A Case Study of Transit Demand Modeling and Transportation Planning at North Carolina State University

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EXECUTIVE SUMMARY:[1]

Policy Questions:

How should a large urban university make short-term trade-offs in its provision of transit service to a new, multi-use library that is expected to shift demand towards new transit policies? How should the goals of transportation and campus planning fit into a larger decision-making process for university development?

Recommendations:

Based on the emerging preference among the NCSU community for rapid, direct bus services between major trip generators and in particular between Main Campus and Centennial Campus, these recommendations focus on short-term route adjustments and long-term changes in service delivery. The short-term route changes to the Wolfline system can meet demand at the Hunt Library without incurring substantial changes in existing service patterns or increases in transit resources. The long-term route changes impact the larger issues of campus planning and community engagement that NC State Transportation must address as Centennial Campus becomes a larger and more multi-use part of the campus.

Short-term transit demand analysis at Hunt Library: 2012—2013

- Re-route 3A Centennial Express and 8 Southeast Loop to stop at Hunt Library via Main Campus Drive and Partners Way
- Do not change frequencies on 8 Southeast Loop
- Move one bus from 3 Engineering to 3A Centennial Express to improve frequencies
- Increase daily end of 3A Centennial Express service from 6:30 PM to 9:54 PM

Long-term campus development planning and transit planning: 2015—2022

- Wolfline service
    - Shift focus on Wolfline service from circulating loops to prioritize rapid, high-frequency service between campus precincts via major transit hubs and trip generators with limited stops

[1] The research, analysis, and recommendations contained in this paper are the work of the student who authored the document, and do not represent the official or unofficial views of the Sanford School of Public Policy or of Duke University.

    - Develop express bus service between Hunt Library and D.H. Hill Library with limited stops along North and Central Campus precincts
    - Shift express bus service to corridor between Hunt Library and Talley Student Center following completion of renovations
- Development of parking decks for parking supply
    - Ensure that each campus precinct has sufficient parking for people traveling to precinct
    - Maintain sufficient surface parking around campus buildings to permit access for facilities vehicles and emergency service vehicles
- Pedestrian and bicycle infrastructure
    - Implement reductions in automobile access on Dan Allen Drive to improve pedestrian safety
    - Increase bike and pedestrian safety at Avent Ferry and Western intersection
- NCSU community outreach
    - Communicate clear service standards for Wolfline operations to NCSU community to set expectations about public transportation services
        - Stress the use of the TransLoc app to make wait times more predictable
    - Communicate the Wolfline system upgrades and benefits that students, faculty, staff and corporate partners receive from their student fee and parking fee contributions
    - Communicate all restrictions in automobile access as early and as directly as possible to give opportunities for community feedback and travel behavior adjustment
    - Update Office of University Architect and Centennial Campus Development Office on transit technologies and infrastructures at all levels: NCSU; City of Raleigh; North Carolina

Context for Case Study:

This project uses North Carolina State University as a case study for transit planning at large urban university campuses and focuses on a new capital project, a large, multi-use library called the James B. Hunt Jr. Library located on the Centennial Campus of NCSU, a newer satellite campus precinct that is currently undergoing expansion. The NCSU Transportation Department will be responsible for providing public transit service (the Wolfline) for students, faculty and staff who want to travel to and from the Hunt Library, which is scheduled to open in the winter of 2013. Many departments attached to the Hunt Library and Centennial Campus view the Library as a flagship building that will raise the profile of NCSU and will transform the

Centennial Campus from "an office park environment" to a "campus environment," with greater student and pedestrian activity.[2] Since the building will likely have a significant impact on a rapidly developing campus precinct, NC State Transportation must evaluate the potential demand for traveling to and from the Hunt Library that students, faculty and staff demonstrate to determine the impact that the Library will have on the Wolfline system.

This expansion of transit service is one of several changes in transit operations that NC State Transportation is evaluating in its Campus Mobility Plan. The goal of the Campus Mobility Plan is to outline the changes in funding, service provision and streetscape infrastructure that are necessary to create an "enhanced multimodal campus transportation system" over the next ten years.[3] Because the Campus Mobility Plan has far-reaching impact on the physical design of the campus, NC State Transportation will be communicating with and working with numerous departments across the NCSU Administration. Representatives from these departments serve as Advisory Stakeholders to the CMP and have the opportunity to share their visions for the Hunt Library and NCSU transportation in general with the Department at planning meetings.

Methodology:

This report bases its analysis on three evaluations. The first evaluation is an estimation of ridership and transit demand at the Hunt Library based on trip generation rates at the Library as a function of the Library's net assignable square footage. This report compares these estimates to trip generation rates at the D.H. Hill Library[4] and distributes the number of daily trips that each building generates into trips in to the library and trips out of the library and into low-demand morning hours and high-demand afternoon and evening hours. This analysis takes this system of trip generation and distribution from the Institute of Transportation Engineers' Trip Generation Report and applies the system to both libraries.

The second and third evaluations are both qualitative. The second evaluation extrapolates trends in stated preferences from two surveys that NC State Transportation conducted in the Fall of 2011: a Customer Satisfaction Survey that the Department distributed to a sample of students, faculty and staff; and an Engineering Student Survey that the Department distributed to a sample

[2] Johnson, Lisa. Interview with author. In person. 13 January 2012.
[3] "Campus Mobility Plan." *NCSU Transportation.* 13 April 2012. Accessed 16 April 2012. <http://www2.acs.ncsu.edu/trans/planning/campusmobilityplan.html>
[4] D.H. Hill is the largest library currently in operation at NCSU and is comparable to the Hunt Library in its multi-use status and its high level of connectivity to other campus amenities.

of first-years, sophomores and juniors who have a major in the College of Engineering. Both surveys evaluate student preferences for Wolfline services and ask students to predict their interest in using the Hunt Library and their travel behaviors to and from the Library.

The third evaluation is a series of interviews with members of the NCSU community who are serving as Advisory Stakeholders for the Campus Mobility Plan. The author interviews each stakeholder to obtain the stakeholder's perspective on the current services that NC State Transportation offers to the larger community and those that the Department plans on providing. Specifically, these interviews focus on Wolfline services, parking services, the design and planning of campus transportation infrastructure, and the Hunt Library.

Findings:

1. Assuming a seven-percent mode share for Wolfline services, estimated levels of demand for Wolfline services at the Hunt Library are within the system's current capacity and NC State Transportation can meet this demand with small changes to existing services.
2. The Customer Satisfaction Survey and the Engineering Student Survey reflect that the Wolfline service plays an important role in students' mobility on a daily basis and that students show a high level of familiarity with the information technologies that NC State Transportation uses to promote its services and notify riders about changes and updates.
3. Students' priorities for service improvements focus on greater frequency, longer evening service hours, and more connections between Main Campus and Centennial Campus.
4. The Customer Satisfaction Survey and the Engineering Student Survey show high levels of interest in the Hunt Library and high levels of demand for travel between Main Campus and Centennial Campus.
5. The results of the stakeholder analysis show substantial support for an increase in public transportation services and for greater connectivity between Main Campus and Centennial Campus. Many stakeholders express significant concern for reducing automobile access on Main Campus and promoting the development of parking decks over surface parking. Stakeholders also express opposition for increasing parking fees or transportation fees to fund an increase in Wolfline services. Support for greater pedestrian and bicycle infrastructure is present, but opinions are more muted.

6. Many stakeholders state a preference for direct, limited-stop services between major trip generators with low travel times and high frequencies and believe that the growth of Centennial Campus will create greater demand for these services. They assert that NC State Transportation should prioritize these services in its future route planning.
7. Many stakeholders stress that the Department should engage with the NCSU community more directly and openly about the opportunities and limitations of a public transit system and its ability to enhance mobility and connectivity across the campus.
8. Several stakeholders believe that NC State Transportation should increase its investments in transportation infrastructure and develop high-speed, high-frequency transit services that are more capital-intensive than the current Wolfline system, including light rail transit and bus-only corridors.

Problem Statement:

How should a large urban university make short-term trade-offs in its provision of transit service to a new, multi-use library that is expected to shift demand towards new transit policies? How should the goals of transportation and campus planning fit into a larger decision-making process for university development? These questions have important consequences for how a large urban university can meet demand for transportation access to a new, large multi-use campus facility with a university transit system that operates in a dense urban environment and has finite capacity. Space in the larger urban environment is also finite; congestion on university roads and public throughways can have a significant impact on mobility within the university. However, given the pressures for a university to expand its facilities and attract more students, large urban universities will continue to face trade-offs between providing greater access to university facilities and managing resources for campus development. It is important for sustainable university expansion that those involved in the development process understand where transportation goals fall in the hierarchy of priorities.

Additionally, different levels of development on a university campus may create new markets that generate demand for different types of services. This analysis examines a new library in part because libraries are centers high levels of student activity throughout the day. Therefore a library generates demand for travel in a different manner than the peak and off-peak travel patterns that represent class changes for students or regular business hours for staff and faculty. It is important for transportation policy to identify and meet these varying demands, but the university must recognize that the transportation system must make trade-offs between the different markets to do so.

Context and Case Study:

This project uses North Carolina State University (NCSU) as a case study for transit planning at large urban universities and focuses on a new capital project, a large, multi-use library called the James B. Hunt Jr. Library (Hunt Library) located on the Centennial Campus of NCSU, a campus precinct that is undergoing expansion (See Map 1 in Appendix). The Hunt Library doubles the amount of library space on campus. The NCSU community anticipates that the library will create a focal point on Centennial Campus that generates activity from students,

faculty, and staff, as well as outside visitors, for the building's many uses. According to budget projections, the Library will be open 24 hours per day for five days per week.

The NCSU Transportation Department (NC State Transportation) is responsible for planning and operating a public transit system, the Wolfline, which provides access to all NCSU campus precincts: North, Central, and South precincts, which make up the Main Campus,[5] and the Centennial Biomedical Campus, the Arboretum, and the Stadium, which make up the West Campus (See Maps 3 and 4 in Appendix). In addition to operating the Wolfline, NC State Transportation controls the cost and supply of parking at NCSU. The Department will ultimately determine the level of Wolfline service and will control parking access at the Library (although the area around the Library contains multiple parking decks that are already in operation).

While NC State Transportation may have the final word in determining these transportation services, the Department is not the only campus department that has a stake in the Library's development. As a mixed-use building that holds NCSU administrative offices and contains a 400-person auditorium, the Hunt Library's purposes are more heterogeneous than many other campus buildings. Students, faculty and staff will visit the library at different times of day and may come from or go to a wide variety of locations on or off campus. Furthermore, NCSU views the Hunt Library as a flagship building for the Centennial Campus, which gives it a purpose and a prominence that extend beyond simply being a place for students to conduct research and study quietly. Several NCSU departments that were involved in the Library's planning discuss the details of the Library's architecture, physical location, and amenities and the ways that these details contribute to establishing this sense of prominence. The planning processes for these details are discussed in the Appendix.

This complicated relationship between the Hunt Library and the larger NCSU community requires that NC State Transportation work closely with all parties involved with the planning and operation of the library. These parties include University architects, librarians, Deans and other staff members who will work in the Library and communicate with the students, faculty and staff who will use the Library's resources. Additionally, the role that NCSU expects that the Library will play in the development of Centennial Campus means that the Centennial Campus Development Office and other liaisons for the private businesses that are located on Centennial

[5] While the South Campus precinct technically is a part of the Main Campus, this report excludes South Campus from the analysis when referring to Main Campus due to its location on the southern side of Western Boulevard. See Map 2.

Campus have a stake in the Library's planning. All stakeholders must share their visions for the Hunt Library with NC State Transportation. These conceptions not only influence the transit services that ultimately will run to and from the Hunt Library, but also influence how the Centennial Campus develops around its flagship building and the extent to which NC State Transportation priorities will play a role in the development process.

As a way of establishing and communicating its priorities for development, NC State Transportation is developing a Campus Mobility Plan (CMP) that will outline the changes in funding, service provision and roadway and streetscape infrastructure that are necessary to create an "enhanced multimodal campus transportation system" over the next ten years.[6] The NC State Transportation is working with HDR, Inc., a transportation consulting firm, to gather data, analyze current patterns of Wolfline ridership and traffic on surround roads. From this analysis, NC State Transportation and HDR consultants are designing new campus infrastructure and transit demand management policies. Because the CMP has far-reaching impact on the physical design of the campus, NC State Transportation has been communicating and working with numerous departments across the NCSU Administration. Representatives from these departments serve as Advisory Stakeholders to the CMP and have the opportunity to share their visions for the Hunt Library and NCSU transportation in general with the Department at planning meetings. These relationships will be discussed in further detail below.

Additional information on the Hunt Library, the NCSU Wolfline system, and the growth and development of the Centennial Campus precinct is located in this report's Appendix.

Literature Review:

Previous research for this Master's Project comes from analysis of travel behavior at NCSU and from studies of determinants of transit ridership, as well as planning documents on the design of effective public transportation systems. In a 2010 paper, researchers produced a spatial-temporal model of student activity at NCSU.[7] The researchers conducted a survey of activities in which students participate (class, studying, social, work, etc.) and ask students to describe what they do and when. The researchers modeled the distribution of student location by

[6] "Campus Mobility Plan." *NCSU Transportation.* 13 April 2012. Accessed 16 April 2012. <http://www2.acs.ncsu.edu/trans/planning/campusmobilityplan.html>

[7] Eom, Jin Ki, John R. Stone and Kyungwoo Kang. "Empirical Case Study of Spatial-Temporal Student Activity Population." *Transportation Research Record: Journal of the Transportation Research Board* 2157 (2010): 11-21.

estimating the number of students engaged in an activity that can be attributed to a specific location, which the researchers refer to as a destination facility. These destination facilities included libraries, athletic facilities, and academic buildings. The activity presence (the number of students engaged in a certain activity at a specific time in a specific location) was a function of the probability of participation in the activity at a specific time, the number of students in a given student group, and the buildings' capacity for a given activity.

The researchers validated the model against student class schedules obtained from the registrar's office, which included population data for residential buildings and other non-academic buildings. Predictions from the model match the data taken from 30 buildings between the hours of 8:00 A.M. and 8:00 P.M. at a rate of 81 percent, suggesting that the university can predict activity levels on the building level without aggregating large volumes of data, and may be particularly useful for "the testing of scenarios of changes in building ingress and egress … and predicting shifts from auto-oriented to pedestrian and transit-oriented travel as building density increases."[8] While this model would require regular data input to capture activity accurately, it presents the opportunity to target bus service to locations of fluctuating demand throughout the day based on its ability to predict where and when students will move.

A 2009 study used a similar model but focused on its temporal aspects to identify differences in daily activity participation and trip generation between different student groups at NCSU.[9] Rather than simply testing the model, the researchers used the model to analyze travel patterns within the campus, with results that complicate the predictable power of the model. By expanding the survey to include questions on choice of transportation mode, the researchers found that the majority (79.9 percent) of on-campus students choose to walk, while the majority (68.9 percent) of off-campus students choose to travel by automobile.

The substantial difference in mode preference between on-campus and off-campus students is representative of the existence of different markets of travel demand within the NCSU community. Different groups have different preferences for transportation modes and services

[8] Eom, Stone and Kang 2010, p. 19.
[9] Eom, Jin Ki, John R. Stone and Sujit K. Ghosh. "Daily Activity Patterns of University Students." *Journal of Urban Planning and Development* 135, 4 (200): 141-149.

based on the distribution of their origins and destinations, the distances between them, and the amount of time that is necessary to travel between them.[10]

In the context of a transit system with finite capacity, NC State Transportation makes a policy decision whenever the Department chooses to redesign its routes and divert its resources from one market to another. Switching resources between routes or reducing service levels on existing routes to create a new route represents a shift in the distribution of user costs among NCSU community members. If NC State Transportation had previously operated three buses on a route but reduces services on that route to two buses, the students, faculty and staff who travel along that route effectively experience an increase in travel costs.[11] Both the marginal changes and larger redesigns that the Department implements represent changes in transportation policy that communicate to the NCSU community which populations' demands the Department prioritizes.

The high percentage of non-transit trips[12] that NCSU students make may be a reflection of more general trends in consumer demand for transit. A study of transit demand modeling found that on average, commuters are willing to exchange one minute of wait time for a transit vehicle with 2.12 minutes of travel time in the vehicle.[13] This trade-off suggests a high elasticity of demand[14] for transit in situations where commuters have to wait.[15] Given the relatively low travel speed of the Wolfline system (due to frequent stops and traffic congestion), the trade-off between walking and waiting for transit service may be low enough for students to choose the former.[16] As a result, a model of transportation demand must expand beyond where students are and when they travel to analyze how they travel around campus. Analyzing travel patterns also has implications for long-term planning choices over which NC State Transportation has more control; the Department may not be able to control where buildings are constructed (this

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[10] Toor, Will and Spenser Woodworth Havlick. *Transportation & sustainable campus communities: issues, examples, solutions.* Washington, D.C.: Island Press, 2004.

[11] These riders experience an increase in wait times when the route that previously had service every 10 minutes now has service every 15 minutes.

[12] In this case, "non-transit" trips refer to all trips that did not use public transportation but instead used any other mode, including single-occupancy vehicles and non-motorized transportation.

[13] This exchange implies that a traveler is willing to experience an additional 2.12 minutes in the vehicle if doing so enables that traveler to experience a decrease in his or her waiting time equal to 1 minute.

[14] Demand elasticity measures the change in the quantity of a good or service that a consumer demands that results from a change in the costs associated with the production or delivery of the good or service.

[15] Evans, John E., IV. "TCRP Report 95, Ch. 9: Transit Scheduling and Frequency." Transportation Research Board: Washington, D.C., 2004.

[16] A evaluation of Wolfline routes that NC State Transportation conducted in May of 2011 found that across all routes, Wolfline buses have an average travel speed of 10.40 mph.

responsibility belongs to the Office of the University Architect), but they can influence many of the processes that determine how students can access new buildings, including the construction and price of new parking supply.

Will Toor and Spenser W. Havlick's *Transportation & Sustainable Campus Communities: Issues, Examples and Solutions* performs the important task of contextualizing transportation's goals for service provision within a larger campus environment.[17] The text assumes that the reduction of single-occupancy vehicle trips to, from and around campus is a goal of sustainable transportation policy. From this assumption, the authors describe and evaluate different ways to promote and achieve that goal as well as the efforts to draw these methods into coherent, long-term campus planning proposals. Their research draws on case studies of urban universities that promoted transit use and pedestrian-oriented campus planning, including the University of Washington at Seattle and the University of New Hampshire.[18]

A common theme within these case studies is the economics of travel choice: the monetary costs of different modes influence the decision to use those different modes. The provision of free or heavily subsidized parking at or very near to campus buildings plays a particularly significant role in this, as it provides the "final mile" of connection between origin and destination. The "final mile" represents the last step in an individual's travel from an origin to a destination.

A university that supplies parking in close proximity to a traveler's destination incentivizes that traveler to use an automobile; since the parking spot is closer to the destination than the nearest transit stop, the traveler can spend less time walking and incurs no cost for using the parking spot. Transportation departments frequently plan last-mile improvements to address public perceptions of transit systems as inconvenient.[19] To this end, the researchers recommend that university transportation departments change the price structures by increasing parking fees and subsidizing transit passes.

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[17] Toor and Havlick 2004.

[18] Toor and Havlick 2004, citing University of New Hampshire Office of Sustainability Programs 1999; University of Washington 2002; University of Washington 2003.

[19] Nelson/Nygaard Consulting Associates. ""Maximizing Mobility in Los Angeles—First & Last Mile Strategies: Final Report." Prepared for the Southern California Association of Governments. December 2009. <http://www.scag.ca.gov/nonmotorized/pdfs/LA-Maximizing-Mobility-Final-Vol1.pdf>; Wilbur Smith Associates; Kimley-Horn and Associates; Moor Iacofano Goltsman, Inc; Harley & Associates. "MTC Transit Connectivity Plan: Final Summary Report." Prepared for the Metropolitan Transportation Commission. 1 May 2006. <http://www.mtc.ca.gov/planning/connectivity/Final_Connectivity_Study/finalsummary. pdf>

Similar results regarding the importance of monetary costs of transportation and parking, have been found in research documents prepared by the Transportation Cooperative Research Program (TCRP), including a synthesis of transportation systems and policies at colleges and universities.[20] In these reports, researchers conducted extensive analysis of changes made to route design and frequency scheduling for bus systems. Results vary broadly between specific examples, but general trends emerge, including the importance of reliable service frequency and the critical role that the provision of transit information can play in shaping riders' perceptions of reliability. Ridership generally shows a positive elasticity with regards to increased service frequency that varies between 0.3 and 1.0, but elasticities can increase above 1.0 when frequency increases in off-peak hours.[21] While this last trend may seem promising, it does not describe universities in particular, but merely urban and suburban transit systems in general. Furthermore, the heavy traffic flows throughout the day on the streets that border the NCSU campus may limit the ability for NC State Transportation to increase service frequency. There is only so much that the system can do to increase frequency before the geographic distance between campus precincts and the reality of traveling in mixed traffic and encountering delays at intersections place fundamental limitations on service frequency.

The reports on college and university transit systems highlight the unique funding role that student fees play within these systems and the fact that additional and separate parking fees provide critical support as well.[22] These observations highlight the important role that students play in supporting university transit systems and introduce an additional element of campus politics into the decision-making process. Students not only comprise the majority of a university transit system's ridership, but they often provide substantial funding for the system through student transportation fees. As such, they represent important constituents whose demands must be balanced against those of the larger university. Although students do not necessarily have the power to prevent NC State Transportation from making changes to Wolfline services, having

[20] Evans 2004; Krueger, Tara and Gail Murray. "TCRP Synthesis 78: Transit Systems in College and University Communities." Transportation Research Board: Washington, D.C., 2008; Miller, James H. "TCRP Synthesis 39: Transportation on College and University Campuses." Transportation Research Board: Washington, D.C., 2001.
[21] These elasticity values describe changes in transit ridership that result from changes in service frequency. If a transit route experiences an increase in frequency such that buses pass by a route stop every 10 minutes instead of every 20 minutes, the route has experienced a 50 percent increase in frequency. If the elasticity value is between 0.3 and 1.0, the 50 percent increase in frequency results in an increase in ridership that ranges from 15 percent to 50 percent. If the elasticity value is greater than 1.0, the 50 percent increase in frequency generates an increase in ridership that is greater than 50 percent.
[22] Krueger and Mary 2008; Miller 2001.

their support and approval facilitates the Department's efforts to negotiate with other departments or to request additional funding from NCSU for transit operations.

Transit also plays a role in reducing single-occupancy vehicle traffic at and around university campuses and therefore acts "to mitigate the perceived negative impacts of campus growth".[23] This mitigation of traffic makes the transit system not only important to the regular flow of university traffic, but also to the relationship between universities and their surrounding communities. This point may be particularly salient for NCSU, as Hillsborough Street and Western Avenue, which respectively form the northern and southern borders of the Main Campus precinct, are major throughways that connect downtown Raleigh with campus edge and suburban residential neighborhoods and interstate highways and Research Triangle Park to the west of campus (See Map 5 in Appendix).

However, NC State Transportation already has a structure of parking fees and the Wolfline system, which is open to the public, does not charge fares (annual student fees and parking permit revenues fund transit, respectively providing approximately 80 percent and 20 percent of funding). While it is possible for NC State Transportation to increase the fees for parking permits, the Office of the Provost limits the Department from raising parking permit fees for students by more than 2 percent annually.[24] Additionally, parking fees for corporate partners on Centennial Campus are bundled into the building rents that the partners pay; the partners do not pay these fees directly. Consequently, NC State Transportation has limited opportunities to change the relative costs of different transportation modes to incentivize the NCSU community to replace automobile trips with transit trips. While NCSU community members may dislike the fees that they pay for parking (this topic will be discussed in further detail below), it is unlikely that they will experience changes in marginal costs of driving on a daily basis that incentivize them to change their behavior.

Methodology:

This report bases its analysis on three evaluations. The first evaluation is an estimation of ridership and transit demand at the Hunt Library based on trip generation rates at the Library as a function of its net assignable square footage. For comparison, this report calculates trip

[23] Miller 2001, p. 20.
[24] The ability of NC State Transportation to negotiate with or lobby the Office of the Provost to change this limitation is outside of the scope of this analysis.

generation statistics and transit ridership at the D.H. Hill Library and compares the statistics to those generated at the Hunt Library.[25] This analysis then distributes the number of daily trips that each Library generates into trips to the Library (entrances) and trips out of the Library (exits) and into low-demand morning hours (A.M.) and high-demand afternoon and evening hours (P.M.). This analysis takes this system of trip generation and distribution from the Institute of Transportation Engineers' Trip Generation Report and applies the Report's values to the two libraries as approximate estimates of trip generation rates. From these trip distributions, the analysis makes recommendations for route changes based on the current level of Wolfline services on Centennial Campus. This analysis uses predictions for trip generation and transit demand since the Hunt Library is not yet open and its actual patterns of usage are unknown.

The second and third evaluations are qualitative. The second evaluation analyzes trends in stated preferences from two surveys that NC State Transportation conducted in the Fall of 2011: a Customer Satisfaction Survey that the Department distributed to a sample of students, faculty and staff; and an Engineering Student Survey that the Department distributed to a sample of first-years, sophomores and juniors who have a major in the College of Engineering. This analysis targets engineering students because the College of Engineering is in the process of moving its educational and research resources to the Centennial Campus. Much of the growth on the campus precinct will come from the College of Engineering, and its students will make up the majority of the student population that uses Centennial Campus resources. NC State Transportation must understand the needs of this student population and determine how these students' preferences differ from the larger student community's.

Both surveys evaluate student preferences for Wolfline services and ask students to predict their interest in using the Hunt Library and their travel behaviors to and from the Library. The purpose of these evaluations is to determine what service improvements and changes NC State Transportation should focus on to meet student demand.

The third evaluation is a series of interviews with members of the NCSU community who are serving as Advisory Stakeholders for the CMP. The author interviews each stakeholder to obtain the stakeholder's perspective on the current services that NC State Transportation offers to the larger community and those that the Department plans on providing. Specifically, these

[25] D.H. Hill is the largest library currently in operation at NCSU. The selection of this library will be discussed in further detail.

interviews focus on Wolfline services, parking services, the design and planning of campus transportation infrastructure, and the Hunt Library. This analysis organizes the results of the interviews into a stakeholder matrix that displays each stakeholder's support for, opposition to, or concern with the Department's current and future plans. A summary of each stakeholder interview is located in this report's Appendix.

Analysis:

Trip Generation and Transit Demand Analysis:

NCSU Transit Ridership Share and ITE Trip Generation

Because the Hunt Library is not yet in service, this project bases its transit demand analysis on a building whose student activity closely parallels the amount of activity that the new library is expected to generate. The D.H. Hill Library is comparable in its purpose and connectivity to campus amenities. D.H. Hill is the largest library currently in operation at NCSU, receiving an average of 5,317 visits (i.e. entrances) per day from August 2010 to May 2011. Its location on the northern edge of North Campus fronts Hillsborough Street, providing access to the shopping and dining on Hillsborough as well as a wide range of services and amenities on Hillsborough Street and North Campus.

The Library is a multi-use building, with technology resources, study and collaboration space, and food service in addition to library resources. Because of its ample space and high student traffic, the Library serves as a social hub for student activity. The Hunt Library mirrors this combination but offers greater space for students relative to the amount of space dedicated to library resources. Therefore the buildings are similar enough in purpose and potential for student activity to be compared as trip generators.

In 2004, transportation consulting firm Martin/Alexiou/Bryson conducted a survey of student travel patterns at NCSU. In its analysis of travel modes, the firm found that three percent of all trips take place on the Wolfline for on-campus students.[26] The share for Wolfline trips for off-campus students is seven percent, which the firm attributed to the use of Wolfline services at park-and-ride locations that NCSU offers to students without any associated parking permit fees.

[26] Martin/Alexiou/Bryson. *NCSU Student Travel Survey*. Prepared for North Carolina State University. 30 July 2004.

For on-campus residents, 96 percent of all trips use a single mode, and 83 percent of these single-mode trips use walking as a mode. Yet given the high priority that students and Advisory Stakeholders place on inter-precinct travel (which this analysis will discuss in greater detail) and the distance between Main Campus and Centennial Campus will incur significant travel times for walking. Consequently, travel behavior between campus precincts will more likely follow the patterns of off-campus residents, for Wolfline trips make up seven percent of trips for off-campus students, many of whom use the Wolfline system to travel to and from park-and-ride services. Assuming that travel demand at park-and-ride lots is more similar to travel demand for service between the Hunt Library and locations on Main Campus (which this analysis will discuss in further detail), this transit demand analysis uses seven percent as the benchmark value for the Wolfline's share of generated trips at D.H. Hill and the Hunt Library.

Although students use walking as a travel mode for 80 percent of all campus trips, there is a limit to the distance that most travelers are willing to walk. An approximate "rule of thumb" in transportation planning asserts that pedestrians prefer to walk to all destinations within 1,300 feet.[27] While D.H. Hill is within 1,300 feet of many amenities on North Campus, its status as the largest NCSU library currently in operation defines it a large trip generator that pulls students from all campus precincts. With high service demand and access to a wide range of amenities on North Campus, D.H. Hill has a high level of visibility for the student population. These variables make the library an ideal location for frequent Wolfline service; the stop immediately outside of D.H. Hill receives service from three of the six Wolfline routes that travel on Main Campus and serves as a Bus Transfer Stop[28] for the two routes that serve West Campus. Wolfline stops that offer access to the other three routes that serve Main Campus are within 1,300 feet of the north and south entrances of D.H. Hill (See Map 6 in Appendix).

Given the combination of high levels of transit service and high levels of student activity, D.H. Hill likely attracts students from other campus precincts, whose travel behavior relative to the library is more similar to an off-campus student traveling from a park-and-ride location. D.H. Hill serves as a transit center: students can access nearly every Wolfline route and use the library as a hub for travel to different campus precincts, including the park-and-ride locations.

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[27] Walker, Jarrett. "basics: the spacing of stops and starts." *Human Transit*. 6 Nov 2010. Accessed 19 April 2011. <http://www.humantransit.org/2010/11/san-francisco-a-rational-stop-spacing-plan.html>

[28] The NCSU Physical Master Plan designates the stop by this title.

To determine the raw number of transit rides that is the seven-percent transit share, it is necessary to have an estimation of the number of trips that the library will generate. Based on the 8th Generation Edition of the Institute of Transportation Engineers' Trip Generation Report, a library generates 56.24 average vehicle trip ends per 1,000 square feet with a standard deviation of 22.45 average vehicle trip ends per 1,000 square feet.[29] In the Trip Generation Report, an average vehicle trip end represents the conclusion of an individual's trip in a single-occupancy vehicle. This definition acknowledges that for the majority of trips in the United States, an individual uses an automobile as the only mode of transportation between an origin and a destination. The Trip Generation Report uses directional distribution of average vehicle trip ends to evaluate the trips to and trips from a building, therefore regarding trip ends as "trip beginnings" when calculating exiting trips.

This analysis applies the Trip Generation Report's values for average vehicle trip ends per 1,000 square feet to the D.H. Hill and Hunt Libraries and assumes that average vehicle trip ends capture all mode shares for the trips that libraries generate. Ergo, in this analysis, "average vehicle trip ends" refers to trip ends that result from individuals using non-motorized transportation (bicycles, walking, etc.), single occupancy vehicles, and public transit vehicles to travel to and from the libraries. Additionally, this analysis assumes that the average vehicle trip ends that a library generates in the Trip Generation Report apply to all possible uses that generate demand for travel rather than differentiating for the multiple uses that each library offers (food service, social space, etc.).

The net assignable square footage of the D.H. Hill Library is approximately 275,000 square feet. This calculation yields a total of 15,466 total daily generated average vehicle trip ends. Seven percent of this daily trip number represents 1,083 transit-based vehicle trip ends. It is important to note, however, that the total number of daily generated vehicle trip ends counts both trips to the library and trips from the library, rather than the number of unique visits. Accounting for the standard deviation of ITE estimates, the D.H. Hill Library could generate a number of vehicle trip ends ranging from 9,292 per day to 21,640 per day, which represents a range of transit-based vehicle trip ends equal to 650 per day to 1,515 per day.

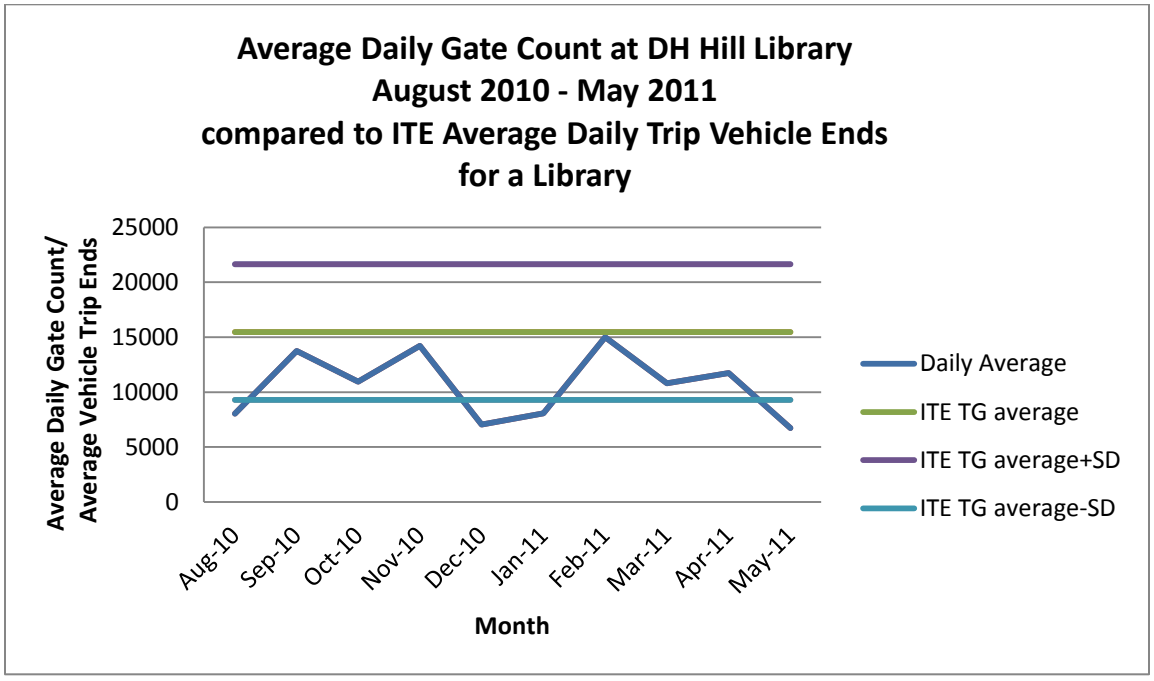
As cited previously, average daily counts at the D.H. Hill Library from August 2010 to May 2011 averaged 5,317 visits, with a maximum of 11,004 counts on October 25th. Assuming

[29] Institute of Transportation Engineers. ITE Trip Generation Manual, 8th Edition. 2008.

that every visitor to D.H. Hill generates an "exit" trip as well as an "entrance" trip, average daily trip generation during this time was 10,634 trips, with a maximum of 22,008 trips on October 25th. Using data gathered at the entrance and exit gates of D.H. Hill on February 14, 2012 reflects this: over a 24-hour period, the entrance gates recorded 8,116 persons and the exit gates recorded 7,463 persons, resulting in 15, 1579 trips (See Graph 1 in Appendix).[30]

These numbers largely correspond with the ITE Trip Generation Report predictions for average vehicle trip ends at a library. The standard deviation of average vehicle trip end generation rates reflects the variation in student demand for D.H. Hill resources (although days in which classes are not in session lower the average daily values for each month. See Graph 2 below). However, given the operational difficulty of tailoring Wolfline service to day-to-day variation in demand for a given trip generator, this analysis focuses on average trip generation at the Hunt Library to design more predictable service for riders and more cost-effective service for NC State Transportation.

Graph 2:



[30] The discrepancy between the number of entrances and the number of exits could be explained by "confusion" in the counting mechanisms. The gate mechanisms could record multiple people entering or exiting at the same time as being fewer in number due to an inability to identify each person separately.

In Spring 2011, the total average daily ridership of the three stops closest to D.H. Hill that serve all Wolfline routes was 3,120.[31] These three stops provide access to all six routes that travel on Main Campus as well as the two routes that service West Campus. This value represents 20 percent of the generated trips based on ITE estimations (or 14 percent of all generated trips on the day of highest count in the 2010-2011 academic year).

In analyzing these discrepancies, it is important to note that D.H. Hill's status as a transit hub may distort ridership statistics relative to its rate of trip generation. In serving as a transfer point for the Wolfline system, D.H. Hill facilitates transfers between routes, and students may travel to the library only to make such a transfer. For example, the 6 Carter-Finley route has one stop on North Campus along its route from the Carter-Finley park-and-ride to Hillsborough Street. This stop is at Founders Drive and Scott Hall, which is located approximately 380 feet from the north entrance at D.H. Hill. Similarly, the first stop on North Campus for the 3 Engineering Route is at Current Drive and Stinson Drive, which is approximately 1,080 feet from the south entrance at D.H. Hill. Students may use these stops as an alighting point to access North Campus without traveling to D.H. Hill. Consequently, this analysis does not assume that all 3,120 Wolfline trips had D.H. Hill as an origin or a destination.

Despite the difficulty in determining the origins and destinations of transit trips, the uncertainty surrounding D.H. Hill will likely be present at the Hunt Library as well. The Hunt Library is located on the southwestern end of the Oval, an expansive greenspace that is currently bordered by Engineering Buildings I, II and III. The length of the Oval is approximately 1,000 feet, suggesting that the Engineering Buildings and the Hunt Library are within walking access of each other. The College of Textiles and the Monteith Engineering Center are similarly within a walkable distance (See Map 7 in Appendix). Thus the Hunt Library's location provides a high level of access to numerous other origins and destinations that will generate separate levels of trip demand. While many of these other buildings are within walking distances of other transit stops, the distribution of routes throughout Centennial Campus may lead students to prefer boarding or alighting at the Hunt Library. Additionally, the food service at Hunt Library may encourage riders to use the Library as a first or last stop in their travel on Centennial Campus.

[31] The three stops are: Founders Drive at D.H. Hill Library, Founders Drive at Scott Hall, and Current Drive at Stinson Drive. As stated, these three stops represent the combination of stops that serve all 12 Wolfline Routes (with the exception of the 3A Centennial Express and the 10 Southside Circulator, which do not travel on North Campus).

Regardless of possible distortions in the relationship between building space and trip generation, it is important to note that travel demand will vary throughout the day. The ITE's Trip Generation Report provides more specific distributions of average vehicle trip ends that evaluate demand during A.M. and P.M. periods and separate demand into "in" trips and "out" trips. However, these values represent the average vehicle trip ends that occur as a result of adjacent street traffic for one hour between 7 A.M. and 9 A.M. and for one hour between 4 P.M. and 6 P.M. Again, this analysis assumes that adjacent street traffic levels capture trip demand for a library in an environment where single-occupancy vehicles are the dominant transportation mode.[32] During the A.M. peak hour, a library generates 1.04 average vehicle end trips per 1,000 square feet, 71% of which are entrances and 29% of which are exits. During the P.M. peak hour, a library generates 7.30 average vehicle end trips per 1,000 square feet, 48% of which are entrances and 52% of which are exits.

Applying the values for these periods to the D.H. Hill Library, the ITE statistics show that trip demand is higher during P.M. hours: demand during the peak hour between 7 A.M. and 9 A.M. generates 286 vehicle trip ends per hour, while demand during the peak hour between 4 P.M. and 6 P.M. generates 2,008 vehicle trip ends per hour. During the A.M. hours, people generate 203 "in" vehicle trip ends and 83 "out" vehicle trip ends, while in the P.M. hours people generate 964 "in" vehicle trip ends and 1,044 "out" vehicle trip ends. The data that Library Services collected on February 14, 2012 complicate the ITE estimations, showing that exits are higher than entrances between the hours of 12:00 AM and 6:00 A.M. and between 4:00 PM and 7:00 P.M. and 9:00 P.M. and 12:00 A.M. However, entrances remain higher than exits from 6:00 A.M.to 2:00 P.M. and from 7:00 P.M. to 9:00 P.M.. Between the hours of 2:00 P.M. and 4:00 P.M., the two patterns of movement are nearly equal. (See Graph 1 in Appendix).

To interpret the 137,600 square feet of the Hunt Library as a single unit, the estimated number of trips that the Library will generate is 7,750 trips. Dividing these trips into time of day yields 102 "in" vehicle trip ends and 42 "out" vehicle trip ends during the peak A.M. hour between 7 A.M. and 9 A.M. and 482 "in" vehicle trip ends and 522 "out" vehicle trip ends during the peak hour between 4 P.M. and 6 P.M. (See Table 1 below).

[32] A reference guide to the ITE Trip Generation Report produced by Spack Consulting (a traffic analysis consulting firm) uses these values to express general trip generation at all buildings and land use types that the Trip Generation Report contains. The author received this reference guide in personal correspondence with Daniel Findley, a senior research associate at the Institute for Transportation Research and Education. Findley, Daniel J. Personal communication with author, 28 March 2012.

Table 1: Generation Rates of Average Vehicle Trip Ends at D.H. Hill and Hunt Libraries

	Net Assignable Square Footage (KSF^2)	ITE Trip generation rate (average vehicle trip ends per KSF^2)	Daily trips generated	Peak Hour of Adjacent Street Traffic Between 7 A.M. and 9 A.M. (entrance)	Peak Hour of Adjacent Street Traffic Between 7 A.M. and 9 A.M. (exit)	Peak Hour of Adjacent Street Traffic Between 4 P.M. and 6 P.M. (entrance)	Peak Hour of Adjacent Street Traffic Between 4 P.M. and 6 P.M. (exit)
D.H. Hill	275.0	56.24	15,466	203	83	964	1,044
Hunt	137.6	56.24	7,739	102	42	482	522
Standard Deviations	--	22.45	--	1.02		3.81	

Source: Institute of Transportation Engineers. ITE Trip Generation Manual, 8th Edition. 2008.

While actual trip rates will most likely vary from these estimations, they do reflect the results of the student surveys that this report discussed above: more students showed a greater interest in using the Hunt Library during the evening hours. Based on the seven percent figure, the Wolfline system would serve 542 transit-based vehicle trip ends at the stop located outside of the Hunt Library throughout the day. To apply this percentage to hourly trips, 7 passengers board the Wolfline system and 3 passengers alight the system during the peak hour between 7 A.M. and 9 A.M.; the respective number of passengers for the peak hour between 4 P.M. and 6 P.M. is 34 and 37 (See Table 2 below).

Table 2: 7 Percent Transit Share of Generated Average Vehicle Trip Ends During Peak Hour of Adjacent Street Traffic Between 7 A.M. and 9 A.M. and Between 4 P.M. and 6 P.M. at D.H. Hill and Hunt Libraries

	Daily trips generated	AM in	AM out	PM in	PM out
D.H. Hill	1,083	14	6	67	73
Hunt	542	7	3	34	37

Source: Institute of Transportation Engineers. ITE Trip Generation Manual, 8th Edition. 2008.

As stated previously, these passengers may not regard the Hunt Library as an origin or destination, but are simply using the Library as a locus for pedestrian access to or from surrounding academic, research, and residential buildings. These dynamics will likely balance out trip generation and ridership: just as ridership at D.H. Hill represents a larger transit share for generated trips than the travel survey estimates, travel demand at nearby buildings will lead to

higher demand for transit in the area than the Trip Generation Report estimates that either library generates.

The difference between the distribution of entrances and exits at the D.H. Hill Library and the distribution of entrances and exits during peak hours of A.M. and P.M. demand reflect a limitation of the analysis. The trip generation rates in the ITE Trip Generation Report represent average values that ITE has taken from a wide variety of studies; they fail to capture variation in patterns of demand at individual libraries. The results in Graph 1 suggest that peak demand at D.H. Hill does not align with the hours that the Report designate as peak demand.

While this disparity limits the accuracy of this analysis' estimation, its impact on available transit capacity may be less significant. The different hours that the data from D.H. Hill and the Trip Generation Report identify as peak demand fall within the service hours when Wolfline buses operate with higher frequency and higher system capacity, which are approximately 7 A.M. to 6.30 P.M. While the distribution of peak demand hours at the D.H. Hill Library has consequences for capacity levels at certain times of day, the differences in peak demand between the ITE Trip Generation Report estimations and the data from D.H. Hill are not substantial enough to suggest that the overall Wolfline system will experience overcapacity. Therefore, while the estimations in this analysis are not wholly accurate, they are acceptable for short-term transit planning.

Route Analysis

Given the headways[33] of several of the systems that travel on Centennial Campus, it is very likely that the Wolfline system will be able to accommodate the number of passenger trips per hour that the Hunt Library will generate. The following routes serve the Centennial Campus: 3 Engineering, 3A Centennial Express, 8 Southeast Loop, 10 Southside Circulator, and 11 Village Link. The intersection of Varsity Way and Partners Drive, which has the highest level of ridership on Centennial Campus,[34] receives services from four routes in a combination that results in bus service every four to five minutes. Due to the demand for quicker service between campus precincts, demand for the 3 Engineering is often above capacity during the late mornings and early afternoons when students are traveling between classes (See Graph 3 in Appendix).

[33] A headway is the amount of time between buses. NCSU Wolfline maps label these headways as "frequencies" that describe the number of minutes between each bus for a given route.

[34] This stop receives 1,258 boardings and 1,157 alightings on average each day, placing it in the top three stops for both boardings and alightings at NCSU.

This high demand is likely due to the shorter travel times that riders experience on the 3 Engineering: , the 3 Engineering route has the shortest observed headway of any route at 9.96 minutes between southern North Campus and northern Centennial Campus in Spring 2011.[35]

Despite its high demand, the 3 Engineering receives lower ridership than the 8 Southeast Loop. After the introduction of the 3A Centennial Express in the Fall of 2011, the 8 Southeast Loop has nearly double the monthly ridership as the 3 Engineering. This high level of ridership is likely due to the fact that the 8 Southeast Loop travels through North Campus and stops at Founders Drive and Scott Hall, where it facilitates transfers between other Wolfline routes.[36] Due to its wide service area (it is the only Wolfline route that travels on both North and Centennial Campuses) and relatively short headway of 12 minutes, the Southeast Loop generates high ridership but experiences demand in excess of its capacity for an average of once per day during the Spring of 2011. This balance between ridership and capacity may be due to the fact that some of its route segments serve as major boarding stops and others serve as major alighting stops, creating a high level of flow and a moderate level of available capacity on the overall route (See Graph 4 in Appendix).

While the 11 Village Link also serves Centennial Campus, it provides connectivity between the South Campus precinct and Centennial Campus, with some service on the southern part of Central Campus, as a circulator service between more geographically distant parts of campus. The route operates with 15-minute frequency and a 30-minute travel time around the route. Although it has a higher level of available capacity than many routes, this is largely a reflection of the low level of ridership that it generates (See Graph 5 in Appendix). In the Spring of 2011, multiple route segments often report per-hour boardings and alightings that were in the single digits. While this service plays an important role in providing connectivity between campus precincts, its focus on connectivity limits its ability to provide high-frequency service. The route's high level of available capacity suggests that there is low demand for its services.

NC State Transportation added the 3A Centennial Express and 10 Southside Circulator routes in the Spring of 2011 as responses to customer feedback. The Department designed the 3A Centennial Express to provide more capacity with larger buses and slightly more direct service

[35] The Wolflink Shuttle has an equally short headway, but this analysis focuses less on this route due to its purpose as a circulating service that stays largely on Central Campus.
[36] This stop is located approximately 360 feet from the Bus Transfer Stop at D.H. Hill Library. It receives service from seven Wolfline routes.

for riders.[37] The 3A Centennial Express operates on a 15 minute-frequency compared to the 10-minute frequency of the 3 Engineering Route, but the former route operates along a 3.4-mile route, while the latter travels along a 4.9-mile route and therefore has a shorter travel time.[38] Despite the lower frequency, Wolfline riders have responded positively to the new route. In the first two weeks of the Fall 2011 semester, the 3A Centennial Express generated per-bus ridership comparable to the 3 Engineering route.

The 10 Southside Circulator route travels on the southern part of Centennial Campus to link the Avent Ferry Road corridor with the precinct. The service directly responds to feedback from students who live in the apartment complexes in the corridor and have requested more direct service between these apartments and Centennial Campus. Due to its status as a new service that travels on an "unfamiliar" route, the 10 Southside Circulator level of service is relatively low: one bus travels the 4.7-mile route, offering 16-minute frequency. Furthermore, the service only operates from 7:00 A.M. to 12:06 P.M. and from 3:00 P.M. to 7:02 P.M. While feedback on this service has been positive, its ridership is the lowest of any Wolfline route. This low ridership may be due to the large amount of "dead zone" on the route: to complete the loop around the southern part of Centennial Campus and return to Avent Ferry Road, the 10 Southside Circulator travels along long stretches of road that have few trip generators on them.

This low ridership likely results from both the low level of service and the lack of student familiarity with the route; the Department's evaluation of ridership patterns have shown that multiple stops along the route frequently receive no boardings or alightings throughout the service period. The fact that the route is the only Wolfline route to offer service that is not in continual operation throughout the day may impact its ability to attract riders, who may not have travel demands that fit into a morning-evening commute pattern. These service gaps were a necessary step to test the demand for this route and avoid sinking substantial operating costs into a service that riders did not value.

Route Changes for Hunt Library Demand

Given the uncertainty surrounding the demand for the Hunt Library and the accompanying travel patterns of those who use the Library, this analysis recommends that NC

[37] The 3A Centennial Express route uses 40-foot Wolfline buses, which are unable to travel on the 3 Engineering route due to their inability to turn on the tighter corners of the narrower roads on the interior of North Campus.
[38] This difference in frequency stems from the fact that during peak hours, the 3 Engineering operates with three buses and the 3A Centennial Express operates with two.

State Transportation make small changes to the current routes that serve Centennial Campus during the first semester that the Hunt Library is in operation to serve demand for inter-precinct travel to and from the Hunt Library with greater effectiveness. These small changes in the Wolfline system, however, may lay the groundwork for more fundamental changes in the system's route design.

Assuming that the trip generation statistics represent an acceptable approximation of travel demand at the Hunt Library, NC State Transportation needs to maintain service at the Hunt Library at all times of day. To promote the development of Hunt Library as a center for student travel, NC State Transportation should establish the Hunt Library stop as a transit hub for Centennial Campus routes. The relatively high level of Wolfline service across multiple routes on the campus precinct will facilitate the extension of services to the Hunt Library Wolfline stop. However, given the short-term nature of these recommendations, NC State Transportation should not make substantial changes to the distribution of Wolfline routes until the Department has evidence of high levels of demand for travel to and from the Hunt Library. While it is necessary for NC State Transportation provide Wolfline services in anticipation of some level of demand, these service changes should be marginal to avoid incurring substantial reductions in Wolfline service in other campus precincts.

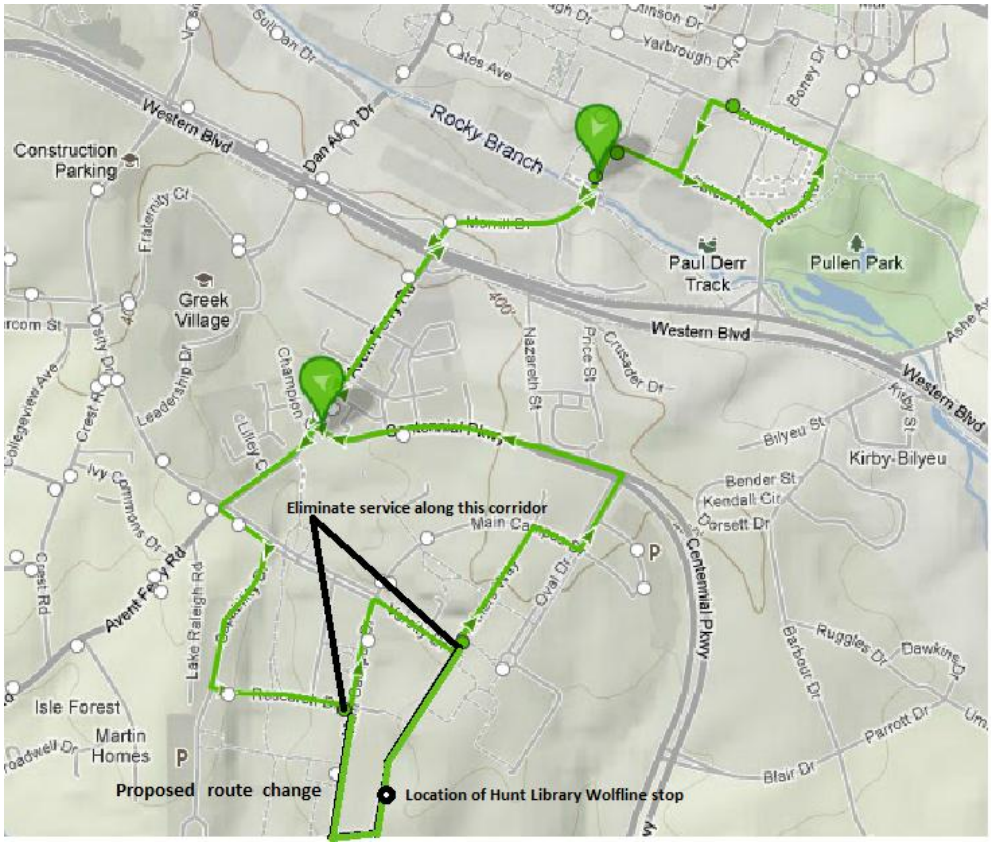
To offer a combination of express and local service, this analysis recommends that NC State Transportation extend two routes to the Hunt Library stop: 3A Centennial Express and 8 Southeast Loop. Both routes currently travel on Research Drive and turn left on to Main Campus Drive to travel to the Partners Way at Varsity Drive stop. This analysis recommends that instead of turning left on Main Campus Drive, Wolfline buses should turn right and travel 0.27 miles to the intersection of Campus Shore Drive, Partners Way and Main Campus Drive (See Maps 8 and 9 below). At this intersection, Wolfline buses turn left onto Partners Way and travel to the Hunt Library, where they stop to collect riders.[39] After this stop, the buses continue to travel north to the Partners Way at Varsity Drive stop, at which point the routes revert to their current design: both routes travel to Main Campus via the Centennial Parkway and Avent Ferry Road.

This shift in the two routes replaces a 0.3-mile trip on Main Campus Drive and Varsity Drive with a 0.5-mile trip, adding approximately one minute of total travel time to route

[39] NCSU is extending Partners Way from its current dead end behind the Partners I Building to connect with the intersection of Campus Shore Drive and Main Campus Drive. See "The Hunt Library" in Appendix.

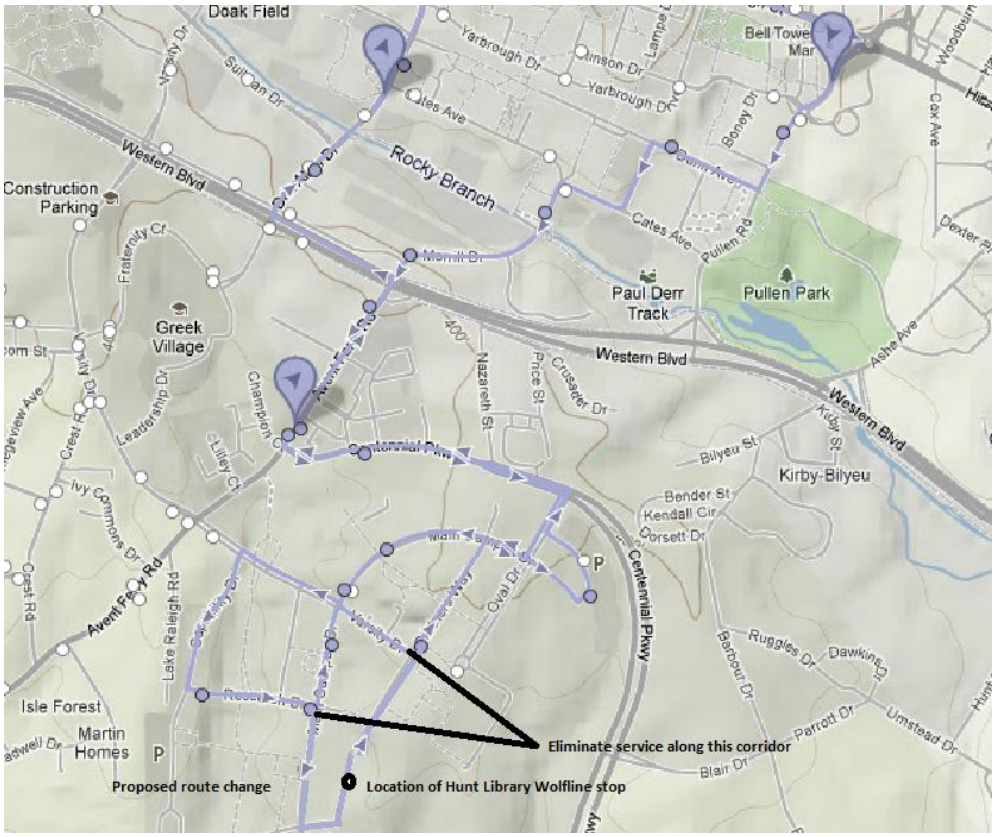
headways (without factoring in stopping time). The shift will also displace a current Wolfline stop. The stop is located on Main Campus Drive and serves the Venture I and Venture II buildings, receiving service from the 11 Village Link and the 8 Southeast Loop. However, the stop is located within 1,000 feet of the Wolfline stops at Partners Way and Varsity Drive and the Hunt Library. The stop also has access to multiple pedestrian campus paths. This connectivity suggests that riders at the two stops may easily substitute the other nearby Wolfline stops for access points without experiencing a significant loss in system access.

Map 8: Proposed Route Changes for 3A Engineering Express



Source: "The NCSU Wolfline—Transit Visualization." *TransLoc*. Accessed 23 Feb 2012. <http://ncsu.transloc.com/> Edits made by author

Map 9: Proposed Route Changes for Route 8 Southeast Loop



Source: "The NCSU Wolfline—Transit Visualization." *TransLoc*. Accessed 23 Feb 2012. <http://ncsu.transloc.com/> Edits made by author

Additionally, this analysis recommends that NC State Transportation reduce service at a stop located at the intersection of Research Drive and Main Campus Drive. This stop receives service from the 11 Village Link and the 10 Southside Circulator in addition to the two routes under consideration. This analysis recommends that the Department shift the 3A Centennial Express and 8 Southeast Loop services to the transit stop at the Hunt Library. The distance between the Hunt Library stop and the stop at Research Drive and Main Campus Drive is approximately 850 feet along a series of campus paths and greenspaces. Furthermore, the distances between the College of Textiles, which is a major trip generator for the current Wolfline stop, and each of the stops are approximately equal to each other. Similar distances in an environment with high levels of pedestrian access suggest that the stop at the Hunt Library will provide similar levels of access to the Wolfline system as the current stop at Research Drive and Main Campus Drive.

Reducing service at the Wolfline stop at the intersection of Research Drive and Main Campus Drive will play an important role in promoting the 3A Centennial Express as an express bus service. Replacing one stop with another rather than adding a new stop will maintain riders' interpretation of the 3A Centennial Express as an express system. The route will offer limited stop access to provide more rapid service between campus precincts. Assuming that the Hunt Library becomes a major activity center, the placement of the route's southernmost stop on the 3A Centennial Express will encourage riders to view the Library as an anchor for the route.

The elimination of 3A Centennial Express service at the stop at the intersection of Research Drive and Main Campus Drive could lead to a decrease in available capacity within route segments, as those riders who had previously boarded or alighted at the intersection will transfer their point of access to the Hunt Library. Providing the same level of service at the Hunt Library and the stop at Partners Way and Varsity Drive may encourage riders who would board at the latter stop to walk to the Library and board the bus at an earlier point in its route. This shift will disperse Wolfline demand from one access point to two and could potentially limit available capacity within each route segment. However, promoting the limited-stop service of the 3A Centennial Express with a focus on faster travel times will maintain riders' familiarity with an express bus corridor between campus precincts.

To facilitate rapid travel times between campus precincts and address potential strains on available capacity, this analysis recommends that NC State Transportation move one Wolfline bus from the 3 Engineering route to the 3A Centennial Express route, increasing frequency along the latter route from 15 minutes to 10 minutes. While this loss in frequency would likely reduce the available capacity on the 3 Engineering Route, increasing the frequency along the 3A Centennial Express will increase capacity and counterbalance the concentration of rider demand along a smaller number of stops. The increase in frequency will also ensure high levels of service at the Hunt Library while largely maintaining the current level of service at the stop located Partners Way and Varsity Drive. Maintaining frequent Wolfline service will further promote the Library as a transit hub.

Furthermore, given the extensive overlap between the 3 Engineering and 3A Centennial Express routes, the shift in frequency between the two routes will not significantly decrease access along the corridor that the two routes travel. Instead, riders who board the 3A Centennial

Express at the outbound stop at Morrill Drive and Cates Avenue[40] will have direct, no-stop access to the Hunt Library along a high-frequency route. Riders who board the 3A Centennial Express at the Hunt Library will have limited-stop access to the inbound stop at Morrill Drive and Cates Avenue[41] without having to travel to North Campus via Western Boulevard and Pullen Road. Although riders who want to travel to points on North Campus will experience longer wait times for the 3 Engineering than they currently do, the change nevertheless maintains connectivity to North Campus. This shift in route frequency will therefore promote more rapid access between campus precincts. Establishing the Library as a transit hub may be more important for NC State Transportation in the next five to ten years. If Hunt Library becomes an activity center and students orient their trips to Centennial Campus around the Library, providing express service to the Library will meet the students' demand for rapid access to one central location on Centennial Campus. Meeting demand at a visible high-traffic area may introduce inefficiency onto other routes, but if students prioritize travel to the Hunt Library, the trade-off will ultimately meet rider demand for Wolfline services.

Additionally, this analysis recommends that NC State Transportation extend the service hours of the 3A Centennial Express to provide service into the evening hours, when stated preferences from student surveys suggest that demand for the Hunt Library will be higher. Currently, the 3A Centennial Express stops at 6:30 P.M., while the 3 Engineering route continues to operate (with lower frequency) until 8:24 P.M. NC State Transportation should extend 3A Centennial Express service hours to 9:54 P.M., the time at which the 8 Southeast Loop also stops and the Wolfline night service route begins. NC State Transportation can similarly expand the service hours of the 3A Centennial Express by moving the one bus that operates on the 3 Engineering route between 6:06 PM and 8:24 P.M. to the 3A Centennial Express. While this service shift will result in a lower frequency of service for travel between Centennial Campus and North Campus, the entire Wolfline system experiences a decrease in frequency around 6 P.M. that correlates with a system-wide decrease in ridership. Riders are therefore familiar with longer wait times between buses during evening hours and will likely accept the decrease in frequency on the 3 Engineering.

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[40] This stop represents a major transit hub on Central Campus that currently receives service from seven Wolfline routes. It is known as the Carmichael Gym stop due to its close proximity to the facility.

[41] While this stop only receives service from the 3A Centennial Express, the stop is approximately 230 feet from the outbound stop at Morrill Drive and Cates Avenue. This short distance places the stop within close proximity to the Central Campus transit hub.

This analysis does not recommend that NC State Transportation change the frequency of the 8 Southeast Loop. Although the 8 Southeast Loop has a high travel time, three Wolfline buses travel the route during peak hours and provide a relatively high level of frequency along the route. Furthermore, the 8 Southeast Loop provides frequent-stop local service between campus precincts as the only route that travels from Centennial Campus to North Campus. The route's high ridership shows that riders are willing to trade longer travel times for high levels of access across campus precincts. With the opening of the Hunt Library, the 8 Southeast Loop will be the only service that will take riders from the Hunt Library to the D.H. Hill Library. Connectivity between the two libraries will provide a sense of similarity between the two activity centers, encouraging riders to view the Hunt Library as they view D.H. Hill: a high-traffic area where riders transfer to other routes and connect to other campus amenities via pedestrian paths.

Both the 3A Centennial Express and the 8 Southeast Loop will be able to accommodate the new travel demand at the Hunt Library with little difficulty. As of April 2012, NC State Transportation has not developed a ridership by time of day profile for the 3A Centennial Express, but the two routes have similar route designs and the high levels of boarding and alighting at Partners Way and Varsity Drive suggests that this stop has a substantial impact on overall route ridership. Since both routes service the stop, this analysis assumes that overall demand patterns between the two routes are similar. Both the 3A Centennial Express and the 8 Southeast Loop experience near-peak capacity (or exceed available capacity) during the late morning and early afternoon hours. The ITE trip generation predictions suggest that travel demand at the Hunt Library in A.M. hours will be relatively low and may not significantly contribute to capacity pressures during these times.

However, available capacity in late afternoon hours and evening hours on both routes align with the preferences for evening Library use that respondents in both surveys stated (the survey results are discussed in greater detail below). In the Customer Service Survey, 50 percent of student responses stated that they would use the Library between 1 P.M. and 7 P.M., and 35 percent of responses selected the option between 7 P.M. and 1 A.M. In the Engineering Student Survey, 83 percent of respondents said they would use the Library between 1 P.M. and 7 P.M., while 60 percent said they would use the Library between 7 P.M. and 1 A.M. This high level of stated preference for evening hours suggests that demand for travel to and from the Hunt Library will increase at the time that per-bus available capacity will increase on these routes. The 8

Southeast Loop experiences a decrease in capacity from the removal of two buses from the route at 6:42 P.M. Under these recommendations, the 3A Centennial Express will experience a similar decrease. However, the decrease in ridership is greater than the decrease in capacity and will result in an overall increase in per-bus capacity.

It is important to qualify these stated preferences with a comparison to the patterns of demand that are displayed in the one-day entrance and exit counts at D.H. Hill. The record of entrances and exits shows a dramatic increase in demand from 11 A.M to 3 P.M., suggesting that the students' stated preferences for Library use between 1 P.M. and 7 P.M. may contain a bias of demand towards early afternoon hours. While both routes demonstrate available capacity during these hours, it is not as large as the available capacity for evening hours.

This analysis does not recommend that NC State Transportation redirect the 10 Southside Circulator to provide service at the Hunt Library. Because the 10 Southside Circulator travels south on Main Campus Drive, turning on to Partners Way to serve the Hunt Library would require that the Wolfline bus complete a loop. After leaving the Hunt Library, the 10 Southside Circulator would turn left onto Varsity Drive, then turn left to return to Main Campus Drive and resume its route. This loop would extend the 10 Southside Circulator by 0.8 miles. While the addition of this loop contributes a relatively small amount of time to the 10 Southside Circulator's headway, the act of traveling in a circle represents a redundancy that may cause riders to perceive the route as inefficient. A low perception of service quality could discourage riders from using the service.

To provide an adequate level of Wolfline service at the Hunt Library, NC State Transportation should reroute the 3A Centennial Express and 8 Southeast Loop to travel past the Hunt Library and resume their respective routes. The Department should improve frequency on the 3A Centennial Express by moving one bus from the 3 Engineering to the 3A Centennial Express and extend the end of the route's operations from 6:30 P.M. to 9:54 P.M.

While these recommendations maintain the status quo of a loop-based route design that many Advisory Stakeholders have criticized, these conservative recommendations are necessary given the uncertainty of Hunt Library demand patterns, the high ridership of the 8 Southeast Loop, and the limited resources of the Wolfline bus fleet that are available to NC State Transportation. In the short term, NC State Transportation should prioritize existing patterns of travel demand over new activity centers to avoid creating inefficiencies within the Wolfline

system. Smaller shifts towards limited-stop express Wolfline services are acceptable, as the 3A Centennial Express already offers similar services, but NC State Transportation should not attempt to create a transit hub through extensive provision of transit services at the Hunt Library until the Department has evidence of high student demand for the library's resources. It is possible for NC State Transportation to make marginal changes that lay the groundwork for rapid bus services between campus precincts (i.e. increasing the frequency on the limited-stop 3A Centennial Express), but the Department should avoid investing substantial resources into an unknown area if doing so could reduce service levels in other corridors on campus.

Additionally, there is little evidence to suggest that student interest in library services is waning. Taking numbers of visits to D.H. Hill as a representation of student demand for library services, annual visits at D.H. Hill have increased from 1.22 million in the 2000-01 academic year to 1.68 million in the 2010-11 academic year. While visits decreased from 1.14 million in the 2004-05 academic year to 1.02 million in the 2005-06 academic year, they steeply increased from 1.1 million in the 2006-07 academic year to 1.39 million in the 2007-08 academic year (See Graph 6 in Appendix). Although electronic access to resources represents an important aspect of the consumption of library resources, students value the physical space of D.H. Hill and its social aspects. It is likely that Hunt Library will achieve similar levels of demand for its physical space.

Survey Results and Discussion:

Customer Satisfaction Survey

As part of its regular solicitation of feedback from Wolfline riders and the NCSU community at large, NC State Transportation conducted a Customer Satisfaction Survey in October of 2011. Questions addressed respondents' Wolfline usage patterns, campus travel patterns, satisfaction with service levels, preferences for system improvements, and opinions on the Hunt Library. Respondents had two opportunities to make additional suggestions for improvements to Wolfline drivers' customer service and to the Wolfline system at large. The NCSU community could take the survey on-line between October 10th and October 24th. 307 people responded to the survey, consisting of 265 students, five faculty, 33 staff members, two Centennial Campus corporate affiliates, and two visitors.

The survey demonstrated that the Wolfline system plays an important role in campus travel: 72 percent of Wolfline riders use the system at least five times per week. However, the

Wolfline is not the sole method of travel: 54 percent respondents said that they transferred from CAT buses to the Wolfline system, and 9 percent respondents said that they drive a private automobile to the nearest Wolfline stop (See Table 3 in Appendix). Respondents showed a high level of familiarity with the various systems that NC State Transportation uses to inform the community about Wolfline services: 43 percent of respondents had visited either the Wolfline's website or www.gotriangle.org[42] at least ten times in the past month (See Table 4 in Appendix), and 95 percent of respondents reported using the TransLoc system[43] to plan their trips (See Table 5 in Appendix).

On metrics of customer satisfaction, respondents gave the lowest scores to the convenience of bus routes and the system's frequency of service and service hours, with respective average rankings of 4.51, 4.71, and 4.66 (on a scale of 1 to 8, with 8 being the highest) (See Table 6 in Appendix). In providing recommendations for service improvements, frequency of service and service hours were the highest priorities, with respective average rankings of 2.50 and 3.05 (on a scale of 1 to 8, with 1 being the highest). While respondents did not have a specific option for "route convenience," the options that described greater connectivity (more connections between different precincts and more service to off-campus areas) received average rankings below one standard deviation of the first two priorities (See Table 7 in Appendix).

The demand for travel between Main Campus and Centennial Campus is significant and is likely to increase with the opening of the Hunt Library: 46 percent of respondents who travel between the two precincts do so at least three times per week (See Table 8 in Appendix), but 67 percent of respondents said they would be likely or very likely to use the Hunt Library (See Table 9 in Appendix). In a question about hours of usage, 50 percent of respondents said they would use the Library between 1 P.M. and 7 P.M., while 35 percent said they would use the Library between 7 P.M. and 1 A.M. (See Table 10 in Appendix)

Perspective Hunt Library users offered transit service priorities that were very similar to overall service priorities: service frequency and evening service hours are the first and second priorities, respectively. Respondents gave both options average rankings that are at least one

[42] www.gotriangle.org is an on-line trip planner that the Triangle Transit Agency maintains.
[43] The TransLoc system is a map that shows real-time information about the location of Wolfline buses on each route and displays wait times for each bus at a given Wolfline stop. The system is also available as an app for smart phones. For more detail, see "The NCSU Wolfline System" in Appendix.

standard deviation above the average ranking that they gave to greater connections between Main Campus and Centennial Campus (See Table 11 in Appendix).

Engineering Students Survey

Because the Hunt Library is located on a part of NCSU that will experience high growth over the next five to ten years and currently serves as the center for the engineering program, this report gives additional attention to the demands and priorities of engineering studentsThese students' preferences should not necessarily take priority over other students (i.e. eliminating one route to provide an exclusive service to engineering students), but the high growth of Centennial Campus will require an increase in Wolfline services to the precinct. As these students will make up the majority of Centennial Campus' student population, identifying the priorities for future transit service on a high-growth campus precinct requires that NC State Transportation understand the needs of the students who will be using those future services. Substantial differences between their transit needs and the needs of students who do not travel to and from Centennial Campus may result in more substantial shifts for NC State Transportation's policies regarding Wolfline service provision.

This analysis designed a survey similar in content to the customer service survey, but NC State Transportation sent the survey to a subset of freshman, sophomore and junior engineering students. This project excluded senior engineering students since the majority will most likely not be at NCSU when the Hunt Library opens. This population was able to take the survey between November 2nd and November 16th. 430 students responded to the survey: 32 percent were freshmen, 32 percent were sophomores, and 36 percent were juniors.

Centennial Campus generates multiple trip purposes for the majority of respondents. In a question about activities on Centennial Campus wherein respondents could choose all options that apply to them, 71 percent of respondents selected classes, 46 percent selected meetings with faculty, and 41 percent selected meetings with fellow students (See Table 12 in Appendix). Responses to a similar question regarding destinations on Main Campus showed greater diversity, which is likely a product of Main Campus' wider range of campus amenities: 83 percent of respondents chose classes, 59 percent selected residence halls, 50 percent selected libraries, 47 percent selected campus dining, and 30 percent selected athletic or recreational facilities (respondents could select all options that applied to them) (See Table 13 in Appendix).

The distribution of engineering resources and extracurricular campus amenities likely explains the relatively high levels of inter-precinct travel reflected in the survey: 30 percent of respondents said that they travel between Main Campus and Centennial Campus three to four times per week, and an additional 30 percent said they traveled at least once per day (See Table 14 in Appendix). Responses to a question about transportation mode choice between Main Campus and Centennial Campus show strong use of the Wolfline system. Respondents could select all applicable answers, and although 33 percent respondents selected "car," 93 percent of respondents selected "Wolfline." (See Table 15 in Appendix).

However, the respondents' high level of interest in the Hunt Library may alleviate some demand for inter-precinct travel for engineering students. 71 percent of respondents said they would be likely or very likely to use the Hunt Library (See Table 16 in Appendix). In a question of hours of usage (in which respondents were able to select all applicable options), 83 percent of respondents said they would use the Library between 1 P.M. and 7 P.M., while 60 percent said they would use the Library between 7 P.M. and 1 A.M. (See Table 17 in Appendix)

Preferences for transit service to and from the Hunt Library nevertheless suggest that even if the Library is able to reduce travel demand between Main Campus and Centennial Campus, it will not eliminate that demand. In a ranking of priorities for Wolfline service to and from the Hunt Library, respondents gave frequent service the highest average ranking of 1.67 (on a scale of 1 to 6, with 1 being the highest). However, the average ranking for faster connections between Main Campus and Centennial Campus, which was the second-highest option, was 2.42. This score was within one standard deviation of frequent service (See Table 18 in Appendix), suggesting that the two options are relatively equal in terms of priority for the student population.

Analysis of the Survey

The high percentage of TransLoc usage in the Customer Service Survey could be very valuable for improving future ridership. Given the high elasticities associated with wait times for public transit, the TransLoc service can introduce greater certainty and predictability into transit use by making accurate information on bus frequency more accessible and less costly to riders. This reduction in uncertainty could enable riders to match their travel times to available service and encourage them to substitute walking trips for short travel distances with Wolfline trips.

With real-time transit information available at a relatively low cost to riders, NC State Transportation could introduce greater flexibility into Wolfline service provision. Kim Paylor, a

Transit Manager within the Department, has suggested that the Department eliminate its time schedules for the Wolfline and replace it with a simpler system of running times (i.e. hours of service operation) and headways. Rather than waiting for a bus to arrive at a given stop at a given time, riders would know how frequently buses travel along a given route and could control their waiting time by using the TransLoc system. By eliminating the need to maintain a schedule, the Wolfline system could eliminate the need for timepoints where buses wait to correct for inconsistencies and "reset" their running times to the time schedules. Simplifying the service could reduce travel times and improve frequencies, meeting survey respondents' highest demand for service improvement.[44]

Travel behavior among engineering students shows a high level of diversity that presents challenges to the Wolfline system as long as Centennial Campus offers a limited range of campus amenities. This heterogeneity suggests rider demand for a diversity of travel times and destinations and implies that travel between campus precincts will remain high. However, the high percentage that "meeting with fellow students" received as a trip purpose on Centennial Campus may be particularly noteworthy. This result suggests that students prefer Centennial Campus when they have a variety of potential meeting spaces, and that when the Hunt Library opens, students will utilize the Library as a meeting space with relative frequency. The use of the Library as a meeting space will likely generate demand throughout the day and into the evening, which will in turn require inter-precinct Wolfline service to run into the evening to serve North Campus residents who want to use amenities on Centennial Campus.

The self-reported nature of these data qualifies any assessment of interest in the Hunt Library. The Library's location on southern Centennial Campus may draw in students who are already on the campus precinct, but accessing this precinct on the existing Wolfline system in most cases would require that a rider board a route that travels by D.H. Hill. It may be difficult for a student to accept the longer travel time or to travel during lower frequency levels if the student believes that he or she can substitute the Hunt Library's resources with D.H. Hill's amenities. The stated dissatisfaction with evening service in the Customer Service Survey may provide evidence of this: respondents in both surveys expressed a high level of interest in using the library during off-peak evening hours, when frequencies on many Wolfline routes decrease

[44] Interview with Kim Paylor. In-person. 25 Jan 2012.

by half or more. If students perceive the system as too infrequent to use during this time, their usage levels of the Hunt Library may be lower than what their stated interest registers.

However, the stated preference for using the Wolfline for current travel between Main Campus and Centennial Campus in the engineering student survey reinforces the high stated preference for traveling to and from the Hunt Library via Wolfline. This pattern of behavior reflecting preference provides a strong argument for integrating the transit stop at the Hunt Library into existing Wolfline services, including the 3A Centennial Express, to ensure that this high-volume rider market can transition to the new Library.

Stakeholder Analysis:

This stakeholder analysis evaluates general trends that emerge from a series of interviews with the author that center around the interviewees' perspectives on NC State Transportation planning and system design as well as the concerns and priorities that the interviewees had with regards to campus planning and transportation management at large. The author provided the interviewees with a set of questions to set the context for the interview but gave the interviewee the freedom to discuss any issues that he or she felt was relevant to the discussion.

The list of interviewees comes largely from the group of Advisory Stakeholders whom NC State Transportation invited to participate in the Campus Mobility Plan (CMP). These Advisory Stakeholders represent a diverse range of groups: administrative departments, academic departments, liaisons for Centennial Campus corporate partners, and student representatives. A small number of interviewees are not currently serving as Advisory Stakeholders, but the author contacted them at the suggestion of other stakeholders.

The majority of Advisory Stakeholders attended a December 2011 kick-off meeting with NC State Transportation and consultants from HDR, Inc., who are assisting in the CMP. At this meeting, stakeholders had the opportunity to learn about the CMP and to provide feedback on the presentation or voice concerns for the direction of the CMP. In February of 2012, a small number of stakeholders who are more directly connected to the campus planning process met with NC State Transportation and HDR consultants to discuss findings and provide feedback from the perspective of their departments' planning priorities. A follow-up meeting in March of 2012 with that was open to the whole committee of stakeholders gave them the opportunity to evaluate initial findings from the CMP and provided additional feedback.

This analysis summarizes the overall distribution of support and concern for five major NC State Transportation priorities in a stakeholder matrix. The purpose of this matrix is to evaluate "at a glance" the level of support that the larger NCSU community has for five major areas of NCSU development:

- increases in student, faculty and staff fees to increase Wolfline and parking services
- promotion of transit service to the Hunt Library and Centennial Campus;
- increases in the use of public transportation;[45]
- increases in the level of bicycle and pedestrian access on campus; and
- increases in restrictions of automobile movement and surface parking access.

The matrix lists each Advisory Stakeholder, the department he or she represents, and a symbol that summarizes their perspectives and opinions on each of the five major areas. A (+) signifies that the stakeholder demonstrates support for the issue and offers very few qualifications for his or her support. A (?) signifies that the stakeholder has concerns about the issue that he or she wants NC State Transportation to address before taking action on the issue. A (--) signifies that the stakeholder opposes the issue and is unlikely to change his or her perspective without the Department making significant changes to the CMP's plans for that issue. A (Ø) signifies that the stakeholder does not offer his or her opinion on the issue. In these cases, the issue did not come up during the course of the interview, or the stakeholder did not believe that his or her opinion on the issue was relevant to the interests of his or her department. These symbols are simplifications of hour-long discussions on complex topics; this analysis uses the symbols for a succinct summary of which departments will most likely agree with or oppose the NC State Transportation as the Department moves forward with its changes to transportation services. This report includes summaries of each individual interview in the Appendix to explain the greater nuance of each stakeholder's opinions.

[45] This analysis uses "alternative transportation methods" as a catch-all phrase to public transit systems that serve the NCSU campus (including CAT and TTA) and options for future public transit services, such as bus priority corridors, light rail systems, and high-speed people movers.

Stakeholder Matrix (Campus Transit Mobility Plan)

	Increased Fees for Wolfline and Parking Services	Promotion of Transit Service to Hunt Library and Centennial Campus	Support for Increases in Public Transportation Use	Support for Increases in Bicycle and Pedestrian Access	Support for Reductions in Automobile Access and Surface Parking Supply
Kristi Alpi, NCSU Library System and Centennial Biomedical Campus	(--)	(+)	(+)	(?)	(+)
Carolyn Axtman and Rachel Patrick, Capital Planning Management	(--)	(?)	(+)	(+)	(?)
Lauren Ball, International Student Association	(--)	(+)	(+)	(Ø)	(Ø)
Dick Bernhard, Industrial and Systems Engineering	(--)	(+)	(--)	(+)	(--)
Carson Cook, Office of Institutional Equity and Diversity	(--)	(+)	(+)	(Ø)	(?)
David Goldsmith, NCSU Library System	(Ø)	(+)	(+)	(Ø)	(?)
Susan Grant, Housing Department	(Ø)	(Ø)	(+)	(Ø)	(--)
Mike Harwood, Centennial Campus Development Office	(?)	(+)	(?)	(+)	(--)
Louis Hunt, Enrollment Management and Services	(+)	(+)	(+)	(+)	(?)
Kristy Jackson, Institute for Transportation Research and Education	(Ø)	(?)	(?)	(+)	(+)
Lisa Johnson, Office of the University Architect	(Ø)	(+)	(+)	(+)	(+)
Amy Lubas, Centennial Partners Office	(?)	(?)	(+)	(+)	(?)
Steve Nettles, Housing Department	(--)	(+)	(?)	(Ø)	(?)
Josh Privette, Student Government	(+)	(+)	(+)	(Ø)	(?)
John Royal, College of Engineering	(Ø)	(+)	(+)	(+)	(+)
Tom Skolnicki, Office of the University Architect	(Ø)	(+)	(+)	(+)	(?)
Cameron Smith, Capital Facilities and Housing	(--)	(Ø)	(+)	(+)	(+)
John Stone, College of Engineering	(Ø)	(?)	(+)	(Ø)	(Ø)

KEY: (+): support; (?): concern or frustration; (--): opposition; (Ø): no opinion offered

Increased Fees for Wolfline and Parking Services

This issue receives the most consistent opposition from stakeholders. Administrative staff and liaisons for Centennial Campus corporate partners frame high parking prices as a source of competitive pressure for NCSU relative to other employers. They express concern that parking fees at NCSU are substantially higher than what other universities or office parks offer and that raising these fees would disincentivize potential employees or corporate partners from agreeing to work or locate at NCSU. Furthermore, administrative members and liaisons express skepticism that faculty and staff use the Wolfline with enough frequency to regard their higher parking fees as an acceptable trade-off for greater Wolfline service. The liaisons point out that corporate partners do not directly pay for their parking services as separate fees or permits but instead pay for their parking fees as a bundled service in the overall building rents. An inability to separate the parking fees from the rent will hinder the corporate partners' ability to recognize the connection between an increase in fees and an increase in services. The liaisons see this disconnection between fees and services as a hindrance to building support among the corporate partners, as they will not identify the increase in fees as a source of funding for transit services.

Among student representatives, support for increased parking fees is higher but still reluctant. Student representatives stress that if students were to see a higher-than-usual increase in transportation fees, they would demand to see a substantial increase in transportation services. Recognition of the increase, however, would require NC State Transportation to market the service improvements directly and aggressively. Specifically, they recommend that NC State Transportation explain that the new services are a direct result of the parking fees (even if this is an exaggeration) and will answer student demands (i.e. greater frequency, more evening hours). If NC State Transportation does not create any new services, the representatives believe that students would accept a nominal fee increase as a sign of appreciation for existing services. However, the representatives recognize that students technically have few options for resisting these fee increases and instead offer that students can provide visible public support if they feel that they are receiving effective services as a result of higher fees.

Promotion of Transit Service to Hunt Library and Centennial Campus

Discussions of transit service on Centennial Campus focus extensively on the predicted growth and development that the precinct will experience over the next five to ten years. Generally, stakeholders have a very high level of optimism for the Hunt Library and the future of

Centennial Campus development. The more conservative predictions for student interest in the Hunt Library suggest that students who spend most of their time on the Main Campus will not likely want to incur the long travel times that are necessary to travel from Main Campus to Centennial Campus. Yet the majority of stakeholders across all groups describe the Hunt Library as a building that will change the entire pattern of use and development on Centennial Campus. Regardless of the size of its draw, the Library will improve pedestrian movement and the campus environment and will extend the period of student activity into the evening hours. The Library will also increase the appeal of Centennial Campus and will draw students from all precincts onto Centennial Campus, which will in turn create a unifying effect for the entire NCSU campus community. Stakeholders from Library Services anticipate that students will meet the Library's supply of 24-hour access for the services and argue for a build-up of transportation services that can meet 24-hour demand.

Stakeholders do not assume that the Library can meet the entire spectrum of needs that a campus community demands. In almost every discussion of the future of Centennial Campus, the lack of food service on the precinct came up as a principle concern for the creation of a campus environment and a driving force for travel demand between campus precincts. Many of the stakeholders who have been involved in the planning of the Library praise the coffee shop that the building will contain as a first step towards a more self-contained campus but recognize that the shop is not enough to sustain student demand for food. Several stakeholders suggest that NCSU and Centennial Campus administrative decision-makers encourage local food trucks and other mobile food services to operate on Centennial Campus.

The limitations of the amenities that Centennial Campus currently offers influence the high priority that stakeholders give to the improvement of Wolfline service between Main Campus and Centennial Campus. Many administrative staff members cite the long travel times and infrequent service between the two precincts as a substantial challenge to scheduling meetings or attending events on Centennial Campus. Similarly, the liaisons for corporate partners describe the complaints that they have received from corporate partners who experience difficulty in hiring student interns due to the students' challenges with traveling between campus precincts. In several cases, stakeholders cite the inadequate transit services between the precincts as the largest determinant in their decision to use automobiles for inter-precinct travel. These responses represent an unmet and unexpressed demand that rapid inter-precinct service could

meet. By designing limited-stop services that can operate with faster traveling speeds and higher frequencies, NC State Transportation could capture ridership among staff members who currently drive between points on campus throughout the day.

Many stakeholders respond very positively to the concept of high-frequency rapid bus service with limited stops between the two campus precincts (which the author suggests to stakeholders as a potential solution to this issue). A system with high frequency and short travel times would represent a dramatic increase in efficiency over the existing Wolfline system since it would improve travel times and waiting times. A high-frequency bus service would reduce uncertainty surrounding wait times for the next bus. The service would improve riders' confidence that they will reach their destination with a travel time that is competitive with those that automobiles offer. Such service would meet the travel needs for students, faculty and staff who believe that automobiles are the most efficient way to travel between points on campus. While a portion of these trips occur during peak periods (i.e. students who are traveling between classrooms), travel for staff and faculty meetings likely occur at off-peak periods when Wolfline buses have higher levels of available capacity. This distribution of trips suggests that staff and faculty members may transition to the Wolfline system without stressing system capacity.

While stakeholders are confident about the proposed system's benefits, their recommendations for which physical points would serve as the most effective centers for rapid transit service vary. Several administrative staff members recommend that the express route should connect the Hunt Library and D.H. Hill Library to offer a sense of consistency between the two campus precincts and communicate to the NCSU community that the Hunt Library shall serve as an activity center and focal point on Centennial Campus just as D.H. Hill does on Main Campus. However, stakeholders who are more directly involved with Centennial Campus recommend that the route travel between the Hunt Library and the Talley Student Center to create a shorter route that will enable higher frequencies and shorter travel times. A small number of stakeholders strike a compromise between the two plans and suggest that D.H. Hill serve as the Main Campus transit hub until the Talley Student Center renovations are complete, since D.H. Hill currently generates greater travel demand as a social center and activity hub. Once the renovations are complete, these stakeholders anticipate that the Talley Student Center will become the primary social center on Main Campus. At this time, NC State Transportation should shift the express route to the renovated building.

Despite the emphasis on rapid Wolfline service with limited stops that many stakeholders place on the future of travel demand between the campus precincts, several stakeholders insist that NC State Transportation should maintain the Wolfline circulators that provide local service on precincts. Many of these stakeholders have greater connections to facilities or services on Centennial Campus; they stress that local service is necessary to enhance connectivity and manage traffic flows and parking demand on the precinct. By increasing circulator service in the Avent Ferry Road and Gorman Street corridor, NC State Transportation will facilitate transit travel to Centennial Campus from the apartment complexes located in this corridor.

Increases in Public Transportation Use

While every stakeholder has an overall positive opinion of Wolfline services, many stakeholders believe that NC State Transportation should change the structure of the system. The stakeholders' recommendations suggest that they perceive the current Wolfline system as a series of loops on campus precincts peripheries and thoroughfares. These "loop" systems offer extensive connectivity with high numbers of stops along lengthy routes. Consequently, Wolfline riders experience long travel times and frequent stops. Stakeholders criticize these trips as inefficient relative to other travel options and ineffective at promoting mobility across campus. Many stakeholders cite these trips as the primary reason why they choose to drive on campus.

As an alternative to the loop system, many stakeholders recommend that NC State Transportation shift from a system that prioritizes loops to a system that prioritizes short, direct connector routes between origins and destinations. This system would prioritize travel time and waiting time by focusing on short trips with high frequencies. The routes would connect major trip generators with limited stops in between. Routes would operate in predictable north-south and east-west directions to reduce system complexity. This system would rely extensively on transfers at these major trip generators to facilitate movement between campus precincts, but a high level of frequency throughout the system would improve route reliability and increase riders' willingness to make transfers.

Stakeholders believe that NC State Transportation's plan to replace surface parking lots with parking decks will create major trip generators on campus peripheries that will facilitate a direct connection from these decks to destinations on precinct interiors. A few stakeholders argue that these connections would reduce the impact of traffic congestion on on-time performance, since shorter routes on the campus interior would have less interaction with thoroughfare traffic.

The goal of a connector-based system is to promote accessibility throughout the campus through short travel times and frequent service. Reducing the uncertainty surrounding when a Wolfline bus will arrive and reducing the time that a rider will spend in between trip generators will ultimately make the Wolfline bus more responsive to travel demand and make the Wolfline system more competitive with automobile travel.

Several stakeholders who are involved more directly with students and administrative staff assert that NC State Transportation must take a more active role in marketing public transportation to the NCSU community. Specifically, NC State Transportation must communicate the advantages of using the Wolfline, but the Department must qualify these advantages with a clear understanding of the nature of a public transportation system. A few stakeholders recognize that faculty, students and staff all suffer from a misunderstanding of the capabilities of a public transportation system. One stakeholder warns that many students view the Wolfline system as a private taxi service for their respective origins and therefore believe that the system is failing to fulfill its duties when a Wolfline bus is at capacity and cannot take additional riders. To address this sense of disservice, NC State Transportation must temper the community's expectations with a media campaign that explains the size of the Wolfline's market and the need for careful travel planning during peak periods of demand.

However, the size of the Wolfline's market also describes the size of the system's network and the mobility that this network gives to riders. With more assertive explanations of the time costs and monetary costs that parking an automobile generates, NC State Transportation can demonstrate that the costs of travel planning are less than the costs of cruising for parking during inter-campus trips. Through a more comprehensive discussion of the costs and benefits of each transportation mode, NC State Transportation can inform the NCSU community about the Wolfline system and present the system as cost-effective.

To expand public transportation use beyond the campus boundaries, a small number of stakeholders who are more directly involved in campus planning and transportation analysis recommend that NC State Transportation work with TTA and CAT to promote an inter-agency network of public transportation services. While coordination between the different systems to enable inter-agency transfers plays an important role in the development of a network, many of the stakeholders focus their suggestions on the branding of the systems rather than the route

design. In these stakeholders' perspectives, the problems with the network stem from a lack of information rather than a lack of access.

To this end, NC State Transportation should promote the TTA and CAT systems as mobility options that are as effective as the Wolfline. These efforts can be part of a media campaign that demonstrates that there are numerous ways to connect with nearby destinations outside of NCSU's campus. This campaign can also partner with NCSU research centers and event planning services to provide visitors with alternative travel options for their visits. NC State Transportation currently offers a multi-system fare-free transit pass to the NCSU community. The transit pass, known as GoPass, is available at no direct cost to all current NCSU students, faculty and staff. GoPass holders are able to travel on CAT and TTA buses for no fare throughout the academic year. Thus NC State Transportation already has an established relationship with these systems that enables NCSU community members to eliminate the monetary costs of transferring between systems.

Looking to five- and ten-year outlooks for transportation services, several stakeholders envision that NC State Transportation will upgrade its infrastructure to improve Wolfline service and expand NCSU transportation options. Many stakeholders either recommend or respond positively to the development of a bus priority corridor between Main Campus and Centennial Campus. The focus of the corridor is relatively consistent across different departments: rapid transit access between campus precincts with limited stops and high frequencies. Stakeholders show greater variation with regards to corridor design. Some envision a relatively inexpensive system, in which current Wolfline buses operate within a lane that street signage and paint designate as bus-only. Other stakeholders who are more directly involved with transportation planning, suggest greater infrastructure and technological improvements for the corridor, including signal priority on buses and grade-separated lanes for the vehicles.

Locations for the bus priority corridor also vary. Some stakeholders advocate for the corridor to operate only within Dan Allen Drive, as this corridor has a high level of Wolfline service and provides access to a wide range of amenities on North and Central Campuses. Others advocate for the corridor to follow the path of the preserved transit corridor that the Physical Master Plan outlines to promote shorter travel times between Main Campus and Centennial Campus. This preserved transit corridor runs along Varsity Drive from Centennial Campus to the

intersection of Varsity Drive, Dan Allen Drive, and Western Avenue. At that intersection, the corridor continues onto Dan Allen Drive.

Despite these differences, the stakeholders' visions reflect a need to elevate the presence of the bus priority corridor and, by extension, public transportation services at NCSU. Several stakeholders assert that the bus priority corridor will enhance the perception of public transportation as an efficient method of travel and will therefore play an important role in encouraging the NCSU community to use transit instead of their automobiles.

Stakeholders who are more directly involved with Centennial Campus planning and development point out that multiple departments, including the Office of the University Architect (OUA) and the Centennial Campus Development Office (CCDO), are reserving physical space on Centennial Campus to ensure that NC State Transportation has sufficient space to expand transportation infrastructure on the precinct. Specifically, representatives from the OUA mention the space that their department has set aside for the development of a bus priority corridor. Currently, this bus priority system exists as a "line on a page" in the OUA's Physical Master Plan. These stakeholders stress that NC State Transportation should develop its vision for higher levels of transit service in this corridor so that OUA can begin working with the Department to secure funding for the project.

Additionally, a more complete vision for this transit service would give stakeholders who work with Centennial Campus corporate partners a new service to promote to potential corporate partners as a benefit of locating their businesses at NCSU. However, this group of stakeholders also places high priority on the maintenance of circulator services over the next five to ten years. They point out that the development of Centennial Campus will create a build-up of infrastructure around the precinct's periphery. The presence of multiple trip generators, including a Centennial Campus residence hall that is under construction and will open in the summer of 2014, will require that NC State Transportation expand Wolfline service along the periphery of the precinct as it develops its eastern edge.

Moving beyond changes to Wolfline services, some stakeholders advocate for higher-capacity transit systems, including light rail transit and personal rapid transit systems, to operate between campus precincts. Frequently, stakeholders select one system or another, rather than advocating for a multi-modal network of high-capacity systems. They stress that the demand for inter-precinct travel is too great for Wolfline buses to serve with an effective level of frequency.

NC State Transportation should therefore consider expanding capacity between precincts with a high-speed system that operates with a high level of frequency throughout the day. A small number of stakeholders believe such a system will raise the profile of NCSU as a progressive and technologically-advanced university and generate greater interest in alternative transportation, creating "spillover benefits" for other public transit systems that operate on campus.

Unfortunately, these stakeholders offer very few details with regards to how to pay for a high-capacity system, although many remain optimistic that the NCSU community would recognize the system's benefits and would accept an increase in transportation fees to support it. Multiple stakeholders who work in the College of Engineering voice concerns for the high costs that any transportation project would generate if it were to require a substantial build-up in road infrastructure. These stakeholders also point out the limited space for additional infrastructure on parts of Main Campus, including Dan Allen Drive; the limitations of the streetscape would therefore necessitate that NC State Transportation displace road capacity for automobiles if the Department were to build a high-infrastructure transportation system.

Increases in Pedestrian and Bicycle Access

Many of the discussions regarding improvements for pedestrian and bicycle access focus on safety enhancements in areas of the NCSU campus where automobiles and alternative methods of transportation interact. Stakeholders largely are in agreement about where these enhancements are most needed: the intersection of Avent Ferry Road and Western Boulevard and the pedestrian crossings along the Dan Allen Drive corridor. Several stakeholders also advocate for the expansion of pedestrian infrastructure along Cates Avenue as well. There is substantial variation in recommendations for these safety improvements. Many stakeholders are familiar with the proposal to create a tunnel for pedestrians and bicyclists at the intersection of Avent Ferry Road and Western Boulevard, but there is disagreement regarding its costs and benefits. A small number of stakeholders believe that the tunnel will not provide sufficient safety for pedestrians. They advocate for alternatives, including a pedestrian bridge over the intersection and an increase in the number of mid-block crossings along Western Boulevard.

Despite the differences in recommendations for technologies or infrastructures, these stakeholders focus on the reduction of interactions between automobiles and non-motorized transportation modes, either through the designation of space in the streetscape for different modes of transportation (i.e. bicycle lanes and pedestrian bridges) or through the restriction of

automobile movement on the NCSU campus (which is discussed in greater detail below). A small number of stakeholders recognize that regardless of what methods NC State Transportation uses to separate the different modes from each other, non-motorized transportation modes will benefit from the reduction in competition for road space and will provide greater mobility and access for the NCSU community members who use these modes. However, these stakeholders generally see these enhancements as secondary benefits that result from improvements in safety.

While they prioritize the safety of those using alternative methods of transportation, the stakeholders who are more directly involved with Centennial Campus and with campus planning processes view pedestrian and bicycle access as part of a larger effort to promote a sustainable, pedestrian-oriented campus environment. Given the larger role that pedestrian and bicycle access play in these efforts, the stakeholders advocate for more comprehensive development of pedestrian-friendly, "human-scaled" infrastructure. Stakeholders who represent corporate partners on Centennial Campus support the development of pedestrian-oriented infrastructure to create a stronger campus environment that will encourage student activity on the precinct. These stakeholders are not suggesting that the corporate partners themselves will use these amenities (aside from short walking trips within the precinct), but the partners do value the amenities for their ability to create a more active student presence.

As such, their recommendations include large-scale projects that link different green spaces into cohesive campus paths and connect to the City of Raleigh's network of green infrastructure. However, these recommendations also include small-scale amenities that are attached to individual buildings, such as covered bike lockers and park benches. These stakeholders recognize that the development of a pedestrian-oriented campus requires smaller changes in the campus environment that facilitate access up to the door of the building and fill in the gaps in the system of campus paths. Yet the large-scale projects will raise the profile of the pedestrian-scaled infrastructure and create a greater sense of permanence on the NCSU campus, facilitating non-motorized mobility across the entire campus.

Reductions in Automobile Access and Surface Parking Supply

Stakeholder feedback on reductions in automobile access shows significant variation between different groups of stakeholders. While the majority of stakeholders support efforts to reduce vehicular access on campus precincts (particularly for through traffic on campus interiors), they have several concerns regarding the implementation of these restrictions in

automobile access. In the stakeholder interviews, the author frequently cites Dan Allen Drive as a location for a restriction in automobile access, since NC State Transportation has considered implementing this policy in previous planning documents. However, several stakeholders offer Dan Allen Drive as an ideal location for an experiment with vehicle restrictions due to the high level of traffic congestion in the corridor and its impact on Wolfline bus movement. A small number of stakeholders also discuss the restriction of automobile access on Cates Avenue in the form of conversion to a one-way street and the removal of on-street parking.

The stakeholders who support vehicular restrictions on Dan Allen Drive view these restrictions as the implementation of numerous principles of sustainable design, including orientation of campus planning around pedestrian movement, enhancement of pedestrian safety, enhancement of public transportation operations, congestion mitigation, and reduction of environmental impact. They are enthusiastic that these restrictions would play an important role in the promotion of NCSU as a pedestrian-oriented campus by giving community members a consistently high level of mobility across larger areas. These vehicle restrictions would also promote the campus environment to the outside community by signaling that drivers have come to an area where the NCSU community has priority in the streetscape. Yet pedestrian safety is the most frequently supported benefit of the vehicle restrictions. The stakeholders who focus on improving pedestrian safety stress that the reduction of interaction between automobiles and pedestrians is key to establishing a pedestrian-oriented campus.

The stakeholders who support restrictions in automobile access come from all areas of the NCSU community, including those who are involved with campus planning and those who work in the College of Engineering. However, these stakeholders also offer the strongest concerns for the implementation of these restrictions. They stress that without an aggressive advertising of the restrictions' impact and the benefits that these restrictions will generate, public opposition will be substantial and could come from within the NCSU community as well as from outside of it. NC State Transportation must begin this communication effort far in advance of the automobile restrictions and must provide opportunities for community members (from within and from outside of NCSU) to give feedback on the restrictions and adjust their travel behaviors.

Additionally, these stakeholders stress that NC State Transportation must maintain access to the Dan Allen Parking Deck or carefully evaluate the reduction in resources that the Department will face if it is unable to do so (See Map 10 in Appendix). The Department must

also conduct extensive analysis of traffic flows to determine what level of automobile restriction is optimal for managing traffic congestion along Dan Allen Drive in the initial tests of these restrictions. Stakeholders stress that facilities vehicles and emergency service vehicles must maintain access within the corridor as well. Ideally, NC State Transportation should implement these restrictions as short-term increments or experiments that give the Department and the NCSU community an opportunity to evaluate these restrictions' impact over time without incurring infrastructure costs for a permanent system that may not provide substantial benefit.

A small number of stakeholders point out that pedestrians create much of the congestion on Dan Allen Drive by interrupting the flow of traffic; one stakeholder recommends that NC State Transportation and OUA consider designing a pedestrian bridge to remove pedestrian traffic from the streetscape. This stakeholder also warns that the restriction of automobiles on Dan Allen Drive could displace traffic congestion from the corridor to Western Boulevard and Hillsborough Street, both of which already have high levels of traffic. However, the majority of stakeholders who express concern for the restriction of automobiles along Dan Allen Drive recognize that NC State Transportation has few options for reducing traffic congestion along the corridor. They point out that the level of build-up in the corridor greatly limits opportunities for increasing road capacity.

There is similar concern among stakeholders for the development of parking decks on campus precinct peripheries. Many stakeholders regard the shift away from surface parking towards parking decks as a decision that NC State Transportation and OUA have already made and are in the process of implementing. As a result of this perspective, stakeholders generally offer suggestions for the location of parking decks and the processes that the departments use to develop the new parking infrastructure. The priority among these suggestions is that NC State Transportation maintain a relatively constant parking supply within each campus precinct.

A small number of stakeholders express a fear that the Department will shift parking supplies away from each campus precinct and centralize them in an off-campus park-and-ride that NCSU community members can only access via Wolfline trips with long travel times. For NC State Transportation to mitigate this concern, these stakeholders stress that the Department replace surface parking lots with parking decks on a precinct-by-precinct basis. This system will enable each precinct to maintain its current level of access to parking structures and will reduce the need for NCSU community members to make significant changes to their travel behavior.

Additionally, several stakeholders stress that a small supply of surface parking remain available for facilities vehicles and emergency vehicles that need to have direct access to buildings so that staff in these departments may carry out their duties effectively and quickly.

Stakeholders who represent the corporate partners on Centennial Campus are particularly emphatic on this point, stressing that the businesses are very protective of their parking supply and would strongly oppose any change that they perceive as a threat to that access. The student demand for the Hunt Library could reduce the availability of the Centennial Campus parking supply; some stakeholders are concerned that students who live off-campus will use the Research I Parking Deck and compete with corporate employees for these spaces. This high demand for parking access leads many stakeholders who are involved with Centennial Campus planning and development to conclude that private developers will oversupply parking at new developments on the precinct for the foreseeable future.

Additionally, several stakeholders insist that NC State Transportation must accompany its shift to parking decks with an increase in Wolfline service to these decks. Several stakeholders who work in administrative services or represent student interests stress the need for NC State Transportation to operate rapid, limited-stop Wolfline services between these peripheral parking decks and major trip generators during peak-hour travel demand for trips to campus precinct interiors. The stakeholders who work in administrative services insist that these services provide access to the buildings that staff member use more frequently than students (i.e. Administrative Services II on Central Campus). If NCSU community members are going to lose the surface parking spaces that currently provide immediate access to their offices or classrooms, they must receive transit services that reduce the travel costs that peripheral parking access will incur. One stakeholder cites the West Deck parking deck on Central Campus as an example of a parking deck that receives adequate levels of Wolfline service and provides students with access to precinct interiors. This stakeholder recommends that NC State Transportation use this level of service as a standard for designing the routes that will serve other parking decks in the future.

Several stakeholders nevertheless recognize and appreciate the benefits of parking decks and view them as positive contributions to the NCSU campus environment. Stakeholders who are more directly involved with campus planning acknowledge that parking decks represent a cultural change in the relationship between NCSU community members and automobiles, but they assert that it is an appropriate way to maximize usable space on campus. These stakeholders

frequently cite the opportunities that parking decks create to convert more space on campus precinct interiors to pedestrian space. One stakeholder describes the shift to parking decks as a way to create a "self-contained" campus environment in which campus design moves automobile traffic to the edge of campus and enables higher levels of safety and mobility for pedestrian movement. In this stakeholder's opinion, the shift to parking decks can accompany the reduction of automobiles on campus interiors to facilitate the shift to a car-free campus interior.

Many other stakeholders who are involved in administrative services are more cognizant of the development pressures and demand for usable space that the urban environment of NCSU create for NC State Transportation and the OUA. Even though these stakeholders express frustration with or concern regarding the development of parking decks, they recognize the reasons for NCSU to adopt them and locate them on the periphery of campus precincts. As stated above, these stakeholders have concerns about the changes in travel behavior that NCSU community members will have to make. Therefore, they wish to remain part of the decision-making process that determines the relationship between the parking decks and the larger NCSU transportation network and stress that the NC State Transportation and the OUA should provide opportunities for community feedback on the development of these parking decks.

Conclusion:

The trip generation and transit demand analysis make short-term recommendations for improving services based on common trends that appear in the customer feedback surveys and the stakeholder analysis. Namely, these recommendations attempt to improve Wolfline frequency and travel speeds. These short-term changes should be part of a larger policy shift towards the recommendations that stakeholders made and that respondents' stated preferences suggest that they would value: rapid, limited-stop bus service that facilitates mobility between different campus precincts via major trip generators. By promoting rapid bus services that offer short travel times between campus precincts, NC State Transportation can present its Wolfline system as a predictable and frequent service that is competitive with automobile travel.

To identify the appropriate levels of service that riders at major trip generators demand, NC State Transportation should develop local trip generation rates that evaluate the level of transit usage and transit demand at these specific trip generators. As discussed previously, this analysis bases its estimate of transit demand at D.H. Hill Library and the Hunt Library on the

Institute of Traffic Engineers' average values of vehicle end trips. Using this average value ignores the variations in demand that occur throughout the day and separates the libraries from their respective spatial contexts. The existing status of D.H. Hill as a transit center and Bus Transfer Stop may influence transit ridership at the nearby stops in ways that a simple evaluation of the building's square footage does not capture.

To address these limitations, NC State Transportation should develop an estimation of local trip generation rates for D.H. Hill, the Hunt Library and other major trip generators by collecting data on travel mode choice among visitors who are entering and exiting the building. The surveys of these visitors should focus on what modes they used to travel from their origin or what modes they will use to travel to their destination This data collection process should occur at several different times to capture any possible changes between mode choice and time of day (i.e. if students choose to walk during times when they expect that the Wolfline routes are operating at capacity) and to capture changes in demand for the trip generator's services. The number of visitors who express a preference for traveling to or from the trip generator on Wolfline divided by the total number of visitors in the survey will provide an approximation of the mode share for Wolfline at the trip generator.

NC State Transportation can then compare the data on visitors' mode choice preferences to ridership at nearby Wolfline stops during the times when staff members were collecting data. The number of visitors who express a preference for Wolfline services to or from the trip generator divided by the number of riders who board or alight at a Wolfline stop near the trip generator will provide an approximate percentage of riders who take transit to or from the trip generator. This evaluation will also provide insight into the extent to which the trip generator serves as a hub for travel demand in the area around the trip generator. The accurate identification of trip generators that can serve as transit hubs will be a necessary part of designing rapid, limited-stop services between campus precincts. To adopt a policy of express bus service between precincts will likely require NC State Transportation to reduce its circulator services, but the high level of inter-precinct connectivity may ultimately lead to higher transit ridership and less inter-precinct automobile congestion.

While the NCSU community has a high level of familiarity with the Wolfline system and with transportation issues on campus, there is a need for greater communication between NC State Transportation and the larger community to inform NCSU about the role that transportation

can play in connecting the campus and bringing the community together. The community must have a clear understanding about the advantages of public transit, but they must also be able to place their individual travel demands in the context of a system that is moving many people between numerous origins and destinations.

As Centennial Campus continues to develop and expand its range of amenities over the next five to ten years, NC State Transportation must pay greater attention to the NCSU community's changing patterns of demand for transit services. As demand shifts among different markets of Wolfline riders, the Department will likely have to make more significant trade-offs in its distribution of services. High demand for inter-precinct travel may ultimately require that NC State Transportation invest in higher-capacity transit services that are separate from the existing Wolfline system and specifically serve these markets. The NCSU community at large will benefit from these high-capacity services, but their maintenance may require a more dramatic change in the mechanisms that NC State Transportation uses to fund its services, including the implementation of a fare for the higher-capacity system. To make such a dramatic change in policy, NC State Transportation should assert itself within the community to ensure that transportation issues more actively factor in to the campus planning discussion. Rather than allowing an automobile-centric culture to drive decisions about how the campus will look and what amenities it will offer, the Department should directly engage the community to improve alternative transportation modes and expand the campus infrastructure that supports them.

Summary Recommendations:

Short-term transit demand analysis at Hunt Library: 2012—2013

- Re-route 3A Centennial Express and 8 Southeast Loop to stop at Hunt Library via Main Campus Drive and Partners Way
- Do not change frequencies on 8 Southeast Loop
- Move one bus from 3 Engineering to 3A Centennial Express to improve frequencies
- Increase daily end of 3A Centennial Express service from 6:30 PM to 9:54 PM

Long-term campus development planning and transit planning: 2015—2020

- Wolfline service
    - Shift focus on Wolfline service from circulating loops to prioritize rapid, high-frequency service between campus precincts via major transit hubs and trip generators with limited stops
    - Develop express bus service between Hunt Library and D.H. Hill Library with limited stops along North Campus and Central Campus
    - Shift express bus service to corridor between Hunt Library and Talley Student Center following completion of renovations
- Development of parking decks for parking supply
    - Ensure that each campus precinct has sufficient parking for people traveling to precinct
    - Maintain sufficient surface parking around campus buildings to permit access for facilities vehicles and emergency service vehicles
- Pedestrian and bicycle infrastructure
    - Implement reductions in automobile access on Dan Allen Drive to improve pedestrian safety
    - Increase bike and pedestrian safety at Avent Ferry and Western intersection
- NCSU community outreach
    - Communicate clear service standards for Wolfline operations to NCSU community to set expectations about public transportation services
        - Stress the use of the TransLoc app to make wait times more predictable
    - Communicate the Wolfline system upgrades and benefits that students, faculty, staff and corporate partners receive from their student fee and parking fee contributions
    - Communicate all restrictions in automobile access as early and as directly as possible to give opportunities for community feedback and travel behavior adjustment
    - Update the Office of the University Architect and the Centennial Campus Development Office on transit technologies and infrastructures at all levels: NCSU; City of Raleigh; State of North Carolina

Appendix:

Additional NCSU information:

The NCSU Wolfline System

The Wolfline system consists of 35 buses traveling along 12 daytime routes and three nighttime routes during the Fall and Spring semesters, with additional limited service during student breaks and summer months. The Wolfline system uses two types of buses: a 30-foot bus with a capacity of 55 people and a 40-foot bus with a capacity of 75 people. The 30-foot buses are able to run on roads that run on the "interior" of Main Campus, such as Stinson Drive, due to their smaller turning radii. The system largely serves the five campus precincts, although the WolfProwl evening service travels to downtown Raleigh on Thursday, Friday and Saturday nights. Wolfline service is fare-free and open to the public. In the 2011 calendar year, the Wolfline system had 2,547, 812 riders, an 18.4% increase in ridership from 2010, and produced approximately 70,000 service hours.

Bus frequencies vary by routes, from 10 to 12 minutes on the 3A Engineering Express route to 22 to 30 for the 4 Westgrove route. With the exception of the 10 Southside Circulator, which travels between Centennial Campus and Avent Ferry Road, all routes circulate through the Main Campus. However, while a small number circulate within the Main Campus on two loop routes, several other routes facilitate travel between North Campus and other campus precincts, as well as the three park-and-ride facilities located on the western and southern edges of NCSU.

Many of these routes operate along time schedules to make Wolfline service more predictable for riders. NCSU DOT lists these schedules on its website and identifies time points where Wolfline buses will wait to correct for discrepancies in the route. NCSU DOT also distributes pamphlets containing detailed information about routes and schedules and updates the pamphlets each semester.

NCSU DOT uses a Transit Visualization System to make real-time Wolfline locations available to the public. Since 2005, NCSU DOT has partnered with TransLoc, Inc. to produce and display this information. The TransLoc website, which NCSU DOT's website links to, shows the location of Wolfline buses, identifies the different routes using NCSU DOT's color scheme, and displays the wait time at a given stop for each bus route that serves the stop. The TransLoc service is also available as a smart phone app, and several television monitors around campus run a continual TransLoc display of current Wolfline service.

Funding for the system comes from a "combination of dedicated student fees, parking permit sales and federal sources," with student fees covering approximately 80 percent of transit service hours. The parking revenues fund the remaining 20 percent of service hours and transit amenities (signage, bus shelters, etc.) (Bhattacharya et al. 2009).

NCSU DOT coordinates its Wolfline services with Raleigh's Capital Area Transit (CAT) and with the regional Triangle Transit Agency (TTA) system along several of the corridors where the different systems run their respective services: Hillsborough Street, Avent Ferry Road, and Western Boulevard. However, the NCSU DOT has not integrated Wolfline schedules with these systems: while different systems may share bus stops within a corridor, their schedules are not timed to minimize wait times between system transfers.

Additionally, several off-campus apartment complexes that have high NCSU student populations operate private shuttle services that enable students to travel to campus. These shuttles operate independently from the Wolfline system, but NCSU DOT permits these shuttles to access the campus. Currently, these shuttles use the Reynolds carriageway on Dunn Avenue as their on-campus stop.

NCSU DOT conducts multiple types of surveys with Wolfline riders and with community members to determine general levels of user satisfaction with and perception of Wolfline services and to identify areas for further service improvements. The Department also maintains a Facebook page to provide the NCSU community with service change updates and to receive feedback from riders.

Centennial Campus and NCSU Campus Growth

The Centennial Campus is a twenty-five year-old campus precinct located south of Western Boulevard, the historic boundary for NCSU's Main Campus. NCSU describes Centennial Campus as a research campus that partners academic resources with private entrepreneurship; in the literal sense, for-profit and non-profit companies occupy much of Centennial Campus' space and work directly with NCSU students and faculty. Federal and state government offices, including the USDA and NOAA, also reside on NCSU. These partnerships focus on the hard sciences and high-tech sectors. To facilitate working relationships with corporate partners, the College of Textiles, the College of Engineering, and the College of Veterinary Medicine have classroom space and laboratory resources on Centennial Campus.

Because of the prominent role that private businesses play on Centennial Campus, the Campus' design currently reflects the needs of a business community: abundant deck and surface parking for employees and visiting guests; substantial building set-backs for large buildings with ample greenspace. Much of this "office park" environment results from the active role that private developers have taken in the development of Centennial Campus. While these developers must meet basic design standards that the Office of the University Architect has set in its Physical Master Plan, they must also meet the City of Raleigh's parking and zoning ordinances, their profit motive requires that they also respond to pressures from private financiers, which will be discussed in greater detail below.

Over the next five to ten years, NCSU is aggressively expanding its undergraduate and graduate programs for engineering, biomedical sciences, and other hard sciences. As a result, both the population and the physical environment of Centennial Campus are expected to grow rapidly. To accommodate this growth, NCSU is constructing the first residence hall on Centennial Campus, which will house 1,200 students and contain a 20,000-square foot dining facility. The first two housing buildings will open in the summer of 2013, with an additional four opening in the summer of 2014. The Office of the University Architect has sited two additional Engineering Buildings for construction on the western and eastern sides of the Oval, although construction will not begin until NCSU has secured funding, which the Office of the University Architect anticipates will occur after 2013.

Private growth will also grow over this time. The Alliance Center will open in June 2014, creating 150,000 square feet of office space at the intersection of Varsity Drive and Main Campus Drive. The Town Center development is a mixed-use development that will be located on Main Campus Drive and will front Lake Raleigh. As the only waterfront property development in Raleigh, the Office of the University Architect anticipates that the Town Center will offer "destination retail and dining" to draw in customers from the larger Raleigh community. Additionally, the Town Center will likely have between 200 and 400 apartment units that NCSU students will utilize for off-campus (non-NCSU) residence.

Student Population Growth

As of 2011, total enrollment at NCSU is 34,764. The total number of students who take classes on Centennial Campus is 7,130, which represents 21 percent of the total student population. The Office of the University Architect estimates that by 2025, total enrollment at

NCSU will have increased to 38,000, and the number of Centennial Campus students will grow to 11,000 representing nearly 29 percent of the total student population. While the number of non-residential undergraduate Centennial Campus students will grow from 4,900 to 5,800 during this time, the non-residential student population for the total student body will decrease slightly from 15,015 to 14,000. The Office of the University Architect predicts that total undergraduate resident students will increase from 8,500 to 11,000.

The graduate student population will increase by a larger percentage than the total undergraduate student population during this time period. Within Centennial Campus, the total undergraduate student body will increase by 43 percent, whereas the graduate student body will increase by 79 percent. The respective statistics for total NCSU enrollment are 6 percent for undergraduate students and 24 percent for graduate students.

Table I: Student Population Growth on Centennial Campus and NCSU, 2011—2025

	2011	2015	2020	2025
Centennial Campus				
Total undergraduate students	4900	5200	6950	7000
Graduate students	2230	2500	3840	4000
Total student population	7130	7700	10790	11000
NCSU				
Total undergraduate students	23515	24000	24300	25000
Graduate students	8691	9500	10400	10800
Non-degree students	2558	2500	2300	2200
Total student population	34764	36000	37000	38000

Source: NCSU Office of the University Architect. Accessed 13 January 2012.

The Hunt Library

The Hunt Library is scheduled to open in the winter of 2013. As a mixed-use building, which the Capital Project Management Office describes as a "microcosm of Centennial Campus," the Library offers a wide range of resources to the College of Engineering, which is relocating from Main Campus to Centennial Campus, and to the larger NCSU community. The Library contains 1,694 seats, effectively doubling the amount of studying space for students at NCSU. The Library will have an initial stock of one million volumes, largely focused on engineering and other hard sciences. An Automated Book Delivery System built two-and-a-half stories into the ground holds the majority of the library's stock in one-ninth the amount of space.

The Hunt Library is placing a premium on collaborative research, offering one hundred bookable study rooms for private and group study. The Library offers additional bookable group

study space, teaching space, and specialized workspaces that provide access to high-tech resources. The Library will also contain a coffee shop and a gaming room to meet a wider range of student needs.

Several NCSU institutions will move into the Hunt Library and will occupy and maintain approximately one-fifth of the total space. The Institute for Emerging Issues will have office space on the fourth floor, but will also operate a gallery space on the second floor and a 100-person auditorium on the fourth floor, which Library Services, campus departments and student groups will be able to book for evening events. The fifth-floor Chancellor's Suite will contain the Kenan Institute, the Institute for Non-Profits, the Public Communication of Science and Technology Project, and other rotational office space for faculty research.

In addition to the 100-person auditorium, the Hunt Library will contain a 400-person auditorium on the first floor. The College of Textiles has expressed interest in using the auditorium for large lecture classes, and the Library has considered using the space for evening activities and guest lectures.

The Office of the University Architect has categorized the Hunt Library within the corpus of NCSU buildings as an "iconic building:" with no bricks in the building's structure, the Library is unique. The Library's design deliberately makes the building stand out aesthetically, while its form keeps the building on the same scale as the rest of the Centennial Campus. Because of this unique aesthetic and its wide range of uses, many departments attached to the Hunt Library and Centennial Campus view the Library as a flagship building that will raise the profile of NCSU and will transform the Centennial Campus from "an office park environment" to a "campus environment," with greater student and pedestrian activity.

In its more immediate environment, the Hunt Library will be one of several buildings that create a ring of activity around the Oval, an area of greenspace located on southern Centennial Campus and currently bordered on the north by Engineering Buildings I, II and III. A Centennial Campus student housing project will open on the southeast corner of the Oval in the summer of 2014, providing 1,200 beds and a 20,000-square foot dining facility. The OUA has also sited two areas on the western and eastern sides of the Oval for Engineering Buildings IV and V, but NCSU will not likely secure funding for these buildings until after 2013. Despite the longer time horizon for the Engineering Buildings, the Capital Project Management Department is optimistic

that the Hunt Library will create an anchor on the Oval that promotes pedestrian activity and raises the greenspace's profile.

The Hunt Library is accessible by two entrances: a pedestrian entrance on the east side of the building that connects the Library to the Oval, and an off-street entrance on the west side of the building that connects the Library to Partners Way. Wolfline service at the library exists at a single stop outside of the west entrance. Per the request of Library Services, the stop does not have a bus shelter. However, the stop has a bus pullout long enough for two Wolfline buses, and the Library entrance at Partners Way has a lobby with glass doors that may serve as a de facto bus shelter for riders.

As part of the Hunt Library project, Partners Way will be extended from its current "dead end" behind the Partners I Building to travel between the Library and the Partners I Parking Deck and connect to the intersection of Campus Shore Drive and Main Campus Drive.

Tables:

NB: Tables 3 through 11 display data from the October 2011 Customer Feedback Survey

Table 1: Generation Rates of Average Vehicle Trip Ends at D.H. Hill and Hunt Libraries

	Net Assignable Square Footage (KSF^2)	**ITE Trip generation rate (average vehicle trip ends per KSF^2)**	**Daily trips generated**	**Peak Hour of Adjacent Street Traffic Between 7 A.M. and 9 A.M. (entrance)**	**Peak Hour of Adjacent Street Traffic Between 7 A.M. and 9 A.M. (exit)**	**Peak Hour of Adjacent Street Traffic Between 4 P.M. and 6 P.M. (entrance)**	**Peak Hour of Adjacent Street Traffic Between 4 P.M. and 6 P.M. (exit)**
D.H. Hill	275.0	56.24	15,466	203	83	964	1,044
Hunt	137.6	56.24	7,739	102	42	482	522
Standard Deviations	--	22.45	--	1.02		3.81	

Source: Institute of Transportation Engineers. ITE Trip Generation Manual, 8th Edition. 2008.

Table 2: Table 2: 7 Percent Transit Share of Generated Average Vehicle Trip Ends During Peak Hour of Adjacent Street Traffic Between 7 A.M. and 9 A.M. and Between 4 P.M. and 6 P.M. at D.H. Hill and Hunt Libraries

	Daily trips generated	**AM in**	**AM out**	**PM in**	**PM out**
D.H. Hill	1,083	14	6	67	73
Hunt	542	7	3	34	37

Source: Institute of Transportation Engineers. ITE Trip Generation Manual, 8th Edition. 2008.

Table 3: Responses to "How many days in the past week did you ride Wolfline?"

Answer	**Response**	**%**
5	123	40%
7	69	23%
6	27	9%
3	25	8%
0	23	8%
4	17	6%
1	11	4%
2	10	3%
Total	**305**	**100%**

Table 4: Responses to "How many times have you visited the Wolfline's website or www.gotriangle.org in the past month?"

Answer	Response	%
More than 10 times	119	43%
1 - 2 times	57	20%
6 - 10 times	38	14%
3 - 5 times	33	12%
None	32	11%
Total	**279**	**100%**

Table 5: Responses to "How do you prefer to receive information concerning routes and service changes? (check all that apply)"

Answer	Response	%
Inside the bus	166	60%
Website	164	59%
Email alert	155	56%
At major bus stops	132	47%
Transloc TVS announcements	131	47%
Facebook	75	27%
Text message	43	15%
Twitter	22	8%
Phone	15	5%
Other	4	1%

Table 6: Responses to "Please answer the following questions regarding Wolfline customer service" (1 being worst, 8 being best)

Statistic	Overall, how do you rate Wolfline?	Courtesy of bus drivers	Quality of driving	Available seating	Convenience of bus stop locations	Convenience of bus routes	Frequency of service	Days/hours of service	Convenience of coordinating with other transit system stops and schedules
Min Value	1	1	1	1	1	1	1	1	1
Max Value	8	8	8	8	8	8	8	8	8
Mean	5.61	6.04	5.81	5.17	4.83	4.51	4.71	4.66	5.59
Variance	1.46	1.34	1.49	1.90	2.16	2.06	2.04	2.37	3.29
Standard Deviation	1.21	1.16	1.22	1.38	1.47	1.43	1.43	1.54	1.81
Total Responses	293	292	292	289	292	289	291	290	292

Table 7: Responses to "Please rank the following transit improvement priorities by order of importance" (1 being highest priority, 8 being lowest)

Statistic	Frequency of service	Expanded evening service hours	Expanded weekend service hours	Improved stop amenities such as benches, shelters, trash cans and/or lighting	More north/south connections between Main Campus and Centennial Campus	More east/west connections between Main Campus and Centennial Biomedical Campus (Vet School)	Expanded coverage to near-campus residential areas, not currently served by Wolfline	Improved transfer times to/from CAT and Triangle Transit systems
Min Value	1	1	1	1	1	1	1	1
Max Value	8	8	8	8	8	8	8	8
Mean	2.50	3.05	3.31	4.82	4.84	6.52	4.27	6.62
Variance	2.21	1.89	3.54	3.28	3.20	2.16	6.26	3.23
Standard Deviation	1.49	1.37	1.88	1.81	1.79	1.47	2.50	1.80
Total Responses	234	234	234	234	234	234	234	234

Table 8: Responses to "How frequently do you travel between Centennial Campus and Main Campus?"

Answer	Response	%
Once a week	99	37%
3-4 times per week	52	20%
1-2 times per week	46	17%
Daily	45	17%
More than once per day	24	9%
Total	**266**	**100%**

Table 9: Responses to "How likely are you to use the Hunt Library?"

Answer	Response	%
Very likely	124	50%
Likely	42	17%
Somewhat Likely	20	8%
Undecided	18	7%
Somewhat Unlikely	7	3%
Unlikely	20	8%
Very Unlikely	19	8%
Total	**250**	**100%**

Table 10: Responses to "During what times of day are you most likely to visit the Hunt Library?"

Answer	Response	%
7am - 1pm	27	12%
1pm - 7pm	113	50%
7pm - 1am	80	35%
1am - 7am	8	4%
Total	**228**	**100%**

Table 11: Responses to "Please rank the following transit service options to/from the future library in terms of importance" (1 being highest priority, 5 being lowest)

Statistic	Frequency of service	Evening service hours	Overnight service hours	Connections between Main Campus and Centennial Campus	Multiple stops on Centennial Campus
Min Value	1	1	1	1	1
Max Value	5	5	5	5	Selected
Mean	1.87	2.44	3.20	3.45	3.98
Variance	0.89	1.08	1.68	1.81	1.84
Standard Deviation	0.94	1.04	1.30	1.35	1.36
Total Responses	188	188	188	188	189

NB: Tables 12 through 18 display data from the November 2011 Engineering Student Survey

Table 12: Responses to "For what purposes do you spend time on Centennial Campus? (select all that apply)"

Answer	Response	%
Class	308	71%
Meetings with faculty	198	46%
Meetings with fellow students	175	41%
Internship or Research Assistanceship	27	6%
Independent research	27	6%
Other	47	11%
I don't spend any time on Centennial Campus	70	16%

Table 13: Responses to "When you travel from Centennial Campus to Main Campus now, what are your typical destinations on Main Campus? (select all that apply)"

Answer	Response	%
Classes	286	83%
Administrative buildings	61	18%
Campus dining	163	47%
Athletic or recreational facilities	104	30%
Residence Halls	202	59%
NCSU Libraries	173	50%
Other	12	3%

Table 14: Responses to "How frequently do you now travel between Main Campus and Centennial Campus?"

Answer	Response	%
Never	10	3%
Less than 1 time per week	77	21%
1-2 times per week	59	16%
3-4 times per week	107	30%
Daily	74	21%
More than once per day	33	9%
Total	**360**	**100%**

Table 15: Responses to "When you travel between Main Campus and Centennial Campus, which modes of transportation do you use? (select all that apply)"

Answer	Response	%
Bicycle	51	15%
Car	113	33%
Walk	65	19%
Wolfline Bus	319	93%
CAT Bus	5	1%
Other (please specify)	5	1%

Table 16: Responses to "How likely are you to use the Hunt Library?"

Answer	Response	%
Very likely	176	43%
Likely	110	27%
Somewhat Likely	66	16%
Undecided	41	10%
Somewhat Unlikely	8	2%
Unlikely	6	1%
Very Unlikely	6	1%
Total	**413**	**100%**

Table 17: Responses to "During which hours do you think you would visit or use services in the Hunt Library? (select all that apply)"

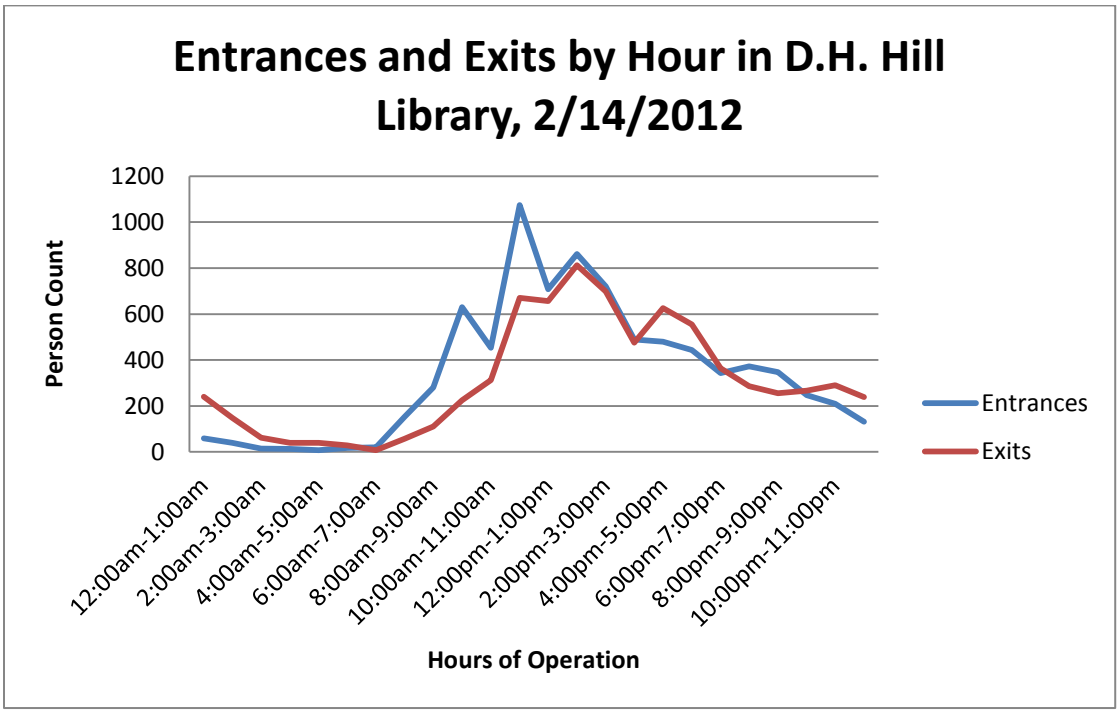
Answer	Response	%
7am - 1pm	168	41%
1pm - 7pm	340	83%
7pm - 1am	245	60%
1am - 7am	39	10%

Table 18: Responses to "Please rank the following Wolfline bus service options for transportation to/from Hunt Library in order of importance." (1 being the highest priority, 6 being the lowest)

Statistic	Frequent service	Evening service hours (7-10pm)	Overnight service hours	Faster connections between Main Campus and Centennial Campus	Multiple stops on Centennial Campus	I would not use Wolfline
Min Value	1	1	1	1	1	1
Max Value	6	5	6	5	6	6
Mean	1.67	2.91	4.00	2.42	4.17	5.82
Variance	0.94	1.12	1.06	1.38	1.24	0.84
Standard Deviation	0.97	1.06	1.03	1.17	1.11	0.92
Total Responses	358	358	358	358	358	358

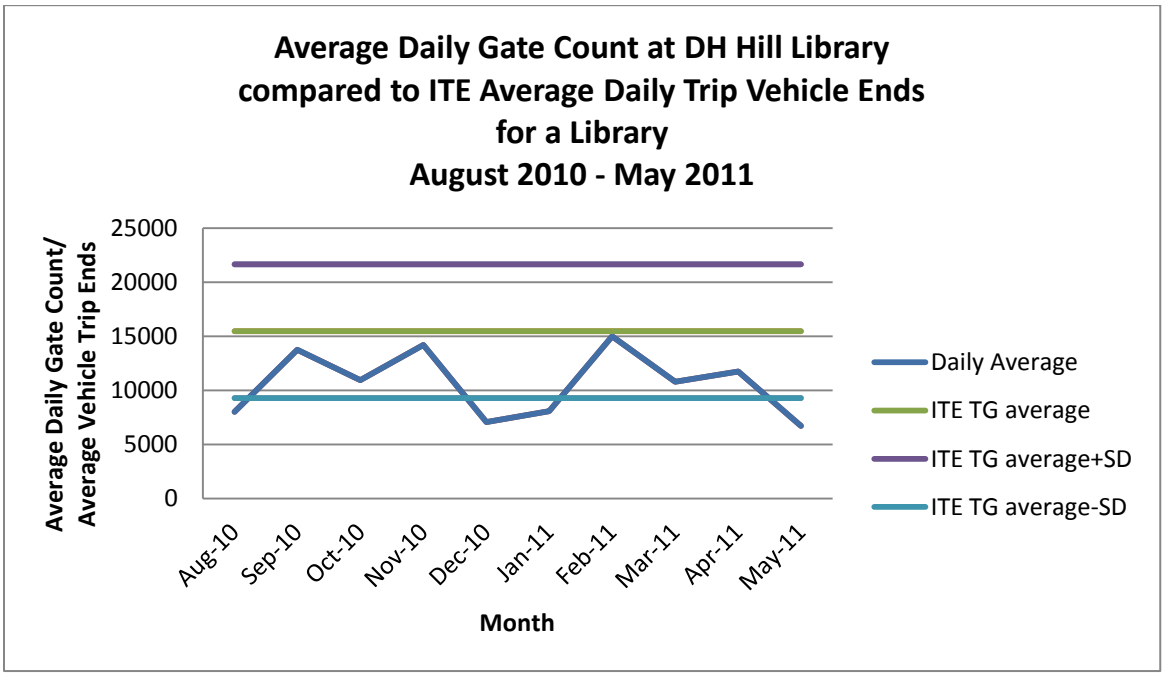
Graphs:

Graph 1:



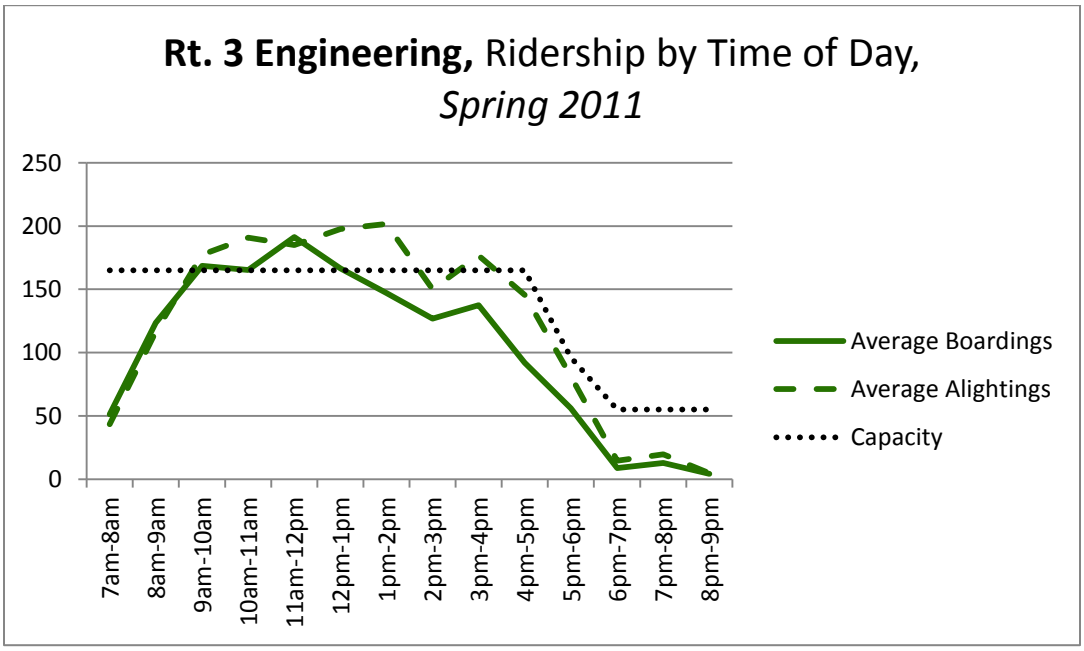
Source: David Goldsmith. Personal communication, 15 Feb 2012.

Graph 2:



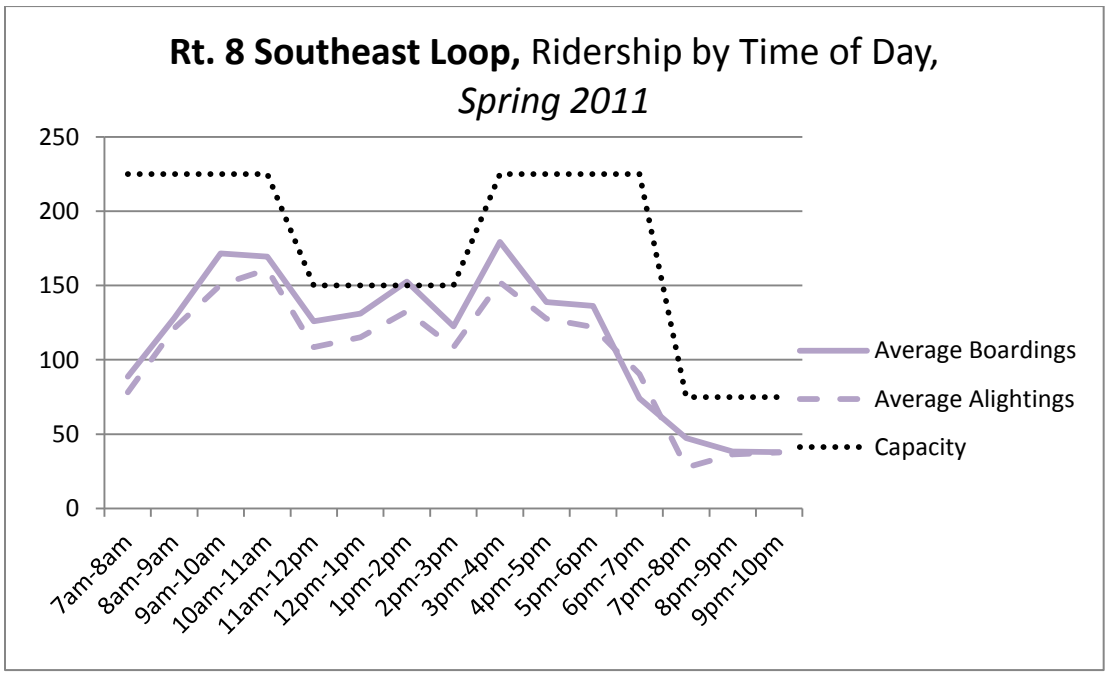
Source: David Goldsmith, personal communication, 15 Feb 2012.

Graph 3:



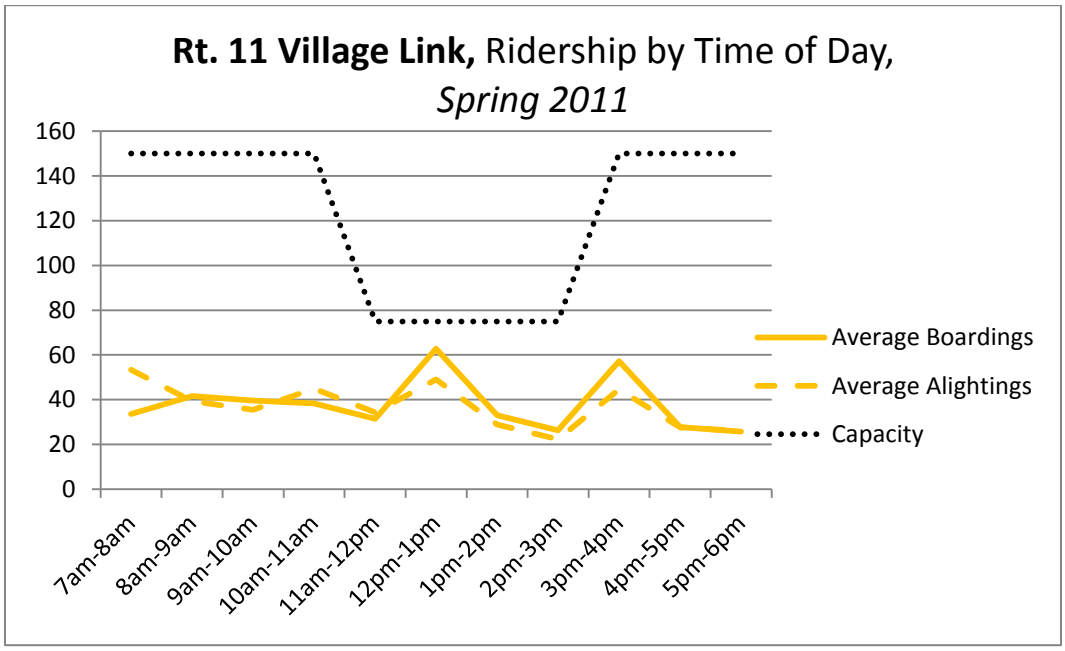
Source: NCSU Transportation Department. "Spring 2011 Ridership by Segment." Accessed 31 October 2011.

Graph 4:



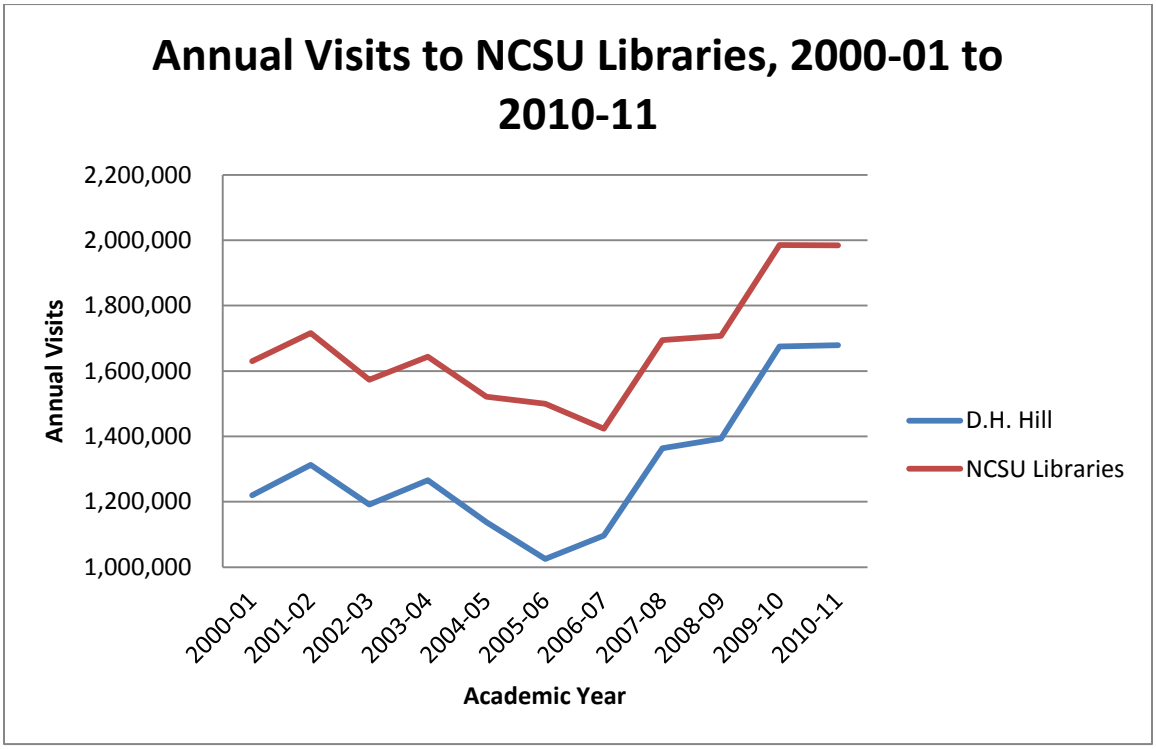
Source: NCSU Transportation Department. "Spring 2011 Ridership by Segment." Accessed 31 October 2011.

Graph 5:



Source: NCSU Transportation Department. "Spring 2011 Ridership by Segment." Accessed 31 October 2011.

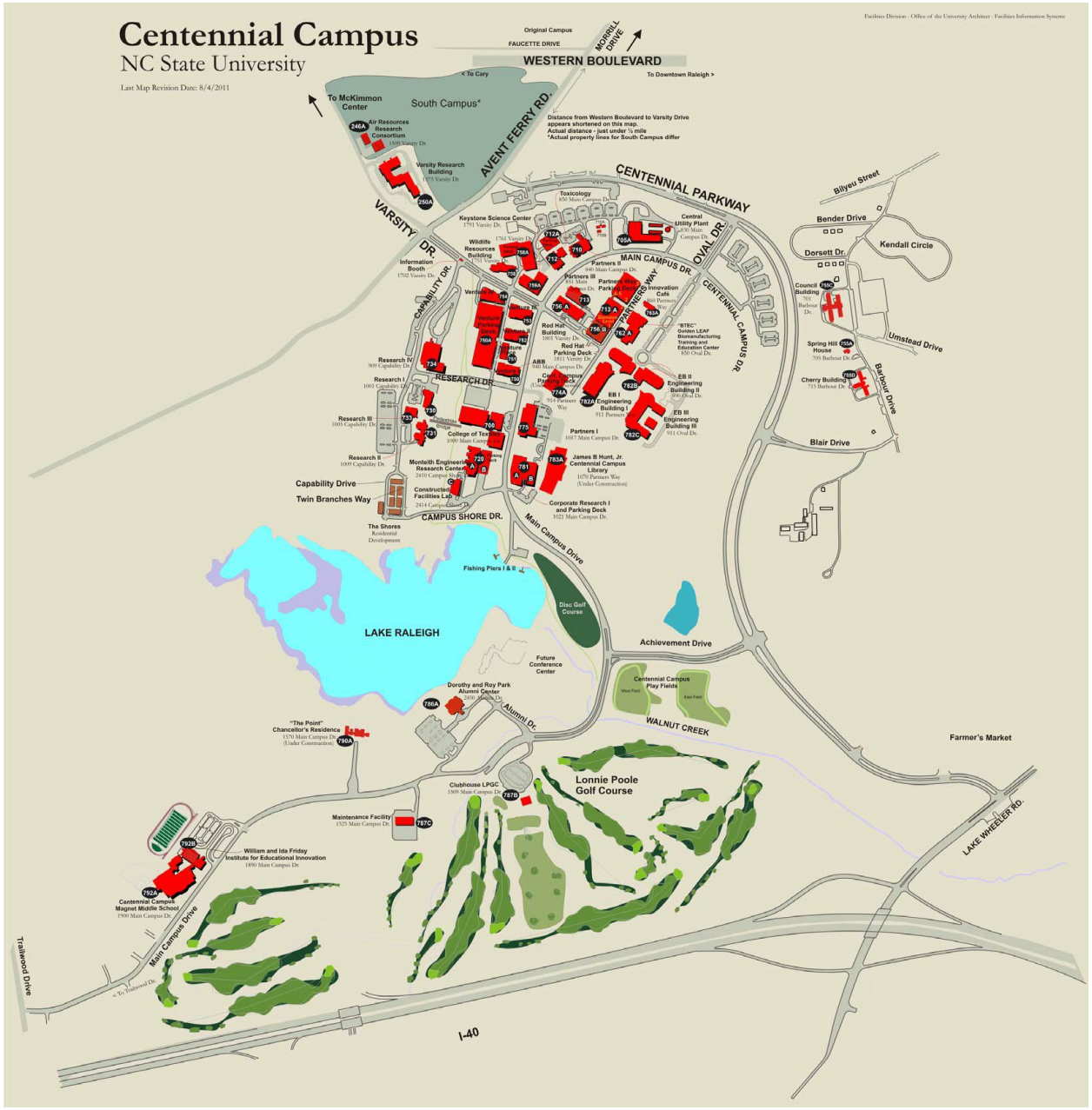
Graph 6:



Source: David Goldsmith, personal communication, 15 Feb 2012.

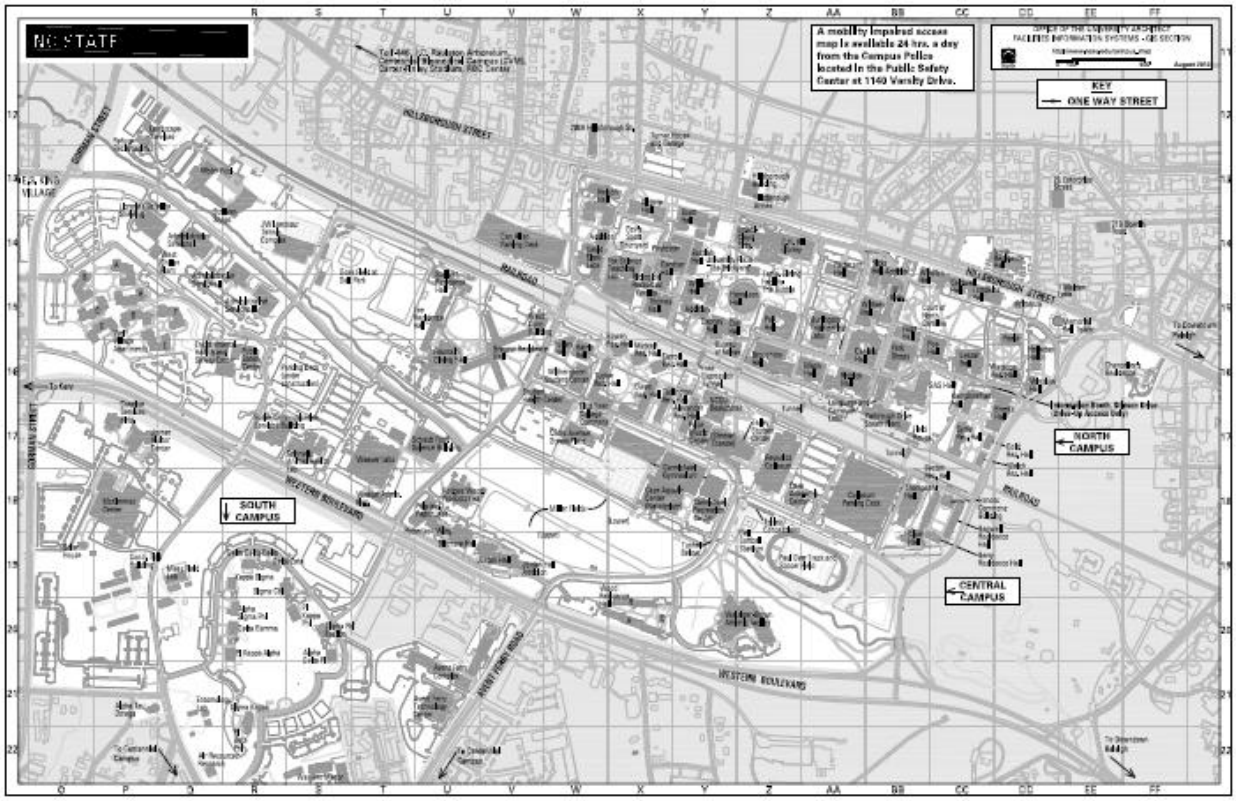
Maps:

Map 1: NCSU Centennial Campus



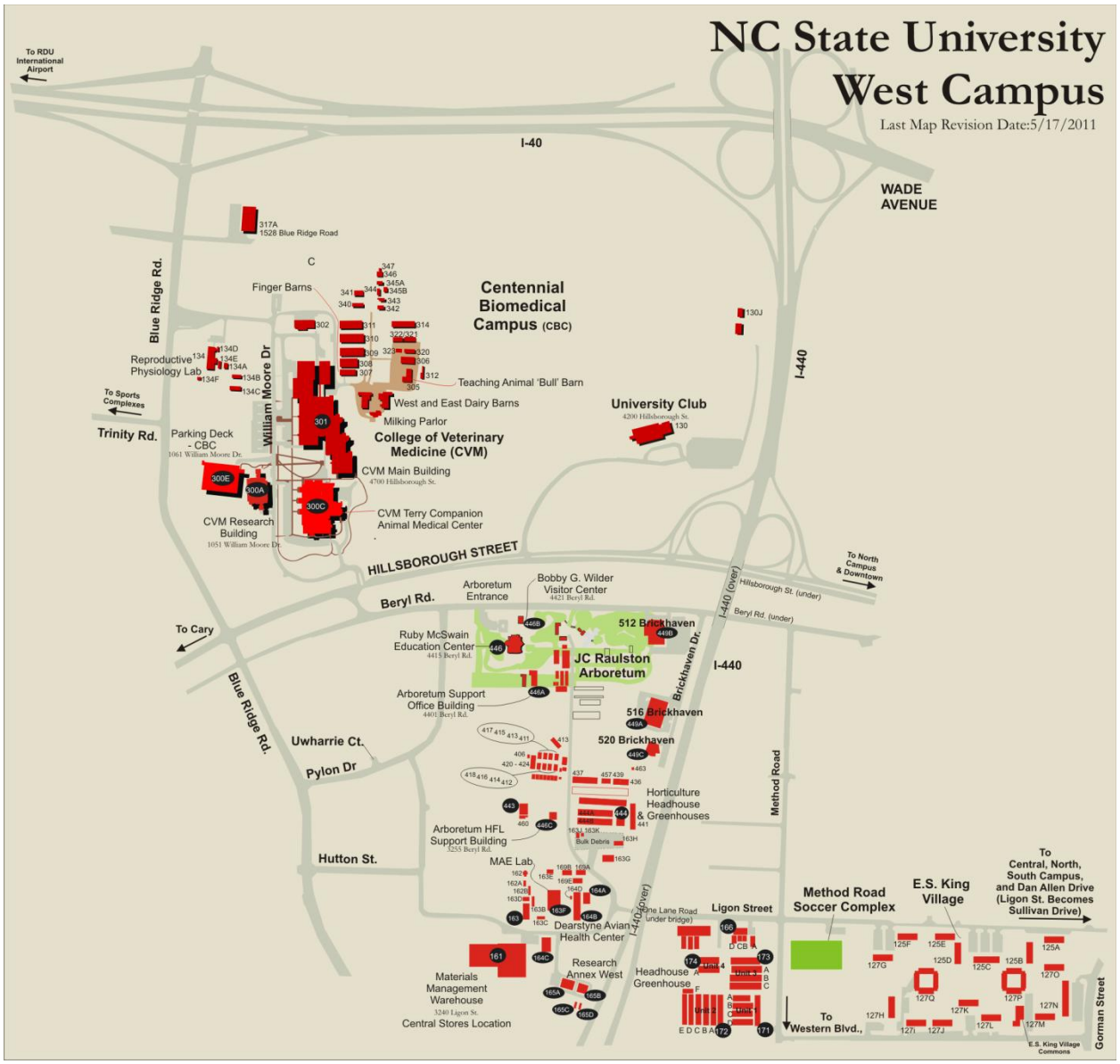
Source: Centennial Campus Printable Map. *North Carolina State University.* Accessed 14 November 2011. <http://www.ncsu.edu/campus_map/cent-print.pdf>

Map 2: NCSU Main Campus (North, Central and South Precincts):



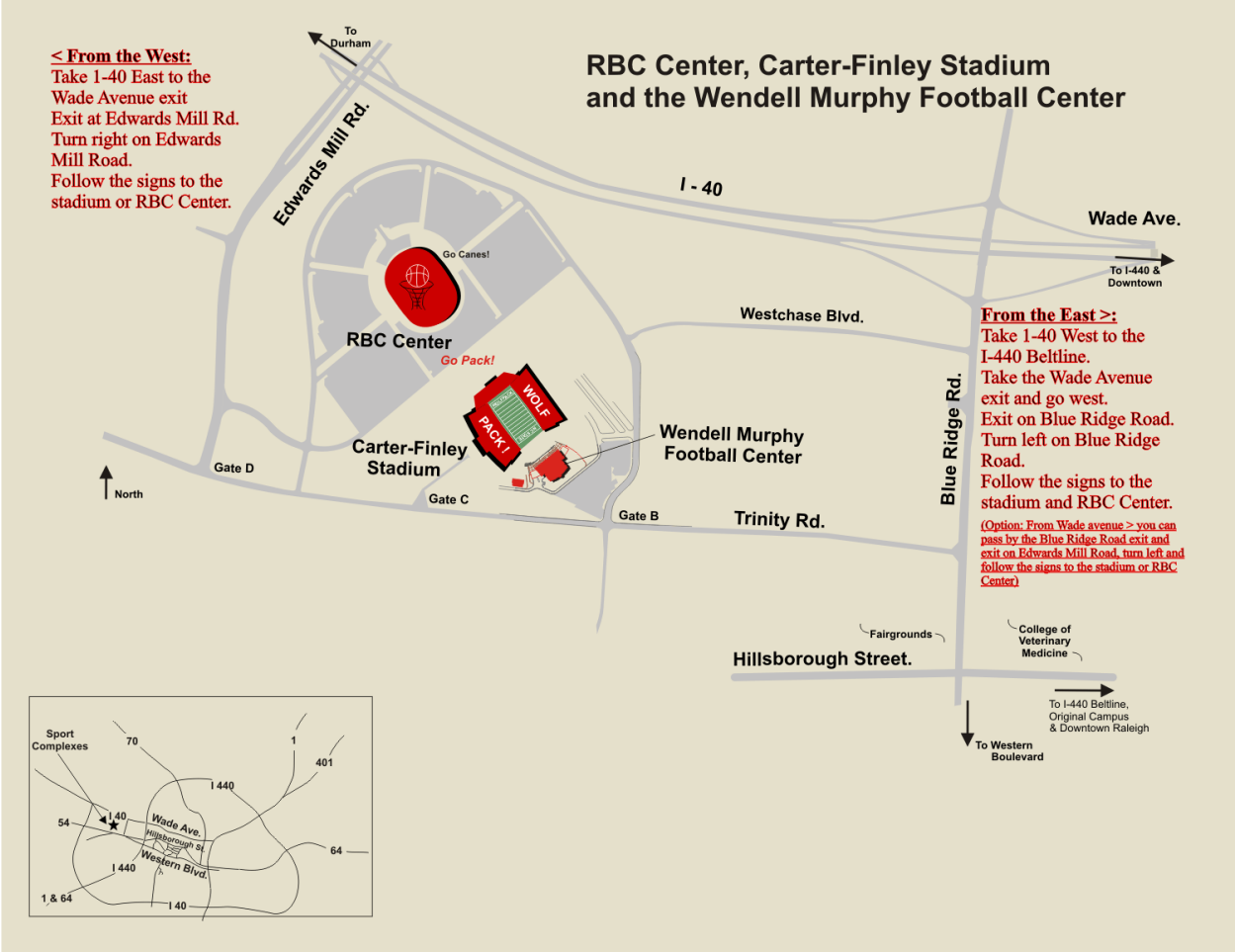
Source: North, Central and South Campuses Combined Printable Map. *North Carolina State University.* Accessed 14 November 2011. <http://www.ncsu.edu/campus_map/main-print.pdf>

Map 3: Centennial Biomedical Campus and Arboretum, West Campus



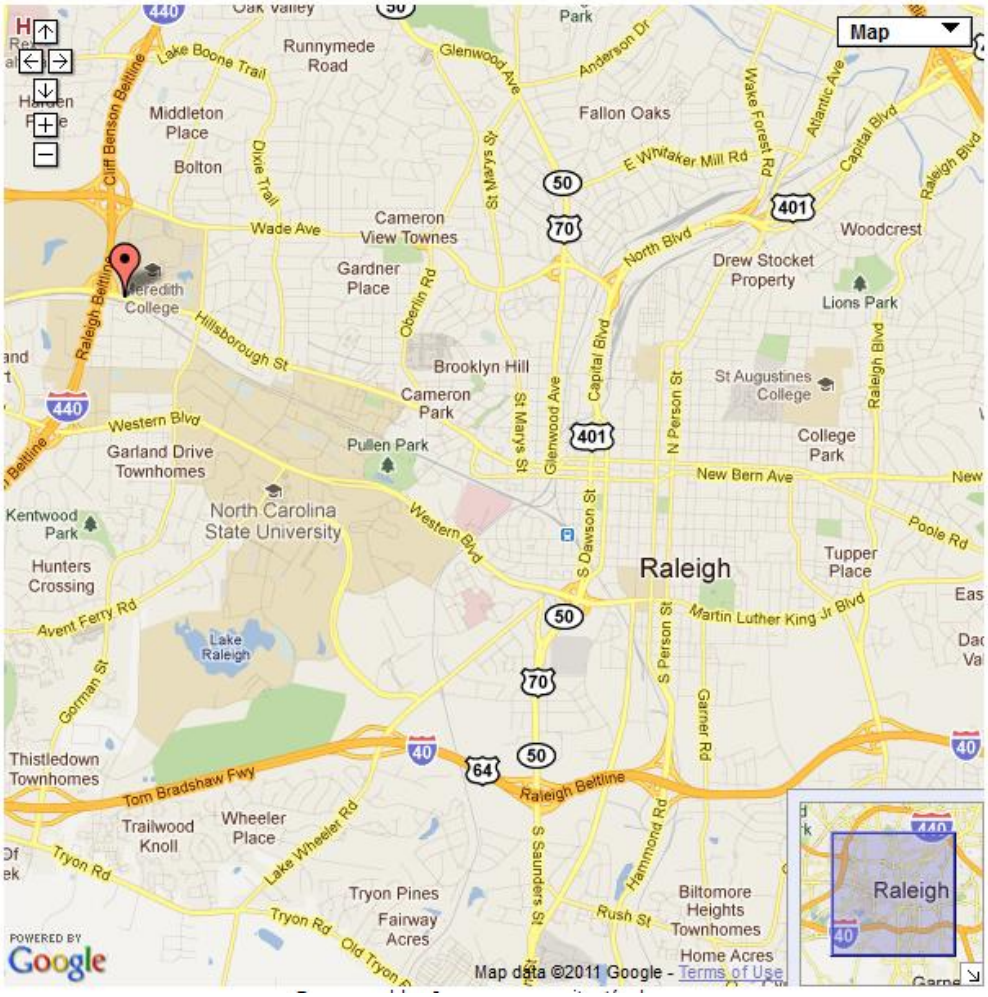
Source: Centennial Biomedical Campus Map, part of the West Campus Precinct. *North Carolina State University*. Accessed 13 March 2012. <http://www.ncsu.edu/campus_map/cvm.htm>

Map 4: Carter-Finley Stadium & RBC Center, West Campus



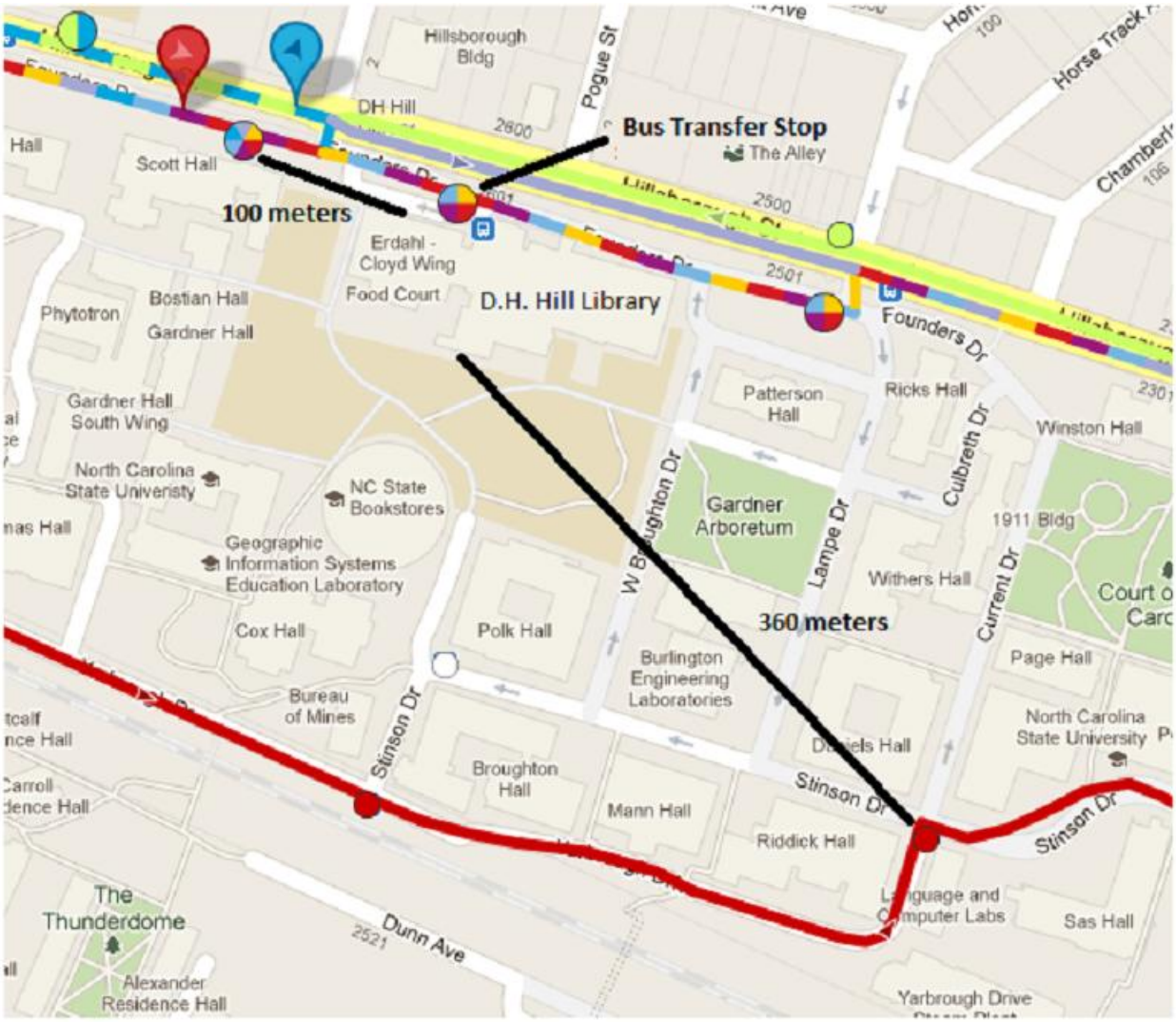
Source Cited: Carter-Finley Stadium & RBC Center Map, Part of the West Campus Precinct. *North Carolina State University*. Accessed 13 March 2012. <http://www.ncsu.edu/campus_map/stadium.htm>

Map 5: Downtown Raleigh and Interstate 440



Source: Google Maps. Accessed 14 November 2011. <www.maps.google.com>

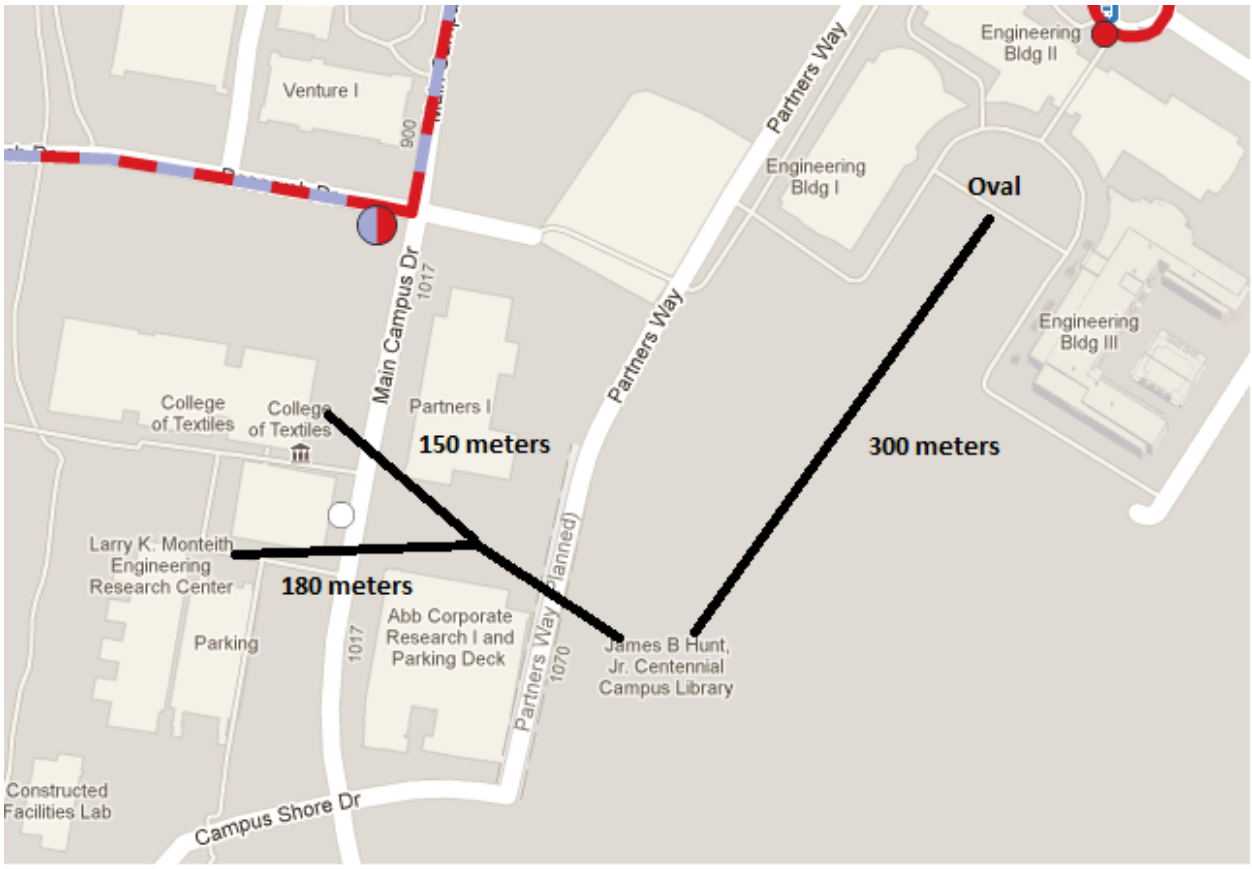
Map 6: Proximity to Transit Service at D.H. Hill Library



Source: "The NCSU Wolfline—Transit Visualization." *TransLoc*. Accessed 23 Feb 2012. <http://ncsu.transloc.com/>

Edits made by author

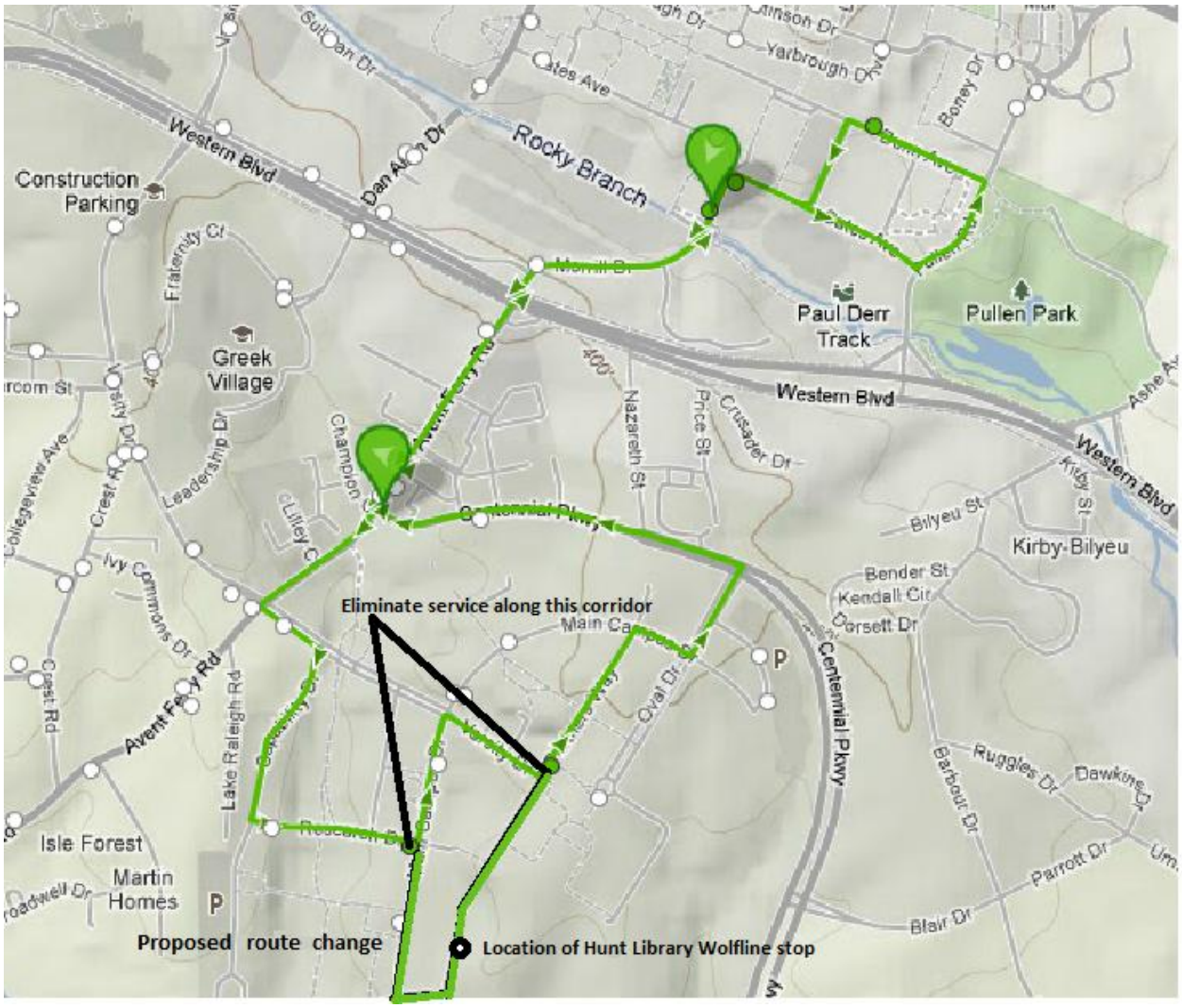
Map 7: Walking Distances to Centennial Campus buildings from Hunt Library



Source: "The NCSU Wolfline—Transit Visualization." *TransLoc*. Accessed 23 Feb 2012. <http://ncsu.transloc.com/>

Edits made by author

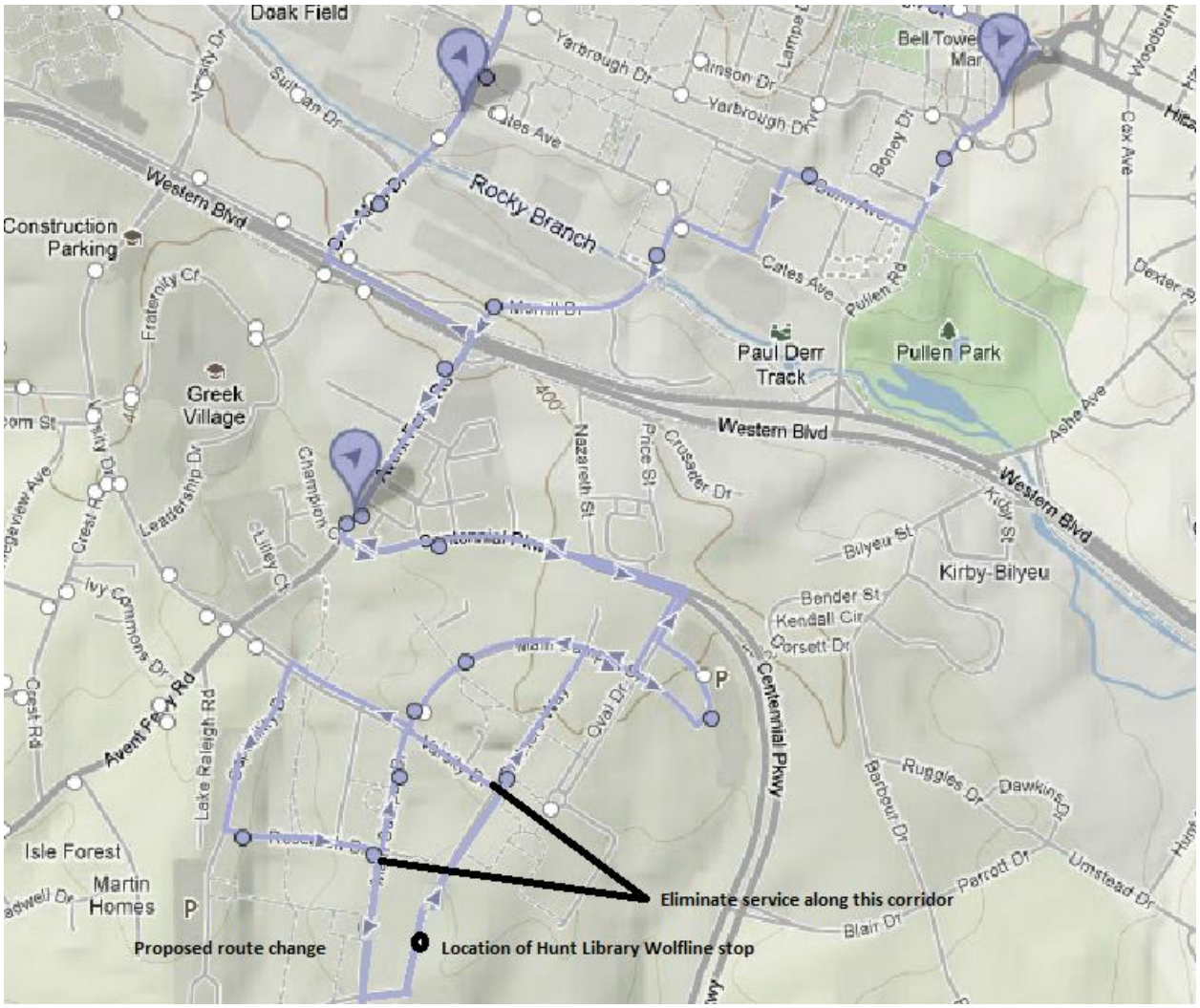
Map 8: Proposed Route Changes for 3A Engineering Express



Source: “The NCSU Wolfline—Transit Visualization.” *TransLoc*. Accessed 23 Feb 2012. <http://ncsu.transloc.com/>

Edits made by author

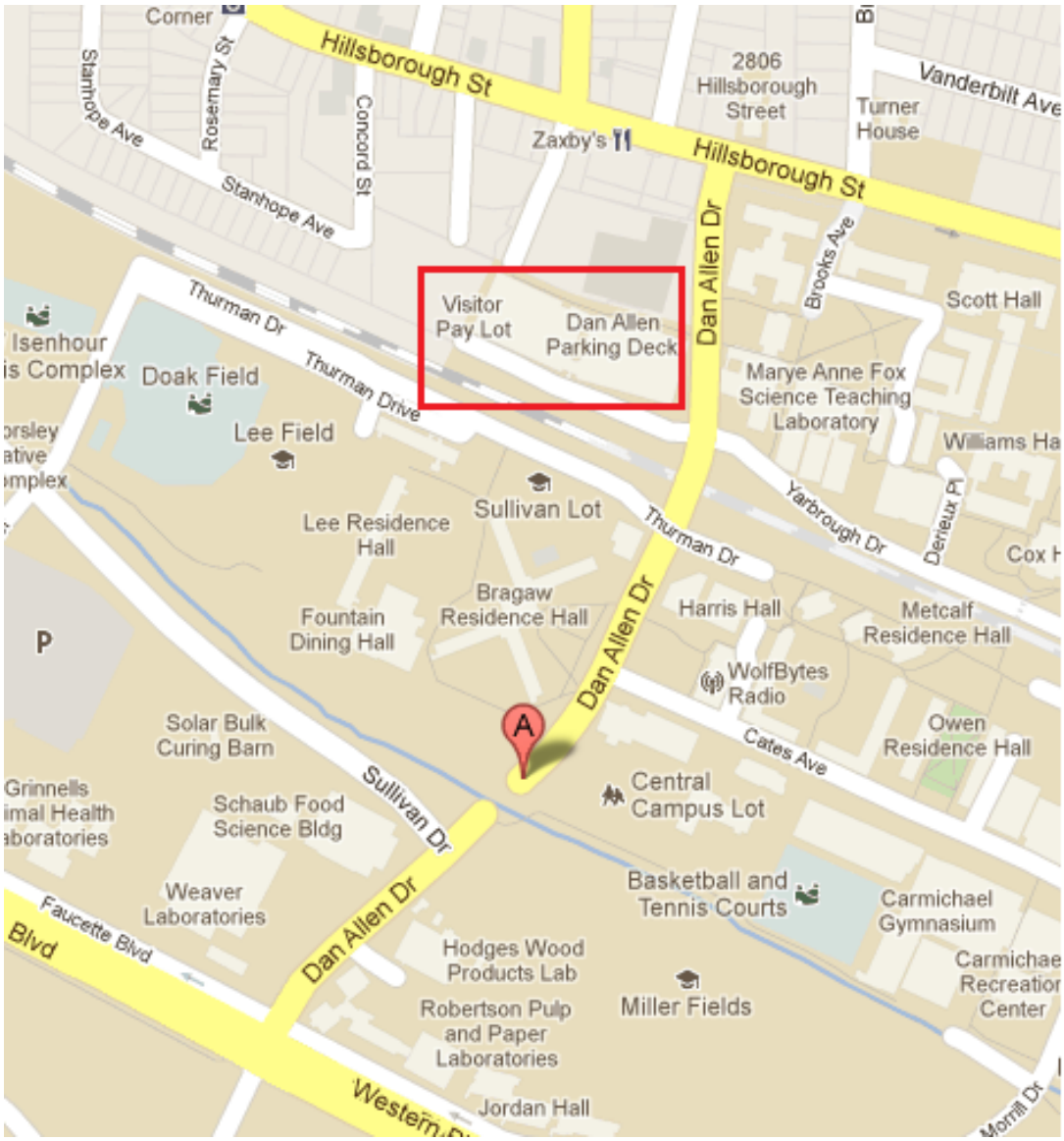
Map 9: Proposed Route Changes for Route 8 Southeast Loop



Source: "The NCSU Wolfline—Transit Visualization." *TransLoc*. Accessed 23 Feb 2012. <http://ncsu.transloc.com/>

Edits made by author

Map 10: Dan Allen Parking Deck, Dan Allen Road



Source: Google Maps.Accessed 5 April 2011. <www.maps.google.com>

Edits made by author

Stakeholder Interviews:

Interview with Kristi Alpi, Library Services and Centennial Biomedical Campus—1/9/12

As the Director William Rand Kenan, Jr. Library of Veterinary Medicine on the Centennial Biomedical Campus, Ms. Alpi is familiar with the challenges of inter-precinct travel and the opportunities for sustainable planning on a still-developing campus precinct. Ms. Alpi points out that the Centennial Biomedical Campus' distant location from campus creates greater concerns for safety. For example, she points out that many staff members in the School of Veterinary Medicine and the Veterinary Library will park on North Campus or in the free fairground parking lots located on the western side of Blue Ridge Road as a way to save money. The staff also recommends the fairground parking lot to visitors who travel to the campus precinct. However, staff members have expressed concern for their safety at night, since accessing these parking lots require walking through the parking deck located at the Biomedical Centennial Campus. By the time staff members who work the night shifts have closed down their offices, the Wolfline has stopped running, which leaves them with no other option than to walk.

Yet this free parking supply plays a critical role in parking access for the staff. Ms. Alpi warns that if NCSU DOT or the City of Raleigh were to bring the state fairground parking lots under a parking permit plan, staff and visitors would lose a key part of their parking supply. Ms. Alpi does suggest that NCSU DOT could partially alleviate this problem by enabling visitors to purchase parking permits online. She points out that visitors can only purchase visitor parking permits on Main Campus and Centennial Campus, and Biomedical Centennial Campus staff are reluctant to direct visitors to multiple campus precincts.

Although Ms. Alpi describes the 6 Carter-Finley bus route (the only route that travels on the Biomedical Centennial Campus) as reliable and effective, she stresses that the route does not provide adequate service to meet the demand for inter-precinct travel among staff on the precinct and recommends that NCSU DOT increase service on the route. She points out that during peak travel demand times, the route fills its capacity with park-and-ride commuters at the Carter-Finley park-and-ride stop before the bus serves the buildings on the Centennial Biomedical Campus. Because of this, Biomedical Centennial Campus staff frequently schedule meetings with other departments on different campus precincts during off-peak periods when the Carter-Finley route is more likely to have available capacity. Students must make similar decisions.

The difficulty of accessing transit to other campus precincts requires that Biomedical Centennial Campus staff and students practice in-advance planning and experience what Ms. Alpi refers to as "missed opportunities." These missed opportunities are the class lectures, events and departmental meetings on other campus precincts that students and staff must pass on because of a lack of easy and rapid access to the precincts. Ms. Alpi specifically cites a prosthesis design project involving collaboration between graduate students in Veterinary Medicine and Biomedical Engineering. Despite the collaborative nature of the project, the veterinary students were unable to participate in the experiments that required extensive engineering resources. The NCSU sciences departments has focused its investment in large lab equipment on Centennial Campus, suggesting that the problems that complicated the prosthesis design project will continue. Ms. Alpi fears that a lack of adequate Wolfline services between campus precincts occur on other campus precincts as well.

To address these issues, Ms. Alpi recommends that NCSU DOT increase direct transit services between campus precincts. She criticizes the opportunities for transferring from the 6 Carter-Finley route to routes that serve the Centennial Campus, describing the transfers as complicated and difficult. Again, she cites the need for planning trips in advance and recommends that NCSU DOT adopt a "pilot program" of evening transit services between the two campus precincts for staff and students. In describing the nature of these services, she recommends that NCSU DOT prioritize 30-minute round-trip travel times on direct services rather than rely on shorter travel times with transfers between systems.

Turning to the Library System at large, Ms. Alpi expresses a high level of enthusiasm for the Hunt Library, but stresses that the travel demand for the Library will require a substantial shift in transportation resources for Library Services staff in addition to students. She believes that the current levels of usage at D.H. Hill in the evenings will incentivize many students to use the Hunt Library during the evening hours. To maintain student safety and strong connectivity, Ms. Alpi stresses the need for late-night Wolfline service that connects students to residential halls. However, she believes that lower levels of frequency during these evening hours are acceptable, asserting that students will be willing to experience higher travel times as a trade-off for direct access to their housing.

With regards to library staff, Ms. Alpi explains that the Library Delivery System delivers to all library locations twice a day and may expand to include deliveries of technologies and

other materials. Library Services staff also travel between the different libraries and have greater mobility needs. Ms. Alpi recognizes that the Wolfline may not be able to provide service between D.H. Hill and the Hunt Library that is exclusive to the Library Services staff and states that the Library Services Department has considered including passenger service for staff members in its delivery van service. Despite the need for additional Wolfline services between libraries, Ms. Alpi warns that library staff members would resist paying more for transit services in the form of higher parking fees and instead would expect funding for transit to come from other sources that collect from a larger portion of the NCSU community.

In discussing a rapid transit service between the Hunt Library and the Talley Student Center, Ms. Alpi warns that Library Services would have difficulty if they had to walk from the Talley Student Center to D.H. Hill. Although she recognizes that the Talley Student Center's central location on Central Campus makes it an ideal transit hub, the surrounding environment has a high level of pedestrian movement and vehicular traffic that could hinder rapid Wolfline movement and possibly create an unsafe environment for pedestrians. Similarly, many students and staff members may feel unsafe walking to D.H. Hill from the Talley Student Center at night because of the risk that walking through the campus tunnels may present. Ultimately, she is skeptical of the assertion that rapid service between these two destinations will incentivize students, faculty or staff to stop using automobiles to travel between campus precincts due to the remaining need to transfer between routes or walk to different destinations. Instead, she recommends rapid express service between D.H. Hill and the Hunt Library, since D.H. Hill already serves as a major trip generator and transfer point for many Wolfline routes.

Ms. Alpi is supportive of limiting automobile traffic on Main Campus, specifically citing the potential for a more pedestrian-friendly environment that would result from a restriction of cars on Cates Avenue. Ms. Alpi also recommends that NCSU DOT take a more active role in promoting TTA and CAT transit services as ways for students, faculty and staff to travel between campus precincts. Specifically, she recommends that NCSU DOT encourage different departments, research centers, and event centers to list nearby transit stops and the system routes that service those stops. NCSU DOT should encourage these organizations to include transit options in their directions on how to travel to the physical building.

Interview with Carolyn Axtman and Rachel Patrick, Capital Project Management—1/31/12

As project managers with the Capital Project Management (CPM) Department, Carolyn Axtman and Rachel Patrick describe their task as "[bringing] all stakeholders together … to build consensus on the best design solution for a particular building project." In this regard, they stress the importance of consensus-based decision making that balances stakeholders' varied requirements while complying with the campus Physical Master Plan. CPM maintains the "budget, scope and schedule" of physical capital projects and integrates site-specific plans that the Office of the University Architect (OUA) sets for a given project into the Leadership in Energy and Environment Design (LEED) certification process.

NCSU has committed itself to achieving LEED Silver certification for all buildings that exceed 20,000 GSF. The department achieves this certification by earning "points" through certain design choices, such as the building's location relative to open space and transit systems or the amenities that it offers to those who use it, such as bike racks and showers for bike commuters. The LEED-silver standard requires that a project achieve 50 points. The department also incorporates design principles that the City of Raleigh has established in its zoning regulations, including minimum parking requirements of one space per 600 square feet of university space.

These requirements naturally shaped the design of the Hunt Library. For example, the Library was able to earn LEED-silver certification due to its geographic access to the Wolfline system (the "public transit access" credit). Ms. Axtman and Ms. Patrick stressed that credits that are based on geographic access can be particularly useful for negotiating the location of amenities with other departments, such as Wolfline route planning with NCSU DOT.

The Hunt Library project included partial funding of the Partners I Parking Deck, which fulfilled the project parking requirements This payment, which all NCSU departments are able to make, compensates NCSU DOT for the loss of revenue that the DOT incurs as a result of not being able to sell parking permits for the "unconstructed" parking places and provides funding for future parking deck projects. This agreement in turn enables a building site to devote less space to parking and more space to other purposes and amenities. Ms. Patrick and Ms. Axtman are optimistic that the Hunt Library's proximity to existing and future Centennial Campus facilities (including the Centennial Campus housing project) will alleviate parking pressures on

Centennial Campus by creating a more pedestrian-friendly environment that encourages students to walk to destinations around the Oval.

While the Hunt Library was able to integrate several design options that LEED certification standards did not mandate, including rooftop solar panels for heating the Library's water, CPM was not able to achieve all of its goals for the Library. Specifically, the department was unable to secure an agreement with NCSU DOT for setting aside five percent of parking spaces in the Partners I Parking Deck as spots designated for low-emissions vehicles (LEVs). Some potential LEED points related to building orientation on site were sacrificed to better utilize the available space on site. Similarly, there was negotiation between departments over the bus pullout at Hunt Library. Ms. Axtman describes the concerns that different departments shared with balancing pedestrian access and greenspace against transit access. Capital Project Management and the OUA felt that there would be sufficient access to Wolfline stops on Main Campus Drive via the Partners I Plaza that separates Main Campus Drive and Partners Way. However, the Library Services Department and NCSU DOT thought that demand for transit access adjacent to the Library was essential and received a bus pullout long enough for two buses to wait at the transit stop.

Ms. Patrick and Ms. Axtman are very optimistic about the role that the Hunt Library will play in the continued development of Centennial Campus. They anticipate that the Library will become a significant social hub, as much akin to a student center as a library, and bring greater pedestrian activity to Centennial Campus. The Library's design, they assert, implicitly reflects this social role, incorporating more space for student interaction via its physical consolidation of library resources. They also believe that the Hunt Library will be a draw for off-campus students who live in the Avent Ferry corridor, but hesitate to make any specific predictions as to what levels of off-peak, evening-hour activity these students could generate.

However, Ms. Patrick and Ms. Axtman believe that the Library cannot fulfill all the necessary aspects of campus life, and stress that the Centennial Campus Housing project and its dining hall are critical elements of this environment. In addition to providing a wide array of amenities for students, the buildings will further create a ring of activity around the Oval, establishing the Oval as a center for pedestrian activity. In an earlier interview on the Hunt Library's design elements (9/26/11), Ms. Patrick envisioned that NCSU could cultivate the Oval as a programmed greenspace, using its northern space for public events or outdoor classrooms.

Additionally, Ms. Patrick and Ms. Axtman believe that the Hunt Library will play a valuable role in linking the different campus precincts together, and hope that NCSU DOT will maintain frequent Wolfline service at the Library. But rather than using Wolfline service to incentivize students to use the Library, they suggest that the Wolfline could respond to the demand that the Library generates and avoid overwhelming the space around the Library with near-empty buses. Express service between Main Campus and Centennial Campus could be valuable to facilitate inter-precinct access and the Hunt Library could be a natural hub for this service. D.H. Hill Library could serve as a Main Campus hub until NCSU completes the Talley Student Center renovations. D.H. Hill is Main Campus' social hub because of the inadequate supply of space and amenities at the Talley. However, they believe that once the Talley renovation and addition is complete, the Talley Student Center will become a more significant generator of student activity, at which point the center may serve as a more useful transit hub for express service between campus precincts.

Ms. Patrick and Ms. Axtman support facilitating alternative transportation methods on all campus precincts, stressing that NCSU could provide more campus space to pedestrian and bicycling movement, ensuring safer passage, particularly at Western Boulevard, Dan Allen Drive and Cates Avenue. In light of these safety risks, they support the reduction of vehicular access on Main Campus and support the construction of parking decks on the campus periphery to allow these streets to maximize their efficient use as "pedestrian highways." Main Campus precinct is small enough for alternative methods of transportation to provide adequate access to campus amenities, although the precinct must maintain a sufficient level of vehicular access and parking for non-commuter traffic, including delivery trucks, emergency service vehicles, and vehicles which the Facilities Division operates.

While they believe that the private developers play an important role in generating activity on Centennial Campus, their department has less influence over the patterns of private development.

Interview with Lauren Ball, International Students Association—1/22/12

As a Program Coordinator in the International Students Association (ISA), Ms. Ball has a firm understanding of the travel needs of the international student community. Opening her discussion, Ms. Ball points out that the international student body is much more transit-reliant than the overall NCSU community. She estimates that out of a population of approximately 3,000 international students, 75 percent use CAT and Wolfline as their sole means of transportation. In no uncertain terms, Ms. Ball states that "Wolfline is one of the most important [services] at the University [NCSU] for international students."

The majority of these students are in the College of Engineering and so have a need for direct, rapid access to Centennial Campus. However, many of these students live in off-campus apartments that are located in the Avent Ferry Road and Gorman Street corridor, generating transit demand in an area that Wolfline currently serves with inter-precinct bus routes that have long travel times and high demand. The fact that many of the apartment complexes in which international students live do not offer charter shuttle services to NCSU further exacerbates their reliance on Wolfline and CAT.

Because of their high level of transit dependency, Ms. Ball describes international students as very informed about Wolfline services and very responsive to service changes. She specifically sites the highly positive feedback that international students have provided in praise of the 10 Southside Circulator, a new service that travels between the southern part of Centennial Campus and Avent Ferry road, serving multiple apartment complexes that are located south of Centennial Campus. Ms. Ball explains that many of the international students regard the Southside Circulator as a direct response from NCSU DOT to their requests for greater service on Centennial Campus, and consequently are deeply appreciative. Additionally, international students have been very active in using the TransLoc service, and since recommending it, Ms. Ball reports that she receives fewer complaints from the international student community about missing buses or misreading the bus schedule.

Despite the praise she gives to the Wolfline system, Ms. Ball does have several recommendations for improvements. She points out that although NCSU DOT organizes the system around class hours, international students have needs that extend beyond class hours. She cites late nights in engineering labs as an example of this and acknowledges that 24-hour service would be useful; she expresses concern for the students' safety due to the fact that the Werewolf

evening services have very low frequency. Ms. Ball adds that international students often start their orientation or return to campus before the rest of the student body to file immigration paperwork, and in this time, Wolfline service is too limited. The ISA operates a van shuttle service in the spring to bring students to orientation, but Ms. Ball is worried that the association will not be able to support the shuttle service for much longer due to budgetary pressures. Ms. Ball also points out that despite the concentration of international students in the College of Engineering, there is still a need for transit service between the campus precincts due to, among other amenities and services, the movement of the ISA from Daniels Hall on North Campus to a wing of the D.H. Hill Library.

The need for inter-precinct travel colors Ms. Ball's opinions on the Hunt Library. While she is very optimistic about the Hunt Library and believes that it will become a major trip generator for the international student community, she stresses that it will not address the entire spectrum of needs for this community. Ms. Ball explains that international students frequently use the technological resources in D.H. Hill as an alternative to Centennial Campus labs. The concentration of engineering and hard-science resources in the Hunt Library and its close proximity to those labs will therefore represent a substantial pull for international students. International students are very optimistic about the Hunt Library's ability to create a "campus feel" on Centennial Campus that will further incentivize them to stay on campus due to the increased sense of safety and activity. Because of the high level of interest in the Library, Ms. Ball strongly recommends that "there should be [Wolfline service] constantly while the Hunt Library is open," including late at night. This service should focus on rapid access between campus precincts but also provide access to the apartments in the Avent Ferry/Gorman corridor.

In discussing travel between Main Campus and Centennial Campus, Ms. Ball describes the 3A Centennial Express service as "helpful" at providing more direct service, but criticizes the other routes for operating along loops that take too much time. She believes that a rapid express service between the Talley Student Center and the Hunt Library would be sufficient for travel needs. Although international students do not use the Talley Student Center very often, the proximity of the Carmichael Gym and the current location of the ISA make the location reasonable enough to serve as a transit hub for international students.

In general discussions of international students' priorities for transportation planning, Ms. Ball recommends greater connectivity between the Main Campus and downtown Raleigh on

weekends for the community's social needs and job searches. Despite these recommendations for an increase in services, Ms. Ball stresses that an increase in transit fees would be difficult for international students to accept due to the limited access to financial aid under which many international students operate. However, Ms. Ball acknowledges that the students would accept a "nominal fee" as a statement of support and appreciation for the Wolfline. Similarly, the opening of the Hunt Library may make the small percentage of international students who drive on campus more amenable to paying higher parking fees in exchange for service improvements, as the Hunt Library may create sufficient travel demand for the Centennial Campus that those students who park on Main Campus will want greater Wolfline access to the precinct. Ms. Ball points out that there is a small number of international students in the School of Veterinary Medicine who collaborate with students on Centennial Campus and may create demand for travel between the Centennial Campus and the Centennial Biomedical Campus, but she is amenable to the concept of providing this connectivity via a Biomedical Campus shuttle system that the School of Veterinary Medicine operates. Ms. Ball expresses reluctance to NCSU DOT limiting vehicular access on Dan Allen Drive on behalf of the ISA rather than the international student community. Because the ISA holds events for visitors, she is concerned that any restrictions of vehicular access on Main Campus will frustrate visitors and could have a negative impact on the visibility of or support for ISA events. She recommends that NCSU DOT hold a town-hall meeting on campus for community input on such a change in policy.

Interview with Dick Bernhard, Industrial and Systems Engineering--1/9/12

Professor Bernhard is an Emeritus Professor of Industrial and Systems Engineering and is a dedicated rider of both the Wolfline and the CAT systems. He believes that many of the problems with congestion and travel planning can largely solve themselves, based on the willingness of students and commuters to adapt their travel plans to off-peak travel times.

In this belief, he believes that there is little need for the Wolfline system to improve its frequency, especially in the context of limited resources. Professor Bernhard expresses concern with the high labor costs associated with expanding Wolfline service and the high capital costs associated with constructing new road infrastructure. Unfortunately, he regards new road infrastructure as one of the few ways to improve traffic flow around NCSU. Alternative plans, such as limiting vehicular traffic on Dan Allen Drive or establishing bus-only corridors would only displace traffic onto other streets. Given the prominent role that Hillsborough Street and Western Boulevard play in the flow of traffic through Raleigh as well as NCSU, he feels that it would be inefficient to displace any traffic onto these roads. The increase in traffic time along these roads would likely counteract any improvements in travel time that restricting automobile access would accomplish elsewhere on campus.

Despite these reservations, Professor Bernhard nevertheless believes that there are areas where NCSU DOT can pedestrian access. He feels that investments in pedestrian-friendly road infrastructure produce greater benefits to connectivity and access around campus and argues that the walkability of the surroundings around Wolfline system stops offer substantial access for student travel demand. However, he acknowledges that the pedestrian infrastructure has gaps. For example, he recommends that NCSU DOT establish mid-block crossings on Western Bouelvard and develop the center islands into spaces that can accommodate pedestrian wait times. He believes that traffic flows along Western are predictable enough to pose a low risk to student safety and that students and bicyclists waste too much time at crosswalks located at intersections as they wait for the walk signals. Similarly, he believes that constructing a pedestrian overpass bridge or underpass tunnel on Dan Allen Drive would be more valuable for improving traffic flows along that street, as the pedestrian deck crossings often create greater congestion along the corridor than the vehicles themselves. He believes that pedestrian traffic on Dan Allen causes much of the inefficiency that reduces the Wolfline's on-time performance.

Additionally, Professor Bernhard is optimistic about the potential that further development of Centennial Campus could have on demand for parking and vehicular travel around NCSU. He points out that the engineering faculty's demand for "swing space," i.e. space for laboratories, classrooms and offices, has greatly increased parking demand: since these different spaces are frequently separate from each other, faculty demand that they have parking access outside of each separated space. As the development of Centennial Campus consolidates these different spaces into individual buildings (or clusters of buildings in closer proximity to each other), travel demand will naturally decrease and alleviate traffic flows.

Currently, however, Professor Bernhard is critical of Centennial Campus' "office park" atmosphere, which he feels undermines the safety of pedestrians, and its lack of amenities, which he feels increases demand for travel between Main Campus and Centennial Campus. He is optimistic that the Hunt Library will change travel demand patterns and promote student activity on Centennial Campus. Like the construction of additional engineering facilities, will lessen demand for inter-precinct travel by consolidating trip purposes into one building. Most important among these trip purposes, he argues, is food service. While he believes that the coffee shop in the Library will help, the dining facility attached to the Centennial Campus housing project will establish Centennial Campus as a "self-contained" campus that enables students to "stay put for longer periods of time." Lengthening students' "visiting time" on Centennial Campus will reduce the need for frequent service between Main Campus and Centennial. However, Professor Bernhard hesitates to offer any recommendations for specific service changes due to his uncertainty surrounding student usage patterns at the Hunt Library.

Professor Bernhard acknowledges that the consolidation of trip purposes in the Hunt Library will not duplicate the services on Main Campus, and so the Wolfline system will have to maintain connectivity between the two campus precincts.

Interview with Carson Cook, Office for Institutional Equity and Diversity—1/11/12

As an Assistant Vice Provost who frequently travels around campus for inter-departmental meetings, Mr. Cook is familiar with the Wolfline and is supportive of efforts to encourage students and staff to rely on alternative transportation means to travel between campus precincts. His co-workers and staff in the Office for Institutional Equity and Diversity use transit to travel between campus precincts, but more frequently choose their cars and confront the challenges of a shrinking on-campus parking supply.

Citing conversations with members from several administrative departments as well as his own experience, Mr. Cook expressed a general reluctance to have higher permit fees, as most people who have come from other colleges and universities think that NCSU parking permits are "outrageous." Mr. Cook describes the parking permit as "the right to hunt for a parking space, not the guarantee of a parking space." He adds that the current economic environment represents a bad time to try to push for higher parking fees: NCSU employees have had a pay freeze for the past three years.

Furthermore, the system of parking is inefficient: he mentions that people are very reluctant to move their cars because parking is "crazy," and the process of trying to find a parking spot is very time-consuming and inefficient. Nevertheless, many staff members feel forced to use their cars because their department schedules require them to move around the campus precincts for multiple meetings. As a result, staff members are afraid that waiting for a Wolfline bus would pose too large a risk to their time demands; they would prefer to travel to their destination and then spend time searching for a parking space. The travel time between Main Campus and Centennial campus is particularly concerning to staff members, and the need to return to Main Campus quickly provides the strongest incentive for driving. Similarly, the frequency of "unplanned trips" for unexpected meetings or sudden schedule changes weakens staff members' willingness to carpool or share trips; no one wants to feel stranded by a sudden change of plans.

However, Mr. Cook feels that NCSU community members do not necessarily recognize the physical limitations of the campus. In his perspective, the on-going construction and development projects have reduced the parking supply and placed parking spaces at a high premium for staff members. However, he feels that "outward expansion" of the campus is not practicable, and so the NCSU DOT should construct parking decks, including one on North

Campus. Mr. Cook believes that a greater focus on park-and-ride service would be acceptable for the large percentage of NCSU staff members who spend the majority of their work hours in the office (as opposed to traveling between campus precincts for meetings) and represent the majority of NCSU employees.

He believes that the shift to parking decks would present an opportunity for NCSU to change the culture of driving and parking on campus: if the DOT located these parking decks on the campus periphery and provided on-peak rapid service between the Main Campus and these decks, people would be willing to accept "nominally" higher parking fees in return for a greater guarantee of parking access. Turning the parking permit system into a system with assigned parking spots for each permit holder would also improve staff members' willingness to pay for the same reason.

However, he asserts that any substantial, long-term shift away from vehicular travel on NCSU campus would require "a marketing campaign to convince employees that they do not need to bring the car on campus" and an educational program to "know how many alternatives ways there are to get from point A to point B" around campus. In his view, NCSU is part of North Carolina's larger car culture, and NCSU DOT needs to take a more active role in encouraging the community to understand that giving up a car does not mean giving up independence. Specifically, the department should stress that the traveling on the Wolfline system is more convenient and quicker than traveling in a car.

To facilitate this sense of independence, Mr. Cook recommends more "direct, no-stop-in-between" services between different campus precincts. He criticizes current Wolfline services as "indirect and circuitous," making many staff members perceive the system as unreliable and unable to make timely departures. Rapid, direct service between "major campus destinations" is ideal, but Mr. Cook stresses that this system would have to include high-demand destinations for staff, such as Admin II on Central Campus. Additionally, Mr. Cook recommends that NCSU DOT should design transit service for off-campus trip generators, such as Cameron Village, to facilitate transit travel for NCSU community members who need to run errands at off-campus destinations such as pharmacies or grocery stores. NCSU should also promote greater mixed-use development on its campus precincts to reduce the need to make multiple trips. Specifically, Mr. Cook cites the lack of food service on Centennial Campus as a deterrent to relying on transit.

He also recommends that these services should include all campus precincts, and that a given transit hub should try to include as many direct services as possible. For example, he asserted that a direct service route between the Hunt Library and the Talley Student Center makes sense for student demand and suggested that an express route should also connect the Talley Student Center to the College of Veterinary Medicine on the Centennial Biomedical Campus. In a campus environment with high-speed connectivity, Mr. Cook believes that walkability would become more acceptable and that community demand for parking access located outside of campus buildings would decrease.

Interview with Susan Grant, University Housing Department—2/1/12

As the director of University Housing, Ms. Grant has been extensively involved with the development of the Centennial Campus housing project. However, she feels reluctant to offer commentary on transportation issues, as she feels that they do not fall under her jurisdiction. Nevertheless, she asserts that the Housing Department follows changes in Wolfline service and informs students about these changes via updates on the University Housing website. While she does not advocate for any specific service change, Ms. Grant does mention that current levels of Wolfline service are frequently insufficient for travel demand at the Kings Village and Wolf Village dormitories, stating that students frequently have to wait for a second Wolfline bus to come by because the first one is full. However, she believes that students who live on Main Campus by and large have a sufficient level of access to the Wolfline system.

In her discussion of the housing development process, she describes the competitive pressures that the Housing Department faces from off-campus apartment complexes. Because of the large supply of off-campus apartment complexes, the Housing Department must respond to the demands and preferences of the students. As a result, Ms. Grant asserts that the Department places a high priority on developing access to parking at or near dormitories because "that is what the students want."

Since the Housing Department receives much of its budget from on-campus residents' room and board fees, the students' decisions to live off-campus has a direct impact on the Department's resources. Ms. Grant summarizes the trade-off that students make between on-campus and off-campus residence as one of convenience: on-campus housing facilitates access to NCSU resources, but the nearby apartment complexes can offer greater access to parking. Consequently, the Housing Department is very aware of its competitors; Ms. Grant states that "we [the Housing Department] look to what our neighbors offer to determine what we do need to build and what we don't need to build."

With regards to the rate of Centennial Campus growth, Ms. Grant asserts that the Housing Department has been actively involved in the campus planning process. She states that the OUA and the representatives for Centennial Campus have supported the size and scale of the new Centennial Campus housing project. Unfortunately, the available space for parking does not meet minimum requirements based on the number of beds that the housing project will contain, but she recognizes that a construction project must operate within the confines of the space that

NCSU has allotted to the Department. Fortunately, she is optimistic about the level of access to the Wolfline system at the housing project. She describes the siting process for the location of the Wolfline stop as a collaborative "partnership" to balance the needs of the Housing Department with the design goals of the OUA, but she concludes that the Department is satisfied with the proposed location on Entrepreneurship Way, a road which is currently under development.

Similarly, Ms. Grant is optimistic about the level of accessibility between the Hunt Library and the Centennial Campus housing project. She cites the Oval as a key component of this access, attributing the campus paths along the greenspace as effective pedestrian paths for linking the two buildings. This level of connectivity is very important for the success of the Centennial Campus housing project, as the dormitory and the Library are dependent on each other. The dormitory's proximity will alleviate pressures on the Hunt Library to provide access to motorized transportation services (i.e. Wolfline stops and parking spaces), while the technological amenities and study space in the Library have enabled the Housing Department to provide more space for dormitory beds. Ms. Grant asserts that the decision to not include computer labs in the Centennial Campus housing project, which have previously been standard amenities in other dormitories, resulted from the high level of access between the two buildings.

Interview with Mike Harwood, Centennial Campus Development Office—1/13/12

As Associate Vice Chancellor, Mike Harwood has balanced NCSU campus development standards with the pressures that private developers and corporate partners on Centennial Campus place on campus planning efforts. While the Centennial Campus Development Office (CCDO) has followed NCSU DOT policies and procedures in outlining Centennial Campus development, Mr. Harwood emphasizes that the private developers must provide a parking supply that is large enough to convince outside financiers and banks that the building can turn a profit. As a result, many developers have constructed a parking supply that is greater than the City of Raleigh's minimum parking requirements. Mr. Harwood cites that the CCDO has had some success in lowering parking construction by formally allowing business partners to use a portion of university parking supply at the Keystone Center.

He is also optimistic that as the development of Centennial Campus continues and patterns of demand emerge, the CCDO will establish more formal parking guidelines that moderate the growth of the parking supply. On-street parking plays an important mitigating role in this moderation, as it creates a more flexible supply of parking for visitors to the corporate partners. Mr. Harwood also stresses that the on-street parking plays an important role in traffic calming and pedestrian safety, which are priorities in the CCDO development plans. Mr. Harwood states that the CCDO is giving significant attention to identifying of gaps in the Centennial Campus pedestrian infrastructure and developing pedestrian paths through deliberately-maintained greenspaces.

Much of Mr. Harwood's optimism in Centennial Campus planning stems from his belief that the "workforce of tomorrow wants more from a business environment." He strongly believes that the businesses that Centennial Campus has drawn and will continue to draw are choosing to locate at NCSU because they enjoy the environment and amenities of NCSU, including the campus' student life and promotion of sustainable principles.

However, Mr. Harwood stresses that NCSU must actively develop the sustainable amenities that will create a greater sense of community on Centennial Campus. He cites the Town Center development as the start of private developers taking a role in the Centennial Campus community and foresees future development including private housing and a conference center. He describes Centennial Campus as having the potential to develop into a city-within-a-

city that contributes significantly to campus life at NCSU and to the overall economic activity of North Carolina.

To achieve this vision, Mr. Harwood discusses the promotion of accessibility at every level of transportation. His office's focus on the pedestrian infrastructure stems from a belief that pedestrian movement is necessary for successful transit service and enables the community to derive greater enjoyment from the physical campus environment. The physical environment, in turn, must integrate extensive greenspace to promote a "campus feel" in a larger business environment. Mr. Harwood outlines an "integrated transit service plan" that establishes a sense of permanence for transit infrastructure, including highly-visible bus shelters (in place of simple bus stop signage) and covered bike storage units located next to transit stops. The Wolfline system must similarly improve its visibility and adopt new technologies that enable more rapid point-to-point services between major transit hubs. Mr. Harwood cites the bus priority corridor along Dan Allen Drive and the dedicated transit corridor that the Office of the University Architect (OUA) has set aside as key parts of this transit network.

Ideally, he envisions the dedicated transit corridor as a space for a high-tech, steel-wheel people mover that terminates at multi-modal transit hubs with access to low-tech busways. He stresses that even as NCSU DOT develops rapid, direct services, the department must maintain circulator services to facilitate access to all parts of Centennial Campus. He believes that corporate partners' travel needs should be a part of transit planning, as they too will demand more sustainable transportation options. However, Mr. Harwood acknowledges that CCDO needs to develop a clearer understanding of the travel demands between Centennial Campus and Main Campus. In this effort, he asks that the OUA and NCSU DOT work directly with CCDO to determine what transit technologies represent the best investment for this corridor. He sees the completion of the "ring road" around Centennial Campus (parts of which are currently under construction) will facilitate the circulator services, but he stresses the need for greater research of transportation preferences to determine where these services should stop.

Unfortunately, Mr. Harwood believes that there is limited support among corporate partners to pay for these developments through higher parking fees. Because building rents bundle parking costs into the total value, corporate partners will not perceive these higher rents as providing them with any benefits. However, he does suggest that there may be greater support for direct payments into transit improvements.

In the short term, Mr. Harwood believes that the Hunt Library will be a valuable addition to campus life on Centennial Campus. He is skeptical that students from non-science departments will use the Library very frequently because of its focus on science and technology, but its mixed-use design will promote enough non-academic student activity that the Library will still be a viable transit center. To this end, he supports the idea of an express transit service between the Hunt Library and the Talley Student Center, but he does not regard it as an acceptable substitute for circulator services between Main Campus and Centennial Campus.

Interview with Louis Hunt, Enrollment Management and Services—2/29/2012

As a Vice Provost and University Registrar, Dr. Hunt is heavily involved in the scheduling and distribution of student courses and thus is cognizant of the challenges that NCSU faces with moving students around the campus. He mentions how the Registrar has introduced a half-hour offset in the University course schedule between courses on Main Campus and courses on Centennial Campus. This half-hour gap is necessary to permit students to travel between the two campus precincts, but Dr. Hunt stresses that this gap is no longer sufficient due to the long travel times on inter-precinct Wolfline routes, which he describes as "horrific" and states "you're might as well just walk [between the precincts]." He states that he "can't be certain that kids aren't taking longer to graduate because it takes so long to get between campuses."Consequently, the Registrar has been expanding this gap to an hour-and-a-half. Dr. Hunt believes that this longer gap is unsustainable and consumes too much time in the course schedule to be efficient.

As a result of this inefficiency in the course schedule, he strongly advocates for greater connectivity between Main Campus and Centennial Campus and recommends that the Wolfline system use the Pullen Road extension to create an express bus service loop between the Coliseum parking deck and the Engineering Buildings. The heavy concentration of off-campus student residences around the southern part of Centennial Campus also poses a substantial challenge to traffic flows and parking demand at multiple campus precincts; Dr. Hunt suggests that NCSU DOT should expand rapid Wolfline service through this corridor to encourage students to leave their cars at home. He also recommends the establishment of an express bus corridor with a dedicated lane to connect Centennial Campus to Dan Allen Drive. He suggests that this latter service would be particularly visible for campus tours and visiting days, during which time the demand for inter-precinct travel greatly increases.

Dr. Hunt believes that the current system of routes operating as circulating loops is too inefficient and recommends that NCSU DOT redesign its service to operate "like an airport shuttle," with routes providing short, direct trips between major travel centers. Dr. Hunt cites the West Lot parking deck as an example of a center that would benefit from this service, as he believes that the deck is located too far away from destinations on North Campus for students to walk, but too close for a circulator service to be acceptable. This service design would reduce travel times for riders and also reduce the impact of traffic conditions on travel times, especially if these services could operate on roads on the interior of campus precincts.

Despite his support of higher-infrastructure Wolfline services, Dr. Hunt asserts that NCSU DOT should consider moving towards higher-capacity transit systems. He believes that the Wolfline buses are frequently at capacity and are too vulnerable to the high levels of vehicular traffic on Dan Allen Drive, Hillsborough Street and Western Boulevard. As a result, and the NCSU community has difficulty supporting the system when its members see buses that read "FULL." Additionally, the waiting times associated with circulator bus services greatly undermine willingness to use the Wolfline system. Dr. Hunt points out that if a destination is a 15-minute walk from a point of origin, a short waiting time makes the Wolfline service significantly less attractive than walking. The branding of the Wolfline buses does not reflect the value of the fees that support the system.

While he recognizes that the bus fleet is less expensive than high-capital rail systems and argues that an elevated people mover is too expensive for the campus' needs, he believes that the advantages that a light rail system would bring to NCSU would create significantly greater benefits in a long-run time horizon. Specifically, he recommends that in addition to any rail service that the City of Raleigh or the Research Triangle establishes along the rail corridor that crosses the campus, NCSU should establish a light rail that travels between Main Campus and Centennial Campus. He asserts that in addition to providing higher-capacity service with lower travel times, a light rail system would raise the profile of NCSU and boost its reputation as a forward-thinking university. He optimistically believes that the NCSU community will be willing to pay more for these high-capacity systems because the community will recognize their value and the benefits that such systems give to NCSU's reputation and esteem.

Dr. Hunt strongly believes that if NCSU wants to promote this value of progressive campus planning, the University needs to take a more active role in facilitating pedestrian access on campus. He criticizes the campus for being "too car friendly" and recommends that NCSU adopt planning policies that limit automobile access, especially on the campus interior. Currently, the expansion of pedestrian facilities without any reduction in automobile access has introduced substantial inefficiencies into campus traffic. Dr. Hunt cites the poor interface between vehicular and pedestrian traffic, arguing that while the pedestrian right-of-way signage has improved the responsiveness of cars to pedestrians, it has also resulted in greater vehicular traffic. He points out that pedestrian demand to cross Hillsborough Street at the intersection of Hillsborough Street and Dan Allen Drive is so high that cars are unable to turn onto Hillsborough

from Dan Allen, which results in traffic congestion that backs up along Dan Allen Drive. He recommends that NCSU DOT should study the traffic signals around the campus and coordinate the signals to allow for smoother traffic flows. At points of high pedestrian travel, he recommends that the signals allow for a pedestrian scramble to avoid conflict between vehicles and pedestrians. Dr. Hunt also expresses approval of the development of roundabouts as a more efficient way to move traffic, although he acknowledges that pedestrian safety concerns remain.

Expanding on the avoidance of conflict between vehicles and pedestrians, Dr. Hunt strongly advocates for the restriction of automobiles on Dan Allen. He stresses that NCSU should designate the corridor for "campus business" rather than allowing it to serve as a "thoroughfare for cars" that are connecting between Western Boulevard and Hillsborough Street. He qualifies his statement, saying that some student travel requires short trips between campus precincts for brief administrative meetings. In describing these trips, he points out the inefficiencies that parking decks have created for students. Because of the walk to and from the deck, these 15-minute meetings can turn into hour-long trips when one factors in all travel times. To address these issues, Dr. Hunt suggests that NCSU DOT establish a number of small-capacity parking lots on Main Campus and designate the parking lots as spaces for short-term administrative trips.

However, Dr. Hunt acknowledges that the solution may lie in moving administrative offices or creating duplicate services on the campus periphery to reduce travel demand to the interiors of campus precincts. This change in the distribution of services would enable students to access administrative services near peripheral parking decks, but Dr. Hunt stresses that the administrative offices would have to have a guarantee of a "critical mass" of student demand on the periphery before these departments would create duplicative services or undergo a complicated move from their existing locations.

In Dr. Hunt's perspective, the University should focus on the development of pedestrian infrastructure in all areas and "err on the side of pedestrian-friendly [planning]," stating that creating opportunities for personal interactions within the campus community is one of the fundamental purposes of a university. He recommends that NCSU DOT and the OUA invest in greater traffic calming measures and redesign roads to divert traffic away from campus interiors. Citing the improvements in traffic flows that resulted from changing Cates Avenue from a two-lane street to a one-way street after it intersects with Morrill Drive, Dr. Hunt suggests that NCSU

DOT should also convert the western length of Cates Avenue to a one-lane street with traffic traveling to the east to divert traffic away from Dan Allen. He also identifies the high level of risk for pedestrian crossings at the intersection of Western Boulevard and Avent Ferry Road, saying that if cost were no issue, he would recommend the construction of a pedestrian bridge over the intersection. He dismissed the concept of a tunnel, arguing that it did not provide sufficient safety for pedestrians.

On a smaller scale, Dr. Hunt recommends that NCSU make small changes to the infrastructure that make these pedestrian spaces more inviting and more innovative, such as outside public water fountains and bike parking decks. He also advocates for more bike lanes that offer a formal design and directional bike travel to promote bike commuting between campus precincts. Acknowledging the role that his department could take in alleviating traffic pressures, he discusses the consideration that the University Registrar has given to starting classes at 8:30 AM to separate the arrival of students from the arrival of faculty and staff, who would travel to campus for 8:00 AM. He points out that around NCSU, the City of Raleigh is developing dense, mixed-use activity centers that offer opportunities for a focused build-up of alternative transportation methods. Dr. Hunt believes that it is very important for NCSU to establish itself as a leader in these development patterns and embrace alternatives to auto-centric design. He believes that a university should be on the cutting edge of new technologies and new ways of looking at the world rather than reaffirming the status quo, and so NCSU should integrate considerations for pedestrian access into all aspects of campus planning.

Interview with Kristy Jackson, Institute for Transportation Research and Education—1/30/12

As a pedestrian and bicycle infrastructure research associate in the Institute for Transportation Research and Education, Kristy Jackson believes that NCSU DOT should pay greater attention to efforts to integrate alternative transportation modes into a more seamless transportation network. Such efforts include working more directly with Capital Area Transit (CAT) and the Triangle Transit Authority (TTA). Specifically, Ms. Jackson stresses that NCSU DOT should brand the other two systems as "equals" in terms of their effectiveness at connecting NCSU community members with destinations at NCSU, in Raleigh, and throughout the Triangle. Expanding working relationships between NCSU DOT and the City of Raleigh may also facilitate streetscape improvements at the intersections of campus streets and city streets.

Within the Centennial Campus, Ms. Jackson criticizes the overbuilt street capacity and the extensive building setbacks. While she recognizes that these setbacks enable ample amounts of greenspace, she asserts that this greenspace expands the sense of space and discourages walking for employees and students alike. This separation of self-contained buildings results in a low level of pedestrian activity and a high sense of isolation on Centennial Campus. She cites the food trucks and farmers' markets that sporadically serve Centennial Campus as generators of activity, but stresses that more sustained activity generators, including permanent food service, is necessary to promote a pedestrian environment on Centennial Campus.

Ms. Jackson recommends that NCSU DOT take advantage of the wide street lanes on Centennial Campus and stripe them for full bike lanes. Citing the lack of accidents in the bike lanes on Hillsborough (which she describes as having "standard bike lane design"), she stresses the advantages of bike lanes over shared-lane markings in facilitating legal bicycle movement past automobiles that have stopped to make turns. The dramatic building set-backs provide an opportunity to match on-street amenities for bicycle commuters with off-street amenities, including covered bike lockers that promote greater security for bicycles.

Wherever NCSU DOT wants to promote a culture of alternative transportation, she argues, the department must promote the amenities and facilities that enable alternative transportation. With regards to potential limitations of vehicular traffic on Main Campus, Ms. Jackson again stresses the "equalization" possibilities of branding. Specifically, she recommends that NCSU DOT should design pedestrian crossings at the front of any street enclosure to communicate to automobile drivers that other commuters are still using the street space.

Ms. Jackson is optimistic about the positive impact that the Hunt Library will have on student life on Centennial Campus, but warns that it could negatively impact corporate partners. Since the private employees of Centennial Campus are not likely to use the library resources, they will receive little direct benefit from the Library but will experience the heavier traffic patterns that result from increased travel demand on Centennial Campus. The lack of road connectivity on Centennial Campus will exacerbate these problems: Ms. Jackson argues that the majority of vehicular and bus traffic on Centennial Campus must travel from Varsity Drive to Avent Ferry Road to connect to Main Campus and the rest of Raleigh simply because Centennial Campus lacks connecting roads. She acknowledges that the Office of the University Architect (OUA) has planned many of these roads and includes them in planning documents, but she feels that relying on private development to lead the process of constructing these roads greatly extends the amount of time under which Centennial Campus must operate with limited mobility.

To facilitate greater mobility on Centennial Campus and between campus precincts, Ms. Jackson recommends that NCSU DOT should shift its route planning from a concept of "loops" that travel around campus precincts to a concept of "connectors" that travel in linear directions between transfer points with limited stops and more frequent headways. This model of service would ideally reduce travel times and wait times by promoting shorter trips with more direct service between points. While she agrees with the concept of rapid transit service between the Hunt Library and Talley Student Center or D.H. Hill Library, she stresses that NCSU DOT must make investments in the system's infrastructure to achieve more rapid and more reliable service. She recommends that NCSU DOT install signal priority systems in the buses to eliminate the long waits at the intersection of Avent Ferry Road and Western Boulevard and that the department develop a dedicated bus-travel lane along Varsity Drive through the South Campus precinct.

Interview with Lisa Johnson, Office of the University Architect—1/13/12

NB: With Ms. Johnson's permission, this interview also includes information from a presentation that Ms. Johnson gave to Professor John Stone's Senior Seminar on January 26, 2012th entitled "Building a New NCSU."

As University Architect, Ms. Johnson is actively engaged with the Campus Mobility Transit Plan, since the results of the plan will influence the OUA's reevaluation of the Physical Master Plan and the Capital Plan. These two documents serve as important guides for the planning and design of the physical campus. The OUA is paying careful attention to Centennial Campus, as the Office and the Registrar identify this precinct as an area of very rapid growth. The current student population that uses the facilities on Centennial Campus is 7,130, but by 2020, these departments estimate that 11,000 students will be centered on the precinct. Yet even these projections represent a decrease from previous estimations that suggested the entire campus population would grow to 40,000 by 2025. Ms. Johnson states that while the current levels of predicted growth are still substantial, they nevertheless create the opportunity for the OUA to put the University's limited resources to use over a larger space, which would increase opportunities for greater greenspace development.

This growth is the motivation behind the student housing project and its accompanying 20,000-square foot dining facility; the OUA determined it was necessary for the Centennial Campus to expand its range of amenities and become a more "self-sustaining" campus. Ms. Johnson stresses that the incomplete development of Centennial Campus limits its "campus feel." She points out that while much of the pedestrian infrastructure is already in place, the underdevelopment of the precinct creates long, monotonous walks between buildings and amenities and ultimately undermines pedestrian movement.

However, she is very optimistic about the ability of the Oval projects, many of which are already underway in terms of planning and construction, to "complete" the Oval and center the greenspace as a major pedestrian circulator on the precinct. Additionally, the OUA has secured funding to expand the greenway infrastructure of the precinct and connect it to the City of Raleigh's pedestrian and bicycle pathways, further integrating the campus community with the city. Ms. Johnson stresses that the completion of the Centennial Campus greenway is a critical step in the overall development of the precinct, and thus OUA is striving to build the infrastructure in concert with the physical buildings. The OUA is in the process of reaching out

to the City of Raleigh to work with its planning department on infrastructure improvements in the spaces where city infrastructure and campus infrastructure overlap. She cites the design for a new greenspace development on the southwestern corner of the intersection of Western Boulevard and Avent Ferry Road as an example of university-city collaboration. She sees this collaboration as an important step in the development of a pedestrian and bicycle tunnel under Western Boulevard that will greatly improve pedestrian safety and movement at the intersection.

Unfortunately, funding for the parking decks that the OUA has cited for the Oval is at this time uncertain. While Ms. Johnson admits that Centennial Campus currently has an oversupply of parking, she nevertheless asserts that a total parking supply that is approximately double the capacity of the large buildings on Centennial Campus would benefit the precinct and enable it to manage its travel demand. In light of this need for maintained travel demand, Ms. Johnson recognizes the value of minimum parking requirements that the City of Raleigh sets for NCSU and asserts that the OUA plans to follow them while participating in NCSU DOT's shift to parking decks, which she describes as a "culture change."

However, she also acknowledges that this shift is "the right way" for the campus to handle vehicular traffic, as surface lots represent an inefficient use of campus space. NCSU DOT and OUA will most effectively implement this shift in implements over time. Ms. Johnson cites the plans for "section-by-section" removal of parking on Cates Avenue as an example. The reduction in parking over time makes the existing parking supply increasingly competitive, but it provides drivers with the opportunity to adjust their travel patterns over time and identify alternative methods of transportation without putting sudden and dramatic shocks of travel demand onto other areas. To maintain a stable distribution of travel demand, Ms. Johnson also stresses the need to make these parking shifts within each campus precinct to ensure that each precinct's parking supply remains constant.

The OUA's interest expands beyond the parking supply. Ms. Johnson expresses an enthusiasm for streetscape improvements that could lead to more efficient Wolfline service. She recommends that NCSU DOT change the system from its current loop-based design to a series of short, rapid corridors where express bus services operate with limited stops and rapid travel speeds. This service will become all the more important as the demand for inter-precinct travel increases with the development of Centennial Campus. Specifically, she believes that NCSU DOT should develop a bus priority corridor to establish the central role that the Wolfline plays in

campus mobility and connectivity. She stresses that NCSU DOT should take action on the corridor design and present the OUA with a plan that outlines preferred infrastructure improvements. Ms. Johnson points out that the OUA cannot assign priorities in its planning schedule or secure funding as long as the bus corridor simply exists as "a line on a page."

Ms. Johnson identifies the opening of the Hunt Library as a key opportunity for moving forward with a bus priority corridor. She believes that the building's iconic status and wide range of amenities will make the Library a major activity center on Centennial Campus. In its initial opening, she anticipates that students who are generally centered on Main Campus will nevertheless travel to the Centennial Campus for the purpose of visiting the Library. The proximity of the Library to the Town Center development will add to the Library's attractiveness as a hub for community travel.

Despite her enthusiasm for rapid bus services, Ms. Johnson acknowledges that NCSU DOT must maintain local service to provide connectivity within a campus precinct and recommends that the Department set aside a small number of routes to travel along precinct exteriors. She cites the ongoing development of the ring road around Centennial Campus as an example of the OUA's "approval" of such systems. Additionally, she expresses support for the reduction of vehicular traffic on Main Campus, but stresses that NCSU DOT must implement these reductions slowly and deliberately to ensure cooperation and support from the larger Raleigh community. If NCSU DOT plans to close a section of Dan Allen Drive to automobile traffic, Ms. Johnson suggests that the Department pursue this project in increments, with week-long closures that the Department clearly explains and aggressively advertises in advance of the actual closures.

Interview with Amy Lubas, Centennial Partners Office—1/13/12

As Director of Partnership Development in the Centennial Partners Office (CPO), Ms. Lubas represents the corporate partners of Centennial Campus and highlights the issues that most concern them with regards to future planning. However, she also promotes Centennial Campus to prospective corporate partners and knows how a sustainable campus environment factors into the decisions that high-tech companies make about where to locate themselves.

Ms. Lubas describes the Centennial Campus environment as low-profile and balanced, seeking to promote all corporate partners equally. The campus precinct operates on a 9-to-5, 5-days-a-week schedule and consequently has needs that are different from the rest of NCSU. For example, Ms. Lubas stresses that with regards to parking, Centennial Campus has oversupplied parking as a "necessary trade-off" for the higher building rents that corporate partners pay. Centennial Campus has some of the highest rents in the Research Triangle Area, and a reliable supply of parking for visitors is "an absolute priority" for the corporate partners; it helps to convince them that the campus has enough space to attract visitors and clients and generate enough business to offset the higher rents. Corporate partners become very frustrated, Ms. Lubas warns, when students travel to NCSU and use the parking that NCSU DOT has designated for visitor. She believes that NCSU DOT should take a more active role in differentiating the parking that it has designated for visitors and in communicating to the NCSU community proper standards of behavior with regards to parking.

A corollary to the importance of parking is that corporate partners are less willing to accept higher parking fees than other faculty and staff at NCSU. This reluctance partially stems from the relationship between parking and parking fees for corporate partners: rather than paying parking fees as separate fees, as NCUS faculty and staff do, corporate partners' building rents bundle the parking fees into the rents. Thus for corporate partners, there is a disconnect between their parking supply and the amount they pay for parking. Corporate partners interpret their parking supply as a fixed amount that NCSU provides to them.

However, Ms. Lubas stresses that this relationship between corporate partners and their parking supply does not imply that corporate partners are only interested in auto-centric design. Based on her experiences presenting information on alternative transportation methods to them, Ms. Lubas says that corporate partners have shown enthusiasm for installing electric-vehicle charging stations on Centennial Campus as well as participating in the free GoPass system that

enables NCSU community members to use CAT and TTA services without paying a fare. Similarly, the corporate partners have been very supportive of on-street parking and recognize the important role that it plays in promoting on-street activity. Furthermore, corporate partners have demonstrated concern for vehicle speeds and pedestrian safety on Centennial Campus; Ms. Lubas suggests that NCSU DOT consider narrowing lanes and installing other traffic-calming measures on Varsity Drive and the southern part of Centennial Campus.

She also praises the pedestrian-scaled infrastructure of Centennial Campus, citing the wide sidewalks and ample greenspace, and recommends that NCSU DOT expand pedestrian amenities, such as benches and outdoor seating, to promote the environment further. She asserts that the CPO has encouraged corporate partner employees to eat at the Innovation Café on Centennial Campus to promote the "campus feel" of the environment. While she jokingly criticizes the "corporate mindset" that makes corporate employees less willing to walk on campus, she stresses that the corporate partners recognize and appreciate the marketability of a "green halo:" a campus that promotes sustainability and alternative transportation methods. These principles play an important role in employee recruitment for corporate partners.

Ms. Lubas believes that the university environment of Centennial Campus (and NCSU as a whole) also plays an important role in reducing the stigma of riding a bus for the corporate partners. However, she criticizes the lack of rapid access between Main Campus and Centennial Campus. Including waiting time and transfers, she estimates that round-trip bus travel between the two precincts would take one hour, and corporate partners cannot afford that much time when they need to schedule multiple meetings in a given day. Therefore she stresses that NCSU DOT design more rapid Wolfline service between campus precincts as well as additional circulator service, saying plainly "the more bus service for Centennial Campus, the better." Even if corporate partners do not use the increased services, they know that students will, and they recognize that shorter travel times will increase students' willingness to work for the businesses on Centennial Campus.

Corporate partners are also very enthusiastic about the Hunt Library's ability to incentivize an increase in travel to and from Centennial Campus. In Ms. Lubas' words, the Library will "tell the story of Centennial Campus' success" and become a center for student activity. While she does not believe that the corporate partners will use the Library with much frequency, she asserts that the corporate partners support the Library as a way to bring student

activity to the campus precinct. Creating greater student activity in the evening will be a particular boon to the Centennial Campus tech companies that do not operate on the same 9-to-5 schedule as other corporate partners. In this support for student activity, corporate partners are supportive of greater Wolfline service on Centennial Campus, especially if expanded service could alleviate the potential pressure that Hunt Library travel could place on the parking supply. Ms. Lubas does not believe that rapid service between the Hunt Library and the Talley Student Center is ideal for corporate partners, since their destinations on Main Campus are often the academic buildings that are located on North Campus. However, she believes that corporate partners recognize that public transportation does not provide door-to-door service, and therefore they may be more willing to walk if they benefit from rapid service between precincts.

Based on this evaluation, Ms. Lubas stresses that if NCSU DOT levies any new fees on corporate partners to pay for new transit services or changes in the parking supply, the corporate partners must be able to recognize and experience directly the benefits of the new fees. Corporate partners would support a shift from tenant surface lots to clustered parking decks because the CPO stresses that they would face a similar dynamic if they were to locate in downtown Raleigh, but they would still expect that NCSU DOT designate visitor parking in these decks and enforce these standards.

One exception to this principle, however, is the Town Center. Ms. Lubas stresses that corporate partners will not likely support any restriction that NCSU DOT would place on the Town Center by requiring that visitors pay for parking. As a center for private development and private business activity, corporate partners fear that any paid parking at the Town Center will greatly limit business interest in the development. Corporate partners may also push for a similar oversupply of parking at the development to prevent any risk that community interest in the new development would overwhelm the parking supply and increase traffic on Centennial Campus.

Interview with Kim Paylor, Transportation Department—1/25/12

NB: Although Ms. Paylor does not serve as an Advisory Stakeholder, the author conducted an interview with her to gain a greater understanding of the opinions and perspectives of NCSU DOT on the Campus Mobility Transit Plan.

As a transit planner for NCSU DOT, Ms. Paylor has a direct role in determining the level of service that the Wolfline system provides to the NCSU community. Because of the high level of data collection that NCSU DOT obtains through the Wolfline Automatic Passenger Counters and real-time bus location systems, Ms. Paylor is very optimistic about the system's ability to respond to changes in demand. For example, it is possible to redirect buses to respond to changes in demand on an hour-by-hour basis from a low-ridership route to a high-ridership route. Unfortunately, such changes require a sacrifice in frequency along those low-ridership routes, and these service changes can often produce frustrated responses from Wolfline riders. Since students and other riders can provide feedback through the Wolfline system's Facebook page, expressions of confusion with service changes are not uncommon. However, the Facebook page also enables NCSU DOT to respond to these comments with up-to-date information that directly addresses each rider's comment.

Yet these changes represent the best options that are available to the Wolfline in the short run. Although NCSU DOT is replacing five buses, the 35-bus fleet represents a fixed number for the time being. Any expansion in the size of the fleet would require a substantial increase in student fees. The fixed number of buses and the current status of vehicular traffic along NCSU also mean that the Wolfline's overall system frequency has a very real limit. At best, travel time between any two campus precincts has a 10-minute minimum, which in turn limits bus headways to 12 minutes. Without substantial investments in bus-priority road infrastructure, Wolfline buses experience too much traffic congestion to maintain their time schedules.

Because of these physical limitations, Ms. Paylor has considered redesigning the Wolfline system to operate without a time schedule. Rather than creating a system that designates when a bus should arrive at a given bus stop, the system would operate with a time frame and an expected frequency that would inform riders how frequently a bus would pass by a given stop. Rather than expecting a bus to arrive at their stop at 8:15 a.m., riders would understand that between 8:00 a.m. and 12:30 p.m., they could expect a bus to pass by their stop every fifteen minutes. This change would reduce the need for bus drivers to pass by or stall at a

given stop in order to correct for inconsistencies within their time schedule, ultimately creating a more flexible service for riders.

While the NCSU DOT has not yet adopted this change in service, Ms. Paylor believes that the patterns of campus development are organically facilitating a more flexible bus service. The opening of the West Deck parking deck on Varsity Drive brought more students into the interior of campus and consolidated several smaller trip generators into one larger trip generator. This consolidation of trip generators reduced the number of stops that the Wolfline system had to serve, enabling faster travel times. Ms. Paylor believes that similar improvements are possible with the opening of the Hunt Library. She believes that the Hunt Library will serve as a large center of student activity, creating a natural location for consolidated travel demand. This activity center will alleviate some of the boarding pressure at the stop located at the intersection of Partners Way and Varsity Drive, which has the highest daily boardings and alightings in the entire Wolfline system, and will thus contribute to a "smoothing out" of ridership between multiple activity centers.

The development of a major activity center on Hunt Library will also enable the Wolfline system to integrate rapid, direct service between Main Campus and Centennial Campus. Ms. Paylor believes that the Hunt Library and D.H. Hill would serve as ideal transit hubs, as both have the level of infrastructure and space devoted to transit necessary to serve a high volume of buses and have a central location on their respective campus precincts that facilitate pedestrian access to a wide range of trip generators.

Interview with Josh Privette, Undergraduate Student Council—1/23/12

Mr. Privette's role in NCSU's Undergraduate Student Council has him receiving concerns and criticisms from students regarding Wolfline services, and sums up his assessment of student demands with a paradox: "The students don't like change but they like better service." However, Mr. Privette positively notes several improvements that NCSU DOT has made to the Wolfline services, and asserts that students are able to recognize and appreciate the updates that NCSU DOT continually makes to the system. Communication between the department and the student body needs to improve, however. He warns that students do not have a proper understanding of public transportation—especially those students who come from more suburban or rural environments where they have never interacted with transit service—and so they have distorted expectations of service. He specifically cites Greek Village residents' frustrations with being unable to board Wolfline buses at peak-hour services.

Yet part of these frustrations, he argues, come from students' expectations that the Wolfline is going to guarantee service whenever they need it. Students need to understand that "it's not a taxi service," and he feels that it is the responsibility of NCSU DOT to explain these differences to students. Mr. Privette does cite the decrease in complaints that he has received about service at Greek Village since NCSU DOT changed the name of the route that serves Greek Village from 9 Greek Village to 9 Gorman St. Local. Changing that sense of "ownership" of the route, Mr. Privette, makes a big difference to students, because once their residence's name is no longer on the bus, they have an easier time accepting that the bus has other riders to transport. He recommends that NCSU DOT promote this sense of community-based transportation that needs to meet demand in many different areas across the entire campus.

Mr. Privette does recognize that students have more legitimate concerns about the Wolfline system that education alone will not address. For example, he describes the "persistent issue" of inadequate transit service between Main Campus and Centennial Campus. He also encourages greater connectivity between NCSU and downtown Raleigh, citing that most students drive to the downtown on weekends because the Wolfprowl service has too few stops downtown. He also expresses concern with regards to access between off-campus apartments and NCSU. Students are aware of transit services at other universities, such as Eastern Carolina University, that offer greater connectivity and more reliable service between off-campus apartments and university campuses.

He stresses that off-campus students want direct, rapid access to NCSU and recommends using transit hubs, such as D.H. Hill, at central locations on campus to facilitate this access with limited stops. On-campus students, however, desire more cross-campus shuttle service, but place less of a priority on familiarizing themselves with the Wolfline system—he jokes that on-campus students are most likely going to use the system when the weather is bad.

Mr. Privette praises the TransLoc service as very useful for helping students feel more comfortable taking Wolfline by reducing the information costs associated with learning how the service operates. He also asserts that the service is helping students recognize the overlap between Wolfline and CAT services, and thus is encouraging ridership on Raleigh's system as well. He recommends that NCSU DOT should expand the use of TransLoc displays on campus, arguing that "in an ideal world, we'd have a TransLoc computer screen at every bus stop."

Unfortunately, there are still gaps in students' awareness about Wolfline services. Many students, he argues, are unaware of the park-and-ride services at the West Lot, and so student demand puts excessive pressure on the Carter-Finley park-and-ride. Mr. Privette argues that this lack of awareness poses a problem for any new parking restrictions on Main Campus. He plainly states that students would oppose any efforts to reduce resident parking, and stresses that NCSU DOT would have to counterbalance parking reductions on Main Campus with equally convenient deck parking within the same campus precinct. In his words, "Carter-Finley [park-and-ride] is not an effective substitute for Dan Allen, because the latter is convenient and the former is cheap." He does cite the West Deck as a positive example of well-planned parking that receives adequate transit service and provides sufficient access to campus for students and stresses that future parking decks should receive similar levels of frequent bus service.

As NCSU DOT continues to promote parking decks, Mr. Privette believes that students will disagree with higher parking fees, but will most likely pay them. He stresses that students' tolerance for higher parking fees greatly increases whenever NCSU DOT is able to provide new services, as students believe that they are benefitting from their contributions to the system. He believes that students would express similar preferences for increased student transit fees: as long as the students are able to discern an improvement in Wolfline services, they are willing to pay more for them. However, full buses represent a particularly strong frustration for students, which will present an on-going challenge for Wolfline services at peak demand times.

Frequent bus service will be particularly important at the Hunt Library. Mr. Privette is very optimistic about the Library's attractiveness to a wide variety of students. While he is skeptical that non-engineering students will travel from Main Campus to Centennial Campus for the single purpose of using the Hunt Library's resources, he does believe that the Library will raise the visibility of Centennial Campus for the student population as a whole. As the Hunt Library establishes its presence and expands its resources on-line, it will ultimately draw "students from every corner of the campus." He believes that off-campus upperclassmen students who live along the Avent Ferry corridor will prefer to use the Hunt Library rather than D.H. Hill if they have parking access at the Partners I Parking Deck.

The Hunt Library will become an activity hub on Centennial Campus that represents an ideal location for express bus service between Main Campus and Centennial Campus as well as local service around Centennial Campus. In this combination of services, Mr. Privette envisions a substantial bus stop with multiple bus shelters and a bus pull-in to reduce traffic congestion along Partners Way. He believes that students will use the Hunt Library to "catch every bus that travels on Centennial Campus" but will also expect service that travels between the Hunt Library and D.H. Hill with "as few stops as possible." He envisions D.H. Hill as the Main Campus hub at least until NCSU completes the renovations at the Talley Student Center , as D.H. Hill provides better connectivity to Main Campus amenities. Rather than trying to differentiate the express bus service between the two campus precincts from local services, Mr. Privette believes that NCSU DOT should simply stress that the limited-stop route between the two precincts is the fastest way for NCSU students to reach Centennial Campus.

Interview with John Royal, College of Engineering—1/6/12 & 1/11/12

As a Traffic Engineering Professor in the College of Engineering, Professor John Royal is following the development of Centennial Campus as the College of Engineering continues its move over to the campus precinct. Professor Royal believes that due to the lack of funding for Engineering Buildings IV and V, the College of Engineering will not move a significant amount of additional engineering resources to Centennial Campus over the next few years. He estimates that there will be a three-year gap between the identification of funding and the completion of the facilities. This delay implies that COE students will still generate demand for travel options between Main Campus and Centennial Campus for the foreseeable future.

Professor Royal expresses optimism about the Hunt Library's impact, describing it as "a great addition to the campus." However, the D.H. Hill Library and the Talley Student Center both provide a wide range of student resources and amenities on Main Campus, namely "quiet individual study areas and group study areas." As a result of these existing resources, Professor Royal is skeptical of the Hunt Library's ability to establish itself as a destination for trips from Main Campus. Instead, he believes that "the students are going to go to whichever location is quickest and easiest to get to," and that students will effectively sort themselves into each library based on their use of the resources around each building. This sorting will in turn lead to a more efficient distribution of student demand between the two resources and, as a consequence, traffic patterns around NCSU. Professor Royal is confident that the existing level of Wolfline transit service on Centennial Campus will provide adequate service for travel demand to and from the Hunt Library.

Despite his optimism regarding the re-allocation of traffic, Professor Royal recognizes that there are substantial traffic flow problems on many of the campus thoroughfares. He specifically cites the interchanges at Western Boulevard and Avent Ferry road and at Western Boulevard and Pullen Road as generators of "major traffic congestion," particularly during the times at which classes change. He stresses that NCSU DOT must continue to develop "faster and safer ways" to move Wolfline buses, pedestrians and cyclists across Western Boulevard. He does not offer a single solution but recommends that the Department consider infrastructure improvements (such as a tunnel or a road extension) as well as technological improvements. As soon as NCSU DOT identifies the most effective solution, the Department should implement it as soon as possible. Unfortunately, Professor Royal acknowledges that any improvements that

NCSU DOT implements will be expensive and will face the challenges of limited resources. He points out that NCSU owns very little property on the south side of Western Boulevard east of Avent Ferry Road, which will limit NCSU DOT's ability to establish new rights of way.

With regards to traffic congestion on the campus interior, Professor Royal identifies Dan Allen Drive as the highest priority for improving traffic flow and recommends that NCSU DOT reduce automobile access on the road. Specifically, he recommends closing the road between West Dunn and Sullivan Drive to personal vehicles using access gates similar to those in place on Founders Drive. These gates will permit access for Wolfline buses, Facilities vehicles and emergency vehicles. The closure will still enable drives to access the Dan Allen parking deck, leaving a large supply of parking on Main Campus in place. Additionally, the access to Sullivan Drive will enable drivers to reduce their travel time on Western Boulevard and Hillsborough Street and therefore reduce traffic pressures on these corridors. Professor Royal stresses, however, that NCSU DOT advertise any road closure "as far in advance as possible" to allow the Raleigh community to anticipate the closure and adjust their travel behavior accordingly. As an example, he states that if NCSU DOT were to enact this restriction in August of 2012, the Department should announce the changes during the Spring 2012 semester.

Interview with Tom Skolnicki, Office of the University Architect—1/11/12

As a University Landscape Architect, Mr. Skolnicki is directly involved with translating the principles of the NCSU Physical Master Plan into the design of individual campus buildings. His recommendations largely center on a single guiding principle: "effective movement in a pedestrian-oriented campus." A key aspect of the implementation of this principle is the ongoing relationship between campus planning and the distribution of the campus parking supply. Mr. Skolnicki believes that NCSU DOT will continue to promote parking decks on the campus periphery, and asserts that the Physical Master Plan has planned for this shift with its distribution of parking on Centennial Campus. He explains that the goal is a "self-contained" campus that offers automobile access on its periphery but maintains a car-free transit environment on its interior. However, he acknowledges that the corporate partners on Centennial Campus must meet parking ordinances that the City of Raleigh has set and often supply parking beyond these minimum requirements to secure financing from private funders. Therefore he expects that Centennial Campus will maintain an "oversupply" of parking for the foreseeable future even though the City of Raleigh has signaled to many major institutions throughout the city that the city's zoning requirements will likely reduce minimum parking requirements.

Yet Mr. Skolnicki is optimistic about the potential for Centennial Campus to develop a pedestrian-friendly environment. He cites the Alliance Center on Main Campus Drive as part of a densification effort to create a "Main Street" on Centennial Campus akin to Stinson Drive on the Main Campus precinct. He recognizes that the buildings and the streetscape on Centennial Campus are larger than their respective counterparts on Main Campus, but he stresses that development on Centennial Campus has been predictable enough that the Office of the University Architect has been able to design and construct pedestrian amenities that are appropriately scaled to encourage a walkable environment. Additionally, the Centennial Campus Development Office has played an important role in facilitating sustainable campus development through the collection of an acreage-based assessment that NCSU levies on every Centennial Campus property development. The CCDO deposits these assessments in the Centennial Campus Trust Fund, which the NCSU Office of Finance and Business operates. The Centennial Campus Trust Fund has provided extensive funding for greenways, roads and utility infrastructure on Centennial Campus. Mr. Skolicki describes the relationship between the Trust Fund and the

NCSU DOT and the OUA as cooperative and cites the Trust Fund's support as a key driver of sustainable design on the campus precinct.

This focus on sustainability may face a challenge, however, with the new mixed-use Town Center project on the southern part of Centennial Campus. Although the private developers for the Town Center will have to meet the OUA's standards and principles (with regards to aesthetic design, land ecology, and building sustainability, among others), the developers will set the mix of services and retail. While this mixed-use design centralizes trip demand, it also creates the potential for high travel demand that could overwhelm the project's parking supply and generate traffic spillover on to Centennial Campus streets. As the only property in Raleigh to have its location on a waterfront, Mr. Skolnicki anticipates a high level of draw that connects Centennial Campus and NCSU to a larger city community.

In explaining the planning process that influences design on Centennial Campus, Mr. Skolnicki describes a series of back-and-forth conversations between the OUA as lead and other Centennial Campus organizations (including academic departments and corporate partners) as stakeholders. He asserts that the goal is to obtain a completeness of input to arrange campus planning priorities into an order that is agreeable to as many parties as possible rather than to overcome opposition. Corporate partners on Centennial Campus operate through the Centennial Campus Development Office and have frequently supported the expansion of pedestrian-friendly infrastructure. Mr. Skolnicki does mention that several faculty members have often resisted the shift to peripheral parking decks**,** arguing that NCSU DOT should be making it harder for students to park on campus to reduce pressure on NCSU parking supplies. However, the overall build-up of sustainable infrastructure on Centennial Campus has been relatively simple, with an expansion of sidewalks along campus paths that parallel the major street thoroughfares of campus to create a level of access and connectivity for "people-powered transportation" comparable to that of automobiles. This level of infrastructure has also minimized conflict between Wolfline operations and pedestrian movement on Centennial Campus, enabling the Wolfline to maintain relatively high travel times.

The focus on a pedestrian-oriented campus makes Mr. Skolnicki a supporter of limiting access to automobiles on campus, but he stresses the need for careful planning and execution of such a restriction. He stresses that NCSU DOT must obtain community input not only from the NCSU community, but from Raleigh residents who use Dan Allen Drive as a shortcut between

Hillsborough Street and Western Boulevard. Mr. Skolnicki points out that NCSU DOT will have to anticipate the challenges of notifying these restrictions to a larger community well in advance of their implementation and must clearly communicate the safety and sustainability concerns that led to the restriction as well as the environmental gains that the NCSU community will receive. He stresses that NCSU DOT must understand the optimal number of hours in which the restrictions should be in place to maintain effective traffic flows and manage losses in parking revenues at the Dan Allen Parking Deck. Despite these challenges, Mr. Skolnicki acknowledges that there are few options for alleviating congestion on Dan Allen Drive, as the railroad bridge that travels over Dan Allen Drive greatly limits the ability for NCSU DOT to expand road capacity or create a new exclusive lane for Wolfline buses.

Mr. Skolnicki supports the concept of an express bus service between Main Campus and Centennial Campus, citing the road space on the Physical Master Plan that the OUA has "set aside" from development considerations so that the NCSU DOT has the space available for infrastructure improvements to create a bus priority corridor. However, Mr. Skolnicki stresses that NCSU DOT must take action and propose options for this corridor that describe the necessary technologies and infrastructure improvements so that "it's more than just a line on a page" for the OUA. Specifically, he asserts that NCSU DOT should develop a schedule for completion and a budget for the project. He strongly believes that the goal for NCSU DOT should be high-quality infrastructure that enables rapid bus service rather than a series of half-measures that only improve services incrementally. Mr. Skolnicki asserts that the implementation of the project in phases will keep cost pressures under control.

However, Mr. Skolnicki does caution that any attempt to establish the bus priority corridor along Varsity Drive will require negotiations with the City of Raleigh. This complication stems from the fact that the City of Raleigh owns the corridor along Varsity between Marcom Street and Avent Ferry Road due to the presence of a housing zone in that corridor. Getting the City of Raleigh to acquiesce to any changes in road capacity or streetscape design will expand the time horizon and the costs for any project that NCSU DOT chooses to establish in this corridor.

Mr. Skolnicki nevertheless acknowledges that NCSU DOT has made progress on facilitating transit access through the area around the Talley Student Center, citing the redirection of apartment charter shuttles from Morrill Drive to Dunn Ave. carriageway to reduce congestion

on Morrill and give greater priority to Wolfline buses. In support of these changes, he cites that the OUA is designing its updates to the Physical Master Plan on the assumption that the majority of Wolfline routes will travel along Morrill Drive and Cates Avenue to provide more rapid access between campus precincts. The OUA has incorporated this change in service into its plans through its prioritization of the Cates Avenue and Morrill Drive corridor's pedestrian improvements and bus stop improvements.

More generally, Mr. Skolnicki recommends that NCSU DOT consider a "dual loop" system of campus circulators. To provide a wide range of service across the campus precincts, he suggests that NCSU DOT establish a circulator route on Main Campus and one on Centennial Campus that travel along the edges of these respective precincts and meet at the Talley Student Center, where students can transfer between the two systems. These services will provide a relatively high level of connectivity along the precincts but will offer lower travel times than a comparable frequent-stop service that travels between both campus precincts.

Mr. Skolnicki expresses a high level of optimism for the Hunt Library, describing it as a "sea change" for student activity on Centennial Campus. He believes that the Library will create a greater student pull for Centennial Campus and draw students from around the greater NCSU community, encouraging students who had previously traveled to Centennial Campus to do so. The effect of this campus-wide draw will be to "pull the different campus neighborhoods together." Mr. Skolnicki anticipates that the Hunt Library will become a "poster child" for promotional and symbolic NCSU literature, essentially serving as a public face that the University presents to a larger community. The OUA carefully developed the physical relationship between the Library and its surrounding environment, using glass and open space in the building's design to integrate the views of the outside world into the interior spaces. This integration of interior space with exterior environment ultimately creates a more enjoyable and enriching interior.

Because of the prominent role that the Hunt Library's environment plays in a visitor's experience of the Library, Mr. Skolnicki anticipates that once the Hunt Library has established itself as an alternative to the D.H. Hill Library, the two buildings will draw different student populations. The Hunt Library will attract students who appreciate the surrounding environment and want a more relaxing atmosphere in which to study, while the D.H. Hill Library will attract students who want to have access to the food and retail services on Hillsborough Street.

Mr. Skolnicki also believes that these differences in preference for surrounding amenities will express themselves in housing choices. With regards to the new Centennial Campus residence hall, Mr. Skolnicki believes that the students who choose to live here will prefer the quieter environment of Centennial Campus, whereas students who choose to live on Main Campus will prefer the greater level of access to social spaces and other amenities. However, the dining facility in the new Centennial Campus dormitory will play a critical role in "balancing out" the difference in amenities on each campus precinct. Mr. Skolnicki asserts that the OUA regarded the large dining facility as a "necessary step" for the housing project's design. The dining facility will expand the range of amenities on Centennial Campus and help foster a campus environment on the precinct. However, the facility will also increase amenities located on or near the Oval, turning the greenspace into a "mirror" of the University Plaza, a highly-active public space on North Campus that holds numerous campus events. The housing project is also providing an incentive to build up the road infrastructure around the northeastern and eastern areas of Centennial Campus. While many of the larger roads are only in development phase and NCSU has not identified funding for these roads, the OUA has begun construction on "temporary" roads that will extend Oval Drive to the housing project. This temporary extension will form a loop around Centennial Campus and connect the eastern edge of the precinct to the Centennial Parkway, a minor thoroughfare that provides greater access to Avent Ferry Drive.

In anticipation of the higher travel demand, the OUA is paying greater attention to the pedestrian infrastructure around the Hunt Library. Mr. Skolnicki cites the planned construction of a concrete walking path on the western side of the Oval to facilitate pedestrian access between the Engineering Buildings and the Library. He also mentions that the OUA has evaluated the streetscape around the Hunt Library and asserts that there is space to expand on-street parking if travel demand requires it. This evaluation is a response to the OUA's concern that parking demand for the Hunt Library will put heavy pressure on the parking supply located around the Library. The OUA views the large off-campus student population located in the corridors near Centennial Campus as a potentially major source of demand for Centennial Campus parking. After 5 pm, students will be able to park in the permit-only parking decks that corporate partners currently use. The permission of student parking could create conflict between corporate partners whose employees may not operate on a reliable 9-to-5 schedule.

Interview with Cameron Smith, Capital Project Management—1/24/12

Cameron Smith shows strong support for alternative transportation modes and a greater focus on transportation demand management. He views the movement towards parking decks as a "standard" for campus parking development. Mr. Smith believes that such a shift would enable NCSU to maximize its potential for mixed-use development on its real estate. However, he emphasizes that some parking supply must be available at all campus buildings for service vehicles to have immediate and easy access to address the buildings' physical needs. While he acknowledges that students will continue to demand "front row parking," he does not feel that these demands should take priority over the pressure that NCSU faces to expand its campus amenities in an environment of limited physical space.

Mr. Smith also advocates for greater infrastructure development for buses and bikes, stressing the need for better bike storage units and the inclusion of bike showers in more campus buildings. In the near future, however, he wants to see NCSU DOT focus on higher-capacity transit systems, namely a people mover that connects Main Campus to Centennial Campus. He believes that the expansion of housing facilities on Centennial Campus will increase travel demand between Main Campus and Centennial Campus to such a degree that a higher capacity system with faster travel times will be necessary. Unfortunately, Mr. Smith is not optimistic that students or staff will support paying more in parking fees to expand this transit service.

Interview with John Stone, College of Engineering—1/6/12

As a Professor of Civil Engineering, Professor Stone will experience the growth of Centennial Campus and the completion of the College of Engineering's move to the campus precinct while also analyzing the trends in travel demand and traffic generation that these demographic changes create. Professor Stone expresses concern with the availability of resources that are necessary to build the academic buildings and laboratory space that will house the few sub-departments of Engineering that remain on Main Campus. He discusses the reduction in build-out visions for Centennial Campus that NCSU and the COE have undertaken as a result of a weak economy. These pressures are also creating high levels of competition within COE departments for research partners to provide private funding. Despite these pressures, Professor Stone describes the process of moving to Centennial Campus as harmonious and notes the lack of complaints that have surrounded the planning and construction processes for classroom and laboratory space on the precinct.

However, he asserts that regardless of the availability of these resources, NCSU DOT needs to focus on building up the transportation infrastructure that connects Main Campus and Centennial Campus. While NCSU DOT, COE and the Registrar's Office may be able to coordinate the distribution of courses around different campus precincts to manage the "spatial aspect" of course planning, inter-precinct travel will be a priority for Engineering students. He agrees that the Talley Student Center and the Hunt Library are adequate locations for rapid express Wolfline service between the two campus precincts. He points out that the two locations are central to the campus precincts, representing potential major activity centers, and provide ample opportunities for pedestrian and bicycle access "beyond the [transit] hubs." However, he believes that the express system should include a small number of intermediate stops to distribute boardings and alightings across the system rather than concentrating demand in a few locations and creating large numbers of leave-behinds.

Professor Stone does not necessarily believe that NCSU DOT should interpret either hubs as "given" destinations for the express system. While he acknowledges the role that a building's visibility may play in generating traffic demand (i.e. students using certain buildings around which to orient their travel patterns, such as D.H. Hill), mobility needs ultimately form a more useful basis for determining transit hub location. With that regard, NCSU DOT may achieve greater improvements in mobility if the Department runs the express transit system between

areas with higher connectivity to a larger transportation network. He suggests that a parking deck may provide greater mobility than the Hunt Library, while still being geographically proximate to the Library, such that students are able to walk to the Library. Alternatively, if NCSU DOT wants to lay the groundwork for a rail-based people-mover, the Department should base the express service at the Reynolds Coliseum, since this location offers sufficient space for the Department to build a rail infrastructure that connects to the existing rail system.

Additionally, he believes that rapid access between the two campuses is insufficient for connectivity. Drawing on the structure of public transit systems in cities with a central business district that serves as a major trip generator, Professor Stone stresses that NCSU DOT should provide a hub-and-spoke system that uses circulator routes that radiate off the central transit hub to provide connectivity on Centennial Campus. The building densities on Centennial Campus are lower than the densities on Main Campus, making pedestrian access to the edges of the precinct more difficult.

While the increase in express Wolfline service between campus precincts will facilitate connectivity between the campus precincts, Professor Stone does not believe that these services will have a significant impact (positive or negative) on traffic conditions at Centennial Campus. Unless the price of oil significantly increases, he believes that corporate partners on Centennial Campus will not use the Wolfline system for home-to-work commuting since employees will be reluctant to make transfers onto other transit systems. Similarly, COE faculty and staff will likely spend the majority of their time during the work day on Centennial Campus and therefore have little need to travel between campus precincts. Professor Stone evaluates the Wolfline's main role on Centennial Campus is to move engineering students from engineering courses to humanities and social sciences courses on Main Campus.

For broader recommendations to Wolfline services, Professor Stone recommends that NCSU DOT continue to market Wolfline services to promote the mobility and access that the system provides across campuses. He stresses that the Department must aggressively promote enhanced services that it designs to replace trips made in cars (such as those from the Avent Ferry Road/Gorman St. corridor) to ensure that the Wolfline is able to increase its appeal and reduce traffic generation along these corridors. However, he is skeptical that the Wolfline system will have a substantial impact in vehicular traffic and recommends that NCSU DOT raise parking prices if it decides to pursue that goal. He acknowledges that NCSU DOT may not be

able to have any impact on vehicular traffic for off-campus streets regardless of how aggressively the Department raises parking prices or reduces vehicular access on campus.

Professor Stone does stress, however, that NCSU DOT can play a role in improving traffic flow around campus. He identifies the Dan Allen Drive and Gorman St. corridors as two areas that generate excessive levels of traffic congestion and stresses that the intersections at Western Boulevard and Pullen Road and Western Boulevard and Avent Ferry Road are the most problematic. Professor Stone recommends that NCSU DOT adopt a broader perspective and evaluate all possible intersections along Western Boulevard as potential solutions to traffic congestion.

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