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16. Abstract

This research study produces a recommended sustainable transportation implementation plan for Texas A&M University (TAMU) to enhance the environmental performance of its campus transportation system. To achieve the goal, this study followed a historical design approach using existing documents and materials, along with the knowledge gained from interviews with campus transportation services and from site visits to a selected sample of universities whose size characteristics are similar to TAMU and who have successfully implemented sustainable transportation strategies. A series of data collection efforts was also conducted to provide a general picture of parking usage and parking users at TAMU.

The recommended implementation plan consists of an organizational framework of a sustainable campus transportation system as well as a series of specific strategies addressing different elements of such a system. It is concluded that TAMU needs to shift its approach to campus transportation from the current practice of providing to an approach based on controlling single-occupancy vehicular traffic to campus and improving its alternative transportation options, such as walking, biking, and transit.

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TOWARD A GREEN CAMPUS:
A TRANSPORTATION STRATEGY FOR TEXAS A&M UNIVERSITY

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ABSTRACT

This research study produces a recommended sustainable transportation implementation plan for Texas A&M University (TAMU) to enhance the environmental performance of its campus transportation system. To achieve the goal, this study followed a historical design approach using existing documents and materials, along with the knowledge gained from interviews with campus transportation services and from site visits to a selected sample of universities whose size characteristics are similar to TAMU and who have successfully implemented sustainable transportation strategies. A series of data collection efforts was also conducted to provide a general picture of parking usage and parking users at TAMU.

The recommended implementation plan consists of an organizational framework of a sustainable campus transportation system as well as a series of specific strategies addressing different elements of such a system. It is concluded that TAMU needs to shift its approach to campus transportation from the current practice of providing to an approach based on *controlling* single-occupancy vehicular traffic to campus and *improving* its alternative transportation options, such as walking, biking, and transit.

EXECUTIVE SUMMARY

The importance of transportation sustainability has been gradually gaining acceptance among different organizations. Higher education institutions are adopting the concept of sustainable transportation in order to reduce their parking construction and operations costs, improve livability on their campuses, and reduce their campuses' negative impact on the environment. Transportation is one of the most critical and difficult issues that university campuses face in the process of transitioning to environmental sustainability. Most university transportation systems across the nation are highly car-dependent, and higher education institutes are now facing the consequences of such systems, namely reduced safety, noise pollution, lack of land for new parking lots, and degrading air quality.

When referring to a higher education campus, sustainable transportation almost always translates into reducing single-occupancy trips to campus and encouraging the use of more efficient transportation modes. The most important challenge with regard to a sustainable campus transportation system is to ensure that its concepts are implemented in a comprehensive manner, addressing aspects such as institutional organization, parking management, improved alternative transportation infrastructure, incentives, and marketing and education. This study addresses these aspects of transportation sustainability with a focus on Texas A&M University (TAMU), in College Station, Texas.

TAMU is growing fast. This rapid growth provides the campus with the opportunity to grow smart by implementing sustainable transportation strategies and policies to provide convenient accessibility to its students, faculty, and staff in an environmentally responsible manner. This study provides a set of recommendations to enhance the sustainability of TAMU's campus transportation system. The overall goal of this research study was to develop an implementation plan for (TAMU) to enhance the performance of the university's transportation system with regards to its environmental impact.

The research was able to address its goal through the completion of a review of literature, correspondence with TAMU's parking and transportation services, a review of the sustainability plans of other universities in Texas, site visits to a sample of selected universities with successful sustainable transportation programs, and a review of the university's master plan. Together, these resources provided a context for determining a sustainable transportation framework for the TAMU campus.

TAMU is the major trip generator in the area, is experiencing growth, and is facing an increasing parking and traffic problem. The research project focused on four objectives:

- to assess the current state of TAMU's transportation system,
- to document and evaluate the experiences of other universities that have incorporated sustainable transportation strategies into their environmental performance improvement plan,
- to identify contributing factors for establishing a sustainable campus transportation system, and
- to develop a sustainable transportation framework for the TAMU campus and provide

specific recommendations with regards to sustainable transportation strategies best suited to TAMU.

Researchers found that the majority of the investigated universities in Texas do not have a sustainable transportation plan for their campuses. Many of these universities have stated a commitment to general sustainability; however, the concept of sustainable transportation is generally missing from their master plans. The master plans of the majority of these universities include a goal to improve the pedestrian and biking traffic on campus by restricting private vehicles to the periphery of their campuses and to building parking structures instead of parking lots.

Furthermore, the research team found that, currently, the air quality impact of a campus transportation system is not an important factor in campus transportation planning and policy-making. There are very few universities throughout the nation that are in the process of incorporating air quality impacts of their system as a decision factor in their planning processes.

The researchers performed two data collection efforts: a parking user survey and a parking count. The results of these efforts show that more than 80 percent of vehicular traffic to the TAMU campus consists of single-occupancy vehicles. It is also observed that traffic share appears to be evenly divided between passenger cars and light trucks (SUVs/trucks/minivans). The collected data reveal a statistically significant difference between students and university employees in terms of their commuting driving distances. Employees tend to live farther than students. The travel time for the majority of TAMU parking users is observed to be between 10 to 20 minutes.

The researchers visited three universities with a nationally renowned sustainable campus transportation system: University of Washington at Seattle (UW), University of California at Davis (UC Davis), and Stanford University. The case studies of these universities show that in a successful sustainable transportation system, single occupancy vehicle (SOV) traffic demand control measures and improved alternative transportation choices must be implemented at the same time. People are discouraged from driving to campus (higher parking prices, parking-cash-out), and at the same time, they are provided with a package promoting alternative transportation modes (e.g., transit passes, improved bike network, emergency ride home services, etc.).

Marketing and outreach programs were found to play a critical role in maximizing the sustainable transportation strategies, which is achieved through informing people about their transportation choices, emphasizing the benefits of alternative transportation, and making the use of alternative transportation part of the mainstream culture of the campus.

The researchers then developed a set of recommendations for TAMU to establish a sustainable transportation system on its campus. The recommended sustainable transportation framework for TAMU consists of the following steps and components:

1. recognize the drive-alone vehicular traffic to campus as a problem of the system and commit to reduce it;
2. establish a sustainable transportation council to set goals, objectives, and guiding principles for the campus transportation system;
3. include recommendations of the council in the future revisions of the campus master plan;

4. adopt an integrated transportation planning approach for the campus; and
5. establish a performance monitoring system to screen the progress toward the established sustainability goals and objectives.

More specifically, this study recommends establishing programs to 1) create disincentives for driving alone to campus through restructuring parking permits and fees and adopting a more reasonable parking-to-user ratio on campus; and 2) encourage individuals to shift to alternative transportation modes through an improved pedestrian and biking infrastructure, an enhanced marketing and outreach program, and an incentive/ benefits package for alternative transportation users.

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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CHAPTER 1: INTRODUCTION

The environmental performance of university campuses has been one of the issues that the federal government has been increasingly focusing on in recent years *(1)*. The federal government urges universities to review their role in promoting excellence in environmental stewardship as an integral part of their teaching and research in order to set an example for their students. In this context, transition to an environmentally sustainable campus, also referred to as a green campus, serves as an essential step to enhance the environmental performance of campuses and to teach and demonstrate the principles of environment stewardship to the next generation.

Transportation is one of the most critical and challenging issues that university campuses face in the process of transitioning to environment sustainability. Most university transportation systems across the nation are highly car-dependent, and higher education institutes are now facing the consequences of such systems, namely decreased safety, noise pollution, lack of land for new parking lots, and degrading air quality. Addressing these issues is more critical for universities like Texas A&M University (TAMU) that are experiencing growth. A sustainable transportation system provides access to people, goods, and services in an economically viable, socially acceptable, and environmentally responsible manner.

It is estimated that transportation is responsible for over two-thirds of the U.S. petroleum consumption. Automobiles continue to be among the major sources of air pollutants. Transportation energy use is also contributing to the global climate change. Motor vehicles are estimated to account for about 25 percent of U.S. green house gas (GHG) emissions *(2)*.

In the context of a university campus, transportation directly impacts the campus population as well as neighboring communities. University campuses are usually among the largest employers and are, therefore, a major trip generator in their area. Damage to a campus' visual environment by parking lots and loss of greenery, negative health and environmental impacts, traffic congestion, and parking shortages in neighboring communities are a few of the negative impacts of a car-based campus transportation system. The traditional "predict and build" approach to campus transportation planning assumes that the solution to increased demand is to build new capacity, i.e., parking *(2, 3)*.

To address these negative impacts of their campuses, universities need to take steps toward reducing the impact of their transportation system in the interest of the general public and their own and surrounding communities. Orr (1992) argues that "colleges and universities must learn to act responsibly not only because it is right to be responsible, but also it is in their self interest" *(4)*. Since single-occupancy vehicles dominate transportation to the majority of U.S. university campuses, minimizing the negative environmental and societal impacts of a campus transportation system by large translates to the reduction of drive-alone traffic to campus. A campus transportation system that supports this goal is usually referred to as a sustainable campus transportation system.

The benefits of implementing a sustainable transportation system on a campus go far beyond reducing the negative impact of the campus. Efforts that reduce car traffic also have positive

impact on the livability of the campus and surrounding neighborhoods and can provide substantial fiscal benefits for the university by reducing the demand for expensive parking structures. In addition, the transportation habits that students learn during their college years are likely to stay with them in the future.

Sustainable transportation strategies provide opportunities for university campuses such as the TAMU campus at College Station to increase investments in alternative transportation programs; these programs create cost-effective transportation substitutes, thereby decreasing or eliminating the need to build additional campus parking facilities to accommodate growth and loss of parking due to campus construction projects. The implementation of sustainable transportation strategies can also promote the culture of sustainability within TAMU and the local community. A successful implementation of a sustainable campus transportation system requires a close working relationship between the university administration, the campus population, and the local community, as well as clear campus vision and objectives and available baseline data associated with campus master planning efforts *(5)*.

SUSTAINABLE TRANSPORTATION

Sustainable transportation refers to a concept developed in reaction to unsustainable performance of our car-oriented transportation system. The current car-based transportation system consumes excessive energy, affects the health of society, and cannot maintain an acceptable level of service despite increasing investments. Many of these negative impacts disproportionately affect those socio-economic groups who are least likely to own and drive a private vehicle. Sustainable transportation mainly addresses human behavior and not technology, focusing on a behavioral approach, including non-polluting and human-scaled alternative transportation choices, regardless of the means and technology used.

Despite its popularity, the term sustainable transportation still does not have a formal definition. Balsas (2003) defines a sustainable transportation system as one that provides our current transportation and mobility needs without jeopardizing future generations' ability to meet their needs *(3)*. The Canadian Centre for Sustainable Transportation (2006) uses the following attributes to define a sustainable transportation system *(6)*. According to this definition, a sustainable transportation system is one that:

- provides our mobility needs in a manner that is safe and consistent with human and ecosystem health, and also ensures equity within and between generations;

- is efficient and affordable, offers choice of transport mode, and supports a vibrant economy; and

- limits emissions and waste within the environment's capacity to absorb them, conserves non-renewable resources, and limits consumption of renewable resources to the sustainable yield level.

The concept of sustainability is long-term in nature. According to the World Business Council for Sustainable Development (2004), the following dimensions must be considered for a sustainable transportation system *(7)*:

- accessibility,
- financial outlay required of users,
- travel time,
- reliability,
- safety and security,
- greenhouse gas emissions,
- environmental and health impacts,
- resource use,
- equity implications,
- impact on public revenues and expenditures, and
- prospective rate of return to private business.

In the context of a campus transportation system, transportation sustainability is commonly referred to a set of actions and policies that encourage more attention to alternative transportation modes. Examples of such strategies include improved bicycling, pedestrian, and public transit infrastructure, as well as measures focusing on reduced car use, especially single-occupancy vehicles.

DEFINING THE PROBLEM

In a recent report by the Sustainable Endowment Institute (SEI), none of the universities in Texas made good grades, with Texas A&M earning a C- in the category of Climate Change and Energy *(8)*. Table 1 shows TAMU's sustainability report card for the year 2008. A review of the report shows that energy efficiency, sustainable transportation, and renewable energy usage are the most important factors that influence the scores of schools. In addition, the results of the report also show that none of the investigated higher education institutes in Texas has implemented a comprehensive sustainable transportation strategy to achieve better environmental performance. In that regard, development and implementation of a sustainable transportation strategy would enable TAMU to improve its profile with regards to campus transportation sustainability.

Table 1. TAMU's Sustainability Report Card in 2008.

Texas A&M University	C-
Administration	**C**
Texas A&M supports campus sustainability in its master plan. The university Office of Energy Management works with the Energy Conservation Committee to look into energy savings on university campuses. Additionally, the office maintains a website that promotes energy and water conservation, allows reporting of energy or water waste, and informs the campus community about energy conservation.	
Climate Change & Energy	**C**
The university adopted an energy conservation plan in 2005. As part of this plan, the Office of Energy Management engages the campus community in conservation awareness. A pilot energy conservation competition was conducted in the spring of 2007. Significant investments have been made to improve energy efficiency at the university, resulting in a 33 percent reduction in energy consumption per gross square foot over the last eight years.	
Food & Recycling	**C**
Texas A&M's dining services organized a farmers market with organic, locally grown produce in March 2007. The market will be expanded to a weekly event beginning this year. Dining services also recently opened a venue on campus that serves meals made from organic ingredients. Cooking oil is recycled into biodiesel and powers the delivery truck.	
Green Building	**B**
The campus master plan stipulates that buildings should qualify for LEED Silver certification whenever possible. The $95 million Interdisciplinary Life Sciences Building, currently under construction, will be the first university facility to be certified as LEED Silver. Two other facilities, currently under construction, will also qualify for the LEED Silver rating. Lighting retrofits have been implemented in 42 of 139 campus buildings.	
Transportation	**C**
Biodiesel is used in all 79 of the campus transit buses and in some other campus vehicles. The university provides a free shuttle system for all students, faculty, and staff. A new rideshare webpage is being implemented by transportation services that will give students and employees wishing to carpool or rideshare the opportunity to communicate.	
Endowment Transparency	**D**
The university makes its proxy voting record available only to trustees and senior administrators. Investment managers must be posted on the website per statute, while individual holdings are generally shared only within the treasurer's office.	
Investment Priorities	**B**
The university aims to optimize investment return and is also exploring renewable energy investment funds or similar investment vehicles.	
Shareholder Engagement	**F**
The university asks that its investment managers handle the details of proxy voting.	

OBJECTIVES OF THE STUDY

The goal of this research was to develop an implementation plan for Texas A&M University to enhance the performance of the university's transportation system with regards to its environmental impact. To achieve the goal, this study focuses on the main campus of TAMU at College Station, Texas. This campus is the major trip generator in the area, is experiencing growth, and is facing a growing parking and traffic problem. The research project will focus on the following four objectives:

- to assess the current state of TAMU's transportation system,
- to document and evaluate the experiences of other universities that have incorporated sustainable transportation strategies into their environmental performance improvement plan,
- to identify contributing factors for establishing a sustainable campus transportation system, and
- to develop a sustainable transportation framework for the TAMU campus and provide specific recommendations with regards to sustainable transportation strategies best suited to TAMU.

ORGANIZATION OF THIS REPORT

The report has been divided into eight chapters. Chapter 1 includes an introduction to the research and covers aspects such as statement of the problem, research objectives, and organization of the report. Chapter 2 provides a description of the state of transportation sustainability in major universities of Texas. Chapter 3 provides a discussion on the available strategies for a sustainable transportation system. Chapter 4 continues Chapter 3's discussion with a specific focus on strategies related to walking, biking, and public transit. Chapter 5 discusses case studies covering three university campuses with a successful, working sustainable transportation system. Chapter 6 investigates and discusses TAMU's current transportation system and practices as well as the campus' vision for its future transportation system. The chapter focuses on vehicle usage for trips to campus and presents the results of a parking user survey. Chapter 7 presents the recommended framework for implementing a sustainable transportation system at TAMU, followed by specific strategies addressing different components of such a system. Chapter 8 contains the concluding remarks.

CHAPTER 2: SUSTAINABILITY AND TRANSPORTATION AT TEXAS A&M UNIVERSITY

This chapter provides an overview of transportation services and related sustainability programs at Texas A&M University, in College Station, Texas. The chapter also presents the results from a series of data collection efforts on TAMU's parking users that were carried out as part of this research study.

Texas A&M University is located in College Station, Texas, with a total area of 5200-acre campus.

SUSTAINABILITY PROGRAMS

Texas A&M does not yet have a dedicated sustainability office. However, a sustainability officer has been hired to begin developing a sustainability plan for the university. The following provides a description of campus master plan and campus sustainability-related programs at TAMU.

Campus Master Plan

The campus master plan achieves the ideals of the university's roadmap (Vision 2020)(*9*) and focuses on enhancing the quality of campus life. Goals of the master plan are presented as follows *(10)*.

- reinforcing campus identity,
- enhancing campus community with a compact and cohesive environment,
- establishing connectivity between places, activities, people, and campus and community,
- creating buildings that enhance their connection to the campus community,
- promoting spatial equity and appropriateness with equitable standards and allocation,
- creating an accessible, pedestrian-friendly campus with enhanced circulation patterns,
- promoting sustainability by teaching, planning, and acting, and
- developing a supportive process for achieving goals of the plans.

One goal of the campus master plan related to campus sustainability is to promote sustainability by teaching, planning, and acting in an environmentally sustainable manner. Five specific policies directly related to the sustainability goal can be presented as follows.

1) policy of community and resources for a compact and efficient campus,

2) policy of green reserve for preserving existing open spaces,

3) policy of development densities and zones for mandating development pattern,

4) policy of land use for efficient use of current campus, and

5) policy of assignable space for improving spatial equity, efficiency, and appropriateness.

Some goals and policies that are presented in the campus master plan are consistent with the goals and objectives of transportation sustainability. They will be described later in this chapter.

Other Activities

Sustainable Development Program
The Sustainable Development Program (SDP) provides comprehensive information on programs and projects related to sustainable development at TAMU. It aims to encourage collaborations, coordinate programs and projects, and promote multi-faceted research and education *(11)*.

SDP comprises two initiatives and five signature programs. The first initiative, the Sustainable Coastal Margins Program (SCMP), promotes collaboration and coordination to develop interdisciplinary research, provide joint degrees, and facilitate linkages to other organizations and programs in support of the sustainable utilization of coastal margins. The second initiative, the International ALERT Federation (IAF), is an international confederacy of organizations and people interested in sustainable development to perform common research agendas and to promote cooperation and communication among them. The five signature programs include Environmental Planning and Sustainability Research Unit, Ocean Drilling and Sustainable Earth Science, Geochemistry of the Earth, Sea and Atmosphere, Sustainable Urbanism, and Center for Atmospheric Chemistry and the Environment.

Student Organizations and Outreach
Environmental Issues Committee (EIC) has been established in the Student Government Association (SGA) since 1990. EIC provides and supports programs and initiatives that improve environmental awareness, decrease the environmental impact, and enhance quality of life through education, research, and legislation. Current projects and programs include Aggies Recycle, a comprehensive recycling program at the university; Clean Energy Now, which supports the Renewable Energy Policy; Curbside Recycling; Earth Day, which improves environmental awareness; Galveston Cleanup at Galveston Island State Park; Go Green! and Maroon, which provides tips for reducing our impact on the environment; Kyle Field Recycling, which promotes recycling after a home football game; Renewable Energy Policy, which promotes purchasing renewable energy; SGA Highway Cleanup; and Texas Recycles, which provides recycling information *(12)*.

In addition, TAMU puts many initiatives and programs into action throughout the campus *(13)*. These include:

1) The university's Dining Services provides its campus delivery truck with biodiesel fuel.

2) The Recycling Center practices the move-in cardboard collection.

3) The Office of Energy Management posts an energy-saving tip in each day's edition through the email news brief service.

4) New buildings on campus are expected to qualify for the U.S. Green Building Council's Leadership in Energy and Environment Design (LEED) Silver certification.

5) Some of the architecture students are building energy-efficient, solar-powered homes.

TRANSPORTATION SYSTEM AND OPERATION

Texas A&M's Department of Parking and Transit Services was created on September 1, 1988. Previously, transportation-related services and parking enforcement were handled by the university's Physical Plant, Bus Operations, and University Police *(14)*.

The department's administrative structure designates managers for the following transportation-related functions and services:

- communications & marketing,
- parking access & maintenance,
- parking compliance & traffic,
- special events & visitor parking,
- customer service,
- fleet leasing, and
- transit.

The department also has designated managers for administrative functions, including human resources and payroll, fiscal affairs and compliance, and information technology.

University Transit System

All TAMU students pay a transit fee as part of their semester enrollment. The fee per semester is $60 during fiscal year 2008, and it will increase to $70 per semester in fiscal year 2009; this fee increase will cover the expense of new buses. The transit system operates seven on-campus and 10 off-campus routes. While the campus transit system does not connect to or coordinate with the Bryan-College Station transit system (The District), the campus transit website provides a link to The District's website.

Some of the bus routes have been in place for over ten years without significant changes. Minor changes are made to the routes as needed, based on student requests and the density of TAMU students in certain apartment areas.

The transit fleet consists of 80 buses fueled with biodiesel. Ridership on the routes totals about 4.5 million per year, with typical daily ridership of about 14,000 to 15,000 on-campus and 15,000 to 18,000 off-campus. Buses are not equipped with bicycle racks.

Parking on the TAMU Campus

Approximately 37,000 parking spaces are available on the TAMU campus, totaling about 250 acres (around 13 percent) of the university's almost 6,000 total acreage. As the campus and its population continue to grow, future plans are for additional parking garages to be built, which will gradually replace many of the surface lots. The designed occupancy rate of parking facilities is 90 to 95 percent; actual occupancy varies widely depending on the facility and the time of day/week.

The cost of parking spaces, not including land, is approximately $3,000 per space for surface parking and $12,500 per space for garage parking. Capital costs for parking are funded via 20-year bonds borrowed through Treasury Services. Parking revenues come primarily from parking permit sales ($10,621,948 in FY 2008) and from parking violation fines ($2,000,000 in FY 2008).

Parking permits are assigned to individuals (rather than to specific vehicles). This allows parking customers to transfer their permit to any vehicle, and it simplifies permit issuance. Permits are usually fulfilled through an automated process. The available parking supply exceeds demand (in total, though some facilities are in more demand than others, depending on the time), so everyone who wants a permit can purchase one. There are waiting lists for higher-demand parking facilities (such as the ones close to dormitories); permits are issued according to a priority system (permit renewals first, then new permits, with faculty/staff receiving first priority, followed by graduate students and undergraduate students).

Permit prices range from $240 (surface lot) to $600 (garage priority spot) per year. Motorcycle permits are $80. In the current fiscal year (2008), TAMU has issued 2,867 faculty permits, 8,000 staff permits, and 25,411 student permits. Parking enforcement is performed by Transportation Services staff. The current parking policy assigns each permit holder to a specific lot or garage (though many of these facilities are open for any permit holder on nights and weekends).

Transportation Planning in the Campus Master Plan

As stated earlier, several goals and policies of the campus master plan support transportation sustainability. The goal of establishing connectivity in the master plan states that places, activities, faculty and students, and campus and the surrounding community should be connected with each other. Two policies are distinctly associated with this goal: integrating eastern and western parts of the campus, and connecting the campus and the surrounding community *(10)*.

Creating an accessible, pedestrian-friendly campus community is also one of the goals of the campus master plan that addresses the sustainability. This goal states that campus circulation

network should be improved and campus should be more accessible and pedestrian-friendly without cars in the core area. Three policies are directly linked to this goal: circulation for accomplishing a pedestrian-oriented campus and the gradual reduction of surface parking; parking for maintaining the ratio of parking spaces to people and encouraging structural parking integral with the building construction plan; and connecting the east and west parts of the campus *(10)*.

Parking and Transportation Services
Currently, a comprehensive transportation plan is not prepared for the campus and surrounding area, including Bryan and College Station. Only several segmented goals and policies that are pertinent to the goals of transportation sustainability are included in the campus master plan.

Transportation Sustainability and Policy

Texas A&M does not yet have a dedicated sustainability office. However, a sustainability officer has been hired to begin developing a sustainability plan for the university.

The university does not currently have a transportation master plan, nor does the campus master plan (completed in 2004) have a comprehensive transportation element. At the present time, the university does not plan to discourage personal vehicle travel to and from the campus, though within the campus itself, steps have already been taken over the past twenty years to promote safe pedestrian travel while restricting vehicle traffic. This trend will continue over the next twenty years: the interiors of the main and west campuses will be increasingly designed to favor pedestrian and bicycle travel, with vehicle traffic and parking largely confined to the campus perimeter.

TAMU offers on-campus housing that can accommodate approximately 7580 students. University-owned apartments provide additional student housing close to the campus. New on-campus dormitories are being planned, and the new residence buildings will meet LEED silver certification for energy efficiency.

Alternative Transportation

The TAMU transit fleet of 80 buses operates on biodiesel. The TAMU fleet currently includes no other alternative-fuel vehicles.

The level of bicycle use on and around campus is unknown. The campus has nearly 13 miles of bicycle lanes. Other bicycle and pedestrian facilities include bicycle parking facilities, broad walks and sidewalks, and a pedestrian passageway under Wellborn Road, connecting the west campus with the main campus. There is currently no bicycle outreach program at the university. The campus master plan will continue to emphasize bicycle and pedestrian accessibility and connectivity, while increasing the density of new campus development to further facilitate non-motorized travel.

The University Police Department (UPD) is responsible for traffic control and enforcement primarily within the TAMU campus, though its jurisdiction extends throughout Brazos County.

UPD officers patrol in cars, on bicycles, and on foot as needed; a typical shift will include at least one officer on a bicycle (13 officers are bicycle-trained).

TRANSPORTATION IN BRYAN/COLLEGE STATION

Transportation Coordination with TAMU

UPD coordinates traffic control with the College Station Police Department and the Texas Department of Transportation (TxDOT) for large events such as football games. Additionally, the Texas A&M Vice President for Facilities is on the Brazos Valley MPO* Policy Committee along with representatives from Bryan and College Station.

Bicycle/Pedestrian Infrastructure

Both cities have developed plans to expand the infrastructure for bicycles and pedestrians over the next several years. Appendices B and C show the planned bicycle/pedestrian network for College Station and Bryan.

College Station's Master Plan from 2002 lists three types of existing and planned bicycle/pedestrian facilities: bike/ped shared-use paths that are separate from roadways; bike lanes, marked off with stripes on roadways; and bicycle routes, which share low-speed roadways with motor vehicles without lane striping (though separate roadway signage is provided for bicyclists). Three miles of shared-use paths existed in 2002, with 40 additional miles planned. Bike lanes in 2002 totaled 25 miles, with another 20 miles planned. Ten miles of bike routes existed in 2002, with an additional 70 miles planned. While it is difficult to ascertain the mileage of planned bicycle facilities that have been built since 2002, a number of projects have been completed by the city, some in conjunction with related roadway improvements. One of the nearly-completed projects is the College Station Bike Loop, which is a combination of bike lanes, bike routes, and off-street bike paths that connect College Station parks and several residential areas with Texas A&M University.

Bryan's 2006 Comprehensive Plan documents the following bikeway system as of that year:

- 5 miles of bike paths along FM 158 between FM 60 and SH 6,
- 3.5 miles in Park Hudson, Austin's Colony, and Shirewood subdivisions,
- 17 miles of off-street trails at Bryan Utilities Lake, and
- bike lane on South College Avenue between Villa Maria and Dodge Street.

The city's Hike and Bike Access Plan shows the locations of proposed on-street bike lanes and bike routes plus proposed off-street bike paths and trails. Implementation of the plan has begun; the Turkey Creek bike path is now complete, and the Park-Hudson Trail from State Road 158 to Harvey Drive will soon be underway.

* MPO: Metropolitan Planning Organization

CHARACTERISTICS OF TAMU PARKING USER

Similar to the other major universities around the country, passenger cars are the dominant mode of travel to/from campus. Parking construction, maintenance, and operation are the main components of TAMU's transportation services. Effective parking management policies and strategies are essential to any plan for achieving a sustainable transportation on the campus. Parking management policies are specifically and directly related to the users of the system, and, therefore, knowing the characteristics of these users is a necessary step in developing a successful parking management plan.

Two data collection efforts were designed and carried out by the researchers: a parking user survey and a parking count. A sample of TAMU parking lots and garages were selected for this purpose. Table 2 shows the list of these parking facilities. The data collection efforts were performed between March and May 2008.

Table 2. TAMU Campus Parking Lots and Garages Covered in This Study.

	Parking Lot																	
	100a	100b	100c	97	47	51	6	23	53	19	113 S	30	54	55	50	WCG* levels 1,6,5	SSG** levels 1,3,4	CCG***
Parking Survey	✓	✓	✓	---	✓	✓	---	---	---	---	---	---	✓	✓	✓	---	---	---
Parking Count	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

*West Campus Garage, **South Campus Garage, ***Central Campus Garage

The parking user survey (Appendix A) was designed to capture the following characteristics of parking users:

- users' designation at TAMU (faculty/staff, undergraduate, graduate, others),
- number of days per week driving to the campus,
- number of people who rode in the car with the driver,
- distance they drove,
- duration of the driving, and
- type of vehicles driven to campus.

The research team approached parking users at the selected parking lots and garages around the campus. The participants were randomly selected, and the only criterion used in the selection was their usage of parking, i.e., they had parked a vehicle in the parking facility. Participants were asked to answer the questions based on their most recent trip to campus. A total of 411 questionnaires were completed (59 percent male, 41 percent female). A total of 85 percent of the interviewed parking users reported driving in a single-occupancy vehicle (SOV). Eighty-seven percent of them drove to campus at least four days per week, and 12 percent drove two to three days per week. 61 percent stated that they had only one round trip per day to/from campus while

37 percent drove two or three times per day to campus. Figure 1 shows the general characteristics of the participants in this survey.

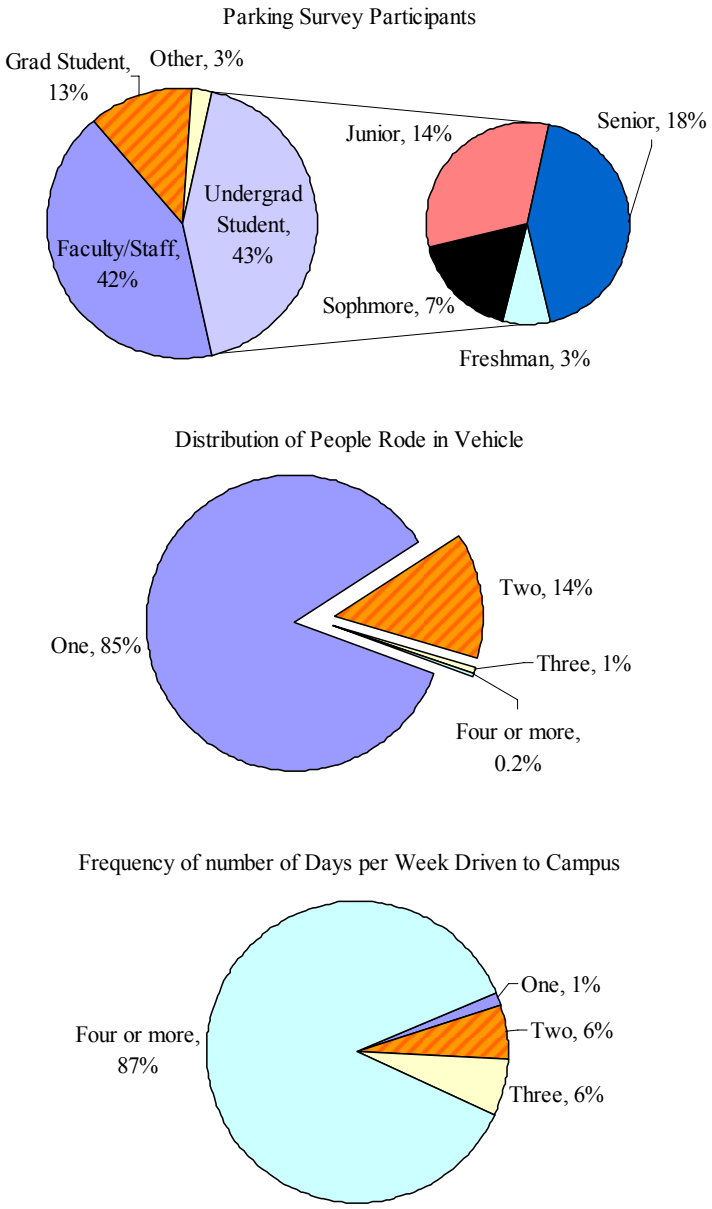

Figure 1. General characteristics of participants of TAMU parking users' survey.

The majority of the participants were either faculty/staff members (42 percent) or undergraduate students (43 percent). Graduate students composed 13 percent of the participants. Other participants, such as service staff and visitors, were only 3 percent of the total participants. It appears that the undergraduate students' vehicle usage increases with their seniority in the

university. Freshman students were found to have the lowest parking usage level (3 percent), whereas senior students have the highest (18 percent).

It must be noted that these percentages do not represent the real parking usage share between these population groups. This is because some parking lots and facilities are mostly used by one or two population groups. For example, parking lot 100 on the west campus is usually used by undergraduate students, whereas parking lot 55 is mostly used by faculty/staff.

The number of vehicles, the type of vehicle, and the distance that people drive these vehicles to campus are the main factors determining the emissions contribution to mobile source emissions. Any change in any of these factors directly impacts the amount of pollutants emitted from vehicles using campus parking. Approximately half of the participants (statistically significant at 95 percent confidence level) drove an SUV, pickup truck, or minivan to campus. These vehicle types are usually heavier and have bigger engines than passenger vehicles and, therefore, are categorized as light-duty gasoline truck (LDGT1) for emissions modeling purposes.

A statistical analysis of vehicle type by participant's designation, as shown in Figure 2, showed that the differences between different population groups were statistically significant at 95 percent confidence level. Graduate students have the highest percentage of passenger vehicles (63 percent of graduate students) and the lowest percentage of pickup trucks (18 percent of graduate students). Faculty/staff and undergraduate students appear to have the same level of passenger car usage (49 percent of group). Undergrad students have the highest percentage of driving a pickup truck (32 percent of undergraduate students). The data show that SUV usage level is similar between the major population groups (around 20 percent). Faculty and staff were found to be the main users of minivans.

To confirm the results of Figure 2, a parking count data collection effort was carried out during the same time period the survey was conducted. The number of vehicles and the type of vehicles were the information that was collected in this effort. Figure 3 shows that similar to survey results, almost half of the vehicles are light duty trucks (SUV, pickup, or minivan). A statistical analysis showed that at 95 percent confidence level, there is no statistically significant difference between the vehicle type distributions from the two data collection efforts.

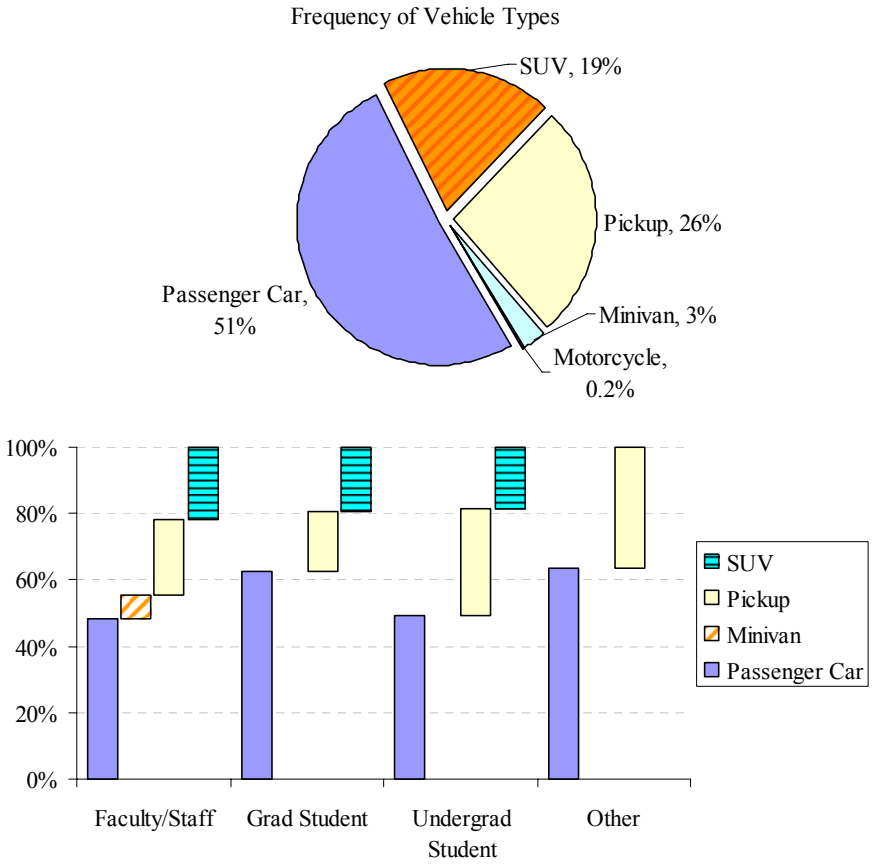

Figure 2. Frequency of vehicle types based on survey data.

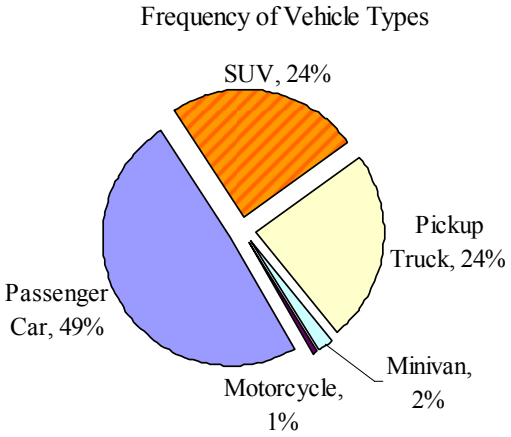

Figure 3. Frequency of vehicle types based on parking count data.

Figure 4 shows the frequency of driving distance to campus. The results show that only 6 percent of the participants in the survey were living within one mile of campus. Since only parking users participated in this survey, these results could be an indicator that considerable percentages of this group (people who live within 1 mile) use other modes for their trip to campus. A relative majority of participants (37 percent) stated that they drove between 2–5 miles to campus. This group is followed by participants who drove 5–10 miles (27 percent). Fourteen percent of participants stated that they drove more than 10 miles to campus.

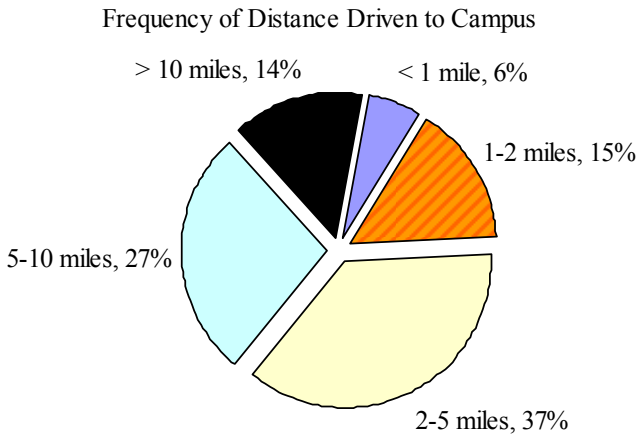

Figure 4. Frequency of driving distance to campus.

The breakdown of driving distance according to participants' designation in TAMU is shown in Figure 5. These results were found to be statistically significant at 95 percent confidence level. With approximately 60 percent driving more than 5 miles and more than 20 percent driving more that 10 miles to campus, faculty/staff appear to have the highest driving distance to campus among the regular TAMU parking users (faculty/staff, undergraduate students, graduate students). The percentage of participants who drove less than 2 miles was the highest for undergraduate students (33 percent). Also, 74 percent of undergraduate participants drove less than 5 miles to campus. Graduate students had a similar trend to undergraduates, but with higher percentages driving farther distances (67 percent drove less than 5 miles). The "other" population group was found to have the highest percentage of people who drove more than 10 miles. This was expected since most of the participants in this group were visitors from out of town.

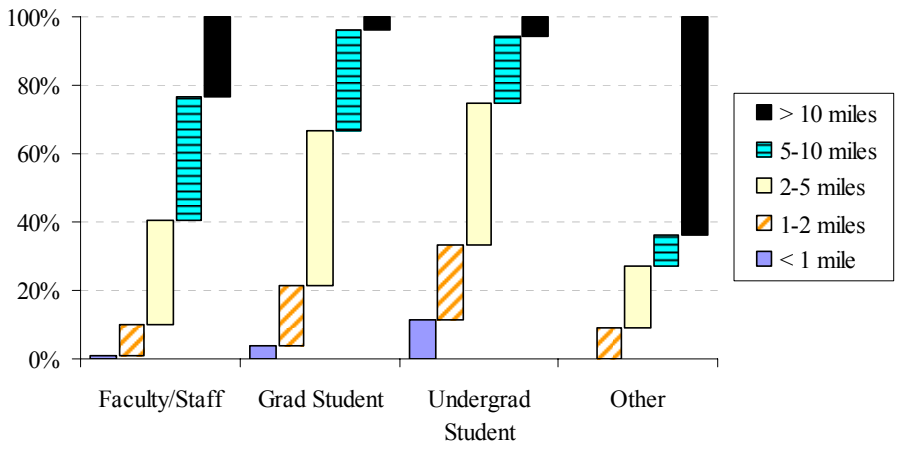

Figure 5. Frequency of driving distance to campus by different participants.

These results are of special interest because driving distance and consequently travel time from destination (in this case: TAMU campus) are two of the main factors affecting transportation mode choice. People who live within 1 mile from campus can walk or ride a bike. Biking is a practical option for people living within 2 miles, and a combination of transit and biking could be a feasible option for people within 5 miles from their destination. The results shown in Figure 4 and Figure 5 are most helpful to identify the target population for different strategies aimed at a certain alternative transportation option.

Figure 6 shows a breakdown of driving distances for different vehicle classes. A statistical analysis showed that the differences between different car types with regards to driving distance are not statistically significant at 95 percent confidence level. The data shows that approximately 20 percent of all vehicle types are driven less than 2 miles (statistically significant at 95 percent confidence level).

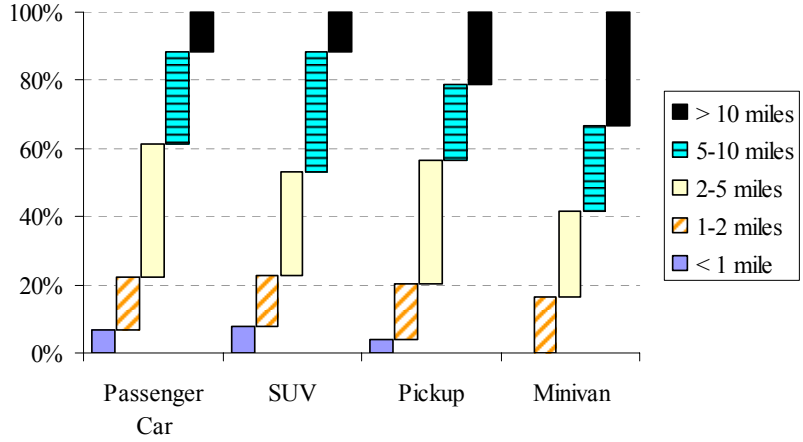

Figure 6. Frequency of driving distance to campus by vehicle classes.

Figure 7 shows the impact of drivers' gender on participants' vehicle types. The impact of gender on vehicle choice was found to be statistically significant at 95 percent confidence level. Female SUV drivers were found to be twice the number of male SUV drivers (28 percent female, 14 percent male). This was also the case for minivan (4 percent female, 2 percent male). On the other hand, the number of male participants who drove a pickup truck was three times higher than their female counterparts (12 percent female, 36 percent male). Female passenger car drivers were relatively higher than male passenger car drivers (59 percent female, 46 percent male).

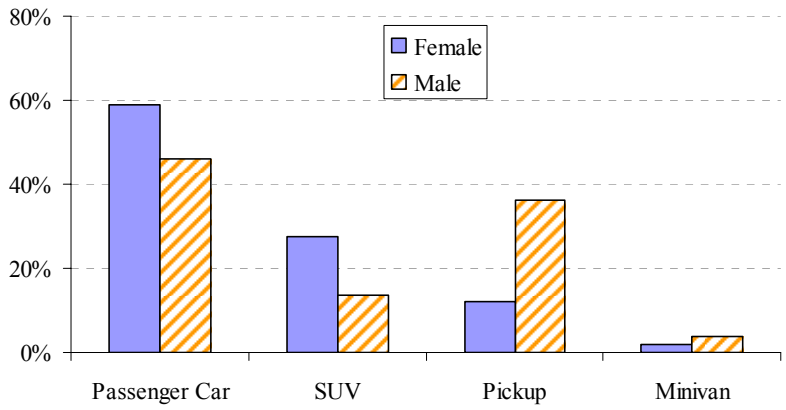

Figure 7. Frequency of vehicle type by drivers' gender.

The participants were also asked about their travel time to campus. The frequency of these reported travel times is shown in Figure 8. A relative majority (47 percent) of the participants stated that they had a travel time between 10 and 20 minutes. Thirty-seven percent stated that their travel time was less than 10 minutes, and only 15 percent had travel times higher than 20 minutes. These results indicate that the travel times in general are relatively short (less than 20 minutes). This is an important factor to consider when designing strategies that promote alternative transportation. If the alternative transportation options have significantly higher travel times and no other benefit is provided to alternative transportation users, then the drivers will not have enough incentives to switch to these alternative options.

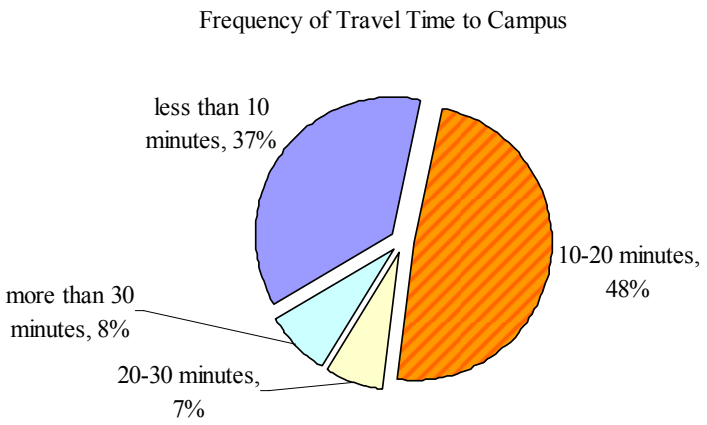

Figure 8. Frequency of travel times to TAMU campus.

Age of vehicle is one of the factors affecting the amount of pollutant emission from moving vehicles, although it is not as important as the class of the vehicles. Older vehicles usually tend to have higher emissions rates than the newer ones. Survey participants were also asked about the model year of their vehicle. Figure 9 shows these results. Almost half of the participants stated that their vehicle was older than 6 years, with 16 percent being older than 10 years. This information is specifically useful if strategies that promote purchase of new and more fuel efficient vehicles are considered.

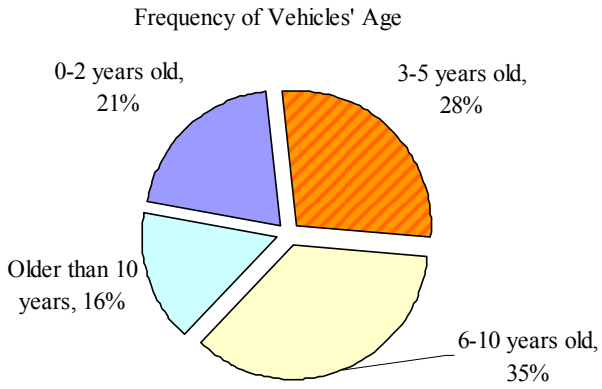

Figure 9. Frequency of vehicle age.

CHAPTER 3: TRANSPORTATION SUSTAINABILITY IN OTHER TEXAS UNIVERSITIES

The following chapter provides an overview of sustainability programs in the major universities and colleges of Texas. The chapter specifically explores different transportation sustainability initiatives and projects in these universities in order to identify their objectives, elements, and impacts.

TEXAS UNIVERSITIES AND COLLEGES

The number of students enrolled in 2007 was used to identify major universities and colleges in Texas. In addition, three smaller universities that have had successful campus sustainability programs were also included. Overall, campus sustainability programs in 15 Texas universities were investigated. The list of Texas universities that were included in this investigation is presented in Table 3.

Table 3. Texas Universities Examined in This Study (Source: wikipedia.com and universities' websites).

University/College	Student Enrollment*	Campus Area (acres)
University of Texas-Austin	49,696	350
Texas A&M University	46,612	5,200
University of Houston	35,344	560
University of North Texas	34,268	860
University of Texas-San Antonio	28,520	
Texas State University-San Marcos	28,132	
Texas Tech University	27,996	
University of Texas-Arlington	24,825	
University of Texas-El Paso	20,154	
University of Texas-Brownsville	17,065	
University of Texas-Pan American	17,048	
Sam Houston State University	15,934	
Southern Methodist University	10,901	
Rice University	4,808	
Abilene Christian University	4,609	

* Student enrollment includes both undergraduate and graduate students in 2007.

UNIVERSITY OF TEXAS – AUSTIN

The University of Texas at Austin (UT Austin) is located in Austin, Texas, about 2 miles from downtown and the State Capitol with a total area of more than 350 acres.

Sustainability Programs

UT Austin has approved the Campus Sustainability Policy to address sustainability challenges in collaboration with different components of the system, including academic programs, research centers, planning and operations, administration, student organizations, and outreach. The Campus Sustainability Policy puts forward policy guidelines, which are composed of policy statement, scope of policy application, definition of campus sustainability, and implementation principles. In particular, six general implementation principles are suggested for academics, operations, campus planning, administration, outreach, and implementation *(15)*.

The Campus Sustainability Policy and Environmental Science Institute (ESI) presents the concept of sustainability, which is consistent with the definition of the World Commission on Environment and Development *(16)*. Sustainability programs at UT Austin are implemented through academic research and educational programs, student groups, and a number of sustainability centers *(17)*.

Campus Master Plan

The campus master plan intends to develop a sense of community and to guide planned growth of the campus. The campus master plan covers four specific issues: architectural character, open space character, movement and way-finding, and places. UT Austin's campus sustainability goals are not specifically addressed in the campus master plan; rather, they are covered indirectly in the following seven planning principles *(18)*.

1) restoring the core campus for pedestrians and keeping traffic to its edges,

2) adhering to Paul Cret's architectural elements for new projects,

3) building a community where open spaces and buildings are in harmony,

4) supplying more on-campus housing, creating an academic community,

5) creating new centers for student activities to expand housing and academic uses,

6) concentrating future construction in the core campus, and

7) improving accessibility through identity and way-finding programs.

Sustainability issues are covered more specifically in the Campus Sustainability Policy. The Campus Sustainability Policy guides campus planning to set up its goal with minimizing the environmental impact of the campus. It also encourages related parties to assess the impact of their projects and to introduce advanced methods to incorporate green building and design elements as well as to consider future needs of the community in their decision-making process *(15)*.

Other Activities in the Campus

ESI provides comprehensive information about existing campus sustainability programs and resources as well as campus operations and student organizations *(17)*. The following presents a brief description of these elements.

Sustainability Centers

Organizations engaged in sustainability issues at UT Austin include Environmental Science Institute, Center for Sustainable Development (CSD), Center for Energy and Environmental Resources (CEER), and Center for the Science and Practice of Sustainability (CSPS).

ESI is a multidisciplinary research center focused on enhancing the public understanding of the environmental system. It has developed many programs with regard to interdisciplinary research, education, and outreach activities *(17)*. CSD focuses on the connection between the built environment and the concept of sustainable development. Topics include energy-efficient modular systems, sustainable residential and affordable housing, and preservation of architectural and cultural resources on the campus *(19)*. CEER specializes in advanced processes and technologies for energy efficiency and economics, and environmental quality improvement *(20)*.

Sustainability Administration and Operations

The Environmental Health and Safety (EHS) office plays a major role for campus sustainability administration. This office helps the campus to achieve health and safety requirements and prevent accidents and environmental hazards *(21)*.

Operations include a variety of administration and management efforts: facility services for landscaping and recycling programs, project management and construction services, campus planning, utilities and energy management, parking and transportation, housing and food, and historically underutilized business program.

Sustainability Education

Sustainability education consists of several programs and many courses available on campus. Programs include the Bridging Disciplines Program (BDP) in the Environment, Graduate Portfolio Program in Sustainability, and Graduate Portfolio Program in Integrated Watershed Science.

BDP in the Environment is a certificate program that encourages students to understand various environmental processes and issues through a series of academic courses *(22)*. The Graduate Portfolio Program in Sustainability prepared by CSD helps graduate students conduct studies on sustainability issues and prepare leadership in research and practice *(19)*. The Graduate Portfolio Program in Integrated Watershed Science is a certificate program provided by ESI that is focused on interdisciplinary study on many water-related issues *(23)*.

Sustainability courses include a signature course titled “Sustaining a Planet” and other courses provided by various colleges and departments.

Student Organizations and Outreach

Three student organizations play an important role in campus sustainability: Engineers for a Sustainable World (ESW), Campus Environmental Center (CEC), and Net Impact.

ESW focuses on making technological advances that do not have adverse effects on the environment *(24)*. CEC is the main student organization that focuses on reducing the effect of the campus on the environment and encouraging environmental stewardship of the students. Current projects include Trash to Treasure, Students for Sustainability, Recycling, Energy, Food,

Gardening, Dorm EcoReps, Green Living, Green 'Horns, Litter Reduction, Volunteering & Outdoors, and Orange Bike Project *(25)*. Net Impact focuses on raising awareness and education about the importance and powerful impact of sustainable business and corporate social responsibility.

The UT Sustainability Network is a regular meeting for people to discuss campus issues related to the environment and sustainable development. The meeting is held on a monthly basis and promotes cooperation and collaboration for campus sustainability. In addition, sustainability outreach activities include several speaker and lecture series focused on sustainability issues.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

As the Campus Sustainability Policy encourages campus planning to set up the goals and objectives of campus sustainability, planning principles and issues are compatible with the goals of transportation sustainability. In particular, the first principle indicates that the core campus should be redesigned for pedestrian-friendly places with walking surfaces, landscaping, and street furniture and lighting. Biking mode is also encouraged with bicycle pathways, separated lanes, and parking facilities. Automobiles are restricted and parking structures are built at the campus perimeter to connect with other modes, including shuttle buses. The fourth principle of the UT master plan, which focuses on creating a more balanced learning and living community in the campus, states that more on-campus housing is needed to accommodated various student activities and environmental needs. This strategy can decrease the parking demand and promote a walking environment *(18)*.

The movement and way-finding plan in the master plan presents a comprehensive guideline for campus transportation. It encourages pedestrians in the core campus, while leading vehicles to the edges. This plan contains pedestrian movement, bicycles, and changes in the road network, parking garages, service vehicles, and shuttle buses *(18)*.

Parking and Transportation Services

The Parking and Transportation Services (PTS) is the main transportation authority on the UT Austin campus. With regards to sustainability issues, the PTS promotes policies that are customer-centered, environmentally friendly, and economically reliable while providing access, mobility, and services *(26)*.

The PTS provides a set of services that directly or indirectly support sustainability on and around the campus. These programs include vanpool, carpool, E-Bus, UT Shuttle System, Texas Express, fare-free program, and Bike UT.

The vanpool at UT Austin is a collaborative program with Capital Metro. The vanpool and carpool program participants are given benefits, including Capital Metro's guaranteed ride home, preferred parking spaces, and discounted parking permits. The E-Bus is a circulatory bus service at night to take people to their homes safely. The UT Shuttle System is the largest university shuttle system in the U.S. The system provides service on 15 routes throughout Austin and has an annual ridership of over 7.5 million passengers. Texas Express is a special round-trip service from campus to Houston and Dallas between Friday and Sunday. The fare-free Program offers

free rides on Capital Metro buses. The Bike UT program helps registered cyclists to protect their bikes *(26)*.

UNIVERSITY OF HOUSTON – HOUSTON

The University of Houston (UH) is located southeast of downtown Houston, Texas, with a total area of 560 acres.

Sustainability Programs

The following provides a brief description of campus sustainability issues addressed in UH's campus master plan.

Campus Master Plan

The campus master plan or framework plan proposes three broad framework principles for accomplishing goals of the university during the next 20 years. They include framework principles of open space, transportation, and development with specific planning elements. For example, the development framework principle aims to increase on-campus residents, accommodate future campus population growth, encourage artistic and professional development, and encourage campus infill development *(27)*.

In summary, the campus master plan intends to double the learning space and residential space; establish various districts for a stadium, graduate students, and undergraduate students; and enlarge parking structures along the perimeter of campus. However, no programs or goals that are directly related to sustainability are proposed in the campus master plan.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

The transportation framework in the master plan presents four elements as follows *(27)*.

1) establishing a loop road and extending the pedestrian corridor,

2) providing parking structures to house growth of the campus population,

3) introducing shuttles, handicapped services, and emergency vehicles, and

4) integrating the proposed Metro light rail and express bus lines into the campus.

Although the master plan does not specifically mention the transportation sustainability on campus, most of its transportation elements support the concept of campus transportation sustainability on campus.

Parking and Transportation Services

The transportation plan is not available for the campus and Houston metropolitan area. Parking and transportation services (PTS) provides some programs currently available in the university. They comprise Carpool, Vanpool, Campus Shuttle, Charter Services, and Metro transit system. Carpool and Vanpool programs provide online ride matching services and courtesy parking

permits to the participants. Campus Shuttle service is available on campus and connected with the Metro system in the Houston area *(28)*.

UNIVERSITY OF NORTH TEXAS – DENTON

The University of North Texas (UNT) is located in a suburban area in Denton, Texas, with a total area of 860 acres.

Sustainability Programs

The following is a description of the campus master plan and other activities related to campus sustainability.

Campus Master Plan

Goals and objectives are presented in the campus master plan as follows *(29)*:

1) establishing a master plan based on sustainable design principles,

2) developing a vision for the campus,

3) developing an open space, landscape, and circulation framework,

4) combining the surrounding community and the city of Denton,

5) developing an integrated strategy for providing various transportation options,

6) developing campus unity,

7) establishing campus identity, and

8) providing services and amenities that support campus life.

Some guidelines and recommendations for specific issues are also presented in the plan: urban design and land use recommendations, program accommodation, integrated transportation and parking, environmental recommendations, landscape design guidelines, architectural design guidelines, and implementation strategy. In particular, the environmental recommendations section proposes many strategies to improve campus sustainability, including natural environment, land use, site design, landscape, and traffic and parking demand management. The land use policy, for example, suggests two strategies for developing on-campus housing and a compact, pedestrian-oriented campus *(29)*.

Other Activities

Students for a Sustainable Campus (SSC) was organized in order to educate students, staff, and community members about environmental issues and to propose innovative and effective solutions. It has been involved in research and programs including a campus recycling program, transportation connecting to the city, and an energy conservation program *(30)*.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

One of the planning goals aiming for an integrated strategy for providing various transportation options agrees with the goals of transportation sustainability. Not only does it intend to provide strategies for coordinating pedestrian, bicycle, transit, vehicle, and parking, but it also aims to reduce the dependence on private vehicles and improve the quality of walking, cycling, and transit modes. The strategies for achieving the goal address the housing strategy, both on and off campus, and the commuting mode choices, while encouraging commuters to use transit services and alternative modes *(29)*.

In addition, recommendations are made in terms of natural environment, land use, site design, landscape, and traffic and parking demand management. In particular, traffic and parking demand management suggests that an integrated transportation strategy needs to be established for providing many transportation options; strategies to reduce automobile dependence need to be developed; and parking spaces should be decreased in order to encourage mode choices other than automobiles *(29)*.

Transportation Services

The research team could not find a comprehensive campus transportation plan for the campus or the city of Denton. The services provided by transportation services include E-ride, campus shuttle, and other alternative transportation modes. The E-ride program provides late-night transportation services. The Campus Shuttle is available on campus and is connected with surrounding areas *(31)*.

UNIVERSITY OF TEXAS – SAN ANTONIO

The University of Texas at San Antonio (UTSA) is situated on 600 acres near the city's northern edge, a suburban area of San Antonio, Texas.

Sustainability Programs

The following provides a brief description of campus sustainability issues addressed in UTSA's campus master plan.

Campus Master Plan

The goals of the campus master plan can be summarized as follows *(32)*:

1) accommodating the large building program for meeting academic needs,

2) following environmental mandates for endangered species and stormwater treatment,

3) integrating additional land into the design of the campus,

4) preserving open spaces and improving connections to the areas,

5) expanding infrastructure in a balanced way, and

6) enhancing the way-finding system with appropriate information and signage.

Two of these stated goals—following environmental mandates and preserving open spaces and improving connectivity—are directly related to the campus sustainability concept. In order to achieve these goals, UTSA is implementing the following four actions *(32)*.

1) enhancing the pedestrian-friendly qualities of the campus,

2) maintaining flexibility, adaptability, and interchangeability of building design,

3) supporting human-scale features in large-scale construction, and

4) championing high density development.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan
Although the campus master plan states a goal of cohesive infrastructure expansion and way-finding improvement, the goals of transportation sustainability are not presented. Only a strategy for enhancing the pedestrian-friendly qualities is directly connected to them.

In addition, a plan for transportation systems considers campus roadways, bicycle paths, parking facilities, pedestrian facilities, and an external transportation system. The campus roadways plan establishes efficient circulation throughout the campus. The bicycle lanes and paths plan encourages alternative modes. The parking plan provides a decentralized scheme across the campus. Pedestrian facilities are designed to encourage walking and discourage automobile use. An external transportation system is planned to connect the campus to surrounding areas *(32)*.

Parking and Transportation Services
A transportation plan is not available for the campus and San Antonio metropolitan area. In addition to providing parking services, UTSA parking and transportation services (PTS) supports campus shuttle and carpool programs as well as encourages alternative modes such as biking and walking *(33)*.

TEXAS STATE UNIVERSITY – SAN MARCOS

Texas State University at San Marcos (TSU) is located in San Marcos, Texas. The total area of the campus amounts to 456 acres.

Sustainability Programs

Campus Master Plan

The guiding principles of the campus master plan (2005) are identity, community, natural environment, architecture, and mobility *(34)*.

1) Identity means to integrate the campus with proper entrances and borders.

2) Community implies the status of excellence while protecting small campus atmosphere and enhancing relationships with the San Marcos community.

3) Natural environment emphasizes the physical characteristics of the campus.

4) Architecture focuses on a cohesive architectural style.

5) Mobility intends to manage motorized and pedestrian traffic more effectively and safely.

Final plans and guidelines presented in the master plan include built systems, natural systems, interventions, guidelines for urban design, architecture, and landscape design. Two principles are generally consistent with campus sustainability: natural environment and mobility.

Other Activities

A Quality Enhancement Plan (QEP) presents a course of activities for long-term institutional improvement while focusing on student learning opportunities. One of the proposed themes is the Sustainable Communities Initiative, titled Building Sustainable Communities, which is compatible with the goals of sustainability. This initiative promotes sustainability issues through degree programs so that students are required to complete at least one service learning project on sustainability *(35)*.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

Transportation sustainability is not stated clearly in the campus master plan. A guiding principle of mobility is associated with its goals. The master plan suggests an efficient and safe campus network and pathways for all modes. It also proposes reallocating core surface parking to parking garages, encouraging alternative modes, and ensuring pedestrian safety.

The final plan for built systems includes more specific suggestions for various transportation modes on campus, including walking, bicycle, bus and electric shuttle, commuter rail, and automobile. The plan promotes walking as the primary mode and a cycling network throughout the campus. It also encourages an efficient and reliable bus, shuttle, and commuter rail system; on the other hand, automobile use on campus is discouraged *(34)*.

Parking and Transportation Services

Transportation services at TSU are administered by two entities: Parking Services manages campus parking facilities and services, and Auxiliary Services provides limited transit and alternative transportation programs. The bus system at TSU, Bobcat Tram System, has been operating to reduce campus parking demand and traffic congestion. It serves both on-campus and densely populated areas of the surrounding city of San Marcos. The bus service is included in the master plan to develop a regional, equitable, inter-modal transportation system. The Capital Area Rural Transportation System (CARTS) is also available where the bus services are available as a cooperative effort between the university and the city *(36)*.

Auxiliary Services also promotes biking and other alternative transportation through the Bicycle Alternatives and Alternative Transportation programs. The Bicycle Alternatives program encompasses bike racks on all tram buses, bikeway development, and bicycle co-op. The Bicycle co-op program provides maintenance and repair facilities and learning opportunities for maintaining and repairing bicycles. In addition, several initiatives have been suggested to support transportation alternatives by increasing bus utilization and developing pedestrian alternatives *(36)*.

TEXAS TECH UNIVERSITY – LUBBOCK

Texas Tech University (TTU) is located in an urban area in Lubbock, Texas, with a total area of 1839 acres.

Sustainability Programs

Campus Master Plan

The campus master plan is not available. Instead, the goals of the TTU 2005 Strategic Plan include investment in the people involved in the university; reinforcing the educational experience; promoting research and creative activities; and building partnerships with others *(37)*.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

No programs or goals that are directly related to transportation sustainability are mentioned in the strategic plan.

Parking and Transportation Services

A comprehensive transportation plan is not available for the campus and surrounding area. Parking Services provides some programs, including Free Car Clinic, Carpool, Education Partnerships, Expectant Mother Parking, Guaranteed Ride Program, and Motorist Assistance Program.

The Free Car Clinic is designed to provide quick vehicle inspection services, including oil and fluids and tire pressure. The Carpool program provides incentives for carpooling to campus. With Education Partnerships, students are given an opportunity for education through assistantship, internship, and research projects. Expectant Mother Parking helps pregnant women

access campus facilities. In addition, the Motorist Assistance Program intends to provide some vehicle services in need *(38)*.

UNIVERSITY OF TEXAS – ARLINGTON

University of Texas at Arlington (UT Arlington) is located in a suburban area in Arlington, Texas, with a total area of 400 acres.

Sustainability Programs

Campus Master Plan

The guiding principles of the campus master plan are identity and aesthetics, reputation and tradition, campus and community, spaces and linkages, and environment and sustainability *(39)*.

1) Identity and aesthetics aim to build a sense of place and strong identity, and establish a connection to the City of Arlington Downtown Master Plan.

2) Reputation and tradition aim to achieve academic achievement and a traditional campus.

3) Campus and community promote student achievement and broader community activities.

4) Spaces and linkages suggest creating a campus of outdoor rooms, shaded gardens, and activity hubs, all linked to the natural regional systems.

5) Environment and sustainability aim for responsible implementation of the master plan.

These five guiding principles generally support the sustainable development on campus. In particular, the master plan encourages growth within the existing boundaries by transforming underutilized land on campus to sustainable buildings and open spaces. The master plan also recommends that alternative modes be encouraged throughout the campus and downtown Arlington. It further suggests that automobile traffic should be kept to the periphery of campus in structural parking facilities *(39)*.

Other Activities

UT Arlington recognizes its responsibility to strive for sustainable development and environmental stewardship and commits to provide comprehensive information for campus sustainability *(40)*. Projects for achieving campus sustainability include recycling and composting; energy conservation; resource conservation, such as copy paper, official stationery, and other paper options; campus master plan; and LEED's certification for new buildings.

The President's Sustainability Committee (PSC) was launched October 2007 to facilitate further development of policies and practices that help the university advance its commitment to sustainability. Members of the campus faculty, staff, student body, and the general public are encouraged to use the PSC Forum to communicate and share resources. The forum includes academic programs, research, administration, and other projects as follows *(41)*:

1) Academic programs – Environmental & Earth Sciences Program, Earth & Environmental Sciences Department, Civil Engineering Department, School of Urban & Public Affairs, and OneBook & Conversations.

2) Research – Center for Renewable Energy Science & Technology, and faculty engaged in environmental research.

3) Administration – Environmental Health and Safety, Energy Conservation Program, Master Plan, and Recycling and Composting Program.

4) Projects – Carbon Footprint Analysis, Green Roof, and Transportation Planning.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan
A guiding principle of environment and sustainability is directly connected to goals of transportation sustainability. Parking and transportation in the master plan maintain that new parking structures are located to the periphery of the campus to meet future campus parking demands. The campus shuttle system becomes more important in the future. It also states that campus streets should be improved to incorporate bike lanes and bikeways on campus, and pedestrian facilities should be increased to protect sidewalks and crosswalks *(39)*.

Parking and Transportation Services
The parking department and transportation services at UT Arlington are both operated under the management of the university police department. The office of transportation services at UT Arlington provides limited shuttle services to the campus community. No other specific programs and objectives that are related to transportation sustainability are listed on their website.

UNIVERSITY OF TEXAS – EL PASO

University of Texas at El Paso (UTEP) is located in an urban area of El Paso, Texas, with a total area of 366 acres.

Sustainability Programs

Campus Master Plan
The goals of the campus master plan are presented as follows *(42)*:

1) consider growth in research programs, program diversification, and graduate programs,

2) attend to space planning and facilities utilization,

3) express the unique character of the campus,

4) examine future demand for parking and circulation, and create a vision for the campus,

5) accommodate growth in intercollegiate athletic and recreational sports,

6) tackle changing housing priorities,

7) design academic communities,

8) preserve and reinforce sense of community,

9) construct safe, convenient, and attractive pedestrian linkages throughout the campus,

10) establish visitor-friendly campus, and

11) integrate previous plans to prepare a final plan.

The master plan addresses many specific issues: land use and site development, utilities and infrastructure, transportation plans, vehicles, parking and pedestrians, open space and landscape plans, and implementation plan. Issues related to sustainability are not addressed in the master plan; however, several goals are associated with it.

Other Activities
The College of Engineering has developed the Sustainable Engineering Initiative for understanding the concepts and searching for solutions for sustainable engineering. Many departments have participated in the initiative, including Civil Engineering, Computer Science, Electrical and Computer Engineering, and Mechanical and Industrial Engineering. Its objectives are presented as follows *(43)*:

1) enhance understanding of environmental issues and the impact of engineering solutions,

2) expand the knowledge of the legal framework guiding a sustainable engineering solution, and

3) reinforce the insight into the needs for resource conservation and energy utilization.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan
The goals of sustainable transportation are not directly mentioned in the master plan, although several goals related to transportation planning are specified. Transportation sustainability issues are dealt with indirectly by addressing a campus transportation plan, vehicles and parking, and pedestrians' needs. The master plan specifically recommends restricting private vehicles to the periphery of the campus and improving the walking quality in the core area. It also encourages other types of alternative transportation modes, including a carpool program, campus shuttle system, and public transportation *(42)*.

Parking and Transportation Services
A comprehensive transportation plan is not prepared for the campus and surrounding area. Several programs are presented, including campus shuttle, city bus, and bicycle. There are no specific programs and objectives addressing the transportation sustainability on campus.

UNIVERSITY OF TEXAS – BROWNSVILLE AND TEXAS SOUTHMOST COLLEGE

University of Texas at Brownsville and Texas Southmost College (UTB/TSC) is located in an urban area of Brownsville, Texas, with a total area of 380 acres.

Sustainability Programs

Campus Master Plan

Major tasks of the campus master plan are to enhance the functional and aesthetic values of the campus by combining new lands and to anticipate the capacity and the probable net present value of new construction.

The values of the 2020 master plan include *(44)*:

1) environmental nature of the campus;

2) a safe and secure environment;

3) community involvement;

4) accessibility;

5) harmony in design;

6) openness in design and space;

7) intimate gathering areas with seating;

8) an inviting ambiance;

9) historical nature of the campus;

10) ecology;

11) region's unique cultural character;

12) natural features;

13) effective communications networks;

14) shelter;

15) flexibility in design; and

16) low maintenance cost, energy efficiency, and durability.

No values and tasks of the master plan are directly associated with the goals of sustainable development. But some of the planning values are consistent with sustainability goals, including accessibility, ecology, and low maintenance cost, energy efficiency, and durability.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

Main tasks and values of the master plan do not directly address the issues related to transportation sustainability on campus and the surrounding area. The accessibility element of the master plan mostly focuses on general aspects of campus transportation planning. However, some elements of the master plan indirectly support a sustainable transportation system on campus by providing recommended guidelines for traffic circulation, pedestrian ways and portals, and parking and green spaces. These plans propose that traffic should be limited to the periphery of the campus; parking facilities should be located on the perimeter to minimize its impact on the pedestrian core and green spaces; and pedestrian walkways should be improved around campus *(44)*.

Transportation Services

A Transportation Task Force was organized to develop programs and strategies for enhancing accessibility on- and off-campus. The strategies include more parking spaces, a shuttle system between campuses, carpools, bicycling, and walking.

UNIVERSITY OF TEXAS – PAN AMERICAN

University of Texas – Pan American (UTPA) is located in an urban area of Edinburg, Texas, with a total area of 238 acres.

Sustainability Programs

Campus Master Plan

No goals or planning principles are specified in the campus master plan. The master plan addresses many detailed issues: land use and site development, real estate acquisitions, utilities and infrastructure, transportation plans, open space and landscape plans, hazardous materials survey, redevelopment of existing facilities, architectural design standards, landscape design standards, and implementation plan *(45)*.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

Transportation plans as defined in the campus master plan deal with the issues of parking, vehicular access and entrances, pedestrian circulation, and accessibility. It is proposed that parking spaces need to be increased as future demand grows; a “tram system” needs to be introduced for future campus expansion; and pedestrian circulation needs to be improved throughout the campus *(45)*.

Parking and Transportation Services

Parking and transportation services are managed by the police department. No specific programs and objectives that are related to transportation sustainability are mentioned.

SAM HOUSTON STATE UNIVERSITY – HUNTSVILLE

Sam Houston State University (SHSU) sits on 272 acres in the central urban area of Huntsville, Texas.

Sustainability Programs

Campus Master Plan

The issues and missions of the campus master plan include academic excellence, student housing, student life, community relations, traffic and parking, campus edges, and habitat. No issues that are consistent with the objectives of sustainable development are addressed in the master plan. However, some of them are associated with campus sustainability. In more detail, traffic and parking issues focus on redevelopment of several streets, adjacent housing and facilities, structural parking, and others. The issue of campus edges pays attention to directive campus graphics, pedestrian pathways and safety, handicap access, and energy concerns. In addition, the habitat issue addresses sustaining the environment and promoting concepts of excellence.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan

Transportation sustainability issues are not stated directly in the master plan; however, traffic and parking services are discussed as part of campus transportation planning. It suggests that new parking structures be placed into the campus periphery; adequate access corridors be established to improve accessibility; the natural environment be preserved; alternative travel modes be encouraged; and other transportation options be provided *(46)*.

Parking Management

Parking management is conducted by the police department. No specific programs and objectives that are related to transportation sustainability are mentioned.

SOUTHERN METHODIST UNIVERSITY – DALLAS

Southern Methodist University (SMU) is located in an urban area of University Park in Dallas, Texas, with a total area of 210 acres.

Sustainability Programs

Campus Master Plan

The Centennial Master Plan establishes a framework for future development on campus. The objectives of the master plan are as follows *(47)*:

1) creating a plan for facilities growth,

2) preserving Collegiate Georgian architectural integrity,

3) determining campus edges and points of entry,

4) improving the pedestrian character of the campus,

5) reinforcing the area and quality of landscaping, and

6) enhancing campus navigation.

Transportation sustainability is not directly addressed in the master plan; however, improving the pedestrian character of the campus is in line with the concept of sustainable development and transportation.

Other Activities
Environmentally friendly programs and projects at SMU include the areas of electricity, water conservation, trash and recycling, energy recovery, and indoor air quality *(48)*.

1) Electricity – wind-generated electricity, replacing exit sign bulbs with LED bulbs, automatic room lighting, and flat-screen computer monitors consuming less electricity.

2) Water conservation – rain water recovery, condensation recovery, cooling water recycling.

3) Trash and recycling – integrated recycling containers.

4) Energy recovery – excess energy recovery and heat recovery device placement on boilers.

5) Air quality – Aircuity portable unit for testing air quality in buildings.

6) Others – U.S. Green Building Council and LEED.

In addition, the School of Engineering created the Environmental and Civil Engineering Certificate in Sustainability. The three courses that are prepared for this program include Introduction to Sustainability, Methods and Technologies for Sustainability, and Design for Sustainability.

Campus and Transportation Sustainability

Transportation Planning in the Campus Master Plan
The master plan does not mention issues of transportation sustainability. Two of the six proposed objectives—improving the pedestrian character and enhancing campus navigation—are associated with transportation planning. However, specific plans are not available. Instead, the parking plan suggests that small parking structures be located along the campus perimeter. Doing so accommodates the parking demand and sustains the pedestrian facilities on campus.

Parking and Transportation Services
A comprehensive transportation plan is not prepared for the campus and surrounding urban area. Parking and ID Card Services provide several programs on campus, including free rides on Dallas Area Rapid Transit (DART) with an SMU transit pass, and free rides on the Mustang Express (http://www.smu.edu/parknpony/default.asp).

RICE UNIVERSITY – HOUSTON

Rice University is located in downtown Houston, Texas, with a total campus area of 285 acres.

Sustainability Programs

Campus Master Plan

The university has prepared a master plan; however, researchers were unable to obtain specific information about the plan.

Other Activities

Sustainability at Rice provides and details comprehensive programs, initiatives, and resources related to sustainability at the university. It also includes specific elements as follows: policies, climate commitment, building design, energy, water, cleaning, composting and the Earth Tub, recycling and solid waste, biodiesel, arboretum, community garden, focus the nation, graduation pledge, and solar decathlon *(49)*.

1) Policies – The Rice University Sustainability Policy was approved in 2004, and the Rice University Sustainable Facility Policy was adopted in 2008.

2) Climate commitment – A plan for a carbon neutral campus should be developed in accordance with the American College and University Presidents Climate Commitment (ACUPCC).

3) Building design – Some level of LEED certification is achieved for all new buildings.

4) Energy – Guidelines are given for people, power source, and energy management system.

5) Water – Water conservation successes are provided, including groundwater reclamation.

6) Composting and the Earth Tub – A composting pilot project was initiated, and an on-site composting device known as an "Earth Tub" is installed on campus.

7) Recycling and solid waste – Rice Integrated Waste Management Services (IWMS) seeks to reduce the environmental impact of the university community while meeting its waste needs.

8) Biodiesel – The Rice University Biodiesel Initiative (RUBI) was founded. Some pilot projects have been done: conversion of waste cooking oil into biodiesel, and production of biodiesel to fuel diesel engines in the Facilities Engineerig and Planning (FE&P) fleet and a campus shuttle bus.

9) Arboretum – As a teaching and research resource, the arboretum contributes to the development of programs in biology, engineering, architecture, literature, and interdisciplinary studies.

10) Community garden – The garden serves as a learning space for members of the Rice community.

11) Focus the Nation – The university offers CO_2 forum and sustainability fairs for the public.

12) Graduation Pledge – The Graduation Pledge at Rice university states is: "I pledge to explore and take into account the social and environmental consequences of any job I consider and will try to improve these aspects of any organizations for which I work." Students can apply for the Pledge by signing and keeping a card stating the Pledge.

13) Solar decathlon – The decathlon intends to promote sustainable construction and energy technology.

Campus and Transportation Sustainability

Parking and Transportation Services
A transportation plan could not be obtained for the university and surrounding Houston metropolitan region. The transportation department provides some programs on and off campus, including shuttle service, Metro public transportation, carpool, and charter bus service.

ABILENE CHRISTIAN UNIVERSITY – ABILENE

Abilene Christian University (ACU) is located in an urban area of Abilene, Texas, with a total campus area of 208 acres.

Sustainability Programs

Campus Master Plan
The research team could not obtain a campus master plan for ACU.

Other Activities
In order to save operating costs and to minimize negative impact on the environment, the following initiatives have been conducted throughout the campus *(50)*:

1) parking lot asphalt recycling and environmentally friendly asphalt;

2) lighting fixture retrofit;

3) energy savings initiatives in heating, ventilation, and air conditioning system;

4) energy efficient outdoor lighting and copiers;

5) campus drain system using a natural bacterium;

6) energy efficient building design;

7) recycling of oil, paper, plastic bottles, and aluminum cans;

8) water-based paint;

9) chemical disposal by a licensed hazardous material disposal company;

10) algae control using natural barley bales instead of chemicals;

11) effluent water for irrigation, new pond for saving water runoff, and water-saving showerheads and toilets;

12) yard waste recycling;

13) food waste reuse;

14) HEPA vacuum cleaner filters for controlling airborne particles in the residence hall;

15) recycled paper purchase; and

16) undeliverable mail reduction project by keeping the mailing lists clean.

In addition, Enviro-Web provides comprehensive information on environmental programs and initiatives at the university. This site has been established in order to offer easy access to comprehensive environmental information.

Campus and Transportation Sustainability

The research team could not obtain any information on transportation planning and transportation services at ACU

CHAPTER 4: SUSTAINABLE TRANSPORTATION STRATEGIES

This chapter presents a broad list of sustainable transportation strategies that are suitable for university and college campuses. The strategies are divided into two broad categories: strategies that are designed to reduce single-occupancy vehicle traffic, and strategies that are exclusively designed to address air quality impact of traffic without changing the other aspects of vehicular traffic to a campus. In addition to a brief discussion of each strategy, the chapter provides supportive materials and examples of successful implementation. Strategies related to bicycle, pedestrian, and transit mode are covered in Chapter 5.

TRANSPORTATION DEMAND MANAGEMENT (TDM)

Transportation Demand Management(TDM) can be defined as a wide variety of transportation programs and strategies to manage and control travel demand in order to improve transportation system diversity, effectiveness, and efficiency. TDM pays attention to the movement of people and goods, rather than automobiles and trucks; therefore, it focuses on alternative modes such as walking, biking, ridesharing, and public transportation. It also aims at more efficient use of current transportation systems without increasing system capacity or supply; consequently, it stresses parking management, incentives, planning strategies, education, and marketing programs. There are a number of TDM programs, and each program has a modest impact on a transportation system; however, it should be noted that comprehensive and integrated TDM programs and strategies can have a significant cumulative effect *(51)*.

Campus TDM programs and strategies are designed and implemented on academic campuses and other campus facilities to achieve general TDM goals. Campus TDM programs and strategies have a number of positive consequences *(51)*. First, they reduce the demand for parking spaces, while relieving traffic congestion and improving air quality. Second, they reduce the costs related to additional construction and maintenance of roads and parking lots. Third, they promote alternative travel options and reduce transportation expenses. Fourth, they improve public health through enhancing air quality and promoting physical activity. Last, TDM programs enhance safety and security on campuses and their surrounding communities.

TDM programs and strategies that are implemented throughout the campuses have an effect on reducing the number of automobile trips by 10 percent to 30 percent *(52)*. Campus students and staff have been encouraged to modify their travel behavior by introducing TDM programs such as transit incentives and service enhancement, parking management, and walking and biking facility improvement in the short-term. In addition, land use policies including increased housing options nearby campuses have had an impact on their travel behavior change *(53)*.

Alternative Transportation

There are a variety of alternative transportation options that can be implemented on a university campus to reduce single-occupancy vehicles (SOV). This section provides a brief description of these alternatives. More detailed discussion on walking, biking, and transit are presented in Chapter 5: “Walking, Biking, and Transit.”

Transit
Transit incorporates various mode services to provide mobility to the public. The services include heavy rail, light rail transit (LRT), streetcar or trolley, fixed route bus with full size, bus rapid transit (BRT), express commuter bus, and paratransit and shuttle services *(51)*.

In particular, paratransit and shuttle services can include a variety of transportation services to provide mobility on and around campus. They contain circulating shuttles, demand-response paratransit, special mobility service, and Jitney services. Circulating shuttles convey passengers mainly for short trips along corridors connecting business and education campuses. Demand-response paratransit includes various types of flexible route services using small buses, vans or shared taxis. Special mobility services provide mobility to people with disabilities. Jitney services offer transit services operated by private operators using vans or small buses. In addition, some compasses offer special night shuttle services.

Shuttle services on and around the campus specifically provide mobility to people who do not drive to/within campus. A well-implemented shuttle system reduces the demand for parking spaces and improves safety and environmental quality.

Transit pass programs are a popular and significant element of the TDM strategies on campuses. The students and staff who live beyond walking or biking distance are the main target for these types of programs *(2)*.

Biking
Biking can play a more important role in the campus transportation system than in other communities because a large portion of students reside within a relatively short distance from campus and most of them are physically active *(2)*. A number of facilities are used to support biking mode. These facilities include trails, bike lanes and routes, designated shared streets, roadways, and sidewalks. Special consideration should be taken when designing and maintaining these facilities to establish and maintain a successful biking program *(51)*.

Biking mode can substitute for automobile trips. Improvements of biking facilities often lead to significant increases in biking travel and decreases in automobile travel *(41, 54)*. For example, a number of universities, including Duke University, Durham, University of North Carolina, and Simon Fraser University (in British Columbia, Canada) have installed bike racks in the cities and on buses *(2)*. Appropriate facilities can also make biking a suitable mode of transportation in the surrounding communities.

Walking
Walking is a travel mode as well as a recreational activity, though walking travelers can take both into consideration when making trips. Walkability places emphasis upon the quality of pedestrian facilities, street conditions, surrounding land uses, safety and security, and comfort for walking. Improvements for walking can reduce automobile trips and support public transit and ridesharing *(51)*.

In order to have walking as a practical mode of transportation, pedestrian facilities such as sidewalks, pathways, and crosswalks are necessary. These facilities should form a well-connected network and be safe and well-maintained on and around a campus. Students and

faculty/staff members who live less than one mile from campus are the main users of this mode; therefore, their needs must be taken into consideration during all stages of walking facility management, including planning, implementation, and maintenance.

Ridesharing

Ridesharing indicates carpooling and vanpooling in which more than two people can share a vehicle for a certain purpose. Ridesharing is an effective and efficient alternative mode, particularly where public transit is not well served and maintained in an area. Ridesharing programs typically incorporate carpool matching, vanpool sponsorship, market programs, and incentives to reduce automobile trips. According to the Victoria Transport Policy Institute (VTPI), ridesharing programs can absorb 5 to 15 percent of total commute trips if only information and encouragement are offered, and 10 to 30 percent if financial advantages such as parking cash out or vanpool subsidies are provided *(51)*.

Carpooling

Carpooling refers to two or more people in a car who share a common origin, destination, and schedule. It includes people living in the same community and working at or near the same place. Carpooling programs need to be considered as an effective mode choice for students and staff who live more than 10 miles from a campus or who have more than 30 minutes of travel time. A set of programs can be used to promote carpooling. For example, the University of Washington allows university employees who need a car during the day to borrow one from the university's car pool fleet. The University of Utah in Salt Lake City offers 50 percent off the regular parking cost to carpool parking permit holders *(2)*.

Vanpooling

Vanpooling generally uses a van that is not owned by the vanpooling members; rather, a van is borrowed for a certain period. Most vanpooling programs are self-sustaining, so operating costs are allocated to vanpooling members *(51)*. The university may purchase vans for the vanpooling program, and the users pay for a rental charge whenever they use it. Vanpooling programs have been more effective where commute distances are greater than 25 miles and where public transit services are not available *(2)*.

According to Evans and Pratt, vanpooling is one of the most efficient and effective vehicle modes and, therefore, can have significant net effects *(55)*. To promote vanpooling, a series of services and incentives need to be provided. These programs usually include on-line ride matching, a guaranteed ride home, subsidized travel costs, convenient drop-off and pick-up spaces, and preferential parking locations. At Yale University, incentives such as a free monthly fee and unlimited access on weekends and evenings have been offered to principal drivers. The University of Washington offers free University Transit Passes (U-Pass) to all drivers joining the vanpooling program *(2)*.

Parking Management

Parking management includes specific policies and programs aimed at making more efficient use of parking resources. Parking management can significantly lower the number of parking lots required to a specific land use pattern. It also has positive economic, social, and environmental effects *(51)*.

Parking (Permit) Pricing

Parking pricing refers to direct payment for utilizing parking facilities. It can be introduced to reduce traffic volume in an area, to diminish parking problems in a place, to compensate for costs of a parking facility, to create financial resources for other programs, or for a mix of these objectives. Parking prices should be set to accomplish the objectives of campus transportation and parking management *(51)*.

Parking pricing is one of the most effective measures to encourage trip makers to change their behaviors. It should be noted that parking demand of a campus differs from that of other land use types, such as retail and commercial. Parking availability is not a significant determinant of choosing a campus for students; therefore, parking pricing can be an effective strategy to manage single-occupancy vehicle travel demand. A number of campuses, including the University of Colorado and the University of Washington, have been introducing the parking pricing strategy *(2)*.

Parking pricing policies can be more effective if convenient and fair pricing methods are applied; if the range of travel choices are enlarged using those strategies; and if information on parking prices and availability and alternative modes is well provided *(51)*.

The land used for surface parking at a university campus is usually treated as free land because it is already owned by the university. In reality, there is an opportunity cost with using a piece of land for surface parking rather than using it for other purposes, such as academic buildings, housing, or recreational and green spaces.

A fair parking pricing schedule should consider the value of the land. Excluding the land value in the parking cost estimation works, in fact, as a hidden subsidy to automobile mode and encourages people to drive their vehicles to campus. Including the market value of the land in parking permit pricing is more equitable because it levels the ground between the users of different modes of transportation. At Stanford University, the transportation services found that most of the students use their cars only sporadically and by charging the full cost of parking to students, it would be cheaper for students to rent a car than to park a car on campus *(2)*.

Parking Cash-Out

In order to reduce potential conflict and opposition caused by the increase of parking price, some organizations have chosen a carrot rather than a stick, i.e., rewarding employees not to drive. This idea is known as a "parking cash-out program." This program implies that a campus pays cash on a regular basis to employees who decide not to buy a parking permit. A combination of two different strategies—a parking cash-out and an increase in parking price—can be put into action together to reduce the net cost related to implementing a parking cash-out program *(2)*.

Stanford University provides a good example. Known as the "Clean Air Cash," Stanford's program encourages employees to find alternative ways for commuting to campus. As of 2008, Stanford pays up to $234 per year in Clean Air Cash. Stanford has combined the program with an increased parking price, which results in expanding the range of alternative travel modes, including bicycle facility improvements *(56)*.

A parking cash-out program can even be effective at a campus where free parking is available. If implemented alone, parking cash-out does not have an effect on changing the travel behavior of the public as much as an increase in parking rates; however, the positive effect can still be obtained from the program. *(2)*.

Parking Cap (Parking Maximums)
Parking cap refers to the maximum number of parking spaces that can be established either at each site or in an area *(51)*. Parking cap or maximums programs have been implemented to reduce the traffic volume of single-occupancy vehicles and to relieve the imbalance among mode choices to a certain level. This strategy is expected to be very effective on campuses because parking cap can be well controlled and managed by campus administration *(2)*.

This policy implies that a campus does not provide parking spaces exceeding the established maximum; thus it may bring about imbalance between mode choices. A campus and surrounding government such as a city or a county can sometimes negotiate to set up the parking cap or maximums. This approach may not show immediate and desired effects. Even areas where public transit is well served can experience overrunning cars with demand for parking spaces *(2)*.

At the University of Washington, the parking spaces are capped at 12,300. This has been a major part of UW's progressive TDM program aimed at keeping the peak-hour traffic to campus at the 1990 level *(57)*. As part of their comprehensive TDM program, Stanford University has capped their parking spaces at 22,000 *(58)*.

Preferential Parking
On campuses, parking regulations do not support the objectives of TDM if they are applied to SOVs, carpools, and vanpools in a similar way. Such an implementation is not effective to encourage students and staff to participate in carpooling and vanpooling programs *(2)*. Preferential parking implies that particular individuals or groups who voluntarily participate in alternative programs should be given an advantage in terms of vehicle parking.

In preferential parking programs, carpoolers and vanpoolers are given parking spaces that are very accessible to buildings. Carpool permit holders at Virginia Tech have access to reserved carpool spaces in the front of most of the large parking lots *(59)*. Preferential parking programs have shown significant effects at large employment centers and at many campuses. One of the most significant advantages for successful preferential parking programs occurs when they are managed with special attention, such as sheltered or covered spaces *(2)*.

Pay-Per-Use Parking
Pay-per-use parking (PPUP) refers to a type of parking program in which the parking fee of a vehicle is charged in proportion to the time spent in a parking space. Parking charges can be varied according to the length of parking time, time of day, and day of week. Pay-per-use parking programs can be used as an incentive for not driving to campus on a daily basis. Users pay only for days they park on campus, and they can save money on vacation days, sick days, personal holidays, or days when commuting via an alternate method. Users swipe their university ID card to access the garage, and parking charges are deducted from each paycheck *(57)*.

There are several forms of PPUP program implementations. Gated parking facilities are probably the most popular form of pay-per-use parking implementations. The drivers receive a ticket upon entering the parking area and are charged when exiting the parking facility based on the time that their car stayed within the facility. Texas A&M uses this implementation in two of its parking garages, mainly for visitor parking *(60)*.

Pre-paid parking is another form of pay-per-use parking programs. Parking meters are examples of this implementation. Recently, pay-and-display and pay-by-space machines, as shown in Figure 10, have become popular alternatives to parking meters. Customers must pay for the amount of time they are planning to park their vehicle in the parking lot. Pay-and-display machines produce a ticket that must be displayed on the dashboard, windscreen, or passenger window of the vehicle. Pay-by-space machines update the parking enforcement system, including handheld devices of parking enforcement patrol, when a purchase is made. Visitor parking spaces at the Texas A&M Northgate garage and parking lot 72 are equipped with these machines.

Figure 10. Left: Pay-per-spot machine at TAMU; Right: Pay-and-display machine at UW-Seattle.

University of Wisconsin-Madison uses a new form of PPUP. Users receive and install a "pay-as-you-use" device inside their cars. The device automatically functions in designated parking spaces. The parking fee is electronically charged to the drivers. It charges higher parking rates at peak periods or rewards drivers using a parking lot at off-peak periods. Toor and Havlick state that these devices make the parking system more equitable because they charge parking fees based on actual parking times *(2)*.

Occasional Parking

Occasional parking aims to address the needs of students and campus employees who mainly use alternative modes but sometimes have to use an automobile for certain purposes. An occasional parking program provides daily parking permits at a discounted rate to users who do not use any

regular parking permit. A variety of occasional parking programs have been implemented successfully in several university campuses in the United States.

MIT issues the "Occasional/Evening Parking Permit" to allow use of parking spaces at a daily parking rate up to eight times a month for unexpected events. A higher fee is charged to people who park more than eight times a month. Unlimited parking is allowed after-hours and on weekends and holidays *(61)*.

The University of Washington has initiated discounted "Individual Commuter Tickets" (ICTs) as an occasional parking program *(2)*. It allows parking on campus for campus employees who need a car and cannot use a commute alternative mode. ICTs can be used an average of twice a week. ICTs provide extra flexibility to anyone who needs occasional parking on campus *(62)*. Virginia Tech provides occasional parking permits to students, staff, and faculty who participate in the "Commuter Alternative Program" (CAP). CAP has two different programs, including a carpool program and a bike, bus, and walk (BB&W) program. The carpool program allows students, faculty, and staff to have five free daily parking permits for each person per semester. The BB&W program provides fifteen free daily parking permits per semester. In both cases, additional daily parking permits are available for purchase *(59)*.

Planning and Implementation

A successful sustainable campus transportation system begins with progressive and comprehensive planning that integrates planning and provision for campus activities and growth with transportation planning. Similar to other planning strategies, it is very important not only to have a plan but also to establish effective planning processes and implementation strategies.

Comprehensive Transportation Plan

Conventional transportation planning is inclined to underrate many benefits of a more diverse transportation system, including transit and non-motorized travel modes. However, a comprehensive transportation planning framework is necessary because transportation-related decisions have a wide range of impacts.

A comprehensive transportation plan considers additional costs and derived traffic volume resulting from roadway construction and improvement, and additional benefits of TDM strategies that improve mode choices and increase efficiency of existing capacity *(51)*. Such a plan can provide mobility and support transportation needs on and around a campus. It also should provide access to campus while maintaining the environment and minimizing financial burden on the system and users. Therefore, a comprehensive planning practice identifies and recommends prioritized parking facility, transit, bicycle, pedestrian, and TDM programs for students, faculty and staff, and visitors *(2)*.

A study by Daggett and Gutkowski found that the majority of campus master plans take into account parking facilities, pedestrian network, and traffic circulation; however, most plans do not consider transit and biking modes *(63)*. A comprehensive campus plan helps to establish transportation goals and objectives; identify transportation needs and facilities; and develop programs, incentives, and organizational and personnel structures *(2)*.

Performance-Based Planning

Performance-based transportation planning (PBTP) combines the transportation services quality measurement as perceived by system operators and users and transportation systems' broader impacts on society and the environment. It utilizes measures affecting the economic, social, and environmental impacts of transportation systems as well as the measurement of the quality of transportation services. PBTP makes an increased emphasis on the quality of service provided to users or "customers" of the transportation system *(64)*.

PBTP is shaped based on two elementary concepts. The first is the growing awareness of the effectiveness and the efficiency of transportation services. Effectiveness is defined in relation to what a transportation system delivers to the customer; providing mobility for all citizens or access to economic activities are examples of effectiveness *(65)*. The second fundamental concept of PBTP is the measurement of external effects, such as the impact of transportation construction and operation on the environment (e.g., air quality and noise level) and society (e.g., dislocation of households and businesses).

The major characteristics of PBTP are as follows *(66)*.

- Policy goals must express the system operator's achievement to support PBTP's mandate.
- Objectives must describe more specific statements to assess the progress toward goals.
- Performance measures must be established based on goals and objectives.
- Appropriate data collection methods and analytical tools are required to evaluate alternative strategies.
- Monitoring and feedback are essential elements in the PBTP process.

Transportation service providers must be realistic and pragmatic about how to monitor and report the contribution of their activities towards broad societal objectives such as economic development, livability, or environmental quality. They need to improve the linkage between their system goals, policies, and actions at different levels of aggregation. PBTP should include performance measures that are broad enough to be used in system planning and more specific measures that can be used to select and prioritize specific projects or programs. A transportation service provider such as a university's transportation services can use a relatively small set of core measures for executive-level decision-making, supplemented by related but more specific and disaggregate secondary measures intended to support decision-making at the program or service delivery levels *(65)*.

Car-Free Planning and Vehicle Restriction

Car-free planning refers to planning and developing areas where it is essential to use private vehicles and it is necessary to restrict vehicle traffic. It is mainly intended to minimize private vehicle uses in certain areas or places. Vehicle restriction can be implemented for a specific time period or a whole day. Sometimes, some types of vehicle uses are exceptional, including delivery vehicles and vehicles for the disabled. Car-free planning can be carried out as follows *(51)*.

1) in residential communities where residents are discouraged from car ownership,

2) in pedestrian-oriented commercial districts where driving is restricted,

3) through car-free days and events, and

4) through temporary restrictions on driving during air pollution emergencies or a sporting event.

Comprehensive car-free planning has a number of effects: more livable community, congestion reduction, cost savings related to transportation facilities, reduced air pollution, enhanced safety, increased consumer savings and travel modes, increased land use access, and increased local economic development. Benefits are variable depending on how it is put into practice. Programs that are effective in a small area or for a certain time period produce moderate impacts, such as temporary traffic movement to another place and time period. On the other hand, comprehensive car-free planning integrated with other TDM strategies such as parking management programs have significant effects *(51)*.

Institutional Reform

Current transportation planning and practices conducted by most transportation agencies including university transportation services tend to be biased toward capacity expansion rather than TDM strategies. They are not suitable to promote TDM strategies, especially in terms of financial incentives and marketing.

Institutional reforms indicate improvements by changing the policies and practices of transportation organizations for achieving TDM objectives. They include diversifying transportation alternatives in the planning process and changing the methods of problem definition and assessment of solutions. Institutional reforms often call for legislative or administrative actions. They encompass goals, objectives and policies supporting TDM, a TDM program or office, a financial plan, education and training, and overcoming problems *(51)*.

Institutional reforms can advocate goals and objectives of TDM strategies. They can help campus transportation services to increase the range of transportation solutions and alternatives. In addition, institutional reform enables them to practice more efficient and accountable management and equitable resource distribution. *(51)*.

One of the major challenges for institutional reform is that university transportation systems do not usually consider SOV traffic to and on campus as a problem. This view of SOV traffic leads to a commitment to provide service to this mode at the expense of more efficient alternative transportation modes. Achieving a successful TDM program requires that the university organization as a whole supports TDM objectives, most importantly discouraging automobile use to and on the campus.

Improved Multi-Modal Connectivity

Conventional street design has not been friendly to non-motorized travel modes, including walking and biking. Some campuses have endeavored to use innovative designs to accommodate various transportation modes and improve multi-modal connectivity. Campus streets with low traffic volume provide better opportunities to serve all transportation modes and enhance multi-modal connectivity. Some streets on and around campuses can be improved to allow diverse

modes to share the same corridor, while decreasing speeds and giving priority to pedestrians *(67)*.

Multi-modal connectivity can be found in the transportation plan chapter of the campus master plan of University of Colorado at Boulder (UCB). A goal is set up stating that the campus should create well-designed, multi-modal streets in the desired campus setting. In addition, specific guidelines can be summarized as follows *(67)*.

1) Enhance crosswalks with multi-modal design characteristics, including raised or textured pavement or meandering routes, to reduce speeds.

2) Prioritize walking and biking modes in multi-modal areas.

3) Improve street furnishings, trees, pavement materials, and lighting.

4) Locate sufficient bicycle parking spaces along multi-modal streets.

Land Use and Surrounding Community

Housing

Land use and transportation are connected with each other in many ways. Campus transportation strategies must take housing on and around campus into consideration. In general, housing development on and around campus is considered desirable for TDM objectives. Students, staff, and faculty who live on or near campus are more likely to take advantage of alternative travel modes, including walking, biking, and public transit. Total distance of vehicle travel and total number of trips would be reduced significantly, even if they chose to drive automobiles.

In reality, however, many campus transportation service users reside far beyond a half-mile of walking distance, far beyond two miles of biking distance, or even farther, where transit is not available. Different strategies can be utilized to mitigate this problem.

An effective solution is to supply a sufficient amount of housing on and around campus and to enhance connectivity between residential areas and multimodal facilities on campus *(2)*. Stanford University provides on-campus housing for nearly 50 percent of faculty, 60 percent of graduate students, and all undergraduate students. Faculty housing is provided in the form of long-term leases. University of California at Davis is planning to start a similar program for their faculty members. A new residential area has been planned to be built on the west side of the campus. The houses will be available to faculty as long-term leases. In addition to transit service to this area, it will be connected to the university's bike network.

Universities can also establish Employer Assisted Housing (EAH) programs to indirectly impact their surrounding communities. Although the main objective of EAH services is to provide affordable housing for employees, it can also be used to support sustainability objectives of university campuses. EAH programs provide faculty/staff members with the opportunity to live near their work. They also strengthen the neighborhoods surrounding the university. EAH services can include help in locating affordable housing, credit counseling, closing costs, and down payment assistance in the form of interest-free and forgivable loans, as well as rent-to-buy options and loan guarantees *(68)*.

The University of Chicago (U of C) launched its EAH program in 2003 to promote investment in targeted redeveloping neighborhoods surrounding the university. The U of C's EAH program provides homebuyer assistance in the form of interest-free forgivable loans, as well as credit and homebuyer counseling services. In 2006, the U of C started a $1 million nonprofit loan fund to preserve rental housing. Through this fund, the university provides low-interest loans for rental property owners to rehabilitate buildings in the EAH program's target areas *(69)*.

On-Campus Amenities

In addition to housing, campus TDM strategies need to consider on-campus amenities. On-campus amenities for achieving TDM goals and objectives encompass recreational facilities, laundry, cafeterias, and conference rooms. These amenities should be planned and organized effectively for achieving self-sufficiency on campus. This strategy can encourage people to use alternative modes on campus and to minimize automobile trips for various activities outside campus.

The Google campus, or Googleplex, is a good example in this regard. It is the company headquarters for Google, Inc., located in Mountain View, California. The Google campus accommodates some essential components that define a Google workspace. Recreation facilities include a workout room, locker rooms, laundry rooms, a massage room, assorted video games, foosball, ping pong, and so on. Other facilities include eleven cafeterias, snack rooms, a 24-hour doughnut shop, and an on-site dentist *(70)*.

Geographic Information System (GIS)-Based Decision-Making

GIS is a system incorporating the data input, data management and analysis, and data output. The most important objective of GIS is to help spatial decisions made in effective and reasonable ways. Decision-making typically involves a number of feasible alternatives, a variety of people and interests groups with different preferences, and uncertainty and imprecision, which make it hard to predict its consequence. In this regard, almost all decisions are made based on multiple evaluation criteria resulting from various and conflicting individuals and interest groups. These characteristics lead spatial decision issues to a GIS-based decision-making approach *(71)*.

Examples of GIS-based decisions in the context of campus transportation planning include selecting pedestrian and bike facilities, providing real-time transit information, and selecting transit stops for new transit systems. Transportation services at Stanford University has implemented a GIS-based database containing local and regional transit services, local bike routes, and their students and faculty/staff members' residence data. This database is used in the university's transportation policy-making and also to identify the target audience of transportation alternatives. Figure 11 shows a map produced from Stanford's GIS system of commuting students and employees.

Figure 11. GIS map showing commuting students and employees at Stanford University.

Traffic Calming and Roundabouts

Traffic calming involves implementing various strategies and design practices to decrease traffic speeds and volume on a certain roadway. It encompasses both minor changes of a street and complete redesign of a street network. Some desired effects can be obtained by implementing traffic calming, including a decrease in vehicle speeds and volume. It also tends to improve safety and diminish noise level. By reducing vehicle speeds and encouraging walking, biking, and transit use, it results in a decrease in vehicle miles traveled (VMT) *(51)*.

A roundabout is a type of road intersection where vehicles enter a one-way traffic flow along a circular way around a center. Compared to signalized junctions, roundabouts lead to more effective traffic movement, reduction in air pollution, safety enhancement, and cost-efficient operation based on non-electricity. A 2-lane street with roundabouts is frequently more efficient than a 4-lane street with traffic signals because roundabouts allow vehicles to keep moving *(72)*. To improve safety and keep consistency, roundabouts should be designed to follow modern roundabout principles *(51)*.

Incentives

Guaranteed Ride Home

Guaranteed ride home (GRH) programs give an instant ride in case of an emergency to individuals who use alternative travel modes. GRH programs work if a bike user has to rush into

an emergency room, or if a bus rider has to stay late for work. In order to provide a solution for these unexpected situations, GRH programs offer taxies, company vehicles, or rental cars for free or with a low payment. The total cost of GRH programs tends to be modest due to their occasional uses *(2, 51)*.

At Pennsylvania State University, all people participating in the rideshare program are registered in a GRH program at the same time. A free ride is provided to participants using a rental car or taxi in an emergency case in the GRH program *(51)*. Virginia Tech also offers a free emergency ride home to carpool program participants *(59)*.

On-Campus Rental Car

On-campus rental car programs serve staff and students who either do not have autos or do not bring them to campus for some reason. The concept of this program is to provide a vehicle to the participants through a rental program. The participants can have the advantage of having a car without paying the fixed costs. In addition, they are less likely to use rental cars and reduce trips because of limited time schedule for using cars and payment rates being proportional to vehicle uses. In this way, the institutions can reduce the required parking spaces for a number of private cars on campuses *(2)*.

There are several ways to implement this program. For instance, a campus can contract with a rental company, and students and staff can lease automobiles picked up on campus. The private agency can have high visibility to a number of potential users. A rental car program at Stanford University provides cars to students and faculty/staff members who are 18 years or older on the condition that they must be covered by their own insurance. The program offers 12 free hourly car rentals for commuter club members *(56)*.

Zipcar® is another rental car service that is currently used on university campuses. Zipcar is a 24-hour, self-service, membership-based car rental service providing hourly and daily automobile rental to its members. The rental fees cover gas, parking, insurance, and maintenance. Zipcar currently provides its services to more than 30 universities and has more than 20,000 active students, faculty, and staff members. Zipcar typically offers a discount on the annual membership fee for members from partner institutions. This service offers an affordable transportation alternative to students aged 18 and higher *(73)*.

Commuter Club

Commuter club refers to programs that urge faculty, staff, and students to use alternative transportation modes, such as transit, carpools, and vanpools, instead of SOVs, while providing the participants with financial and institutional advantages. It can be expected that successful commuter club programs reduce congestion and traffic volume generated to and from campuses and increase alternative transportation mode choices. Like most TDM strategies, commuter club programs become successful with an increase in availability of alternative travel modes *(2)*.

The commute club program at Stanford University provides both financial and institutional benefits to those who join the club and do not purchase a parking permit on campus. Incentives include up to $234 a year in clean air cash or carpool credits, reserved parking spaces for all carpools and vanpools, complimentary daily parking passes for carpoolers, vanpool subsides, online ridematching services, and so on *(56)*. The University of Denver commute club also

encourages university employees to commute by alternative modes at least once a week. After agreeing to the program, commuter club members need to give their travel information and have a chance to win prizes such as travel packages at the end of the month *(74)*.

Flexible Work Arrangement

Flexible work arrangement, or flextime, implies that people may have some flexible daily work schedules. Regular work time, 8:00 a.m. to 4:30 p.m., can be rescheduled to different time periods, such as 7:30 to 4:00 for some and 9:00 to 5:30 for others, based on circumstances. The flexible work time can be different on a daily, weekly, or monthly basis *(51)*.

Flextime produces some positive effects, including reduced congestion during the peak time and increased alternative travel modes such as share-ride and transit. Picado (2000) explains that flexible work schedule programs help people to reduce 7 minutes from their commute time on average a day *(75)*. Flextime, however, is unlikely to make other programs such as carpooling and vanpooling viable, although it may decrease the number of trips to and from campus during the peak period *(2)*.

Telecommuting

Telecommuting is a type of telework program that can be well implemented on a campus by using telecommucations, such as email, website, telephone, and video connections *(51)*. Telecommuting aims at making fewer commute trips and thus reducing congestion by allowing people to work at home or places close to the home. It can also encourage students to take off-campus telecommunication classes that use real-time and interactive communication between the lecturer and students. This program can be implemented on a regular basis, i.e., one or two days a week. It has been argued that telecommuting programs can increase job satisfaction and productivity by minimizing inconvenience and stresses related to daily commute travel and interaction with other colleagues in the office *(2)*.

It is claimed that teleworking, including telecommuting, decreases commute trips by 40 percent if workers join teleworking programs two days a week. In addition, it can result in much less VMT because this program is very appealing to long-distance commuters. It is expected that a 10 percent reduction of total commute trips may lead to a 15 percent reduction in total VMT of long-distance commuters who participate in the program *(51)*.

Financial Incentives

Financial incentives encourage people to take alternative travel modes by giving them financial benefits in the form of tax benefits or direct payments.

Pre-tax transportation expense allocations and tax-free transportation benefits are the most popular forms of financial incentives. The Commuter Choice Program established by the U.S. Department of Transportation and U.S. Environmental Protection Agency is an example of the tax-free transportation benefits. This initiative is intended to promote employers to prepare various travel choices for their employees. The program permits the employers to offer tax-free benefits to their employees who commute to work by alternative transportation modes (other than single-occupancy vehicles). Participant employees do not pay Federal Insurance Contributions Act (FICA) or federal and state income taxes on the benefits *(76)*.

Accor Services USA provides support to its Commuter Choice Program by offering a commuter benefits program called Commuter Check Benefit Solutions. This program is designed to increase alternative transportation modes by offering tax incentives that save commuting costs for employees and payroll taxes for employers *(77)*.

Commuter Check Benefit Solutions encourages companies or employers to offer pre-tax deductions or subsidies for transit, vanpool, and parking expenses that employees pay for commuting. This program can help employees save up to 40 percent of monthly commuting costs and employers save around 8 percent on payroll taxes. Currently, more than 10,000 companies, including different sizes and types of businesses, participate in the program and distribute commuter checks or redeemable vouchers to over 300,000 employees each month *(77)*.

Education, Information, and Marketing

Continuous Marketing and Outreach

Marketing plays a significant role in TDM strategies and programs. One of the most important objectives of TDM strategies is to encourage people to change their travel behaviors and to take alternative transportation modes. In this sense, marketing programs promote drivers to shift from SOVs to transit, carpool, or walking and biking modes. In the long run, continuous marketing programs, when combined with available alternative modes, stimulate people to change their travel behaviors significantly *(2)*.

There are a wide variety of programs offered in terms of marketing strategies. Successful programs include transportation fairs and displays, biking and walking days, support groups for transit, alternative transportation guides, and emails informing people of travel modes available near their homes *(2)*. TDM marketing programs should be continuous so they can provide continual support and encouragement, and respond to future opportunities and changes in individuals' travel needs and preferences *(51)*.

It is claimed that continuous marketing programs lead to an increase in alternative mode choices by 10 to 25 percent as well as a decrease in SOVs by 5 to 15 percent, as with other TDM strategies and available alternative modes. It was found that the TravelSmart campaign in Australia had significant effects similar to those of alternative modes' infrastructure improvement projects *(51)*. TravelSmart is a travel behavior change program that has been implemented by the state government of Victoria, Australia, to decrease vehicle travel and encourage people to use alternative travel modes. The program focuses on developing travel plans for transportation system customers. A travel plan is a simple document outlining place-specific actions to promote the use of alternative travel modes *(78)*.

Stanford University is progressively using TDM marketing as an integral part of its transportation services. This progressive TDM marketing program is considered the main cause of a 17 percent decrease in drive-alone mode at Stanford University between 2002 and 2006. The program consists of three components: user education, alternative transportation promotion, and service evaluation. The goal of the user education component is to inform people about available alternative transportation services and benefits of using these alternatives. This is achieved through special events, university fairs, and new employee orientation.

The promotion component carries the main weight of the TDM marketing program. A variety of strategies are used to continuously promote non-drive-alone transportation modes; informative brochures and guides, bi-annual postcards, poster campaigns, bus advertisements, and targeted email and mail campaigns are examples of these strategies, as shown in Figure 12. To deliver the promotional messages, the university also uses known public figures and local public media to reach a broader audience.

Finally, the evaluation component is used to monitor the service performance and users' needs. An annual commute survey, bus ridership counts, and phone surveys are some of the evaluation methods that the Stanford TDM marketing program is using.

Multi-Modal Access Guide

A multi-modal access guide or a transportation access guide gives helpful information on how many transportation modes are accessible and available in order to arrive at particular places. In particular, it focuses on efficient alternative modes, including walking, biking, and transit. The guide can have a variety of documents, e.g., a simple map, brochure, pamphlet, webpage, and information booklet. It can also be included as a section in other documents. The guide needs to take into account various types of people, including visitors, staff, students, and people with disabilities *(51)*.

It is generally expected that people are more likely to take alternative travel modes and decrease automobile trips if they are given suitable travel information through this guide *(51)*. It has been argued that a good access guide should promote automobile commuters to take alternative travel modes, such as transit, walking, and biking *(79)*.

Educate Faculty, Staff, and Students

Education is the main purpose of higher education institutes. Universities and colleges have a unique role in shaping our future. Higher education influence reaches beyond campuses. Each year, more than 14 million people get an education at U.S. colleges and universities. These are the future citizens and leaders of our society. By providing people with education on sustainability and environmental issues, we hope that they will carry the experiences and behaviors into the real world. College and university campuses are ideal places to communicate sustainability and help reshape society's transportation patterns.

The first step of the process toward sustainability begins with an awakening to emerging problems caused by our current norms of behavior (both institutional and personal). Education is probably the most effective way to achieve this awakening.

<u>Voluntary Travel Behavior Change Programs</u>

Voluntary travel behavior change (VTBC) programs help people change their travel behavior to improve their quality of life in several ways. VTBC programs are designed to make individual mode choice without any type of regulations or external compulsion *(80)*. These programs educate and encourage individuals to reduce automobile driving trips so that desired level of social equity and environmental quality and reduction in greenhouse gases as well as provision of transit services in suburban areas can be accomplished *(81)*.

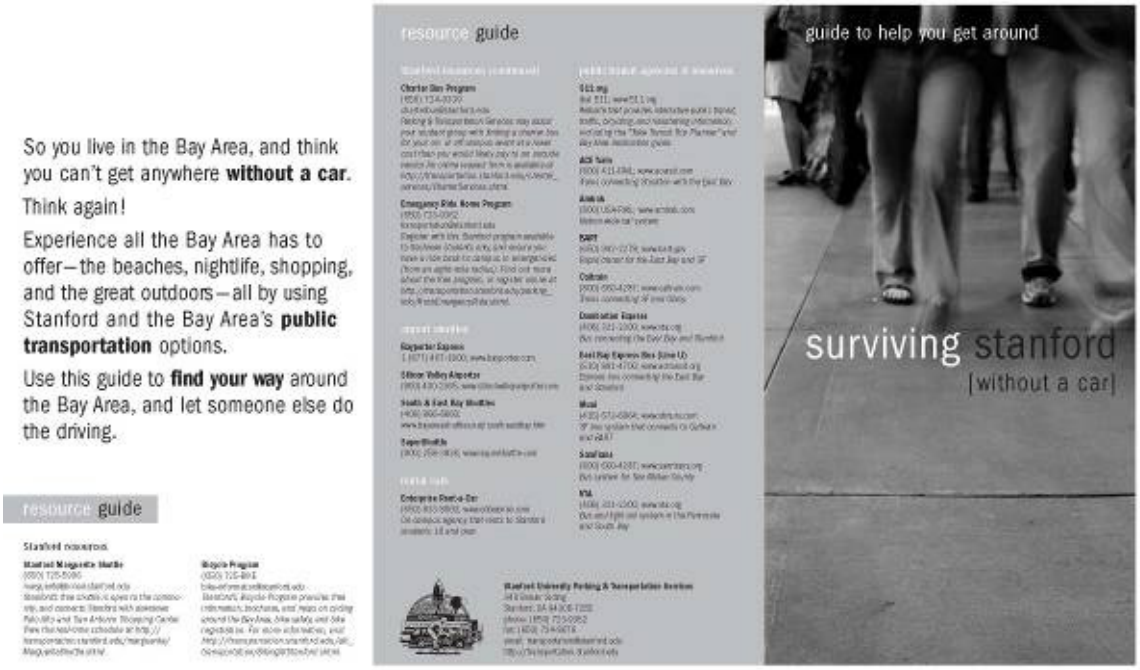

Figure 12. Examples of promotion materials used at Stanford University. Top: Surviving Stanford without a car; Bottom: A poster promoting biking for commuting.

VTBC programs have many positive effects on the following areas: economic development, environmental quality, quality of life, public transit, safety and security, and social equity. The programs promote economic development through reduced congestion and improved mobility; improve environmental quality through reductions in air pollution; increase individual well-being through an increase in non-motorized travels and in public health and social interaction, and a reduction in transportation-related land use, such as large parking spaces and road expansion; improve ridership of public transportation; enhance safety and security through an improved pedestrian network and reduced traffic accidents; and improve social equity through an increase in public and non-motorized transportation modes and self-esteem and satisfaction *(81)*.

Greening Curriculum (Environmental Literacy)

It is generally agreed that a campus can play an important role in educating students and developing expertise. Environmental literacy programs have been established to provide expertise in environmental and social sustainability to the public on campus. These programs incorporate some related courses with action-based interdisciplinary learning experiences. Two objectives become clear in this education program: to provide the skills to improve current status of environment and communities and to prepare a decent foundation for applying new ideas and innovations. It is expected that people can collaborate on various works and establish partnerships with each other to carry out the programs after they have participated in educational opportunities about sustainability *(82)*.

It is necessary to incorporate educational opportunities into institutional processes, including orientation and training programs, and integrate them into the general curriculum. Environmental literacy courses have been initiated by a number of campuses, including Brown University (Environmental Stewardship Practicum), University of Virginia (Energy Star Building Analysis and Design), University of Wisconsin-Madison (Environmental Studies Certificate Program Capstone), and Rice University (Assessment of Rice University as an Environmental System) *(82)*.

Real-time Transit Information

A real-time transit information system provides transit users with information about how a transit system is currently operating; thus it can help people make efficient and confident plans regarding their transit travel and encourage people to take alternative transportation modes.

Stanford University provides Marguerite (Stanford's free public shuttle system) real-time schedule and interactive shuttle map services based on wireless communication infrastructure. This automated bus tracking system uses global positional system (GPS) equipment to make real-time shuttle data available on the website. The information includes current shuttle locations, departure times, and shuttle routes. People are allowed to check out the webpage for real-time shuttle information, including arrival and departure times and the status of the buses. These services can also be accessed by PDA or low bandwidth users *(58)*.

STRATEGIES FOR EMISSIONS REDUCTION

The strategies discussed in previous sections focus mainly on improving mobility on and around university and college campuses. This section discusses strategies targeting the environmental impact of campus transportation systems. These options may not necessarily affect the mobility

on and around a campus; however, they can potentially provide significant environmental and health benefits.

Emission Fees

Emission fees are intended to impose costs for air pollution, noise, and water contamination. They tend to urge drivers to reduce emissions to a certain level by charging disincentives *(83)*. Emission fees have two synergy effects. First, they encourage people who drive high-pollution vehicles to decrease their VMT. At the same time, these charges provide drivers with enough motivation to change to low-pollution vehicles.

The conventional method for estimating emission fees is to charge them based on travel miles while considering average emission rates for each vehicle category. Estimates are updated with vehicle tests and roadside pollution sensors on a regular basis *(84)*. An advanced method is to take advantage of electronic sensors to estimate actual tailpipe emissions *(51)*.

Researchers suggest that emission fees range from 0.5¢ to 10¢ per vehicle mile in terms of air pollution costs *(85)*. It is also argued that these fees have a significant effect on emission reductions; however, they lead to a relatively low and modest benefit on travel mile reductions (*51*).

Promoting Low-Emission Vehicle Purchase

Low-emission vehicle purchases can grow if appropriate information and promotions are given to consumers and fleet managers. Based on federal law, consumers must be notified of fuel efficiency ratings and information, which then helps people choose more energy-efficient and lower-emission vehicles *(51)*.

Institutions and private companies can provide many types of incentives to their employees in order to encourage them to be more environmentally friendly. Topics Entertainment Inc., in Washington, has established an incentive program that offers its employees $1,000 to trade in their automobiles for ones with fewer cylinders in the engine, or $2,500 to buy a hybrid or biodiesel vehicle. Clif Bar & Co. of California offers a forgivable loan of $5,000 to employees who buy vehicles that get at least 40 miles per gallon. Employees don't have to pay back any of the money if they stay with the company for five years *(86)*.

Gas Guzzler Fee

The gas guzzler fee is a special fee charged to people who purchase new gas guzzler vehicles such as SUVs and pickup trucks. This program intends to take the fuel efficiency rates of these types of vehicles into account. Specifically, it aims at deterring consumers from buying inefficient vehicles in terms of fuel economy, such as SUVs and pickup trucks, by imposing an additional fee to their price. In addition, it encourages car makers to develop and produce more fuel-efficient vehicles *(87, 88)*.

A gas guzzler fee can be established as part of a parking management strategy. When issuing a parking permit, university transportation and parking services usually collect vehicle information data. These data can be used to establish a permit pricing schedule based on fuel consumption and EPA emissions ratings of vehicles. This requires that parking permits be issued to vehicles rather than individuals, as is the case at TAMU.

A vehicle-based parking permit program gives universities the necessary flexibility for programs focusing on fuel efficiency and air quality. The vehicle data can be used to establish initiatives, set goals, and define performance measures to monitor the progress of those programs.

Incentives for Alternative Fuel Vehicles

A number of research projects and marketing programs have been conducted to develop alternative fuel vehicles with higher fuel-efficiency and promote their use. There are various strategies and incentives for encouraging the use of alternative fuel vehicles *(89)*. These include reduction in tax rates of both alternative fuels and vehicles using these types of fuels, granting of government subsidies for these types of fuels and vehicles, purchases of government fleet using alternative fuels, supply of infrastructure such as refueling stations, and various types of promotion and marketing campaigns *(51)*.

There are a number of factors affecting emission reduction of alternative fuel vehicles: fuel type, engine type, fuel production system, and consideration of full lifecycle emissions *(90)*. Some studies have suggested that alternative fuels may decrease some types of emissions; however, some types of pollutions increased and total reduction effects were not significant in many cases *(51, 91, 92)*.

College and university campuses can offer a variety of incentives to support people who buy low/zero-emission vehicles. These incentives can include cash incentives, zero percent and forgivable loans, preferred parking permits, and discounted parking permits. The campus transportation services can make a list of approved vehicles or set criteria for vehicles to qualify for the incentives.

Emission Caps and Trading

Emission caps refer to the maximum amount of emission production in a certain boundary for a certain time period. Emission caps are intended to control the total amount of air pollution generated in an area in order to improve air quality as a whole. On the other hand, emission trading indicates a market system where pollution rights are allowed to be traded and reallocated within a designated area *(93)*.

Emission trading is a market-oriented strategy to internalize the negative external effects resulting from air pollution. For instance, if there are ten manufacturers in an area and they are assigned ten maximum tons of emission production per year, then the companies that are able to reduce emissions below the limit are allowed to sell their pollution rights with lower costs to others that do not meet the standard. The emission trading strategy can work effectively where there are a few emitters; however, it was claimed that the impact of current emission trading practices is not significant for the reduction of emissions related to transportation modes *(51)*.

Roadside "High Emitter" Identification

The roadside "high emitter" identification system is an advanced system that can identify and measure the emission levels discharged from on-road vehicles using electronic sensors installed along the roadside. This system can be introduced to encourage drivers to reduce emission rates voluntarily or to force people to repair high-emission vehicles to meet the legal standards *(51)*.

For example, the fuel efficiency automobile test (FEAT) is a set of devices that can measure tailpipe emission rates from running vehicles on the road using a remote sensor. FEAT has initiated a vehicle emissions information system combining roadway message signs with the emissions identification system using an electronic sensor. This system is aimed at presenting information of on-road vehicle emission rates to drivers using a variable message sign. The Smart Sign was introduced in Denver, Colorado, from May 1995 to August 1996 as an Federal Highway Administration (FHWA) Intelligent Transportation System operational test *(94)*.

University campuses can use these technologies in combination with a vehicle-based parking registration system in order to identify the high-emitter vehicles on their campus. These identified high-emitter vehicles can be fined or issued a notice. The system can give these vehicles a period of time to provide proof of repair in order to remove the notice or waive the fines.

Driver Training (EcoDriving)

Driver training programs provide driving skills and maintenance techniques to improve air quality and fuel efficiency of current automobiles. EcoDriving, for example, indicates the driving pattern that is more fuel-efficient, environment-friendly, and accident-free. EcoDriving programs are designed and implemented in order to reduce fuel consumption, air pollutant emissions, and traffic accident rates. These programs aim at providing benefits for drivers of all types of vehicles. For instance, they educate drivers to change gears at low speeds and anticipate traffic flow by looking ahead.

Many European countries have provided EcoDriving programs as a part of their training system. In Britain, familiarity with EcoDriving skills are required in order to pass a driver's license test. An EcoDriving program in Sweden promoted environment-friendly driving skills for conserving energy. This program was evaluated to improve vehicle fuel efficiency by 10 to 15 percent *(51, 95)*. EcoDriving programs help address some concerns related to the transportation sector, including energy efficiency, global climate change, air pollution, and road safety.

Speed Management

Vehicle fuel efficiency (miles per gallon) decreases and per-mile emission rates increase as vehicle speeds exceed 55 miles per hour. Vehicle fuel efficiency diminishes about 1 percent as vehicle speed increases by 1 mile per hour above 55 mph. It is argued that appropriate speed management and control programs result in reducing energy consumption and emission rates significantly *(51)*.

Speed management has two positive effects in general: improving fuel efficiency and reducing emission rates. It is also necessary to understand driving behavior, which significantly affects the benefits of speed management and control programs. Drivers manage a speed while considering the roadway design and use; therefore, it may not be effective to simply post lower speed limits. Traffic speed management strategies that take these factors into account can produce additional benefits in terms of safety in urban areas, specifically in decreases in traffic accidents and their severity. The movement of traffic volumes to other areas as a result of speed management and control programs could cancel the magnitude of these effects.

Campus Fleet Management

University campuses usually operate and maintain a fleet of vehicles to support different tasks around their campuses. While strategies targeting campus fleet vehicles usually do not mitigate parking and traffic congestion on and around the campus, they can improve air quality and decrease energy consumption.

Best management practices, including inspections and maintenance, can improve vehicle performance and efficiency. These practices are effective for managing large vehicle fleets that are operated by a freight company, a bus company, or a campus *(51)*. In this sense, campus fleet management aims at maximizing vehicle performance and increasing effectiveness and efficiency of vehicle operation. Buses, vans, and other vehicles that are owned by a campus can be taken into consideration in campus fleet management practices.

The Energy Environment Excellence Fleet (E3 Fleet) is a Canadian fleet management system focusing on assisting fleet owners and operators with increasing fuel efficiency, reducing emissions though expense management, incorporating new technologies, and using alternative fuels *(51)*. E3 Fleet provides fleet review, fleet rating, custom fleet consulting, and other resources for fleet management *(96)*.

The fleet review service provided by E3 Fleet is a comprehensive analysis of emission, fuel, and operational performance of a fleet. It contains detailed reviews of emissions and fuel performance, vehicle utilization and availability, a capital asset profile, an operational profile, exception reports identifying underutilized vehicles, the implications for vehicle replacement, and fleet performance comparisons with benchmarks. The fleet rating service assesses fleet performance using a point-based rating system checklist and categorizes the performance into three levels, i.e., bronze, silver, or gold. In addition, the custom fleet consulting service is designed to provide advice on how to achieve a green fleet. This service also provides lifecycle analysis of fleet assets, vehicle replacement strategies, emission and fuel efficiency scenarios, and green fleet action plans.

Alternative Fuel Vehicles

Liquefied petroleum gas (LPG), liquefied or compressed natural gas (LNG or CNG), biodiesel, ethanol, and hybrid electric vehicles are the most popular currently-available alternative fuel

technology options for transportation purposes. Hydrogen internal engines, fuel cells, electric cars, and methanol are the other available options *(2)*.

University and college fleets are a distinct market for alternative fuel vehicles because they are often centrally fueled and their operation is usually limited to the campus grounds and surrounding communities. Many universities, such as TAMU, University of Washington, and Rice University, are currently using mixes of biodiesel in their diesel-powered equipment and vehicles. B20, a mix of 20 percent biodiesel and 80 percent regular diesel, is the most popular biodiesel mix used on campuses. The University of California at Davis and Emory University, in Georgia, are using natural gas for their transit bus fleets.

At Uiniversity of California at Davis (UC Davis), nearly 17 percent of campus fleet vehicles are alternative fuel vehicles, and fleet services is committed to continue to purchase alternative fuel vehicles as 75 percent of their new light-duty vehicle acquisitions. The University of Texas-San Antonio (UTSA) uses electric utility carts to replace their fleets of trucks and vans.

Idle Reduction

Idling vehicles discharge various kinds of pollutants into the air, including CO_2, NO_x, CO, VOC, and particulate matters. They have significant impact on air pollution as a whole *(51)*.

There are many programs for idle reduction. The U.S. EPA conducted a field study to observe and report idling behavior of motor coaches in and around Washington, D.C. In general, emission reductions can be achieved when integrated with appropriate education and outreach, effective regulations and programs, and innovative funding and incentives. In addition, a national idle reduction campaign conducted by Clean School Bus USA provides drivers, transportation managers, and children with an opportunity to learn about air quality. It also promotes idle reduction as an effective measure for improving air quality, saving vehicle fuel, and protecting public health *(97)*.

The Office of Energy Efficiency (OEE) in Canada developed the Idle Free Destination program to reduce idling of motor coaches and trucks. The agency proposed three different levels of program participations from simple implementation to intensive program: idling awareness campaign, idling awareness and driver education program, and comprehensive idling reduction program *(98)*.

CHAPTER 5: TRANSIT, BIKING, AND WALKING

This chapter focuses on sustainable transportation strategies that support the most widely used alternative transportation modes: transit, biking, and walking. Suitable implementation of these modes is at the heart of a successful sustainable transportation program and is essential to achieve and maintain a sustainable campus transportation system. Also, the interaction between these modes makes them more attractive for a campus community by diversifying the travel choices.

The target population of walking mode is mostly comprised of the people who live within 1 mile or a 20-minute walking time of their work places. Bicycle mode extends this range to a few miles, and transit provides service to people beyond easy walking and biking distance *(2)*. A well-implemented transit service enables bikers and pedestrians to extend their distance range while a bike- and pedestrian-friendly campus provides more opportunities for a successful transit system.

The strategies discussed in this chapter are divided into four major categories: infrastructure, system support, information and marketing, and incentives. A sustainable transportation program must include all these categories to exploit the potential benefits of alternative transportation modes.

TRANSIT-ORIENTED STRATEGIES

Transit programs are very important element of campus Travel Demand Menagement (TDM) programs. Schedule, route coverage, and travel time are the main factors that determined individuals' choice of transit mode. Although transit includes bus and rail transportation, the high price of a rail system makes it unfavorable for most of the universities; therefore, this document focuses on bus-based transit.

Location and geographic characteristics of a university campus are usually the main factors shaping the type of transit service required. Providing transit service to a rural campus is quite often totally different from servicing an urban campus community. Urban campuses, which are located in densely populated areas with an established public transit service, commonly provide transit service to their campus community through a special arrangement with the public transit authority servicing the community. Under this option, the university will pay for the transit service and the public transit authority provides service to the university community at a subsidized or free rate. Additionally, these contracts usually include special routes and schedules that are suitable for the campus community. The University of Washington in Seattle and Stanford University both use this type of transit service.

Rural university campuses, on the other hand, are usually located in areas where public transit either does not exist or is of poor quality. In these cases, universities are usually forced to be the main driving force (often the service provider) behind the transit service. Texas A&M and Virginia Tech use this type of campus transit system.

Regardless of the type of transit service arrangement, a transit pass is an essential part of a university transit program. A transit pass program lets students and university employees use

local and regional transit services free or at a reduced price by showing their university identification card. Transit pass programs increase the equity between car and transit and create an incentive for individuals to choose transit as their primary mode of transportation. The cost of transit pass programs is usually covered by a mandatory transit fee collected from students. Other funding sources can include general fund sources, parking revenue, and direct user fees.

Transit pass programs provide many benefits to universities. These benefits include higher equity, better relationship with the surrounding community, reduced traffic on and around the campus, increased safety, and reduced parking demand. A study by Litman and Lovegrove shows that the transit pass program at the University of British Columbia had a benefit-to-cost ratio of more than six *(99)*. Toor and Havlick (2004) provide a detailed discussion on structure and pricing issues of these programs *(2)*.

Transit pass programs by themselves increase transit ridership; however, if implemented alone, they would not reach their full potential benefits in the context of a TDM program. A pass program that is supported by a mix of other TDM strategies is far more effective in terms of transportation system performance. Strategies such as a guaranteed ride home, free carpool parking, free/discounted occasional parking, and especially increased parking prices are among the most effective strategies to increase the effectiveness of transit pass programs.

A well-designed and implemented transit also promotes other non-motorized transportation modes, i.e., walking and biking. Without transit, the mobility range of bike riders is usually limited to a short distance from campus. A transit system that is well connected with pedestrian and bike route networks increases the users of these modes.

There are numbers of infrastructure and equipment investments that universities can make to increase the transit use. Bus shelters, dedicated bus lanes, bike racks on buses and at bus stops, a transit center, and a real-time transit display are a few of these investments. Bus shelters provide a relatively comfortable and safe place for transit users while they're waiting. Bike racks on buses and at bus stops make it possible for users to combine transit use and bicycling. Real-time transit information improves the comfort of transit users by letting them know how long they need to wait. A transit center, which includes a climate-controlled waiting area and a small retail space, can potentially increase the attractiveness of transit mode.

There is a major difference between regular local/regional transit services and campus transit programs. Most of the regular transit services are designed to serve the needs of transit-dependant populations. This results in a broad-coverage and low-frequency service. Campus transit programs, on the other hand, serve communities that often have access to other means of transportation. These riders can make a choice between transit and personal car based on relative cost and attractiveness of each mode. Toor and Havlick list the characteristics that riders are looking for in a transit service as follows *(2)*:

- good coverage,
- high enough service frequencies,
- easy-to-understand bus routes,

- fast and direct routes, with a low number of transfers, and
- a pleasant experience.

Heavy investments are usually required to provide a transit service with these characteristics. It also takes a radical change in the campus and surrounding community with regards to transit and other alternative transportation modes. Alternative transportation needs to be viewed as an integral part and a major player in providing mobility to the community. A campus transit system can have its maximum impact on the community if the community treats it equal to the personal vehicle transportation option.

Marketing and information programs also play an important role in supporting campus transit services. The main mission of these programs is two-fold: 1) recruiter new riders, and 2) keep the current users by reminding them of the benefits of using transit services. Marketing campaigns are also a very effective tool to change the community perception and to build an improved image of transit and other alternative transportation modes.

Marketing programs supporting transit programs usually include clear and easy-to-understand transit riders' guides and maps, transit promotions, information kiosks, online and real-time routing and transit information, and targeting of new employees and students in their orientations.

BICYCLE-ORIENTED STRATEGIES

Young student populations living nearby give university campuses a unique opportunity to benefit from non-motorized transportation modes such as bicycling and walking. To take advantage of this opportunity, universities and their surrounding communities need to provide a safe and well-connected system for bikers and pedestrians. Innovative strategies and facilities can be utilized to further support non-motorized transportation modes and increase their share of commute trips to campus. Additionally, marketing and education play an important role in establishing a successful pedestrian and biking program on a campus.

Shifting passenger car commuters to walking and biking has numerous benefits for the community and universities. Walking and biking have lower operation and maintenance costs that the other modes. The operation cost of bicycle and pedestrian programs at the University of Washington in 2000-2001 was reported to be less than 1 percent of the total transportation budget of the university, even though these modes account for 31 percent of all the trips to campus *(100)*. Biking and walking also reduce the demand for parking spaces on campus. Each car parking space can provide parking for more than 10 bicycles. This alone directly translates to significant financial savings for universities since parking user fees are usually heavily subsidized by the universities.

Walking and biking also provide significant health benefits and improve the liveliness of the community. Pedestrians and bicyclists do not consume fossil fuels, pollute air and water, or create noise. Developing pedestrian and bicycle facilities does not usually require converting a significant amount of landscape to paved parking lots. Well-designed pedestrian and biking facilities actually promote and compliment the natural landscape of campuses.

Bicycling is a quick and inexpensive way of commuting to and getting around campus. According to Balsas, the most important factors that affect the level of bicycle use include availability of bike paths and lanes, appropriate signage, bicycle racks, and the level of cooperation between the school and the surrounding community *(3)*.

Bike paths (off-street) and lanes (on-street) are essential elements of any successful campus bicycle program. Generally, bike paths are most desirable for streets on which vehicle speeds are more than 35 mph. Bike paths and lane networks must provide connectivity between the different parts of campus in a direct and safe manner. Separation of bike path from pedestrian sidewalks will further increase their desirability and safety, especially when a route has significant pedestrian and bicycle traffic.

Proper signage is an important part of a well-designed biking network. Appropriate signage for a biking network includes route identification signs, maps, directional signs, traffic control signs, and advisory signs *(2)*. Proper signage increases the safety and efficiency of bike trips and also increases ridership by making the experience easier and safer. Some examples of bicycle-oriented signage are shown in Figure 13.

Figure 13. Examples of bicycle-oriented signage. Left: Directional signs at U Washington; Right: Traffic controls signs at U Washington (above) and UC Davis (below).

Pedestrian and bicycle overpasses and underpasses at intersections of high-traffic roads are very effective means of increasing the safety and connectivity of a biking network. Underpasses and overpasses are by far the most costly option in a pedestrian and biking program; however, they

provide significant safety benefits by decreasing the possibility of injuries to pedestrians and cyclists.

Bike parking is also an essential part of a successful campus biking program. Cyclists are more sensitive to the distance between where they park and their final destination. Bicycle parking facilities that are adjacent to the buildings are most desired by riders. Bicycle parking must also provide means of securing bicycles.

Different levels of security can be provided by different types of facilities. Bicycle lockers and storages are the most secure means of storing bikes. Figures 14 and 15 are examples of bike lockers and storages. If well designed and located, lockers and secured storage rooms provide significant incentives for transit riders to use bicycles to get around the campus.

Figure 14. Bike lockers at the University of Washington.

Figure 15. Bike storage room at Stanford University transit center.

Bike racks are the most widely used type of parking facilities and provide a relatively secure and inexpensive way to provide parking for bicycles. Providing enough bike racks is another important factor for a bicycle parking facility. Figure 16 shows a situation where an inadequate number of racks has forced students to leave their bikes outside the designated area.

Figure 16. Inadequate number of bike racks, UC Davis.

Providing showers for cyclists and pedestrians increases the desirability of biking and walking modes, specifically for those who live within medium distances (3-5 miles) from campus. Bike racks on buses and transit rails extend the range of mobility for bike riders and, therefore, increase both transit riders and cyclists. Figure 17 shows bike racks on buses servicing University of Washington and Stanford University.

Figure 17. Bike racks on buses servicing University of Washington (left) and Stanford University (right).

A full-time pedestrian and bicycle program coordinator can play a significant role in organizing and promoting a successful biking and walking program. A campus pedestrian/bike coordinator oversees and develops programs improving safety, connectivity, and percentage of walking and biking trips to/from campus. A coordinator is responsible for developing marketing and educational programs promoting biking and walking and acts as non-motorized transportation advocate within the university administrative structure, making sure that these modes receive their desired share of campus transportation resources.

Other strategies that have proven to be effective in promoting cycling to/on campus include on-campus bicycle service centers, zero/low-interest rate loans for buying bicycles, free/rental bicycles for on-campus short-term use, and promotional and marketing campaigns. On-campus bicycle service centers provide services such as making minor repairs, selling bike equipment, and renting bicycles. Figure 18 shows examples of on-campus bicycle stations.

Figure 18. On-campus bicycle service stations: University of California – Davis (left) and Stanford University (right).

Universities can also provide free bikes for short-term on-campus use. Bikes provided in this program are usually distinguished by color or other specific features. Universities can use abandoned and donated bicycles or purchase specially designed/painted bicycles for this service. This program is specifically beneficial for universities with big campuses. Mississippi State University (MSU) in Starkville, Mississippi, has implemented a free on-campus bike-sharing program. MSU's program uses specially designed and painted bicycles.

Land use and housing are also main factors that affect the non-motorized transportation modes. In general, universities that have a high percentage of students and faculty/staff members living on or in the vicinity of campus are more successful in increasing the share of non-motorized transportation. Universities can work with their surrounding communities and local development

and planning authorities to promote higher density development of student housing within the campus vicinity. Universities can also provide financial incentives to their employees to buy houses within selected areas around the campus.

PEDESTRIAN-ORIENTED STRATEGIES

Walking is the simplest form of transportation, and all other forms of transportation eventually end with walking. Walking is most appropriate for people that live within 1 mile from campus. Distance, safety, and convenient access are the most important factors determining a person's choice to walk. Walking pedestrians are also sensitive to the aesthetic characteristics of the environment.

Similar to biking mode, land use and housing significantly affect the percentage of people walking to and around a campus. Universities that have higher percentage of their students and employees living within 1 mile of campus also have a high percentage of pedestrian traffic. Each campus expansion plan should consider proximity to student housing as one of the decision factors. Joint planning with surrounding communities is an important factor in providing a successful pedestrian program.

Well-designed and well-connected walkways and sidewalks are an essential part of a pedestrian-friendly campus. Connectivity of a pedestrian network should be given a high priority in campus planning. Sidewalks should be wide enough to accommodate safe pedestrian traffic movement. Sidewalks and crossing sections should be well-illuminated to provide a safe environment at night. Adequate signage and signalization also improve safety for pedestrians, as is the case for cyclists.

Any conflict with motorized traffic discourages many people from walking. Crossing parking lots, which are usually located on the edge of campus, is not a safe and pleasant option for pedestrians and discourages people from walking. Vehicle traffic in parking lots produces great danger to pedestrians.

Motorist must clearly understand that pedestrians have the priority at stop signs and traffic lights. Enforcement plays a crucial role in ensuring that motorized vehicles respect this priority and yield to pedestrians. Cooperation of municipal and campus police is an important factor in enforcing the pedestrian safety laws. Universities and municipalities can also increase speeding fines in pedestrian areas.

Besides providing the safe pedestrian environment, universities can also use different programs to encourage and support walking as a safe and practical mode of transportation. Pedestrian maps and bus route guides are effective tools in ensuring that new students and employees are aware of their options in accessing important destinations in the city. New student and employee orientations are an effective way of passing this information and educating people on available alternative transportation options and programs. Programs such as a guaranteed ride home and flexible work hours also increase the attractiveness of walking.

Citizen involvement and marketing also play a significant role in establishing a successful university pedestrian program. Student groups that support pedestrian and biking programs act as advocates for improving safety and providing better facilities for these modes. Continuous

marketing and public outreach programs promote walking and ensure continuous involvement of the public in pedestrian-related activities. Ribbon cutting ceremonies, press conferences, targeted marketing campaigns, and alumni investment solicitation are samples of these kind of programs.

CHAPTER 6: CAMPUS TRANSPORTATION SYSTEMS CASE STUDIES

This chapter discusses initiatives taken by selected universities in the U.S. towards improving sustainability on campus, with a focus on sustainability of transportation systems and operations. Three universities were selected for a detailed discussion: Stanford University, the University of Washington at Seattle, and the University of California, Davis. The researchers visited these universities and had discussions with their transportation service staff.

The following sections discuss the universities' sustainability initiatives and their methods for addressing transportation issues.

STANFORD UNIVERSITY

Stanford University is located in the heart of the Silicon Valley, in Palo Alto, California. The university campus has a total area of 8,180 acres, and the enrollment as of 2006 was estimated to be 14,890 students, including 6,689 undergraduates *(101)*. Stanford University addresses sustainability through the "Sustainable Stanford" program, which is a university-wide effort to reduce environmental impacts and improve sustainability *(102)*. Campus transportation strategies play an important role in the overall sustainability program at Stanford, and the campus' Transportation Demand Management (TDM) program has gained recognition for its remarkable success over the years.

Sustainable Stanford Program

The Sustainable Stanford program is a university-wide effort undertaken to reduce environmental impacts and improve sustainability. The program is supported by full-time sustainability staff members, as well as a Sustainability Working Group and Sustainability Working Teams *(103)*. The Sustainability Working Group, organized in 2006, is advisory to the president and provost, and is charged with the preparation of policy and program recommendations designed to:

- further learning, knowledge, and community service in the context of sustainability,
- encourage faculty, staff, and students to be active examples of good stewards and provide their expertise to the university, and
- continuously improve Stanford's leadership and practice of sustainability.

The focus areas of the Sustainable Stanford program include:

- climate action,
- energy and atmosphere,

- green buildings,
- green purchasing and food,
- transportation,
- waste,
- water, and
- investment in sustainability.

Of these, the areas of transportation, climate action, and investment in sustainability are discussed briefly in this section. The specific transportation-related initiatives are discussed in further detail in a separate section.

Transportation Demand Management

Stanford has an award-winning TDM program, and was recognized by the U.S. Environmental Protection Agency (EPA) as one of the "Best Workplaces for Commuters" *(104)*. Initiatives taken at Stanford have resulted in a steady decrease in the number of individuals who drive alone to work, down from 72 percent in 2002 to 52 percent in 2007.

Stanford's program is built around the Marguerite, a shuttle system that provides free transit throughout the campus and parts of the surrounding community and that connects to local transit, Caltrain stations, and shopping and entertainment areas. The TDM program includes incentives and services for employees who agree not to drive alone to work. Benefits include cash payments for not driving (referred to as "Clean Air Cash"), guaranteed rides home in case of illness or other emergencies, rideshare matching services, vanpool subsidies, pretax payroll deduction for transit passes and commuter checks, complimentary daily parking passes for those who carpool, and reserved parking spaces for all carpools and vanpools. The TDM program further supports a transportation alternative to single-occupant vehicles via passes for free use of local transit and Caltrain by university employees.

On-campus housing is one of the main factors in the success of Stanford's TDM program. Almost all the undergraduate students, half of graduate faculty members, and 60 percent of graduate students live on-campus. Stanford maintains an agreement with Santa Clara County to have no net increase in peak-period traffic. If the university fails to meet this criterion, it has to pay for the required infrastructure upgrades (e.g., intersection upgrades). Peak-period traffic counts are performed by an independent third party.

Climate Change and CO_2

Through various research institutes and initiatives at Stanford, researchers are working on developing various strategies and solutions to tackle climate change and greenhouse gas emissions *(105)*. The Sustainable Stanford program also seeks solutions to reduce campus greenhouse gas emissions by partnering with such initiatives.

In addition, Stanford joined the California Climate Action Registry in 2006 to monitor and publicly report on progress towards reducing greenhouse gas emissions. An emissions inventory was conducted for the year 2006, which quantified the total annual CO_2 emissions at 165,000 metric tons *(106)*. Staff and faculty are working on developing various solutions to reducing the campus emissions footprint. A presidential task force has also been appointed by university leaders to examine related strategic issues and policy alternatives.

Investing in Sustainability – The Initiative on the Environment and Sustainability
The initiative on the environment and sustainability aims at creating an interdisciplinary approach to promoting research on sustainability at Stanford *(107)*. There are four main research themes identified: energy and climate systems, land use and conservation, oceans and estuaries, and freshwater. The institutes at Stanford involved with sustainability research include the Precourt Institute for Energy Efficiency and the Ward W. and Priscilla B. Woods Institute for the Environment. By promoting research, Stanford is able to contribute to improving sustainability at a global level, and some of the research findings can also be applied to on-campus sustainability programs.

Stanford Parking and Transportation Services

Stanford's Parking and Transportation Services (P&TS) is in charge of implementing the TDM/Alternative Transportation Program, as well as administering the campus Pedestrian Zone *(108)*.

Alternative Transportation and TDM Program
As discussed in the previous section, Stanford has an award-winning TDM program and has experienced great success in reducing the number of persons driving to work alone by providing incentives for university staff and students to carpool, bike, or use public transit.

Stanford's P&TS website provides comprehensive details on many of the incentives and programs offered to students and staff *(108)*. These include:

- Commute Club (offering Clean Air Cash incentives),
- Marguerite Shuttle System,
- Eco Pass/GO Pass,
- Line U Stanford Express,
- bicycle program,
- vehicle rental and car-sharing services,
- charter bus services,
- parking program, and

- other services and options.

Commute Club: The Commute Club provides incentives and benefits to individuals who meet certain eligibility criteria and choose not to drive alone to work. The main benefit is the Clean Air Cash incentive, where up to $234/year is paid to those eligible commute club members who do not purchase an annual parking permit. The other benefits of joining this program include reserved parking spaces for carpools and vanpools, complimentary daily parking passes that can be used as needed, ride-matching services, vanpool subsidies, emergency ride home services, free car rental vouchers, and bonus use of car-sharing services *(109)*.

Marguerite Shuttle System: The Marguerite shuttle system is a free campus shuttle system that is also open to the public. The new buses in the shuttle system run on biodiesel fuel. Marguerite also connects the university campus to local transit and Caltrain stations and many off-campus shopping and dining options *(110)*. A "Midnight Express" service is also offered during the night time as a safe option for those who are on campus late. Marguerite has an automated transportation management system, through which real-time schedules of different buses can be viewed on the web using an interactive map. All the buses are fueled with a mix of 5 percent biodiesel (B5), and a mix of 20 percent biodiesel is under review for future use.

Eco Pass/GO Pass: This allows eligible Stanford employees the free use of Santa Clara Valley Transportation Agency buses and light rail, Dumbarton Express, Highway 17 Express, Monterey-San Jose Express, and Caltrain. The employees may use these free passes at any time, not just for their daily commutes.

Line U Stanford Express: This is an express shuttle bus service running between the Stanford campus and the East Bay on weekdays. Eligible students and staff with a valid university ID may use this shuttle bus service for free.

Bicycle Program: Biking is a major component in Stanford's TDM program. P&TS provides many incentives to encourage biking on campus *(111)*. These include helping bike owners with bike registration, offering free bike rentals, providing folding-bike promotions and bike light giveaways (in collaboration with the campus bike shop), and conducting safety education programs on campus. P&TS also provides free bike maps and information on bike locker rentals and showers for the benefit of bikers. The president of the university and the provost's office are also very supportive of alternative transportation, specifically biking. The president's office provides a $10 subsidy per bicycle helmet. All Marguerite buses as well as local buses are equipped with bike racks. Secure bike storages are provided at Caltrain stations as well as on trains. Biking and pedestrian programs and initiatives are coordinated by a full-time pedestrian and biking coordinator.

Vehicle Rental and Car-Sharing Services: Enterprise Rent-A-Car® has a location on campus that provides hourly, half-day, and full-day car rentals. The services include rentals for students aged 18-20, special discounts for those 20 and older, and free hourly rentals for Commute Club members. Zipcar also offers car-sharing services at Stanford, with discounted rates for university students, staff, and faculty. The Zipcar vehicles are located at many places on campus and may

be used by individual or departmental members through a self-service, on-demand reservation system.

Charter Bus Service: P&TS offers group transportation services for conferences, teams, events, and student activities to both on- or off-campus destinations. There is a convenient online reservation system to encourage use of this service.

Parking Program: The number of available parking spaces on campus is capped at 22,000. The Commute Club offers incentives to those choosing not to purchase an annual parking permit. P&TS also provides many short-term and daily parking permit options for visitors, visiting residents, or those who need to drive alone to campus on certain days. Electric vehicle charging stations are also present at select locations. While the residential parking program provides convenient parking services for on-campus residents, students in their freshmen year are not permitted to drive to or park on campus. This measure was enacted to allow students to explore the various alternative transportation options on campus and to encourage them to not drive in future years also. This program is currently being reviewed to include sophomore students.

Other Services/Options: P&TS runs a successful marketing program aimed at alternative transportation services. Other services provided by P&TS include the P&TS website, which has a wide variety of information and links, and the online sale of transit passes. The website also has a commute cost and carbon emissions calculator *(112)*. E-mail updates are sent to Commute Club members and parking permit holders, and various promotional events for alternative transportation are held across campus. P&TS maintains a database of faculty, staff, and student addresses, emails, and phone numbers. This information is used in a geographic information system (GIS) framework to identify the alternative commuting options for their members. New employees get informed about their alternative commuting options in their orientation as well as through brochures and targeted emails. Wherever approved by supervisors, university employees can make use of flexible work options, including staggered work hours, compressed work week, or flextime. P&TS also offers one-on-one commute planning assistance to help people make the right decisions to improve their commute while reducing driving alone to campus.

Pedestrian Zone Access

Stanford University's central Pedestrian Zone (PZ) has been established to create a safer central campus for pedestrians and bicyclists, preserve facilities, and minimize the disruption of university activities through the elimination of unnecessary vehicular traffic. All vehicles require authorization prior to accessing the PZ and must display the appropriate PZ permit while moving through or parking in the PZ. Authorized vehicle access to the Pedestrian Zone is managed by P&TS. There are three controlled gate entrances to the pedestrian zone, each of which governs access to a certain set of buildings.

UNIVERSITY OF WASHINGTON – SEATTLE

The University of Washington, Seattle (UW) is located in Seattle, Washington. It covers a total area of 643 acres, and as of 2007, the number of students enrolled was estimated to be 40,216, including 30,790 undergraduates *(113)*. The measures the UW administration have taken to address sustainability and sustainable transportation include the Campus Master Plan (which contains a detailed Transportation Management Plan), various services offered by the

university's transportation services, and other initiatives by the Environmental Stewardship Advisory Committee.

Campus Master Plan

UW's plan for expansion in late 1980s was expected to cause approximately 10,000 more daily car trips to campus. The city of Seattle was concerned about the impact of this additional traffic on the city network. In response to this concern, the university entered into an agreement with the city to limit the traffic and parking demand in surrounding neighborhoods.

The Campus Master Plan (CMP) of UW's Seattle campus was developed and finalized in 2003. The CMP was adopted as a guide to be followed for developing the campus *(114)*. The goals of the CMP include respecting the university's stature; ensuring stewardship of resources; enhancing the campus; providing accessibility; promoting safety, efficiency, and respect for the environment,;and valuing the surrounding community. The CMP focuses on three main elements: open space, transportation and circulation, and potential site development. The CMP outlines a set of objectives related to the focus area of transportation and circulation. These objectives are listed below:

- improve the pedestrian experience on campus;
- increase access for pedestrians and bicyclists, both to and within the campus;
- minimize conflicts between pedestrians, bicycles, and vehicles;
- improve public transportation with the goal of minimizing vehicle trips to campus and related parking requirements, and provide safe, convenient access for pedestrians to and from public transportation;
- minimize the amount of new parking facilities while still providing parking for the variety of users on campus, including the disabled, with the least impact on the campus and the surrounding street system, with particular care to street systems that are contiguous with residential neighborhoods;
- maintain the cap of 11,000 parking stalls;
- locate, landscape, and screen parking to prevent detracting from the overall quality of the campus environment while promoting safety and security;
- clearly identify entries into campus and improve signage around campus.

In addition to these objectives, the CMP contains general policies related to each of the elements, including transportation and circulation. These general policies provide broad outlines to be followed for new projects and development, and are discussed below.

General Transportation Policies
The general transportation policies are concerned with issues connected to traffic and the public street system, including neighborhood traffic, transit, bicycles, and commuters. The policies, as listed in the CMP, are given below *(115)*:

- The University, the City, and community groups recognize that they need to work together if growth is to be accomplished in a manner that achieves and maintains acceptable traffic levels.

- The University will cooperate with the City in providing a network of pedestrian and bicycle paths to, from, and on campus. Adequate bicycle parking, including secure racks and lockers will be provided in safe, convenient locations on campus, but not in a manner which would promote unnecessary intra-campus bicycle travel.

- The University will continue to improve campus accessibility for the disabled through provisions of graded pathways, ramps, curb cuts, elevators, and disabled persons' campus transportation.

- The University will cooperate with the City and adjacent communities in improving traffic flow on street networks surrounding and leading to the University including decreasing the impact of street parking.

- The University will continue to act in partnership with King County Metro, Community Transit, and Sound Transit to provide a high level of transit service to the campus, the university area, and nearby residential and neighborhood business districts.

- The University will work with the City and transit agencies to implement improvements to the transit operating environment and to ensure adequate layover to support transit operations.

- The University supports light rail service to the university area and has reached an agreement with Sound Transit under which Sound Transit would construct two stations on campus under the original, locally preferred alternative (LPA).

- The University recognizes that it plays an important role in non-University processes designed to study and address transportation issues that ultimately affect the university area. It will continue to address transportation problems with other major employers in and around the university area, community councils, the neighborhood planning organizations, King County Metro, Community Transit, Sound Transit, Washington Department of Transportation (WSDOT), the Puget Sound Regional Council (PSRC), and the Elevated Transportation Company (Monorail) Public Development Authority.

General Circulation Policies
The circulation policies deal with the design of elements relating to pedestrians, bicycles, the disabled, vehicles, and transit. There are detailed guidelines provided in the CMP for each of the following elements *(115)*:

- pedestrian pathways,
- bicycle pathways,
- access for the disabled,
- vehicular/parking/transportation service,
- emergency access, and
- transit.

Transportation Management Plan

UW's Transportation Management Plan is a component of the overall CMP document. The TMP was first developed in 1983 with the intent to expand commuting options for university students, staff, and faculty, shifting them away from the single-occupancy vehicle trips. The primary goal was to reduce the number of peak hour vehicle trips at the University of Washington.

The goal of the most recent TMP was to achieve limiting peak-period, peak-direction vehicle trips of students, staff, and faculty in order to remain at or below 1990 levels *(116)*. There are nine elements of the TMP, each one being a significant part of the overall TMP program. Figure 19 shows the various elements of the TMP pictorially. For each of the TMP elements, a list of "possible improvements" is presented. These are the improvements/changes that the university can implement in order to ensure that it achieves the overall goals of the TMP.

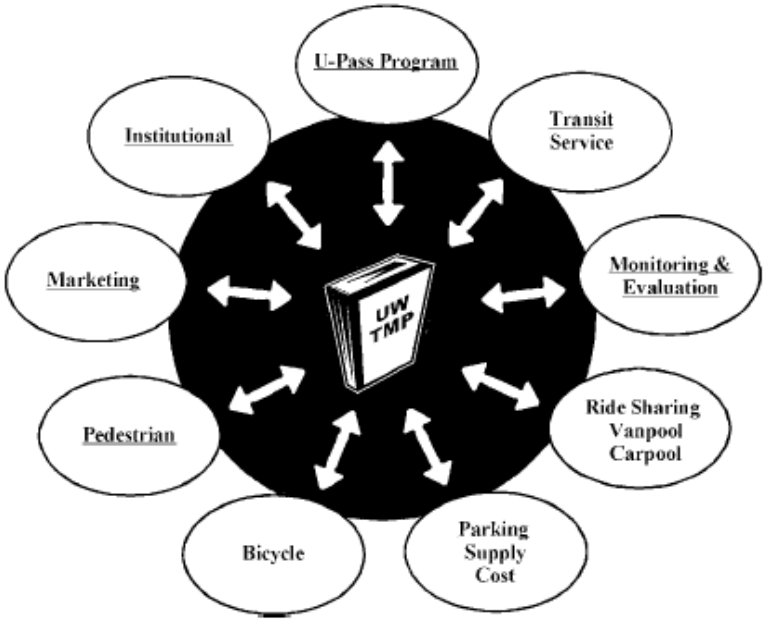

Figure 19. Elements of the University of Washington's Transportation Management Plan *(116).*

The award winning U-Pass alternative transportation program is considered the cornerstone of UW's TMP. The U-Pass program offers a full array of alternative transportation options to faculty, staff, and student members. Sixty-eight percent of faculty, 70 percent of staff, and 85 percent of students participate in U-Pass. U-Pass for students is in an opt-out format, and students who wish not to participate can request a refund. U-Pass provides the following benefits to participants:

- free or subsidized fare to transit and commuter rail services,
- free ride on night ride shuttle,
- discounted parking for carpooling,
- discount on Zipcar rentals, and
- subsidized vanpool fares.

UW Transportation Services

UW's Transportation Services aims to provide innovative and sustainable transportation solutions for the university *(117)*. Transportation Services is responsible for developing and working closely with the TMP discussed in the previous section. Overall, the UW's Transportation Services encompass five programs:

- commuter services,
- fleet services,
- moving and surplus,
- recycling and solid waste, and
- UW shuttles.

Since many of the elements of the Transportation Service's programs are in accordance with the TMP, they are discussed very briefly in this section. Commuter Services provides programs and guidance for those traveling to the UW campus. These include the U-Pass and Flexpass programs for transit riders and occasional drivers, ride-matching services for carpools/vanpools, and safety information, maps, directions, and other helpful advice for bikers and those who walk to campus. The Fleet Services division manages the UCAR carsharing and rental system for the benefit of the university departments. Individual staff and students can also benefit from discounted carsharing rates at Zipcar, under the U-Pass program. The UW shuttle system provides free, on-demand shuttle service for disabled persons, night services from campus that drop users directly at their residences, and regular on-campus shuttle services.

Biking is considered an important part of UW's transportation plan. According to the 2006 U-Pass survey, 13 percent of faculty, 7 percent of staff, and 7 percent of students use bicycles for their commute to the UW campus. It is estimated that approximately 4,000 bikes are parked on campus on any working day. UW Transportation Services maintains 6,000 bike racks around the campus. With 528 secured bike lockers, UW has the largest university bike locker program in the United States. Transportation Services has plans to install covered semi-secured bike parking areas (fenced lockers) to cover the gap between the current available options. Discounted helmets and bicycle lights are available to U-Pass holders. Special signs and pavement markings, appropriate lighting, and under/overpasses are utilized throughout the campus to accommodate the bike traffic. Campus bike routes and lanes are well connected with the city bike system.

Environmental Stewardship Advisory Committee – Green Fleet Initiative

In 2004, UW adopted a "Policy on Environmental Stewardship" and created a permanent Environmental Stewardship Advisory Committee *(118)*. Environmental Stewardship Advisory Committee (ESAC) members were appointed to represent a broad array of environmental stewardship interest and expertise among faculty, students, and staff from the university's three main campuses (at Seattle, Tacoma, and Bothell). The ESAC serves a broad range of advisory and monitoring functions, including the publication of an annual report outlining various on-campus sustainability initiatives, as well as recommendations for future programs, goals, and objectives. The latest annual report of the ESAC outlines the "Green Fleet Initiative" undertaken by the Motor Pool of the Seattle campus (now known as Fleet Services – discussed in the previous section) to create a more sustainable fleet *(119)*. The ESAC annual report also outlines other transportation-related recommendations covering topics such as bike and pedestrian facilities, biodiesel, and campus vehicle fleet efficiencies. The greenhouse gas inventory work undertaken by the Energy Subcommittee of the ESAC is also directly related to many transportation concerns.

UNIVERSITY OF CALIFORNIA – DAVIS

The University of California, Davis (UC-Davis) is located near the San Francisco Bay Area in a campus spread over 5300 acres *(120)*. The university has implemented many programs and policies to address sustainability and sustainable transportation on campus. This section discusses sustainability initiatives at the UC-Davis campus in two major categories: campus development (which includes long-range planning, campus planning and construction, and other sustainable campus initiatives) and transportation-specific measures undertaken by the university's Transportation and Parking Services.

The campus transportation profile for UC-Davis is unique in that bicycling has a much higher mode share when compared to other university campuses. Over 40 percent of undergraduate and graduate students commute to campus by bicycle, and the overall mode share for bicycling (including for faculty and staff) is around 38 percent *(121)*. Thus, the bicycle facilities available to commuters and the actions taken to make the UC-Davis campus more bicycle-friendly are discussed in detail in the following sections.

Campus Development Efforts

UC-Davis' Long Range Development Plan (LRDP) is a comprehensive land use plan to guide physical development on campus to accommodate projected enrollment increases and expanded program initiatives through the 2015-16 academic year *(122)*. An Environmental Impact Report (EIR) was also prepared to evaluate the environmental effects of growth under the 2003 LRDP *(123)*. The goals of the long-range development plan reflect the concepts and concerns of sustainability and are as follows:

1) create a physical framework to support the teaching, research, and public service mission of the campus,

2) manage campus lands and resources in a spirit of stewardship for the future, and

3) provide an environment to enrich campus life and serve the greater community.

The Sustainable Campus Initiative and Sustainability Advisory Committee

UC-Davis also has a Sustainable Campus initiative, which covers programs under seven specific areas, including green buildings, energy and atmosphere, land use, purchasing, transportation, waste, and water *(124)*. The transportation focus area aims to facilitate a "human powered campus" to actively encourage and foster walking and bicycling to get around campus, and to promote mass transit. These transportation initiatives are discussed in more detail in the next section. The university also has a Sustainability Advisory Committee, under which a Campus Planning and Transportation Subcommittee functions *(125)*.

Blueprint for a Green Future

The Sustainability Advisory Committee prepared the "Blueprint for a Green Future," a comprehensive report with recommendations for encouraging and enhancing campus sustainability for the committee's various focus areas *(126)*. This report's main recommendation with respect to campus transportation is quoted below:

> *"Lay the framework for implementing sustainable transportation, including a study of alternative transportation and the marketing of a walk/bike plan, all efforts aimed at gaining control of an increasing number of single-occupancy vehicle (SOV) commuter trips to and from the campus, and decreasing the campus fleet's reliance on carbon-fueled vehicles."*

The report also lists progress to date on specific programs undertaken to 1) promote a more walkable campus, 2) promote a more bikeable campus, and 3) reduce the use of carbon-fueled vehicles on campus.

Promoting a More Bikeable Campus

As mentioned earlier, the UC-Davis campus is notable for the high rates of bicycling on campus and to campus. This is due to various measures that have been proposed and enacted to not only promote biking, but also improve walkability on campus and reduce the use of carbon-fueled vehicles. These measures are outlined in detail in the "Blueprint for a Green Future" report *(126)*. Some selected details from the report are presented below:

- Design of a comprehensive circulation plan for pedestrian, bicycle, and vehicle transportation on campus, together with principles of operation and vehicular restriction, is underway.

- A physical plan for the campus is being mapped and refined that will provide a planning framework for siting new buildings and adjacent circulation; the next step is a multi-year capital improvement plan.

- In general, there is a campuswide shift from constructing surface parking lots to constructing parking structures, with an emphasis on keeping buildings closer together and parking at the campus periphery in order to facilitate walking around campus.

- The first stretch of the Garden Path pedestrian system has been constructed, adjacent to the new Math Sciences Addition Building. The pedestrian areas on east and north quad streets have been improved, and bicycle, vehicle, and pedestrian circulation patterns have been clarified.

- Pedestrian amenities and circulation improvements in the Health Sciences District are planned.

- An administrative draft of the City of Davis Downtown–Campus Connection Concepts and Implementation Plan was released in late 2005, which proposed pedestrian, bicycle, and automobile circulation system improvements between the downtown and east campus.

- UC Davis has about 15 miles of "shared use" paths (used by bicycles/pedestrians/delivery trucks/ maintenance vehicles) and about 16,000 bike parking spaces.

- A joint effort, kicked off in summer 2005, by Transportation and Parking Services and the Office of Resource Management and Planning is underway to build a database within a GIS to document all campus bicycle parking by quantity, location, and type of bicycle rack system. This data will be used to plan replacement and additional bicycle parking.

- The Long Range Development Plan has a bikeway plan that lays out a circulation concept for bicycles on campus and ways for paths to connect to off-campus paths and destinations.

- In 2002, Transportation and Parking Services (TAPS) prepared a Draft UC Davis Bicycle Plan, outlining existing operations and plotting future high, medium, and low priority proposed projects to be funded through grants. The plan estimated that during good weather in fall and spring quarters, between 15,000 and 18,000 bicycles are in use on campus on weekdays.

- UC Davis TAPS successfully applied for grant funding for bikeway connections to off-campus paths and lanes (for example, for paving the Aggie Village bike path)

- Bicycle lanes are under construction along Hutchison Drive from La Rue Road west to County Road 98; a new bicycle path connecting Hutchison Drive to the arboretum near the silo is planned for construction.

- A bicycle path map for UC Davis and the city of Davis (combined) is produced as a joint effort by UC Davis Transportation and Parking Services and the City of Davis Department of Public Works and is readily available at various locations on campus and around the city.

- The Bike Barn operates from 9:00 a.m. to 4:00 p.m. Monday through Friday, offering tire inflation for free, bike repair and maintenance for competitive fees, and bicycles for sale.

- Biannual auctions of abandoned bicycles are hosted each fall and spring to provide affordable bicycles to incoming students.

- As part of the 2003 LRDP, West Village, a neighborhood on the west campus, was proposed. West Village would provide below-market housing for UC Davis faculty, staff, and students, which would reduce the number of SOV trips to campus, as residents would be expected to take Unitrans transit or bicycle or walk to campus from their adjacent neighborhood, and with few exceptions, would not be able to get on-campus parking permits.

- An Alternative Transportation Study was funded, and the final set of recommendations is to be implemented by Transportation and Parking Services.

- Transportation and Parking Services implemented a car rental program in 2005 that helps students (including those under 25 years old), faculty, and staff accomplish trips requiring a car.

- The campus is currently planning a $1,500,000 revamped Unitrans terminal across from the silo to improve bus operations through central campus, as well as improve bicycle and pedestrian connections.

Transportation and Parking Services

The university's Transportation and Parking Services facilitates the access and mobility needs of the campus community through the coordination of efforts among TAPS units and with other campus departments and non-university entities *(127)*. The strategies undertaken by TAPS at UC-Davis to promote alternative transportation on campus have been highly successful. These include commuter and parking programs and bicycle services. TAPS also has an Alternative Transportation Coordinator in charge of these programs.

TAPS commissioned an "Alternative Parking and Transportation Investment Study," the final report of which was published in October 2006 *(128)*. The report indicated that UC-Davis' existing alternative transportation programs (ATP) were already very successful; for example, a mode split study indicated that nearly 40 percent of students commute to campus by bicycle. However, the report did provide information on possible TDM strategies that could be used to curb future demand for parking spaces and other transportation challenges faced due to expansion of enrollment at the university. Besides the findings from the "Alternative Parking and Transportation Investment Study," TAPS also has many successful measures in place to promote a more sustainable transportation system on campus. Some of these are discussed briefly below *(127)*.

Bicycle Services
The Bicycle Program at UC-Davis aims to maintain and encourage the use of the bicycle as an important mode of transportation to, from, and on campus. The city of Davis and the UC-Davis campus have both been recognized as "Platinum Level Bicycle Friendly Communities" by the League of American Bicyclists. Wide streets, well-marked bike lanes and pathways, and availability of bike parking have resulted in this community having one of the greatest numbers of bikes per capita in the nation.

TAPS has many other programs and incentives to encourage faculty, staff, and students to bicycle instead of drive. Since all bikes on the UC Davis campus must have a current California bicycle license, TAPS makes bike licenses available on campus for the convenience of bike users. TAPS also allows bikes to be stored at their office location over the summer months.

The Associated Students of the University of California, Davis (ASUCD) organizes classes on bicycle repair and maintenance and has a "bike barn" that provides tool-loan services and advice, and a location for UC-Davis students to conduct self-service bike repairs. TAPS and the Department of Campus Recreation together offer bicycle commuters free access to showers and a place to change from bike to work clothes at the Activities and Recreation Center. As an incentive to bikers and bus commuters, faculty and staff who do not have a campus parking permit are eligible to purchase 12 daily parking permits every six months for use when they wish to drive to campus.

Carpools
TAPS offers registered carpools discounted parking permit rates, as well as access to reserved carpool parking spaces. Carpoolers are also provided two complimentary daily parking permits per person, per month as an additional incentive. TAPS also has a free rideshare match service and offers an emergency ride home program for those in registered carpool, vanpool, train, or bus programs.

Transit
The TAPS office offers discounted transit passes to local and regional transit services, including Unitrans (the university's transit service), Yolobus from Yolo County Transportation District (YCTD), Sacramento Regional Transit, and Solano Transit.

Unitrans was founded in 1968 as the university transport system by the ASUDC and opened to the general public in 1972, with partial funding from the city of Davis. Currently, Unitrans provides public transportation service to the entire city with 49 buses on 14 routes, carrying over 3 million passengers a year. It also provides connectivity to other transit services. Anyone can ride Unitrans for $1 cash fare, and many types of prepaid discounted tickets and passes are available, including free access for undergraduate students and senior citizens with a valid ID. Approximately 95 percent of Unitrans' service is provided by compressed natural gas (CNG) - fueled buses, with a prototype bus currently being operated on a hydrogen-natural gas blend.

Comet Parking Pass
The Comet parking pass is a program offered by TAPS to students, staff, or faculty who may wish to drive to campus for only short periods of time. It is a personal parking meter that comes preloaded with up to 100 hours of parking time and may be used in visitor or metered parking

spaces on campus. By providing flexibility of usage to customers, TAPS hopes to encourage commuters to use alternative means of transportation for a majority of the time and retain the flexibility of driving to campus when necessary – for example, when attending a single class or running errands on campus.

Electric Vehicle Charging Facilities

There are many facilities available for charging electric vehicles in California. In the Davis area (Yolo County), there are nine locations with charging stations that may be used by the public and commuters to UC-Davis *(129)*. These are shown in Table 4 below.

Table 4. Electric Vehicle Charging Facilities in the Davis, California Area.

Description	Location
5th and G Plaza Public Parking Garage	5th and G Streets (entrance on 4th St.)
Davis Amtrak Station	2nd and G Sts.
Hanlees Toyota	4202 Chiles Road
UC Davis Extension	1441 Research Park Drive
UC Davis Parking Garage	Howard Way between Russell Bl. & North Quad
UC Davis South Campus Parking/ Mondavi Center	Lot 1 (Near the new Mondavi Center of the Arts)
University Covenant Church	315 Mace Blvd.
Wildhorse Golf Club	2323 Rockwell Drive
Yolo-Solano Air Quality Management District	1947 Galileo Court, Suite 103

CHAPTER 7: RECOMMENDATIONS FOR TEXAS A&M UNIVERSITY

The Texas A&M University (TAMU) campus in College Station is home to approximately 50,000 students. The campus is undergoing a transformation and development, as are the surrounding cities of College Station and Bryan. As the campus of TAMU grows and changes, it is necessary to look to the future of this evolving campus in the context of an evolving world.

Like any other major university, TAMU needs to integrate aspects such as its internal functions and interaction with other institutions with its growth and synergy with the surrounding community. TAMU has a stated commitment to promote sustainability by "teaching, planning, and acting in an environmentally sustainable manner." Transportation plays an important role in the operation of any campus. The master plan fails to explicitly address the sustainability of the campus transportation system; however, some of the goals partially support transportation sustainability on campus.

One of the stated goals of TAMU's master plan is to have an accessible, pedestrian-oriented campus by keeping private car traffic to the periphery of the campus. Better transit service and enhanced bicycle system are also recommended in the master plan to support a multi-modal circulation on campus. The master plan calls for decreasing reliance on-surface parking and recommends building large parking garages on the perimeter of the campus. The master plan acknowledges that the campus has one of the highest car/students ratios in the nation; however, it does not address the increasing number of single-occupancy vehicle traffic to campus.

TAMU is growing fast. This growth provides the campus with an opportunity to grow smart by implementing sustainable transportation strategies and policies to provide convenient accessibility to its students, faculty, and staff in an environmentally responsible manner. This section provides a set of recommendations to enhance the sustainability of TAMU's campus transportation system. The recommendations are divided into two categories:

- General Recommendations: Recommendations that address the role of the university system in achieving campus transportation sustainability.

- Specific Recommendations: Strategies addressing specific aspects of a sustainable transportation system that different departments and agencies of the university system can implement.

GENERAL RECOMMENDATIONS

As is the case for many major universities in the U.S., TAMU needs to make a "paradigm shift" to transform the campus transportation system to a sustainable one that supports the smart growth of campus, one that significantly reduces its negative impact, including air pollution and greenhouse gases, and promotes an improved quality of life on and around campus. Like many other universities in the U.S., the following barriers challenge establishing a sustainable transportation system at TAMU:

- financial concerns: lack or shortage of financial resources,
- environmental awareness: scarcity of environmental education, and
- cultural issues: insufficient environmental activism at campus.

Currently, the university system does not consider the personal vehicle traffic to/from campus as a problem. Although the master plan mentions single-occupancy vehicle traffic as a challenge to campus and calls for limiting the private vehicle traffic to the periphery and reevaluating the current practice of maintaining the ratio of people to parking spaces, it fails to provide explicit recommendations to reducing these trips. University campus administrators and planners often overlook their institution's potential to affect the transportation habits and environmental awareness that their students can develop in the long term.

An institutional reform is the first action that the research team recommends as the starting point for establishing a comprehensive sustainable transportation system on campus. The university system administration and transportation services need to reevaluate the stated goals of the transportation system and realign them with goals of long-term sustainability. Recognizing the single-occupancy vehicle traffic to/from campus as the major problem and committing to reduce it is an essential step in this process (Figure 20). Limiting this traffic to the periphery will only shift the problem to the edge of the campus. The literature review and case studies presented in this study show clearly that the commitment of a university system is a key factor in establishing a successful sustainable transportation system.

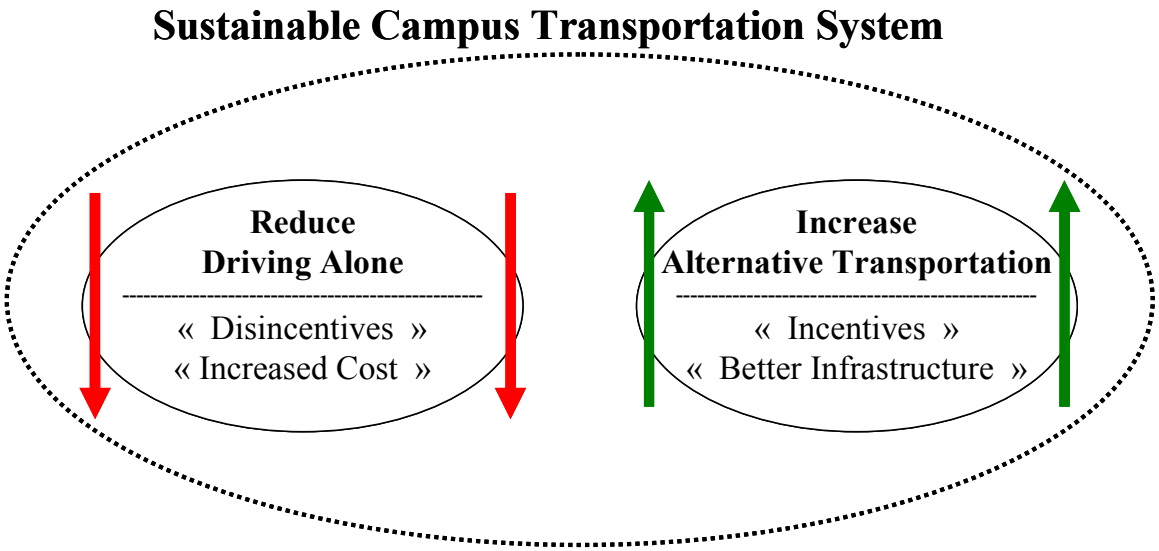

Figure 20. General characteristics of a sustainable campus transportation system.

The following recommendations are based on the research effort:

- Make a system-wide commitment to reduce single-occupancy vehicle traffic to/from campus. Include this in the future revisions of the campus master plan as well as transportation

services' objectives. A lack of this step leads to the commitment to provide service to single-occupant vehicles at the expense of more efficient modes. A visible and meaningful top-level institutional commitment is very important in establishing a successful sustainable campus in general and transportation system in particular.

- Establish a permanent Sustainable Transportation Council with authority to promote transportation sustainability, advise the administration on the subject, and reevaluate campus transportation policies. The council must define/redefine a sustainable transportation system for the campus, establish a transportation sustainability vision for the campus, set goals for the campus transportation system, and establish specific objectives and guiding principles to achieve the sustainability goals of the campus transportation system.

- Develop a comprehensive transportation master plan for the campus based on the recommendations and goals established by the Sustainable Transportation Council and ensure that these goals are aligned with the campus master plan.

- Adopt an integrated transportation planning approach at Transportation Services. Conventional transportation planning usually underrates many benefits of a more diverse transportation system, including transit and non-motorized travel modes. An integrated transportation plan considers additional costs and derived traffic volume resulting from roadway construction and improvement, and additional benefits of sustainable transportation strategies that improve mode choices and increase efficiency of existing capacity.

- Establish a system-wide transportation sustainability performance monitoring system. Such a system should combine different aspects of a sustainable campus transportation system; the transportation services' quality as perceived by system operators and users as well as the campus transportation systems' broader impacts on society and environment. A successful transportation sustainable monitoring system depends on two factors: 1) goals and objectives support transportation sustainability on the campus, and 2) established performance measures express a full view of the campus transportation system. The outputs of the system should be integrated into the planning process as well as strategy selection and system monitoring to track the progress toward the established goals.

Figure 21 graphically shows this recommended general framework for establishing a sustainable transportation system at TAMU. The following section addresses specific recommended strategies for achieving transportation sustainability on campus.

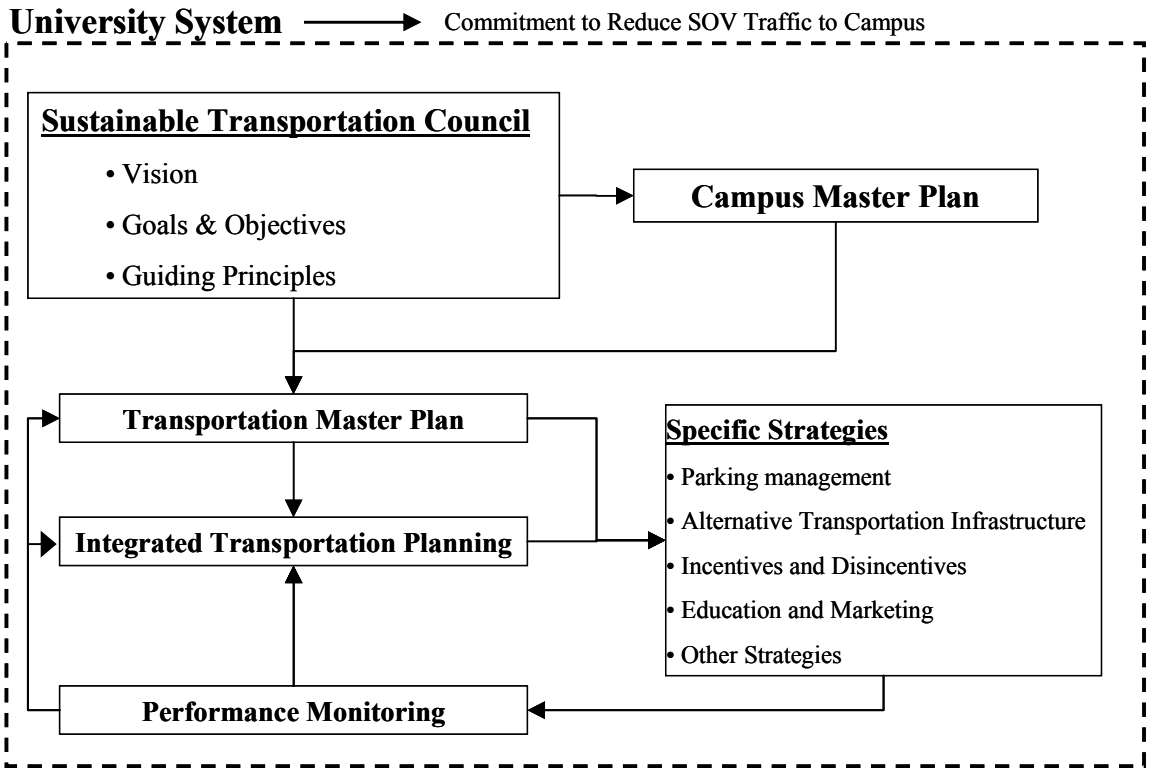

Figure 21. Recommended approach for TAMU's sustainable campus transportation system.

SPECIFIC RECOMMENDATIONS

The research team recommends designing and establishing a comprehensive sustainable transportation program for the campus with the goal of diversifying mode share and reducing SOV traffic to campus. The success of a sustainable transportation program depends heavily on the right administrative structure. A sustainable transportation program manager must be in charge of all the efforts related to enhancing the sustainability of the campus transportation system and report to the Sustainable Transportation Council.

The finding of this study shows that a successful sustainable transportation program consists of two basic elements: incentives for alternative transportation modes, and increased overall cost (disincentives) for single-occupancy vehicles. The overall cost of a transportation mode is a function of many inter-related factors, such as out-of-pocket cost, door-to-door travel time, convenience and safety, and social image. An equitable sustainable transportation system addresses all these factors to ensure that the drive-alone traffic does not have priority over other modes. Strategies used in a sustainable transportation program aim at more efficient use of the current transportation system without increasing system capacity or supply; consequently, it stresses parking management, incentives for alternative modes, planning strategies, education, and marketing programs.

The following discusses specific sustainable transportation strategies that the research team recommends for TAMU. Researchers found that the most successful campus sustainable transportation programs contain a well-balanced mix of strong parking management, alternative transportation infrastructure development, and marketing and outreach programs. Educational and training programs also enhance the long-term success of sustainable transportation programs on university campuses.

Parking Management

The case studies and literature review presented in this research show that parking management is the single most important tool to discourage single-occupancy vehicle trips and enhance the transportation sustainability on a campus.

- Reevaluate the current philosophy on campus parking. Options to current practice at TAMU are as follows:
    - Adopt and implement a reasonably higher ratio of people-to-parking as the target for future campus development. The selected target ratio must be high enough to trigger alternative transportation initiatives in the short run as well as ensure the long-term sustainability of the campus transportation system.
    - In the long run, the campus could adopt a cap on the total number of parking spaces on campus. A parking cap will further motivate Transportation Services to include alternative modes in their planning processes.
- Pricing is the most effective tool among parking management strategies. An equitable pricing scheme should level the ground for all the transportation modes. Parking permit prices at current levels are heavily subsidized and, therefore, are favoring single-occupant vehicles over other more efficient modes. Pricing should be set at a level that discourages people who have access to other modes from driving alone to campus. Parking pricing can also be used to encourage more fuel-efficient and low-emission vehicles on campus.

The following are some specific suggestions for a better parking pricing scheme on the TAMU campus.

- Include the price of land in parking cost calculations. Currently this is not the practice at TAMU. Not considering this cost in the pricing is a direct subsidy to SOV parking on campus.
- Issue parking permits to vehicles instead of people. This gives more flexibility and power to Transportation Services to implement strategies aimed at enhancing transportation sustainability on campus. A vehicle-based parking permit system is essential for strategies such as preferential parking programs and also increases the effectiveness of strategies that limit the parking access for a certain population. Individuals who wish to drive different cars to campus can register all their vehicles on one permit or obtain secondary permits at a reduced rate.

- Move toward implementing a pay-per-use system for the majority of the campus population. Benefits of a pay-per-use (hourly parking) parking system include the following: 1) it improves equity since the users pay only for what they use, 2) it discourages non-necessary parking on campus since the cost is more visible, and 3) it prevents "all you can eat" syndrome associated with regular parking permits (drivers have already paid; therefore, they tend to use it as much as possible).

- Implement special parking pricing (reduced parking cost) for vanpools and carpools. The pricing can also be set in a way to reward high-fuel-efficient vehicles. A more sophisticated system can combine additional factors, such as home distance from campus and vehicle's rated carbon emission rate from EPA.

- Implement a preferential parking program for carpoolers, vanpoolers, and possibly low emission vehicles. Carpoolers and vanpoolers should be given premier parking spaces, for example those that are more accessible to buildings. This implies that the campus transportation system rewards individuals or groups who voluntarily use these alternative modes by giving them benefits over single-occupancy vehicles. Establishing a preferential parking program at TAMU might require a change of the current parking permit practice from a person-specific system to a vehicle-specific system.

- Make people who live within a certain radius of the campus ineligible for a parking permit. This could also include all on-campus residents.

- Evaluate the possibility of restricting undergraduate students (all or partially) from bringing a car to campus. For example, freshman students at Stanford cannot obtain a parking permit, and the university is considering expanding this limitation to second-year undergraduate students.

Alternative Transportation Options

The university needs to implement a variety of alternative transportation options on campus to reduce the need for driving single-occupancy private vehicles to campus. The following recommendations cover strategies related to these alternative options.

- One of the main obstacles to establishing an alternative transportation program is that these modes are often considered individually and thus are found financially insufficient. This traditional view ignores parking subsidies as well as non-financial benefits of these alternative modes. Alternative transportation modes need to be treated as a vital part of the campus transportation system and be given priority over driving alone to campus. Parking permit fees and parking citations are justified sources of funding for more efficient transportation modes. This is because parking is usually heavily subsidized and SOV traffic imposes many hidden costs, such as those associated with congestion, reduced safety, and degraded air quality, on the campus and surrounding community.

- Establish a bicycle and pedestrian program through Transportation Services and hire a full-time bike/pedestrian coordinator. The responsibilities of a bike/pedestrian coordinator would include but not be limited to:

    - maintaining bike and pedestrian system,
    - reviewing new buildings on campus to evaluate their impact on bike flow,
    - managing campus bike registration system,
    - revising and updating bike and pedestrian maps, and
    - representing pedestrian and bicyclist interests in campus transportation services.

- Improve quality and quantity of walkways and bike routes on campus. Shaded and well-lighted walkways and bike routes attract more people to these modes. It is recommended to establish an easy connection between the campus network and the surrounding area. TAMU needs to work with the city of College Station and the city of Bryan to connect and expand their pedestrian/bike networks.

- Evaluate funding alternative transportation improvement projects in campus neighborhoods. TAMU can partially fund pedestrian- and bicycle-oriented projects outside the campus that directly benefit the campus community.

- Install bicycle racks on all transit buses providing service to campus. Bike racks on transit increase the service area of transit service by enabling individuals who live farther than walking distance to utilize transit services.

- Improve the quantity and quality of bicycle parking on campus. Bicycles should be given priority to other modes in terms of parking location and proximity to the final destination. Consider installing different types of bicycle parking options, such as bike racks for short term use, secured bike lockers for long-term regular use, and covered, semi-secured spaces to fill the gap between the other two. If installed on parking lots on the edge of campus, bike lockers and semi-secured bike parking support the efforts to keep the traffic to the periphery of campus.

- Designate shower facilities around the campus that are available to the campus bicyclists and pedestrians. The placement of the shower facilities should be based on the destination distribution of student and faculty/staff members on campus.

- Evaluate the possibility of establishing a bike center on campus. Such a bike center could provide maintenance services and bike rentals as well as bicycle sales and biking accessories. Bike rental services are especially helpful to limit visitors' traffic to the periphery of the campus.

- There are currently not enough bicycle racks available at business locations serving the campus community. It is recommended that Transportation Services works closely with these businesses and the cities of College Station and Bryan to improve the quantity of parking racks around the city.

- Evaluate establishing a forgivable loan for bicycle purchases. Forgiveness of loans must be subject to some limitations on applicants' use of their vehicles for trips to campus. The

university can set criteria, such as commitment to riding a bicycle to campus at least a certain number of days per week and no parking permit for beneficiaries of the loan program.

- Work closely with the city of College Station to implement traffic calming at areas with high pedestrian and bicyclist traffic, most notably the Northgate area.

- Review campus transit services with regard to their connectivity to pedestrian and bike networks and facilities (i.e., bike lockers/racks and showers). Develop a plan to make necessary modifications (operation and infrastructure) to each mode to achieve the maximum multimodal connectivity.

Commuter Club

The research team suggests that a commuter club program be established at TAMU. The recommended commuter club program should consist of strategies and incentives that urge faculty, staff, and students to use alternative transportation modes instead of driving alone in their private vehicles to campus. The program must provide the participants who agree not to drive their vehicle to campus with an attractive package of incentives so that the perceived overall benefit of alternative modes surpasses driving alone to campus. The following incentives are suggested for implementation in such a program on the TAMU campus.

- Free occasional parking permits. For example, Virginia Tech issues 20 daily scratch permits per semester to any vehicle owner (faculty/staff/students) who does not obtain a regular parking permit.

- Free guaranteed emergency ride home through a taxi fare reimbursement.

- Free rental and shared cars. It is recommended that the university establish contracts with rental car and car-sharing (e.g., Zipcar and Flexcar) companies to provide hourly and daily rentals to students/faculty/staff in need of using a car occasionally. The commuter club participant should be offered a limited number of hours or days of free or reduced fee rental car usage.

- Other benefits: The university system can also leverage other benefits to promote participation in its commuter club programs. Examples are reduced-price admission tickets to events, reduced/free admission to university club, and reduced-price recreational center facilities.

Education

Education is the main mission of higher education institutions. Universities and colleges should use this specialty of theirs to prepare students for a sustainable future with the vision of minimal negative impact on our environment. Education is a powerful tool to achieve a mass awakening to the real costs and emerging problems caused by our current norms of behavior. Universities can build a culture of sustainable living by employing direct education as well as using their campuses as a test field for sustainable living. In addition to the short-term impact on the campus

community, it is expected that students will carry these experiences and values with them to the real world.

The research team recommends that the TAMU system evaluate and implement the following strategies as part of its efforts to achieve transportation and campus-wide sustainability. To encourage individuals to participate in these educational programs, the university can use a series of incentives for participants similar to those discussed under commuter club.

- Develop a series of environmental literacy programs to provide expertise in environmental and social sustainability to the campus community. These programs can range from short workshops to regular courses, and can include different subjects, such as transportation sustainability. The main objectives of these programs should be to provide the skills to improve the current status of our environment and communities and to prepare a decent foundation for applying new ideas and innovations.

- Develop and deliver a voluntary travel behavior change (VTBC) program to educate and encourage individuals to make a voluntary choice of alternative transportation options. The program can be delivered on a continuous basis or as a part of new employee and student orientations. This type of program is, in fact, a transportation-oriented environmental literacy program.

- Develop and deliver an annual or biennial driver training (EcoDriving) program to provide skills and maintenance techniques proven to improve fuel efficiency and reduce the negative air quality impact of driving. Many European countries have already established such programs, and improved fuel efficiency up to 15 percent is reported as the result of applying EcoDriving techniques.

- Develop and deliver bicycle education programs to all new employees and students. The bike safety course can be made mandatory for any first-time bike registrant. UC Davis forgives a bicycle ticket, a $120 cost as of April 2008, if ticket recipients take a bicycle education course, which only costs $10. The same mechanism can be applied to EcoDriving programs.

Marketing and Outreach

Marketing and outreach play key roles in reducing single-occupancy vehicles. This is achieved through informing people about their transportation choices, emphasizing the benefits of alternative transportation, and making the use of alternative transportation the mainstream culture of the campus.

The goal of a sustainable transportation marketing program must be to ensure that all the individuals who commute to campus are aware of all available options for commuting and traveling in and around campus. The effectiveness of marketing programs heavily depends on the continuity of it. The target population must be constantly reminded of their choices. The marketing program for the city of Portland, Oregon, is estimated to have reached every household in the target area at least five times. Interested participants are reached at least 10 times.

There are a wide variety of programs offered in terms of marketing strategies. The transportation marketing program at Stanford is one of the best examples of the success of such strategies in lowering the number of SOV trips to campus. It is strongly recommended that a sustainable transportation marketing and outreach program be established within Transportation Services as an integral part of their alternative transportation program. The following are some of the specific tasks that can be implemented through such a program at TAMU:

- Hold a transportation fair, use displays, and designate biking and walking days.
- Prepare and distribute alternative transportation guides.
- Develop place-specific travel plans for campus commuters. A travel plan outlines place-specific alternative transportation options available for the trip to campus.
- Prepare a variety of promotional brochures and guides, bi-annual postcards, poster campaigns, bus advertisements, and targeted email and mail campaigns to promote alternative transportation options.
- Integrate the marketing information and materials into new student and employee orientations.
- Use known public figures and local public media to reach a broader audience for the purpose of promoting alternative transportation options.

Other Strategies

- Evaluate the possibility of including the green house gas (GHG) footprint of campus in the future revisions of the master plan. A system's GHG emissions and its contribution to global climate change have increasingly become important factors in evaluating its sustainability. TAMU needs to plan pro-actively and include this factor in its campus and transportation planning goals and objectives. The University of Washington and Stanford University are examples of university campuses that have started such considerations.
- Maintain a GIS-based database of all students, faculty, and staff through Transportation Services. The database will provide a powerful tool for different purposes, including planning, sustainable transportation, multimodal connection design, and marketing.
- Students, staff, and faculty who live on or near the campus are more likely to take advantage of alternative travel modes. TAMU has different ways to influence the land use around its campus to support its sustainability goal. It is recommended that the university administration evaluate all its options with regards to reshaping the development around its campus. The main objective of such actions should be to increase the density and connectivity of surrounding neighborhoods within walking and biking distance. The following are some of these options:
    - Offer low-cost loans to developers who follow TAMU guidelines for development around campus. Pedestrian and bike network connectivity and

population density are among the factors that such guidelines should address clearly.

  - Establish an Employer Assisted Housing (EAH) program. The program could provide a suite of incentives to faculty and staff members who choose to reside within selected neighborhoods (i.e., within walking distance). Interest-free and forgivable loans, loan guarantees, credit counseling, and down-payment assistance are among the options within an EAH.

- TAMU can utilize its resources to promote the purchase of low-emission and high-fuel-efficiency vehicles by its employees. Interest-free, forgivable loans and preferential parking programs are the two most popular options in this type of program. The university system could set some standards (e.g., fuel efficiency greater than 40 mpg) or establish a list of preferred vehicles for this purpose. The loan forgiveness mechanism could be set up based on the continuous employment with the university system.

- Make an official commitment to increase the share of low-emission and alternative-fuel vehicles in the university fleet. Develop a system-wide guideline for purchasing new vehicles that support this commitment.

CHAPTER 8: CONCLUDING REMARKS

The importance of transportation sustainability has been gradually gaining acceptance among different organizations. Higher education institutions are adopting sustainable transportation systems in order to reduce their parking construction and operations costs, improve livability on their campuses, and reduce their negative impact on the environment.

When referring to a higher education campus, sustainable transportation almost always translates into reducing single-occupancy trips to campus and encouraging the use of more efficient transportation modes. The most important challenge with regard to sustainable campus transportation systems is to ensure that its concepts are implemented in a comprehensive manner, addressing institutional organization of a sustainable campus transportation system, parking management, improved alternative transportation infrastructure, incentives, and marketing and education. This study addresses these aspects of transportation sustainability with a focus on Texas A&M University, in College Station, Texas.

The research was able to accomplish its goal through the completion of the literature review, correspondence with TAMU's Parking and Transportation Services, a review of the sustainability plans of other universities in Texas, site visits to a sample of selected universities with successful sustainable transportation programs, and a review of the university's master plan. Together, these resources provided context for determining a sustainable transportation framework for the TAMU campus. The following are some of the specific findings of this study:

- The majority of the investigated universities in Texas do not have a sustainable transportation plan for their campuses. Many of these universities have stated a commitment to general sustainability; however, the concept of sustainable transportation is generally missing from their master plans. The master plans of the majority of these universities state a goal to improve the pedestrian and biking traffic on campus by restricting private vehicles to the periphery of their campuses and to building parking structures instead of parking lots. Only one university recognizes the traffic to campus as a problem and sets objectives for reducing the overall campus parking demand through a set of transportation demand management programs.

- Currently, the air quality impact of a campus transportation system is not an important factor in campus transportation planning and policy-making procedures. There are very few universities throughout the nation that are in the process of incorporating air quality impacts of their system as a decision factor in their planning processes.

- The current TAMU transportation practice of satisfying the campus' increasing parking demand has led to a commitment to provide service to single-occupant vehicles at the expense of more efficient modes, such as biking and walking. The university needs to make a visible and meaningful top-level institutional commitment to reduce the vehicular traffic to campus in order to improve its sustainability performance record.

- It is found that more than 80 percent of vehicular traffic to campus consists of single-occupancy vehicles. It is also observed that traffic share appears to be evenly divided

between passenger cars and light trucks (SUVs/trucks/minivans). The collected data reveal a statistically significant difference between students and university employees in terms of their commuting driving distances. Employees tend to live farther than students. The travel time for the majority of TAMU parking users is observed to be between 10 to 20 minutes.

- The case studies covered in this project show that in a successful sustainable transportation system, SOV traffic demand control measures and improved alternative transportation choices must be implemented at the same time. People are discouraged from driving to campus (higher parking prices, parking-cash-out) and at the same time they are provided with a package promoting alternative transportation modes (e.g., transit passes, improved bike network, emergency ride home services, etc.).

- Marketing and outreach programs were found to play a critical role in maximizing the sustainable transportation strategies. This is achieved through informing people about their transportation choices, emphasizing the benefits of alternative transportation, and making the use of alternative transportation part of the mainstream culture of the campus.

- The recommended sustainable transportation framework for TAMU consists of the following steps and components: 1) recognize the drive-alone vehicular traffic to campus as a problem of the system and committing to reduce it, 2) establish a sustainable transportation council to set goals, objectives, and guiding principles for the campus transportation system, 3) include recommendations of the council in the future revisions of the campus master plan, 4) adopt an integrated transportation planning approach for the campus, and 5) establish a performance monitoring system to screen the progress toward the established sustainability goals and objectives.

- The recommended sustainable transportation system at TAMU should focus on supporting users of sustainable transportation modes, establishing partnerships between stakeholders, and reevaluating campus automobile-oriented transportation services to create disincentives to driving and opportunities to shift to more efficient modes.

- Specifically, this study recommends programs to 1) create disincentives for driving alone to campus through restructuring parking permits and fees and adopting a more reasonable parking-to-user ratio at campus, and 2) encourage individuals to shift to alternative transportation modes through improved pedestrian and biking infrastructure, enhanced marketing and outreach programs, and a package of incentives and benefits for alternative transportation users.

REFERENCES

1 Sample Letter to Colleges and Universities. American Council of Education (ACE) and United Stated Environmental Protection Agency (EPA) (2004). url: http://counsel.cua.edu/Environment/EPA_ACE_Letter.pdf. Accessed March 2007.

2 W. Toor and S. Havlick. *Transportation and Sustainable Campus Communities: Issues, Examples, Solutions*. Island Press, Washington, D.C., 2004.

3 C.J.L. Balsas. Sustainable Transportation Planning of College Campuses. *Transportation Policy* 10, 2003, pp. 35-49.

4 D. Orr. The Problem of Education. *New Directions for Higher Education, No. 77 (The Campus and Environmental Sustainability)*, Vol. 20, No. 1, pp. 3-8, Spring 1992. Jossey-Bass, San Francisco.

5 *Alternative Transportation and Parking Investment Study, Final Report*. Bay Area Economics and Nelson\Nygaard Consulting Associates. Presented to the University of California, Davis, Transportation and Parking Services, October 2006. url: http://taps.ucdavis.edu/resources/transportation/ATPInvestmentStudy.pdf.

6 What is Sustainable Transportation? *The Centre for Sustainable Transportation* Homepage. The University of Winnipeg. Winnipeg, Manitoba, Canada. 2006. url: http://cst.uwinnipeg.ca. Accessed July 2008.

7 *Mobility 2030: Meeting the Challenges to Sustainability*. World Business Council for Sustainable Development. 2004. url: http://www.wbcsd.org/web/publications/mobility/mobility-full.pdf. Accessed July 2008.

8 *College Sustainability Report Card: A Review of Campus & Endowment Policies at Leading Institutions*. Sustainable Endowments Institute, Cambridge, Massachusetts. 2008.

9 Website, *Vision 2020*, Texas A&M University, College Station, Texas. url: http://www.tamu.edu/vision2020/. Accessed July 14, 2008.

10 *Campus Master Plan*. Texas A&M University, College Station, Texas. url: http://www.tamu.edu/campusplan/. Accessed July 14, 2008.

11 Website, *Sustainable Development Program*. Texas A&M University, College Station, Texas, updated November 2007. url: http://sdp.tamu.edu/. Accessed July 14, 2008.

12 Website, *Environmental Issues Committee*. Texas A&M University, College Station, Texas. url: http://eic.tamu.edu. Accessed July 14, 2008.

13 "Aggieland Maroon is Turning 'Green'," *Texas A&M News and Information*, September 14, 2007. Texas A&M University, College Station, Texas. url:

http://tamunews.tamu.edu/archives/article.php?articleid=5023&month=9&year=2007. Accessed July 14, 2008.

14 *The History of Transportation Services*. Texas A&M University Transportation Services. url: http://transport.tamu.edu/about/history.aspx. Accessed May 9, 2008.

15 Campus Sustainability Policy. *Revised Handbook of Operating Procedures: Part 1*. University Administration, Section A. General Provisions, Policy Number: 1.A.3. University of Texas at Austin, issued April 22, 2008. url: http://www.utexas.edu/policies/hoppm/01.A.03.html.

16 "Our Common Future, Report of the World Commission on Environment and Development." Published as an Annex to General Assembly Document A/42/427, *Development and International Co-operation: Environment*. World Commission on Environment and Development, August 2, 1987.

17 *Sustainability Studies at the University of Texas*. Environmental Science Institute, University of Texas at Austin, updated November, 2007. url: http://www.esi.utexas.edu/research/sustainability.html. Accessed June 10, 2008.

18 *Campus Master Plan*. University of Texas at Austin, 1999. url: http://www.utexas.edu/books/campusmasterplan/pdf/masterplan-toc.pdf. Accessed June 10, 2008.

19 Website, *Center for Sustainable Development*. The School of Architecture at the University of Texas at Austin. url: http://utcsd.org/. Accessed June 16, 2008.

20 Website, *Center for Energy and Environmental Resources*. University of Texas at Austin. url: http://www.utexas.edu/research/ceer/. Accessed June 16, 2008.

21 Website, *Office of Environmental Health and Safety*. University of Texas at Austin. url: http://www.utexas.edu/safety/ehs/index.php. Accessed June 16, 2008.

22 Website, *Bridging Disciplines Program*. University of Texas at Austin. url: http://www.utexas.edu/ugs/bdp/programs/env/. Accessed June 16, 2008.

23 Website, *Integrated Watershed Science Graduate Portfolio Program*. Environmental Science Institute, University of Texas at Austin, updated April 2007. url: http://www.esi.utexas.edu/watersheds/portfolio.html. Accessed June 16, 2008.

24 Website, *Engineers for a Sustainable World*. University of Texas at Austin. url: http://www.utexas.edu/esw/index.html. Accessed June 17, 2008.

25 Website, *Campus Environmental Center*. University of Texas at Austin. url: http://www.utenvironment.org/content/index.php?option=com_frontpage&Itemid=1. Accessed June 17, 2008.

26 *Paving the Way for Success*. 2006-2007 PTS Annual Report. Parking and Transit Services, University of Texas at Austin, 2007. url: http://www.utexas.edu/parking/about/annual_report/. Accessed June 24, 2008.

27 Website, *Campus Master Plan*. University of Houston, Houston, Texas, 2006. url: http://www.uh.edu/about/initiatives/masterplan/. Accessed July 15, 2008.

28 Website, *Parking and Transportation Services*. University of Houston, Houston, Texas. url: http://www.uh.edu/plantops/pts/pts.html. Accessed June 15, 2008.

29 *Campus Master Plan*. University of North Texas, Denton, Texas, 2005. url: http://www.unt.edu/untmasterplan/index.html. Accessed July 16, 2008.

30 Website, *Students for a Sustainable Campus*. University of North Texas, Denton, Texas, updated 2006. url: http://orgs.unt.edu/ssc/. Accessed July 16, 2008.

31 Website, *Transportation Services*. University of North Texas, Denton, Texas, updated July 9, 2008. url: http://www.unt.edu/transit/. Accessed July 16, 2008.

32 *Campus Master Plan*. University of Texas at San Antonio, 2004. url: http://www.utsa.edu/ofpd/1604%20master%20plan%20web%20site/main.html. Accessed June 16, 2008.

33 Website, *Parking and Transportation Services*. University of Texas at San Antonio. url: http://www.utsa.edu/parking/index.htm. Accessed July 16, 2008.

34 *Campus Master Plan and Guidelines 2006-2015*. Texas State University, San Marcos, Texas, 2005. url: http://www.vpfss.txstate.edu/cmp/. Accessed June 23, 2008.

35 Website, *Sustainable Communities – Building Sustainable Communities*. Quality Enhancement Plan. Texas State University, San Marcos, Texas. url: http://www.sacs-qep.txstate.edu/QEP-timeline/Narrowed-themes/Sustainable-Communities.html. Accessed June 23, 2008.

36 Website, *Bobcat Tram*. Texas State University, San Marcos, Texas. url: http://www.tram.txstate.edu/. Accessed June 23, 2008.

37 *Texas Tech University 2005 Strategic Plan*. Texas Tech University, Lubbock, Texas. url: http://www.ttu.edu/stratplan/universitystratplan.php. Accessed June 23, 2008.

38 Website, *Parking Services*. Texas Tech University, Lubbock, Texas. url: http://www.depts.ttu.edu/parking/index.php. Accessed June 28, 2008.

39 *Campus Master Plan Update and Design Guidelines 2005 – 2020*. University of Texas at Arlington, 2007. url: http://www.uta.edu/masterplan/. Accessed August 4, 2008.

40 Website, *Mavericks Go Green: Campus Sustainability*. University of Texas at Arlington, 2007. url: http://www.uta.edu/sustainability/. Accessed August 4, 2008.

41 Website, *President's Sustainability Committee*. University of Texas at Arlington, 2008. url: http://blog.uta.edu/sustainability/. Accessed August 4, 2008.

42 *Facilities Master Plan 2002*. University of Texas at El Paso, 2002. url: http://admin.utep.edu/Default.aspx?alias=admin.utep.edu/construction. Accessed August 5, 2008.

43 Website, *Sustainable Engineering Initiative*. University of Texas at El Paso, 2001. url: http://www.utep.edu/green/index.htm. Accessed August 5, 2008.

44 *2020 Master Plan*. University of Texas at Brownsville and Texas Southmost College, 2004. url: http://blue.utb.edu/vppa/MasterPlan.html. Accessed August 5, 2008.

45 *Campus Master Plan*. University of Texas at Pan American, 2000. url: http://www.utsystem.edu/FPC/docs/CampusMasterPlan/UTPANAM.PDF. Accessed August 5, 2008.

46 *Y2K + 10 Campus Master Plan*. Sam Houston State University, Huntsville, Texas. url: http://www.shsu.edu/administrative/y2k+10/. Accessed August 6, 2008.

47 *Campus Planning and Plant Operations: Executive Summary*. Southern Methodist University, Dallas, Texas, 2004. url: http://smu.edu/campus_planning/Master_Plan.asp.

48 *Fast Facts: SMU Environmentally Friendly Programs and Projects*. Office of Public Affairs, Southern Methodist University, Dallas, Texas. url: http://www.smu.edu/publicaffairs/. Accessed October 4, 2007.

49 Website, *Sustainability at Rice*. Rice University, Houston, Texas, updated July 25, 2008. url: http://cohesion.rice.edu/facilities/sustainability/index.cfm. Accessed August 6, 2008.

50 Website, *Administrative Services: Campus Operations*. Abilene Christian University, Abilene, Texas. url: http://www.acu.edu/campusoffices/adminsvcs/green/Initiatives/index.html. Accessed August 6, 2008.

51 *Online TDM Encyclopedia*. Victoria Transport Policy Institute, updated September 2007. url: http://www.vtpi.org/tdm/index.php. Accessed April 17, 2008.

52 J. Brown, D. Hess, and D. Shoup. Unlimited Access. *Transportation*, Vol. 28, No. 3, 2001, pp. 233-267.

53 T. Shannon, B. Giles-Corti, T. Pikora, M. Bulsara, T. Shilton, and F. Bull. Active Commuting in a University Setting: Assessing Commuting Habits and Potential for Modal Change. *Transport Policy*, Vol. 13, No. 3, 2006, pp. 240-253.

54 Parsons Brinckerhoff Quade & Douglas, Inc. *Data Collection and Modeling Requirements for Assessing Transportation Impacts of Micro-Scale Design*. Transportation Model Improvement Program, Federal Highway Administration, Washington, D.C., 2000.

55 J. Evans and R. Pratt. *Vanpools and Buspools - Traveler Response to Transportation System Changes*. In TCRP Report 95, Transit Cooperative Research Program, Transportation Research Board, Washington, D.C., 2005.

56 *Commute Club* Homepage. *Parking and Transportation Services* website. Stanford University, Stanford, California. url: http://transportation.stanford.edu/alt_transportation/Commute_Club.shtml#join. Accessed May 9, 2008.

57 Website, *University of Washington Commuter Services*. University of Washington, Seattle, Washington. url: http://www.washington.edu/commuterservices/parking/fees_descriptions/WCGPPUP.php. Accessed July 9, 2008.

58 Website, *Parking and Transportation Services*. Stanford University, Stanford, California. url: http://transportation.stanford.edu/alt_transportation/Programs.shtml. Accessed February 19, 2009.

59 Website, *Virginia Tech Facilities*. Virginia Tech University, Blacksburg, Virginia. url: http://www.facilities.vt.edu/ot/alternative/cap.asp. Accessed June 4, 2008.

60 *Visitor Parking* Homepage. Texas A&M University Transportation Services, College Station, Texas. url: http://transport.tamu.edu/parking/visitor.aspx. Accessed July 9, 2008.

61 Website, *MIT Department of Facilities*. Massachusetts Institute of Technology, Cambridge, Massachusetts. url: http://web.mit.edu/facilities/transportation/parking/student. Accessed May 9, 2008.

62 Website, *University of Washington Facilities Services*. University of Washington, Seattle, Washington. url: http://www.washington.edu/commuterservices/programs/upass/driving_alone.php. Accessed May 9, 2008.

63 J. Dagget and R. Gutkowski. *University Transportation Survey: Transportation in University Communities*. City of Fort Collins and Colorado State University, Fort Collins, Colorado. 2002.

64 W.L. Schwartz. Applying Performance-Based Planning to Congestion Management. *ITE Journal*, Vol. 68, No. 1, 1998, Institute of Transportation Engineers, Washington, D.C.

65 *Multimodal Transportation: Development of a Performance-Based Planning Process*. NCHRP 8-32(2), Draft Final Report. Transportation Research Board, Washington, D.C., 1999.

66 S. Pickrell and L. Neumann. Use of Performance Measures in Transportation Decision Making. In *Performance Measures to Improve Transportation Systems and Agency Operations* (Conference Proceedings 26). National Research Council, Transportation Research Board, Washington, D.C., 2001.

67 *The Plan* Homepage. *CU Boulder Campus Master Plan*. University of Colorado at Boulder, 2001. url: http://www.colorado.edu/masterplan/plan/index.html. Accessed May 9, 2008.

68 P. Hart. Would Incentives Prompt Employees to Buy Homes Near Pitt? *University Time – The Faculty and Staff Newspaper*, Vol. 36, No. 10, January 22, 2004. University of Pittsburg, Pittsburg, Pennsylvania.

69 *Understanding Employer-Assisted Housing: A Guidebook for Employers*. Homes for Working Families Metropolitan Planning Council. Washington, D.C., 2007. url: http://www.msgcrc.com/pdfs/UnderstandingEmployerAssistedHousing.pdf. Accessed February 17, 2009.

70 *Google Information* Homepage. Google, Inc. url: http://www.google.com/corporate/culture.html. Accessed May 9, 2008.

71 J. Malczewski. *GIS and Multicriteria Decision Analysis*. J. Wiley & Sons, New York, New York. 1999.

72 Website, *Missoula Institute for Sustainable Transportation*. url: http://www.sustainabletransportation.org/round.html. Accessed May 9, 2008.

73 L. Weiner and C. Katz. *Fact Sheet: ZipCars on Campus*. CooperKatz & Compancy. Updated January, 2008. url: http://www.zipcar.com/press/onlinemediakit/zipcars_on_campus.pdf. Accessed February 17, 2009.

74 *University of Denver Commute Club* Homepage. Transportation Center at the University of Denver, Denver, Colorado. url: http://www.du.edu/transcenter/commute/. Accessed May 9, 2008.

75 R. Picado. A Question of Timing, *Access,* No. 17, Fall 2000, pp. 9-13. University of California Transportation Center, Berkeley, California.

76 *CommuterChoice.com* Homepage. url: http://www.commuterchoice.com/. Accessed May 9, 2008.

77 *Accor Services USA* Homepage. Updated 2007. url: http://www.accorservicesusa.com/. Accessed June 9, 2008.

78 *TravelSmart* Homepage. State Government of Victoria, Australia. url: http://www.travelsmart.vic.gov.au/. Accessed June 4, 2008.

79 *RTA Mobility Management Case Study*. Roads and Traffic Authority, New South Wales, Australia. 2003. url: http://www.rta.nsw.gov.au. Accessed February 17, 2009.

80 E.S. Ampt. Understanding Voluntary Travel Behaviour Change. *Transport Engineering in Australia*, Engineers Australia, Vol. 9, No. 2, 2004, pp. 53-66.

81 M. Taylor. Voluntary Travel Behavior Change Programs in Australia: The Carrot Rather Than the Stick in Travel Demand Management. *International Journal of Sustainable Transportation*, Vol. 1, No. 3, 2007, pp.173-192.

82 *2006 Blueprint for a Green Campus*. University of Colorado Envirnomental Center, University of Colorado, Boulder. 2006. url: http://ecenter.colorado.edu/blueprint06/. Accessed February 19, 2009.

83 M. Sevigny. *Taxing Automobile Emissions for Pollution Control*. Edward Edgar Publishing, Northampton, MA. 1998.

84 T. Litman. *Socially Optimal Transport Prices and Markets: Principles, Strategies and Impacts*. VictoriaTransport Policy Institute. 2007.

85 T. Litman. *Transportation Cost and Benefit Analysis*. Victoria Transport Policy Institute. 2007.

86 K.K. Spors. *Workers Get Incentives to Live Greener*. The Wall Street Journal, February 26, 2008. Dow Jones & Company, Inc. New York, New York.

87 *Fuel Economy* Homepage. U.S. Environmental Protection Agency. 2008. url: http://www.epa.gov/fueleconomy/guzzler/. Accessed June 4, 2008.

88 *Gas-Guzzler* Homepage. Wikipedia, the free encyclopedia. url: http://en.wikipedia.org/wiki/Gas_guzzler. Accessed May 9, 2008.

89 *A Roadmap for Cleaner Fuels and Vehicles in Asia*. Asian Development Band and Clean Air Initiative for Asian Cities Center. Asian Development Bank. 2007. url: www.adb.org.

90 M. Delucchi. *A Lifecycle Emissions Model (LEM): Lifecycle Emissions from Transportation Fuels, Motor Vehicles, Transportation Modes, Electricity Use, Heating and Cooking Fuels, and Materials*. ITS-Davis, Publication No. UCD-ITS-RR-03-17. Institute of Transportation Studies, University of California at Davis, 2003. url: www.its.ucdavis.edu/publications/2003/UCD-ITS-RR-03-17-MAIN.pdf. Accessed February 19, 2009.

91 D. Pickrell. *Fuel Options for Reducing Greenhouse Gas Emissions from Motor Vehicles*. U.S. Department of Transportation's Center for Climate Change and Environmental Forecasting. 2003. url: http://climate.volpe.dot.gov/docs/fuel.pdf. Accessed February 19, 2009.

92 J. Bourne. Biofuels: Boon or Boondoggle? *National Geographic*, October 2007, pp. 38-59.

93 A. Neiderberger. The Swiss Climate Penny: An Innovative Approach to Transport Sector Emissions. *Transport Policy*, Vol. 12, No. 4, 2005, pp. 303-313.

94 *Fuel Efficiency Automobile Test (FEAT) Data Center* Hompage. University of Denver. url: http://www.feat.biochem.du.edu/. Accessed May 9, 2008.

95 *Energy Efficiency Policies and Measures: Eco Driving Courses*. url: http://www.iea.org/textbase/pm/?mode=pm&id=355&action=detail. Accessed June 4, 2008.

96 *The Energy Environment Excellence (E3) Fleet* Homepage. url: http://www.e3fleet.com/mc/page.do. Accessed June 9, 2008.

97 *Air* Hompage. U.S. Environmental Protection Agency. url: http://www.epa.gov/ebtpages/air.html. Accessed June 4, 2008.

98 *Office of Energy Efficiency* Homepage. National Resources, Canada. url: http://oee.nrcan.gc.ca/english/index.cfm. Accessed May 9, 2008.

99 T. Litman and G. Lovegrove. *UBC TREK Program Evaluation: Costs, Benefits and Equity Impacts of a University TDM Program*. Victoria Transport Policy Institute. 1999. url: http://www.trek.ubc.ca/research/pdf/utrek_eval.pdf. Accessed February 19, 2009.

100 *U-Pass Report 2006-2007*. Commuter Services, University of Washington, Seattle, Washington. url: http://www.washington.edu/commuterservices/programs/upass/reports/annualreport2007.pdf. Accessed February 19, 2009.

101 *Stanford University* Homepage. Stanford University, Stanford, California. url: http://www.stanford.edu/. Accessed October 2008.

102 *Sustainable Stanford* Homepage. Stanford University, Stanford, California. url: http://sustainablestanford.stanford.edu/index.php. Accessed October 2008.

103 Website, *Sustainable Stanford Working Group and Teams*. Sustainable Stanford Program, Stanford University, Stanford, California. url: http://sustainablestanford.stanford.edu/working_group_and_teams. Accessed October 2008.

104 Website, *Transportation*. Sustainable Stanford Program, Stanford University, Stanford, California. url: http://sustainablestanford.stanford.edu/transportation. Accessed October 2008.

105 Website, *Climate Action*. Sustainable Stanford Program, Stanford University, Stanford, California. url: http://sustainablestanford.stanford.edu/climate_action. Accessed October 2008.

106 *Annual Emissions Report*. Stanford University, Stanford, California. May 2008. url: http://sustainablestanford.stanford.edu/sites/sem.stanford.edu/files/documents/Stanford_emissions_inventory.pdf. Accessed October 2008.

107 Website, *The Initiative on the Environment and Sustainability*. *Giving to Stanford* Homepage. Stanford University, Stanford, California. url: https://pgnet21.stanford.edu/get/layout/tsc/Environment. Accessed October 2008.

108 *Parking and Transportation Services* Homepage. Stanford University, Stanford, California. url: http://transportation.stanford.edu/. Accessed October 2008.

109 Website, *Alternative Transportation*. Parking and Transportation Services Department, Stanford University, Stanford, California. url: http://transportation.stanford.edu/alt_transportation/. Accessed October 2008.

110 Website, *Marguerite Shuttle*. Parking and Transportation Services, Stanford University, Stanford, California. url: http://transportation.stanford.edu/marguerite/MargueriteShuttle.shtml. Accessed October 2008.

111 Website, *Biking at Stanford*. Parking and Transportation Services, Stanford University, Standford, California. url: http://transportation.stanford.edu/alt_transportation/BikingAtStanford.shtml. Accessed October 2008.

112 Website, *Commute Cost and Carbon Emissions Calculator*. Parking and Transportation Services, Stanford University, Stanford, California. url: http://transportation.stanford.edu/alt_transportation/calculator.shtml. Accessed October 2008.

113 *University of Washington* Homepage. University of Washington, Seattle, Washington. url: http://www.washington.edu/. Accessed October 2008.

114 *Campus Master Plan* Homepage. Office of External Affairs, University of Washington, Seattle, Washington. url: http://www.washington.edu/community/cmp_site/final_cmp.html. Accessed October 2008.

115 Website, *General Policies*. *Campus Master Plan* Homepage. Office of External Affairs, University of Washington, Seattle, Washington. url: http://www.washington.edu/community/cmp_site/cmpfinal/03_General_Policies_FP.pdf. Accessed October 2008.

116 *Transportation Management Plan*. University of Washington, Seattle, Washington. January 2003. url: http://www.washington.edu/community/cmp_site/cmpfinal/07_TMP_FP.pdf. Accessed October 2008.

117 *Transportation Services* Homepage. Facilities Services, University of Washington, Seattle, Washington. url: http://www.washington.edu/facilities/transportation/index.php. Accessed October 2008.

118 *Environmental Stewardship* Homepage. University of Washington, Seattle, Washington. url: http://www.washington.edu/about/environmentalstewardship/about_esac.html. Accessed October 2008.

119 *Environmental Stewardship Advisory Committee 2007 Annual Report*. University of Washington, Seattle, Washington. September 2007. url: http://www.washington.edu/about/environmentalstewardship/ESAC_2007_Annual_Report.pdf. Accessed October 2008.

120 *University of California, Davis* Homepage. University of California, Davis, California. url: http://www.ucdavis.edu/visiting/. Accessed October 2008.

121 S. Shaheen, C. Rodier, and R. Finson. *University of California, Davis Long-Range Development Plan: A Davis Smart Mobility Model*. California PATH Program, University of California Berkeley, Berkeley, California. October 2003. url: http://www.its.ucdavis.edu/publications/2003/UCD-ITS-RP-03-14.pdf. Accessed November 2008.

122 *University of California, Davis 2003 Long Range Development Plan* Homepage. Office of Resource Management and Planning, University of California at Davis. url: http://www.ormp.ucdavis.edu/environreview/lrdp.html#2003LRDP#2003LRDP. Accessed October 2008.

123 *Environmental Impact Report*. Office of Resource Management and Planning, University of California at Davis. url: http://www.ormp.ucdavis.edu/environreview/lrdp.html#lrdpeir. Accessed October 2008.

124 *The Sustainable Campus* Homepage. University of California at Davis. url: http://sustainability.ucdavis.edu/campus.html. Accessed October 2008.

125 Website, *Sustainability Advisory Committee*. *The Sustainable Campus* Homepage. University of California at Davis. url: http://sustainability.ucdavis.edu/about/committee.html. Accessed October 2008.

126 Website, *Blueprint for a Green Future*. *The Sustainable Campus* Homepage. University of California at Davis. January 2006. url: http://sustainability.ucdavis.edu/pdflibrary/sustainabilityblueprint.pdf. Accessed October 2008.

127 *Transportation and Parking Services* Homepage. University of California at Davis. url: http://www.taps.ucdavis.edu/. Accessed October 2008.

128 *Alternative Transportation and Parking Investment Study*. University of California at Davis. October 2006. url: http://www.taps.ucdavis.edu/resources/transportation/ATPInvestmentStudy.pdf. Accessed October 2008.

129 *EV Charger News* Homepage. url: http://www.evchargernews.com/regions/ch-sac-all.htm. Accessed October 2008.

APPENDIX A: CAMPUS PARKING SURVEY

2008 TTI QUICK CAMPUS PARKING SURVEY

This survey is designed for drivers who are using on-campus parking.
Please fill in all answers completely. The information from this survey will be used only for research purposes.

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1. Gender? ○ Female ○ Male

2. What is your designation at TAMU?
- ○ Staff
- ○ Undergraduate Student → ○ Freshman / ○ Sophomore / ○ Junior / ○ Senior
- ○ Graduate Student
- ○ Faculty
- ○ Other (visitor, etc.)

3. Including yourself, how many people rode to campus in your vehicle today?
- ○ One
- ○ Two
- ○ Three
- ○ Four or more

4. How many days did you drive to campus last week?
- ○ One
- ○ Two
- ○ Three
- ○ Four or more

5. How many times do you drive to campus today?
(including all trip purposes such as: going to class, lunch, gym, etc.)
- ○ One
- ○ Two
- ○ Three
- ○ Four
- ○ Five or more

6. What is your home ZIP code that you drove from today? ☐☐☐☐☐

7. How far did you drive to campus today? (approximately)
- ○ less than 1 mile
- ○ between 1 and 2 miles
- ○ between 2 and 5 miles
- ○ between 5 and 10 miles
- ○ more than 10 miles

8. How long did it take to drive to campus today? (approximately)
- ○ less than 10 minutes
- ○ between 10 and 20 minutes
- ○ between 20 and 30 minutes
- ○ more than 30 minutes

9. What vehicle did you drive to campus today?
Make:_____ Model:_____ Model Year:_____

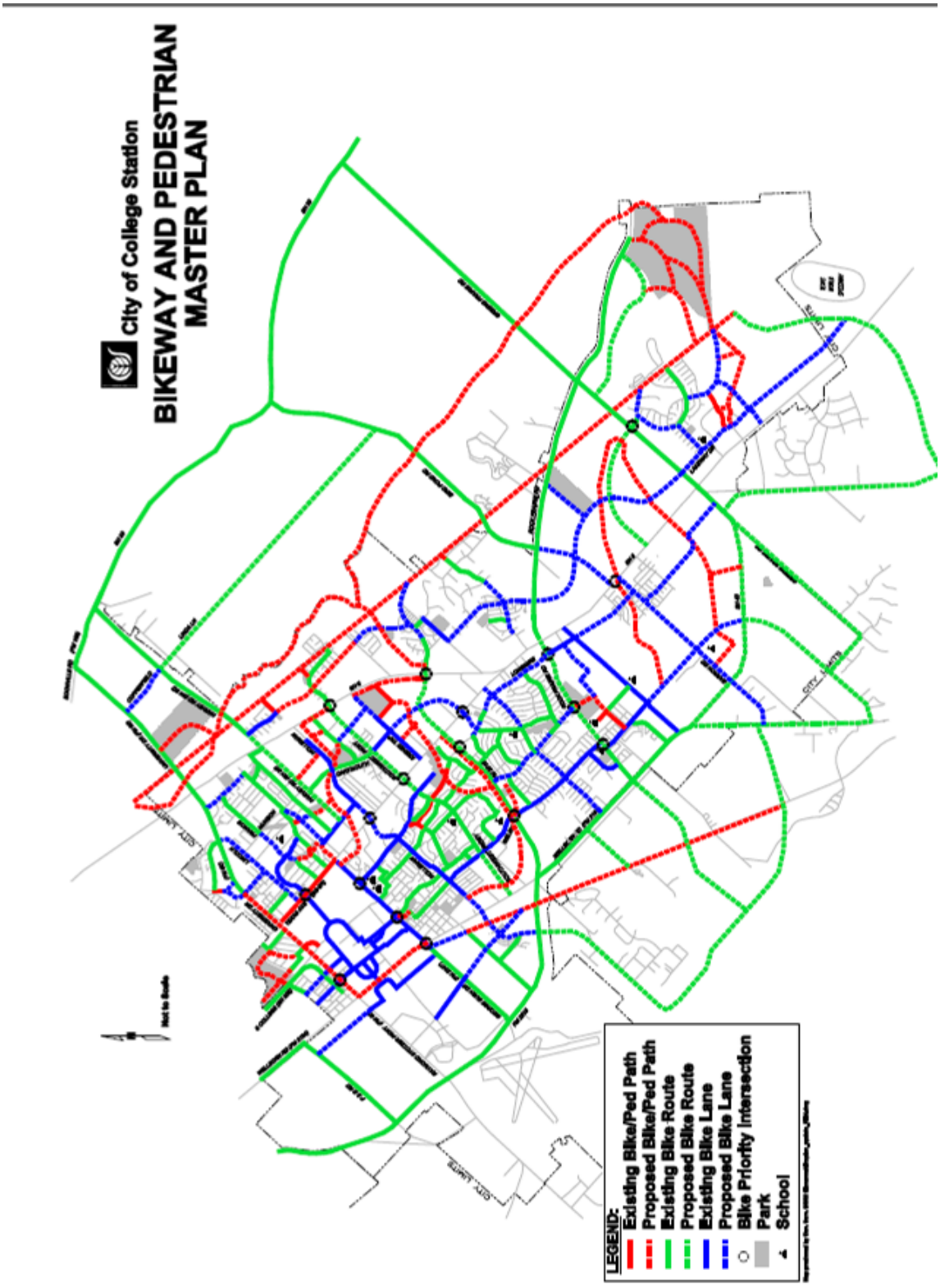
❖ Please, also provide the following information regarding this vehicle;

Vehicle Type			Fuel Type
○ Small Passenger Car	○ Small SUV	○ Light-duty Pickup Truck	○ Gasoline
○ Mid-size Passenger Car	○ Mid-size SUV	○ Mid-size Pickup Truck	○ Diesel
○ Full-size Passenger Car	○ Full-size SUV	○ Full-size Pickup Truck	○ Electric Hybrid
			○ Fully Electric
○ Motorcycle	○ Minivan		○ Natural Gas
			○ Other (specify)……....

This section is for TTI staff use only

Full name of the data collector:	**Date:** / /	
Parking lot location:	**Time:**	

APPENDIX B: COLLEGE STATION BIKEWAY AND PEDESTRIAN MASTER PLAN 2002



APPENDIX C: CITY OF BRYAN HIKE & BIKE ACCESS PLAN 2006