Princeton Campus Mobility Framework

Volume 3: Recommendations and Stakeholder Input

July 2020

NUNES-UENO CONSULTING

JARRETT WALKER + ASSOCIATES

Table of Contents

Executive Summary

The Princeton Campus Mobility Framework is meant to align future decisions about how people and goods move around campus with the University's future vision: an open and inclusive campus, where ideas are exchanged through planned and serendipitous encounters, with a distinctive sense of place.

This Framework articulates **ten guiding principles** that can inform the University's short- and long-term decisions. Some of the long-term decisions at first glance have little to do with mobility, but in fact, greatly influence whether the campus is dependent on motorized transportation in the future.

The result of a year-long exploration that included input from students, staff, faculty, and members of the community—thousands responded to a survey, many hundreds attended presentations, and an open house—this Framework shines a light on sustainability and equity of access. When asked to imagine the future, people consistently described more human-powered mobility; a campus where people of all abilities are free to travel around—including when they have a disability.

In addition to the guiding principles, the Framework includes strategies for providing mobility services such as transit, bike share, and making sure University students and other travelers on campus have the information they need to get where they want to go. The TigerTransit Service Guidelines, for example, which are also based on input from the University community, will help future transportation managers make decisions about transit service.

Based on these guidelines, consultants and University administrative staff collaborated to develop new services for TigerTransit. Some existing services remain largely unchanged while others have been altered, combined, or in a few cases dropped altogether, to be replaced by other less-costly transportation solutions such as shared cars, shared bikes or changes to parking assignments.

Two brand-new services are included in this new offering: a campus shuttle for those with mobility challenges, and an all-day transit connection between campus, the Dinky station, and Princeton Junction. This new route along Nassau and Alexander Streets will make more connections with the Dinky and Northeast Corridor trains, allowing more people who commute to campus to leave their cars at home.

The new TigerTransit network will be easier to learn and remember, will be more useful to a larger number of people, and will cost a bit less to operate—a win, win, win.

When asked about the most important mobility improvements the campus can make, graduate students were united—over 70% said they wanted it to be easier to walk and bike from their residences. The Mobility Framework recommends strategies and projects to make walking and biking from graduate student residences to central campus, E-Quad, and the future East and Lake Campuses more appealing for more people.

As the campus grows both in its physical layout and in the number of students, staff, and faculty, we can expect more people to want a faster way to get across campus than walking. Yet their trips around the central campus are so short that they'll naturally balk at waiting even ten minutes for a transit ride. The Mobility Framework recommends a large bike share system, equipped with electric bikes to serve some of this need. Personal bike use is also likely to grow, especially in the short-term due to the Covid-19 pandemic. The Framework flags the need to invest in supporting infrastructure such as covered bike racks and bike routes throughout campus.

The Princeton Campus Mobility Framework is intended to be a living document that adapts to and helps shape the development of the campus starting this year and for the coming decade.

Campus Mobility Framework

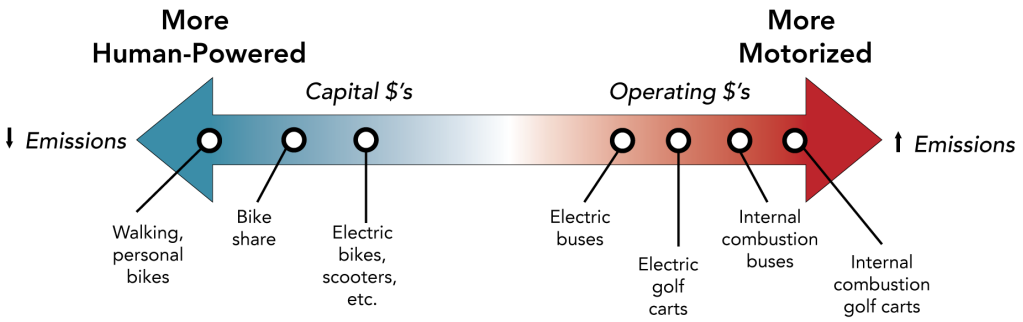
This team was hired by Princeton University to develop a campus mobility framework that guides University decisions, designs, and programs.

During a year of study, we have collected data; talked to students, staff, and faculty; and biked, walked, and taken transit on and around the campus. We have observed how streets and walkways operate on campus using photos, videos, and camera counts. We have spoken with local leaders and staff from the Township and NJ Transit. We also gathered input from thousands of students, staff, and faculty through a survey and at an open house event.

Throughout this, we've been inspired by the idea that Princeton University is a special place where, as President Eisgruber recently wrote, scholarly excellence and curiosity-driven research are joined in an environment of openness and inclusivity.

The campus represents an example of human-powered mobility very rare in America. This is because it developed largely before cars, and because of the University's tradition of housing all students on or near campus. Whereas in the average American city over 85% of people drive to work, Princeton's students and staff overwhelmingly move around campus by walking. They use transit, bikes or scooters to move around campus more than they use cars.

Unfortunately, the campus is an island in a sea of auto mobility. The mobility framework we propose here addresses the urgent need to cultivate the University's human-scale walkable condition and protect it from the auto domination that makes so many of our public streets and places unsafe, unpleasant, and uninteresting. The usual American transportation toolbox is all wrong for Princeton University's campus.



Many of the University's choices about campus mobility can be located somewhere on this spectrum. More human-powered mobility would decrease emissions from transportation, but would require more capital investments up front. A more motorized system does not require much capital investment now, but has a high annual operating cost, and also higher emissions from transportation.

Some of the decisions that have the greatest effect on walking, biking, and transit are made long before the bike paths, sidewalks or transit routes are designed, sometimes many years prior. These decisions have to do with where offices, residences, and classes are located. Mobility is most affected by location decisions, and secondarily affected by design. Location decisions take many years to show their effects, while design changes can be made more quickly. Both types of decisions should be informed by this framework.

In the few months since community input was gathered to inform these principles, the world has been shaken up by the COVID-19 pandemic. Conditions on campus have changed, and in Fall 2020 mobility offerings will be adapted to provide social distancing and other health guidelines.

The short-term changes necessary to adapt to the pandemic are mostly consistent with these principles, in part because walking and bicycling allow for social distancing without imposing high additional transportation costs on either individuals or the University.

Ten principles

1. Nearly all movement around campus happens through low-emission and human-powered modes

The campus currently uses diesel transit buses, private cars, maintenance vehicles, golf carts, and off-highway vehicles for many trips. In order to enhance the pedestrian and cycling experience around campus, the number of motorized or carbon-emitting trips should be reduced, even as the campus grows. This will require making walking and cycling around campus irresistible, and changing expectations around the use of motor vehicles for short trips. The walking, biking and transit networks should be as intuitive and easy-to-follow as a road network, and welcoming to newcomers.

2. Newly built or leased University spaces are proximate, walkable, and easy to serve with fixed-route transit

The University should choose new locations for classes, offices, or residences that are within walking and biking distance of the central campus whenever possible. These new facilities should be in existing well-connected street and sidewalk networks, or the University should be prepared to build such a network. If they are located down cul-de-sacs or loop roads, or along barriers such as highways, ramps, or waterways, they may be impossible to serve with linear transit without their own route.

Regardless of where property is leased or developed, the operating costs of providing mobility to people who work, live or study there should be taken into account as part of the location decision process. Alexander Street is an obvious place where future campus development would be proximate, walkable, and benefitting from existing linear transit service, and where there would be almost no marginal cost to provide mobility for any new residents, students, or staff located there.

3. Alternatives to driving to campus are easy, fair, and popular among staff, faculty, and non-residential students

While this Mobility Framework was initially focused on peoples' movement within campus and among University buildings, we received ample public input asking for improvements to the services and programs that help people reach campus from afar. As a result we have broadened our recommendations to include some improvements to services that can help large numbers of people travel to work, to reach services, for shopping or for recreation.

4. Ensure design standards incorporate the questions: *"How will people want to walk and bike through this space? And how many of them?"*

Only later, once the requirements for excellent and ample walking and biking routes are clear, do we ask, "Do motor vehicles need access to this place? When? And why?"

Planning for a future of less-motorized mobility requires changing the way we initiate projects. Rather than starting with the "requirements" for motorized transportation, and then trying to make walking and biking good despite the cars, the University should start by defining the requirements for excellent walking and biking, and then make it possible for motor vehicles to gain access as strictly necessary. This also means quantifying demand for walking and biking (not just driving), and collecting data regularly on how much walking and biking happens on campus, and where.

5. The campus is built and maintained so that all people have access, including when they have a disability

Some people have a life-long disability and use mobility devices to move around. Some people become injured for a short time. We can all hope to someday be an elderly person, visiting a grandchild on campus, wary of tripping and falling. Campus must become safer and more comfortable for everyone to freely explore it by walking or rolling.

6. Campus streets and paths don't just move people, they also carry ideas and conversations

Mobility on campus is not only about getting people from one place to another. It is also about giving people opportunities to walk and talk together, to have spontaneous encounters with a diversity of people, and to build healthy habits.

7. Walking and biking is so appealing that few people choose to use transit for trips of less than two miles

Transit should be mostly used for longer trips. Transit can be very efficient, but walking and cycling are much more efficient and enrich peoples' lives in other ways. Transit capacity and investments should be mostly used to help people make trips that are too far to walk, and to provide mobility for people who cannot comfortably walk or bike. For newcomers to campus, walking or biking is intuitive and the intended routes are easy to find and follow.

8. It is clear which modes are a high priority on each street and path

Every campus street does not need to serve each mode equally – some links will be critical to the function of the cycling network, and others will be ancillary. Some links should be designed for vast numbers of pedestrians, while others may need only sidewalks. Some links are critical for regular maintenance and service vehicles, while others need to have vehicles on them only in rare situations.

9. Cars, trucks, golf carts, and other motorized vehicles are mostly behind the scenes

Maintenance, repairs, deliveries, and supplies are all crucial to the functioning of the University, but today the motor vehicles that are used to deliver those services on campus are overbearing and making the outdoor experience less comfortable and productive for students.

Many different types of vibrant places have figured out how to do good maintenance and deliveries without putting trucks or carts in competition with pedestrians for scarce space.

Develop a set of tools, standard operating procedures, and a road/path network that allows for this necessary work even as walking around campus becomes easier and more appealing.

10. The University works with other organizations to improve transportation off campus

Peoples' mobility to, from, and around campus is affected by infrastructure, programs, and culture that are outside of the University's direct control. The University should use this new mobility framework to clarify its own goals as it works on planning with the Townships, the County, NJ Transit, the State, and other local organizations.

Recommendations

A. Improve campus access for people with disabilities

Immediate physical improvements

Take immediate action to address the most critical problems with the physical accessibility of campus streets, walkways, and buildings. We suspect that the following will likely top the list:

- **Update standards for paths, sidewalks, and curb ramps** in the ongoing maintenance program so that using a wheelchair or other device is comfortable on every pedestrian route conceivably used by someone with a mobility device. For example, reevaluate the use of Belgian blocks at pedestrian curb ramps, and the use of paving materials that crack and shift quickly. Replace or repair pavement and pavers that are not meeting these standards.

- **Establish covered bike parking** near each residential college, so that students' personal bikes aren't ruined by one or two winters of being stored outside. Use bike racks that hold bikes upright with two points of contact. Promptly remove any bikes and scooters locked to handrails or blocking stairwells, passageways, power-operated door buttons, or doors.

- Consider a recurring campaign that builds **cultural expectations of where scooters and bikes should not be parked**, to reduce the frequency with which they block access to doors, power-operated

Conditions on the ground make navigating paths, streets, and sidewalks difficult, risky, and even painful for people with a disability (top left). Because there are not yet social norms that discourage parking scooters everywhere, scooters often block indoor spaces (top right). A lack of covered bike parking and inconsiderate parking behaviors (bottom left and right) contribute to access problems for people using mobility devices.

door buttons, handrails, passageways, and other key access points for people using mobility devices. Monitor the progress and success of the campaign and consider stronger tools such as pavement markings or enforcement if necessary.

Daytime flexible service for people with disabilities

Princeton University should offer a flexible transit service for people with temporary and permanent disabilities. For trips to farther-away destinations like Princeton Junction, PPPL or Forrestal, this service can make timed connections with the TigerTransit fixed routes (described in detail on page 16) to those places. This would allow people to reserve a ride between campus destinations at the right time to make a class, a job, or a connection with a fixed route transit.

If there is enough capacity and it does not impact reliability, some trips could also be offered on-demand, without a reservation. However, especially given the social distancing requirements that are likely to be in force for the next year, an on-demand flexible service can't handle very many passengers at a time before it becomes unreliable. Peaks in demand for such services are typically met by increasing the number of vehicles and drivers, which rapidly increases costs.

We recommend the University be conservative about the description of this service, and commit to offering a reliable, reservable shared-ride service that reduces walking distances. Whether it can handle short-notice requests reliably within a reasonable cost should be evaluated once the reservable service is launched.

This service should be publicized as being specifically for people with disabilities in order to preserve capacity for people who need it, and to keep rider volumes low, again to maintain reliability and control costs. However, barriers to entry like asking someone to prove a disability should be avoided if possible.

B. Publish TigerTransit service design guidelines

The allocation of service to certain times, places, and patterns has not been guided by clear policies in the past. This makes it harder for University staff to be consistent in their responses to such requests.

Some transit outcomes trade-off against others. Without a clear statement of policy describing where, when, and why service is provided, any transit service can be considered "failing" if measured against a purpose for which it was not intended.

For example, service to PPPL and Forrestal will almost always look from the outside like "empty buses" because the number of people who could conceivably ride on each trip of the bus is just not enough to fill up even a small vehicle. And yet, those are critical educational facilities. The true measure of success of a route serving PPPL should therefore not be how full the buses are, but how many students are able to access a course, a lab, or another activity as a result of that route, even if they only ride it occasionally.

Documenting any non-ridership purposes of TigerTransit, and defining the circumstances under which service will be provided despite low ridership, will help the University set reasonable expectations and measure performance. Operating transit service, year in and year out, is costly, and the University wishes to be responsible with its transit investments. Many wonderful people, places, and destinations would be very costly to serve with transit, and would therefore consume service that could be used for trips that are more central to the University's mission.

We recommend the following service allocation policy for TigerTransit:

- The purpose of TigerTransit is primarily to connect University buildings and facilities to one another, to parking and to public transit, at the times when students, faculty, and staff must travel among them.
- Most TigerTransit routes will be expected to attract 20 boardings per service hour. This is because they are designed to:
  - Offer high frequencies where large numbers of people need to travel over distances too far to walk.
  - Provide for direct, non-circuitous travel among major destinations.
  - Serve two-way demand and overlapping markets with the same route when possible.
- Some TigerTransit routes will be needed even if they do not attract 20 boardings per service hour, in order to:
  - Connect students to classes that are not easily reachable by walking or bicycling.
  - Serve those who have difficulty walking or riding fixed-route transit.
  - Support student life by providing access to shopping and services.
- Services that meet these guidelines may require people to walk up to 10 minutes from a University building to reach a TigerTransit stop.
- For University buildings which are costly to reach with transit or where very few people can be expected to ride, the University will find other more cost-effective ways to help people commute and move around throughout the day.

Existing services that do not meet these guidelines

A few existing TigerTransit services do not meet these guidelines, and we do not recommend continuing them:

- Very low-demand services between central campus and outlying administration buildings, i.e., 693 Alexander and 701 Carnegie.
- Deviations from an otherwise direct route to serve non-University residential developments, e.g., Lakeview Terrace.
- Deviations from an otherwise direct route to get closer to non-University community destinations, e.g., Princeton Medical Center.

There are people currently using TigerTransit routes who live or work in these places, and ceasing the service will impact them. While they are a small number of people, the impacts on their lives are real.

For staff who work at 693 Alexander, there will be TigerTransit stops within walking distance along Alexander Road but not longer in the 693 building parking lot. For staff who work at 701 Carnegie and 100 Overlook, TPS will develop other options to help them travel to and from central campus (for example, the free NJ Transit Commuter Bus Program for Route 605). Non-transit options are described on page 19.

C. Establish a new transit network

The patterns that existing TigerTransit routes follow are not necessarily the highest-demand or the most-needed patterns.

For example, the Central Loop offers very high frequencies all day, but attracts little ridership relative to its cost. It also covers such a small area that most trips can be made faster by walking (which is probably why few people ride it).

The Dinky service to Princeton Junction makes a critical connection for University students, staff, and faculty, whether they use it as part of their commutes or for less regular but still important trips out of town. Yet it is difficult to use. While more than 160 Northeast Corridor trains pass through Princeton Junction each day, the Dinky only makes timed connections with some of them.

The Dinky also offers scant service overall, so frequency is poor, and people have few choices of when to travel. There are about two departures per hour, so someone's average wait to use the Dinky is about 15 minutes. These two departures per hour aren't scheduled evenly, however, because NJ Transit has written the schedule to make timed connections with certain trains, rather than running a consistent frequency pattern. People's worst-case waits can therefore be very long if they are trying to make a connection for which NJ Transit *didn't* time the Dinky schedule.

Through our survey of University stakeholders (described starting on page 36) we received many complaints about the Dinky service and requests for either better-timed connections or a larger number of trips per hour from campus to Princeton Junction. It is not possible for the existing Dinky train and crew to make many more timed connections than they currently do, so the only way to reliably shorten waits for connections at Princeton Junction would be to increase the sheer number of trips going there per hour. Increasing the number of hourly trips on the Dinky rail line would require a second set of cars and a second crew, and it seems unlikely that NJ Transit will be able to justify the enormous expense of those additions.

Finally, the Dinky station is a good location for the University (walking distance to all of central campus) but it is not very close to town destinations north of Nassau Street.

Considering all of these facts, there is an opportunity to supplement and complement the Dinky service with a bus route that connects many dense, walkable places with one another, and with the Northeast Corridor. This new route would not only help people connect between campus and Princeton Junction, it would also help people get to Nassau St. and E-Quad, including people who are starting their trip at the Dinky station.

The new network we recommend is shown in maps and charts on the following three pages.

Reduce frequencies at times when many people are willing to walk

Even on the most productive routes today, ridership at midday and in the afternoon is mostly very low. Ridership in the evening rush hour is lower than in the morning rush hour.

Based on conversations with students and staff, we believe this is because people are in less of a hurry in the evening, the weather is a little warmer in the afternoons and evening, walks towards Lawrence, Lakeside, parking lots, and the Dinky Station are downhill, and many people are therefore more content to walk.

In conjunction with our recommendations that the walking and biking environment on campus be improved immediately, we therefore recommend that midday, afternoon and – in some cases – evening frequencies be lower on TigerTransit routes, so that transit isn't inadvertently competing with walking trips for many people.

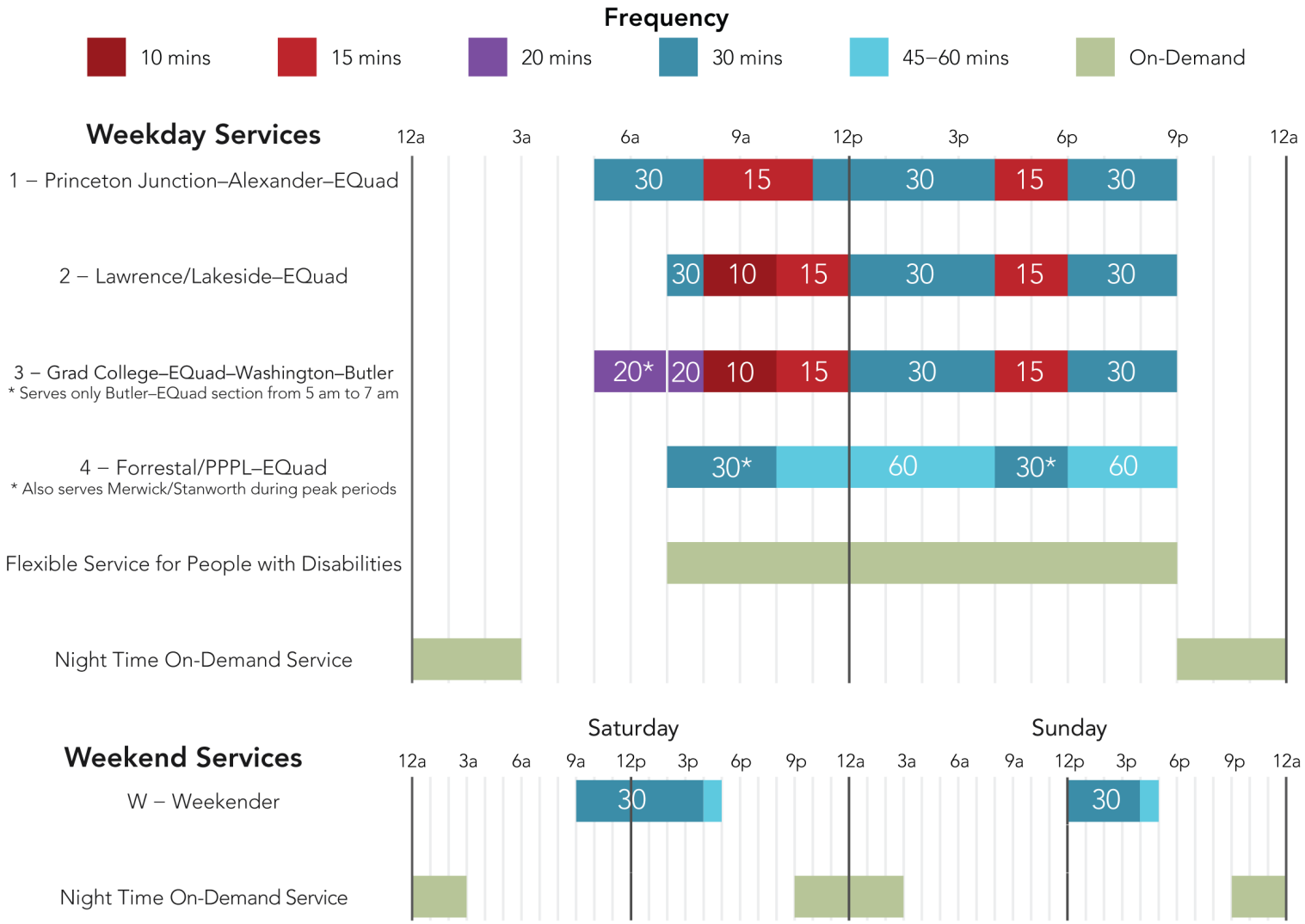
The first three routes described below would provide high frequency in the peak periods when TigerTransit usage is highest. This serves staff who commute as well as graduate students going to and coming from their offices, labs, and some morning and evening classes.

Frequencies at midday and in the afternoon would be lower, both because demand is lower then and because service should be less needed if the University makes walking and biking easier for short trips within campus.

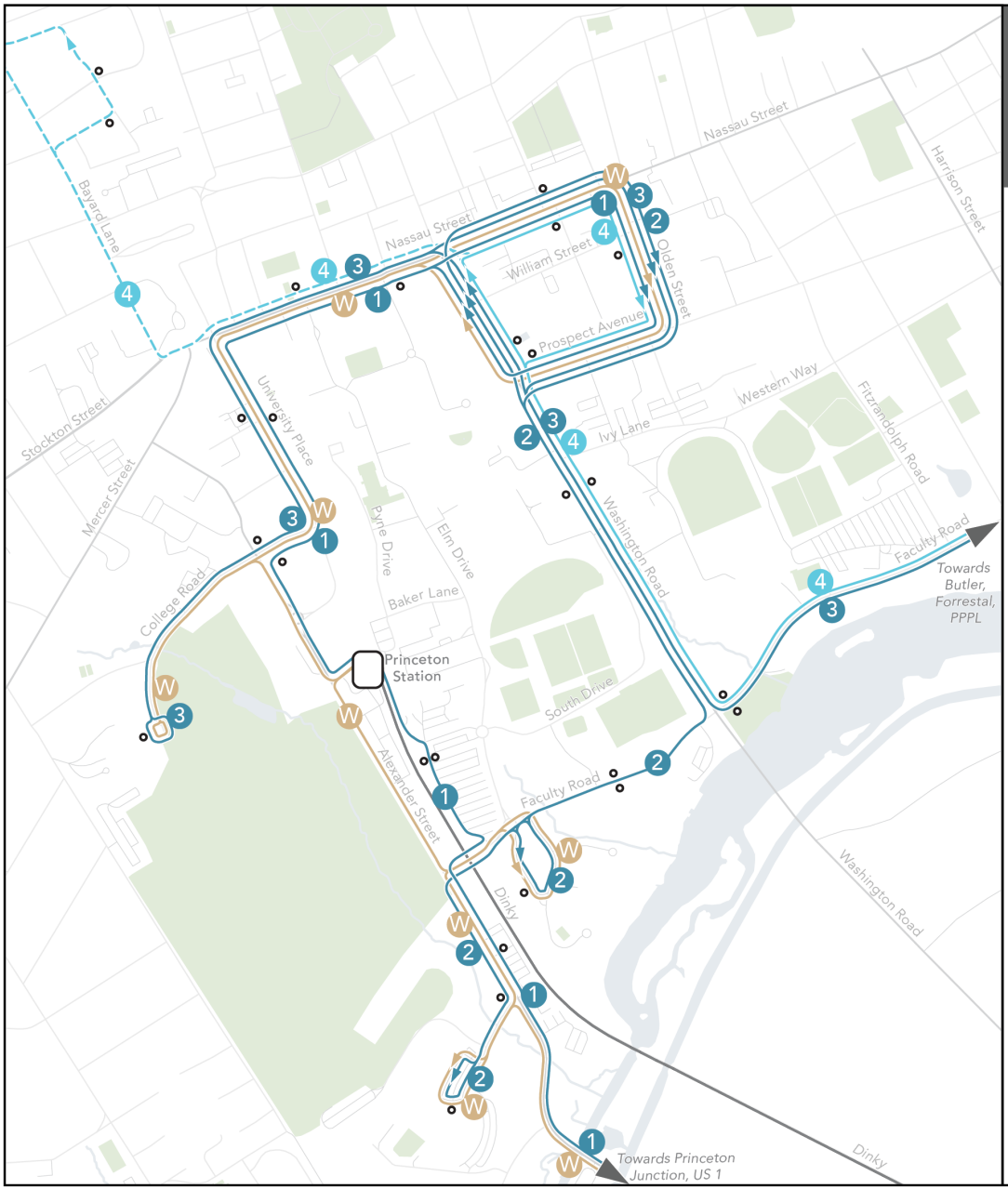
Frequencies and spans of all recommended routes are shown in the chart on the next page.

Future Normal Academic Year TigerTransit Network

Transit Frequencies and Hours of Service



The frequencies and spans of each route in the future recommended network are shown in this chart. Colors represent different frequencies – brighter colors mean shorter waits for a bus.



Princeton University Campus

Normal Academic Year TigerTransit Network

Once social distancing to address COVID-19 is no longer in force, this is the network we recommend TigerTransit provide.

Weekday Midday Frequency

- 30 minutes
- 60 minutes
- Weekend service
- Certain times only

Fixed Route Services*

1. Princeton Junction–Alexander–EQuad
2. Lawrence/Lakeside–EQuad
3. Graduate College–EQuad–Washington–Butler
4. Forrestal/PPPL–EQuad
   Also serves Merwick/Stanworth during peak periods.

W Weekender

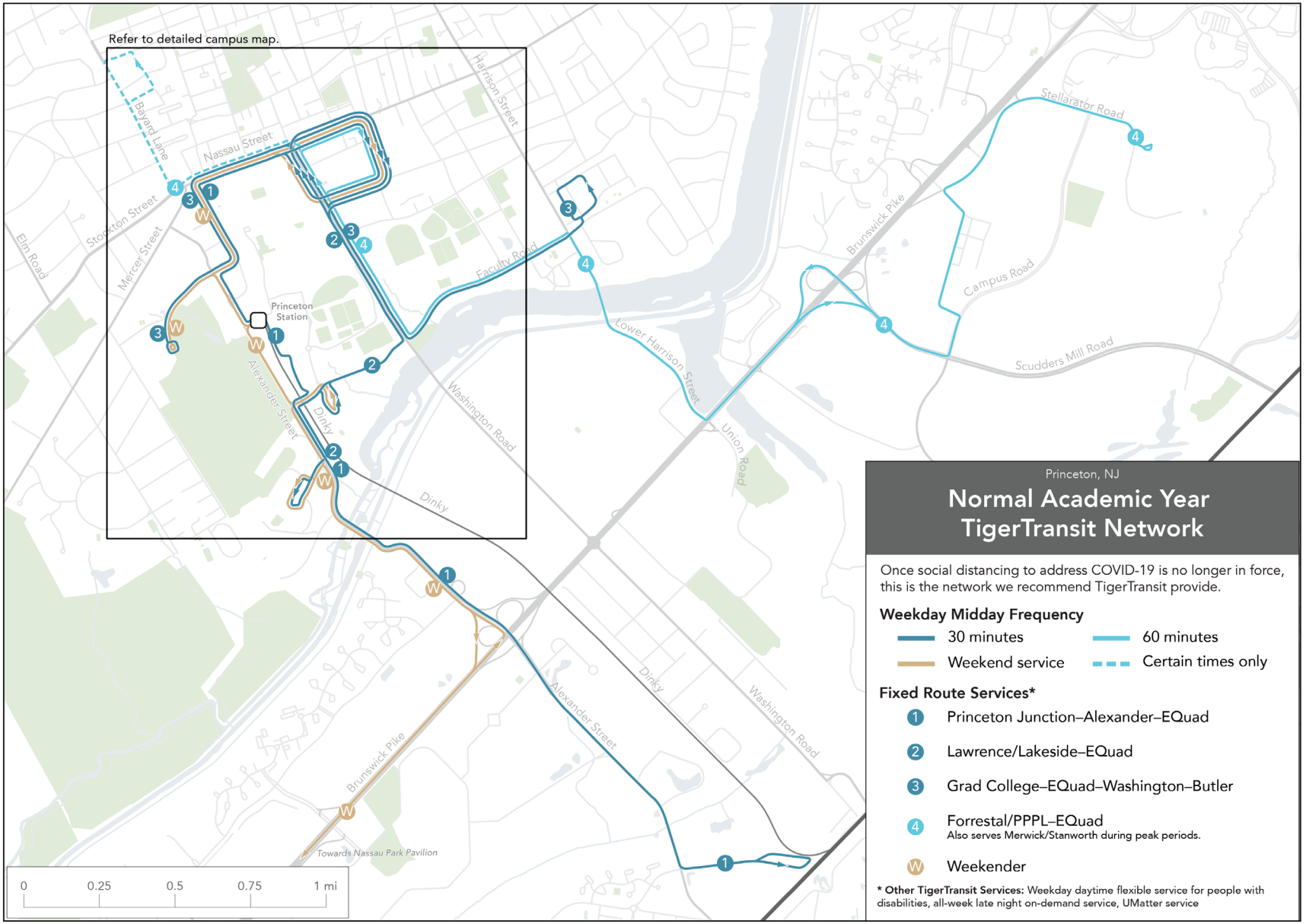
Symbols

TigerTransit Stop

0 1000 2000 ft

*** Other TigerTransit Services:** Weekday daytime flexible service for people with disabilities, all-week late night on-demand service, UMatter service

This map shows the weekday routes we recommend for a future normal academic year, once the COVID pandemic has passed. The color of each route represents the midday frequency – all weekday routes would offer a better frequency during morning and afternoon peaks.



This map shows the same weekday network as on the previous page, but zoomed out so that the routes serving Forrestal/PPPL, Princeton Junction and US-1 are visible.

1. Princeton Junction–Alexander–Nassau

This new route will offer a fairly direct ride among many major destinations. The places it connects are mostly quite dense, yet the walk between them is too far for most people to make regularly, and so high ridership can be expected.

Alexander Road and Princeton Junction are not walkable to many nearby jobs or residents, but given the huge supply of transit at Princeton Junction (more than 160 trains per day) and the importance of aiding University staff, faculty, and students with their off-campus travel and commutes, the southern part of the route is justifiable.

The overlapping transit markets this route can serve are:

- Princeton University commuters who arrive by intercity transit (to the Dinky Station, Princeton Junction, or Nassau Street).
- Commuters who drive and park in West Garage, Lots 20, and 16 (including many, but not all existing Central Loop riders).
- Visitors who park in Lot 23 or arrive via the Dinky, many wanting to reach the Undergraduate Admissions Information Center.
- Undergraduates living in the colleges on Alexander Street and University Place.
- Grad College residents who don't mind walking out to University Place if this bus is coming sooner.
- Princeton Township residents, workers, and visitors who ride Northeast Corridor trains and the Dinky.

This route would run on Alexander Road in West Windsor Township, where there are many employment centers (including some where University staff work) but they are impossible to serve with linear transit. The buildings are so isolated from one another, and cut off from the road by freeway ramps, such that a route cannot get close to them without becoming a long, winding milk-run. In addition, Alexander Road is so hard to cross on foot in many places that even if this route stops on one side of the road, people working on the other side of the road may not be willing to brave the crossing to reach it.

If the Township and the State can make Alexander Road walkable and crossable, that will make this transit corridor useful to more people, and will make any future transit service on the Dinky right-of-way accessible to developments on both sides of Alexander Road as well.

Princeton University staff will consult with NJ Transit and with the Municipality of Princeton about the potential for this route to supplement the Dinky, NJ Transit bus routes, and the town's freeB service.

2. Lawrence–E-Quad via Washington

This existing route is quite useful as it helps people make trips which are a bit too far to walk both ways and currently difficult to bike. The usefulness of the existing route is evident in its high productivity, and we recommend only minor changes to its schedule and stop locations.

3. Grad College–Butler via E-Quad and Washington

This route combines the existing E-Quad and East Commuter routes to make a longer, linear, and more useful route. It goes farther east in order to serve the new Butler parking area, which will partly replace Lot 21 (on Faculty Road) while the new east garage is under construction.[1]

In addition to the Grad College-to-E-Quad and parking lot-to-E-Quad connections that the current routes provide, the new route will also connect Grad College to Washington; and it will connect Butler to Nassau Street and University Place. It can be used in both directions all day, rather than being full in one direction and empty in the other as the existing routes are.

With the frequencies proposed here, this would provide shorter waits during the morning and evening peaks compared to the services it replaces.

4. PPPL–Forrestal–E-Quad–Nassau–Stanworth

This proposed future route connects the academic facilities at PPPL and Forrestal with the E-Quad. At rush hours, it also connects Merwick/Stanworth to central campus and E-Quad (and, if any residents are going so far) to PPPL and Forrestal. In the future, this route can also pass through the Lake Campus.

By serving multiple overlapping markets, this route should be used in both directions for

1 Extending the route to Butler slightly increases its costs compared to the existing distance to Lot 21. It requires an additional 15 revenue hours of service per week, at the frequencies and spans shown in the chart on page 13.

most of the day. However, given the frequencies that can be afforded on it (which are limited by its long length), and the very isolated buildings it serves on its eastern end, we do not expect it to attract high ridership.

This new route will provide higher frequencies at rush hour to Forrestal and PPPL. It will serve Merwick/Stanworth at rush hours only. Today, Merwick/Stanworth has midday service, but midday boardings there are extremely low.

The new route will be more direct, because it will no longer make a long deviation to provide one-way service to Princeton Medical Center, nor another deviation to the Lakeview Terrace housing development.

As described on page 11, the existing route does not meet the recommended new service guidelines for three reasons:

- It serves a small number of people,
- It makes the route more costly to operate, and
- It makes the trip among essential student destinations much less direct.

In addition, there is no justification for TigerTransit to serve this particular residential subdivision (Lakeview Terrace), but not the many other nearby subdivisions from which people might ride the bus. Because of the freeway-oriented development patterns, these places are not "on the way" along a route that TigerTransit would operate anyway – they require substantial deviations from the direct route between University destinations.

Nassau Street is on the way between E-Quad and Stanworth, for example, because the most direct path between those University destinations also serves Nassau Street. The same cannot be said of the places visible from US-1 on the way to Forrestal – they look close, but they're actually far away if you try to get a transit route close to them.

If the residents who currently use this route to commute to campus struggle to find other options, we suggest that the University work with them to ease their commutes in ways that are less costly than transit.

Offer later evening service on weekday fixed routes

Longer spans of service give people more flexibility in choosing when to travel during the day, and reduces the fear of missing the last bus. This increases the reliability of transit in people's minds.

Choosing frequency patterns that are consistent for most or all routes also helps make a system more legible. For example, for these routes, "7 am to 9 p.m." would be easy to remember as the span of service when all daytime routes are running.[2] Similarly, it is easy to remember that "all the routes run more frequently between 4 and 6 p.m."

That said, if demand consistently peaks on a certain route at a certain time, some customization of the hours may be appropriate even as it makes the system a bit more complex.

A chart showing approximate recommended hours of service and frequencies for each of these daytime routes is shown on page 13. On many routes, we are recommending that scheduled service continue later into the evening than it has in the past.

Combine weekend services into one route

In the existing network, TigerTransit has offered two weekend routes:

- The Shopper, which travels from the three graduate residents and the Dinky station to shopping centers along US-1.
- The Weekender, which connects the grad residences, Merwick/Stanworth and E-Quad.

We recommend that these two services be combined into one. This would have the effect of doubling the frequency, so that people would have twice as much choice in when to travel. Instead of having one opportunity per hour to go between Lawrence and E-Quad, a graduate student would have two; instead of having one opportunity per hour to go shopping at Trader Joe's, an undergrad would have two.

Combining the two routes would allow the University to double the frequency of the Weekender, and double the frequency of the Sunday Shopper, while less-than-doubling the cost.

However, there is one drawback, which is that the combined route cannot go *both* to E-Quad *and* to Merwick/Stanworth if it is to be reasonably direct between Lawrence, Lakeside, Grad College, and E-Quad. Given the very small

2 Commuters who commute to campus early and park in Butler Garage would know that there is service between 5 and 7 am. After 9 p.m., the Evening Circulator route, and then the late night On-Demand and UMatter services would provide transit connections on campus.

number of boardings at Merwick/Stanworth on weekends, we recommend not ending the route there, but instead going straight to E-Quad via Nassau Street.

This route should run at least as many hours as the existing Shopper, and possibly as many hours as the existing Weekender. It would also be possible to stop running the US-1 segment in the early evening but keep the short segment among residences and E-Quad running later.

D. Procure electric kneeling transit buses

Electric buses are quieter and travel with no exhaust, and are hence suitable for campus environments where a peaceful walking and biking experience is desired. Electric buses will also help the University meet its sustainability goals by allowing for the use of less-polluting fuels (or renewable energy) than diesel fuel.

But propulsion isn't the only critical choice the University should make about buses – comfort for passengers, reliable operations, and the ease of access for people with disabilities are also critical. Only some buses can "kneel" at the curb and quickly unfold a little ramp. These features vastly improve the boarding and alighting experience for passengers with a disability or anyone who has difficulty with a big step up – including visiting grandparents and athletes with torn ACLs.

Compared to vehicles with big mechanical lifts for wheelchairs, and steps that people have to walk up, kneeling buses are much more civilized. They benefit passengers who use the kneel and the ramp, but they also make service faster and more reliable for everyone.[3]

For a very frequent route like Lawrence–E-Quad, buses are coming every 10 minutes and the stops fill with people constantly during peak morning hours. On such a route, a 5 minute wheelchair-boarding process would set a bus far behind and would cause it to be quickly overloaded with extra passengers. This would lead to over-crowding and would cause the route to fall off-schedule, which could cause reliability problems that last all through the morning.

Based on today's boardings and allowing for a bit of growth, transit vehicles should be able to carry at least 40 people. This capacity is required for the Lawrence–E-Quad route, which at present regularly sees loads of up to 30 people per bus in the morning peak period.

The new Alexander route could also have full loads in the peak period, depending on how much the ridership between Princeton Junction and Nassau overlaps with ridership between West Garage and E-Quad.[4]

Morning peak loads on the existing E-Quad line are lower, at around 20 people per bus, but this will increase when the parking garage at Lot 21 is built.

Smaller shuttle-type vehicles can be used for the Merwick-E-Quad-Forrestal-PPPL route and for flexible services—the disability day-time and the on-demand late night services. These vehicles should be low-floor and equipped with a roll-on ramp rather than a lift to ensure access for the widest range of riders. High-floor vehicles that require climbing stairs are not recommended; wheelchair lifts cannot carry standing passengers, limiting access for many people who use a different assistive device or simply have difficulty with steps.

Currently, low-floor ramp-accessible shuttles only come with internal combustion engines; Princeton University should convert to low or no emission vehicles when these become available. The University should look at the Arboc Spirit of Freedom as a reference vehicle for smaller 'cut-away' shuttles built on van chassis with no-step low-floors and ramps.

3 While we are also recommending a flexible transit service for people with disabilities, it is still critical to use kneeling buses and buses with graceful wheelchair loading ramps. This is because people with a disability often find that scheduled transit service gives them more independence and allows for more spontaneity. Also, flexible on-demand services are costly to provide per passenger, so making fixed routes maximally accessible helps the University use its transportation funds more efficiently. Finally, people with disabilities may prefer to travel with their friends or colleagues in a group, and this is far easier done in a big fixed route bus than through a reservable flexible service.

4 Ridership can be high without necessarily resulting in big loads or crowding. This happens if seats "turn-over" rapidly and major trip patterns don't overlap on the route. In such situations, just as one person is alighting another is boarding to take her place.

E. Use car- and bike-based solutions where transit works poorly

It is very expensive to run transit to distant, isolated locations, especially where the walkability is so poor that the buses have to pull down individual driveways and cul-de-sacs. It also makes for non-linear, slow routes that are less useful to anyone riding through.

Even demand-response ("flexible" or "on-demand") services in such places are inefficient, because each rider is located far from the next rider, so the responsive vehicle spends a lot of time meandering.

Instead of trying to make shared-ride transit work for the administrative buildings located in such car-oriented places (such as **693 Alexander, 100 Overlook, and 701 Carnegie Center**) the University should find car-based solutions for people who need to travel between these places and campus. These places were designed to be served by cars, and hence car-based solutions will be most effective at satisfying their mobility needs.

Such solutions can include shared cars available to staff at those buildings, changes to on-campus parking management, or ride-hailing service reimbursements.

Once planning is underway for the Dinky right-of-way, it will become apparent that without major changes to the design and operation of Alexander Road and US-1, very few people are actually within walking distance of the Dinky right-of-way. The same changes that would make the Dinky right-of-way reachable from places like Carnegie Center and Overlook would also make a linear transit service on Alexander Road accessible to nearby (but far away, on foot) buildings.

The replacement of the Alexander Bridge in spring 2020 has reduced barriers to cycling between the main campus, Carnegie, and Overlook. While off—and on—campus roads still lack comfortable, protected bikeways, there are paths that allow some trips to main campus to happen off of the roads. Some people may be more comfortable making the trip by bike now that the bridge is improved.

The University should therefore consider adding shared bikes to the Carnegie Center and Overlook buildings, and expanding the bike share operating program to include rebalancing between those stations and main campus stations.

F. Improve the campus environment for walking and biking

Walking and biking should be so appealing that few people choose to use transit for trips of less than 2 miles. Transit will be mostly used for longer trips.

Shifting more trips to walking and biking, from driving and transit, will allow the University to use less land for roads and parking, and to use more land to further the University's mission.

The highest priority routes for immediate investment on the existing campus are:

- Elm Drive, which should serve as a north-south axis for walking and biking on campus.
- Lawrence Drive, which should make it easy for people to walk and bike the short distance between the Lawrence Apartments and campus.
- College Drive, which like Lawrence Drive connects graduate student housing to campus over a distance short enough to walk or bike.

These are places where the need is greatest (based on public input), the travel distances are or will be short enough for walking and cycling to be the predominant modes (rather than transit), and the University has the most control over the design and operation of walkways, bikeways and streets.

As planning for new buildings takes places, especially in the East and Lake Campuses, it will be important to forecast and then plan for future pedestrian demand just as future car demand has been forecast and planned for.

In addition to investing in bike lanes, paths, and other infrastructure, the University should take these actions to make cycling on campus easy and appealing:

- Providing covered bike parking, especially near residences, so that bicycles can be parked outside overnight and through the winter without turning into rusty garbage. (Long-term parking examples are provided starting on page 25.)
- Changing the standard campus bike rack to one that offers two points of contact with a bike, so that bikes don't fall over and tangle in one another when they are parked.
- Offering a better working space, greater visibility and accessibility, running water, and other support to the existing student-run bicycle cooperative, the CYCLAB.
- Offering discounts or other forms of partnership with bike shops in nearby towns.
- Offering a University-sponsored bicycle rental or library program, so that students who are unsure of the practicality of cycling (or unable to transport and store a bike over breaks) can try it out with little or no up-front cost.
- Expanding the bike share system (as described starting on page 28).
- Providing classes, encouragement, and support to people who are new to cycling and wish to try it out.

Update and implement the 2017 University Bicycle Network Plan

In 2017 the University published a plan that identified where new paths, greater protection, and other improvements are needed to make a complete bike network connecting all academic, sports, and housing buildings. This plan needs substantial updates in order to:

- Apply the principles we recommend here, which should raise the standards for bicycle and pedestrian separation on many roads.
- Reflect planned expansions in the East and Lake Campuses.
- Respond to the bike plan published by the Township of Princeton in 2017.

Decisions about University investments in bikeways should be made with an awareness of the Township's Bicycle Master Plan, which was completed in 2017.

Despite the fact that the Township and the University both completed bike plans in 2017, the two plans don't always agree with one another. Segments of road or path that are recommended as part of the network in one plan are absent in the other. The specific treatments (separated path, bike lane, shared marking, etc) that are recommended for some segments also differ between the two plans.

Princeton Township's planning staff should be involved as key stakeholders in future University bikeway planning, so that the two organizations can continue learning from, debating, and reinforcing one-another's plans over the years.

Take motor vehicles – including transit – *off* of Elm

Elm Drive, running through the center of campus, is the ideal grand walkway for the central campus, similar to the east-west experience offered by McCosh Walk. Taking transit and motor vehicles off of Elm would free up that space to be dedicated to a walkway and bike lanes. There are various design alternatives possible for a reduced-motor-vehicle Elm Drive.

In the short term, these alternatives can be tested through temporary demonstration projects such as painting bike lanes and expanded sidewalks or temporarily placing street furniture. The feedback collected from such projects can inform future decision making for larger projects to make more permanent changes. These projects would also demonstrate a commitment towards making campus more walk-and-bike friendly.

Taking motor vehicles off of Elm will require not only a change in infrastructure but also changes in culture, habits, programs, and rules that govern vehicles within campus. Our recommendations related to these changes are described at greater length on page 24.

A few service vehicles probably need access to Elm at all times a day, as do emergency vehicles and the aforementioned demand-responsive service for people with disabilities. However, some service trips can probably be shifted to other places or other times.

Taking transit off of Elm means that there would not be a transit service bisecting central campus as today's Central Loop does. Instead, most of the trips that the Central Loop serves today (for example, from West Garage to Nassau Hall or Lot 21 to the Undergraduate Admissions Information Center) would be served by the Alexander–Nassau route recommended above. Some of those trips would also, hopefully, be shifted to walking, biking, or rolling trips on Elm.

Test new street and path designs

Starting in September 2020, the University should begin testing temporary versions of walking and biking infrastructure in places where it will serve the most people. This can be a series of "pilot" projects. Gathering feedback from the campus stakeholders who use the projects in diverse ways will be valuable, as will simply mocking-up potential designs and experimenting with physical materials.

Temporary installations like this separated cycletrack can use paint, street furniture, and creative materials to test a design on a street before committing to it. Low-cost, creative tests may be the right approach for Elm Drive, which handles so many different uses, and is so central to many peoples' experience of campus.

For example, if transit service comes off of Elm Drive in September, it should be replaced with a great walking and biking solution. This will send a clear message that Elm Drive is not turned over to private cars, but is becoming the north-south axis of central campus, where the vast majority of trips are made on foot.

Among the design concepts for Elm Drive that we presented to campus this winter, the concepts with separated bike facilities were most popular. Without transit on Elm Drive, there would be room to test:

- A two-way bike and scooter lane on one half of the road, with a one-way car/truck/golf cart lane on the other.
- A two-way bike/scooter/golf cart lane on one side of the road, with a pedestrian promenade on the other (and all full-sized cars or trucks prohibited during daytime hours).
- A two-way street with advisory shoulder lanes for pedestrians and bicyclists, without a center dividing line. (An example is pictured on the next page.)

Cities have been running tests of designs like these for many years, using decorative planters, boulders, temporary plastic bollards, and temporary tape or paint on the pavement.

Create a "tool kit" for designing or retrofitting plazas, streets, and paths

Just as there is a set of acceptable architectural and landscape treatments for use in campus development, there can be a set of acceptable street treatments that make walking and cycling irresistible. This tool kit should include general designs for a variety of campus conditions, and guidance as to when each design is most appropriate. It will likely include separated walking or biking facilities (like side paths and cycletracks), low-traffic shared streets (like woonerfs), promenades, and plazas (where walking is dominant and social interaction is maximized), and painted road treatments (such as bike lanes or suggestion lanes). A limited toolkit was included in the 2017 Bicycle Network Plan but an update is needed with a greater emphasis on pedestrian enjoyment and social engagement in public space.

Advisory shoulders or bike lanes give people a place to walk or bike in the street. Cars are permitted in the space, but drivers use the center of the road and then move over for oncoming traffic. This has the effect of slowing down traffic and improving safety, while also encouraging walking and biking.

Work with the townships, Mercer County, and NJDOT to improve walking and biking conditions

Work must continue with Princeton and West Windsor Townships; Mercer County; and NJDOT to improve walking and biking conditions on the streets, roads, and bridges that they own.

While the University has existing relationships with those agencies, and has been doing this type of planning work with them for many years, the University now has an opportunity to participate in those conversations with new clarity about the mobility principles that guide its own decisions.

For example, in the short term, the University should advocate for a design that will allow large numbers of people walking, cycling, or using mobility devices to reach the new Lake Campus. Until the flyover is built, the Washington Road Bridge will be the route for all trips (hopefully nearly all of them by walking or rolling) between the Lake Campus and main campus. Some other examples of University collaboration with agencies include:

- Participating in planning for the future use of the Dinky right-of-way.
- Participating in planning for Washington Road and a new Washington Road Bridge.
- Advocating for pedestrian crossings of Alexander Road that allow University employees working in 693 Alexander, 100 Overlook, and 701 Carnegie Center to walk to transit stops on Alexander Road.
- Providing a visible public bus stop on Nassau Street for TigerTransit service between Princeton Junction and E-Quad.

Prioritize proximity, walkability, and linearity as campus expands its footprint

When building or leasing new University space:

- Choose locations that are within walking and biking distance of the central campus whenever possible.
- Choose locations that are already located on a well-connected local street network or build a well-connected local network for walking and biking.
- Avoid locating students, staff, or classrooms in places that are isolated by highways, waterways, or large undeveloped areas.

This will allow TigerTransit service to be useful for travel to these new spaces without the University having to fund the operation of a whole new unique route.

For example, developing along Alexander Street (in Princeton Township) would require

very little new transportation capital or operating costs.

In general, avoid leasing or building new University destinations on cul-de-sacs or loop roads unless there is excellent pedestrian access to both directions of travel on a nearby main road.

Control golf carts, off-highway vehicles, cars, and trucks on campus

The dominance of golf carts, off-highway vehicles, cars, and trucks on the University's internal roads and pathways is a source of annoyance and friction for people walking, cycling, or using a mobility device on campus.

Opportunities to walk side-by-side or stop and talk are made more scarce by the regular passage of vehicle traffic down roads and paths, and by the narrowing of roads and paths by parked vehicles. In the survey, many people expressed frustration with these vehicles both in our questions about them and in the free-form comments. While some vehicles will be needed to move large tools, supplies, food, and people with disabilities around campus, their use should be reduced below its current level.

In order to do so, we recommend that the University establish a task force that develops new criteria, systems, operating procedures, and culture around vehicle procurement and use on campus. In particular, the University should:

- Exercise more control over the purchasing and permitting of golf carts and off-highway vehicles, rather than leaving it up to individual departments to determine their needs and build their own vehicle fleet.
- Define the purposes of these vehicles more narrowly.
- Set criteria for where, when, and why they will be purchased and used, and under what conditions pathways or sidewalks may be blocked.
- Monitor how these criteria are being met, and consider using a more rigorous program of permits, "no cart" zones or enforcement if necessary.
- Evaluate the usefulness of lower-impact vehicles such as hand-carts, wagons, and cargo bicycles for some trips that are currently made by motorized vehicles today.

G. Encourage the use of personal bikes on campus

An effort to dramatically improve conditions for personal bike ownership should be initiated in 2020. Personal bikes are the second-most space efficient, sustainable, and low-cost transportation option that the University could possibly hope for among its students (after walking).

Personal bikes require very modest space for parking, low costs for purchase and maintenance, and no operating cost or vehicles to move bikes around throughout the day (as bike share systems do). However, owning a personal bike on or near campus is currently harder than it should be:

- There are few places to park a bike on a rack near many of the residential colleges, and almost none that are under cover from rain or snow. As a result, parked bikes litter stairwells and passageways, blocking access to doorways and handrails.
- The standard bike rack for installation on campus does not provide two points of contact for a parked bike, and as a result parking and locking is more difficult than it should be, and many locked bikes fall over when they are touched.
- The University's student-led bicycle shop, CYCLAB, operates out of a sub-standard space. At many other universities, the student-led bicycle shop is able to provide higher levels of service and greater cultural leadership, but to do so at Princeton the CYCLAB would need more support from University administration. University support could also make the bike shop in town a greater resource for students.

Today Princeton University is a more difficult place to ride, own, and store a personal bike than many other campuses. This is partly addressed by the bike share system (though, at time of writing, the current bike share provider has just ceased operations). Shifting short trips from transit to cycling will require that the University make it easier for students, faculty, and staff to have their own bike on campus.

Improve bike parking

Bicycle parking is not one-size-fits-all. Princeton University's outdoor racks—useful for students, staff, and faculty attending class or meetings are not appropriate for overnight bike storage. The University should adopt standards for short term bike parking, long-term covered bike parking, and secured bike storage. New buildings and campus facilities should include bike rooms that provide lockers, showers, tools, and other amenities that support year-around bicycle commuting.

The Association of Pedestrian and Bike Professionals (APBP) has published the short and useful Essentials of Bike Parking guide. It contains nearly all the information the campus will need to select highly functioning designs for bike parking. Princeton University should adopt these guidelines and ensure consistent application of these principles.

Short-term parking

Princeton University's short-term bike parking racks, for the most part, are located near entry ways in visible and well-lit areas. The University's go-to bollard style rack, however, is listed among the "Racks to Avoid" by APBP — they do a poor job of keeping bikes upright — and should be replaced with a design that meets the performance criteria listed in the Essentials of Bike Parking.

Long-term covered parking

Princeton's campus needs covered bike parking to support students who live on campus. Unlike cars, bicycles — with their open transmissions: chains, derailleurs, and cables — degrade with continued exposure to rain, snow, and de-icing agents like salt or sand.

The dearth of covered racks leads people to crowd covered walkways and stairs with parked bikes causing serious accessibility challenges for those with disabilities. When bikes become unusable they take up valuable space on racks and cause significant work to remove and dispose of at the end of the year.

The University should identify locations where overnight bike parking is needed and pilot prototypes to identify the preferred campus design. Examples of covered bike parking from Harvard, Oregon State University, and Maastricht University in the Netherlands are shown on page 26.

Secure bike parking in garages

Princeton University should install secured bike parking as a standard feature in garages. A few car parking stalls can be easily and cheaply converted into high-quality secured bike parking with fencing and access control. Some car commuters will choose to leave a bicycle overnight and pedal the last leg of their trip. Bike commuters with more expensive bicycles will choose the added protection from theft and

Harvard recently installed covered shelters at many of its bike racks.

Dormitories at Oregon State University have both covered and uncovered racks.

At Maastricht University, this covered bike rack has an enclosed portion accessible with ID cards for added security.

Bike cage at in an Oregon Health & Science University garage.

vandalism even if it means walking or taking TigerTransit to their campus destination.

Bike rooms with showers and lockers

New University buildings should include high-quality end-of-trip bike facilities. When purpose-built and well designed, bike rooms provide a high level of comfort and security for bike commuters, particularly in the fall and winter months when a place to hang wet rain gear and take a shower may make the difference between riding a bike or driving.

H. Expand the bike share system and add electric bikes

We recommend the University update and expand its bike share system by adding more bikes, a better user interface, and possibly more operating budget to meet higher standards for rebalancing.

Bike sharing has potential to be a very cost effective and positive part of the campus mobility system. However, it requires more investment and management than currently devoted to it. It is also ready for an update to take advantage of the many innovations that have rapidly emerged since the Princeton Zagster system was designed and launched. Zagster announced in May 2020 that it was ceasing operations in Princeton, and thus the University will have to find a new provider anyway.

A substantial portion of the fleet could be comprised of electric bicycles. E-bikes have been shown to produce higher ridership per vehicle in most markets where they have been deployed. They replicate all of the mobility advantages of scooters, in particular making hill climbing and long trips easier for more people.

Reduce time required to begin bike share trips

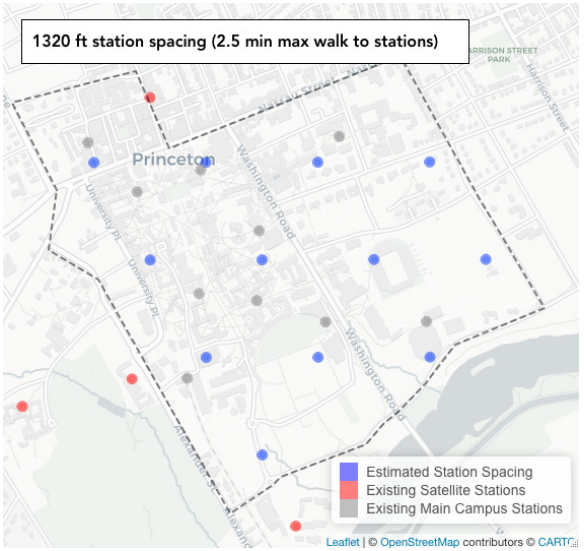
Two factors contribute to the usefulness of a bike share trip: the ease of finding a bike and the ability to end a trip near the desired destination. Station based bike share systems need, therefore, a great density of stations to be useful. Free floating bike share systems that allow riders to end trips at their destination solve this problem but can create a nuisance for pedestrians when bikes are parked in pathways and doorways.

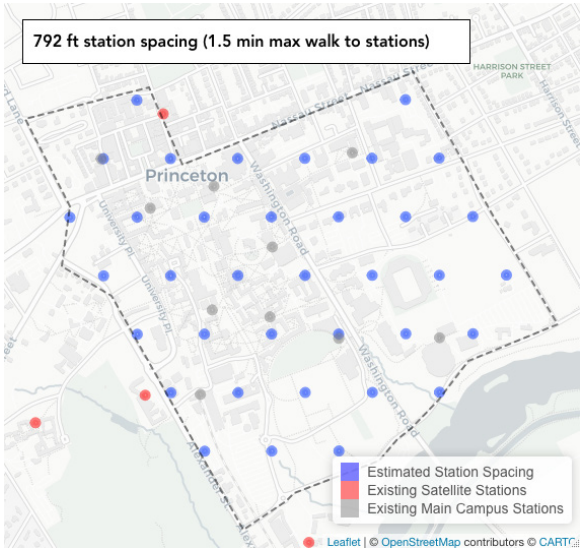
We recommend that the University take a hybrid approach to bike share where riders are encouraged (via incentives) to park bikes in particular places ("virtual" stations) and are discouraged from parking in ways that create a nuisance, a hazard, or undermine the efficiency of the system. This increases the number of possible destinations on campus that can be reasonably reached by bike share. The virtual stations should be built into the operator's rebalancing plan so that users can rely on bikes being available, at the right time and place, for most trips.

Establish a high density of virtual bike share stations

Stations (reliable concentrations of bikes) should be plentiful and closely spaced.

Modern bike share systems do not require a capital-intensive "station" to be built – the same mobility benefits can be accomplished by geofencing and clearly-marking a parking area or rack, such as the ones shown in photos on the next page. This is becoming best practice with bike share and scooter systems, and is also how systems like Portland's Biketown and Switzerland's Publibike work. In the case of Biketown, the "station" is essentially a set of highly visible orange bike racks within a geofence. Regardless of the level of infrastructure provided at a "station," any bike racks that are provided for shared or personal bikes should





In order to offer short walks to a shared bike, Princeton University would have to have stations (physical or dockless) spaced evenly across campus. At left, a demonstration of how many stations would be needed to offer a 2.5 minute maximum walk from every point on the central campus to a bike; at right, the spacing needed for 1.5 minute maximum walks to a bike.

Dockless bike share stations in (top to bottom) Seattle, Bern, and Minneapolis.

provide two points of contact with the bike (unlike the existing standard campus rack) so that bikes do not easily fall over.

Ideally, no part of the core historic campus should be further than a 2 minute walk from a station. In very high-demand areas (such as the vicinity of the main library), clusters of stations can be established to prevent overloading any one point or requiring any single station to be very large.

The two maps above illustrate two different degrees of potential improvement in station density on the central campus. The first map shows the average station spacing if every building on the central campus were within a 2.5 minute walk to a station. Rather than the 10 stations on central campus today, 12 stations would be required.

The map far to the right shows the average station spacing were every building to have a station within a 1.5 minute walk. This would require 36 stations in the central campus.

These maps are not meant to show actual station locations, as stations should be placed based on hyper-local aspects of demand, pedestrian access, and bikeway access. But fairly even spacing is necessary if consistently short walks are to be achieved.

Define service goals through a Service Level Agreement

The University will negotiate a Service Level Agreement (SLA) with its bike share contractor. The SLA should:

- **Ensure the system stays balanced.** The SLA should require bikes be stocked at outlying stations at times most likely to otherwise result in low availability (e.g., grad residences and other places where single land use results in one-way demand).
- **Set clear standards of maintenance and vehicle time out of service.** One potential way to do this is to stipulate a minimum vehicle availability (in terms of percent of the fleet available each day) and then establish an incentive structure for exceeding that target.
- **Plan for efficient operations.** One of the most important aspects of bike share operations is a facility near the service area (depot or warehouse) where vehicles can be maintained, staff can be based, and rebalancing operations can be coordinated. It may be helpful for the University to identify one or more suitable locations on or very near to campus.[5]

Do not operate shared scooters on campus at this time

The purpose of a shared micromobility fleet is to provide a useful mobility option for 5-15 minute trips that are difficult to serve with transit. E-bikes and scooters provide the same mobility benefit – they allow people to travel faster than walking but still under 15 mph, and they make climbing hills easy.

5 Just like with contract transit operations, operators who have to find, lease, and build their own operations base face an additional hurdle to providing service and an additional cost which they will recover through their contract. In addition, if the depot or warehouse is far from campus, the "deadhead" time to shuttle bikes (or buses) back and forth to the depot will be an operating cost ultimately borne by the University.

Yet bikes are a safer platform for riders. In more than a decade of bike share operations in the U.S. across nearly all major cities and many small towns and universities, there have been only three fatal crashes. In just the past two years of scooter share systems there have been dozens of fatal crashes. Scooters, as a vehicle, are simply less stable and more prone to crash (due to tiny wheels and small steering bars) than bicycles. Bicycles are also more useful due to their cargo capacity (a basket or rack), to say nothing of the fact that a bike can be safely ridden with a single hand while a scooter cannot. E-bikes are also more resilient as they can still work even if they run out of charge.

Scooters are an exciting, heavily hyped product, but our purpose in recommending mobility tools is not to sell a product, it is to improve mobility and help the University meet its goals.

One of the major observed challenges with scooters is parking. Bikes and scooters require a similar amount of space for parking, and peoples' desires to park close to their destination are similar for both. There are many effective and attractive bike rack designs. Most scooter parking amounts, sooner or later, to a large pile. If scooters parking continues to be an issue, we recommend creating designated parking areas for scooters which can be simply done with painted markings on the ground and basic signage.

One way of managing scooter parking on campus would be to ban private scooters, and allow a private operator such as Lime or Bird to enter. Then the private operator would become responsible for where and how scooters get parked. However, this would produce a duplicate electric micromobility system that would be difficult or impossible to manage alongside bike share as a coherent, integrated system.

I. Publish accurate TigerTransit data that works in Google Maps and other apps

Reliable and useful real-time transit information can have a big positive impact on passenger experience. It reduces wait time as passengers can go to the bus stop closer to when the bus arrives. At the stop, it assuages anxieties about when the bus is arriving. It allows people to make smarter choices about what mode to use for a trip, and if a transit route is delayed, it helps them make another travel plan quickly.

Because TigerTransit routes are open to the general public, their data can be used by popular trip-planning apps.

Maintain and publish accurate transit data feeds

There is a standard data specification for transit schedules and geographic data used by several transit agencies, including TigerTransit. This is called General Transit Feed Specification (GTFS) Static.

GTFS makes trip planning possible with any transit app a passenger prefers. It can also be integrated with systems like crew and vehicle scheduling and automatic passenger counts (APC) which enables consistency between scheduling, passenger information dissemination, and performance supervision. It is necessary that this GTFS Static feed be updated regularly to accurately reflect schedules.

A GTFS feed (Static or Realtime) is published as a compressed folder hosted at a consistent location on the internet. This can be done in several ways but hosting on the agency website is most preferred.

Maintain and publish accurate real time transit data

An extension of GTFS static feed is GTFS Realtime, which enables agencies to publish up-to-date real-time information. This allows widely-used transportation apps to show people where buses are currently located, make predictions about when the bus will be at the stop, and do trip-planning using that real-time data.

A GTFS Realtime feed also lets agencies publish information like trip updates, service alerts, and by integrating with Automatic Vehicle Location (AVL) systems, the vehicle position. Real-time information about TigerTransit vehicles is currently provided through a different method, which is not compatible with popular trip-planning applications.

Software can estimate stop arrival times based on GTFS Static schedules and real-time vehicle locations. These arrival time predictions can be integrated with information displays at stops and mobile applications.

This white paper by Trillium Transit and the Oregon DOT is an excellent resource for planning and setting up GTFS Realtime.

Provide transit information to popular trip-planning apps

The usability of transit data is greatly impacted by the fact that it is only available through TransLoc and Princeton University apps, when a vast majority of Princeton students, staff, and faculty use Google or Apple Maps to get around places[6]. This is especially true for each group of arriving students at the University, and for the campus's numerous visitors.

Providing GTFS Static and Realtime information through widely-used apps enables much easier and comprehensive trip planning by enabling people to mix TigerTransit trips with other modes. It is not reasonable to expect occasional users and visitors to install an app just to access TigerTransit information for the first (and possibly only) time.

In order to get its GTFS feeds on to navigation apps, TigerTransit or its vendor will have to contact them to register the feeds on their platform. This would involve some time to set up at the beginning, but once this is established, the process of updated GTFS being updated on the apps would be mostly automatic.

Specifically for Google Maps (and likely for others as well), Google requires that participating transit agencies' services be publicly available. Hence ***the University should clearly state*** TigerTransit service is open to non-University affiliated people. It will still be necessary to emphasize that TigerTransit's purpose is still to serve the University.

6 See survey results on page 44.

Dedicate staff resources to ensuring that schedules and GTFS are maintained accurately throughout the year

Several free-form comments from survey participants noted that real-time information about TigerTransit arrivals was at times unreliable – for example, the TransLoc/University app indicating that a bus had arrived when none showed up. This highlights the importance of accuracy of transit data and of the consistency between GTFS Static and GTFS Realtime.

Additionally, TPS receives inquiries every year from students requesting access to a TigerTransit GTFS as part of their senior thesis work. Maintaining an open data feed will allow students to try their hand at creating the next great transportation app or measuring transportation related emissions on campus, at little cost to the University.

Route stops, frequencies, vehicle locations, and schedule changes need to be accurately reflected in the GTFS feeds so that they can be publicized to users. On the back end, TigerTransit and its vendor also need to ensure that GTFS feeds, AVL, APC, and crew/vehicle scheduling systems are integrated well and have consistency.

Avoid spending resources to develop an in-house information/trip planning app

From a user's perspective, a separate mobile app just for TigerTransit arrivals or trip planning does not have much utility except for the most regular and committed users. The transit system can be made more inviting and useful by letting people access transit information using whatever travel app they already use.

The University can recommend a particular app, and can even pay a modest fee to have Transit App branded for the University. The resources that would be spent developing and rigorously maintaining an in-house transit app would be better spent on other improvements to transit's usefulness and to campus mobility.

The University's new contract with a service provider will include multiple performance standards, for example relating to reliability of service, cleanliness, crashes. There should also be performance measures that relate to the accuracy of published schedule information and of published real-time bus locations or arrival time predictions.

J. Adequately staff campus mobility and demand management

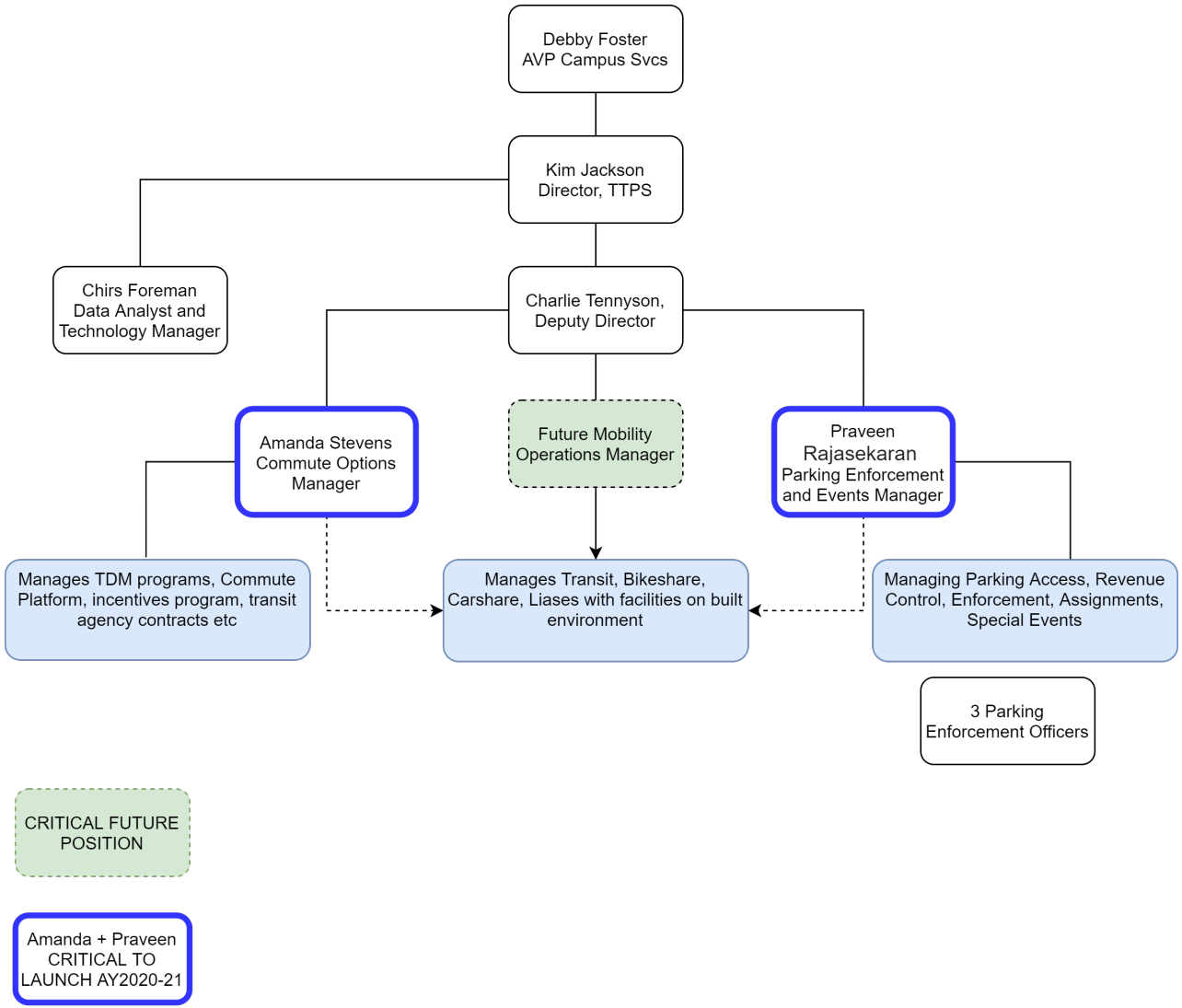
The University currently has seven permanent positions and one temporary position devoted to transportation. Three of those positions are parking enforcement officers; only five positions manage all of the parking, transit, bicycling, incentive, and other programs. Compared to other university transportation programs this is a very lean operation.

At Vanderbilt University our team has recommended 12 positions for their MoveVU program. The University of California–Davis devotes about 25 positions to transportation management. Harvard's transportation team numbers about 32 people. However, an apples-to-apples comparison among campuses is difficult. Campus populations and program responsibilities vary—UC Davis is much larger than Princeton, Vanderbilt provides some transportation services to its medical center, and all charge for parking while Princeton still does not.

Based on our observations of current Princeton University programs, we recommend that the University commit more staff resources to transportation. This will help the University get the best performance out of existing capital and operating commitments and deliver on the high expectations students, staff, and faculty bring to campus. It will also be critical if the University hopes to provide the higher levels of service and of inter-departmental coordination described in this memo.

We recommend the University make the

Existing and recommended Transportation & Parking Services organizational chart



following staffing investments:

- Make the Commute Options Manager position permanent. Transportation Demand Management and expanding Revise Your Ride is a vital body of work to the success of the University as a whole. The University has committed to itself and to its neighbors that a mix of infrastructure, services, and TDM programming will reduce the use of single-occupancy vehicles. Supplying this program with only a term-limited position is not consistent with these commitments.

- Add a new, permanent position – a transportation operations manager – to oversee fixed-route transit service, on-demand night shuttles, the new disability service, expanded bike-share operations, bicycle lending and support programs, and car-sharing. This position will also be the liaison between University Services and Facilities on built environment changes and maintenance to support mobility.

- As parking operations on campus change, the University should reevaluate staffing needs for that aspect of the program.

The Mobility Framework will be implemented incrementally, and in Fall 2020 there are fewer students expected on campus due to the COVID-19 epidemic. We therefore recommend that in Fall 2020 the Commute Options Manager and the Parking Enforcement and Events Manager split the responsibilities of the future Transportation Operations Manager. The new position can be created and filled after 2020 when more students, staff, and faculty are on campus and when more of the Mobility Framework has been implemented.

K. Test new wayfinding strategies and tools to support campus mobility

The University is reimagining the campus's wayfinding as this report is being written. As wayfinding recommendations are developed into prototypes and tested, the University should strive to:

- Provide information to help people navigate the campus by bike and foot.
- Show how short walking and biking trips to key campus destinations can be.
- Support transit users with clear information, provided at the right level of detail for the context.
- Take advantage of bus stops and shelters to help people understand the transit network and to orient themselves more generally to the campus. Tools used at bus stops could include:
  - Bus stop flags
  - Real-time arrival display boards, especially at stops used heavily by visitors and occasional riders.
  - Maps that help people understand the campus geography, walking and cycling distances, and the transit network.
  - Information that helps people understand just how close many destinations are by foot or by bike.

Illustrations of how wayfinding could be improved through bus stops, campus maps, on buses, and elsewhere are shown in an appendix starting on page 60.

Summary of Stakeholder Input

In February of 2020 the Princeton Campus Mobility Project asked for public input in a variety of ways: an open house, many presentations throughout the campus, and a survey with over 2,000 responses.

Across all of these engagements, people were asked about their preferences regarding how they move around campus:

- What was their most common travel mode?
- Did they prefer to walk farther to get a shorter wait for transit?
- What apps do they use to navigate?

Additionally, the project asked the public to consider and choose between various alternatives in order to help understand which priorities are most important to the University community:

- How did they think Princeton University should invest its transit resources?
- How should Elm Drive space be allocated and designed, among buses and people walking, biking, and driving cars or trucks?
- How should the University prioritize potential mobility improvements?

The survey also collected free-form comments, which resulted in some insights for the planning team - how people feel about scooters, for example, and a widespread desire for more frequent connections to trains at Princeton Junction.

This chapter provides a high-level overview of some important takeaways from the survey, as well as representative quotes from the collected comments.

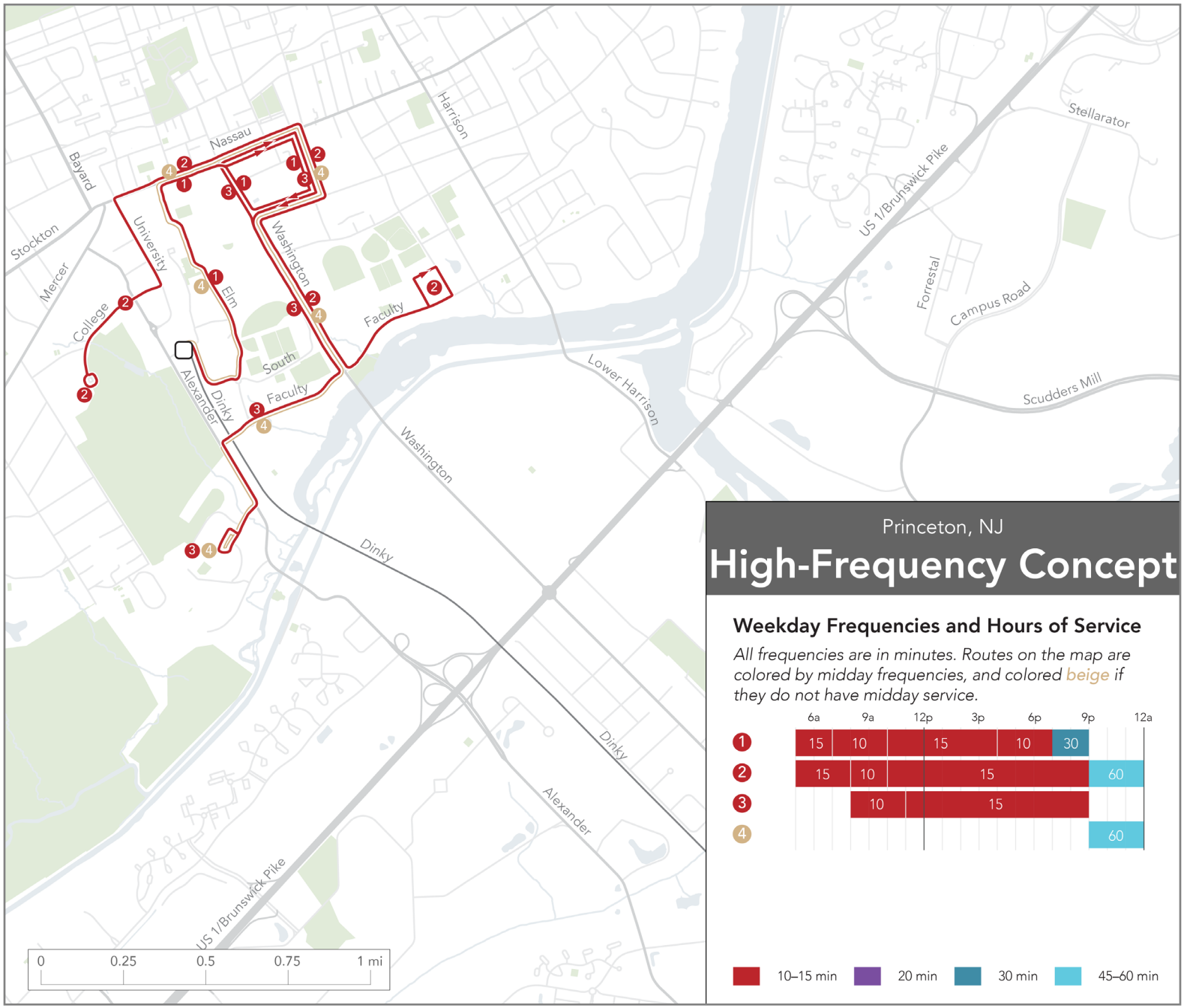
Future Concepts for transit and Elm Drive

In order to help event participants and survey respondents make informed choices, they were provided with visual examples.

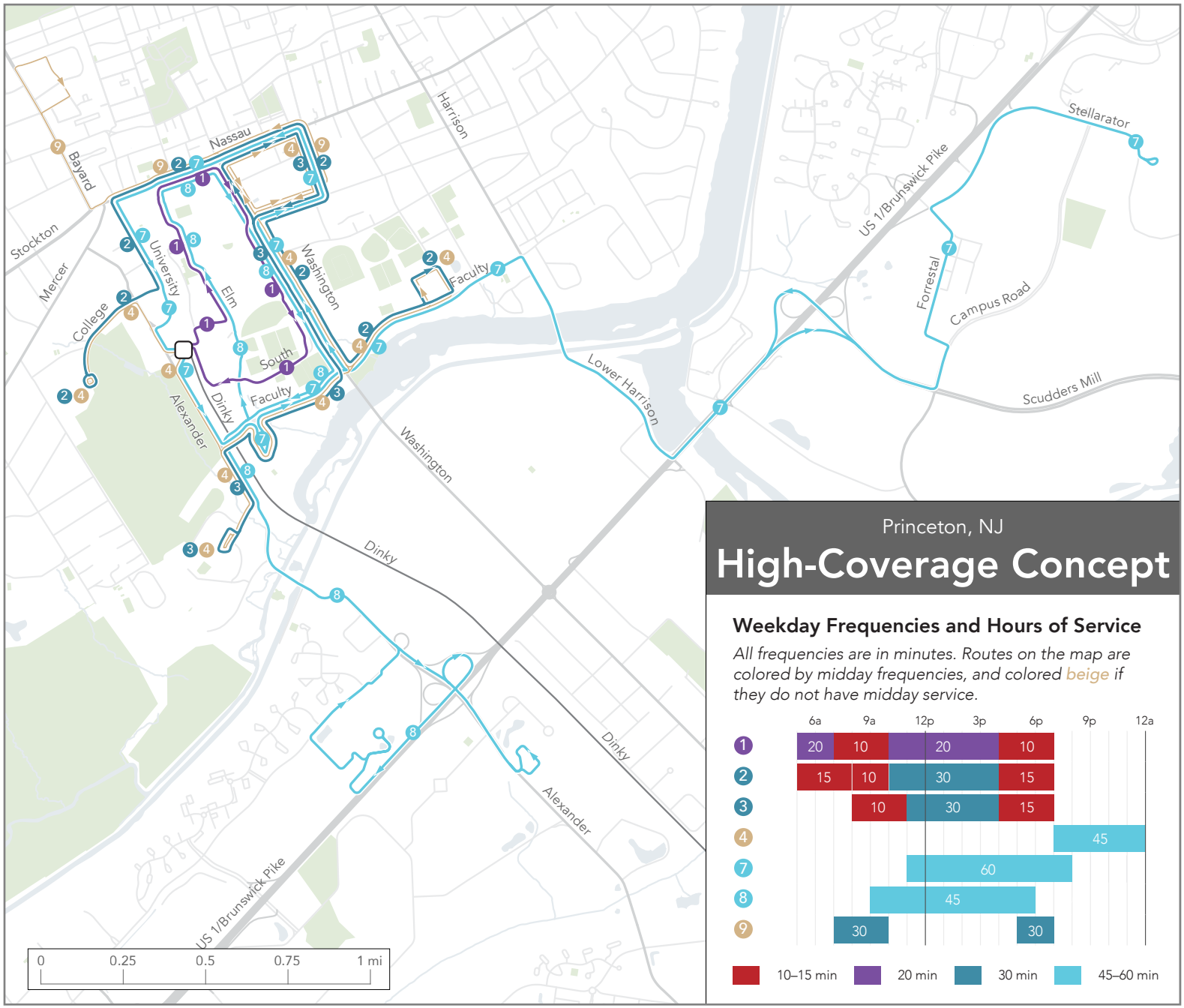
For the question about how to invest transit resources, the Mobility Project created two contrasting transit concepts that highlight ***the trade-off between providing higher frequency and higher coverage.*** The two alternative concepts are shown in the following maps on pages page 38 and page 39.

To assist survey and open house participants with choosing how to allocate space on Elm drive, they were presented with four conceptual designs (pictured on page 40):

- A promenade with two-way bike lanes.
- Two-way transit lanes shared with bikes.
- A one-way transit lane with a wide shared sidewalk.
- A one-way transit lane with two-way bike lanes.

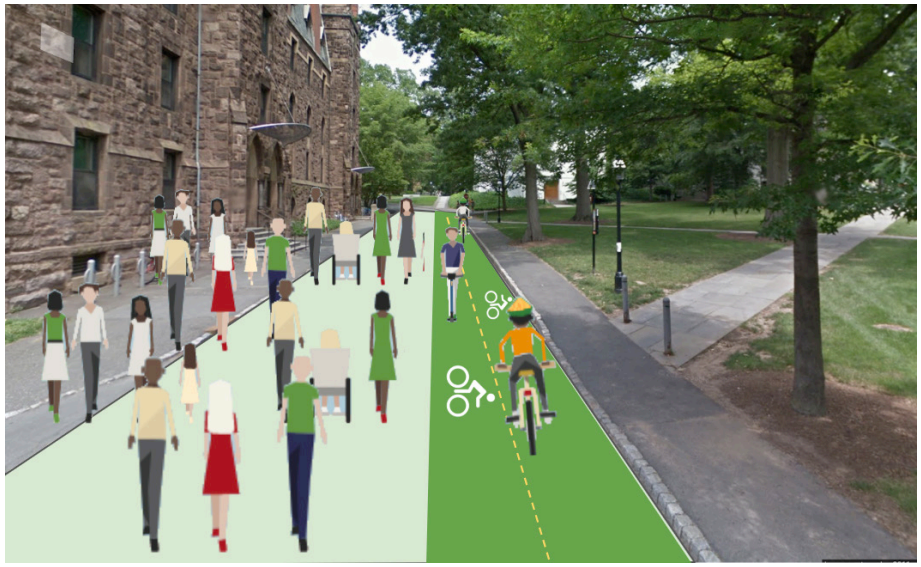


The High Frequency Concept includes more frequent routes with large numbers of riders, but covers a more limited area.

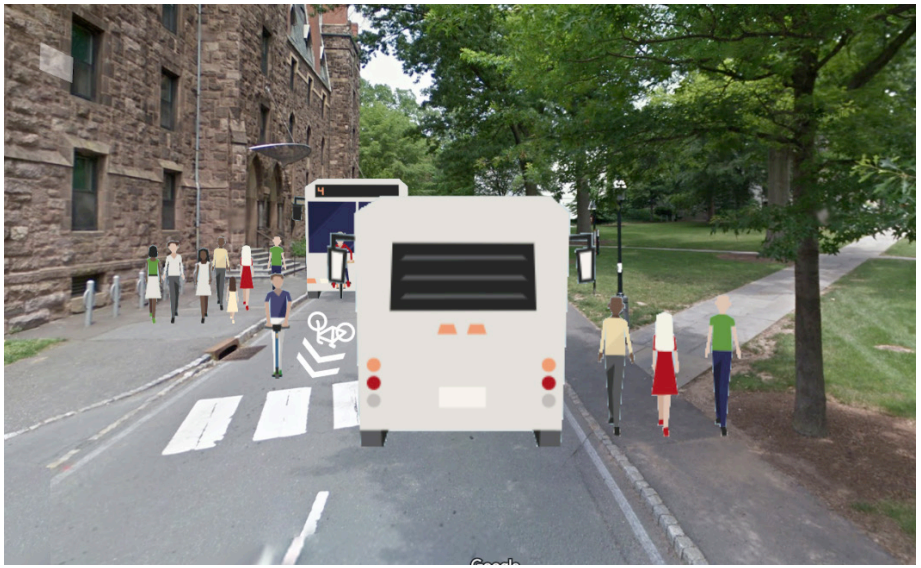


The High-Coverage Concept includes infrequent routes but covers a larger area and more buildings.

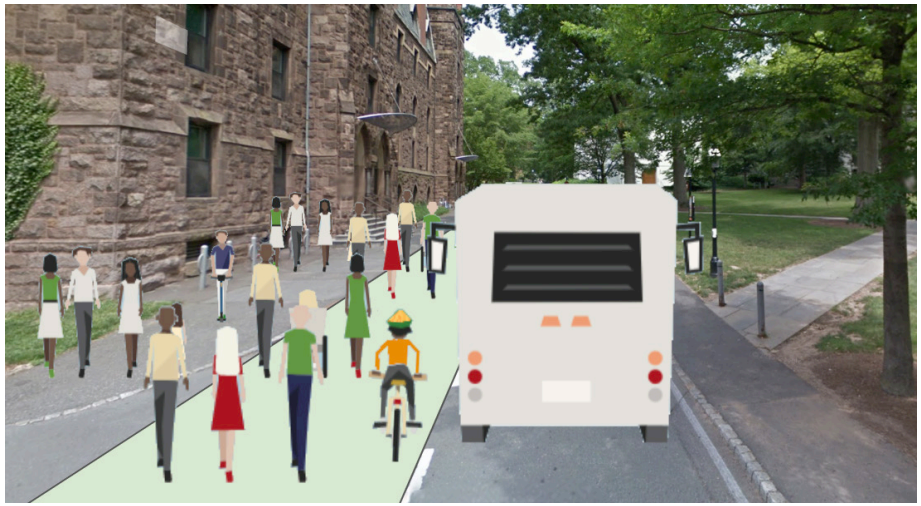
Concepts for Elm Drive



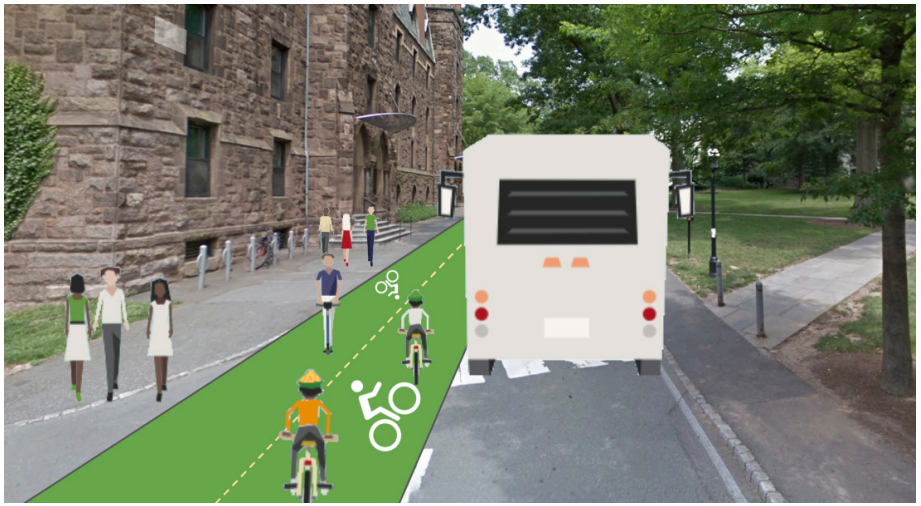
A. Promenade with bike lanes



B. Transit and bikes share lanes



C. One-way transit (with a wide shared sidewalk)

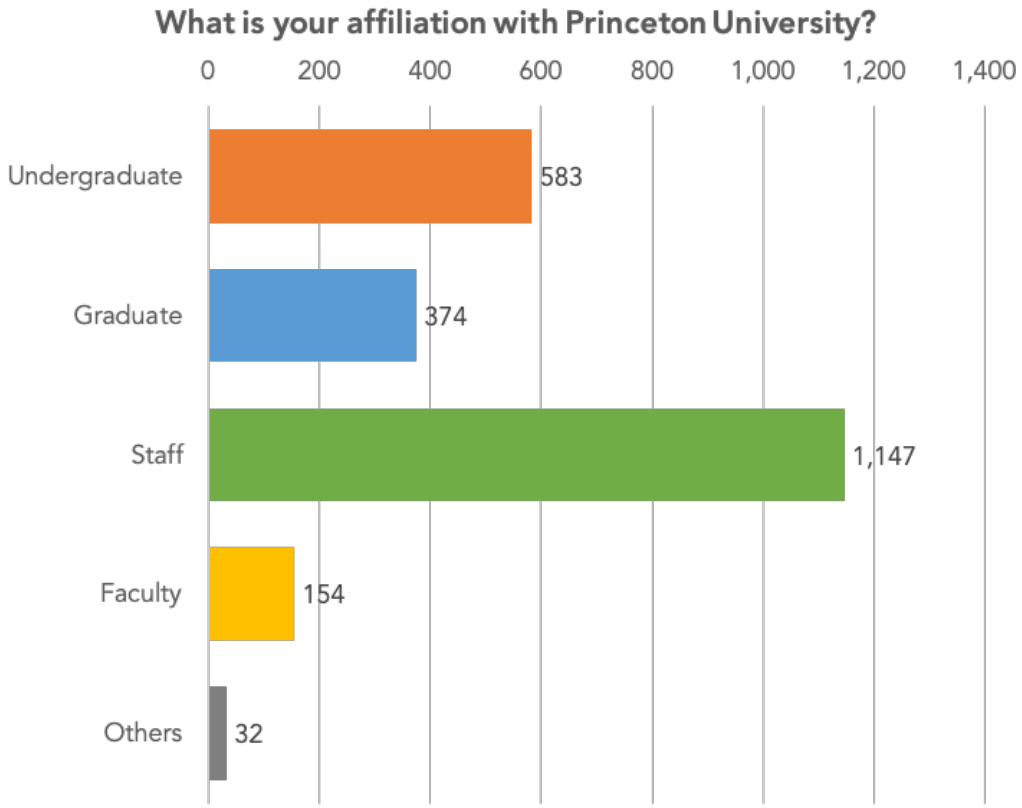


D. One-way transit (with bike lanes)

Survey participation

Almost 2,300 people responded to the survey. Hundreds of people attended the open house, where they answered questions similar to the online survey but using stickers on large poster boards.

As the chart on this page shows, the online survey respondents skewed toward staff (50% of all the responses) so the results here are separated by demographic group so we can better understand the preferences among undergraduate, graduate students, faculty, and staff.



Walking is the most common mode of travel

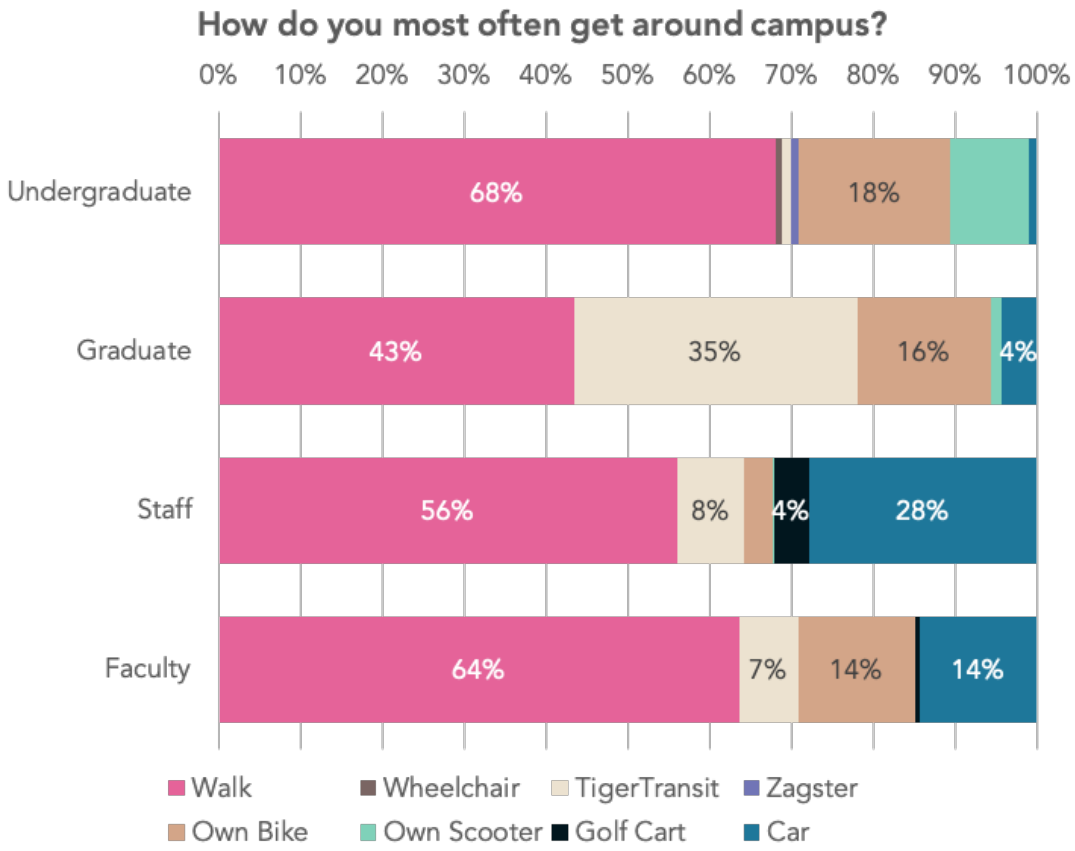
Every group reported that walking is their predominant mode of transportation on the campus by large margins. Among undergraduate students and faculty, 'own bike' was second, and for graduate students TigerTransit at 35% was a high second. Among staff, car was the second most common mode at 28%.

"I never take the bus because I find it faster to just walk, so I always walk."
—An Undergraduate Student

"The highest traffic currently on TigerTransit are the buses that go from graduate housing to campus...These routes NEED to be prioritized, because the bulk of TigerTransit clients use these services."
—A Graduate Student

"Personally, I will walk to anything on campus and have used the shuttle service only when traveling off main campus."
—A Staff Member

"I have never used TigerTransit, and I don't expect ever to use it. I walk or bike."
—A Faculty Member



Preference for walking over waiting

When given a hypothetical scenario that describes a choice between waiting for 15 minutes for a bus at one's doorstep or walking for 5 minutes to wait for a more frequent bus, large majorities of all groups expressed a strong preference for walking.

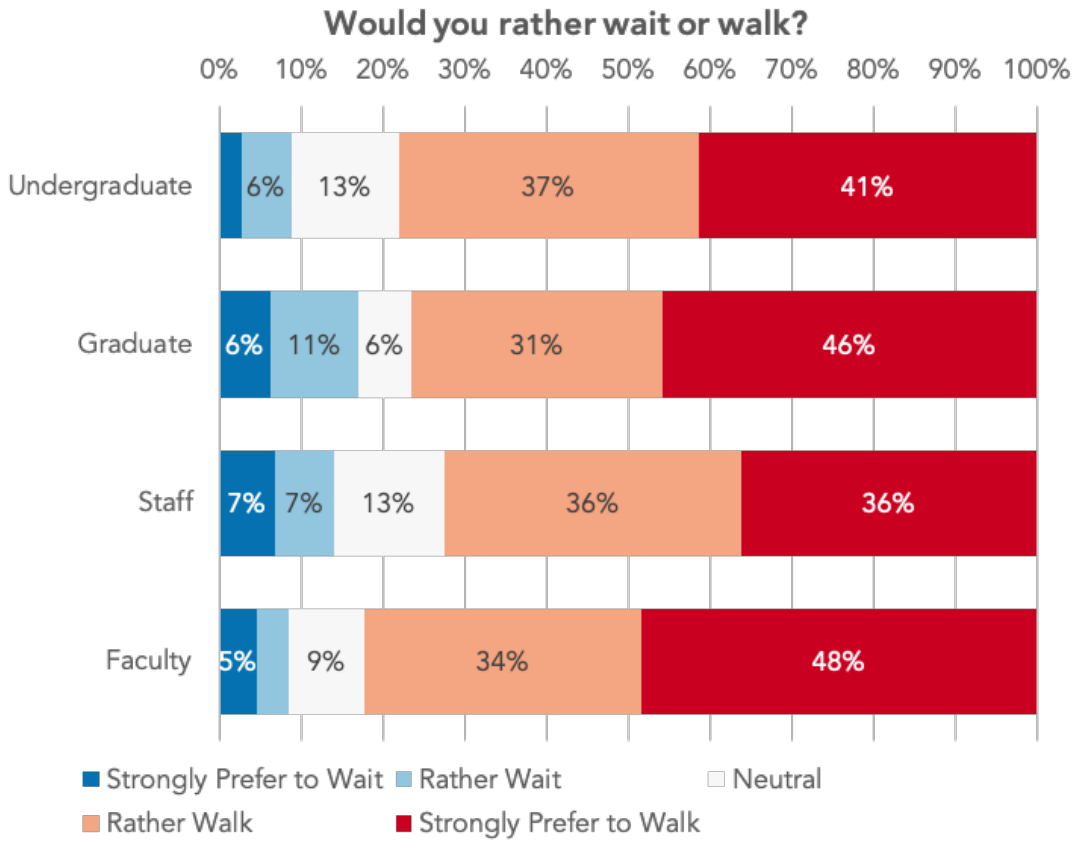
For all respondents combined, 75% said "I'd rather walk" or "I'd strongly prefer to walk."

"As an undergrad I don't go to the far out places and stay on central campus so longer waits would generally mean I could walk there faster since campus isn't that big."

—An Undergrad Student

"I like the idea of shorter waits (a long wait time kind of defeats the purpose of a bus *for me* because I know I can walk pretty much anywhere on campus in the time to wait 15 minutes for a bus), but as a commuter, I like the fact that (as far as I can tell on the map) the second, longer-wait option has a bus that stops in Lot 20. If it's terrible weather, I might consider using a bus that departs from that grad parking option."

—A Graduate Student



"For my particular situation, there is less opportunity for me to travel to outlying locations; exception is 701, in which case I would prefer to drive my personal vehicle. For an afternoon meeting up campus, it wouldn't make sense to wait 20-30 min. for a shuttle when I can walk in less time (for example, MacMillan to E-Quad)."

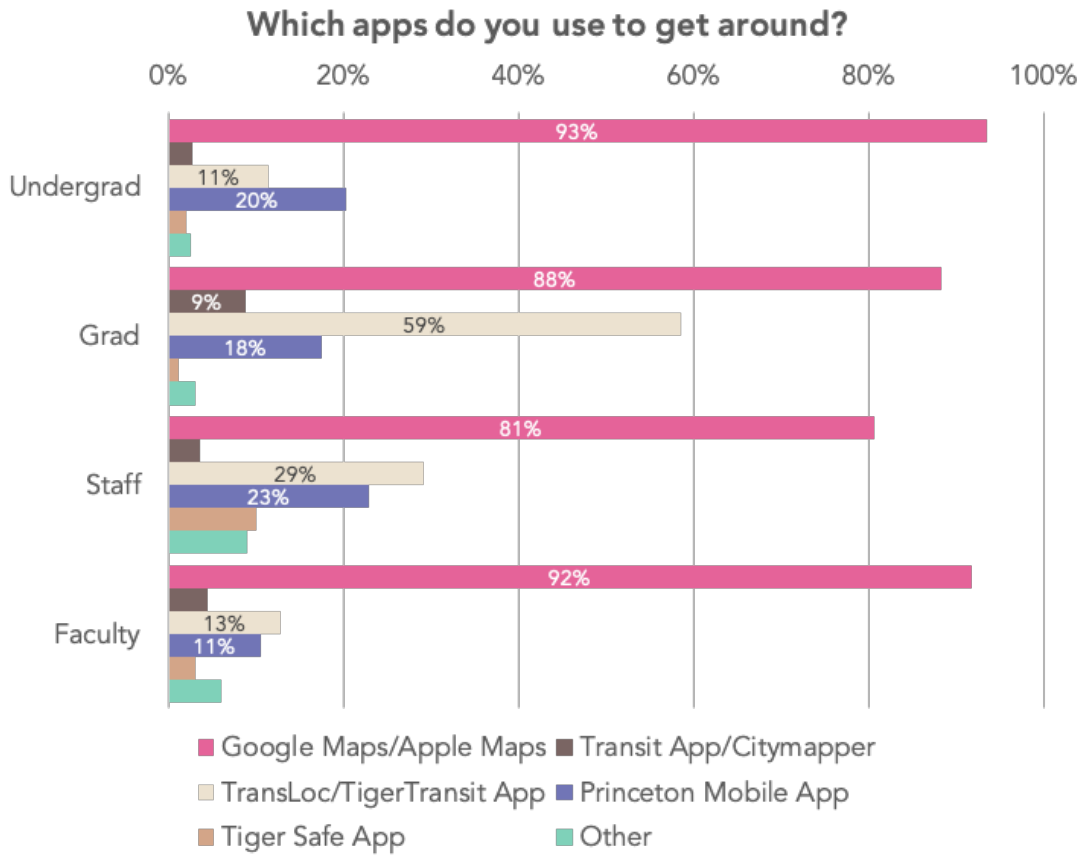
—A Staff Member

Google Maps and Apple Maps predominate

The survey asked which applications people use to get around. Google Maps and Apple Maps are the most used among each group with other choices much less used. Graduate students were the exception in that nearly 60% of them also used the TigerTransit app.

The free-form comments after this question included more than a dozen complaints and details about how and when the existing real-time arrival app is incorrect (respondents were also critical of the bike share app).

Another common refrain was the desire to have schedules posted at bus stops or at least phone-friendly PDF schedules available online, so that people can "fact check" the real-time app, and for international students who do not have internet access through their phones.



"The [current] app is so bad. In my experience, living at Lakeside, it is literally wrong more often than right...the information about when the buses are going to arrive is right maybe half the time, and often it's just nonsensical."
—A Graduate Student

"Real-time updated electronic or app-based countdown clocks to the estimated arrival of the next tiger trams at transit stops would be very helpful in knowing whether to wait or walk."
—A Faculty Member

"Please just make the bus schedule and system more accessible to find on phones and the app more accurate with times and places of buses."
—An Undergraduate Student

People don't mind walking with bikes but many dislike walking with scooters and carts

When asked about walking on campus with bicyclists, all groups overwhelmingly responded they were not bothered about sharing space with bikes. However, scooters and golf carts drew different reactions. Undergraduate students were most positive about scooters, though 40% of them said they don't like walking with scooters. Staff members were the most positive about golf carts.

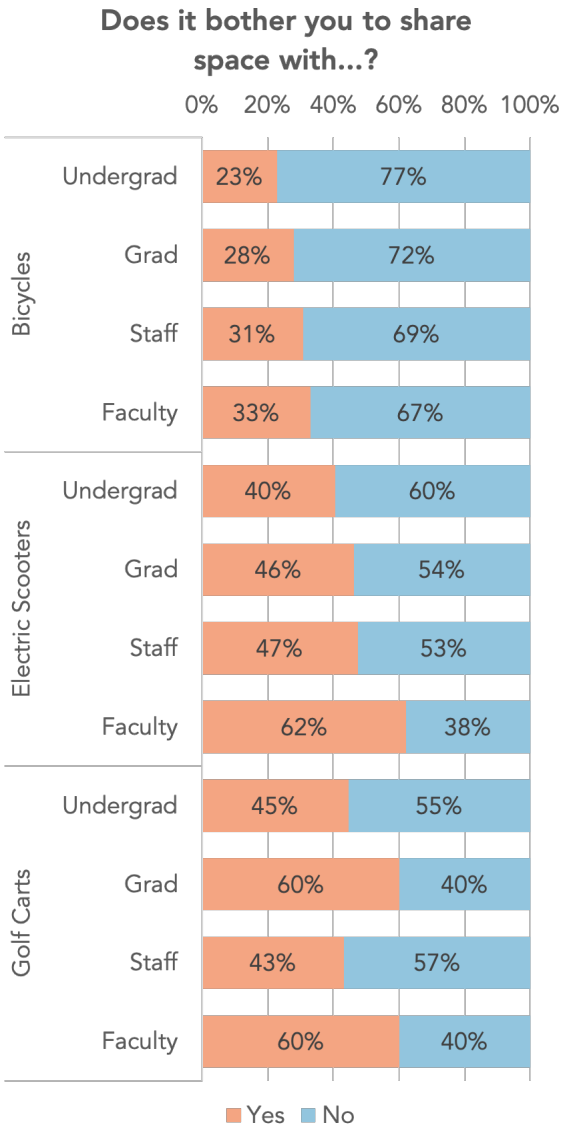
"Campus scooters are a hazard to inhabiting this campus. Particularly horrible are people who listen to music while on a scooter, but I don't know how you can do anything about that."
—An Undergraduate Student

"I'd prefer to keep bikes and electric scooters on the road away from pedestrians. I have young kids walking with me and find the people on bikes and scooters aren't always considerate of unpredictable children."
—A Graduate Student

"Separating bikes/scooters from pedestrian walkways is high priority for safety reasons. Have been nearly run over many, many times. It's scary to walk in some areas on campus at certain times."
—A Staff Member

"I don't mind the bikes so much, but these skateboards and motorized scooters can be scary!"
—A Faculty Member

"Specified bike lanes makes it safer for everyone: pedestrians, cyclists, and cars. The pedestrian lane should be clearly marked and protected so that cyclists don't zip around one another and venture into the pedestrian space."
—A Faculty Member

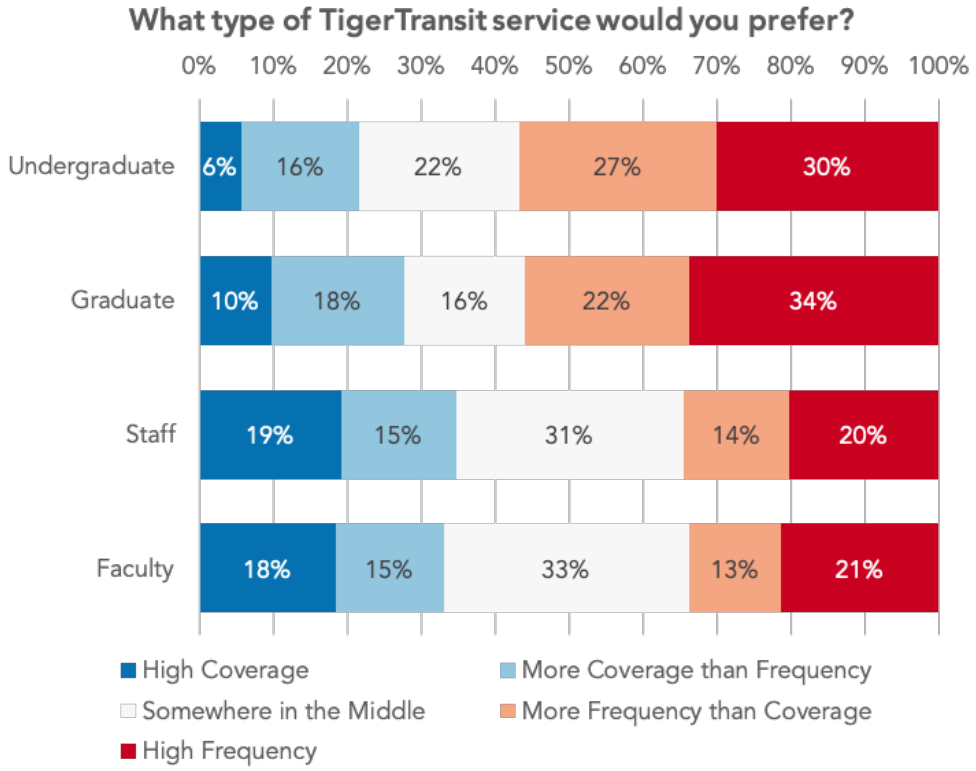


Survey responses to the transit Concepts were divided

When faced with the choice between higher frequency and higher coverage (concept maps on pages page 38 and page 39), students and non-student groups reacted differently:

- Students, both graduates and undergraduates, tended to favor frequency.
- Staff and faculty were evenly split between high frequency and coverage, with the plurality remaining neutral.

With all responses combined, somewhat more people chose "High Frequency" or "More Frequency than Coverage" (43%) than chose "High Coverage" or "More Coverage than Frequency" (30%).



"Princeton is not a large campus and most of the main campus can be reached by walking...I seldom ride the bus on campus because it is almost always faster to walk, even from the parking areas. Buses are more useful when they connect remote areas to main campus."
—A Faculty Member

"I enjoy walking, so I'd rather have bus service for longer distances too long to walk versus shorter ones that are very walkable."
—An Undergraduate Student

"While the High-Frequency concept is most appealing (given the wait times we've experienced, and given that the main campus is not so large that we can't walk a little farther to arrive at a stop), I am concerned by the idea of no service to outlying areas like 701 Carnegie, Forrestal, and PPPL. It's simply not realistic to expect people to walk or bike to these locations (especially in bad weather), which leaves private car and Uber/Lyft."
—A Staff Member

"I like the simple high frequency concept, but feel that this would be very concerning to people working at PPPL and off campus places so want to make sure that is considered."
—A Graduate Student

"If I were taking a bus and it was going to take more than 15 minutes to get to me, I wouldn't take it. I feel like the longest walks on campus are maybe ~20-25 minutes end to end, so if I have to wait more than that it isn't time efficient."
—An Undergraduate Student

"I like the high frequency, but there needs to be some way to get from 701 to campus. If private car, that's OK but there would need to be parking available within 5 minute walk of the bus. I split my time between campus and 701."
—A Staff Member

"I work in 693 Alexander, and I am strongly in favor of high frequency, even knowing that it removes a route from 693. I'd rather drive to a large lot on campus that is frequently serviced by a shuttle. It's not worth it for a shuttle to come to 693 infrequently."
—A Staff Member

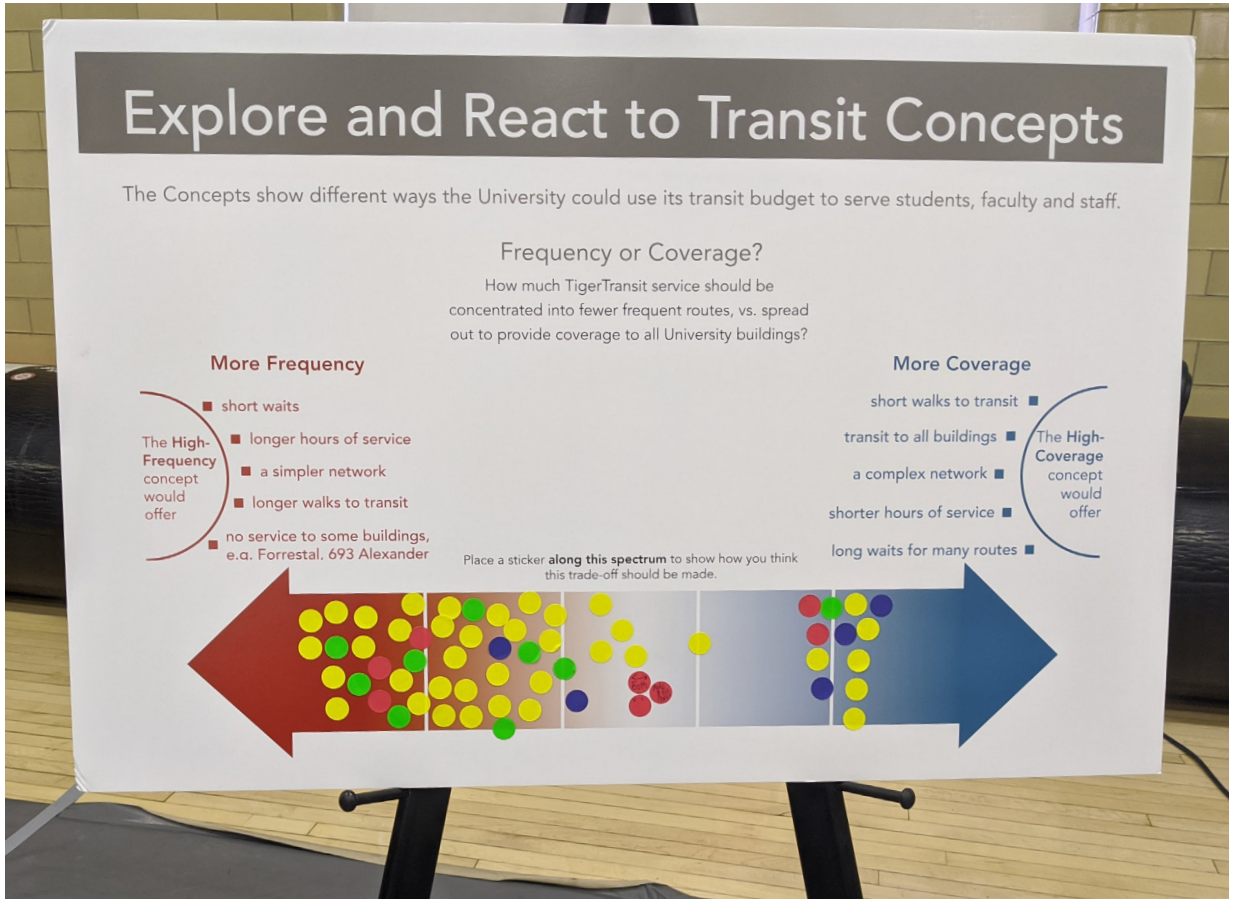
"I work at PPPL. For me and for some of my colleagues, it is crucial to have the option of using the TigerTransit even if it only comes every hour."
—A Faculty Member

"There should be a high frequency option that also provides service to 693 and other Princeton sites. The University Library in particular has staff that work on campus and over at those locations."
—A Staff Member

"More frequency means people can get places faster. There is nowhere in Princeton I would wait 15-30 min. for the next bus when I could just walk or take an Uber. Students are busy and don't want to wait."
—A Graduate Student

Most open house attendees preferred High Frequency

Among the people who attended the Open House, there was much more interest in "More Frequency" than "More Coverage," as shown on the sticker board at right. Sticker color denoted someone's role at the University. Yellow stickers were used by staff.



No consensus on the Elm Drive Concepts

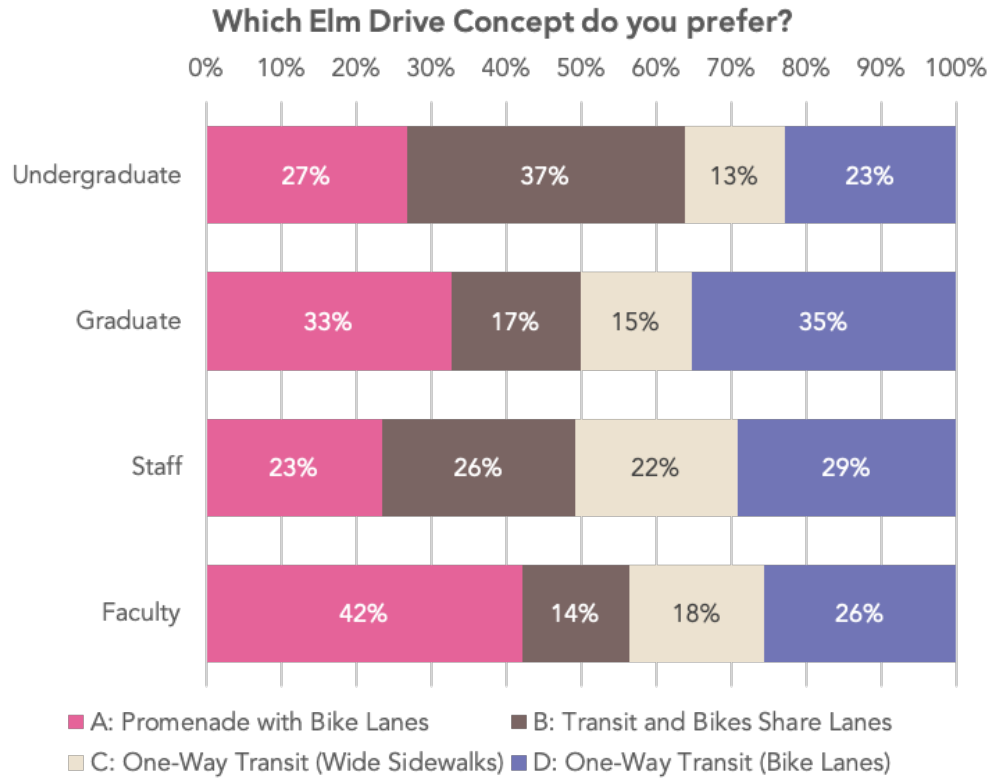
When presented with the four alternative configurations for Elm Drive (pictured on page 40) no group expressed a majority preference for a particular concept. Three of the Concepts were the most popular (by a sometimes thin margin) within at least one group:

- More undergraduate students chose the two-way transit Concept;
- More graduate students chose the one-way transit with bike lanes (but the promenade with bike lanes was a close second); and
- More faculty chose the promenade with bike lanes.
- Staff were almost evenly divided between all four alternatives.

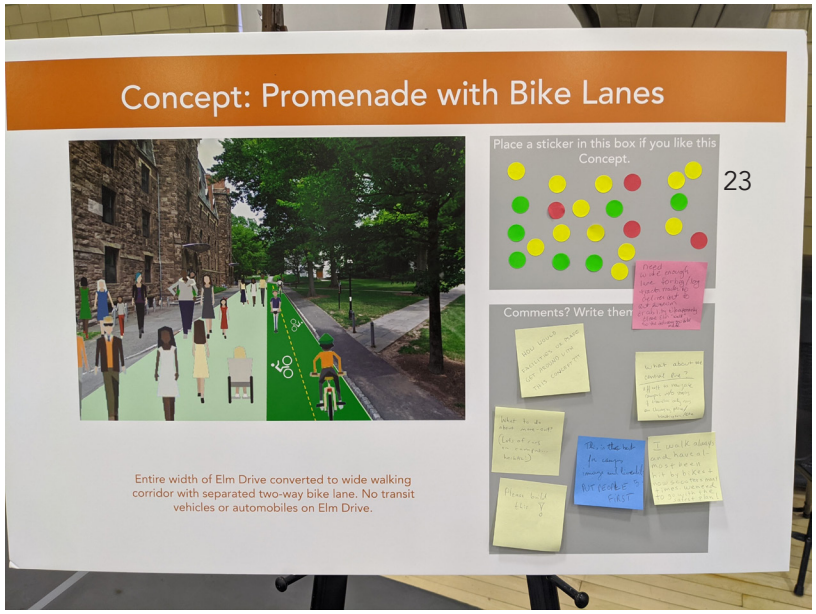
With all responses combined, the one-way transit concept with wide sidewalks received 18% of the votes; the other three concepts, split the balance of the votes nearly evenly, each receiving 26-28%.

Among the people who attended the Open House, there was a greater gap between the preferred and non-preferred concepts (photos of the four sticker boards from the Open House are on page 50). The concept showing one-way transit with bike lanes was by far the most popular, receiving 38 stickers. The second-most popular choice was the promenade with bike lanes, with 23 stickers. The other two concepts got just 8 and 5 stickers.

From these two sources of input, the one-way transit concept with wide sidewalks (shared among people walking, biking or scooting) is the least liked. We suspect that the lack of separation between bikes or scooters and pedestrians was a problem for many people, and that people were drawn to the bike/pedestrian separation shown clearly in the other three concepts.



Open House feedback on Elm Drive concepts



A. Promenade with bike lanes

B. Transit and bikes share lanes

C. One-way transit (with a wide shared path)

D. One-way transit (with bike lanes)

"As is, very few people use Elm Drive as a vehicle-way, yet the right of way is still dominated by automobile use rather than as a pedestrian or biking friendly thoroughfare. It's prominent placement in the center of campus as a biking and walking friendly zone will encourage more individuals to convert to biking."
—A Graduate Student

"Driving on campus should be minimized. People don't expect cars."
—A Staff Member

I think a promenade with bike lanes, but also includes a lane for golf carts/small vehicles, would be best. No cars or buses.
—A Staff Member

"We should encourage people to walk or bike in the main parts of campus."
—A Faculty Member

"I would prefer to have buses on outskirts of campus and limit internal campus to walking and bicycles."
—A Faculty Member

"I would keep buses off Elm."
—A Faculty Member

"My department is currently located along Elm Drive, and we frequently need to move various pieces of equipment for workshops or trainings that we are hosting (e.g. 6 CPR mannequins to be transported to the E-quad). For that purpose, it is incredibly helpful to be able to access our office by personal car. These instances are irregular but frequent, and getting materials to the appropriate location already is a headache even with cars. Other than this specific business need, I like the promenade (A) concept."
—A Staff Member

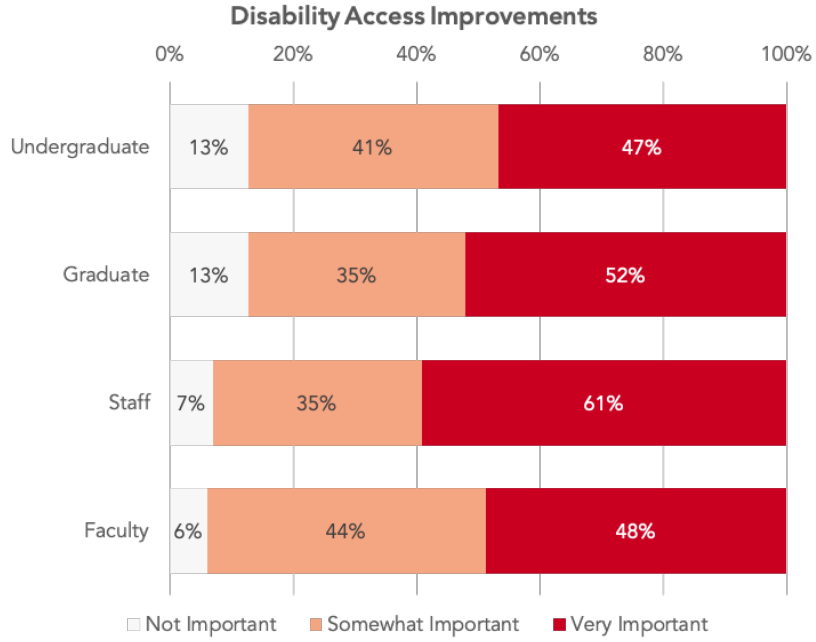
Given that I never use or plan to use Tiger Transit, I would prefer the option that is less disruptive to pedestrian and bike traffic. If Elm and Washington have less car traffic, the campus becomes better walkable and bikeable."
—An Undergraduate Student

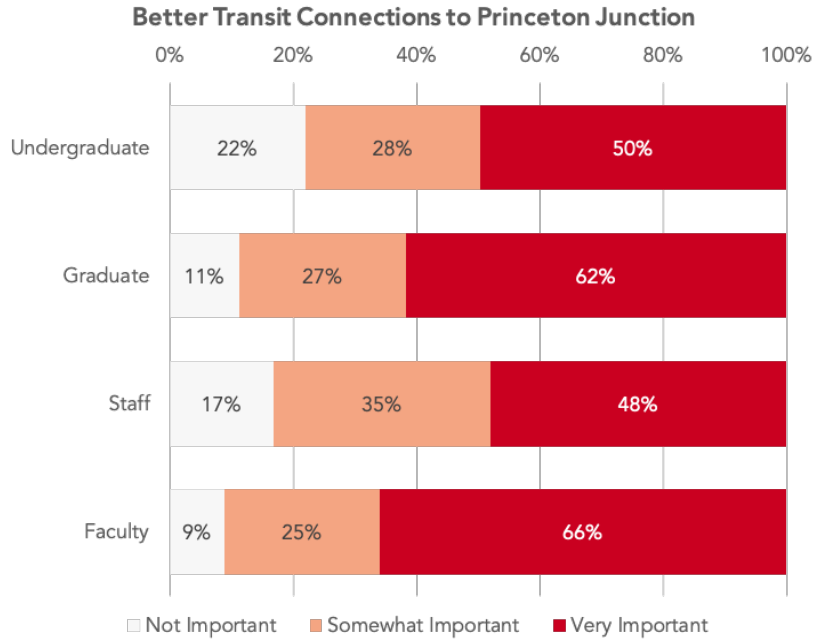
All respondent groups rank disability improvements and better connection to Princeton Junction as very important

We asked the survey respondents to rank several potential mobility improvements on campus as "not important", "somewhat important", and "very important".

Respondents placed the highest value on increasing accessibility for people with disabilities. At least half of the respondents in every category rated it as "very important". Among all respondents, the weighted rank for "Improve disability access, e.g., sidewalk ramps" was higher than any other choice.

Better transit connections to Princeton Junction was next-most-often ranked as "very important" and had the second-highest weighted rank.





"Make the Dinky free! Or make it more frequent!"
—An Undergraduate Student

"A TigerTransit route to Princeton Junction would be helpful."
—An Undergraduate Student

"Could we have a bus that goes to Princeton Junction, the Dinky is so unreliable!"
—A Graduate Student

"It would actually be much more helpful to have more shuttles go to and from the Princeton Junction station. You have to hope to God that the NJ Transit trains line up to get you to campus."
—A Staff Member

"The university offers so many incentives to take public transportation, they should find a better way to integrate local transport with regional transport."
—A Faculty Member

"More than anything I would like a fast and easy way to get to the Dinky and, if possible, to the Princeton Junction train station."
—A Faculty Member

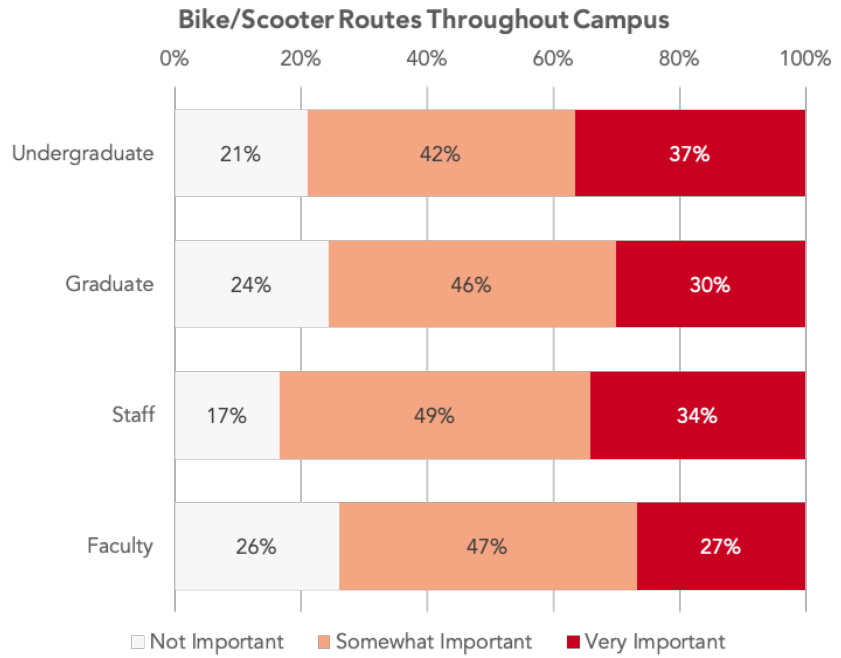
"I barely use TigerTransit, because my commute is from the Princeton Junction station to the Northeast corner of campus. That route is currently *very* poorly served, since the Dinky is so far away."
—A Faculty Member

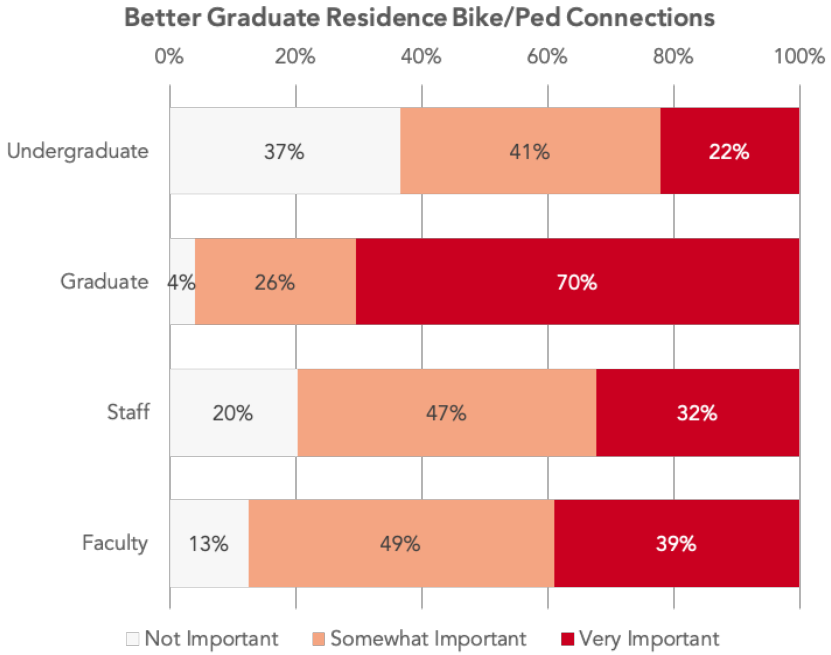
"There needs to be a mobility audit done especially for people who need to use wheelchairs or other assistive devices. I confess to not being aware of just how difficult it is to get around until I broke my ankle and discovered that many buildings don't have easily accessible ramps for people in wheelchairs/using medical scooters."
—A Faculty Member

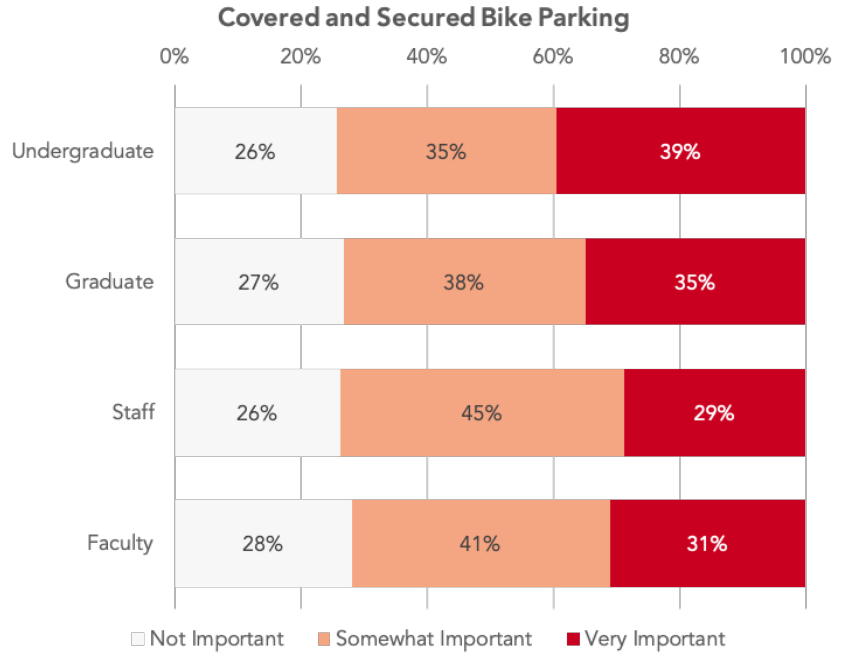
Improvements to walking and biking conditions were rated highly

Graduate students overwhelmingly think that safe and attractive walk and bike connections to residences are very important. Even with all responses combined, "Safe and attractive walk and bike connections to grad residents" was the third-highest ranked item.

Dedicated routes for biking and other 'rolling' devices like scooters were ranked highly, as was more secure bike parking.







"Walking to Fine Hall through the Butler/Wilson area has become very stressful and dangerous with all the bikes and scooters, especially in high traffic times. There needs to be a much better solution that makes it safe for pedestrians to walk when everyone is looking at their phones."
—An Undergraduate Student

"[Create] more bike mobility through campus with bike lanes."
—An Undergraduate Student

"Make sure it's completely rolling accessible, not just for bikes but for wheelchairs, etc."
—An Undergraduate Student

"More covered bike parking at grad residences! My bike, which I use daily for commuting and exercise, is currently rusting away [...] because I sometimes cannot get a covered spot due to the high volume of bikes and low availability. This is expensive (more maintenance and chain replacement) and unfortunate."
—A Graduate Student

"The Central Line is unnecessary. This is the center of the walking paradise."
—A Graduate Student

"Having a specific bike/scooter lane would be better to me. It helps to not have to dodge people when walking and it is more safe for the people on bikes to not share lanes with cars."
—A Staff Member

"Give bikes, scooters, and golf carts their own paths. It is frustrating to have them all on sidewalks. It is also frustrating to have utility vans/trucks parked on sidewalks and taking up much of the space."
—A Faculty Member

Respondents were unsure about micromobility

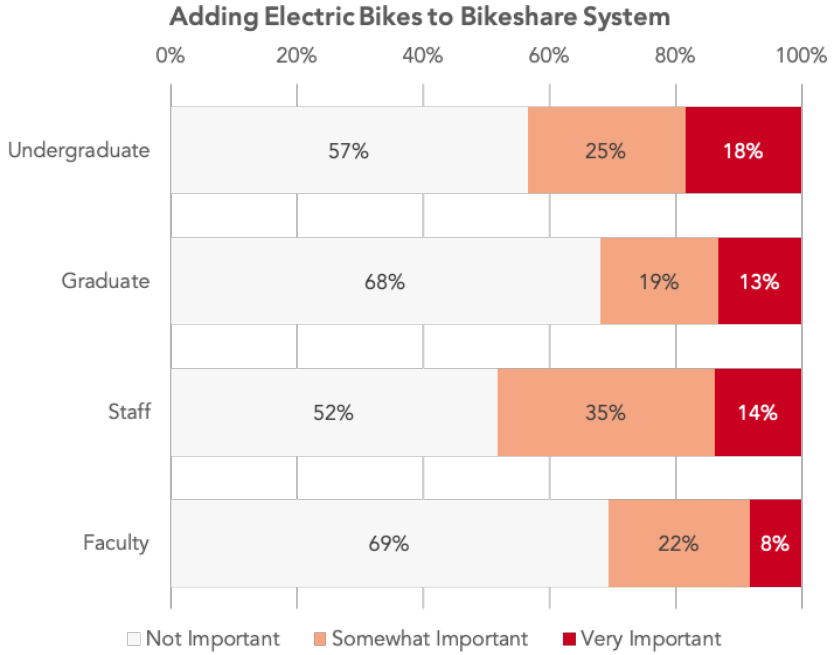
Compared to other mobility improvements, changes in shared micromobility were not as highly ranked in terms of importance.

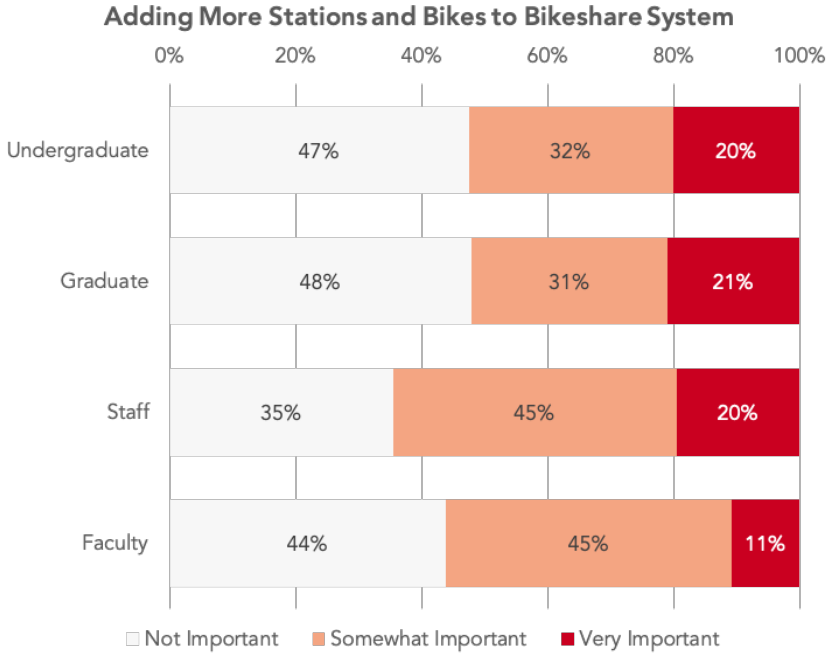
People seemed moderately interested in expanding the bike share system, but most respondents did not feel that adding electric bikes or scooters to the system was important.

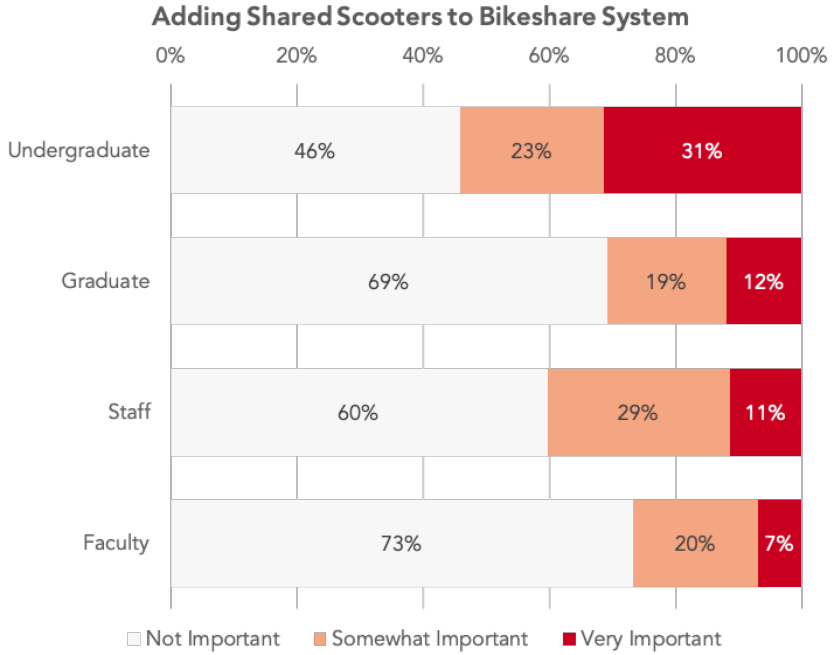
We recommend expanding and improving the bike share system, despite the lack of stakeholder enthusiasm for it, because it has potential to be much more efficient than transit for short trips on campus, and because it can reduce the incentive for students to get private scooters, which are currently causing such discomfort and accessibility problems on campus.

We recommend adding electric bikes to the shared system because of how much electric bikes have increased the use of shared bikes in other places.[1]

1 LA Metro Bike Share's e-bikes, launched in May 2019, had an average of 4.57 rides per bike per day, compared to the systemwide FY19 average of 0.76 (learn more here). However, e-bikes are more expensive, and some cities, such as LA and Philadelphia, have experienced higher theft rates of their e-bikes.







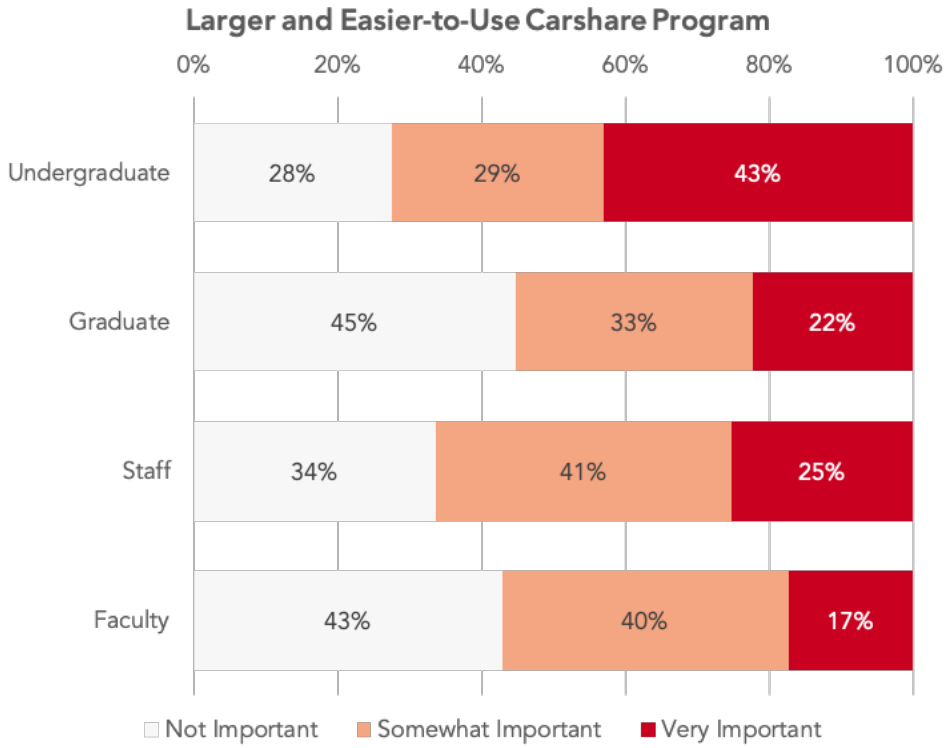
Undergraduates were especially interested in car share improvements

Many people thought improving car share would be important, especially undergraduate students, probably because they are not permitted to have a car on campus.

Many people expressed frustration with Zagster shared bikes

Many people used the free-form comment boxes in the survey to express frustration with the current bike share system. These complains took three forms:

- Not enough bikes, or not enough bikes in the places where someone wanted them at the times they wanted them.
- Bikes that were inaccessible (e.g., behind a locked door) or locked up with a private lock.
- Problems with the app being "glitchy" or giving bad information.



"More Zagster stations and shared bikes or scooters...definitely needed. Zagsters never seem to be there when you need them. Many are damaged or essentially privatized as students put personal locks on them and don't return them... Shared scooters would be a great addition, especially for grad students."
—A Graduate Student

"Having an easy car share program for students that doesn't require the expensive fees that most rental agencies require would be a *huge* improvement. Many students feel very stuck on campus and are required to pay a lot to Uber to doctor's appointments, hikes, concerts, restaurants, etc. The most important of these initiatives in my opinion is short-term rental programs for students to be able to get dinner off campus (even at a place as close as Princeton Shopping Center with Nomad Pizza)."
—An Undergraduate Student

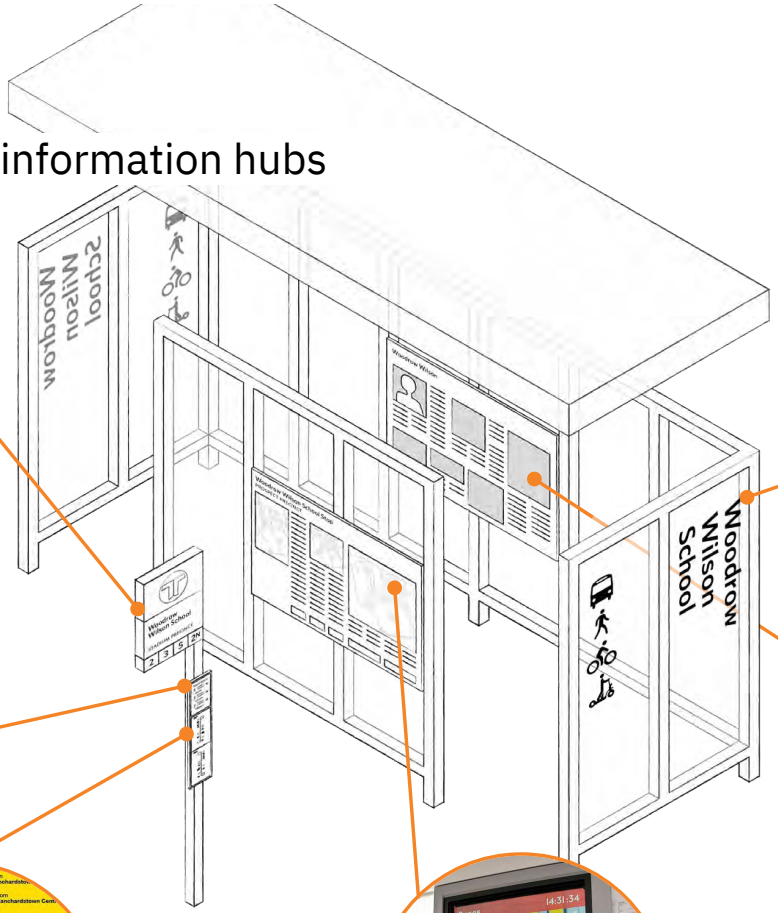
"I wish the car-share program allowed me to go from the Trenton Transit Center to campus and back. I commute from Philly and the Trenton-Princeton campus leg of my trip is the most difficult."
—A Faculty Member

"I participate in Zagster, but it is often a mess – broken bikes, bikes that really aren't available once you reach them. Would appreciate it if there was better maintenance. I also participate in the Enterprise Car share program and it works beautifully. Very reliable."
—A Staff Member

Appendix

Recommendations from the University's wayfinding project

Tiger Transit
Bus stops as information hubs



Bus flag
Identifies the stop from distance. Shows the stop name and which routes operate from here.

Stop naming
Reinforces the bus stop name

Real-time departure information
Provides reassurance that a bus will depart soon

Route diagram
Shows where you can get to from this stop

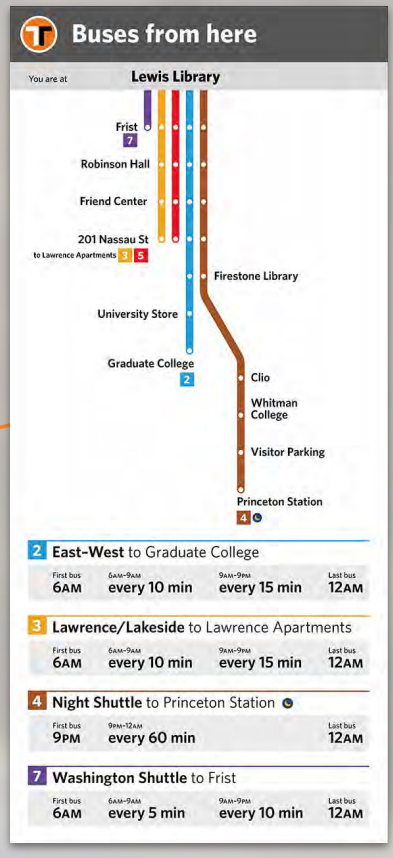
Transit diagram and onward journey information
Provides information about wider transit network. Shows where you can walk to from the stop.

Interpretive opportunities
Shelters offer opportunity for artwork or information that provides a sense of place

129

Tiger Transit
Bus flags advertise services

Live departure times
Provision of live departure times gives the user confidence and ease of mind.



Route diagram
Detailed information showing all routes servicing the bus stop. A timetable or service frequency can also be included.

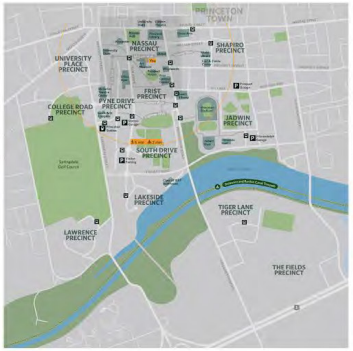
130

Tiger Transit
Information at bus shelters

PLAN YOUR JOURNEY

Transit network

Princeton University



Building Index

Nassau Precinct

Transit Network Map
Gives an overview of all available transit services (including non-Tiger Transit).

Campus Map & Precinct Map
The same two map scales and building index as on other map-based signs give the user an overview of the campus and a detailed view of the Precinct they're in.

Tiger Transit

Information inside the bus can strengthen understanding of the network

Transit Diagram & Next Stop Information

132