LEARNING FROM CAMPUS: UNIVERSITIES AS TRANSPORTATION LABORATORIES

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1. INTRODUCTION

University campuses advance the state of art in transportation planning/engineering and other fields through research and teaching. But campuses themselves, which are often like small cities, can serve as laboratories for innovations in transportation programs and infrastructure.

This paper describes a number of recent innovations from universities that advanced transportation practice. This paper first describes the range of university innovations and the advantages and disadvantages of the campus as a transportation laboratory. Then case studies of recent advancements are presented for four campuses. Finally, the paper discusses other potential near-term innovations and how the knowledge can be disseminated off campus.

2. RANGE AND EXAMPLES OF INNOVATIONS CONSIDERED

In recent decades, there has been a great range of transportation innovations tested on college and university campuses across the U.S. These innovations include both physical improvements and program advances. They have been catalyzed by growth and evolving urban planning practices. Increasing population and expectations to attend college have led to increased demands on enrollment, which in turn has put more pressure on university resources and limited budgets, particularly for the hundreds of U.S. public colleges and universities. These pressures have corresponded with a growing call for sustainable development and reductions in greenhouse gas emissions. Together, these factors have yielded new and expanded transportation programs.

2.1. Transportation Demand Management (TDM)

Campuses frequently encourage use of sustainable modes and discourage auto use via financial incentives, information, and new transportation services and facilities. Financial incentives include discounted public transit passes and subsidies for bikes and bike sharing. Campuses provide information on sustainable mode options through transportation offices and electronic/print materials. Some campuses run their own transit systems or have their own bike sharing systems.

For example, the University of Minnesota, Twin Cities offers a commuter rewards program, which allows students to earn gift cards. It also provides health insurance discounts to staff bicyclists.[1]

2.2. Transit Systems

Most university campuses are connected to urban or suburban public transit systems. A few, like Stanford and the University of California at Davis, run their own bus systems. These can provide on-campus learning experiences in transit system management and operations for student employees.

Technological innovations have also been developed. One of the first automated transit systems in the world is the personal rapid transit (PRT) system at West Virginia University.

Figure 1. West Virginia University Personal Rapid Transit (photo credit: Wikipedia)

[1] University of Minnesota web site: https://www.pts.umn.edu/bike/zap-rfid (accessed April 1, 2019).

The system, which opened in 1975, connects the three Morgantown campuses with the downtown area. The 20-passenger cars can provide a "personalized" direct service during off-peak hours, responding to user button "call."[2]

2.3. Parking facilities

Parking lots and structures are important physical and aesthetic features on campus. Their siting, size, and operations significantly affect transportation conditions.

While parking facilities near the campus core may be more convenience to some drivers, they negatively affect walking and bicycling and even the serenity of the campus core. Campuses often site parking facilities in outlying or intercept locations to promote a quieter, greener central campus.

The design and operation of parking facilities is also a major consideration. For example, electric vehicle charging facilities, preferential parking for car/vanpools, and solar power may be used. Such universities as Texas A&M, University of Oklahoma, and Colorado State University provide electronic signage on real-time parking availability plus lights above spaces to indicate whether each is occupied.[3]

2.4. Lighting

Lighting for roadways and pedestrian/bicycle paths is an important safety and security feature. It also substantially affects university utility bills and the aesthetic feel of the campus.

The University of California, Davis experience with dynamic ("smart") lighting, which adapts light levels to immediate need, is described later. The University of Utah has also been installing LED lighting with shielding to minimize adverse contributions to light pollution "sky glow."[4] The University sponsors an annual "Walk After Dark" during which participants walk every sidewalk on campus to identify potential problem locations. They use their phones to mark exact GPS locations where they find potential safety issues with lighting.

2.5. Testing of autonomous vehicles and networked transportation facilities

University campuses have been in the forefront of developments in autonomous vehicles. They have also pioneered in networking other transportation facilities. For example, since 1984, Carnegie Mellon University (CMU) has been one of the national leaders in researching self-driving vehicles. [5] CMU has branched out from autonomous vehicles through its Metro 21 Smart Cities initiative to promote technology and policy innovations with projects such as "smart curbspaces" and a smartphone-based pavement quality monitoring system.[6]

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[2] West Virginia University Website: https://prt.wvu.edu/about-the-prt/history (accessed April 1, 2019).

[3] Bill Smith, "Parking Goes Hi-Tech", *College Planning & Management,* July 2017.

[4] University of Utah website: https://attheu.utah.edu/facultystaff/bright-lights-under-a-dark-sky/ (accessed April 1, 2019).

[5] Carnegie Mellon University website: https://www.cnbc.com/2017/09/16/pittsburghs-self-driving-car-boom-means-200000-pay-packages-for-robotics-grads.html (accessed April 1, 2019).

[6] Carnegie Mellon University website: https://www.cmu.edu/metro21/projects/smartphone-road-inspection.html (accessed April 1, 2019).

2.6. Pedestrian/bicycle facilities and programs

Five colleges have earned a platinum rating from the League of American Bicyclists. [7] Two of these, Stanford and the University of California at Davis, are profiled in case studies below. The others include:

- *Colorado State University* offers more than 17,000 bike parking spaces, discounted bike share membership, and a bike path directly to downtown Fort Collins.
- *The University of Minnesota, Twin Cities* offers a full-service bike shop, which includes showers, parking, and classes on winter cycling. The University also has a a bike sharing program.
- *Portland State University's Initiative for Bicycle and Pedestrian Innovation (IBPI)* is a national leader in experiential learning, using the campus and Portland as a "living laboratory." IBPI involves government agencies and advocacy groups in research and evaluation, curriculum development, and education.

Although it incurred a tragic structural failure in 2018 leading to six deaths, the Florida International University pedestrian bridge from campus over US Route 41 represented an attempt at innovative construction of a 174-foot "signature" span. Imitation cables connected to a 109-foot-tall pylon.[8]

3. CAMPUS ADVANTAGES AND LIMITATIONS FOR INNOVATING

3.1. Advantages

University and college campuses often function like small cities, but with certain advantages for making transportation innovations. They often have large resident populations, mostly or entirely students, who are relatively young, physically active, and ready to change basic habits, especially to support sustainable transportation. Resident students are subject to campus control of their parking of autos on campus (to an extent that would be unusual for most other citizens). For example, a campus may not provide residential auto parking to first-year students.

Universities of course often have a tremendous talent pool among faculty and students. University culture generally encourages innovation.

University governance is relatively simpler than most local governments. For example, major transportation improvements and programs may be subject only to the approval of a Board of Trustees, relatively insulated from resident "political pressure" compared to city councils. A faculty senate and/or student government body may also be involved in decision making, but these tend to be supportive of sustainable modes.

3.2. Limitations

The typical limitations felt by public agencies concerning programmatic and infrastructure innovation are shared by campuses. Universities usually face stiff competition for limited resources, particularly funding. There are many priorities that must be considered. With students turning over more quickly than residential populations in a typical city, there is less opportunity for grassroots advocates to develop long-term expertise and influence.

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[7] League of American Bicyclists website: https://bikeleague.org/sites/default/files/BFU_Award_List_2018_ALL.pdf. (accessed April 1, 2019).

[8] Miami Herald website: https://www.miamiherald.com/news/local/community/miami-dade/article212571434.html (accessed April 1, 2019).

4. CAMPUS CASE STUDIES

4.1. Overview of Case Studies

This section presents four case studies of transportation innovations at university campuses. Each is intended to illustrate how increasing transportation demands are addressed with innovative solutions to reach academic and campus growth goals. They include three California campuses and one Midwest campus, three public universities and one private, with a range of sizes.

4.2. Stanford University

Stanford University was founded on a large (8,000-acre) suburban site on the San Francisco Peninsula. The University was a major contributor to the development of Silicon Valley.

Stanford has grown significantly in recent years. The campus serves roughly 17,000 students, about a 50 percent increase since the 1970's. This growth has led to friction with affluent neighboring communities.

In 2000, the University agreed to caps on auto trips to and from campus as part of a development approval with Santa Clara County.[9] Mitigation measures are triggered when cordon traffic volumes exceed baseline volumes, modified by trip reduction credits, by 1 percent or more for any two out of three consecutive years.

To reduce auto travel to and on campus, Stanford runs an extensive TDM program and its own shuttle bus network. Stanford's "Commute Club" boasts that in 2017, 57 percent of commuters to campus used alternative (sustainable) modes. The University offers TDM incentives such as:

- Lottery entrance for members to win cash prizes;
- Free and discount transportation offers;
- AC Transit East Bay express bus U free for students;
- Carsharing discount;
- Bike services (free repair stands and safety classes, low-cost registration);
- Free commute trip planning and carpool matching;
- Eligible commuters get commuter rail (Caltrain) pass and a Santa Clara County Transit pass free;
- Folding bike discounts for eligible commuters;
- Vanpool subsidy; and
- Emergency ride home program.

The most substantial measure is the extensive Marguerite shuttle service. It connects the main campus, medical campus, an adjacent regional shopping center, two Caltrain commuter rail stations, downtown Palo Alto, and off-campus research facilities. Marguerite runs 75 buses. Ridership averages around 11,000 boardings daily, with the vast majority of trips during peak hours to and from the Caltrain commuter rail station.[10]

Each campus has a unique set of circumstances that permit innovations such as these, and in Stanford's case, these circumstances identified through this case study involve: availability and commitment of university resources to support new programs, collaborative coordination with regional agencies, and an established campus staff organization to support these creation and maintenance of these programs.

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[9] Santa Clara County, 2000 General Use Permit for Stanford University development.

[10] Personal communication, Brian Jackson, Transportation Operations Manager, Stanford University, April 1, 2019.

4.3. University of California, Davis

The University of California at Davis is located in the small city (about 70,000 residents) that describes itself as the "bike capital of the U.S." The Davis City logo even includes a bicycle. Accordingly, the campus of some 35,000 students has extensive bike facilities and programs, which contributed to a 47 percent student bike commuting mode share, roughly double the shares of either drive alone or bus.[11] Like Stanford, UC Davis is immediately adjacent to a small city's downtown and about 30 miles from a large city (Sacramento). However, unlike Stanford, Davis is not in a major metropolitan area.

There is an extensive network of bike lanes and paths connecting the campus with the city and surrounding more rural areas, including a bicycle underpass of the I-80 freeway, and bicycle signals at key intersections. Services and facilities include:

- Bike storage lockers and access for commuters to showers at the recreation center;
- Bike repair stations located throughout campus;
- Summer bike storage;
- Classes in safe riding and maintenance; and
- Bike lock cutting (with proof of ownership).

UC Davis is also a national leader in energy-efficient lighting research and deployment. With the installation of over 1,500 adaptive, networked LED luminaires, UC Davis has reduced its exterior lighting energy consumption by about 60 percent. [12] In parking structures, when no movement is detected near the luminaire, lighting levels are dimmed to 50 percent, but increase to 100 percent when the sensor field is occupied. The California Lighting Technology Center tests commercial technologies on campus, including networked lighting control, which allows for remote maintenance checks and customizing of lighting levels.

Figure 2. UC Davis "Smart Lighting." (Photo credit: UC Davis website.)

For UC Davis, these creative programs were made possible in part because of a culture on and off campus, developed over decades, that has supported bicycle riding. The university administration has also shown that there is a desire for the university to be an engaged participant in this culture.

4.4. California State University, Monterey Bay

In 1994, most of the buildings of the Fort Ord Army base were turned over to become California State University Monterey Bay (CSUMB). CSUMB has invested greatly to transform a basic road network, numerous small parking lots, and few sidewalks into world-class facilities that support a university population.

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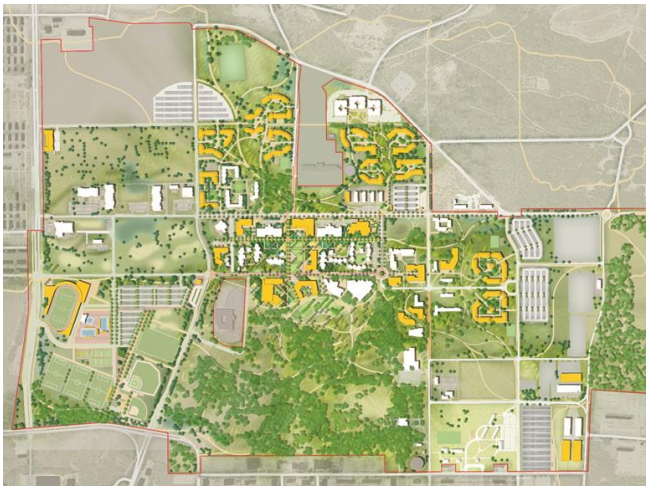
[11] UC Davis website: https://www.ucdavis.edu/news/transit-survey-47-percent-ride-bikes-campus/ (accessed April 2, 2019).

[12] UC Davis website: https://cltc.ucdavis.edu/project/uc-davis-smart-lighting-initiative (accessed April 1, 2019).

The campus Master Plan proposes dense development to prioritize pedestrian safety, promote a sense of place, push motor vehicle traffic around the borders of campus, and maintain a high level of residential students. Vehicle circulation on site was historically uncontrolled. Recently, several internal roads have been restricted to only service and transit vehicles, with plans for more pedestrian place-making elements. Parking is slowly relocating to newly constructed large parking lots on the campus periphery, as internal small lots are infilled with new academic and support buildings.



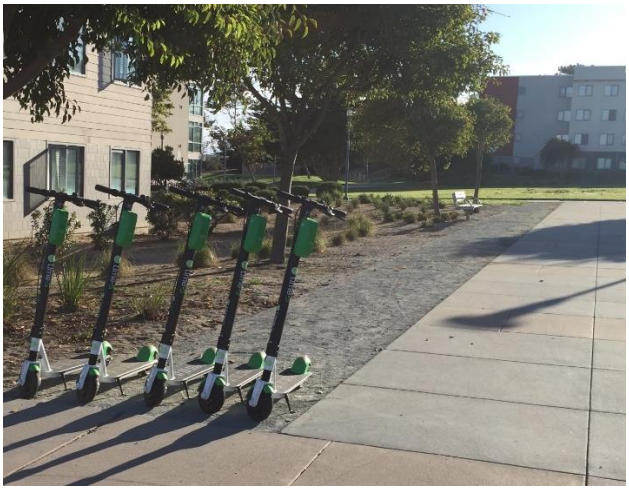


Figure 3 & 4. CSUMB draft Master Plan & E-scooters. (Photo credit: CSUMB Campus Planning)

Along with this new development strategy, new programs have been introduced to promote active transportation and fill gaps in mobility services. For nearly a decade, all students, faculty and staff have enjoyed unlimited boarding on all 60+ Monterey Salinas Transit bus lines, seven of which route directly through campus. In the Fall of 2018, the campus contracted electric scooter services. Over 100,000 rides have been taken to date. This new technology has met demand for first/last mile mobility options, as well as presenting new management challenges. Traditional roadways and sidewalks were not built with scooters in mind, and a culture of safety and responsible riding have yet to develop with this new technology.

The nature of CSUMB's inherited infrastructure has allowed it to start from scratch. This combined with a commitment to sustainable transportation has led to new building development patterns and programmatic technologies that support pedestrian safety and a human-scale campus.

4.5. University of Michigan

Numerous campuses are involved in testing and developing autonomous vehicles as applied research. The University of Michigan, which has over 44,000 students, is notable for testing a driverless shuttle as part of its campus operations and for the breadth of its evaluation.

Located in Ann Arbor (population about 120,000), the campus lies about 40 miles from Detroit, Michigan, which has declined in its role as unofficial capital of the U.S. auto industry.

Figure 3. MCity driverless shuttle vehicle. (Photo credit: U. Michigan website.)

However, the campus has been strengthening its ties to the auto industry recently.[13] As part of this, MCity is a public-private partnership. Two fully automated, 11-passenger, all-electric AUTONOM shuttle vans manufactured by French firm NAVYA operate weekdays on a roughly one-mile round-trip route. They primarily connect satellite parking to activity centers. Vans use Lidar sensing and GPS location software.

The MCity project studies how passengers react to a north campus driverless shuttles to gauge acceptance of the technology.[14] According to MCity Director Huei Peng, "the MCity Driverless Shuttle is the first driverless shuttle project in the US focusing on user behavior research and data collection."

U. of Michigan has bridged its academic mission with its facilities functions through real world applications of new technologies. This case study demonstrates how the campus itself is the best living laboratory, as well as the beneficiary of its own applied research, for everyone in the university community.

5. HOW OTHER NEW INNOVATIONS MAY AFFECT CAMPUSES

Other broad international trends will influence campus form, facilities, and operations over the next decade and beyond. Lessons learned could be useful to transportation planners and engineers.

5.1. Student Housing & Online (distance) learning

On-Campus student housing has become one of the most impactful strategies for increasing graduation rates, as well as decreasing transportation demands on university campuses. The idea of the 'commuter school', which attempts to avoid some of the major facility investments typical of traditional residential campuses, is being viewed more critically and even considered onerous for transportation infrastructure and programming. Providing commuter parking consumes valuable campus space and resources, and infrastructure must meet peak demands, versus having the ability to broadly distribute trips on active modes of transportation for campus residents. CSUMB has embedded this strategy in its most recent draft Campus Master Plan. By 2035, CSUMB seeks to house 60 percent of students, and 65 percent of faculty/staff on campus.

Higher education has also experimented with various forms of on-line learning for decades. There is the obvious potential to reduce campus travel, much like telecommuting for work travel. However, there are many aspects of the college undergraduate experience that cannot be provided online, thus limiting the potential for reducing on-campus population. Furthermore, much online education clearly expands the reach of classes, rather than substituting for traditional classes. For example, the Udacity class on artificial intelligence taught by Sebastian Thrun, then at Stanford University, a landmark in massive open online courses (MOOCs), attracted 160,000 sign-ups.[15] Universities are generally using online learning and services to supplement, rather than supplant, traditional "high touch" classes and programs.

5.2. The Internet of Things

The Internet of Things (IoT) involves online connection of innumerable objects, from street lights to household appliances. For campus transportation, IoT holds potential to network street lights, traffic signals, parking spaces, shuttle buses and other objects. This will allow remote control, monitoring, and maintenance. For example, street lights and traffic signals can be coordinated and checked for failures (as discussed earlier for UC Davis). Campus parking garage occupancies and shuttle ridership can be reported to central information displays in real time, including sharing information live with visitors unfamiliar with the campus.

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[13] Michigan Live website: https://www.mlive.com/business/ann-arbor/2009/05/automakers_strengthen_ties_to.html (accessed April 1, 2019).
[14] U. Michigan website: https://mcity.umich.edu/shuttle/ (accessed April 1, 2019).
[15] CNBC website: https://www.cnbc.com/2017/06/01/sebastian-thrun-udacity-googlex.html (accessed April 2, 2019).

5.3. Data Analytics and Big Data

The ability of artificial intelligence and data mining software to identify patterns in huge streams of data is transforming commerce and transportation. "Big data" and data analytics allow monitoring and understanding travel patterns in a much more comprehensive and nimble manner. For example, travel patterns automatically obtained from cell phone or Bluetooth ™ data could help campus planners determine how to provide facilities and services that more closely match actual demand patterns. This may allow finer tailoring of transportation services to need. For example, campus shuttle bus systems may adjust schedules based on demand as predicted by day of week, weather, ridership earlier that day, and special events.

6. TRANSFER OF LESSONS LEARNED TO OFF-CAMPUS JURISDICTIONS

How can campus transportation innovations be disseminated to the broader community? Potential methods include professional conferences and publications, partnerships with off-campus transportation providers and neighboring jurisdictions, and alumni promotion of innovations in their post-graduate careers.

6.1. Professional conferences and publications

Professional conferences and publications are filled with the ideas of university faculty and students. Some conferences such as the Transportation Research Board annual meeting are dominated by university-affiliated presenters. Universities often sponsor their own conferences. For example, the MetroLab Network, a partnership of 44 cities, six counties, and 60 universities, offers annual conferences at different universities focused on civic data and technology innovations.[16]

There is a wealth of university-generated material online, some directly related to campus innovations. For example, the federally funded Pedestrian & Bicycle Information Center at the University of North Carolina offers archived webinars, project evaluations, and design resources.[17]

6.2. Partnerships

Active partnerships with industry and government are a promising channel for exchanging innovative ideas. For instance, the Metro 21 Smart Cities Initiative at Carnegie Mellon University (mentioned above) includes as partners the City of Pittsburgh, the Pittsburgh International Airport, GM Labs, the University of Pennsylvania, Ohio State University, and others. Carnegie Mellon is also involved in the MetroLabs Network (mentioned above also), whose university/government initiatives include the Civic Innovations Challenge, an Innovation of the Month series, and an online Project Library.

Academic programs are also partnering with outside entities, such as the Sustainable City Year model from the University of Oregon, which has been adopted by CSUMB to develop class projects that directly partner with cities to assist with local projects. A recent student project in this program developed a Feasibility Study regarding Bikeshare for the City of Salinas.

6.3. Alumni promotion

Besides on-the-job support for innovations encountered during undergraduate or graduate education, transportation habits acquired on-campus may influence later off-campus travel behavior. For example, graduates from campuses with heavy bicycle use are naturally more open to bicycle commuting even after moving off-campus. Alumni who encountered such innovations as autonomous vehicles, automated transit, or "smart lighting" as students are likely to support such innovations after graduation.

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[16] MetroLab website: https://metrolabnetwork.org/annual-summit/ (accessed April 2, 2019).
[17] PBIC website: http://www.pedbikeinfo.org/ (accessed April 2, 2019).