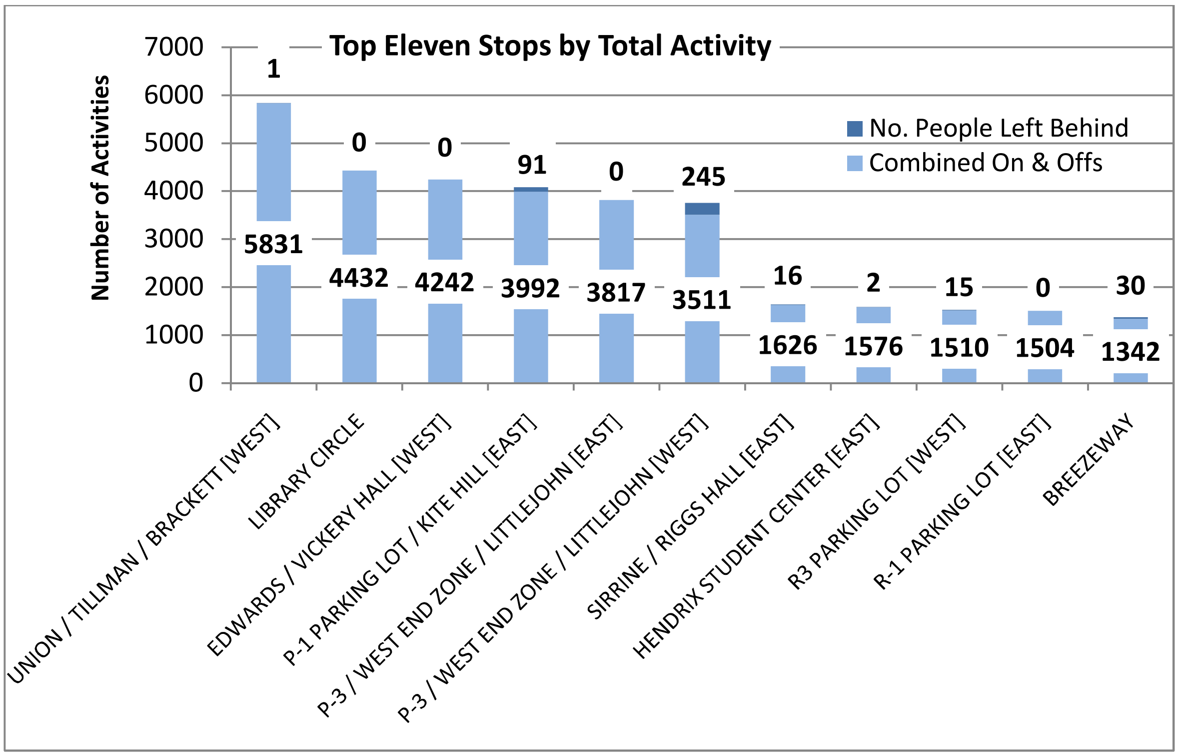

Figure 12: Top Eleven Bus Stops by Total Activity for Fall Survey Week

Tables 8 and 9 list the top ten boarding and alighting locations on campus, respectively. This information was important because the top ten boarding locations require bus stop amenities and space to make people comfortable and keep them safe. In relation to the top ten alighting locations, traffic control and adequate pedestrian safety measures must be taken since passengers getting off the bus are likely to cross the street as a platoon. Not surprisingly, the top ten locations for boardings and alightings mirrored the top eleven stops based on activity. This meant that delays in schedule due to the conflicts created by people trying to get on and off the bus simultaneously are likely to occur at these locations. This delay was combated by CAT policy which stated that all entries must be made through the front doors thus leaving the rear doors as a conflict free exit.

Table 8: Top Ten Boarding Locations for Fall Survey Week

Rank	Stop Location	Total
1	P-3 / WEST END ZONE / LITTLEJOHN [WEST]	2715
2	UNION / TILLMAN / BRACKETT [WEST]	2170
3	P-1 PARKING LOT / KITE HILL [EAST]	2153
4	LIBRARY CIRCLE [EAST]	1763
5	P-3 / WEST END ZONE / LITTLEJOHN [EAST]	1465
6	EDWARDS / VICKERY HALL [EAST]	1237
7	R3 PARKING LOT [WEST]	936
8	SIRRINE / RIGGS HALL [EAST]	884
9	LIBRARY CIRCLE [WEST]	855
10	BREEZEWAY [WEST]	748

Table 9: Top Ten Alighting Locations for Fall Survey Week

Rank	Stop Location	Total
1	UNION / TILLMAN / BRACKETT [WEST]	3661
2	P-3 / WEST END ZONE / LITTLEJOHN [EAST]	2352
3	P-1 PARKING LOT / KITE HILL [EAST]	1839
4	EDWARDS / VICKERY HALL [WEST]	1651
5	LIBRARY CIRCLE [WEST]	1331
6	R-1 PARKING LOT [EAST]	945
7	P-3 / WEST END ZONE / LITTLEJOHN [WEST]	796
8	SIRRINE / RIGGS HALL [EAST]	742
9	EDWARDS / VICKERY HALL [EAST]	711
10	R3 PARKING LOT [WEST]	574

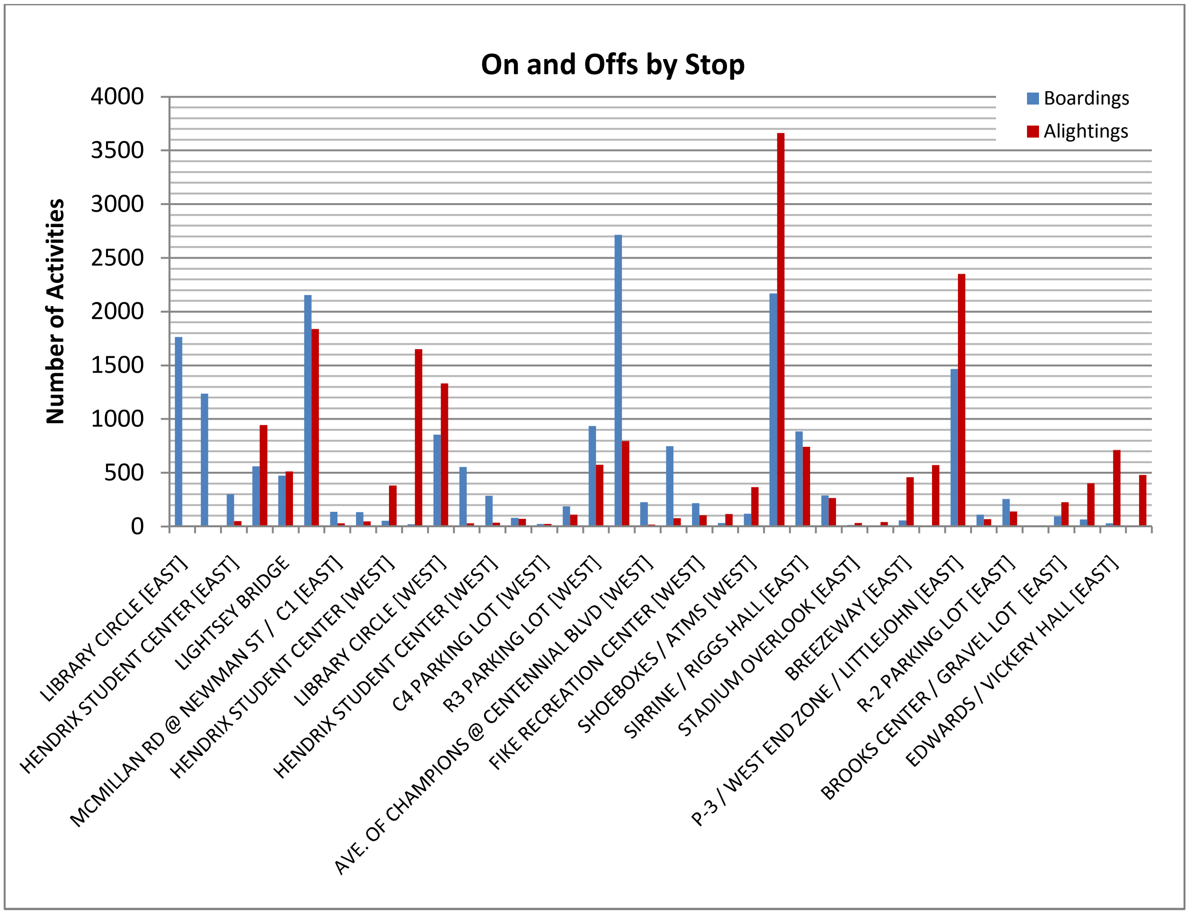

Figure 13: Boardings and Alightings by Stop for Fall Survey Week

Total ridership by day is shown in Figure 14. Ridership Monday through Thursday is consistently above 4,000 trips with a large decrease on Friday. This decrease was consistent with a decrease in class activity since many classes meet only Monday and Wednesday or Tuesday and Thursday. Ridership was near zero on the weekend. This ridership level was significantly less than the past ridership from the Campus Connector route. It was believed that this decrease stems from the purpose and frequency of the route running. The purpose of the Campus Connector was to provide an on-campus circulator at night and on the weekends. On the weekend, the primary riders of the transit system were resident students who were parking their cars and riding the bus back into campus. The purpose of the Tiger Route was to provide access from the commuter lots to the interior of campus. The Tiger Route did not provide frequent or direct enough service for residential students to make the bus an attractive alternative over the demand response service offered. Consistent with the ride check survey results conducted by Connetics in 2007, all boardings on the weekend happened between 6:00pm and 1:00 am.

By reviewing the total boardings by the hour, the peak hours of service were identified. Figure 15 depicts the total boardings by the hour for the entire survey week. By examining this graph, the peak hours could be defined as 8:00 am – 4:00 pm; however, to truly define the peak hours, the time frames needed to be narrowed to see the fluctuations in boarding patterns. By examining the boardings based on a 15 minute time frame, a peak hour factor (PHF) was calculated and the real peak hour determined. The PHF is calculated using the following equation:

$$PHF = \frac{Total\ Boardings\ in\ an\ Hour}{4 \times Boardings_{15\,\min max}}$$

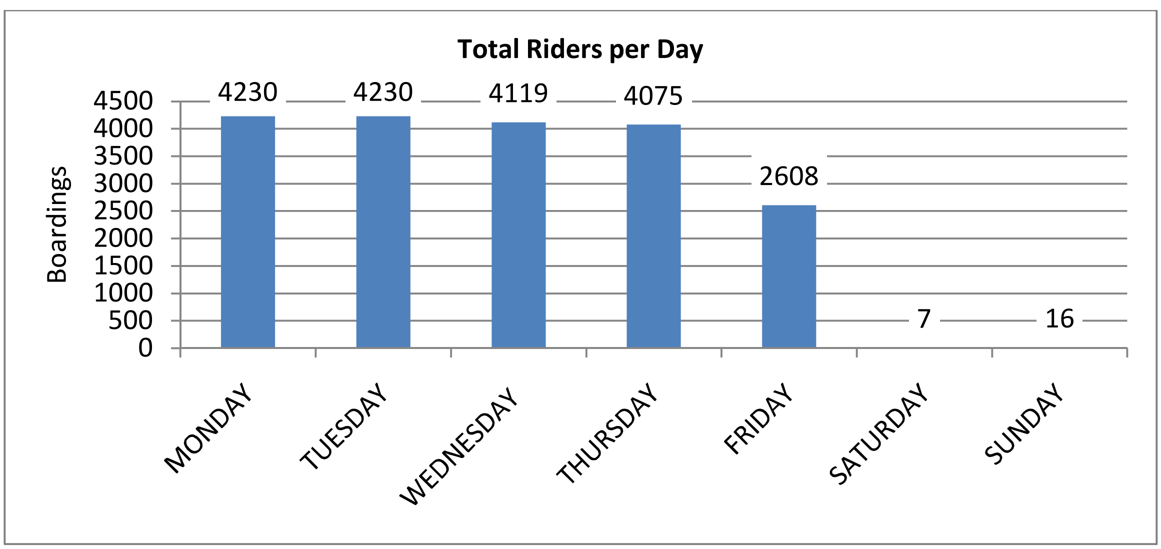

Figure 14: Ridership by Day for Fall Survey Week

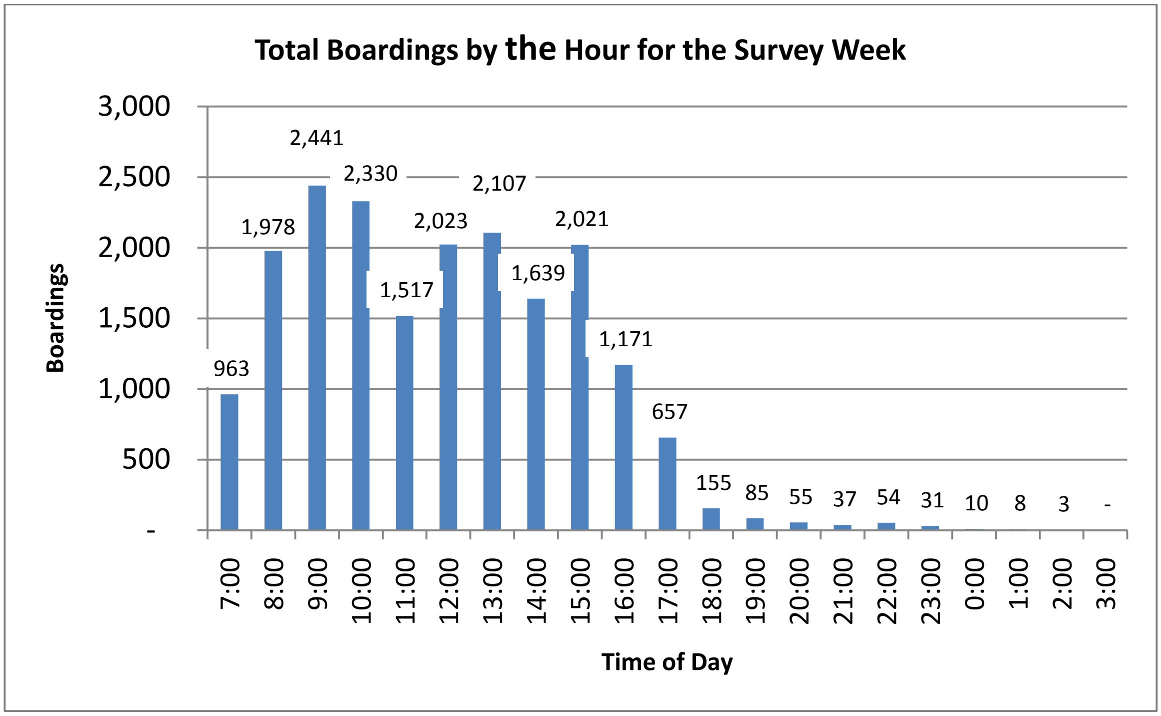

Figure 15: Total Boardings by Hour for Fall Survey Week

The peak hour factor related the total boardings in an hour with the theoretical maximum number of boardings determined by multiplying the maximum 15 minute boardings by 4 to convert it into boardings per hour. Generally this equation is used in traffic engineering, expressed in vehicles per hour, to evaluate the volume of cars and the level of congestion on the roadway. This same principle was applied to the CAT bus system to determine the volume of passengers boarding the system. To increase the accuracy of the factors, a correction factor would be needed to convert backpacks into equivalent passengers since they limit the amount of available space and affect bus capacity. Unfortunately, no information was collected about the size and number of backpacks or other baggage that was brought onto the bus. For the week, the maximum boarding in 15 minutes occurred at 12:00 pm with a total of 915 boardings. For the purpose of this study, any hour with a PHF of greater than 0.6 was considered a peak hour. Two peak times were identified using the factors – 8:15am to 12:30 pm and 1:15 pm to 2:30 pm.

The only hour to exceed a PHF of 0.7 was from 8:30 am – 9:30 am with a PHF of 0.75. It was the most active hour of the week. The peak hours, especially the highest peak hour, indicated the time in which a great frequency and capacity needed to be added to the system to accommodate demand. If the Tiger Route continued to prove its unreliability and leave passengers waiting for the next bus, the route can expect a continued decline in ridership and thus a continued decline in funding revenue. It is a vicious cycle that needs to be stopped by adding capacity and frequency to the route during these peak times.

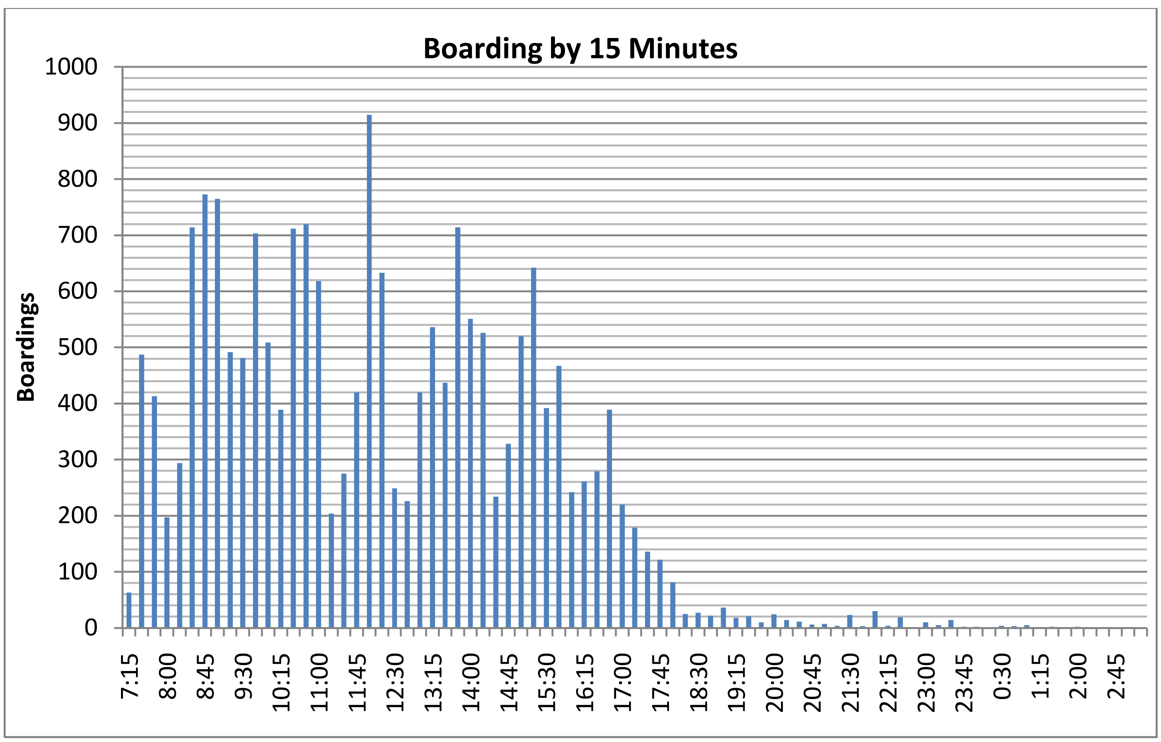

Figure 16: Total Boardings by 15 Minutes for Fall Survey Week

Average ridership on the system during the peak hours was striking. An average of 1,173 riders/hour used the Tiger Route while it was operating on its 8 min schedule during the week. Overcrowding on the buses was a serious concern when speaking about servicing this many people. The load standard of 56, as calculated by Connetics in its previous survey, relating the number of people who can comfortably fit on the bus without being crushed was reached once but never exceeded. The load standard was approached 46 times with the load passing 50. Since this route served primarily students, one must consider the baggage they bring on with them. Although the load standard was never exceeded in the number of people, the load in terms of available spaces was likely exceeded many of these times if the number of backpacks occupying the space of entire person were considered. This likely explains the several instances in the data in which people were left behind even though the load standard of 56 was not achieved. The Tiger Route was servicing a number of passengers during its 8 minute service, but it had the potential of servicing many more by reducing its frequency and/or increasing capacity.

On weekday nights and weekends, the load standard was in no threat of being passed. The average rider per hour significantly decreases to 46 riders per hour when the system switched to its 30 minute service on week nights. On the weekends, the average riders/hour drops down to 2, with no one boarding after 1:00am. There was a great potential to serve a larger number of students on the nights and weekends by changing the focus of the bus route from commuter parking lots into the core to residential parking lots into the core. A greater frequency, such as every 15 minutes, and more direct routes to residential housing from the parking lots would reallocate the burden of transporting students at night back to the bus system instead of relying on the demand response service operated by the Clemson University Police Department.

The peak hours of service were from 8:15 am to 12:30 pm and from 1:15 pm to 2:30 pm as defined by a peak hour factor greater than 0.6. The greatest activity in an hour on the route occurs from 8:30 am to 9:30am with a peak hour factor of 0.75. The highest 15 minutes of activity occurred at 12:00 pm with 915 passengers boarding the buses. Inactive hours, hours which had a peak hour factor less than 0.1, occur from 5:45 pm to 3:00 am. This decrease in boarding corresponded to the switch to the 30 minute service, conclusion of the main academic day, and the ability of commuter and resident students to park in employee spaces around campus. This indicated that the needs of the passengers changed and bus was no longer an attractive means of travel. The weekend service had extremely low ridership which corresponded to the focus of the route which was still getting commuters into campus while the group of passengers needing the route was residential students trying to get to their dorms. Even though the Tiger Route had high ridership over the survey week, there was still room for improvement.

A ride check survey can serve two purposes – 1) it acts as a form of origin-destination study in which travel patterns can be determined and 2) helps identify what the supply and demand is on the system. Table 10 illustrates the difference in the supply and the demand for the summer and fall ride check surveys. In the summer, the supply of transit is far beyond that of demand; however, during the same hours in the fall, demand is much higher than supply indicated by the number of people being left behind. During the day time hours, the West side of campus has the most demand for service with the

East side of campus having the greater demand at night. With this information, further analysis was done to determine how to best align transit with current and future demand.

Table 10: Ride Check Summary

		Summer Ride Check	**Fall Ride Check**	
			Day time	**Night time**
	Dates of Survey	July 27 - July 30	Sept 28 - Oct 4	
Supply	Hours of Operation	7:30am - 5:00pm	7:30am - 6:00pm	6:00pm - 3:00am
Supply	Number of Hours	9.5	10.5	8
Supply	Headway	30 min	8 min	30 min
Supply	Number of Buses Utilized	2	7	2
Supply	Number of Runs Completed	76	385	18
Supply	15 Min Capacity Out of Parking Lots	56	294	56
Demand	Peak Hour	8:45am - 9:45am	8:30am - 9:30am	6:00pm - 7:00pm
Demand	Highest 15 Min Peak Demand	26	362	27
Demand	Total Ridership	257	18,847	438
Demand	Top Boarding Location	Breezeway [West]	P-3 Parking Lot	Library Circle
Demand	Top Alighting Location	Brackett Hall	Brackett Hall	Hendrix Student Center [East]
Demand	Total Number of People Left Behind	0	457	0

Peer University Benchmark Survey

The results of the peer university benchmark survey were broken down into topics. For topics in which information was available from all universities respondents, all information was utilized with the peer institutions' names underlined on the graphs. The topics addressed in the follow up survey only have data from the peer institutions. When reviewing these results, please note that the values expressed are self-reported.

Parking Structures & Fees

Each institution was asked how much a parking permit is for a year for residential students, commuter students, general faculty and staff, and 24-Hr reserved faculty and staff spaces. The 24-Hr reserved spaces included a wide variety of vehicle spaces ranging from a space which is reserved for the use of any faculty member 24 hours a day to individually reserved spaces. For each user group, universities were ranked based on the lowest price for the permit. On each graph, the upper limit of the permit is the dark color. Also, Clemson University has been colored orange and purple for quick identification. Upon examination of the permit fees, Clemson University fell within the middle of the institutions questioned for both residential and commuter parking permit fees. The lowest range of faculty and staff parking permit fees moved Clemson to the lower end of the group; however, the higher end placed Clemson back in the middle of the test group.

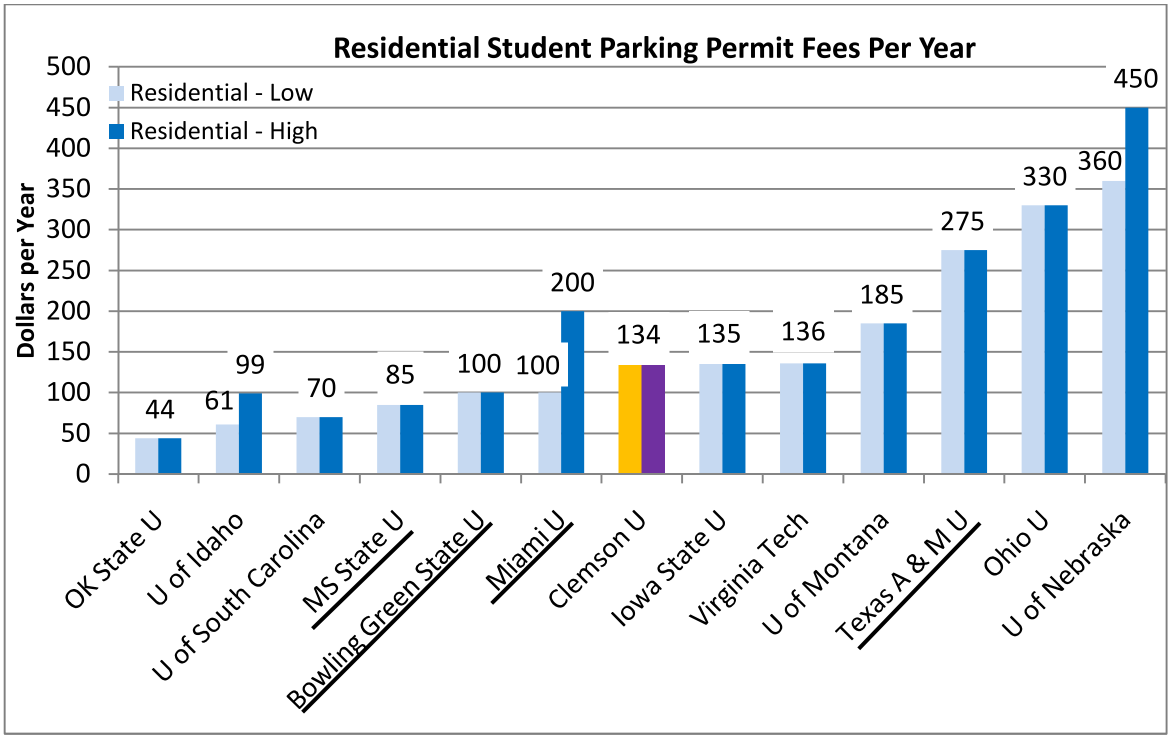

Figure 17: Residential Student Parking Permit Fees

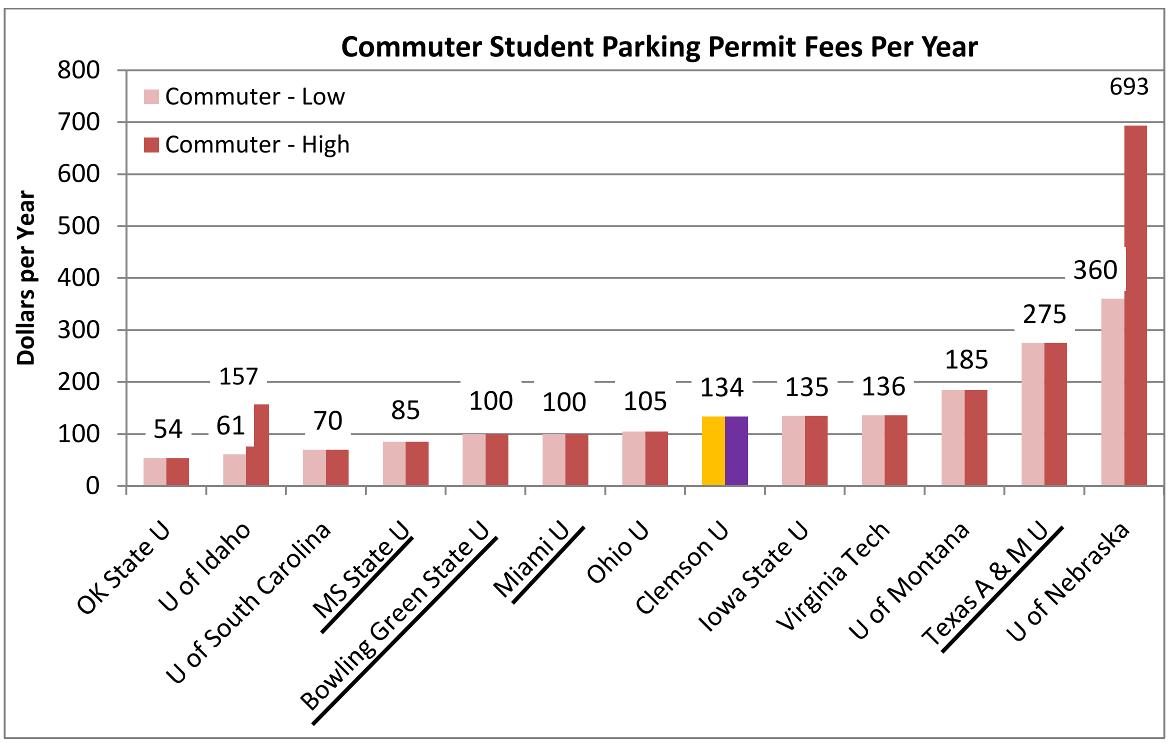

Figure 18: Commuter Student Parking Permit Fees

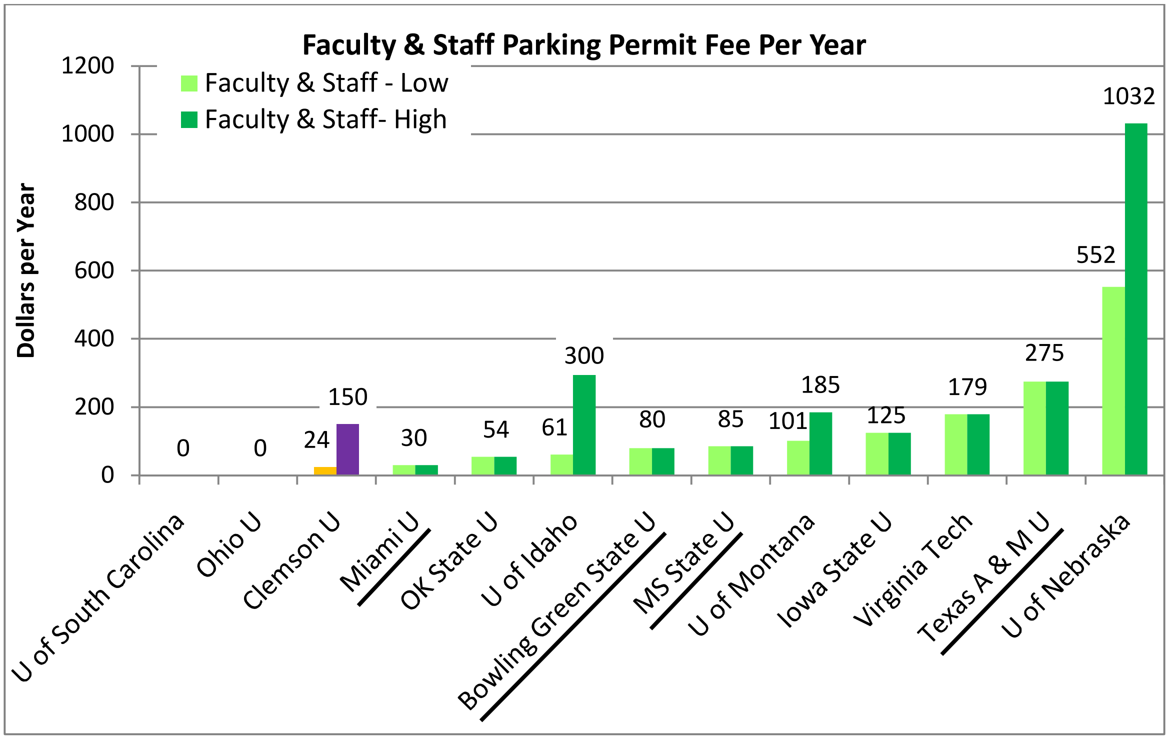

Figure 19: General Faculty & Staff Parking Permit Fees

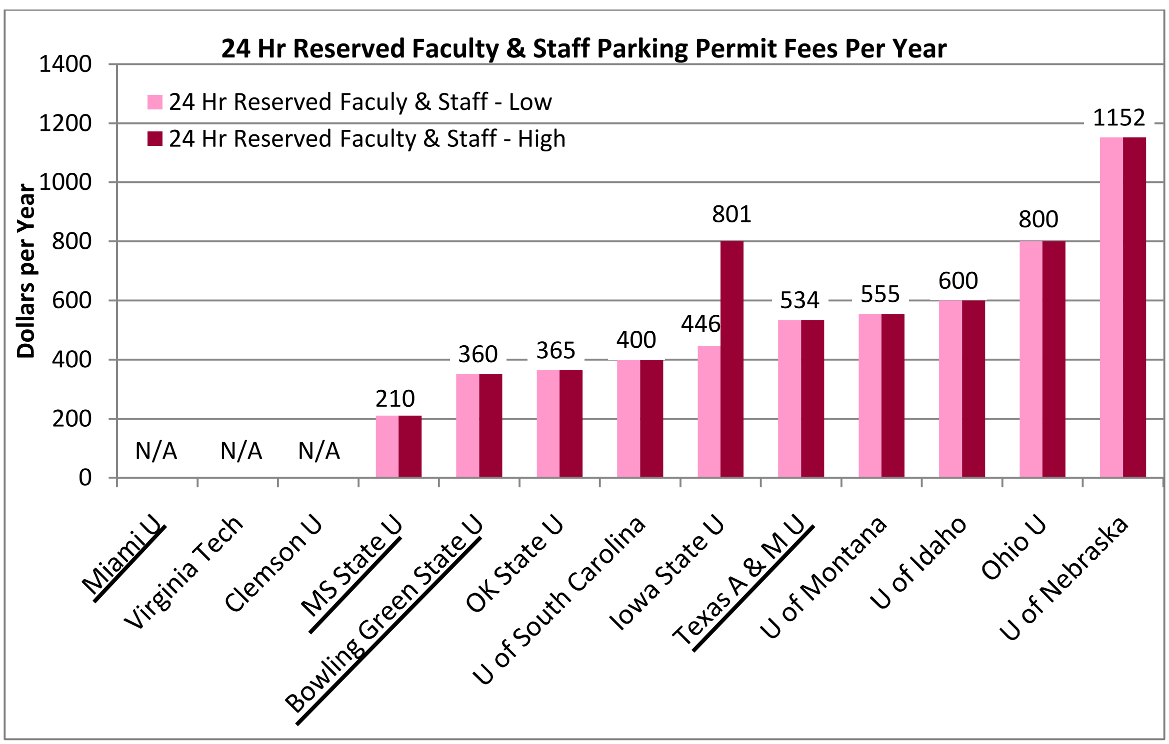

Figure 20: 24 Hr Reserved Faculty & Staff Parking Permit Fees

With the exception of the availability of reserved parking permits, Clemson's parking permits were averagely priced in comparison to the group. It was then necessary to determine if there was correlation between the parking permit fees and the parking structure. Currently, Clemson University utilizes a broad zone system for all user groups. A broad zone system allows users with a valid permit to park multiple facilities grouped into broad zones (e.g. by sector, user group, or price). A district parking structure assigns individuals access to specific parking lots. A hybrid system is a mixture of broad zone and district parking concepts. The most restrictive form of parking structure is assigned spaces in which individuals are assigned specific spaces in specific lots. 9 of the institutions surveyed reported the option of purchasing an assigned space for a high premium. Table 11 to 13 shows the number of institutions in the survey group that uses each type of parking structure and how those institutions relate to Clemson University in enrollment and cost for each user group.

Table 11: Parking Structure for Residential Students

Residential Students				
Parking Structure	Enrollment < Clemson		Enrollment > Clemson	
	Permit Fees < Clemson	Permit Fees > Clemson	Permit Fees < Clemson	Permit Fees > Clemson
Broad Zone	2	1	1	2
Hybrid	2	0	0	1
District	0	0	1	2
*Permit fees based on lowest parking permit fee option				

Table 12: Parking Structure for Commuter Students

Commuter Students				
Parking Structure	Enrollment < Clemson		Enrollment > Clemson	
	Permit Fees < Clemson	Permit Fees > Clemson	Permit Fees < Clemson	Permit Fees > Clemson
Broad Zone	2	1	3	0
Hybrid	1	0	0	1
District	1	0	2	1
*Permit fees based on lowest parking permit fee option				

Table 13: Parking Structure for Faculty & Staff

Faculty & Staff				
Parking Structure	Enrollment < Clemson		Enrollment > Clemson	
	Permit Fees < Clemson	Permit Fees > Clemson	Permit Fees < Clemson	Permit Fees > Clemson
Broad Zone	4	0	1	1
Hybrid	1	0	1	1
District	0	0	2	1
*Permit fees based on lowest parking permit fee option				

Based on these tables, the use of a broad zone system or some elements of one was common at most of the institutions studied. The two universities that used solely a district parking structure were Texas A &M University and Oklahoma State University. Iowa University used a district parking structure for all students and a hybrid approach for faculty and staff while the University of South Carolina used district parking for only the faculty and staff. Of the universities who were selected as transportation peers, Mississippi State University was the only university to only use broad zone parking with Bowling Green State University using a hybrid system for all users. Miami University utilized a hybrid structure for residential students, a district structure for commuters, and a broad zone structure for faculty and staff. As mentioned above, Texas A &M used a district parking structure for all users. Out of all the universities, Mississippi State University was the only university to use a cap on the number of parking permits sold, specifically for commuter student permits.

Parking Availability

As Clemson University's parking supply is decreasing with the expansion of academic buildings, the pressure to build a parking garage is ever increasing. Of the universities surveyed, 7 out of 12 had one or more parking garages with another university building one in the next two years. The top ranked transportation peers were split on parking structures - 2 had them and two did not. On-street parking in the core of campus was only available at 4 out of the 12 universities. Of the transportation peers, Mississippi State University and Miami University allowed limited on-street parking in the core of campus. For the protection of the students and other pedestrians on the university's campus, all transportation peers except Miami University had closed some streets to create pedestrian malls. Table 14 shows what parking facilities were available at each of the peers and what the parking ratio was for the university. Similar to the parking permit fees, Clemson University fell within the middle of the transportation peers. With respect to the number of spaces available and the ratio of users to parking spaces, the average parking ratio for this group of universities was 1.96. This ratio means there were approximately two people for every parking space provided on a university's campus. This figure was not derived from permits purchased, but rather the campus population as a whole. Unlike the identified peers, Clemson had a significant amount of on-street parking. Approximately 28% of Clemson's parking was on-street versus 6% at Mississippi State University, the highest of the peers.

Table 14: Parking Availability

Type of Parking Facility	Clemson U	Mississippi State U	Bowling Green State U	Miami U	Texas A & M
Surface Lot	9,318	12,495	11,000	6,592	27,008
On-Street Parking	3,594	800	0	402	310
Parking Garage	0	0	0	1,263	9,645
Total Parking Availability	12,912	13,295	11,000	8,257	36,963
Student+Faculty+Staff / Total Parking Availability	1.88	1.76	1.95	2.65	1.57

Table 15: Parking Permits Purchased

Type of Permit Purchased	Clemson U	Mississippi State U	Bowling Green State U	Miami U	Texas A & M
Residential	4738	3479	2735	1303	6095
Commuter	6946	9118	4664	2449	24932
Faculty & Staff	4166	3494	2751	4402	11980
Other	16	100	160	0	0
Total Permits Purchased	15866	16191	10310	8154	43007
Permits Purchased / Total Parking Availability	1.23	1.22	0.94	0.99	1.16

Table 15 examines the number of permits sold by user and defines the parking ratio based on the number of permits. Clemson University had the highest value for the permit/parking availability ratio with Mississippi State University close behind. This ratio represents the number of permits that were allocated to each space and the likelihood that a campuses parking system will be over capacity in the peak hour. Thus, Clemson was more likely than most of its peers to be over capacity during peak times. One must be cautious with respect to this ratio because a ratio too low will result in an under utilization of parking spaces whereas the opposite will cause frustration among parking customers and lead to inefficiencies in faculty, staff, and student productivity. All of the studied universities allowed freshmen to park on campus, except for Ohio University, with most parking provided near facilities. Also, none of the transportation peers reported that students regularly park on city streets due to the lack of parking on campus. This same sentiment was echoed at Clemson University. At every university surveyed, with the exception of Iowa State University who was in partnership with the City of Ames, the university was responsible for all parking facilities on its campus.

Parking Permit Priority

With parking availability being a growing concern on Clemson's campus among the students, many people were wondering if having a parking permit priority system was a good option. Clemson University released its parking permits on a first come first serve basis with no cap on the number sold for students, faculty and staff alike. Mississippi State University and Bowling Green University also administered parking permits on a first come first serve basis for all user groups. At Miami University, class standing determined what form of permit a student was eligible. For resident student areas, priority was given to all seniors and juniors. All resident sophomores were eligible for perimeter lot permits with the remaining number of permits released to resident freshmen. A priority system was not in place for the release of faculty and staff permits.

Texas A&M utilized a parking permit priority system that placed value first on years of permit ownership, then years of service to the university, followed by class standing and parking availability. In this system, a freshman renewing his permit would have a higher priority than a senior requesting a permit for the first time. To be considered in the priority system, all permit requests must be made during the annual registration period from mid April to mid July. If Clemson University were to develop a priority system, administrators would need to determine what it values most and create a data management system that will capture the necessary information in order to properly assign priority.

Transit Fees

All initial survey participants were asked if a student fee was charged at the university to support transit operations. 8 out of 12 universities stated that there was a transit fee charged. Figure 21 depicts the transit fee per semester at each of the universities. Miami University and the University of South Carolina levy their transit fee on a per year basis. It was divided in half to represent a per semester charge assuming the fall and spring semesters to be the most prominent. Oklahoma State University's transit fee is levied at a rate of $2.30 per credit hour per semester. The amount represented on the graph is of a full time student taking the minimum 12 hours. The transit fees depicted on the graph below represent the fee levied in the 2008-2009 school year. The University of Montana has raised its transit fee to $26/semester for the 2009-2010 school year and Iowa State University increased its transit fee to $62.61/semester. Of the schools who charge a transit fee, Clemson University again falls in the middle of the group. The average of the transit fees for the group, excluding those who did not charge a transit fee, is $37.44/semester. Once again, Clemson falls just under the average of the universities. Including those universities who did not charge a transit fee, the average transit fee levied is $25.92. Among the transportation peers, two universities did not have a transit fee and other two have some of the highest. The average transit fee among the transportation peers was $32.50 which was only a dollar less of what Clemson University currently charges.

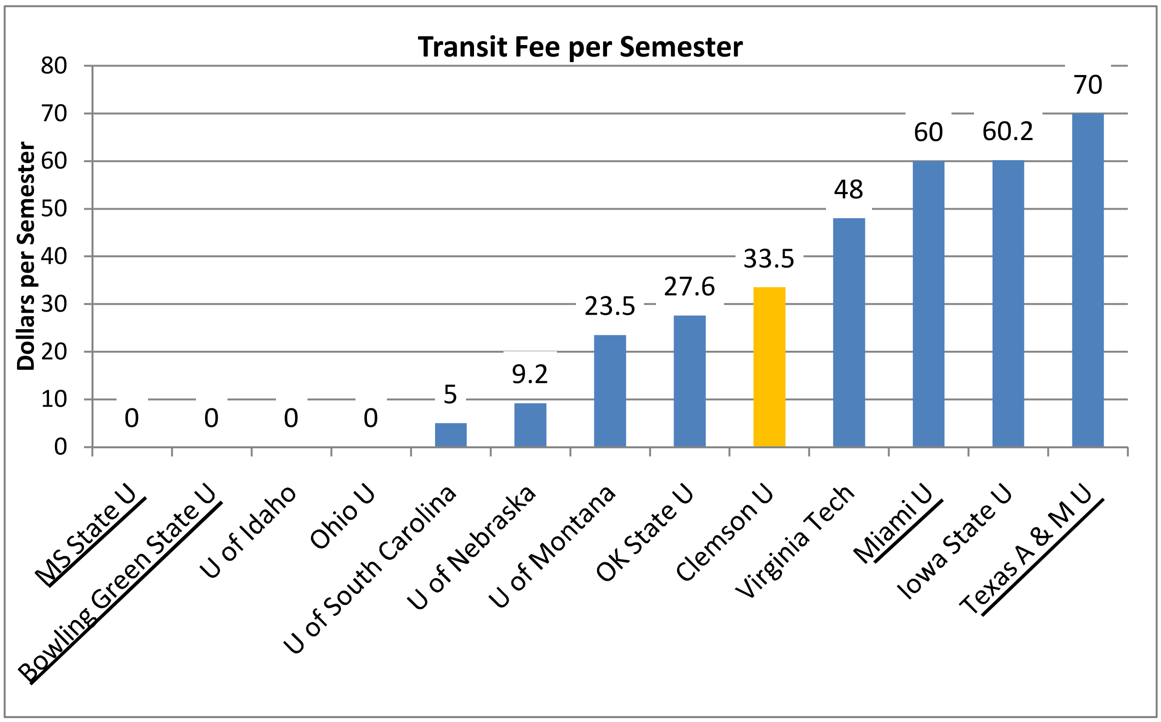

Figure 21: Transit Fees Levied Per Semester

All of the universities who stated they did not have a transit fee have operating budgets for their transit systems of less than $1 million. Figure 22 depicts the money generated by the transit fee for each university and the associated transit operating budget for 2008-2009. No operating budget information was received for the University of

Idaho, University of South Carolina, or Virginia Tech so it is not depicted on the graph. At every university in the initial survey group, patrons with University IDs rode free. At Bowling Green State University, the transit system was for the sole use of university patrons. At 7 out of the 10 universities, including Clemson University, in which transit data was captured offered free fares to the public as well. Iowa State University charged $1.00 per rider, University of Nebraska charged $1.50 per rider, and Oklahoma State University charged $0.25 per child and $0.50 per adult. 6 out of 10 universities, including all of the transportation peers, surveyed stated the universities managed the transit systems; another three universities shared the management responsibilities between the university and the city. One university had the city manage the transit service. Clemson University contracted its transit services on campus to Clemson Area Transit which is run through the City of Clemson.

Demand Response Systems

Clemson University operated a demand response system through the Clemson University Auxiliary Student Patrol funded through the Clemson University Police Department. The service utilized two 12 passenger vans and operated from 7 pm to 7 am seven days a week while school was in session. Last year, the student patrol provided 48,777 trips to students to and from on-campus destinations only. Of the transportation peers, two provided demand response services which operated similar to Clemson University – Bowling Green State University and Miami University. Bowling Green State University operated its service from 6 pm to 6 am utilizing 1 vehicle which services both on-campus and off-campus destinations. In the last year, the services conducted

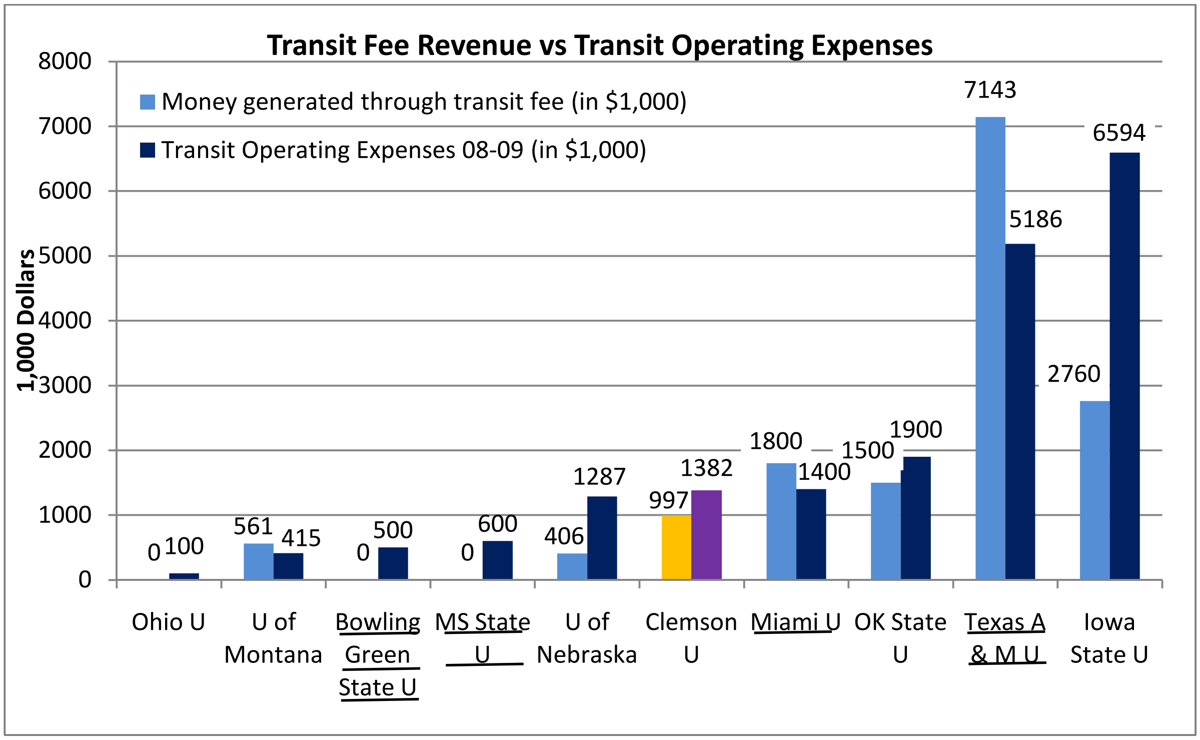

Figure 22: Transit Fees vs. Operating Expenses

8,200 trips. Miami University operated its service from 6pm to 2 am Monday through Wednesday and from 6 pm to 4 am Thursday through Sunday. Its demand response service utilized two vehicles which serviced on and off campus destinations and made 6,053 trips last year. The Clemson University Auxiliary Student Patrol is using the same number of vehicles as the peer services but serviced six times the number of passengers. The demand response system is working extremely well at Clemson and more attention and resources should be provided to the service to continue its exceptional performance.

Carpool Programs

Clemson University initiated a carpool program in 2008 by offering groups of 2 or more students or faculty and staff an option for a discounted permit that was to be shared amongst the group. The participants of the program also received access to specially marked carpool spaces located in prime parking areas near various academic buildings. Of the 12 universities surveyed, 9 of them offered some form of rideshare program. The three universities who did not offer a carpool program are Mississippi State University, Bowling Green State University, and Ohio University. Out of all the programs, Clemson University offered more than three times the number of dedicated carpool parking spaces on campus; however, Clemson is one of two universities, the other being Iowa State University, that had not adopted a service to aid in carpool formations. Four universities offered ride matching using AlternetRides.com, two through GoLoco.com, another through Green Rides, and the final university offered the service through PCEI Vanpool. Out of the universities who reported the number of participants, Clemson University led the group with 39 participants with the next highest at 34 participants at Oklahoma State University. Even though Clemson University's program led in participation, the program could be further expanded with the use of a ride matching program.

Paratransit

All surveyed universities, with the exception of Bowling Green State University and Clemson University, offered a paratransit service on campus. Under the Americans with Disabilities Act, complementary paratransit service is required for passengers who are 1) unable to navigate the public bus system, 2) unable to get to a point from which they could access the public bus system, or 3) have a temporary need for these services because of injury or some type of limited duration cause of disability (49 CFR 37.123). Title 37 also states that "complementary" paratransit to destinations within 3/4 mile of all fixed routes should be provided (49 CFR 37.131). On most university campuses, including Clemson University, a ¾ mile radius from any point on a fixed route system encompassed the whole system. Campus planners and administrators must be considerate of the time necessary for a disabled person to reach his/her destination if walking was a difficult task and he/she must rely on several transfers between buses to reach the destination. Although Clemson University allows persons with a handicap tag to park in any parking spaces without charge, some form of paratransit should be considered for those individuals who do not have access to a personal vehicle.

Funding Campus Improvements

The transition from single occupancy vehicles to a more sustainable multi-modal focus generated many questions about who should pay for the transition. In most universities, the parking services department regulated not only vehicle provisions, but they are increasingly becoming responsible for bicycle provisions. The question on many administrators minds was should the parking services budget help improve bicycle and pedestrian facility improvements in the attempt to reduce the number of vehicles on campus. Clemson University did not have dedicated bicycle paths around campus. Of the transportation peers, only Mississippi State University and Texas A&M University had dedicated bicycle paths on their campuses. Mississippi State University’s Parking

Services department was the only one reporting funding bicycle and pedestrian facility improvements.

Pavement maintenance and restoration projects can become extremely costly for a university. The rate of pavement degradation depends on many factors including the weight of the usual vehicle, repetition of use, climate, age, and its quality of materials. Regular maintenance to roadways and parking lots can extend the life of the pavement significantly; however, resources must be available. Pavement maintenance and restoration projects need to be proactive instead of reactive in order to receive the greatest benefit over the life of the pavement. Clemson University had not devised a pavement restoration schedule or a mechanism for raising the money to complete such projects. The transportation peers were asked if a portion of money raised through either parking permit sales or a transit fee went to pavement restoration or transportation improvement projects. Mississippi State University funded 1/3 of the transit operating budget and all capital expenses for shuttles through the sales of parking permits. Bowling Green State University also funds its transit services through the Parking & Traffic Budget. Neither of these two schools charged a separate transit fee to its students. In 2008 – 2009 Miami University did not have an allocation to any transportation improvements for its campus. Administrators at the university allocated $150,000 out of the Parking Services budget in FY2011 for transportation improvement projects. A 3% annual increase will also be included in future years. Texas A & M University committed money annually from parking permit sales to be used for transportation improvements. In 2008-2009, $2.5 million was earmarked for such projects. In light of increasing budget constraints and the escalating prices of materials, the continual allocation to the preservation of current transportation facilities is becoming essential for universities.

Sports and Major Events

A follow up survey was released to the transportation peers asking about what management changes occur for a major event, including sports events, and what financial support, if any, was given to the parking services budget. At Clemson University, the Athletics Department contributed no money to the parking services budget for the use of parking facilities for sporting events. The same was true for Clemson Major Events who sponsors the large community and concert events on campus. At specified times, depending on the time of the event, management and enforcement of the parking areas transfers from Parking Services to either the Athletics Department or Clemson Major Events with the assistance of the Clemson University Police Department. Any money generated through parking revenues at an event stay within the sponsoring department. Clemson University was looking into options in which these events can help support the parking services budget or transportation improvement projects through examining the practices of the transportation peers.

Mississippi State University separated special event parking and general parking operations. Special Event Parking was a standalone parking operation with its own budget. Most concerts and major events held at the university charge for parking, with some exceptions based on the type of event, and revenues from those events go towards the Special Event Parking budget. The Athletics Department also contributed to this budget through the reserved Bulldog Club parkers. For football games, members of the

Bulldog Club had a parking fee added to the price of their ticket automatically while general parking is available for $15 per game. A portion of these proceeds went to the Special Event Parking budget but no money was contributed to the general Parking Services Department.

At Bowling Green State University, different management teams were used based on the event. For special events held at the university, the Parking and Traffic Division was authorized to enforce parking restrictions based on the event. Home basketball games fall under the category of special events and the two main lots were restricted from access between 5 pm and 8 pm unless the appropriate decal is displayed. For football games, the Athletics Department assumed responsibility over the parking lots and managed parking throughout the campus. The athletics department did not contribute financially to the Parking and Traffic Division.

At Miami University, the Parking Services Division maintained control over parking during all events. For home football game, only the major parking lot at the athletics arena was cleared. A standard budget transfer was made yearly from the Athletics Department to Parking Services. In 2008-2009, the budget transfer was $50,000. Parking restrictions for all other events were arranged with Parking Services as needed.

Texas A & M’s University Transportation Services, which encompasses the Parking Services Department, was responsible for management and enforcement of parking regulations for all events held at the university. For concerts and major events, commuter lots were the primary lots affected around the arena. Since the lots were generally empty by the time of an event, they were not forcefully cleared and permit holders were allowed to park in the area for free. A parking fee of $5 was charged to the public. For home football games, approximately 9,000 spaces were cleared by 6 am on game days. All the lots cleared were faculty, staff, and commuter lots. University Transportation Services was responsible for clearing and staffing the lots on game day. University Transportation Services charged the Athletics Department $13 per space for what they use on game days for each of the 7 home games. In FY 2009, the Athletics Department was charged $508,557 for booster parking alone for the football season. For all events held at the university, including football, $1,187,209 was raised through parking fees.

The issue of special event parking was different at every university. Out of the four universities, which were all chosen to be similar to Clemson, no two schools managed event parking the same. As Clemson University moves forward in managing its event parking regulations, no one style can be directly emulated from a school above. Whatever strategy adopted must be customized to fit the needs and abilities of Clemson University.

Walking Time Study

The average walking speed used in traffic engineering is 4.0 fps for general public applications or 3.0 fps in cases of high percentage of elderly people. To accurately portray the travel times for pedestrians, it was necessary to determine the average walking speeds of students on campus with a primary focus on undergraduate students because they were the most likely to have to switch buildings between classes. 109

samples were captured using a cluster sampling method. A summary of the results are seen in Table 16. For the interest of this study, any values falling outside of four standard deviations from the mean were considered an outlier. Upon examination of the data, only the maximum data point fell outside four standard deviations. It is generally accepted that a speed of 6 mph, translating to 8.8 fps, is running. With the maximum value falling only 0.15 fps from a running pace, it was excluded from the data set and the statistical data was calculated again.

Table 16: Initial Walking Time Study Results

Minimum	2.56
Maximum	8.55
Median	4.54
Average	4.48
Standard Deviation	0.86
Lower Outlier Limit	1.05
Upper Outlier Limit	7.91

Table 17: Walking Time Study Results Excluding Outliers

Minimum	2.56
Maximum	6.97
Median	4.53
Average	4.43
Standard Deviation	0.74
Lower Outlier Limit	1.47
Upper Outlier Limit	7.40

The true average walking speed of undergraduate students was expected to be 4.43±0.14 fps with 95% confidence. Even at the lowest expected value of 4.29 fps, it was still higher than the default value for walking speed using in traffic engineering. Based on an average distance traveled of 3301.75 ft and average walking speed of 4.43 fps, the travel time required for the trip is 12:21.5 minutes which fell within the given class change period. Looking at the longest trip made across campus from P-1 Parking Lot to Brackett Hall, two heavily trafficked locations, took 25:53.1 minutes at the average walking speed which does fall within the allotted time. This distance, however, is not between two class locations which means that students need to budget their time appropriately when they arrive at campus. The longest class to class travel length was 4553 ft Fike Recreation Center to the Brooks Center of Performing Arts. At the average walking speed, this trip would take 17:02.5 minutes to complete. With this being the longest class to class trip, it is likely that most students traveling at an average walking speed should be able to switch academic buildings within the allotted 15 minutes. For those who either consistently walk slower or for those who have an extensive walk, the use of transit could be extremely useful assuming that the route alignment serviced the origin and destination.

Preliminary Alternative Analysis

The members of the Clemson Transportation Continuity Council was tasked with each creating a transit route(s) that they felt best served the needs of Clemson students. Each member was asked to present their alternatives to the council and explain why it was the best solution. The topics addressed in the discussion of the evaluations were input into a matrix and expanded on by university administrators and members of Clemson Area Transit. Clemson Area Transit was also asked to submit transit route alternatives for the review process. Figure 23 – 28 represent the alternatives developed by the students of the Clemson Transportation Continuity Council while Figure 29 represents the alternatives submitted by Clemson Area Transit.

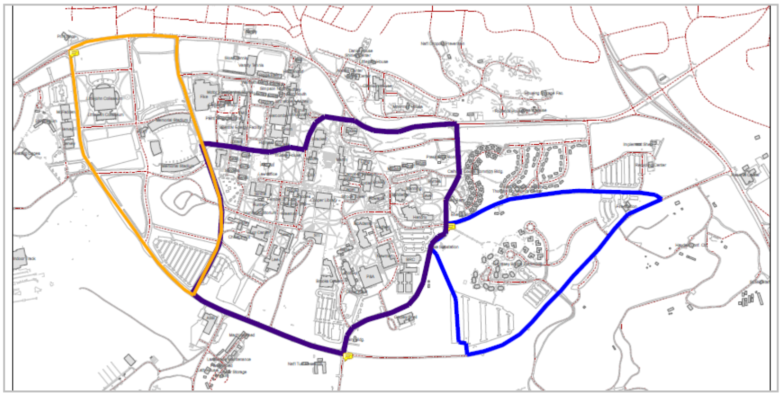

Figure 23: Clemson Alternative A

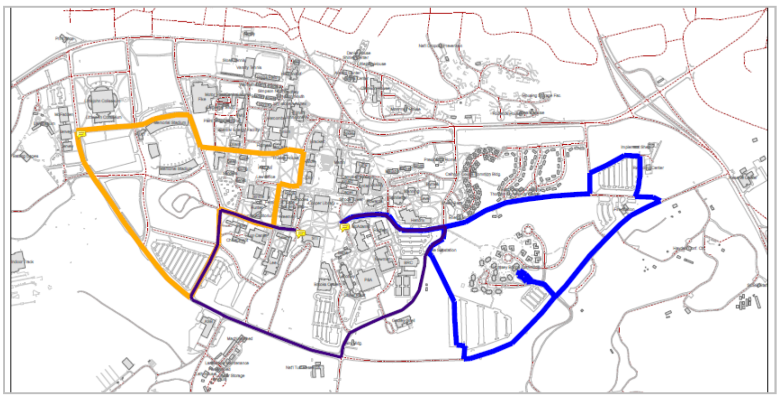

Figure 24: Clemson Alternative B

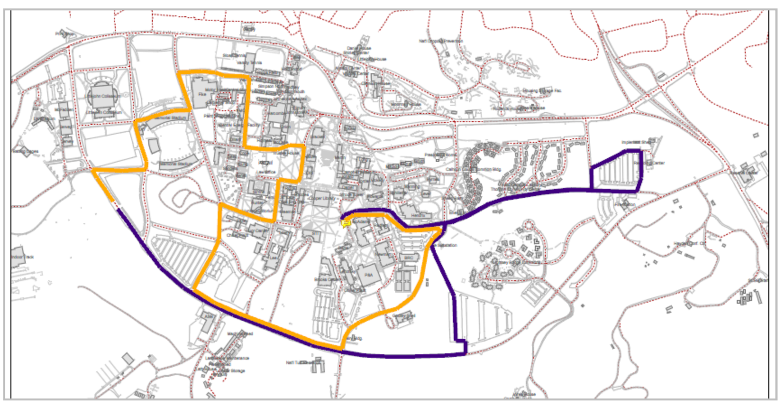

Figure 25: Clemson Alternative C

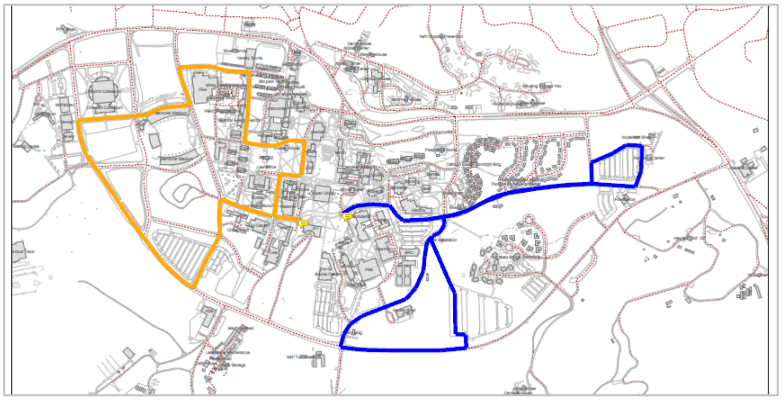

Figure 26: Clemson Alternative D

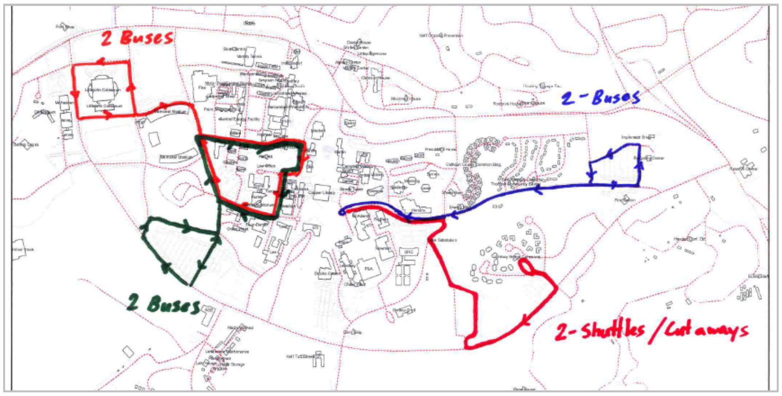

Figure 27: Clemson Alternative E

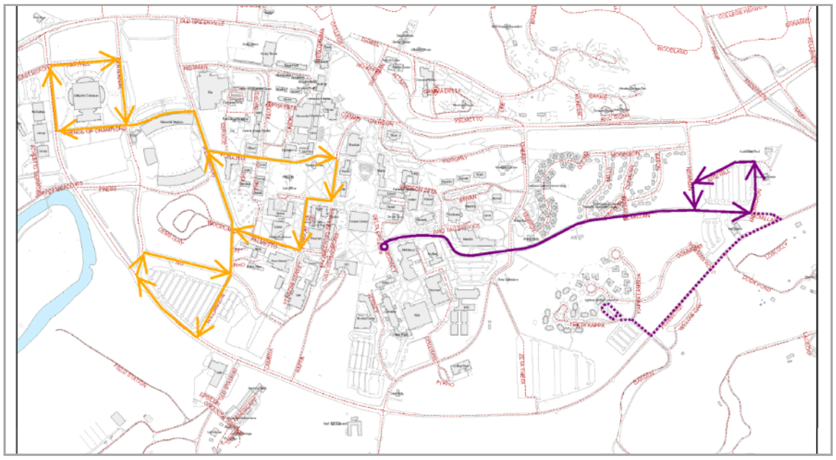

Figure 28: Clemson Alternative F

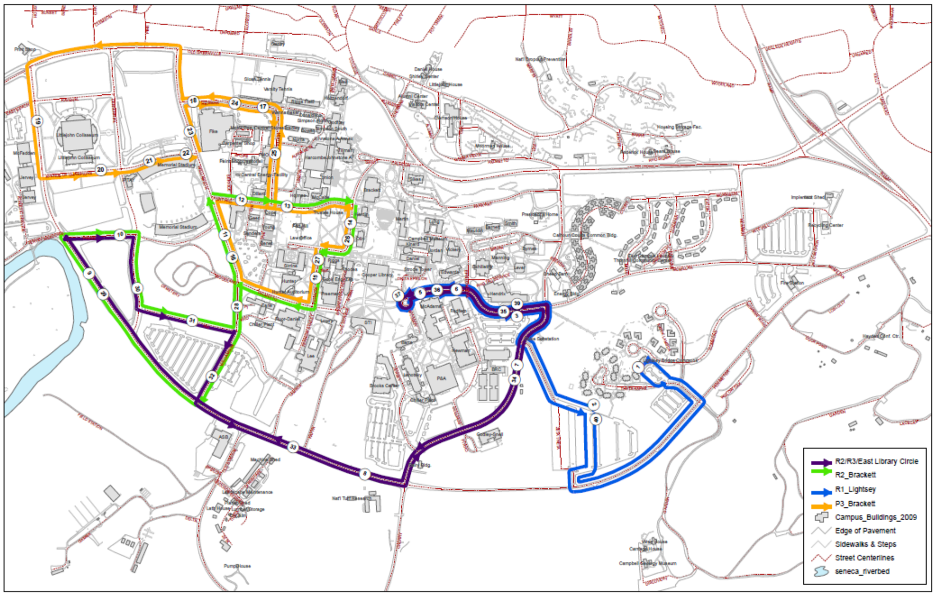

Figure 29: Clemson Area Transit Alternative

Alternative Analysis

After all of the alternatives were developed, a list of concerns was compiled. The concerns of the Clemson Transportation Continuity Council, Clemson University administrators and planners, and Clemson Area Transit were input into a matrix for alternative analysis. Each alternative was rated on a scale of 1 to 5 with 1 being the worst and 5 being the best. The concerns were given equal weights so that no one's concerns were viewed as more important than another's. The scores were summed and the highest combined score represented the best compromise solution. The matrix used in the analysis can be seen in Table 18.

Table 18: Transit Route Alternative Analysis Matrix

	Tiger Route	Clemson Alternative A	Clemson Alternative B	Clemson Alternative C	Clemson Alternative D	Clemson Alternative E	Clemson Alternative F	CAT Alternative
Scale of 1 to 5 = 1 is the worst, 5 is the best								
Trip Directness	2	1	4	2	2	5	5	3
Length of Route	2	3	2	4	4	5	5	1
Route Complexity	2	3	3	2	2	5	3	1
No. of Left Turns Required	3	5	3	3	4	3	3	2
Noise Contributions	3	5	3	3	2	2	2	2
No. of Destinations Served	5	1	3	3	4	3	5	3
Driver Break Locations	5	2	4	5	5	3	5	5
# of Relief Drivers Needed	5	1	3	5	3	1	3	5
Effects of Cumulative Boarding	1	4	3	3	2	5	5	5
TOTAL SCORE	**28**	**25**	**28**	**30**	**28**	**32**	**36**	**27**

As seen from the matrix in Table 18, the Clemson Alternative F is the clear winner. Based on the input of all the stakeholders, it should represent the best compromise solution. With the primary voice coming from the Clemson Transportation Continuity Council, Clemson Alternative F should best meet the needs of Clemson students. The orange route serving the West side of campus could be confusing to visitors or new members of the Clemson community who are not familiar with the destinations on each end of the route. The use of marquees and available maps either in paper or electronic versions will be necessary to minimize to the potential for confusion. Since Alternative F was determined to be the best transit alternative it was the route chosen to be simulated and compared to the current Tiger Route operations.

Simulation of Transit Routes

The base simulation model created in VISSIM version 5.10-03, a microscopic traffic simulator, by Dr. Ryan Fries for the Clemson University roadway network and the fall ride check survey data was the foundation of the transit route simulation (PTV America, 2003). Based on the alternative analysis done in the previous section, the Clemson Alternative F was chosen as the best compromise solution which utilizes a split two route system. With average travels speeds being of greatest concern to Clemson administrators, transportation consultants, and Clemson Area Transit, a comparison existing operations on the Tiger Route to the selected alternative needed to be performed. See Appendices E and F for the route alignment of the current Tiger Route and for the proposed split route system.

When Clemson Area Transit was interviewed to determine what average travel speed it uses for planning purposes, it reported 10 mph. The average travel speed reported was one that took into account both travel time in which the bus was moving and dwell time which was when the bus was stopped at bus stop. To first verify the default value reported by Clemson Area Transit, a hypothesis test was conducted to see if the average travel for the East and West sides of campus was in fact 10 mph based actual run times collected during the fall ride check survey. For the East side of campus, the beginning time was recorded when the bus was leaving P-1 Parking Lot and the end time was recorded when it was leaving Library Circle. The West side of campus utilized the times when the bus was leaving P-3 Parking Lot going into the core of campus to when the bus was leaving the intersection of Centennial Blvd and the Ave. of Champions on its way to

P-3 Parking Lot. 38 randomly selected travel times were used as the sample in the hypothesis test. The distance traveled between each origin and destination was determined from an AutoCAD drawing provided by Clemson University facilities with the route alignments drawn in. To get the average travel speed, the average travel distance traveled in miles as determined from the drawing was divided by the average travel time of the sample in hours. The results of the hypothesis test are shown in Table 19 and 20.

In the hypothesis test for the East side of campus, the decision was to fail to reject the null hypothesis that the average travel speed was 10 mph as reported by Clemson Area Transit. From the test, the true average travel speed on the East side of campus should be between 9.5 mph and 11.4 mph based on a 95% confidence interval. The results of the West side of campus proved to be the opposite. The decision based on the hypothesis test was to reject the null hypothesis that the average travel speed was 10 mph. Based on the test results, the true average travel speed on the West side of campus should fall between 8.9 mph and 9.8 mph with 95% confidence. Although the upper limit is close to 10 mph, the true average travel speed is expected to be lower than the value reported by Clemson Area Transit. Upon initial inspection of the margins of error it was expected that the East side of campus would have more variability in the average travel speeds because they are affected by a traffic signal that the bus must pass through twice.

Table 17: East Campus Travel Speed Hypothesis Test Results

Ho: Average travel speed on the East side of campus = 10 mph		
Ha: Average travel speed on the East side of campus ≠ 10 mph		
Sample size	38	
Minimum speed	6.5	Mph
Maximum speed	17.4	Mph
Average Speed	10.4	Mph
Standard Deviation	2.60	Mph
Median	10.4	Mph
Alpha = 0.05		
Margin of Error	± 0.94	Mph
Lower 95% Confidence Interval Speed	9.5	Mph
Upper 95% Confidence Internal Speed	11.4	Mph

Table 18: West Campus Travel Speed Hypothesis Test Results

Ho: Average travel speed on the West side of campus = 10 mph		
Ha: Average travel speed on the West side of campus ≠ 10 mph		
Sample size	38	
Minimum speed	6.8	Mph
Maximum speed	11.9	Mph
Average Speed	9.4	Mph
Standard Deviation	1.23	Mph
Median	9.5	Mph
Alpha = 0.05		
Margin of Error	± 0.45	Mph
Lower 95% Confidence Interval Speed	8.9	Mph
Upper 95% Confidence Internal Speed	9.8	Mph

Clemson Area Transit's claim that the average travel speed was 10 mph was validated on the East side of campus but not on the West. From a comparison of the new route alignment with the existing system it was deemed unnecessary to simulate the purple route because no changes to the trunk of that route, the area of most concern, had changed from the existing alignment or the alignment from previous years. Clemson Area Transit was adamant that they were best equipped to time that portion of the route because of the level of experience they had with operating and planning that same route alignment. To reach a compromise on this issue, the Purple Route running on the East side of campus was not simulated.

Since the Purple Route was not simulated, only the Orange Route serving the West side of campus was simulated. Throughout the history of transit on Clemson's campus, loop systems have always been utilized on the campus. The Orange Route proposed was the first alternative discussed that mirrors a boomerang effect serving two major parking lots with the cumulative effects of passenger boardings. The simulation of travel speeds during the worst case scenario for both vehicle traffic and transit demand was necessary for this route in order to properly plan the route. Current transit stops utilized on campus composed of a majority of the transit stops utilized by the new route alignment. Three transit stops were added on the portion of the route going around Littlejohn Coliseum but were consist with the location of transit stops previously utilized prior to the switch to the Tiger Route. Once the alignment, boarding, and alighting information was input into the model, the average travel speed for the West side of campus was determined. The results of the simulation can be seen in Table 21.

Table 19: Initial Transit Simulation Results for Orange Route

	Travel Time (min)	Travel Time (Hour)	Total Distance Traveled (ft)	Total Distance Traveled (miles)	Average Travel Speed (mph)
N	40				
Minimum	11.83	0.1972	13575	2.571	7.71
Maximum	26.67	0.4444	18168	3.441	14.20
Median	16.42	0.2736	17891	3.388	12.35
Average	16.56	0.2760	17783	3.368	12.31
Std Deviation	1.97	0.0328	696	0.132	0.98
Alpha	0.05				
Margin of Error	±0.61	±0.0102	±215.6	±0.041	±0.30
Lower 95% Confidence Interval	15.95	0.2658	17567.4	3.327	12.01
Upper 95% Confidence Interval	17.17	0.2862	17998.6	3.409	12.61

From these results, the average travel speed along the route falls between 12.01 and 12.61 mph with 95% confidence. The average travel speed took into account traffic conditions at the peak vehicle and peak passenger hours. A histogram of the data can be seen Figure 30. The average travel speed obtained from the simulation exceeds both the average travel speed currently experienced on both the East and West sides of campus and the planning value used by Clemson Area Transit. Further investigation was required to refine the model specifically look at speed distributions used in the model.

When Dr. Ryan Fries initially constructed the model, he used observed bus speeds collected during the traffic study to create the speed distributions for the model. Since the posted speed limits change throughout the route, checkpoints were used throughout the model to adjust the speed distributions along the route alignment. Even with the use of checkpoints, the speed distributions allowed the bus to travel at speeds slightly higher than the posted speed limit. It was expected that the average travel speed generated from the model was higher because of the speed distributions used. In 2009, an incident between a Clemson student and a Clemson Area Transit bus created more strict operating guidelines for bus drivers to adhere to. The primary guideline was that no bus was to travel over the posted speed limit to enhance the pedestrian safety in the core campus and prevent any future liabilities. When the initial model was created, this guideline was not in place and further tests were needed to see if a limit on the speed distributions to the posted speed would significantly change the results.

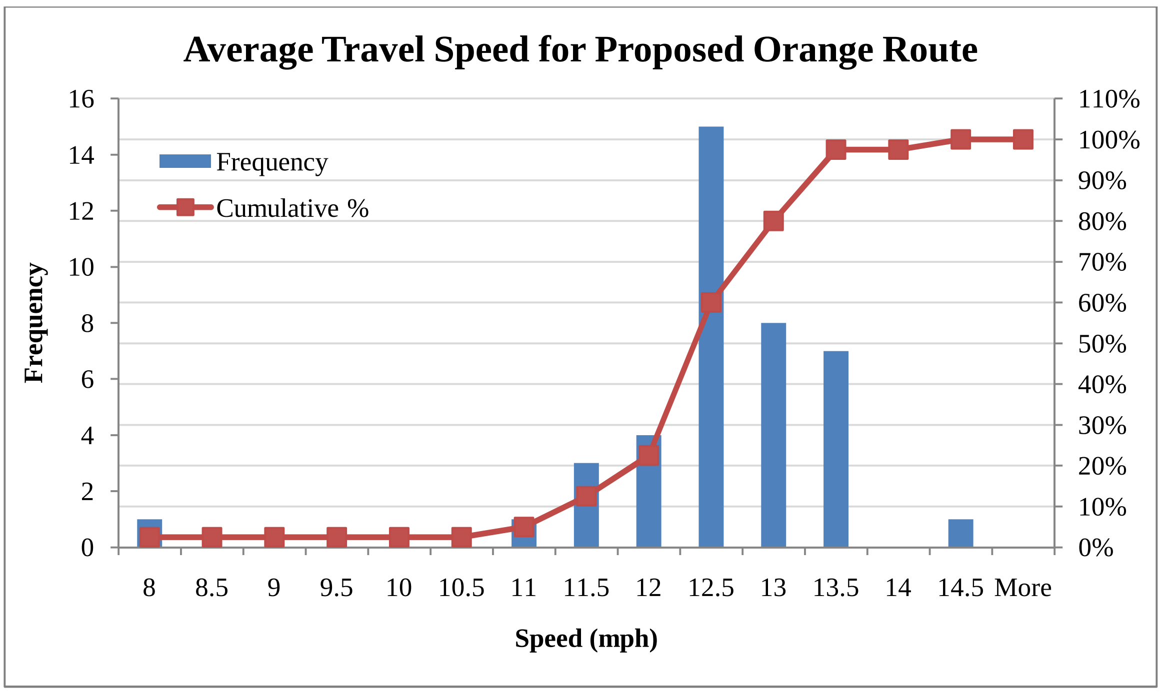

Figure 30: Initial Average Travel Speed for Proposed Orange Route

After determining that the average speeds of the model exceed those of safe operating conditions, all speed distributions were restricted to a maximum of the posted speed limit. Another simulation was executed to determine what the average travel speed was with all buses running at or below the posted speed limit. The new simulation generated an average speed of 9.85 mph which were consistent with the claim made by

Clemson Area Transit. Table 22 depicts the results of the three average travel speeds determinations for simple comparison. The transit simulation proved that Clemson Alternative F is a feasible route and should be sent to the consultant for further design. Based on the average travel speeds determined, the most conservative value to use in design was 9.4 mph found from the current Tiger Route operations. If a higher average travel speed was used in the design of the route, greater layover times should be considered in the bus schedules.

Table 22: Comparison of Average Travel Speeds on West Side of Campus

	Tiger Route	Orange Route w/ 2007 speeds	Orange Route w/ posted speeds
N	38	40	34
Minimum (mph)	6.8	7.71	8.80
Maximum (mph)	11.9	14.20	10.59
Median (mph)	9.5	12.35	9.94
Average (mph)	9.4	12.31	9.85
Std Deviation (mph)	1.23	0.98	0.46
Alpha	0.05	0.05	0.05
Margin of Error (mph)	±0.45	±0.30	±0.16
Lower 95% Confidence Interval	8.9	12.01	9.69
Upper 95% Confidence Interval	9.8	12.61	10.01

Summary

In this chapter, the results of the evaluation process and the case study were presented. From the progression of the case study, the evaluation process proved to be useful order and of an appropriate level of detail. The combination of planning, operations, and performance measurement tasks into one process seemed to help administrators grasp the complexity of the transportation while process helped sort through what needed to be done. The portions completed by Clemson University identified several limitations to the process. Working through the process identified several limitations of it. These limitations are discussed with the result they are associated with.

The Visioning sessions conducted at Clemson University served two purposes in relation to the evaluation process – identification of stakeholders and user and the revision of goals and objectives. The sessions spanned multiple days which allowed for the opportunity of any user group who was not originally included to be invited to the sessions. To provide consistency in the voting on goals and objectives, the voting structure was decided on at the start of the session series and maintained regardless of what other parties were invited. Students were given the predominant voice in the voting structure, but were not given the necessary two thirds votes so that their opinions could trump those of the faculty, staff, and major events. This process proved very effective for gaining a consensus on the goals and objectives of the university. In hindsight, it would have proved helpful for the university to invite the transit agency on the final day when the principles were being reviewed and the final version accepted so that the transit agency could get a sense of what the university is going to want and expect out of its transit service.

The summer ride check survey proved a very helpful tool for both determining travel patterns of students during the summer sessions and for refining the ride check process for the fall survey. The summer ride check survey revealed that 68% of the transit activity (combined boardings and alightings) took place on the West side of campus. Cross campus travel accounted for 24 out of the 514 transit activities during the survey week translating to 4.7%. The survey results also revealed that the peak transit times on campus in the summer were from 8:30 am to 10:15 am. The highest peak hour was from 8:45 am to 9:45 am corresponding to the arrival student for the 9:30am start of class. Never during the survey week did a bus not have seats available meaning that the buses running on campus were being underutilized. From these findings, it was recommended to the university that smaller vehicles be run campus during in the summer semesters to save on fuel and emissions on campus with the primary focus on the West side of campus. It was also recommended that the university consider running its demand response service during the day in the summer to better accommodate the low levels of ridership occurring the in the summer.

The fall ride check survey was invaluable in learning about the travel patterns of Clemson students. It was discovered that the Union/Tillman/Brackett bus stop located at the intersection of Fort Hill St and Calhoun Dr had a total of 5,831 combined on and offs occur at that stop in the one week of the survey. Eleven stops on campus had combined total activities of higher than 1,300 in the week providing a clear definition of locations that need to continue to be serviced. Peak and inactive hours were found utilizing the principle of peak hour factors. A peak hour was defined by any hour with a peak hour factor greater than 0.6 and an inactive hour was defined by any hour with a peak hour factor less than 0.1. The peak hours for the Tiger Route based on the sample of data collected were 8:15 am to 12:30 pm and 1:15 pm to 2:30 pm with the highest peak hour from 8:30 am – 9:30 am. The inactive hours spanned from 5:45 pm to 3:00 am, coinciding with the switch from 8 minute service to 30 min service.

Route frequency, capacity, and purpose were the limiting factors on the success of the Tiger Route. For the day time hours, frequency and capacity were the largest hindrance to ridership. In the evening and on weekends, purpose and frequency were the largest hindrance to ridership. The Tiger Route was designed to bring commuters into the core of campus, but at night and on the weekends the purpose was determined to be to get residential students to and from their dorms and the residential parking lots. It was recommended to the University that alternative transit route alignments be investigated that reduces the effects of cumulative boardings during the day and an expansion of the demand response service at night and on the weekends.

For smaller transit agencies, investments in automatic passenger counters or similar technology are uncommon. Without the aid of that technology, ride check surveys must be conducted manually which can prove to be very costly depending on the size of the system. Since the demographics and travel patterns of students on a university are constantly changing, it was recommended to the university that some form of technology investment be made so that continual monitoring of student travel patterns. With continual monitoring, the university will be able to better align transit alignments with their movements.

Benchmarking with other universities and colleges provides an opportunity to learn from peers and determine how well a university is performing in relation to others. Using the Visioning Committee members as the voice of the university, Clemson University identified four transportation peer universities – Mississippi State University, Bowling Green State University, Miami University, and Texas A & M University. These institutions were chosen based on such characteristics as enrollment, dorm capacity, and town setting. Through several surveys, these were some of the conclusions made about the transportation system at Clemson University in comparison with its peers:

- Clemson University parking permits are averagely priced for residential and commuter students and are the lowest for faculty and staff out of the institutions which charge a fee.
- There is no correlation between the parking structure, permit fees, and enrollment among the universities.
- Most of the universities utilize a broad zone parking structure or some hybrid of it.
- Clemson University's transit fee is approximately $4 less than the average transit fee of the transportation peers who levy a transit fee. All of the universities who do levy a transit fee have operating budgets of less than $1 million.
- Clemson University's demand response system serviced more student trips than its transportation peers at a rate of 6:1.
- All of the transportation peers allocate money to pavement maintenance and restoration projects through the parking services budget. Clemson should consider adopting a strategy to manage these costs as well.
- 3 of the 4 transportation peers have identified strategies in which the Athletics and Major Events Departments contribute to the parking services budget or an equivalent agency for the management of parking assets. Clemson University administrators should investigate strategies in which restoration costs for parking lots heavily used during football traffic can be generated.

The benchmark survey for Clemson University focused on only schools within the United States. Expansion of the list of potential peers to include international schools can provide the international perspective to a university's transportation system similar to the cultural enrichment brought to a university campus by international students.

The walking time study was needed to grasp the primary design value needed to evaluate the primary travel mode on a university campus – walking speed. As universities have to expand the size of their inner campus to accommodate additional academic facilities, allotted class change times must be reasonable for an average student to walk from one academic building to another. The standard design value used in traffic engineering for the walking speed of an average person is 4.0 fps. Through the walking time study, it was found that an average Clemson University student is expected to walk between 4.29 fps and 4.57 fps. Using these design values, it was determined that the allotted 15 minutes currently given on Clemson's campus is an adequate amount of time to change academic buildings, even those across campus. The sample data was generated using a cluster sampling of sophomore civil engineering students. To provide a greater cross section of the university, a random sample of student taken across multiple majors and class standings would produce a better picture of the entire student population.

The members of the Clemson Transportation Continuity Council (CTCC), Clemson University administration, and Clemson Area Transit were tasked with each creating a transit route(s) that they felt best served the needs of Clemson students. The CTCC generated alternatives in a workshop facilitated by project leaders while the administration and Clemson Area Transit created routes on their own and submitted them for review. 8 alternatives were generated including the do nothing option which meant continuing the operation of the Tiger Route. Each CTCC member was asked to present their alternatives to the council and explain why it was the best solution. The topics addressed in the discussion of the evaluations were input into a matrix for alternative analysis and expanded on by university administrators and members of Clemson Area Transit. Since the concerns of each of the stakeholders varied from group to group, equal weight was applied to each of the criteria. Each alternative was then rated against the concerns the highest combined score represented the best compromise solution. Clemson Alternative F, a two route split system consisting of a boomerang type movement on the West side of campus, received the highest score and was chosen for simulation. A summary of the existing transit route, the Tiger Route, and the two highest rated alternatives is shown below in Table 23.

Table 23: Summary of Transit Route Alternatives

	1 Route Tiger Route	2 Routes Split System	3 Routes Split System
Prelim Alternative Analysis Score	28	36	32
West Campus Travel Speed (mph)	9.4	9.85	9.85
East Campus Travel Speed (mph)	10.4	10	10
Capacity out of the parking lots	1113	1325	1484
Length of Route (miles)	7.77	6.08	5.28
Time to complete 1 run (min)	49.6	21.0	11.5
Number of relief drivers needed	0	2	3
Serves Lightsey Bridge with Buses	Y	Y	N

The simulation of the best compromise route alternative, Clemson Alternative F, was used to test the feasibility of the route. An important component of the route's feasibility was its average travel speed. To develop a comparison base, a sample of travel times were taken from the fall ride check survey and the average travel speed calculated based on the distance traveled. The average travel speed for the East side of campus was found to be between 9.5 mph and 11.4 mph which was consistent with an average travel speed of 10 mph as reported by Clemson Area Transit. Since the travel speed results were consistent with Clemson Area Transit's assessment and the new route alignment on the East side campus was not significantly different from the current alignment, the Purple Route was not simulated. An analysis travel speeds on the West side campus to be between 8.9 mph and 9.8 mph which was lower than what Clemson Area Transit was reporting. With the expected travel speeds lower than what was reported and the route alignment significantly different than anything that had been on Clemson's campus to date, the Orange Route on the West side of campus was simulated. The results of the simulation reported an average travel speed to be between 12.01 mph and 12.61 mph. These travel speeds exceed both the design value used by Clemson Area Transit and the results derived from the ride check data. Further analysis was needed to reduce the speed distributions to no faster than the posted speed limit. The average travel speed of the buses with the speed limited was 9.85 mph. This speed was consistent with the claim made by Clemson Area Transit and aligned closer to the actual travel speeds of the Tiger Route.

Based on the results of the process up to this point, Clemson University should consider changing the transit alignment to Clemson Alternative F or a close variation of that alternative in order to align transit with the parking principles and expected disruptions in parking due to academic expansions. The increase in capacity achieved through the minimization of the effects of cumulative boardings present on the current Tiger Route will improve the perception of transit on Clemson's campus and attract more riders to the system. Before the university to commits to changing the transit route, a definite consensus should be achieved across campus through some form of survey. More attention and resources should also be provided to the demand response service at night and on the weekends and potentially the summer in order to further improve a service that is outperforming its peers. Through a coalition of stakeholders invested in the improvement of transit and the transportation system on Clemson University's campus positive change can occur if the process is completed.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

There are many strategies published today that help with planning, operations, or performance measuring. Rarely does one see a process that incorporates all three of these important management pieces. The transit system evaluation process presented here does just that, specifically for a university transit system. By emulating a basic systems approach of identifying stakeholders, defining goals and objectives, generating and evaluating alternatives, and implementing a plan make the process easily understandable and highly customizable. For other universities to adopt the transit evaluation process developed, customization is required. The process was designed to guide administrators and planners through evaluation not to instruct them how to do one. The methodologies for the individual pieces of the process must be customized to fit the organizational structure and available resources at a particular university. The university should investigate what information is currently being collected and aim to supplement that data to generate the necessary data for evaluation. With a constantly evolving set of needs and wants, a university must plan its transportation system appropriately, know what the current state of the system is, and constantly be looking for ways to improve it based on performance measures.

Clemson University served as a test bed for this evaluation process. In the light of state and university mandated budget cuts, budget supplements from the general parking services funds, expansion of academic facilities onto existing parking lots, and parking allocations sending more students to parking lots served by transit and undesirable to walk from sparked a desire to evaluate transit and transportation options for the university. Through a coalition of the various stakeholders on campus, the university was able to redefine its parking principles into transportation principles. These principles were used to guide the evaluation process of the transit system. By conducting a walking time survey, which revealed that the average walking speed of Clemson students is 4.45fps, which is slightly higher than the normal average, planners will be able to judge the time it takes to walk from an existing academic building to a new one and check if the 15 minute class change time is sufficient. Through ride check surveys in the summer and fall, Clemson University was able to refine its transit system and identify times in which safety and convenience can be increased while reducing emissions on campus through the use of a demand response system. Throughout the process, continual reporting of the case study components in the form of brief summaries were presented to the Visioning Committee and university administrators.

Transit route alternatives were developed by members of the Clemson Transportation Continuity Council, Clemson administrators with input from the Visioning committee, and Clemson Area Transit. These alternatives were evaluated using a matrix alternative analysis in which all criteria were given equal weight because one groups concerns was not considered more important than another. Some of the criteria evaluated in the matrix include trip directness, route complexity, number of left hand turns required, accessible driver break locations, and the effects of cumulative boardings. Each stakeholder was given the opportunity to express their opinions on each of the routes before a final ranking was assigned to an alternative. Eight alternatives were evaluated with the Clemson Alternative F considered the best compromise solution which consisted of a two split route system with a boomerang like operation on the West side of campus. After selecting and determining the feasibility of the best compromise solution, there was still some hesitation to adopt the alternative. Clemson University should be at the stage to develop a performance measurement system, but without a definite consensus from all stakeholders involved in the process and those affected by the changes, further planning was considered futile.

From the experiences at Clemson University, it was realized that an important step was missing from the transit evaluation process. That step was gain stakeholder consensus and acceptance. With this step causing an apprehension to move forward at Clemson University because it was not considered in the original plan, it was deemed appropriate to be added to the evaluation process so that no other users would be surprised of this required step. The revised transit evaluation process can be seen in Figure 31.

Through the creation of a means for collaborative innovation, strategies and alternatives are generated and can be evaluated based on the objectives of multiple users and stakeholders. It is the inclusion of all stakeholders both at the university and those outside of it that will help the evaluation process succeed and gain general acceptance. All universities should strive for such success and this process helps achieve that.

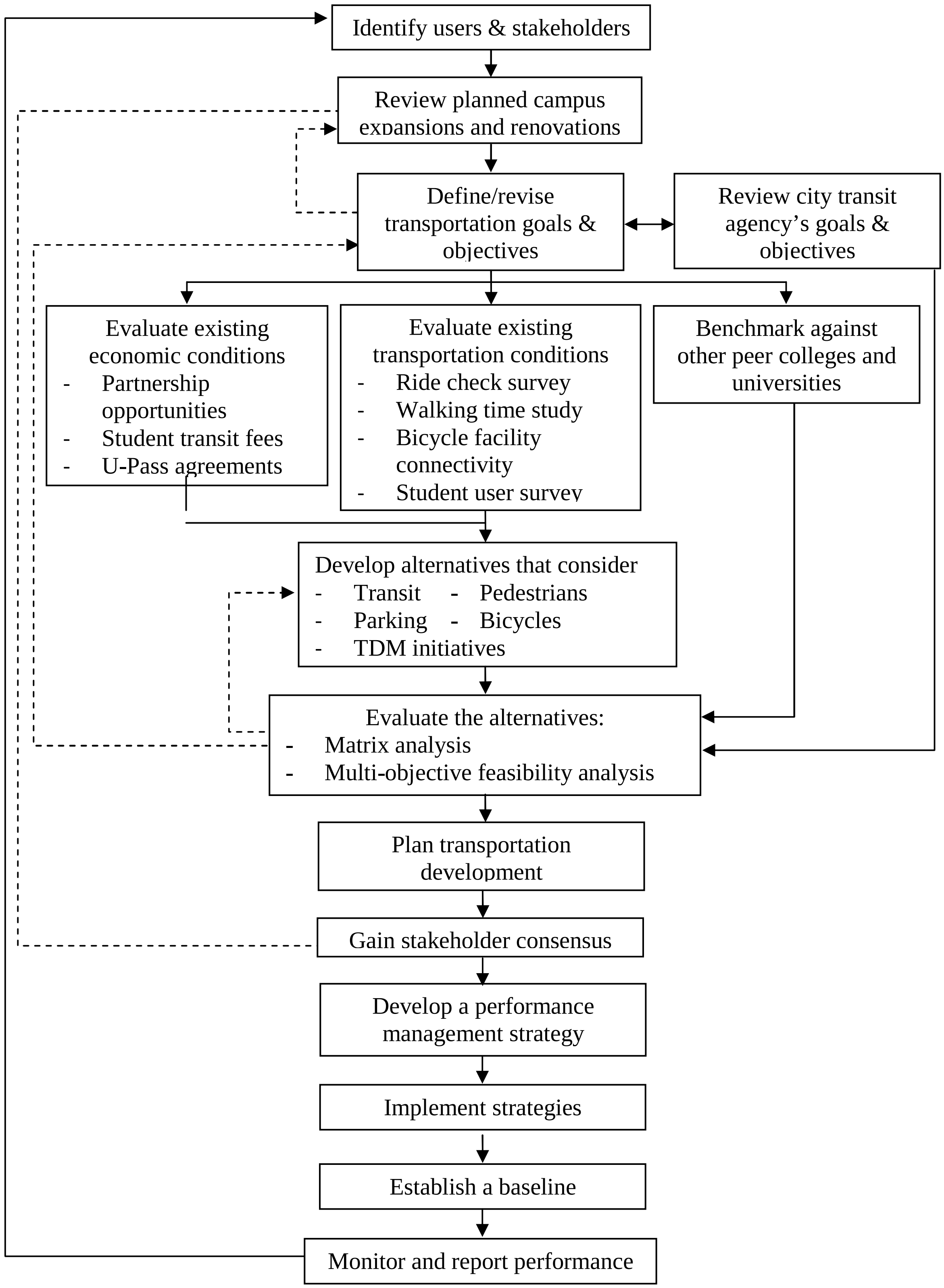

Figure 6: Revised Transit Evaluation Process

Similar to the iterative nature of the process created, the process itself needs to be continually evaluated. Currently, the evaluation process created would seem more appropriate for small to medium size schools outside of urban centers. Further research in these areas can enhance the usability of the transit evaluation process for all universities:

- Integration of technology and intelligent transportation systems
- Pedestrian and bicycle facility expansions and integration
- Effect of changes in parking restrictions and reallocations
- Political organizations and agreements between universities and cities in large urban areas
- Economic impacts of fare changes – elasticity of demand and
- Economic and political changes that occur if a system is incorporated into a metropolitan planning organization (MPO).

No matter what university wishes to utilize the evaluation process created, it must be customized to the political, organizational, and economic atmosphere of the university and supported by the belief that positive change is possible.

APPENDICES

Appendix A

Sample Ride Check Survey Form

FRONT SEAT

	CLEMSON AREA TRANSIT:	Wkday:	Sept 28		Block:			Tiger 1		
	SEPT 2009 RIDECHECK	Time			Passengers					
	ROUTE: Tiger				Front		Back			
STOP		Sched.	Actual	Diff.	OFF	ON	OFF	ON	LOAD	No. People
1	LIBRARY CIRCLE (EAST)	7:57 AM								
2	EDWARDS / VICKERY HALL (EAST)									
3	HENDRIX STUDENT CENTER (EAST)									
4	R-1 PARKING LOT (EAST)	8:01 AM								
5	LIGHTSEY BRIDGE	8:05 AM								
6	P-1 PARKING LOT / KITE HILL (EAST)	8:08 AM								
7	MCMILLAN RD @ NEWMAN ST / C1									
8	THORNHILL VILLAGE APTS (EAST)									
9	HENDRIX STUDENT CENTER (WEST)									
10	EDWARDS / VICKERY HALL (WEST)									
11	LIBRARY CIRCLE (WEST)	8:13 AM								
12	EDWARDS / VICKERY HALL (WEST)									
13	HENDRIX STUDENT CENTER (WEST)									
14	BROOKS CENTER (WEST)	8:17 AM								
15	C4 PARKING LOT (WEST)									
16	R-2 PARKING LOT (WEST)	8:19 AM								
17	R3 PARKING LOT (WEST)									
18	P-3 / WEST END ZONE / LITTLEJOHN	8:20 AM								
19	AVE. OF CHAMPIONS @ CENTENNIAL									
20	BREEZEWAY (WEST)									
21	FIKE RECREATION CENTER (WEST)	8:22 AM								
22	FACILITIES / UNION / GREEK QUAD									
23	SHOEBOXES / ATHS (WEST)	8:24 AM								
24	UNION / TILLMAN / BRACKETT (WEST)	8:26 AM								
25	SIRRINE / RIGGS HALL (EAST)									
26	FLUOR DANIEL / HUNTER (EAST)	8:28 AM								
27	STADIUM OVERLOOK (EAST)									
28	FIKE RECREATION CENTER (EAST)									
29	BREEZEWAY (EAST)									
30	AVE. OF CHAMPIONS @ CENTENNIAL									
31	P-3 / WEST END ZONE / LITTLEJOHN	8:30 AM								
32	C3 / SHOTGUN ALLEY (EAST)									
33	R-2 PARKING LOT (EAST)	8:34 AM								
34	ADMINISTRATION BUILDING (EAST)									
35	BROOKS CENTER / GRAVEL LOT	8:38 AM								
36	HENDRIX STUDENT CENTER (EAST)									
37	EDWARDS / VICKERY HALL (EAST)									
38	LIBRARY CIRCLE (EAST)	8:42 AM								

Appendix B

Peer Institution Summary Comparison Sheet

Institution name	Clemson University	Bowling Green State University	Miami University	Iowa State University*	Texas A & M*	Mississippi State University*	University of Nebraska - Lincoln*	University of Idaho*
Location	Clemson, SC	Bowling Green, OH	Oxford, OH	Ames, IA	College Station, TX	Starkville, MS	Lincoln, NE	Moscow, ID
Enrollment (Fall 2008)	18,317	17,874	17,191	25,856	48,039	17,824	23,573	11,791
Faculty and Staff Members (Fall 2007)	5,549	3,555	4,679	7,651	10,161	5,572	7,630	3,187
Dorm Capacity	6,500	6,671	7,097	9,287	9,776	3,783	6,827	1,950
Town Population	13,012	29,542	22,887	55,510	84,128	24,137	35,582	22,798
Parking permit fees								
Residential Student	$134 / Yr	$60/Sem; $100/Yr	$100 - 200/ Yr	$105 / 9 month; $30 summer	$275 / Yr	$85 / Yr	$360; 450/9 months	$61; 99 / Yr
Commuter Student	$134 / Yr	$60/Sem; $100/Yr	$100 / Yr	$105 / 9 month; $30 summer	$275 / Yr	$85 / Yr	$380; 450; 693 / 9 months	$61; 157 / Yr
Faculty / Staff	$24 - 150 / Yr	$50/Sem; $80/Yr	$30 / Yr	$125/ Yr; $446 rsvd/Yr	$275 / Yr	$85 / Yr; Gated $210/Yr	$552; 612; 1032 / Yr	$61; 157; 300 / Yr
24-Hr Reserved Faculty/Staff	N/A	$360 / Yr	N/A	$801/Yr	$534 / Yr		$1152 / Yr	$600 / Yr
Special Permits (e.g. President)	Free	$180 / Yr	N/A	n/a		Free	$1152 / Yr	$600 / Yr
Park & Ride	$24 / Yr	N/A	$100/Yr	$125-446/Yr			$261; 348 / Yr	
Carpool	$37.50/Sem (Stud) $6.50-42 (F/S)	N/A	N/A	$125-446/Yr			$552 / Yr	
Other	After 5pm - $67/Yr Vendor - $134/Yr				Retirees - Free / Yr	Visitor: $100/3 months		
Method of assigning employee permit fees	Salary based scale	Flat fee	Flat Fee	Fee based on type of space	Reserved vs gated vs non-gated surface vs garage	T2 Flex Fee Schedule	LOS, Perimeter, non-reserved, garage, reserved	Fees increased over time to provide sufficient funding
Total No. of parking spaces available	12,912	11,000	8,257	13,679	36,963	13,295	15001	6,000
Surface Lots	9,318	11,000	5,592	13,277	27,008	12,495	10994	5,700
Parking Garages	0	0	1,263	402	9,645	0	4007	0
On-Street Parking	3,594	0	402	0	310	800	0	300
Students to Total Parking Spaces Ratio	1.42	1.62	2.08	1.44	1.30	1.34	1.57	1.97
Faculty/Staff to Total Parking Spaces Ratio	0.46	0.32	0.57	0.41	0.27	0.42	0.51	0.53
Students + F/S to Total Parking Spaces	1.88	1.95	2.65	1.85	1.57	1.75	2.08	2.50
Type of permit system								
Residential Students	Broad Zone	Hybrid	Hybrid	District	District	Broad Zone	Hybrid	Broad Zone
Commuter Students	Broad Zone	Hybrid	District	District	District	Broad Zone	Hybrid	Broad Zone
Faculty / Staff	Broad Zone	Hybrid	Broad Zone	Hybrid	District	Broad Zone	Hybrid	Broad Zone
No. permits sold / Is there a cap								
Residential Student	4,738 / No	2,735 / No	1,303 / No	6,414 / No	6,095	3,479 / No	4641 / Yes	1500 / Yes
Commuter Student	6,946 / No	4,684 / No	in Park & Ride	698 / No	24,932	9,118 / Yes	4562 / Yes	1800 / No
Faculty / Staff	4,166 / No	2,751 / No	4,402 / No	4,740 / No	9,835	3,494 / No	3975 / No	1000 / No
24-Hr Reserved Faculty/Staff		153 / Yes		23 / No	2,145		6 / No	20 / Yes
Special Permits (e.g. President)		7 / Yes				100 / No	0	
Park & Ride	In F/S count		2,449 / No	0			328 / Yes	
Carpool	16			4 / No				
Other	After 5 in Comm							
Freshmen allowed to park on campus	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parking near facilities or remote	Near & Remote	Remote	Remote	Near facilities	Near facilities	Near Facilities	Near facilities	Near facilities
On-street parking in the core campus	Yes	No	Yes	No	No	Yes	No	No
Do students regulary park on city streets due to lack of parking on campus?	No	No		Yes	No	No	Yes	No

Green = All less than Clemson; Red = All above Clemson

Institution name	Clemson University	Bowling Green State University	Miami University	Iowa State University*	Texas A & M*	Mississippi State University*	University of Nebraska - Lincoln*	University of Idaho*
Vanpool / Carpool program present	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Dedicated parking spaces	35 + Library		0	as needed	0		1	1
No. of participants	16 (Fall 09=39)		unknown	4 groups	n/a		2	14
Services to aid in carpool formation	No		AlternetRides.com	No	AlternetRides.com		AlternetRides.com	PCEI Vanpool
Who is responsible for Parking Facilities	University	University	University	Univ / City	University	University	University	University
Who is responsible for Transit Services	City	University	University	Univ / City	University	University	Univ / City	City
Total miles in Transit System		129,312	unknown	1,153,090	1,276,676		323,695	25
Campus only miles		47,837	unknown	134,868	unknown	All	275,000	5
Average No. of seats on bus	37	32	45	39	40	30	35	30
Average No. of standees on a bus	19	25	15	70-75	75	20	15	10
Bus fare with University ID	Free	Free	Free	Free	Free	Free	Free	Free
Bus fare for public	Free	N/a	Free	$1.00	Free	Free	$1.50	Free
Student transit fee charged	$33.50 / Sem	No	$120 / Yr	$60.20 / Sem (Now $62.61)	$70 / Sem	No	$9.20 / Sem	No
Fee revenue produced in 2008-2009	$996,960		$1,800,000	$2,760,265	$7,143,400		$405,577	
Transit Operating Expenses for 08-09	$1,382,294	~$500,000	$1,400,000	$6,593,773	$5,186,350	$600,000	$1,287,420	
Demand responsive system present	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Hours of operation	7pm - 7am	5:00 pm - 6:00 am	M-W 6pm-2am; Th-Sun 6pm-4am	6 pm - 6 am				24/7 City of Moscow Police
No. of trips made	48,777	8,200	6,053	3,861				
Vehicles utilized	2	1	2	3 or 4				
Off-campus locations serviced	No	Yes	Yes	No			No	Yes
Paratransit offered on campus	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Other demand responsive programs offered	Bridge Program Dial a Ride on weekends	2Ride - on call van	No	Help vans for flat tires, out of gas etc	Free football game day shuttle	No	No	No
Park & Ride program present	Yes	No	No	No	Yes	No	No	No
Dedicated parking spaces	0				100+			
Distance from core campus	0.5 - 1 mile				2-5 miles			
Dedicated bicycle path/facilities provided around campus	No	No	No	Yes	Yes	Yes	No	Yes
Bicycle / Pedestrian facility improvements funded through Parking Services budget	No	No	No	Yes	No	Yes	No	Yes
Closed any streets to create pedestrian mall	No	Yes	No	No	Yes	Yes	Yes	Yes
Other bicycle programs offered	No	No	No	No	No	200 MSU bikes no charge on campus only	No	No
Other TDM programs offered	No	No	No	No	No	No	No	No

*Clemson University identified peer - Office of Institutional Research

Definitions:

Broad Zone - permits valid in multiple facilities grouped into broad zones (e.g. by sector, or price)

Hybrid – a mixture of broad zone and district parking concepts.

District – individuals assigned to specific lots

Green = All less than Clemson; Red = All above Clemson

Institution name	Clemson University	Ohio University	University of Montana	Oklahoma State University	Virginia Tech Institute	University of South Carolina
Location	Clemson, SC	Athens, OH	Missoula, MT	Stillwater, OK	Blacksburg, VA	Columbia, SC
Enrollment (Fall 2008)	18,317	20,927	14,175	22,768	30,380	27,500
Faculty and Staff Members (Fall 2007)	5,949	4,334	3,007	7,070	9,310	8,581
Dorm Capacity	6,500	7,712	3,425	6,517	9,116	6,115
Town Population	13,012	63,255	68,202	47,653	41,796	127,029
Parking permit fees						
Residential Student	$134 / Yr	$330 / Yr (Garage)	$185 / Yr	$44 / Yr	$136 / Yr	$70 / Yr
Commuter Student	$134 / Yr	105 / Yr	$185 / Yr	$54 / Yr	$136 / Yr	$70 / Yr
Faculty / Staff	$24 - 150 / Yr	Free	$185, 101/ Yr	$54 / Yr	$179 / Yr	Free
24-Hr Reserved Faculty/Staff	N/A	$800 / Yr	$555	$54/Yr for permit; $365 / Yr for space		$25/pay pd or $200/sem
Special Permits (e.g. President)	Free	n/a	0	N/A		
Park & Ride	$24 / Yr	n/a	0	N/A		
Carpool	$17.50/Sem (Stud) $6.50-42 (F/S)	n/a	$30	$54 / Yr	$90 / Yr	
Other	After 5pm - $67/Yr Vendor $134/Yr	n/a	Go Green: $61.50 / Yr	Garage - $120 / Yr Vendor $108 / Yr	Daily $2 Turf $50	
Method of assigning employee permit fees	Salary based scale	Free	No	Flat Rate	Flat fee	Seniority determines the type of space
Total No. of parking spaces available	12,912	6,500	4,886	15,372		
Surface Lots	9,318	5,700	4,332	14,273		
Parking Garages	0	800	350	1,100	1200 coming soon	
On-Street Parking	3,594	0	554			
Students to Total Parking Spaces Ratio	1.42	3.22	2.90	1.48		
Faculty/Staff to Total Parking Spaces Ratio	0.46	0.74	0.62	0.46		
Students + F/S to Total Parking Spaces	1.88	3.96	3.52	1.94		
Type of permit system						
Residential Students	Broad Zone	Broad Zone	Broad Zone	District	Broad Zone	Broad Zone
Commuter Students	Broad Zone	Broad Zone	Broad Zone	District	Broad Zone	Broad Zone
Faculty / Staff	Broad Zone	Broad Zone	Broad Zone	District	Broad Zone	District
No. permits sold / Is there a cap						
Residential Student	4,738 / No	800 / Yes	3,739 / No	5,439 / No		
Commuter Student	6,946 / No	3,000 / Yes	In residential	8,405 / Yes		
Faculty / Staff	4,166 / No	4,000 / No	1072 / No	5,547 / No		
24-Hr Reserved Faculty/Staff Special Permits (e.g. President)		100 / Yes	411 / No 32 / No	In F/S count		
Park & Ride	In F/S count		67 / No			
Carpool	16		48 / No	20 / No		
Other	After 5 in Comm		19 / No	Vendor - 334 / No		
Freshmen allowed to park on campus	Yes	No	Yes	Yes	Yes	
Parking near facilities or remote	Near & Remote		Near Facilities	Near Facilities		
On-street parking in the core campus	Yes	No	Yes	Yes		
Do students regulary park on city streets due to lack of parking on campus?	No	Yes	Yes	No		

Green = All less than Clemson; Red = All above Clemson

Institution name	Clemson University	Ohio University	University of Montana	Oklahoma State University	Virginia Tech Institute	University of South Carolina
Vanpool / Carpool program present	Yes	No	Yes	Yes	Yes	
Dedicated parking spaces	35 + Library		0	16		
No. of participants	16 (Fall 09=39)		29	34		
Services to aid in carpool formation	No		Gdoco.com	Green Ride	GoLoco.com RIDE Solutions	Alternetrides.com
Who is responsible for Parking Facilities	University	University	University	University		
Who is responsible for Transit Services	City	University	Univ / City	University		
Total miles in Transit System		10	32.9	439,204.50		
Campus only miles			0.5	116,401.50		
Average No. of seats on bus	37	15	30	36		
Average No. of standees on a bus	19	0	20	12		
Bus fare with University ID	Free	Free	Free	Free	Free	Free
Bus fare for public	Free	Free	Free	$0.50 Adult; $0.25 Child		
Student transit fee charged	$33.50 / Sem	No	$23.50 / Sem (now $26)	$2.30/credit hour/ Sem	$48/sem	$10 / Yr
Fee revenue produced in 2008-2009	$996,960		$560,547	$1,500,000		
Transit Operating Expenses for 08-09	$1,382,294	$100,000	$415,000	$1,900,000		
Demand responsive system present	Yes	Yes	Yes	No		
Hours of operation	7pm - 7am	7pm - 2 am	7 pm to 12 am			Sun - Th 8pm - 12 am
No. of trips made	48,777		765			
Vehicles utilized	2		1 golf cart + police for off campus			2
Off-campus locations serviced	No		Yes			No
Paratransit offered on campus	No	Yes	Yes	Yes		
Other demand responsive programs offered	Bridge Program Dial a Ride on weekends	Remote section of campus - pick up / deliver on demand	No	No		
Park & Ride program present	Yes	No	Yes	No		
Dedicated parking spaces	0		647			
Distance from core campus	0.5 - 1 mile		avg 3 miles			
Dedicated bicycle path/facilities provided around campus	No	Yes	No	Yes		
Bicycle / Pedestrian facility improvements funded through Parking Services budget	No	No		No		
Closed any streets to create pedestrian mall	No	No		No		
Other bicycle programs offered	No	No	2 day free bike checkout; $30/sem bike program	Rent a bike for free with campus ID at Wellness Center	Hokie Bikeways	
Other TDM programs offered	No	No	Missoula in Motion=incentives, Walk n Roll week; Bike ambassadors	No	U Car Share	

*Clemson University identified peer - Office of Institutional Research

Defintions:

Broad Zone – permits valid in multiple facilities grouped into broad zones (e.g.

Hybrid – a mixture of broad zone and district parking concepts.

District – individuals assigned to specific lots

Green = All less than Clemson; Red = All above Clemson

Appendix C

Peer Institution Follow Up Survey

CLEMSON UNIVERSITY Parking and Transit Benchmarking Study

Thank you for agreeing to help with this survey. Please complete this form and email back to Katerina Bartman at KateriB@clemson.edu as a word or .pdf document.

EVENT PARKING & RELATIONS WITH THE ATHLETICS DEPARTMENT

Does your university have special parking restrictions for concerts/major events held at the university?
☐ Yes ☐ No

If yes, please describe. ______________________________

____

____

Does your university have special parking restrictions for football or other athletic games held at the university? ☐ Yes ☐ No

If yes, please describe. ______________________________

____

____

What agency/department is used to enforce additional parking restrictions on event or game days?

____

Does your Athletics Department contribute money to the parking services budget? ☐ Yes ☐ No

If so, what method or formula is used to establish how much should be paid? __________

____

____

____

How much money did the Athletics Department contribute to the parking budget in 2008-2009? ______________

TRANSIT BUDGET

Revenue sources for transit services available at your university (expressed in percent of budget):

Federal / State Grants: __________ Fares: __________

University: __________ Advertising: __________

Local: __________ Other (please specify): ______________________

1

CLEMSON UNIVERSITY Parking and Transit Benchmarking Study

PARKING PERMITS

Is there a priority system used to determine who gets a student parking permit first? ☐ Yes ☐ No

If yes, please describe. ____________________

____

____

Is there a priority system used to determine who gets a faculty/staff parking permit first? ☐ Yes ☐ No

If yes, please describe. ____________________

____

____

How far away are the Park & Ride facilities from core campus (miles) if facilities available?

____

2

Appendix D

Clemson University Parking Principles

1	**ORIGINAL PRINCIPLE** Operating within the framework of principle one, consistently reliable public transit service is integral to the success of an overall parking system.	**MODIFIED PRINCIPLE:** The transportation system includes all mobility elements related to campus access, including parking, transit, pedestrian movement, and other alternate travel modes.
2		**NEW PRINCIPLE** The transportation system should be planned and managed to support broader University goals expressed in the campus master plan, goals for achieving a pedestrian friendly campus, campus housing objectives, promotion of healthy lifestyles, and environmental sustainability.
2.1		**Consistent and convenient "access" should be the goal of campus parking and transportation planning - a combination of parking, alternative travel modes and connectivity.**
2.2		**The context of these broader campus goals should be used consistently as a backdrop in transportation system planning and in establishing operating policies for the system.**
2.3		**15 minutes is an acceptable travel time for students between on-campus housing or parking locations and campus destinations.**
2.4		**The cost of lost productivity and efficiency for faculty and staff should be considered in evaluating parking alternatives, strategies and allocation policies.**
2.5		**The planning process should involve affected constituencies.**
3	**ORIGINAL PRINCIPLE:** There should be reasonably convenient, safe, and consistently reliable parking options for everyone in the campus community, regardless of income level.	**MODIFIED PRINCIPLE:** The University should plan for a progressively lower parking ratio that is accomplished through parking demand reduction measures, but the University should provide sufficient parking capacity to meet the remaining demand if it is financially feasible.
3.1		**Anticipating that campus land use priorities will result**

		in the conversion of some existing surface parking areas to other uses over time, the University should take measures to progressively reduce the need to create new parking capacity through positive Transportation Demand Management (TDM) initiatives.
3.2		**Structured parking facilities can be considered as a way to increase parking capacity while minimizing land consumption, but should be considered as a last resort unless it is fully funded by the actual users through a combination of revenue streams generated by the specific facility such as permit fees, "pay per use" fees, or special events fees.**
4	**ORIGINAL PRINCIPLE** **Walking, biking, a transit system, carpooling, and other alternatives to single occupancy vehicle use should be encouraged.**	**MODIFIED PRINCIPLE** **Walking, biking, riding transit, carpooling, and other alternatives to single occupancy vehicle use should be encouraged.**
4.1		**Transportation Demand Management (TDM) should be developed as a key element of the University's transportation program as a way to reduce parking demand and support sustainability initiatives.** **The TDM program should focus on positive incentives, education and coordination efforts such as rideshare match-up, promotion of carpooling, vanpooling programs, facilitation of bicycle use and efficient transit service, that make alternatives to single occupancy vehicle use attractive, efficient and convenient.** **The TDM program should avoid the use of financial disincentives as a negative means to modify behavior.** **The TDM program should be provided sufficient staffing and funding support to be effective.**
4.2		**The University should work with surrounding communities to develop safe walking and biking routes to the campus.**
4.3		**Campus planning should include enhanced support for the safe use of alternative transportation modes on campus, engaging user groups as part of the planning process.**
4.4		**Parking Services should educate students, staff, faculty, and visitors about campus transportation alternatives and safe intracampus travel.**

4.5		**The University should seek to reduce unnecessary intracampus vehicular travel in order to provide a safer environment for cyclists and pedestrians.**
4.6	On-street parking should be removed from the interior of campus to provide safer conditions for cyclists and pedestrians.	Proposed considerations: Retention of on-street parking in the campus interior should consider the full spectrum of issues including: reduction of interior vehicle movement loss of convenient parking and efficiency loss of the "presence" of activity represented by parked cars, particularly during the evening loss of safety advantage associated with interior parking (evening) cost of replacement
5	**ORIGINAL PRINCIPLE** **Long-range master plans and plans for individual buildings and districts should include plans for parking.**	**MODIFIED PRINCIPLE** **The campus master planning process should anticipate, assess and plan for any impacts on parking sufficiency.**
5.1		**Development plans that would increase parking demand or reduce net parking capacity should include a formal parking impact analysis.**
6	**ORIGINAL PRINCIPAL:** **Clemson should be guided by a parking philosophy that utilizes both "district" and "perimeter" strategies of parking.**	**Clemson should be guided by a parking philosophy that utilizes both "district" and "perimeter" strategies for the placement of parking.**
6.1		**Priority should be given to faculty and staff in the allocation of core area parking but limited provisions may be made for teaching assistants and students with special service obligations.**
6.2		**Wherever feasible, the University should take advantage of "shared parking" opportunities to maximize the utilization of campus parking facilities and the level of convenience they provide to the overall campus population. This may involve:** **Opening restricted parking areas after daytime class hours for general use.** **Locating facilities where they can effectively serve multiple user-groups.**

6.3		**An assigned zone parking system can be considered as a way to: increase the predictability of parking availability reduce interior traffic movement reduce pedestrian-vehicle conflicts reduce congestion minimize work schedule advantages Management of an assigned zone system should ensure that parking is always available to assigned users, but take advantage of shared parking opportunities to achieve a high level of utilization.**
6.4		**Based on the allocation of parking to each user group (faculty, staff, students), each group should be allowed to determine the management strategy that best meets its needs within the confines of overall campus transportation and safety policies.**
6.5		**Zoned pricing based on convenience can be considered as a system management tool.**
6.6		**A range of pricing options should be available to faculty, staff and students, rewarding those who are willing to park in less convenient locations.**
7	**ORIGINAL PRINCIPLE** **Thorough and consistent parking enforcement is critical to ensuring successful management of all parking facilities on campus.**	**MODIFIED PRINICIPLE** **Consistent, reasonable and impartial parking enforcement is critical to the proper management and efficient use of campus parking resources.**
8	**ORIGINAL PRINCIPLE** **The financing framework for parking services should rely more on parking permit revenue and fees than on parking citation penalties.**	**MODIFIED PRINCIPLE** **The funding framework for parking and transportation services should rely more on parking permit revenue, transportation fees, and user fees than on parking citation revenues for its core funding.**
8.1		**Although prudent budgeting dictates that citation revenues be included in the budgeting process, those revenues should not be considered a necessary funding source to be protected or promoted. The system goal should be good system management that promotes a high level of voluntary user compliance.**

	<u>ORIGINAL PRINCIPAL</u> **Emphasis should be placed on parking education, management and preventative maintenance of all parking facilities.**	**(SPLIT INTO 2 NEW PRINCIPALS)**
9	**A**	**<u>MODIFIED PRINCIPAL</u>** **The parking and transportation system should emphasize effective communication of policies and transportation options as a way to increase the level of service and support provided to the campus population.**
9.1		**The parking and transportation services program should employ state-of-the-art methods of communicating parking policies and transportation options to the campus population.**
9.2		**The effectiveness of communication efforts should be monitored, measured and improved to meet changing conditions, objectives, programs and priorities.**
9.3		The program should include formal mechanisms for regular feedback on service and system performance from system users.
9.4		Affected constituency groups should be involved in the planning process.
10	**B**	**<u>MODIFIED PRINCIPAL</u>** **Management of the transportation system should include funding for operation, maintenance and replacement of facilities, buses and related amenities as a basic part of its planning and budgeting process.**
10.1		**Appropriate uses of program funds include operating costs, TDM program funding, subsidy of the transit system, and both capital and maintenance costs for parking facilities, buses, roadway connections to parking facilities, pedestrian connections, and related amenities such as bus shelters and bicycle storage facilities.**
10.2		Reserve funds should be included and protected as a base element of the budget to provide for projected maintenance, repair and replacement costs.
10.3		Reserve funds for future maintenance should not be compromised for current operational needs.
	<u>Sub-Principal</u>	(Included as policy above)

	Parking Services funding responsibilities include the ongoing repair and maintenance of campus streets, sidewalks, bridges, and walkways.	
11	**Campus should be a "visitor friendly" place with appropriate way-finding provided to direct casual visitors to visitor parking appropriate for their ultimate destination.**	**<u>MODIFIED PRINCIPAL</u>** **The campus should be a "visitor friendly" place with appropriate way-finding to direct casual visitors to parking that is appropriate for the purpose of their visit.**
11.1		Enhanced way-finding aids, including signage, promotional materials and web-based resources should be used to direct casual visitors to a central campus location for general information, orientation and parking arrangements.
11.2		As a matter of campus image and community relations, visitor parking at key campus destinations is an appropriate and valuable use of parking resources. Special signage should aid visitors in finding those dedicated parking locations.
12	**<u>ORIGINAL</u>** **Regular visitors and regular vendors should be expected to help pay for Parking Services. Large organized groups of visitors will be expected to work with Parking Services to minimize their impact on campus parking.**	**<u>MODIFIED PRINICIPAL</u>** **Regular visitors and vendors should be expected to pay for parking. Groups and major event attendees should be expected to pay for use of parking resources and/or the transit system.** **Group event organizers will be expected to work with Parking Services to minimize their impact on campus parking.**

<u>Appendix E</u>

<u>Tiger Route Alignment</u>

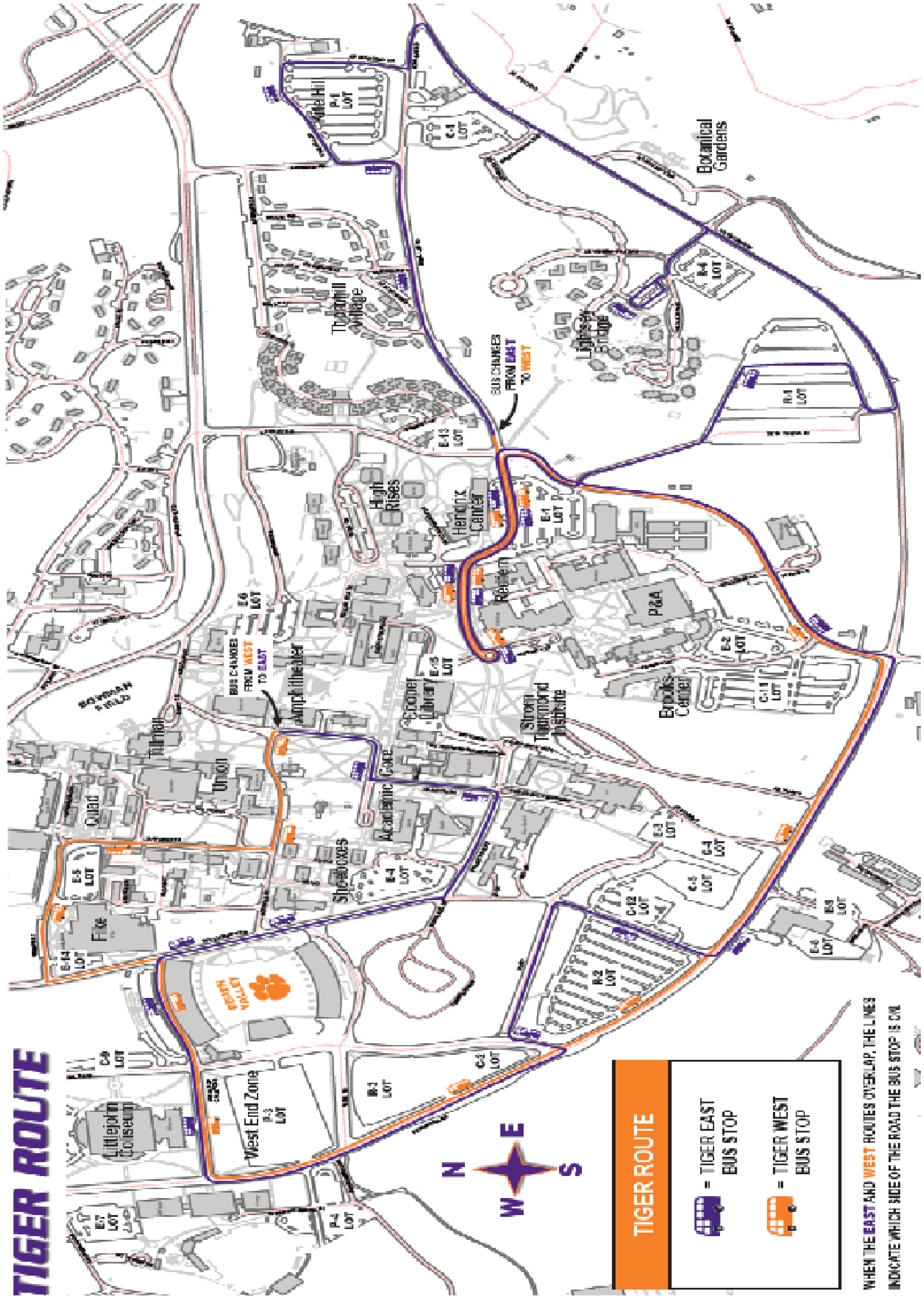

Figure A-1: Tiger Route Alignment

Appendix F

Split Route Alignment

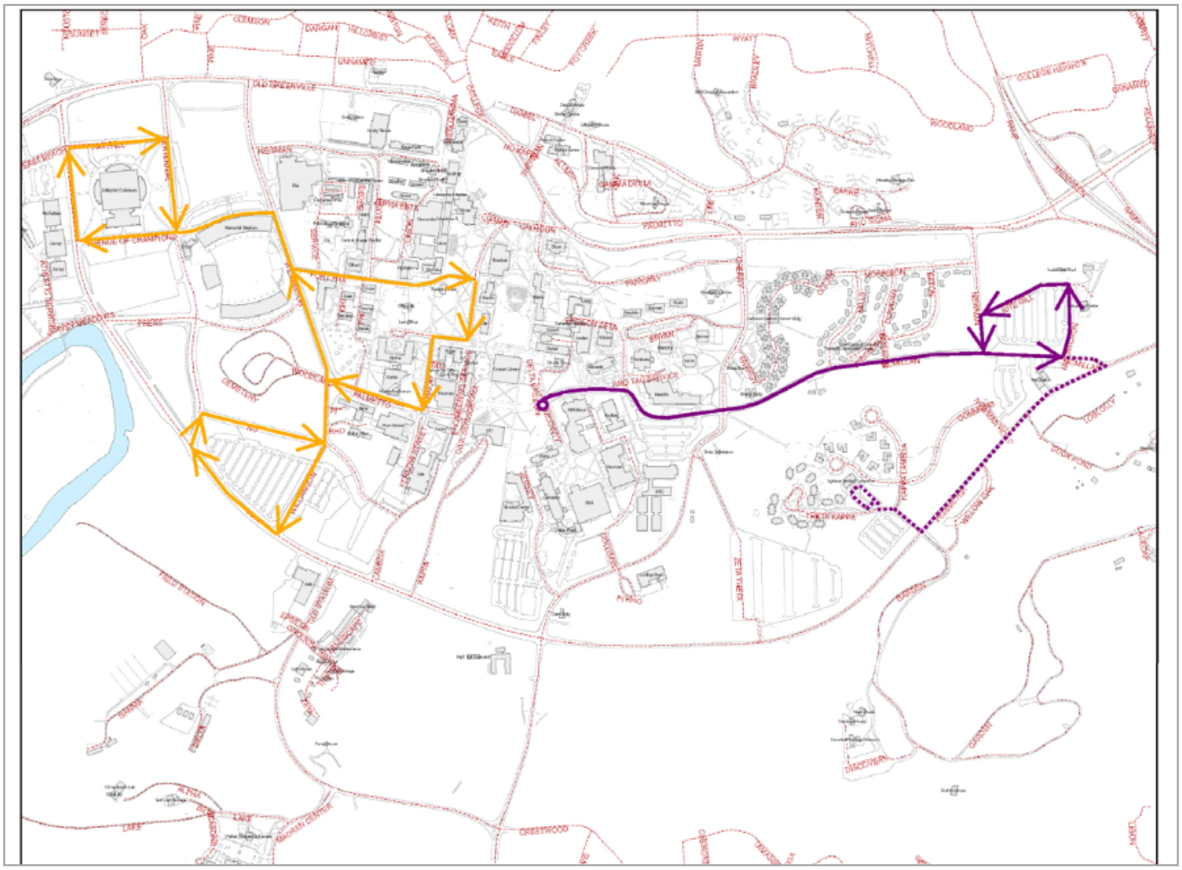

Figure A-2: Split Route Alignment

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