LONG-RANGE REGIONAL TRANSIT PLAN

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Pima Association of Governments

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1 Summary: Why and How Should Transit Improve?

The Tucson region needs better alternatives to automobile travel.

A landscape made for cars

Since 1950, Tucson has transformed from a small town of 50,000 in the Sonoran Desert to the center of a metropolitan region home to over 1 million people. This transformation was enabled by - and planned around - the widespread use of the automobile.

This is clear from the shape of the region's buildings, streets and neighborhoods. Wide and fast thoroughfares like the Miracle Mile and Broadway Boulevard were built with driving in mind, even when most of the city was still on gridded streets close to Downtown. More recent development in suburban areas has reinforced this further, with large arterial roads connecting subdivisions to commercial areas.

The design and planning for cars is reflected in how people behave. From 2012 to 2016, American Community Survey (ACS) data tell us that over 86 percent of commuters in the Tucson metro area reported driving to work in a private vehicle. Local data from Pima Association of Governments (PAG) suggest that transit rides account for only 1.5 percent of all trips in the region.

Despite the very low share of public transit in existing trips, there are good reasons to think that many people would use alternatives to driving, if they were more viable.

Many people have limited access (or no access) to a car. ACS data suggest that nearly one in 10 people in the Tucson region live in zero-vehicle households. Meanwhile, 24% of all households have at least two more people than vehicles. As a result, many people rely on friends, neighbors and family for transportation when they cannot use public transit.

Household transportation costs are high. According to the Center for Neigborhood Technology (CNT)[1], the average household in Pima County drives nearly 20,000 miles per year, and spends over $12,000 per year doing so. That amounts to 26% of the average annual household income. The cost of owning, maintaining and driving a vehicle is in many cases higher than the cost of housing.

Household incomes are low. According to the CNT, the median household income in the Tucson area stands at about $46,000, 15% below the national average. In the City of Tucson, the median household income was only $40,000. High transportation costs impact low-income populations disproportionately.

1 See https://htaindex.cnt.org/map/, as accessed on Jan. 9, 2020.

Figure 1: Miracle Mile in 1958. The development of Tucson from a small desert town to a major metropolitan area has always revolved around increasing the number of places that can be reached by driving in a car. Still, many people today have limited (or no) access to a personal vehicle.

Photo Credit: Tucson Historic Preservation Fund

1 IN 10 PEOPLE LIVE IN HOUSEHOLDS WITH NO VEHICLES

1 IN 4 HOUSEHOLDS HAVE **2** MORE PEOPLE THAN VEHICLES

$12,000 ANNUAL TRANSPORTATION COST PER HOUSEHOLD

$40,000 AVERAGE HOUSEHOLD INCOME IN THE CITY OF TUCSON

$46,000 AVERAGE HOUSEHOLD INCOME IN THE TUCSON REGION

26% OF HOUSEHOLD INCOME IS SPENT ON TRANSPORTATION

Public transit is the most viable alternative to the car for large numbers of trips.

Why focus on transit?

Because of the long distances between homes, schools, shops and jobs in the Tucson region, most people cannot meet their transportation needs on foot, scooter or bicycle alone. This suggests a significant opportunity for motorized public transit.

Of course, transit isn't the only alternative to owning and driving a car. Ridehailing (like Uber and Lyft) and taxis are available in many areas. But these options are more expensive per mile than driving a private car, so very few people can afford to use them on a daily basis. Other alternatives like carpooling and vanpooling only work when several people who know each other come from and go to the same place at the same time.

Another alternative could be on-demand dial-a-ride service, similar to the paratransit service that is required for eligible disabled users by the Americans with Disabilities Act (ADA), or subsidized ridehailing. But this is extremely expensive to extend to the general public, because each trip would cost at least as much as the equivalent taxi ride.

Public transit on fixed routes can help bridge the gap. In the right conditions, fixed-route transit can do two things:

- Extend how far people can go on foot, or on a bicycle, providing some of the benefits of access to a private vehicle but at a much lower cost and without relying on friends or family.
- Replace driving trips in times and places where driving a car is inconvenient or too expensive.

Benefits of Transit

Transit can't serve every trip, but it has many personal and community benefits, such as:

- **Transit is inexpensive to ride.** The Sun Tran public bus fare is less than $2 per trip on most routes, and includes transfers with a SunGO card. The cost of owning and driving a car is about $20 a day in Pima County.
- **Transit can move many people.** The average Sun Tran bus carries 25 passengers per hour and operates 16 hours per day. Most cars carry one or two people, and sit parked most hours of the day.
- **Transit requires very little space.** A typical sedan requires 70 square feet of road space for a single person. A typical bus carries 10 to 60 people on 400 square feet of road space. That's up to 10 times less road space per person!
- **Transit requires less fuel and produces fewer emissions than driving alone.** A conventional diesel bus gets 4 to 8 miles per gallon. That means it only takes 5 passengers on board to make a bus more fuel efficient than most cars. And Sun Tran's newer alternative fuel buses produce lower emissions then conventional diesel buses.
- **Transit is available to everyone near it.** Not everyone can drive or bicycle, and not everyone wants to. Transit allows all individuals the freedom not to rely on a personal vehicle, and not to depend on friends and family for transportation.

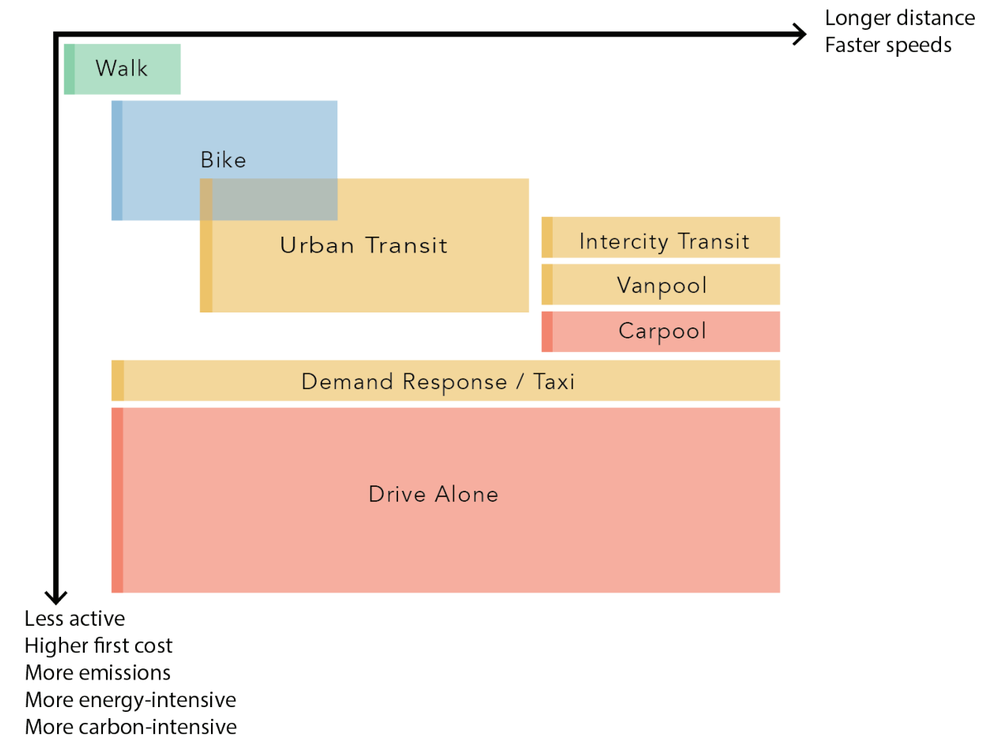


Figure 2: Different transportation modes are useful for different types of trips. When conditions are right, transit can extend the reach of biking or walking trips, or replace driving.

For transit to be a viable alternative, it needs to become more useful and liberating.

People will use transit when it offers satisfactory answers to the following concerns:

- **Access (or Freedom).** Where can you get to on public transit in a reasonable amount of time, compared to your alternatives?
- **Pricing.** What does transit cost, compared to your alternatives?
- **Individual Preference.** This includes subjective factors and other aspects of the transit experience. What are you doing later? Do you feel safe? How much stuff are you carrying home?

A long-range plan can't change how individuals feel about riding a bus on a given day, and it can't set fares and fuel prices 10 years into the future. But it can have a significant impact on how much access the transit network provides.

Ridership and Access (or Freedom)

Wherever you are, you can only reach a certain number of places in a reasonable amount of time. You can think of that range of places as a shape on a map around your location. Figure 3 shows two examples.

If you are located at a starting point shown on these maps, you can think of the edge of the blob around it as "the wall around your life." Beyond this limit are jobs you can't hold, places you can't shop, and things you can't do because it takes too long to get there. So the extent of this area determines a lot about your options in life: if you have a bigger blob, you have more choices, and you are more free.

The shapes in Figure 3 are centered around major destinations: the University of Arizona and Tucson Spectrum shopping mall. So in this case, you can think of the blobs as the areas from which people can access these places in a reasonable amount of time. If you're outside the blob, you're unlikely to go there by transit, even if you really need to and your other options are potentially expensive, or require you to ask for help from friends and family.

How Transit Creates Freedom

On transit, the extent of your freedom is determined by:

- **The network** of bus and streetcar lines with their frequency and speed, which determines how long it takes to get from A to B.
- **The layout of the city**. How many destinations are near each transit stop? Access to places where there are more useful destinations to jobs, services, etc. is valuable to more people.

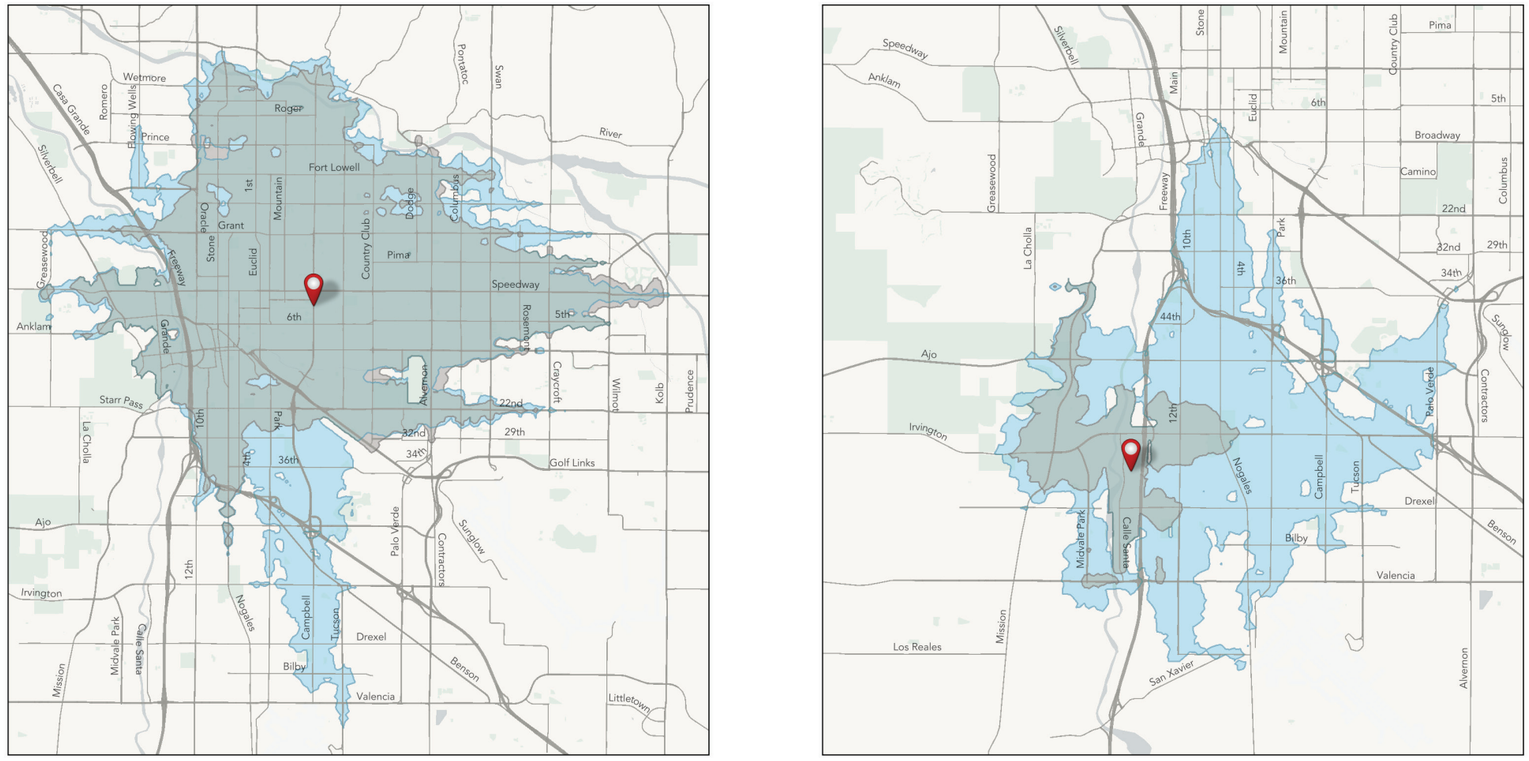


Figure 3: Map examples, showing how far one could travel in 45 minutes by transit from the University of Arizona (left) and Tucson Spectrum shopping mall (right) on a weekday at noon. Gray areas are reachable in 45 minutes today; blue areas would become reachable in 45 minutes with the Medium Term improvements envisioned in this plan. Because these and other important destinations would become easier to reach in a reasonable amount of time, the transit network could be useful for many more trips than it is today.

The way the network and a city's layout determine access from any point is simple math, but it's very important:

- **Access is key** for keeping people employed. If you are deciding where to live based on how you'll reach your job, school, or relatives, you are asking a question about access.
- **Access from any location** gives that location value. Real estate firms routinely study where you can get to by car from a property, and this is the same analysis for transit.

From Better Access to Higher Ridership

As an individual, transit becomes more useful when it provides you with more freedom. So planning for useful transit means planning for more freedom. More broadly, transit ridership arises from providing useful access to many people. So while increasing many peoples' freedom does not in itself predict ridership, it is a necessary foundation.

In planning for better transit, increasing the number of places many people can reach in a reasonable amount of time is the source of ridership that can be influenced the most.

Making transit more useful serves many goals

Expanding where people can go quickly on public transit helps meet many other useful goals, thanks to:

- **Higher Ridership.** People will only use transit if transit is useful. The essence of usefulness is that it's possible to make many trips that need to be made in a person's life. When we make more trips possible in a reasonable amount of time, we increase the likelihood that transit will be useful. Greater ridership also means:
  - » **Protecting the Economy from Congestion.** Higher ridership means fewer cars on the road.
  - » **Environmental Benefits** including reducing emissions that cause air pollution and climate change. These benefits depend on people using transit instead of driving, so they become greater as more people ride transit.
  - » **More Room for Redevelopment.** Private cars take up a lot of space, and higher density means less space per person. Tucson cannot build more densely if everyone has to drive a car everywhere. Higher transit ridership (and more cycling and walking) is critical to making redevelopment viable.
- **Increased Access to Opportunity.** This is an important policy outcome independent of transit ridership, for several reasons:
  - » **Access to Basic Needs.** People who do not or cannot drive need to be able to live, and this means access to shopping and errand opportunities. Expanding where people can go expands how many of these trips are possible on transit.
  - » **Economic Opportunities for Low-Income People.** For many people, lack of transportation is a primary barrier to accessing jobs. To empower people to improve their lives, useful transportation must be available to those who either can't afford a car or aren't able to drive.
  - » **Reduced Isolation.** Lack of transportation is also a barrier for people at risk of social isolation, including many senior citizens.
  - » **Civil Rights.** The ability to move around the city is a measure of physical freedom. People who lack transportation are effectively less free. For a variety of reasons, people with low incomes and people of color are less likely to own a car. Improving the ability of transit to get people to useful places means increasing the rights and freedoms of those who are most disadvantaged.

How This Plan Expands Access to Opportunity: An Example from the South Side

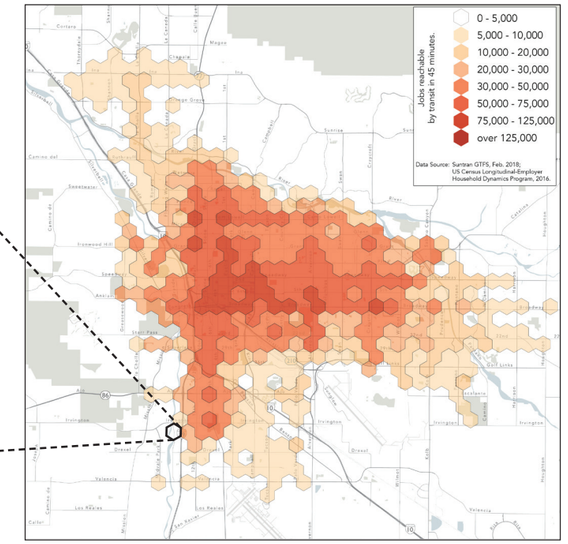
Isochrone Analysis shows how far you can go from a given location in a reasonable amount of time, as an area on a map. We can calculate the number of people and jobs in this area.

Access Analysis shows the results of running an isochrone analysis (see green box on the left) from anywhere in the region. The color of each hexagon indicates how many jobs are accessible for trips starting in that area.

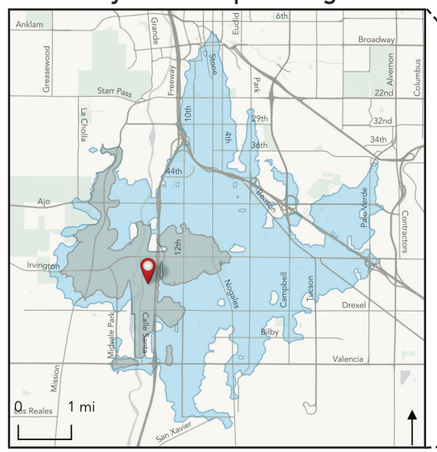
1. Where can I get to in 45 minutes on transit, door-to-door? *(includes walking and waiting)*

3,200 jobs accessible in 45 minutes

2. How much opportunity does that represent?



3. How many more places could I reach in 45 minutes, within 2-5 years of this plan being funded?



+28,300 more jobs accessible in 45 minutes

4. How much more opportunity does that represent?

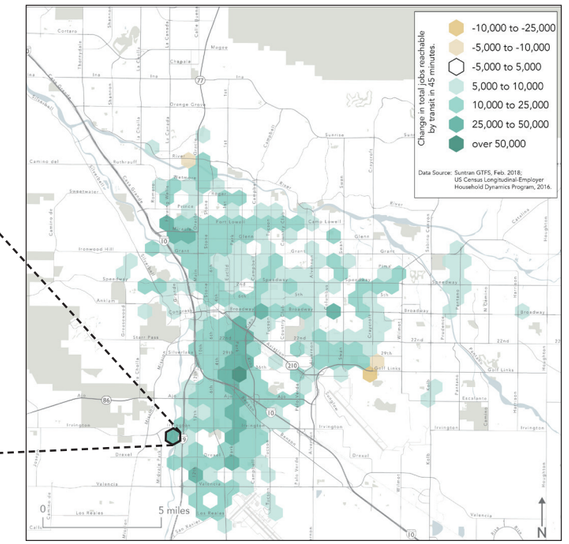


Figure 4: These maps show how we measure the access to opportunity provided by the existing transit network, and the change made possible by the improvements proposed in this plan.

More useful transit is more frequent transit.

How Frequency Increases Freedom

A transit network is a pattern of routes, where each line has a path, hours of service, an average speed and a frequency (i.e. how often a transit vehicle serves a stop).

Frequency is often the dominant element of travel time. More frequent service dramatically improves how far you can go, by providing several linked benefits:

- **Shorter Waits.** Waiting for the bus may be the most onerous part of using transit, since you're not moving at all. The more often the bus comes, the less time you wait.
- **Faster Connections.** Connections are the glue that combines a pile of individual routes into a network. The ability to change from one route to another is critical to reach all the places that are inevitably not on the line you happen to be on. Frequency makes connections easy, because the next bus is always coming soon.
- **Easier Recovery from Disruption.** Frequent service is more reliable. If a bus breaks down, the next bus is coming soon.
- **Spontaneity.** Rather than building your life around a bus schedule, you can turn up at the stop and go.

Because these benefits are independent of each other, transit becomes exponentially more useful as frequency improves.

Room for improvement

The high number of people in Tucson with limited or no access to a vehicle - and the significant expense involved in driving - suggest that many people would use transit if it were more convenient.

Figure 5 shows a map of the existing network, where each route's color reflects its weekday frequency. The network includes Sun Tran and Sun Shuttle bus routes, as well as the Sun Link streetcar.

Routes that operate every 15 minutes or better are drawn in red. These are known as the Frequent Transit Network (FTN). In similar environments, routes that operate every 15 minutes or better tend to see much higher ridership than less frequent routes.

But the FTN is limited to certain areas, mostly main streets in the center, inner north and inner east parts of Tucson. And for the most part, FTN routes are frequent on weekdays only, before 6 p.m. As a result:

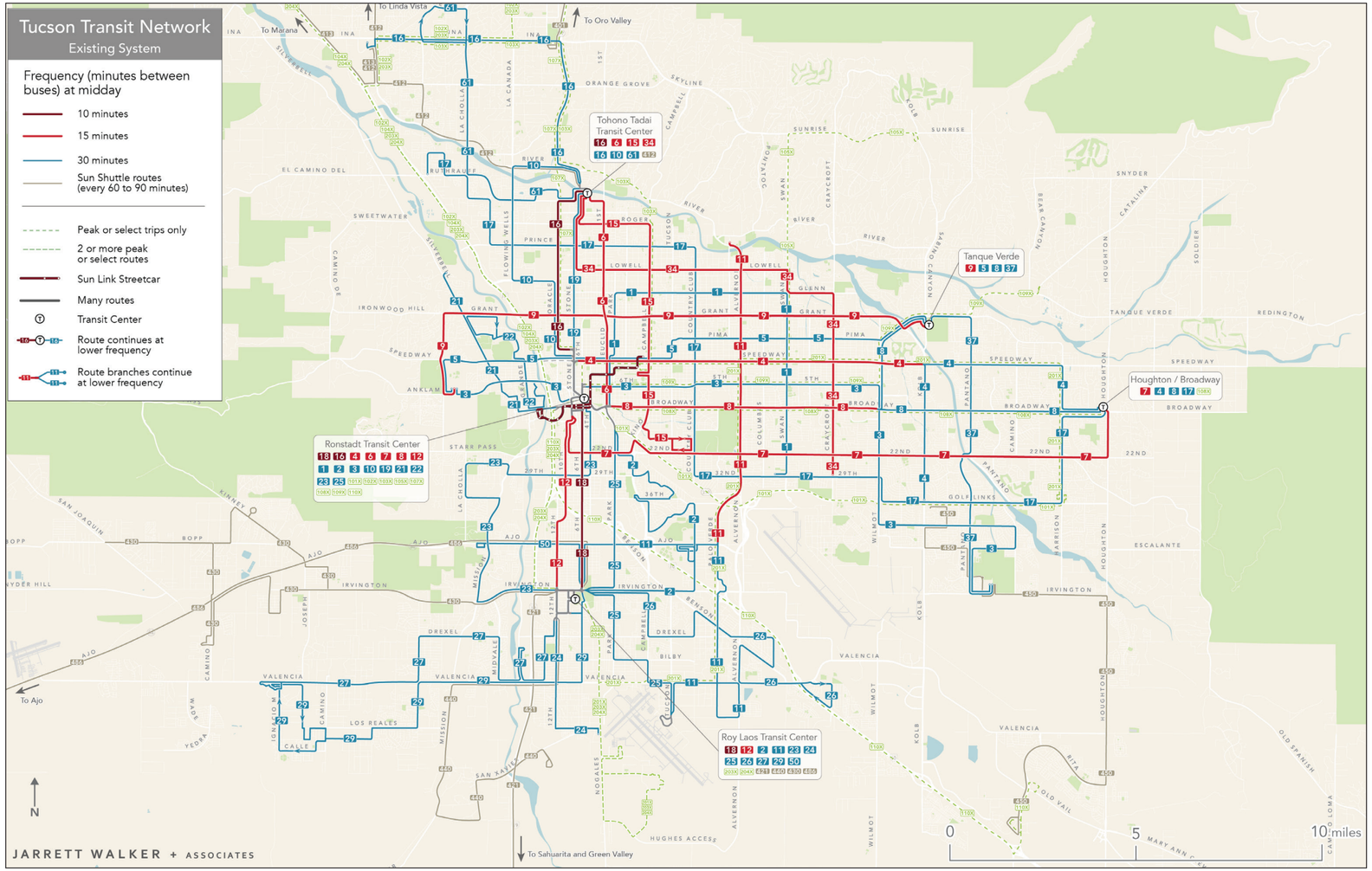


Figure 5: The public transit network in and around Tucson. Frequent service exists on a limited number of streets, mostly north and east of Downtown. Service is much less frequent past 6 p.m. and on weekends. This limits the number of people and trips the system can usefully serve.

- **Most people in the Tucson region don't have access to frequent transit, and many don't have access to any transit.** Only 26% of Pima County residents (57% of City of Tucson residents) live within a half-mile of a bus route that comes every 15 minutes or better. Forty-three percent of Pima County residents live more than half a mile away from any transit service.
- **Trips on transit take much longer in the evenings and on weekends, and sometimes aren't possible at all.** Most bus routes operate once an hour after 7 p.m. and on weekends.
- **Trips on transit often take more than twice as much time as driving alone.** When walking and waiting times are included, it can take over 30 minutes longer to reach Downtown or the University of Arizona from most of Tucson on transit.

Proposed Improvements to Transit: Medium Term

Frequency is the key to making transit useful for more people and trips. As a result, this plan proposes to bring frequent service close to many more people, and to make frequent service available at more times, while also improving conditions for riders using the transit system. **The following medium term improvements are envisioned within 10 years from time of funding.**

Establishing Priorities

Following release of the Draft Plan in September 2019, the project team carried out a survey online and in-person at transit centers to gather public feedback. This survey gathered a total of 824 responses, including people from all walks of life. We found that:

- Majorities of respondents were comfortable with the overall level of improvements proposed in the medium term
- Respondents with more urgent needs (e.g. don't own a car, income below $40,000, frequent transit riders) listed evening and weekend service improvements as their top two priorities.
- Regardless of age, race, income, residential location or car ownership, all respondent categories considered expanding the Frequent Transit Network (FTN) in their top three priorities.
- Suburban respondents generally placed a higher priority on suburban service improvements, and many (40%) wanted more improvements than were initially proposed.
- The proposed level of infrastructure improvements (speed & reliability, improved bus stops and stations) was approved by two-thirds of respondents, but most respondents listed these as a lower priority than service improvements. Speed and reliability were a higher priority for respondents with higher incomes and those who own cars.

As a result, this plan proposes to divide the first decade into three phases of improvements:

- Phase 1, focusing primarily on evening and weekend service improvements.
- Phase 2, focusing primarily on expanding the FTN, and with some initial speed, reliability and bus stop improvements in addition to suburban service improvements.
- Phase 3, focusing primarily on infrastructure improvements to improve speed, reliability and bus stops and stations.

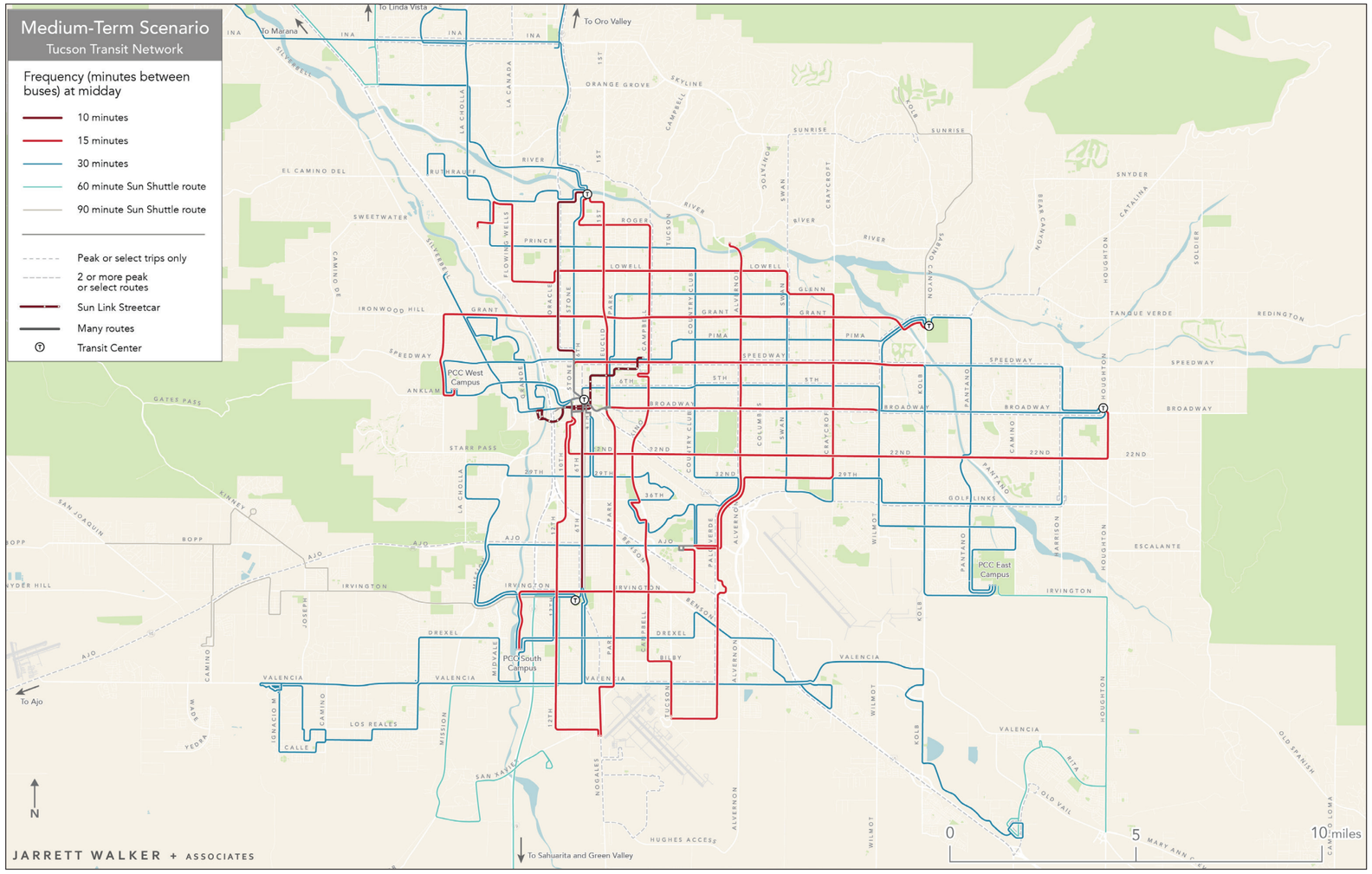


Figure 6: Proposed medium term public transit network. This map shows weekday service levels envisioned by the end of Phase 2, within two to five years of funding. The Frequent Transit Network (FTN) would be expanded to large parts of the south side and Flowing Wells. This would increase the number of people for whom transit would be a viable travel option. Phase 3 would build on the service improvements in Phase 1 and 2 with further improvements to speed, reliability and bus stops.

Please note: This map shows the intended location and frequency of Sun Tran and Sun Shuttle in five years after funding, assuming this plan is adopted and funded. No new transit funding has yet been identified as part of the development of the Draft Plan. Certain details, like exact routes and end of line locations, may evolve over time. All service changes would be subject to public comment before taking place. This map does not show Sun Tran Express service in detail, because this long-range plan does not address these routes (100X and 200X series). Any future changes to these routes would also be subject to public comment.

Phase 1: Consistent Service Seven Days a Week and More Evening Service

People's lives don't start on Mondays and end on Fridays, and neither should transit. Many jobs require people to work on Saturdays or Sundays. People also make many weekend trips for shopping, socializing, recreation, worship and other purposes.

This plan proposes to provide essentially **the same service on weekends as on weekdays**: every 15 minutes until 7 p.m. on FTN routes, and every 30 minutes until 7 p.m. on all other Sun Tran routes.

Service would also improve in the evenings. **Evening service would be available on all Sun Tran routes, from 7 a.m. to midnight, seven days per week.** FTN routes would have service every 30 minutes in the evenings, while other Sun Tran routes would operate every 60 minutes in the evening.

These Phase 1 service improvements could be implemented within a year of funding. Starting in Phase 1, Sun Tran would also begin purchasing new vehicles and equipping all vehicles with modern location tracking systems. These systems would allow passengers to obtain **real-time bus arrival information**.

Phase 2: Frequent Service To More Areas

Most of the existing Frequent Transit Network (FTN) is located between Downtown Tucson and Craycroft Road, north of 22nd Street. This plan proposes to expand the FTN significantly, especially on the south side, all the way to Tucson International Airport.

As a result, **the number of people within half a mile of frequent service would increase to 69% of Tucson residents and 35% of Pima County residents.** Frequent Service would become available:

- On South 12th Ave & Park Ave to the Desert Diamond Casino at Los Reales Road & Nogales Hwy.
- On Campbell Ave & Palo Verde Road to the airport.
- From Pima Community College - Desert Vista Campus to Banner University Medical Center - South, via Irvington Road.
- On Flowing Wells Road, between Miracle Mile & Wetmore Road.
- In addition, service on North Oracle Road & South 6th Ave would be combined into a single route, with service every 10 minutes or better from Tucson Mall to Irvington Road.

These expansions would require significant network restructuring and would increase the number of vehicles required for Sun Tran service. Some routes would also need transit priority and bus stop improvements to operate properly. As result, Phase 2 is envisioned within two to five years of plan funding.

Phase 3: Infrastructure for Faster, More Reliable and More Comfortable Travel

To attract many riders, using transit should be personally useful, but also valued and dignified. Building on the service improvements above, Phase 3 would focus on improving the rider experience.

- **Transit priority measures at over 100 intersections, and up to 25 miles of bus lanes**. These items are key to reducing travel times and reducing the cost of providing service. Because buses need to make stops, they are uniquely vulnerable to congestion. Measures like longer green time at intersections for an approaching bus, or letting buses use turn lanes as through-lanes, help transit run faster and stay on time. At key chokepoints, it may be necessary to establish bus-only lanes.
- **Improvements to over 2,000 bus stops.** Clean and safe bus stops are essential to a decent riding experience. By the end of Phase 3, all bus stops would include a pole, signage and ADA-compliant boarding pad. Bus stops for 99% of boardings would be equipped with a bench or shelter. All bus stops on the FTN would be equipped at minimum with a bench, shelter and lighting.

How many people would live within half a mile of a bus stop with service?

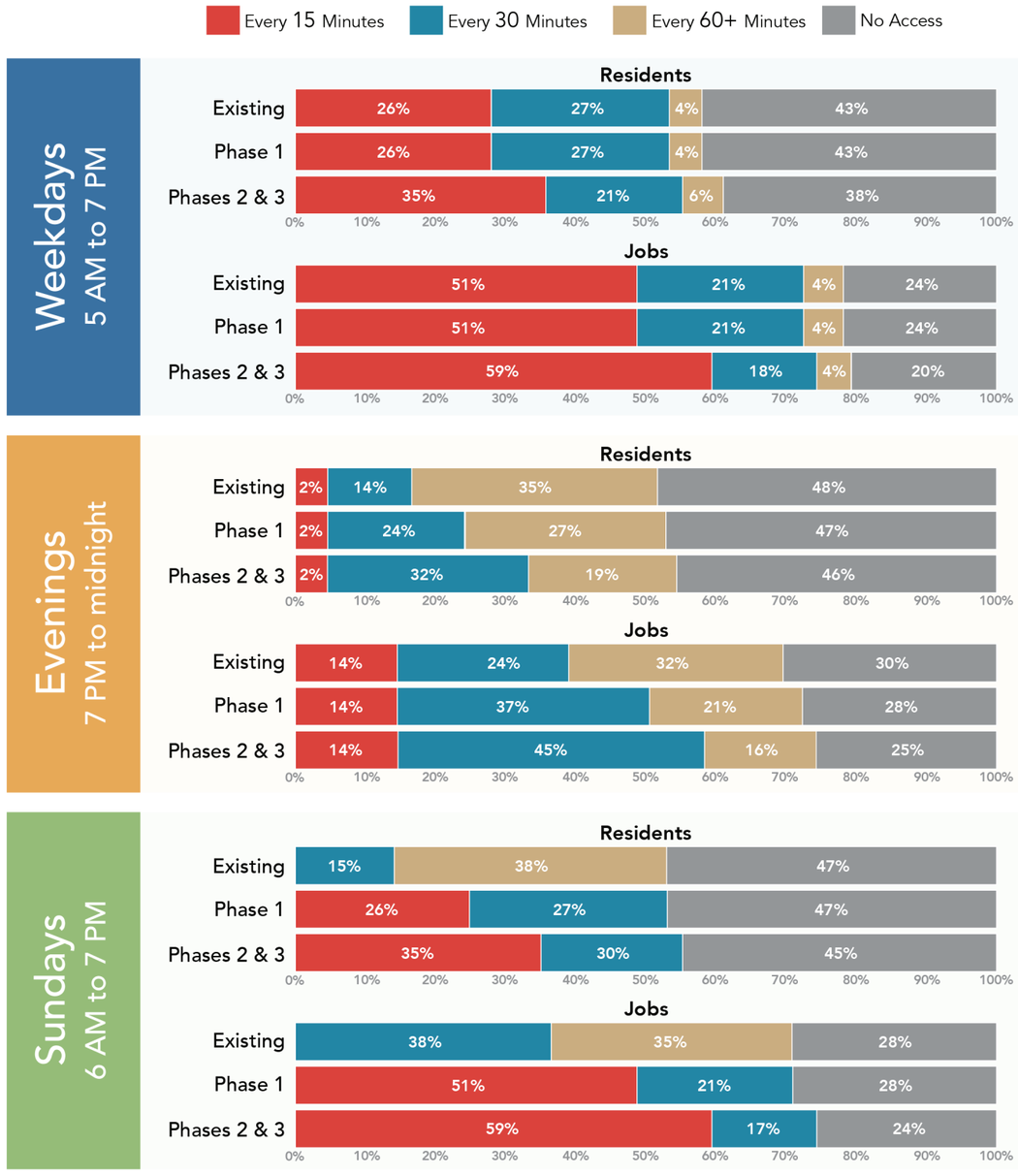


Figure 7: Percentage of Pima County residents near transit service at different frequencies, existing vs. medium term plan. Phase 1 would bring improvements to evenings and weekends, while Phase 2 would expand the area with access to frequent service.

Medium Term: Costs and Benefits

The medium term scenario proposed in this plan would represent a significant investment in service and capital above and beyond what is currently provided by local governments and the Regional Transit Authority.

Service Investment

The total estimated new service investment over the first 10 years of this plan (Phases 1 to 3) would be $309 million. Taking into account new fare revenues, the actual new funds required for this service above and beyond existing revenue sources most likely fall somewhere between $235 and $285 million[1].

On an annual average basis, the cost of each type of service improvement breaks down to approximately:

- Phase 1 improvements: $15.9 million per year
  - » Evening service improvements: $4.7 million per year
  - » Weekend frequencies match weekdays: $11.2 million per year
- Phase 2 improvements: $13.6 million per year
  - » Frequent Transit Network expansion: $11.2 million per year
  - » Sun Shuttle suburban improvements: $2.2 million per year
  - » Sun Link reliability maintenance: $0.2 million per year
- A further average of $1.4 million per year would be set aside to account for structural deficits at Sun Tran and Sun Van under baseline assumptions (see Appendix B - Financial Scenarios).

In actuality, different improvements would be phased in over time, and costs would increase each year due to inflation. As a result, the actual estimated costs over time are approximately:

- Phase 1 (Years 1-2): $11.3 million per year
- Phase 2 (Years 3-5): $31.2 million per year
- Phase 3 (Years 6-10): $38.6 million per year

1 The actual final figure is not possible to predict, because it depends on a prediction of ridership and fare policy. $235 million assumes that the additional service results in very productive, with very high farebox recovery (+50% higher than existing on average). $285 million assumes that the additional service is relatively unproductive and/or fare policies change so that farebox recovery on new service is low (-50% lower than existing on average). We are not aware of future fare policy changes at this time. If this plan is used to craft any funding measures, a conservative approach would be to start from the higher figure and to add the cost of any likely fare policy changes.

Capital Investment

The total estimated investment in capital improvements over the first 10 years of this plan (Phases 1 to 3) would be $207 million. This would include:

- » $105 million in improvements to bus stops and stations.
- » $61 million in new vehicles.
- » $28 million in speed and reliability improvements.
- » $13 million in vehicle technology.

It may be possible to obtain federal matching funds for some of these investments. In particular, Federal Transit Administration (FTA) funds may be able up to 80% of the costs of new vehicles. Some speed and reliability improvements may be partially paid with FTA funds as well, if packaged in the context of a Bus Rapid Transit (BRT) project. Nonetheless, these improvements would likely require at least $160 million in new local or state funding, and may require up to the full $207 million.

As with service investments, these costs would be phased in over time as appropriate. Vehicle and technology costs would be especially "chunky" and concentrated in the early parts of the decade. This is because the frequent network expansion in Phase 2 simply cannot be implemented before Sun Tran owns enough vehicles, and it typically takes two years from the moment a bus is ordered to the moment is put in service.

The estimated annual costs over time are approximately:

- Phase 1 (Years 1-2): $40.2 million per year.
- Phase 2 (Years 3-5): $7.1 million per year.
- Phase 3 (Years 6-10): $21.0 million per year.

In Phase 1, investments would overwhelmingly be in vehicles (76%) and vehicle technology (15%). In Phases 2 and 3, investments would be concentrated entirely on bus stops and station (79%) and speed and reliability improvements (21%).

Summary of Investment Costs and Service Increase by Phase

		Investment (2020 dollars)	Investment (real dollars)		Service Increase (revenue hours)
		Total	Total	Annual Avg.	*by the end of each phase*
Phase 1 (Years 1 to 2)	Service	$19.7 million	$22.6 million	$11.3 million	+ 17%
	Capital	$74.4 million	$80.3 million	$40.2 million	
Phase 2 (Years 3 to 5)	Service	$75.9 million	$93.5 million	$31.2 million	+ 39%
	Capital	$18.7 million	$21.4 million	$7.14 million	
Phase 3 (Years 6 to 10)	Service	$140 million	$193 million	$38.6 million	+ 39%
	Capital	$84.7 million	$106 million	$21 million	

Figure 8: Summary investment cost and service increase by plan phase, for the medium term (first decade). This table shows the level of investment required at current cost levels (2020 dollars), and the likely "real dollar" costs taking into account inflation over time.

Benefits - More People Near Better Service

The benefits of these investments are illustrated by the proximity and access analysis outputs shown in this summary. Figure 7 on page 10 illustrates proximity to transit, or the number of residents and jobs that would be located near transit service at different frequencies. By the end of Phase 2:

- **Over 350,000 people would live within half a mile of a transit stop with frequent service seven days a week**, every 15 minutes or better. That's 85,000 more people than today on weekdays, and 350,000 more people on Sundays (there is no frequent service on Sundays at present).
- **Nearly 350,000 people would live within half a mile of a transit stop with service every 30 minutes or better in the evening** between 7 p.m. and midnight. That's 185,000 more people than today.

Benefits - More Access to Opportunity

Being located near transit does not guarantee on its own that the service is useful to you. That's why we also calculate how many jobs people could access in a reasonable amount of time using the transit system, using the methods shown in Figure 4 on page 7.

Access to jobs is about a lot more than just commuting; it's a broader measure of economic and social opportunity provided by the transit network. Places where many jobs are located often have other interesting features. Shopping centers, hospitals, social services, restaurants and even schools and houses of worship all are employers in addition to providing important services.

Through the analysis illustrated in Figure 9 and Figure 10 (next page), we find that by the end of Phase 2:

- **In 45 minutes on transit** (door-to-door, including time spent walking, waiting and in vehicle), **the average resident of the Tucson region could access:**
  - » **+ 23% more jobs on weekdays**
  - » **+ 25% more jobs in the evening (weekday and weekend)**
  - » **+ 170% more jobs on Sundays**

Both the proximity and access benefits described above would be widely distributed, and are generally similar or slightly higher for minority and low-income populations.

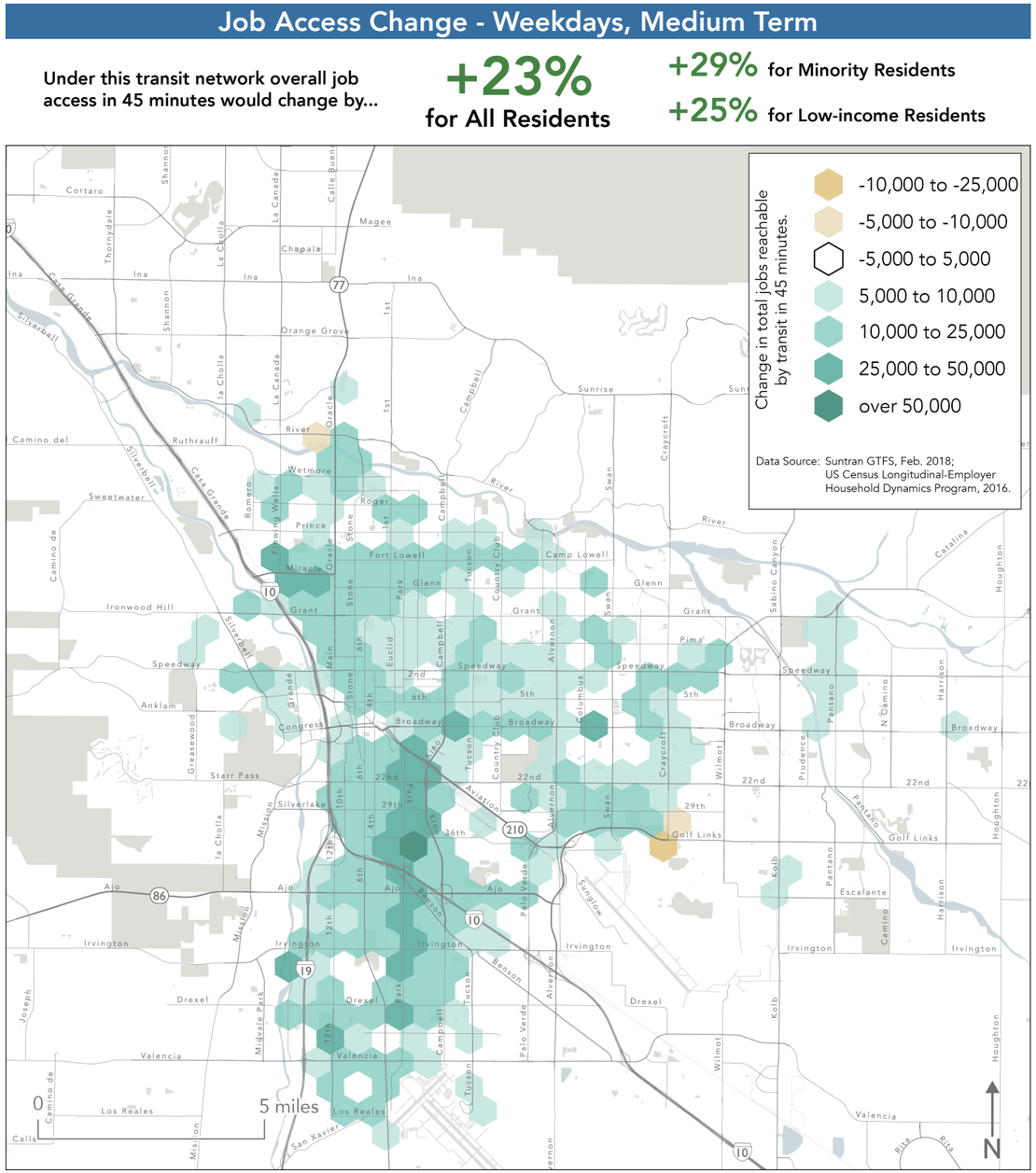


Figure 9: Medium term change in jobs accessible in 45 minutes on weekdays (until 7 PM) by transit, door-to-door (includes walking, waiting and riding). The color of each hexagon represents the change in the overall usefulness of transit from the center of that area: transit becomes more useful in green areas, and less useful in brown areas.

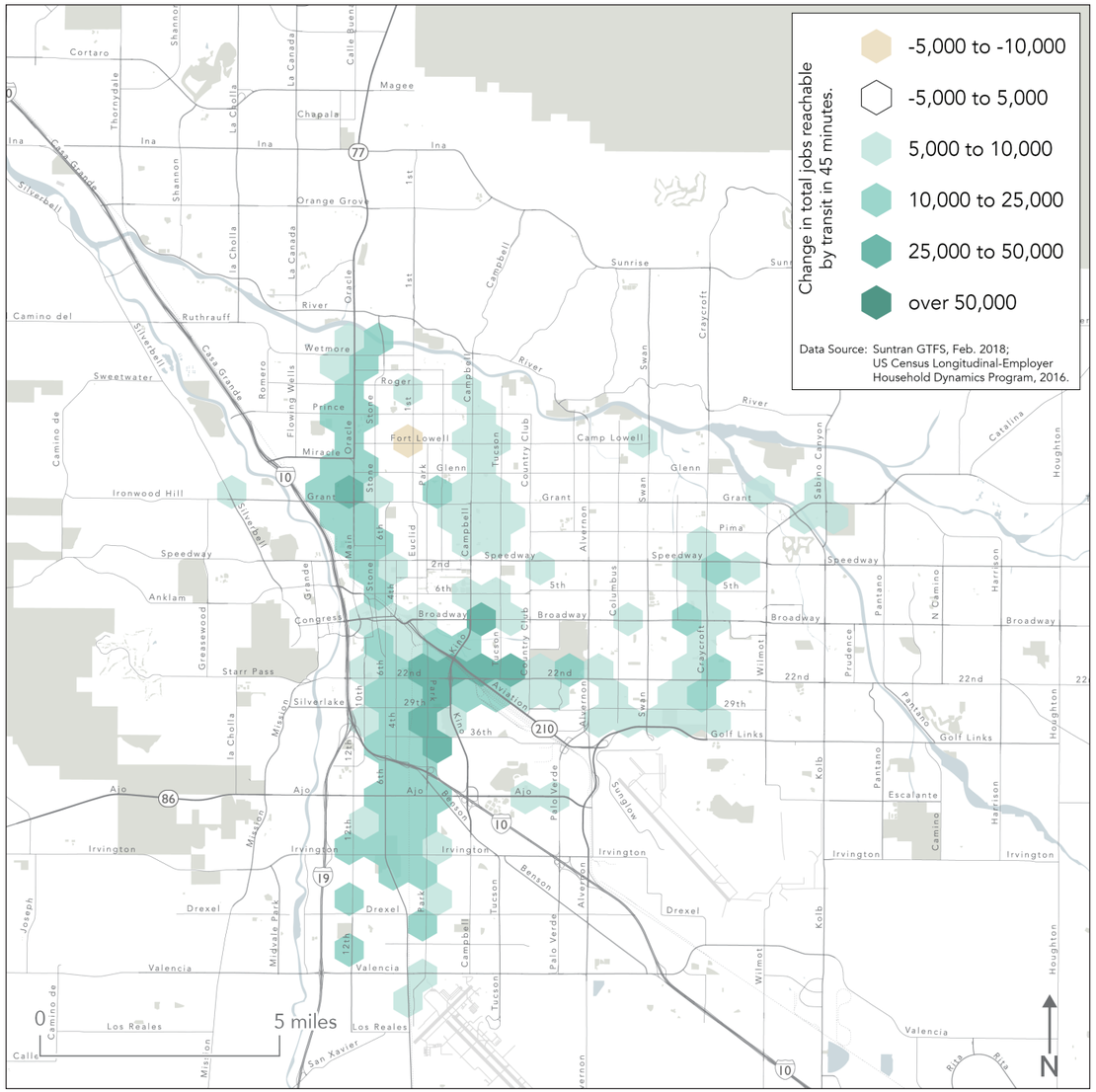
Job Access Change - Evenings, Medium Term

Under this transit network overall job access in 45 minutes would change by...

+25% for All Residents

+32% for Minority Residents

+28% for Low-income Residents



Job Access Change - Sundays, Medium Term

Under this transit network overall job access in 45 minutes would change by...

+171% for All Residents

+193% for Minority Residents

+175% for Low-income Residents

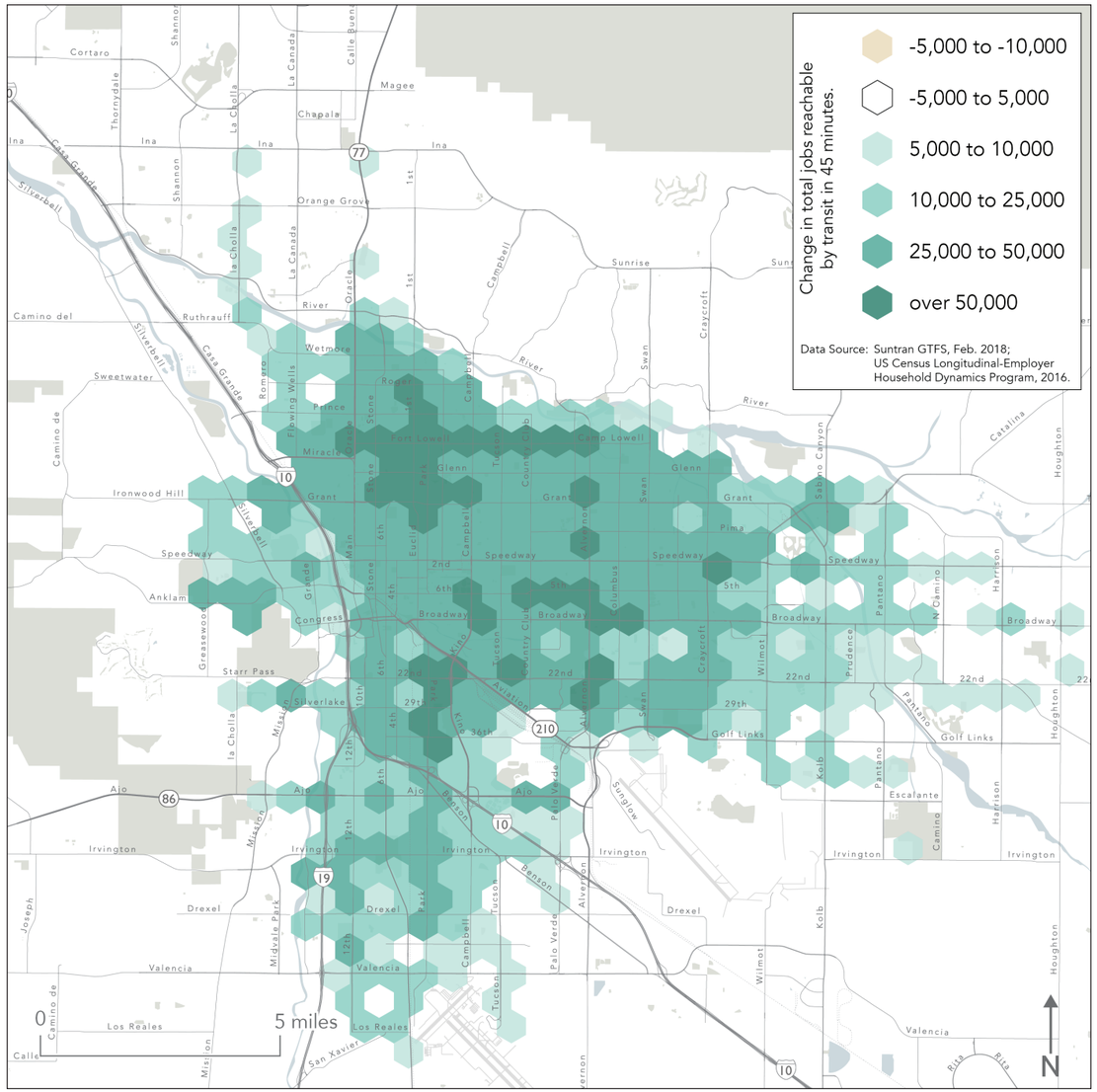


Figure 10: Medium term change in jobs accessible in 45 minutes on evenings (above left) and on Sundays (above right) by transit, door-to-door (includes walking, waiting and riding). The color of each hexagon represents the change in the overall usefulness of transit from the center of that area: transit becomes more useful in green areas, and less useful in brown areas. The highest level of benefit would be on weekends, because nearly all existing transit runs less frequently on weekends than weekdays. Most of the benefit shown on the right would accrue in Phase 1, in the first two years of plan implementation, when service levels would be equalized seven days a week.

Proposed Improvements to Transit: Long Term

The improvements proposed in the medium term address the most urgent ways to make the system useful to many more people. In the longer-term, improvements would focus on making transit even more convenient and comfortable. **The following long-term improvements are envisioned within ten to twenty years.**

1. Frequent Service Closer to Home

In the medium term, the area covered by the Frequent Transit Network would increase greatly, particularly on the south side. In the long term, this plan proposes to bring transit closer to many more people, with:

- Further extensions of the frequent network east of Craycroft Road. (Wilmot, Kolb, Pantano), in the Northwest (N. Oracle and Ina), and west of Downtown (St. Mary's).
- **Frequent routes would be spaced on a 1 mile x 1 mile grid in both east-west and north-south directions in most of Tucson.**
- Service every 10 minutes all day on Broadway and Speedway, and every 7 minutes on North Oracle Road and South 6th Ave.

As a result, the vast majority of people living in even moderately dense urban and suburban neighborhoods would be able to access a frequent transit route going any direction with just a 10-minute walk.

2. Evening Service Every 30 Minutes or Better on All Sun Tran Routes

Just as people's lives do not end on weekends, they also do not end at 7 p.m. Many people hold jobs that may either start or end in the evening, and many people make social, shopping and other trips after their work or school day is done. Hourly evening service may provide basic insurance against isolation, but it's not a viable option for the vast majority of potential riders.

Recognizing this, all Sun Tran routes would run every 30 minutes or better at all times from 6 a.m. to midnight in the long term, regardless of daytime frequency.

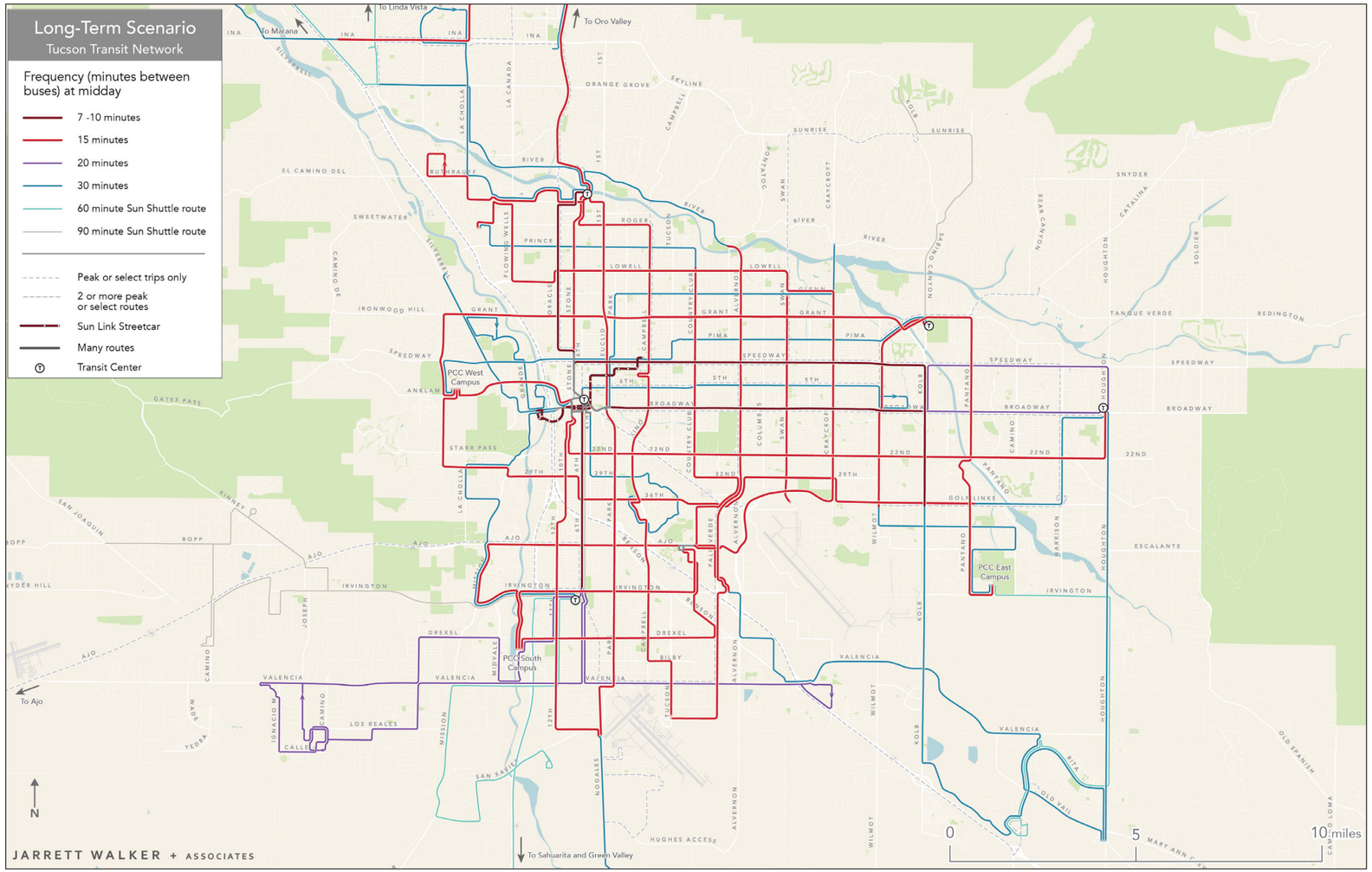


Figure 11: Proposed long term public transit network. A frequent transit service going any direction would be available within a 10 minute walk of the vast majority of Tucson residents. Transit would operate at the same frequency seven days per week, and Sun Tran routes would always operate every 30 minutes or better, from 6 a.m. to midnight, seven days a week.

Please note: This map shows the intended location and frequency of Sun Tran and Sun Shuttle in 10 to 20 years after funding, assuming this plan is adopted and funded. No new transit funding has yet been identified as part of the development of the Draft Plan. Certain details, like exact routes and end of line locations, may evolve over time. All service changes would be subject to public comment before taking place. This map does not show Sun Tran Express service in detail, because this long-range plan does not address these routes (100X and 200X series). Any future changes to these routes would also be subject to public comment.

3. Faster and More Reliable Travel

If traffic congestion continues to grow, it will be important to continue maintaining transit speed and reliability by expanding the number of intersections with bus priority measures. And to maintain 7 to 10 minute frequencies on the system's most important routes, it may become necessary to stripe bus lanes on significant parts of Broadway, Speedway, North Oracle Road and South 6th Ave.

To that end, this plan proposes **transit priority at over 100 more intersections, and up to 50 total miles of bus lanes** in the long term.

4. Better Conditions for Passengers

As service becomes more abundant, it will be important to continue enhancing transit facilities and equipment to efficiently and courteously handle larger volumes of passengers. In the long term, this plan envisions:

- **Improvements to over 800 more bus stops.** As the Frequent Transit Network expands, it will be important to keep pace with corresponding improvements to passenger facilities, upgrading more stops to be equipped with benches, shelters, lighting, and potentially real-time information.
- **New and larger vehicles.** As passenger volumes grow, it will become necessary to purchase at least 80 new vehicles, many of which will be higher-capacity, 60-foot articulated buses to prevent and relieve crowding.

How many people would live within half a mile of a bus stop with service?

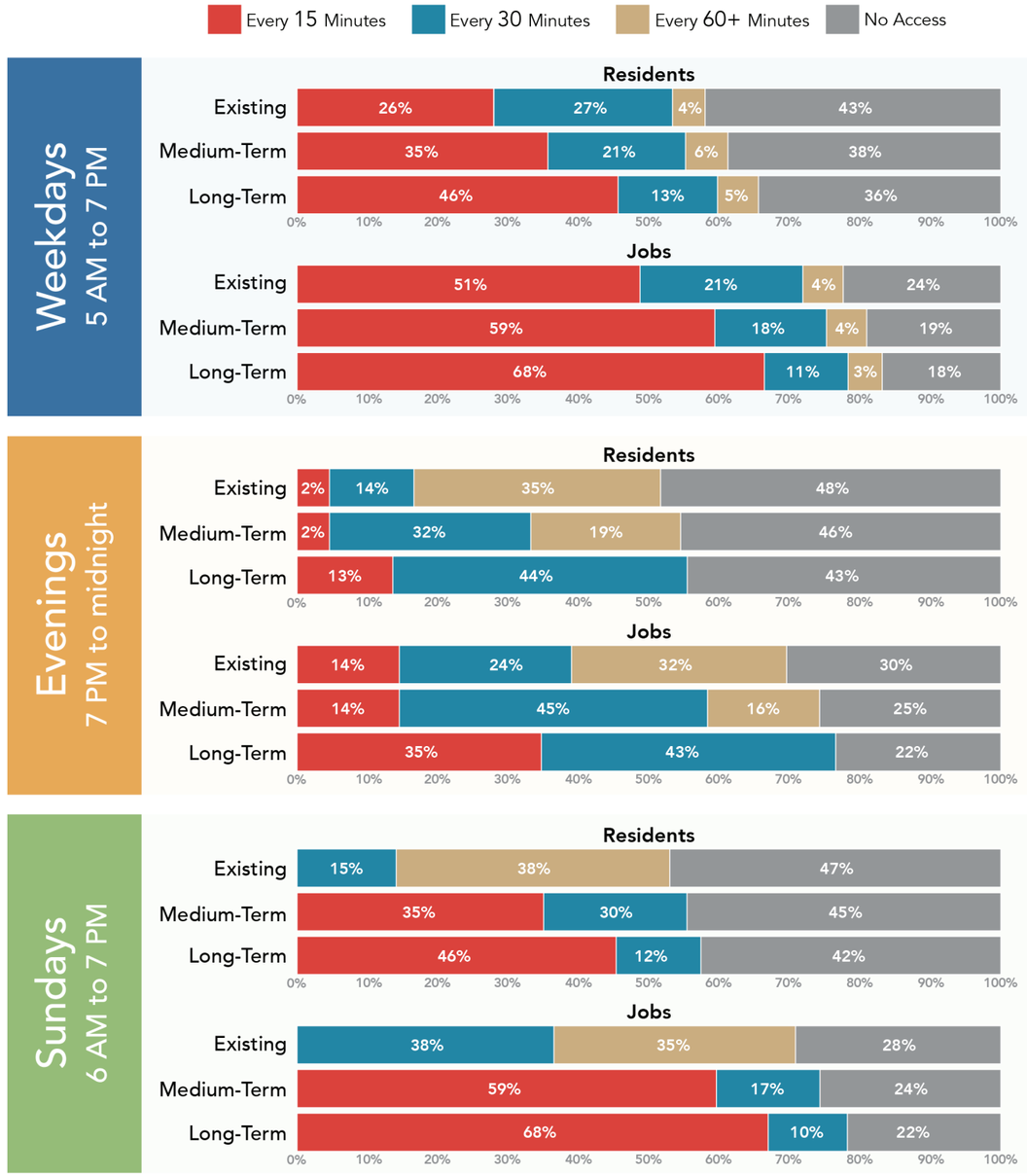


Figure 12: Percentage of Pima County residents near transit service, existing vs. medium term & long term plan. Long term, there would be even more expansion of the frequent network into nearly all urban and inner suburban neighborhoods, on weekdays and weekends. Evening service also would improve.

Long Term: Costs and Benefits

The long-term scenario proposed in this plan would represent a significant investment in service and capital, even above and beyond what is proposed for the first 10 years.

Service Investment

In the second decade of this plan, the total estimated new service investment would be $1.1 billion, of which $630 million would represent new service above and beyond the medium term. Taking into account new fare revenues, the actual new funds required for this service above and beyond existing revenue sources most likely fall somewhere between $820 million and $1 billion[1].

On an annual average basis, the cost of each type of service improvement breaks down to approximately:

- Medium Term improvements: $46.1 million per year
  - » This reflects service improvements already achieved in the first decade of the plan. However, costs would increase each year due to inflation, so those same improvements would cost more in the second decade.
- Long Term Improvements: $63.0 million per year
  - » Frequent Transit Network expansion: $49.0 million per year
  - » Evening Service improvements: $10.1 million per year
  - » Added frequency on Sun Link: $3.5 million per year
  - » Sun Shuttle suburban improvements: $0.4 million per year
- A further average of $0.9 million per year would be set aside to account for structural deficits at Sun Tran and Sun Van under baseline assumptions (see Appendix B - Financial Scenarios).

This plan does not establish a detailed phasing of service investments in the second decade, because it is not clear today which of the proposed improvements would be considered a higher priority at that time.

1 The actual final figure is not possible to predict, because it depends on a prediction of ridership and fare policy. $820 million assumes that the additional service results in very productive, with very high farebox recovery (+50% higher than existing on average). $1.0 billion assumes that the additional service is relatively unproductive and/or fare policies change so that farebox recovery on new service is low (-50% lower than existing on average). We are not aware of future fare policy changes at this time. If this plan is used to craft any funding measures, a conservative approach would be to start from the higher figure and to add the cost of any likely fare policy changes.

Capital Investment

The total estimated investment in capital improvements over the second decade of this plan would be $293 million. This would include:

- » $101 million in improvements to bus stops and stations.
- » $143 million in new vehicles.
- » $41 million in speed and reliability improvements.
- » $8 million in vehicle technology.

Vehicle and technology costs would likely be concentrated in the early parts of the second decade, because these purchases would be required for any additional expansion in frequent service. If current practices at the federal level continue, it will likely be possible to support substantial portions (up to 80%) of the costs for bulk vehicle purchases.

Other investments are likely to be spread out throughout the decade, and will mostly depend on finding new local and/or state funding sources, barring major changes in the national policy environment. As with service, this plan does not establish a detailed phasing of capital improvements in the second decade, leaving flexibility on priorities to future decision-makers.

Summary of Investment Costs and Service Increase, Medium Term vs. Long Term

		Investment (2020 dollars)	Investment (real dollars)		Service Increase (revenue hours)
		Total	Total	Annual Avg.	*by the end of each phase*
Medium Term (Years 1 to 10)	Service	$236 million	$309 million	$30.9 million	+ 39%
	Capital	$178 million	$208 million	$20.8 million	
Long Term (Years 11 to 20)	Service	$623 million	$1.10 billion	$110 million	+ 103%
	Capital	$211 million	$293 million	$29.3 million	

Figure 13: Summary investment cost and service increase, comparison of medium term (first decade of plan implementation) and long term (second decade). Capital investments would be slightly higher in the long-term than medium term. Service investments would be much higher in the medium term than in the long term.

Benefits - More People Near Better Service

The benefits of these investments are illustrated by the proximity and access analysis outputs shown in this summary.

Figure 12 on page 15 illustrates proximity to transit, or the number of residents and jobs that would be located near transit service at different frequencies. By the end of Phase 2:

- **460,000 people would live within half a mile of a bus stop with frequent service seven days a week until 7 p.m.,** every 15 minutes or better. That's 110,000 more people than in the medium term, and 195,000 more people than in existing service.
- **Nearly 570,000 people would live within half a mile of a bus stop with service every 30 minutes or better in the evening** between 7 p.m. and midnight. That's 220,000 more people than in the medium term, and 405,000 more than in existing service.

Benefits - More Access to Opportunity

As in the medium term, the best measure of how much these improvements would improve transit for people in the Tucson region is calculating the change in the number of jobs accessible in a reasonable amount of time using the transit system, using the methods shown in Figure 4 on page 7.

Through the analysis illustrated in Figure 14 and Figure 15 (next page), we find that by the end of Phase 2:

- **In 45 minutes on transit** (door-to-door, including time spent walking, waiting and in vehicle), **the average resident of the Tucson region could access:**
  - » **+ 50% more jobs on weekdays** than today, more than twice as much benefit as in the medium term
  - » **+ 91% more jobs in the evening** than today, more than three times as much benefit as in the medium term
  - » **+ 229% more jobs on Sundays** than today, or about a third more benefit as in the medium term.

Both the proximity and access benefits described above would be more geographically spread out than in the medium term. As in the medium term, benefits would generally be similar or slightly higher for minority and low-income populations.

Job Access Change - Weekdays, Long Term

Under this transit network overall job access in 45 minutes would change by...

+50% **for All Residents**

+58% **for Minority Residents**

+50% **for Low-income Residents**

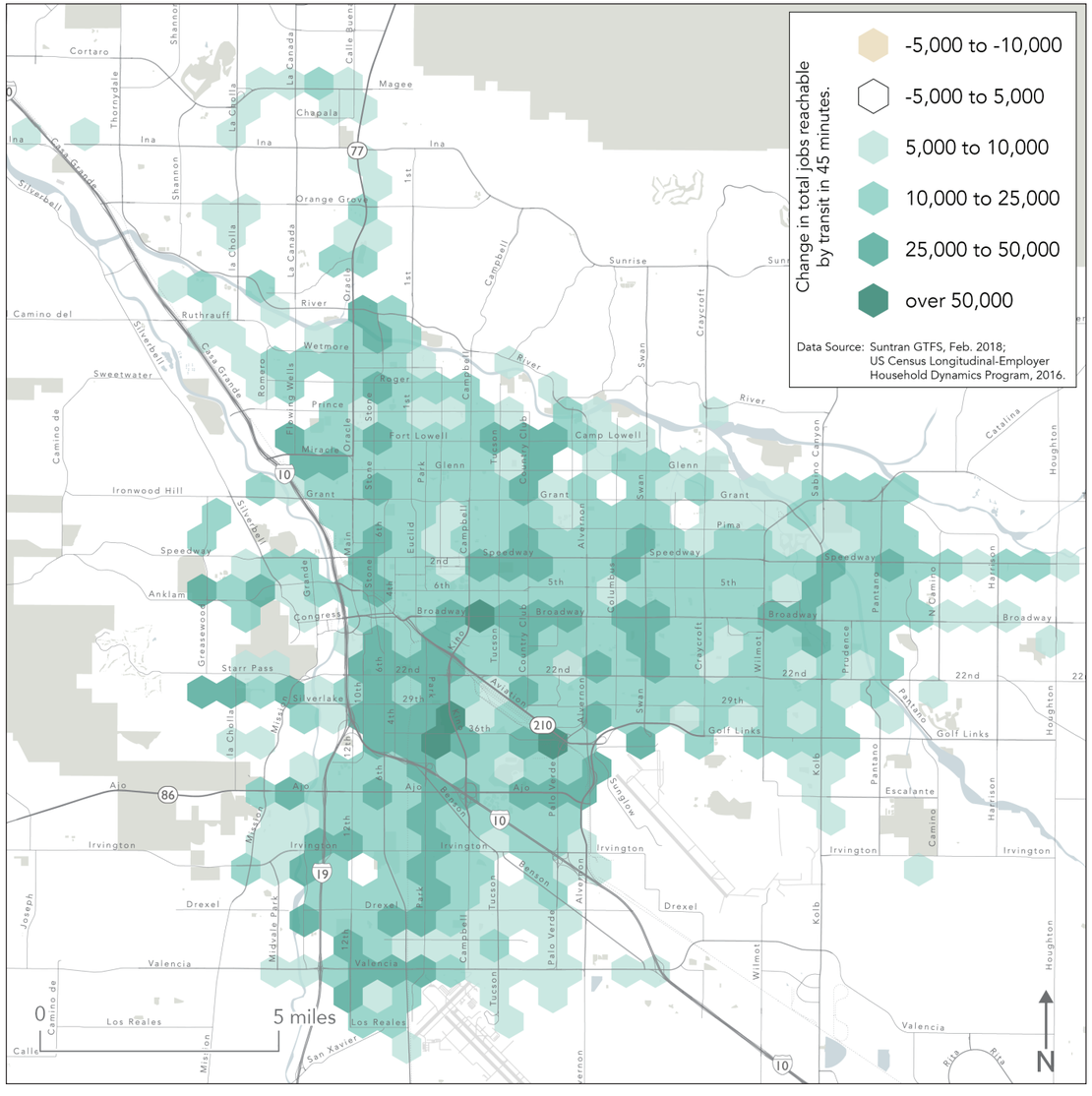


Figure 14: Long term change in jobs accessible in 45 minutes on weekdays (until 7 p.m.) by transit, door-to-door (includes walking, waiting and riding). The color of each hexagon represents the change in the overall usefulness of transit from the center of that area: transit becomes more useful in green areas. In the long term, benefits would be spread even more broadly than in the medium term.

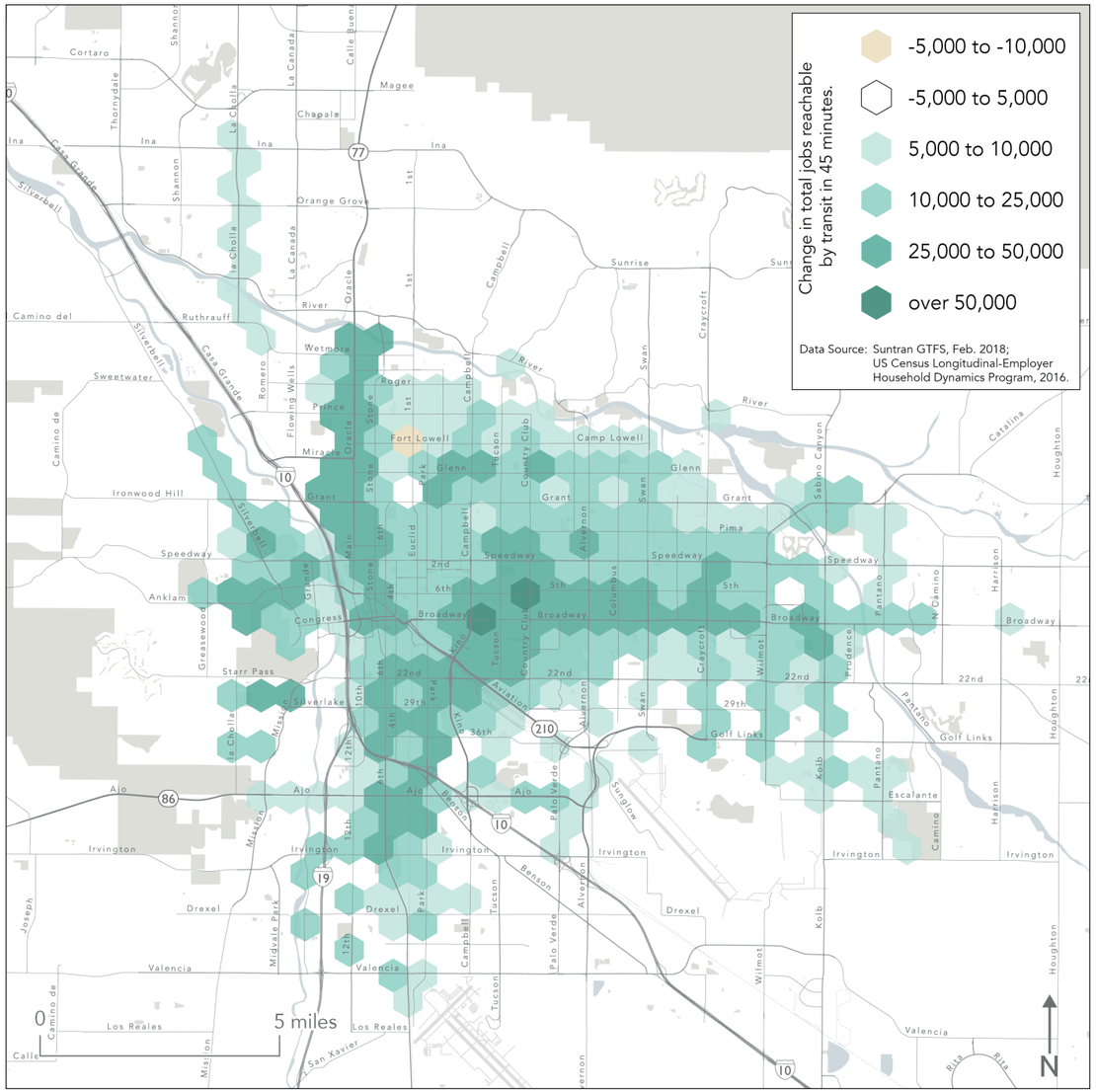
Job Access Change - Evenings, Long Term

Under this transit network overall job access in 45 minutes would change by...

+91% for All Residents

+97% for Minority Residents

+89% for Low-income Residents



Job Access Change - Sundays, Long Term

Under this transit network overall job access in 45 minutes would change by...

+229% for All Residents

+243% for Minority Residents

+232% for Low-income Residents

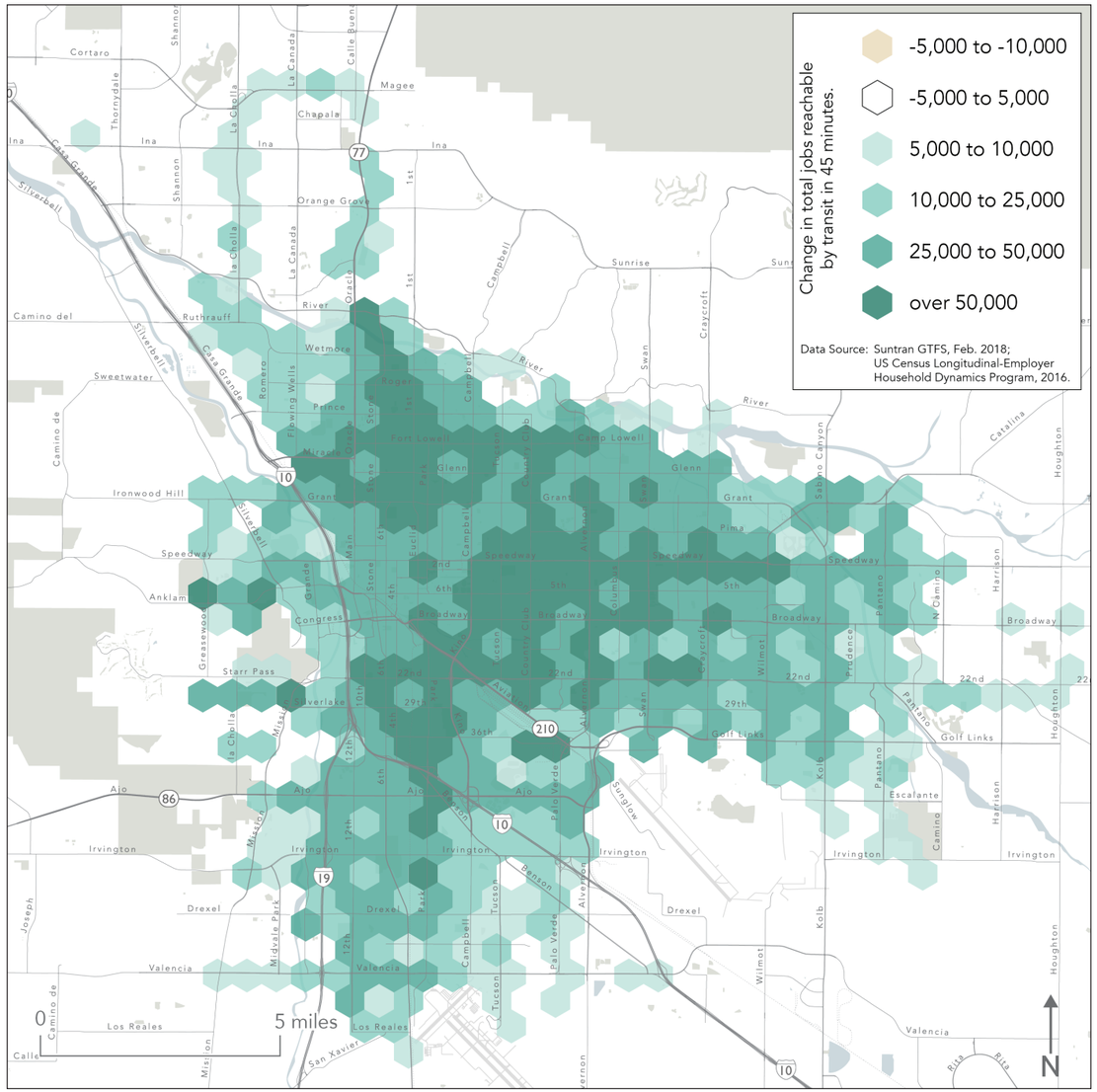


Figure 15: Medium term change in jobs accessible in 45 minutes on evenings (above left) and on Sundays (above right) by transit, door-to-door (includes walking, waiting and riding). The color of each hexagon represents the change in the overall usefulness of transit from the center of that area: transit becomes more useful in green areas. The greatest improvement between the medium and long term would be in the evenings, with more routes remaining frequent after 7 p.m., and the replacement of all hourly service with service every 30 minutes. There would also be significant weekend improvements as a result of the second expansion of the frequent network.

Why doesn't this plan recommend any specific BRT or streetcar lines?

Previous Studies

Following on the Sun Link streetcar, there has been considerable interest in the idea of building more high-capacity transit lines. In 2017, Pima Association of Governments (PAG) carried out a study called the High Capacity Transit Implementation Plan (HCTIP), which narrowed down the transit technologies and corridors under consideration. Two types of high-capacity transit were deemed potentially viable:

- **Rapid streetcar**, similar to the initial Sun Link segment, but with wider stop spacing (1/4 to 1 mile) and more transit priority.
- **Bus Rapid Transit (BRT),** defined as a bus route with wide stop spacing (1/2 to 1 mile), whose speed and reliability is supported by exclusive bus lanes in some segments. A BRT line may be either "open" or "closed."
  - » Closed BRT lines use special vehicles and high platforms at stations, so the bus cannot operate at regular bus stops.
  - » Open BRT lines run as a "rapid" bus route on improved segments, but can continue as a regular bus route in outlying areas.

The HCTIP identified the following best potential corridors:

- **Broadway Blvd**, either as streetcar extension or as BRT.
- **Speedway Boulevard**, as a BRT segment.
- **Stone Avenue**, as a streetcar extension.
- **Oracle Road**, as a BRT segment.
- **South 6th Avenue**, as a streetcar segment.

BRT and Streetcars solve specific problems

This Long-Range Regional Transit Plan concurs that Broadway, Speedway, Oracle Road and South 6th Avenue are the most important transit streets in Tucson, and that Stone Avenue is also an important transit street in the long term.

However, **the BRT and streetcar projects previously envisioned are not necessary purely from the standpoint of maximizing regional mobility** by transit. This is for the following reasons:

- **There are no critical passenger capacity issues in Tucson's transit system.** Part of the point of using streetcars or special BRT buses is to carry far more people. But most Sun Tran bus routes (and Sun Link) carry fewer than 40 passengers per hour of service, well within the abilities of a standard 40-foot bus. This plan does take into account the possibility of higher ridership in the long-term by incorprating articulated 60-foot buses on the busiest routes. But barring significant development changes and much higher density in the long-term, it's unlikely that ridership increases would be so high that streetcars or special BRT buses would be required to meet capacity needs.
- **The speed benefits of BRT and streetcar lines in Tucson are limited**. This is partly because many Sun Tran bus routes already have relatively wide stop spacing (averaging 1/4 mile), and partly because traffic congestion remains fairly limited in Tucson. Furthermore, this plan includes measures to improve intersections and install exclusive transit lanes in places where buses are known to be delayed, likely capturing the majority of time benefits that would be associated with a dedicated BRT or streetcar project.
  - » In fact, the service levels and capital improvements envisioned in the long term on Broadway, Speedway, Oracle Road and South 6th Ave would actually be very similar to what would be achieved in an "open" BRT project.
- **Large capital projects on one or two corridors would have much less impact on regional mobility than improving transit frequency in many locations.** BRT and streetcar projects tend to mobilize large amounts of resources in a small area. As such, they may improve mobility and access for people very nearby, but the broader regional impacts are limited. To that effect, this plan focuses on expanding the range of the Frequent Transit Network, so that eventually the majority of Tucsonans live within walking distance of buses coming every 15 minutes or less, going in all directions.

Transit as a Development Tool

As discussed above, current land-use and development plans do not suggest a need for high-capacity transit improvements above and beyond bus lines with speed, reliability and bus stop enhancements. However, there are possible future circumstances that might warrant a higher-capacity alternative like a streetcar.

The Sun Link streetcar has been widely hailed in Tucson as being behind the renaissance and dense redevelopment of Downtown Tucson. And, although it does not currently carry ridership that distinguishes it from Sun Tran's busier bus routes, it does in fact allow for enough capacity for significant further densification of the area between Downtown and the University of Arizona.

Figure 16: Tier 3 High-Capacity Transit corridors, as identified in the 2017 draft High-Capacity Transit Implementation Plan study. Solid lines represent potential Bus Rapid Transit (BRT) projects. Dotted lines represent potential extensions to the Sun Link streetcar system.

If community consensus builds around supporting significant redevelopment and densification in a specific area beyond Downtown Tucson, then a high-capacity solution like another streetcar could be a viable alternative. In that case, the HCTIP corridors are probably the best place to start.

However, in designing such a project, authorities should remain conscientious of how it would interact with broader regional mobility by transit, and the long-term service envisioned in this plan. The HCTIP, and an analysis of how the HCTIP corridors interact with this plan, are included as appendices.

What if we don't do this?

Implementing this plan is expensive. In its first ten years alone, it would require a 40% increase in the total public funds spent on transit operations, before inflation and before any infrastructure needs are taken into account. In the second decade, spending on transit operations would more than double.

Federal funds may help with some of the infrastructure costs, but under current law it would not help with the cost of additional operations. Some states (not including Arizona) provide funding for transit operations. But in almost all cases, increasing funding for transit requires broad local community support for increased taxation.

It may be easier to describe what the region can expect if transit remains only marginally useful in the Tucson region?

1. If the region continues to grow, congestion and travel times would get worse

All opportunities for regional growth will increase the volume of cars on the road.

- High density growth without more transit service means more people trying to drive in a small area, which is the definition of congestion. This can be mitigated by mixing jobs with housing, and providing good walking and cycling opportunities, but in a region of this size many trips will still be too long to cycle, and cars would be the only choice.
- Low density growth means that the region continues to spread horizontally, requiring people to drive ever farther to complete trips.

In all cases, the region benefits if more people can make use of transit, reducing the load on road space.

2. If the region does not plan for more transit, it's more likely to grow horizontally rather than through density.

Traffic impacts are a primary source of opposition to dense development. Without more transit these impacts will be severe and it will be harder to make a case for denser development patterns that reduce travel times.

3. If the region continues to grow horizontally at low density, even more expensive road expansion would be needed.

Because growth without transit means more traffic, there would be demand for ever greater road infrastructure. This plan may appear much more affordable if it is compared to road expenditures that might be avoided due to much higher transit use.

4. Without this plan, the region would make less of a contribution to addressing climate change.

While renewable energy and electric vehicles will do much of the work on climate change, studies have repeatedly shown that climate targets cannot be met without also reducing the amount of driving.

Hotter and drier weather could threaten the very existence of desert cities like Tucson, and while the climate future depends on global action, that action is the sum of every city's choices.

5. Many low income people would remain trapped in poverty

Unless transit service increases significantly, many low income people will continue to have very limited access to jobs and opportunity. Over time, this will increase the degree to which people are trapped in poverty with no realistic way to improve their situation.

Horizontal, low-density growth makes this problem worse, because travel times to jobs would tend to increase, making these trips more expensive and difficult. Car ownership would become even more necessary than it is today, but this expense would be a huge burden for low-income families, effectively making them poorer.

6. People who cannot drive would experience increased isolation

Transit is a critical means by which people who cannot drive – especially but not only seniors and disabled persons – maintain the social connections that are critical for mental health.

7. Economic growth would be reduced, and the region would likely remain predominantly low-income by U.S. standards

Many companies offering higher-wage jobs with opportunities for advancement are increasingly attracted to transit-rich cities.

Amazon's recent headquarter's search, for example, explicitly required high quality transit. While this is not an absolute barrier it is an important consideration in many industries.

8. Eventually, transit investment would be necessary anyway

Many of the metro areas – such as Los Angeles, Phoenix, Houston, and Atlanta – are now seeing strong voter support for transit expansion.

Unfortunately, those cities waited until the problem was dire. When more of the city has been built, it becomes more expensive, and less effective, to retrofit it for transit.

Tucson is exceptionally well-placed to develop in a more transit-oriented way. The grid pattern of arterials is ideal for transit efficiency, and can gradually be redesigned to be more friendly to pedestrians and cyclists. Streets are wide enough that there are viable options for transit priority whose impacts on other road users are not too severe.

The question, then, is not whether the region should invest in transit. It's whether it's too soon, while it's still (relatively) affordable and easy, or later, when it becomes an emergency.

2 Service Element: Building a More Complete Network

What are the existing transit services in the Tucson region?

Public Transit in the Tucson Region

The complete regional network of public transit services is shown on the map in Figure 17.

The City of Tucson, with support from the Regional Transit Authority (RTA), Pima County, the Town of Marana and regional transit funding through the FTA, offers the following public transit services:

- **Sun Tran**, which provides all-day bus service on 29 routes serving Tucson, South Tucson, Flowing Wells, Casas Adobes, Drexel Heights and Valencia.
- **Sun Express**, consisting of 12 peak-hour express routes operated by Sun Tran, that connect suburban locations to Downtown Tucson, the University of Arizona and the Aero Park.
- **Sun Link**, the streetcar line, with frequent all-day service between Downtown Tucson and the University of Arizona.
- **Sun Van**, the paratransit service, providing rides to passengers who live within Sun Tran's service area but are unable to use transit due to a disability.

The Regional Transportation Authority (RTA) also funds regional service through a countywide excise sales tax and additional funding from Pima County, the Town of Oro Valley, and the Town of Marana. The service includes:

- **Sun Shuttle**, which provides all-day routes connecting outlying communities such as Marana, Oro Valley, Sahuarita, Green Valley and others to places on the Sun Tran network.
- **Sun Shuttle Dial-A-Ride**, which provides a reservation-based demand-responsive service to the general public in Oro Valley, Sahuarita, and Green Valley, as well as a paratransit service for eligible disabled passengers that serves outlying areas not covered by Sun Van.

Sun Tran and Sun Link together account for 66% of total service provided in the region and 96% of ridership. Sun Shuttle accounts for 5% of total service and under 1% of ridership.

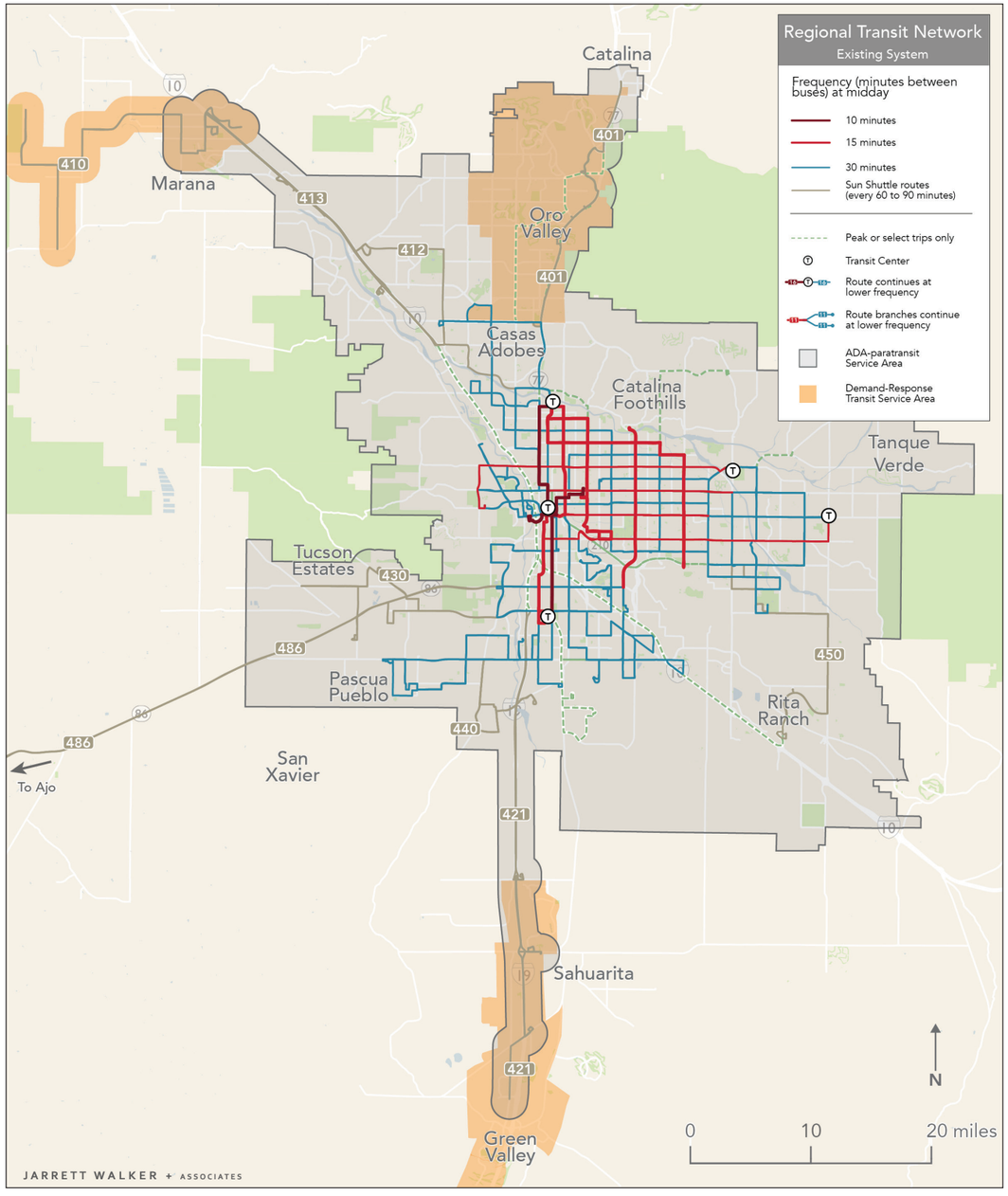


Figure 17: Map of public transit services and their weekday midday frequencies in the Tucson region.

Existing Network: Detailed Map

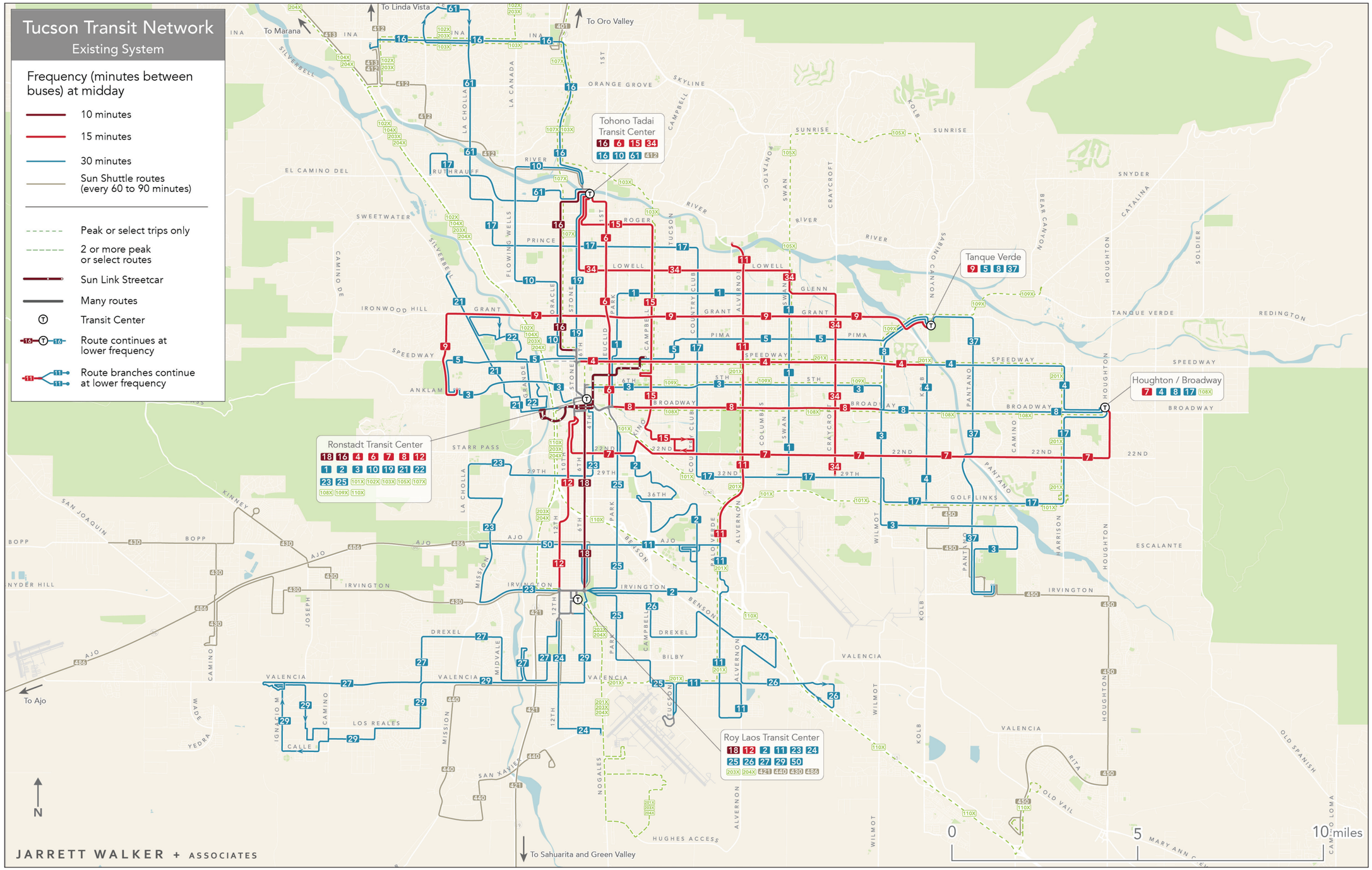


Figure 18: Detailed map of the existing transit network in Tucson and its immediate surroundings. This map shows transit lines organized by their frequency on weekdays, in the middle of the day.

Why is transit available in some areas but not others?

How Urban Form Governs Transit Efficiency

Most of the cost of providing public transit is the cost of the driver's labor. Meanwhile, much of the benefit of transit comes down to the number of transit trips people choose to take. So in designing the most efficient transit service possible, we concentrate largely on two questions:

- **How many people can easily get to each stop or station?**
  - » Density: where more people live or work near a stop, more people are likely to ride.
  - » Walkability: where it's easier for people to walk to and from the bus stop, more people are likely to ride.
- **How long does a bus need to travel to reach useful places?**
  - » Linearity: where destinations are laid out in a straight line, the bus can serve many places in less time. When destinations are scattered far from main roads, the bus may need to make deviations off its path. That means more driver hours (higher cost) and slower travel (fewer riders).
  - » Proximity: where destinations are close together, the bus can serve many places in less time. When destinations are far apart, it takes more time to reach them, which comes at a higher cost.

These geometric facts are the basis of a difficult challenge — a transit system focused on providing the most useful service to the highest number of riders (and the best return on public investment) concentrates service where the cost of operations is lower and the number of people who will benefit is higher.

High ridership transit is therefore not the same as transit that responds to everyone's needs no matter where they are. In fact, these two goals are often opposite.

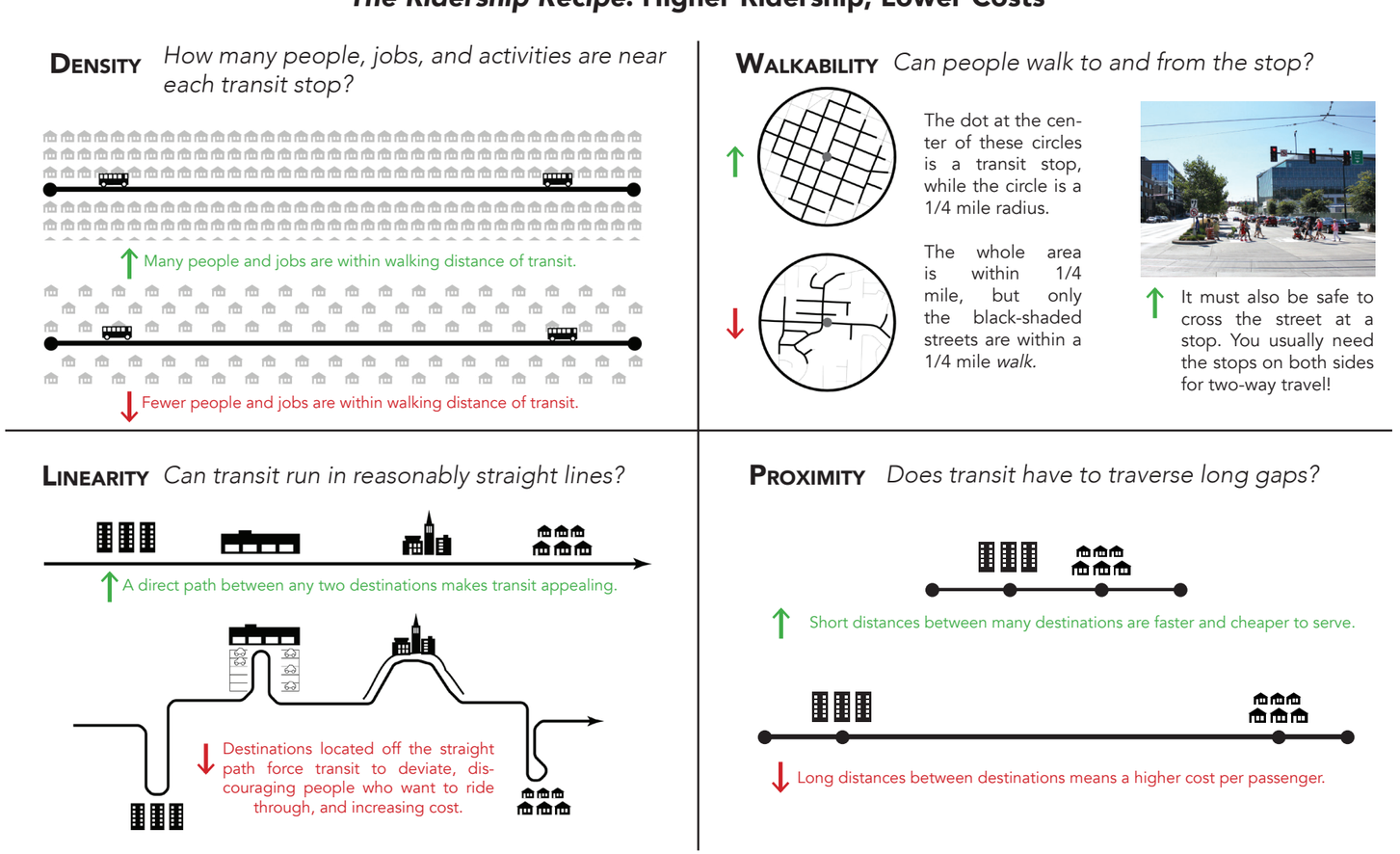


Figure 19: What conditions allow transit to serve the highest number of trips at the lowest cost?

Urban Form and Transit in Tucson

Figure 20 shows a map of residential and job density, which shows how the Tucson region has developed.

The area of relatively dense, linear and continuous development (as described on the previous page) **is basically the area served by Sun Tran** bus routes. With a few exceptions, this area is bounded by:

- Valencia Road to the south
- The Rillito River to the north
- Houghton Road to the east
- Silver Bell Road and Mission Road to the west.

Beyond this area, the likelihood of effectively serving the needs of many people going different places is much lower, and the cost of serving each potential rider is much higher. So, given that resources to operate transit are never going to be infinite, less service is available in the farther suburbs.

In 2009-10, the Regional Transportation Authority assumed operation of and significantly expanded the Sun Shuttle system. The expansion provided new or enhanced service into outlying areas that are either beginning to develop at slightly higher densities (e.g. Rita Ranch, Oracle Road going to Oro Valley, Sahuarita, and Green Valley) or display exceptionally high need (e.g. San Xavier, Ajo, and Why).

But despite targeting the outer suburban places most likely to need transit, Sun Shuttle service remains much less efficient than Sun Tran. Sun Shuttle buses carry an average of 3 boardings per hour of service, compared to an average of 25 boardings per hour on Sun Tran.

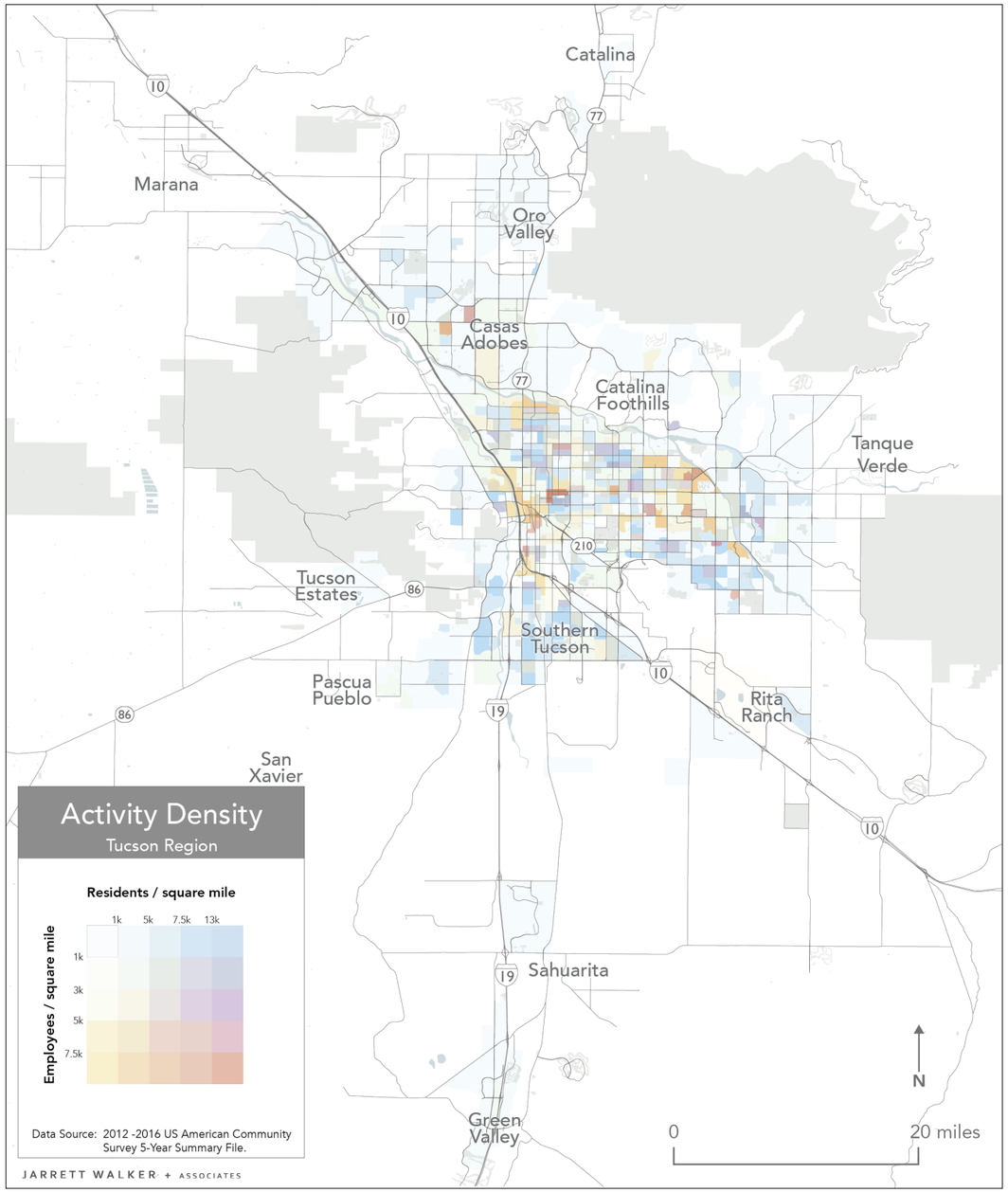


Figure 20: Activity density (residential and employment) by census block group in the Tucson region.

Service Strategy No. 1: Consistent Service, Seven Days a Week

The following pages contain descriptions of intended transit network improvements based on this plan's key service strategies. Detailed maps showing the complete transit network intended in the medium and long term are on page 34 and page 35.

Why Weekend Service Matters

Public transit has traditionally been planned on the assumption that most travel happens on weekdays and during the daytime. The everyday experience of traffic seems to confirm this. Traffic tends to be heaviest on weekdays, during morning and evening commute hours, somewhat lighter on weekends and lightest in the evenings.

Nevertheless, there are good reasons to question whether transit should still be planned primarily around weekday daytimes:

- More and more jobs are on nontraditional schedules requiring occasional or regular weekend shifts. This trend is especially pronounced for lower-wage jobs in retail, healthcare, restaurants and personal services, so improving weekend service especially helps improve the lives of people with lower incomes.
- In addition, these sectors also drive significant and growing numbers of weekend trips for shopping, socializing, recreation and other purposes, many of which could be made by transit.
- Many people may be reluctant to use transit because of its inconsistent availability. If you need to drive to get to a weekend shift, you're less likely to take transit on a weekday, even at a time when the bus comes every 15 minutes.

Two phases of public consultation have made it clear that improving weekend service is a high priority for Tucsonans:

- In an online and in-person survey carried out in Fall 2018, out of 2,379 responses, 93% were in favor of at least some improvements to evening and weekend service, and nearly half of that number, 40% specifically, were more interested in improvements to weekend and evening service than improvements to transit service on weekdays.
- In an online and in-person survey carried out in September 2019, out of 672 responses, 60% indicated that weekend service was one of their top three priorities for improvement.
- In both surveys, improvements to weekend service were most favored by respondents who reported the most urgent needs: people with incomes below $40,000, and people without access to a working, drivable vehicle.

Existing Weekend Service

In existing service, Sun Tran routes have lower levels of service on weekends than on weekdays. This is especially true on Sundays, when almost all routes operate only once an hour.

Phase 1 Weekend Improvements

Public feedback has indicated that improvements to weekend service are a high priority, especially for people with more urgent transit needs. As a result, we proposed to improve weekend service in Phase 1 of this plan. **Within two years of funding, all Sun Tran routes would run at the same frequencies on weekends as on weekdays.**

How to Read the Maps on this Page

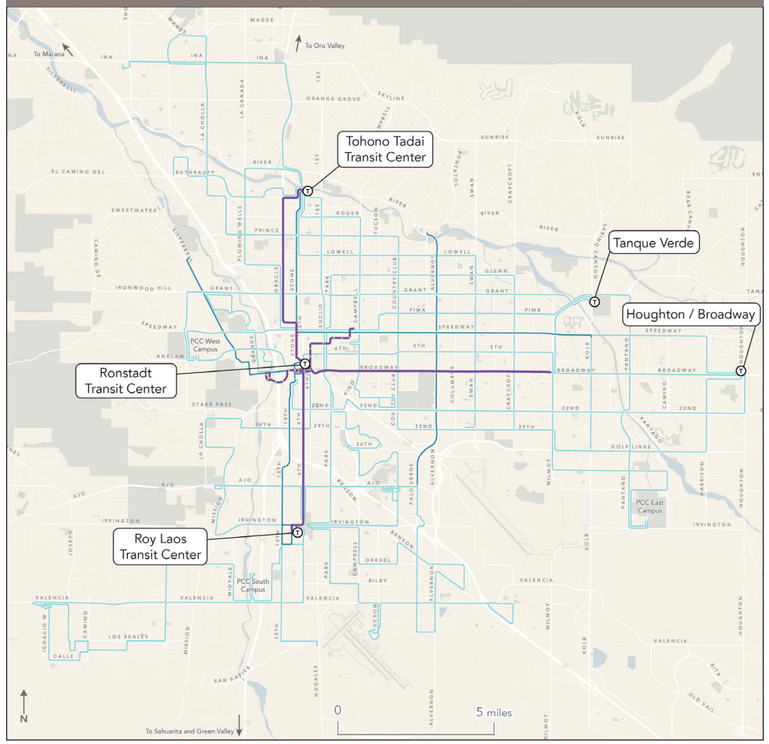
The maps below show the typical frequency of transit service on Sundays, between 6 a.m. and 7 p.m. On these maps, frequency is indicated by color. **Red lines** correspond to frequent service, every 15 minutes or better. **Dark blue** lines indicate service every 30 minutes. Light blue lines indicate service every 60 minutes.

Map Legend

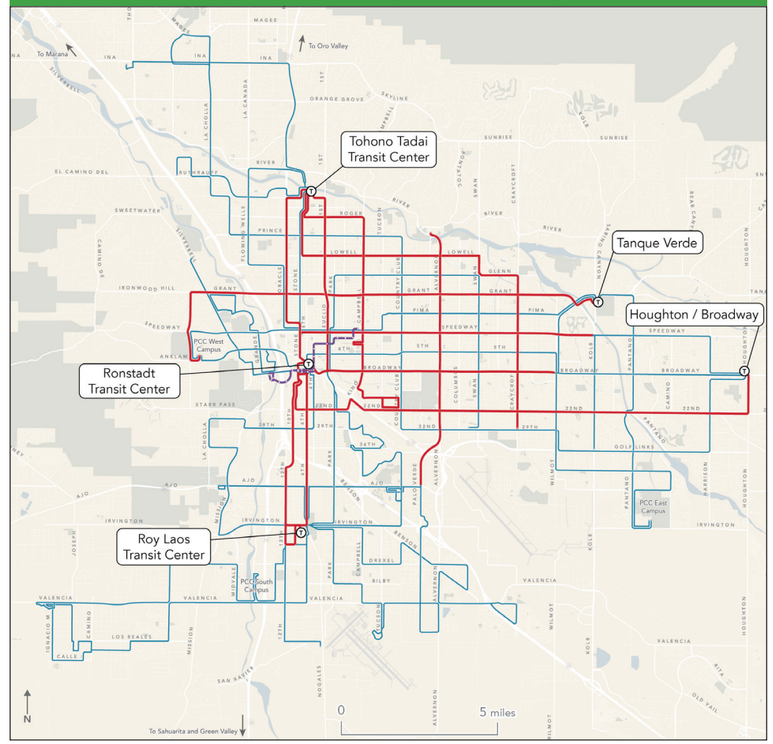
A bus comes every...

- 10 minutes
- 15 minutes
- 30 minutes
- 60 minutes

Existing Network - Sundays



Phase 1 (within 2 years) - Sundays



Phase 2 Weekend Improvements

In Phase 2 of this plan, as the Frequent Transit Network (FTN) expands, so would weekend service. **Within five years, all new FTN routes would have frequent service on weekends as well as weekdays.** See page 30 for plans to expand frequent service more generally.

Long Term Weekend Improvements

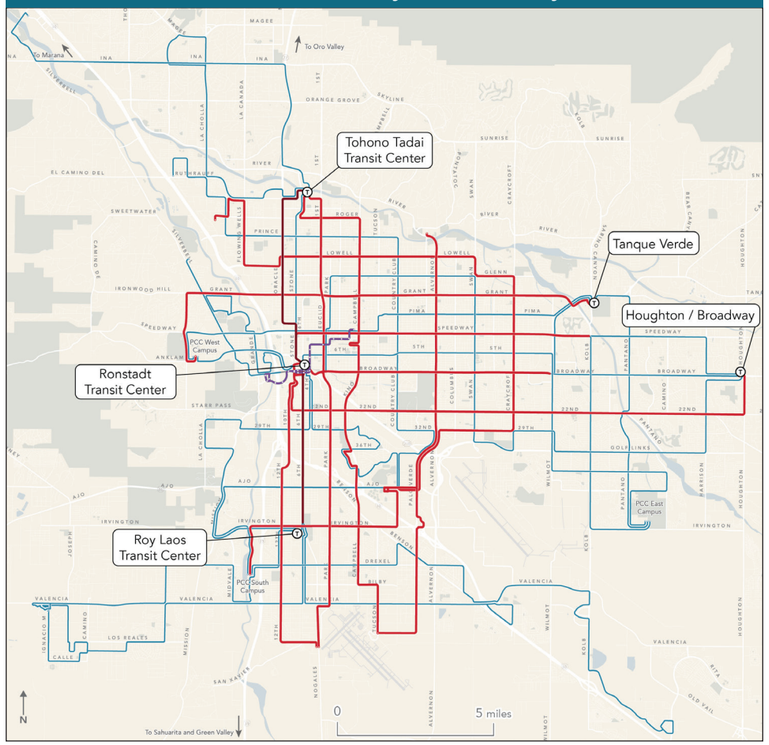
In the long term, FTN expansion would continue. As a result, **within ten to twenty years, frequent service would become available seven days a week within a half-mile of 46% of the region's residents**, and 85% of Tucson residents.

How to Read the Maps on this Page

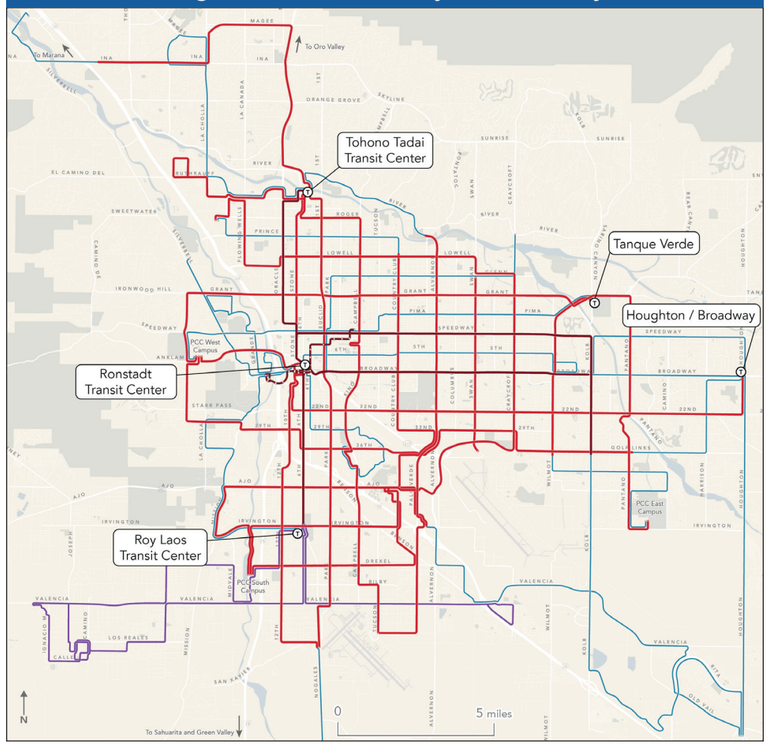
The maps below show the typical frequency of transit service on Sundays, between 6 a.m. and 7 p.m. On these maps, frequency is indicated by color. **Red lines** correspond to frequent service, every 15 minutes or better. **Dark blue** lines indicate service every 30 minutes. Light blue lines indicate service every 60 minutes.

Map Legend
A bus comes every...
10 minutes
15 minutes
30 minutes
60 minutes

Phase 2 (within 5 years) - Sundays



Long Term (within 10-20 years) - Sundays



Service Strategy No. 2: Improve Evening Service

Why Evening Service Matters

In the same way that weekend service has traditionally played second fiddle to weekday service, evening service has long been much lower than daytime service, on the assumption that most trips occur between 7 a.m. and 7 p.m.

While that's probably true, there are still good reasons to question why evening service levels after 7 p.m. should be so low. Many of these are similar to the reasons for improving weekend service.

- Jobs on nontraditional schedules, and especially lower-wage jobs in service, retail and healthcare, often involve shifts that start in the midday and end later than 6 p.m. So, like weekend service, improving evening service especially helps improve the lives of people with lower incomes.
- Just as on weekends, even people who are not working make many evening trips for shopping, socializing, recreation and other purposes, many of which could also be made by transit.
- Many people may be reluctant to use transit because of its inconsistent availability. If you need to drive to get to an evening shift or a once-a-week evening social activity, you're less likely to take transit on a different day and time, even if the bus is convenient then.

As with weekend service, two phases of public consultation have made it clear that improving evening service is a high priority for Tucsonans:

- In an online and in-person survey carried out in Fall 2018, out of 2,379 responses, 93% of respondents were in favor of at least some improvements to evening and weekend service, and nearly half of that number (40%) specifically were more interested in improvements to weekend and evening service than improvements to transit service on weekdays.
- In an online and in-person survey carried out in September 2019, out of 662 responses, 62% indicated that evening service was one of their top three priorities for improvement.
- In both surveys, improvements to evening service were most favored by respondents who reported the most urgent needs: people with incomes below $40,000, and people who don't have access to a working, drivable vehicle.

Existing Evening Service Levels

In existing service, most Sun Tran routes operate only once an hour after 7 p.m. Only a few streets on the Frequent Transit Network (FTN) get service every 30 minutes. Most (but not all) routes operate until midnight on weekdays. But evening service ends around 10 p.m. on Saturdays, and 9 p.m. on Sundays.

Phase 1 Evening Improvements

Public feedback has indicated that improvements to evening service are a high priority, especially for people with more urgent transit needs. As a result, we proposed to improve weekend service in Phase 1 of this plan. **Within two years of funding, all FTN routes would operate every 30 minutes in the evening, and all Sun Tran routes would operate until midnight, seven days a week.**

How to Read the Maps on this Page

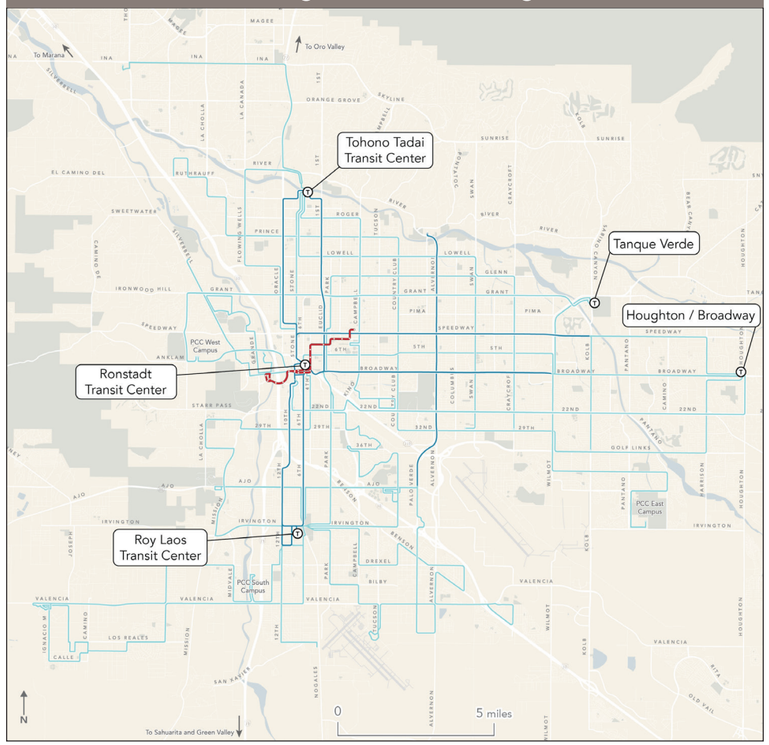
The maps below show the typical frequency of transit service on weekday and weekend evenings, after 7 p.m. On these maps, frequency is indicated by color. **Red lines** correspond to frequent service, every 15 minutes or better. **Dark blue** lines indicate service every 30 minutes. Light blue lines indicate service every 60 minutes.

Map Legend

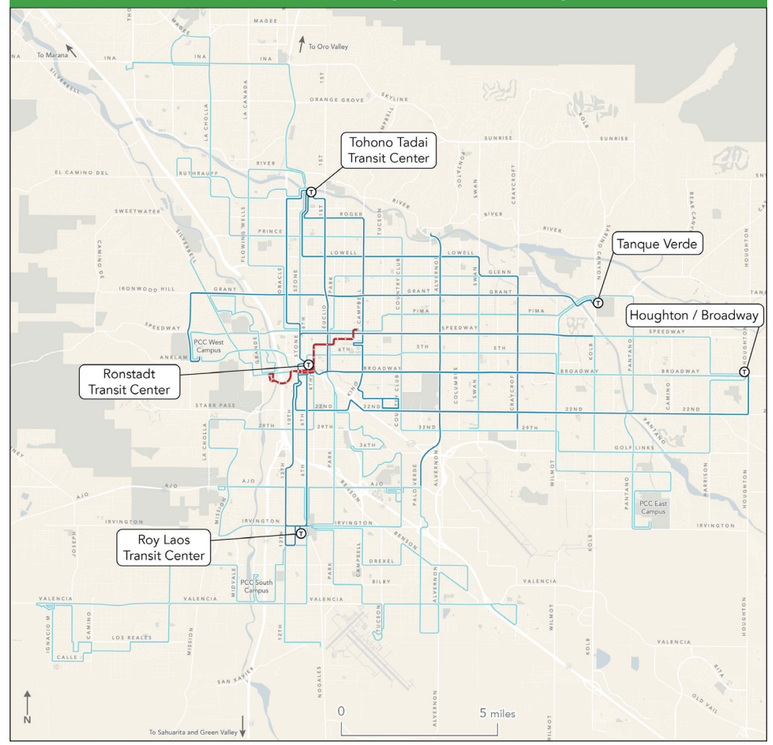
A bus comes every...

- 10 minutes
- 15 minutes
- 30 minutes
- 60 minutes

Existing Network - Evenings



Phase 1 (within 2 years) - Evenings



Phase 2 Improvements

In Phase 2 of this plan, as the Frequent Transit Network (FTN) expands, so would evening service. **Within five years, all existing and new FTN routes would provide service every 30 minutes after 7 p.m.** See page 30 for plans to expand frequent service more generally. As in Phase 1, all Sun Tran Routes would continue to operate until midnight, seven days a week.

Long Term Evening Improvements

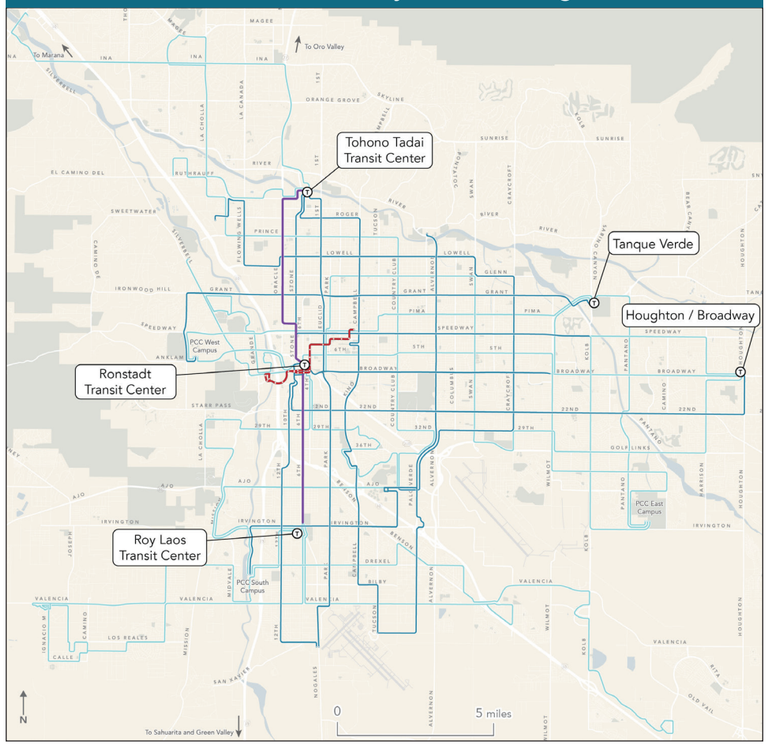
Within ten to twenty years, all Sun Tran routes would operate every 30 minutes or better in the evenings, seven days a week, from 7 p.m. until midnight. And the busiest FTN routes (e.g. Broadway, Speedway, Oracle, South 6th) would retain service every 15 minutes or better until midnight.

How to Read the Maps on this Page

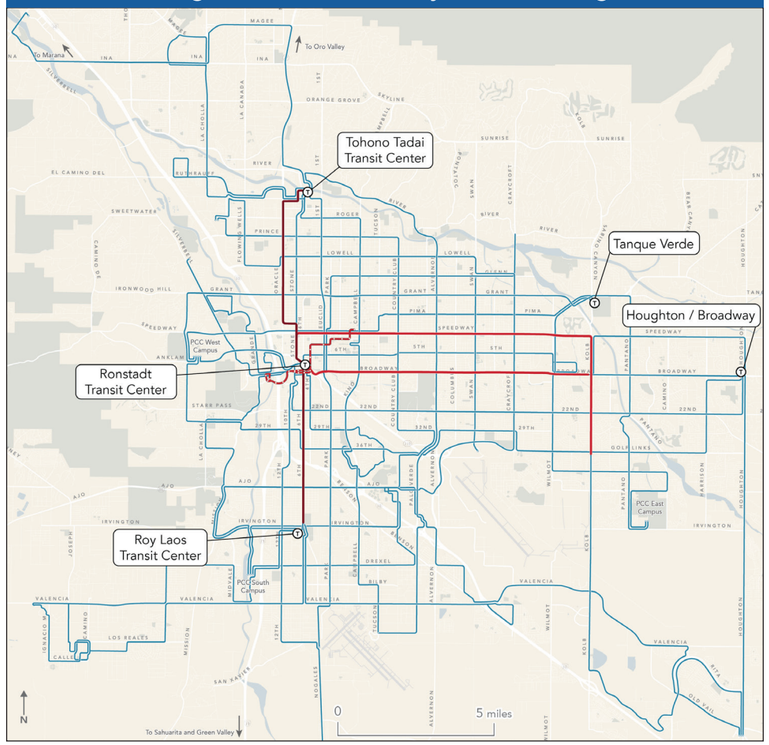
The maps below show the typical frequency of transit service on weekday and weekend evenings, after 7 p.m. On these maps, frequency is indicated by color. **Red lines** correspond to frequent service, every 15 minutes or better. **Dark blue** lines indicate service every 30 minutes. Light blue lines indicate service every 60 minutes.

Map Legend
A bus comes every...
10 minutes
15 minutes
30 minutes
60 minutes

Phases 2 (within 5 years) - Evenings



Long Term (within 10-20 years) - Evenings



Service Strategy No. 3: Expand the Frequent Transit Network

Why Frequency Matters

Waiting time is often a dominant part of travel time, so frequency is one of the most critical features of a successful transit line. The more often the bus comes by:

- The less you need to keep track of the schedule.
- The more you can travel whenever and wherever you want.
- The farther you can go in the same amount of time.

As a result, **frequent service provides more freedom and is useful for many more types of trips** than a bus that only comes every 30 minutes or once an hour, as shown on page 6.

Recognizing this, the City of Tucson and RTA have invested in the Frequent Transit Network (FTN), a set of routes with service every 15 minutes from 6 a.m. to 6 p.m. on weekdays.

Public feedback gathered in the course of preparing this plan has suggested that expanding frequent service is also a high priority for Tucsonans:

- In an online and in-person survey carried out in Fall 2018, out of 2,352 responses, 96% of respondents were in favor of some expansion of frequent service, and nearly a third of that number (31%) were specifically more interested in expanding the FTN than in extending transit service to any new locations.
- In an online and in-person survey carried out in September 2019, out of 659 responses, 65% said that expanding frequent service was one of their top three priorities for improvement.
- In both surveys, expanding frequent service had broad support among respondents regardless of age, income, race, or location.

Existing Frequent Service

Today's FTN includes 11 Sun Tran routes and the Sun Link streetcar. Some of these routes are on streets that have traditionally generated the most ridership, like Broadway, Speedway, Oracle Road and South 6th Ave. Others are more recent additions that have expanded frequent service to large parts of the east side.

Despite expansions, there are still many areas with relatively high densities of people and jobs that remain beyond the FTN. This includes most of the south side, as well as parts of the outer east side and inner northwest.

Medium Term FTN Improvements

Expanding the FTN would require significant restructuring of the existing service, particularly on the south side. This type of effort requires significant advance planning and public outreach. In addition, it wouldn't be possible to operate the expanded FTN without purchasing more buses, which would take about 2 years from the time that new buses are ordered. As a result, the first major FTN expansion is proposed in Phase 2 of this plan, while Phase 1 would focus on evening and weekend service (as explained in prior pages).

Within five years, the frequent network would expand to cover most of the south side and Flowing Wells Road. This expansion would be targeted at reaching the largest swathes of highly populated neighborhoods not on the FTN today, and reaching much higher numbers of people with low incomes and limited access to a car.

How to Read the Maps on this Page

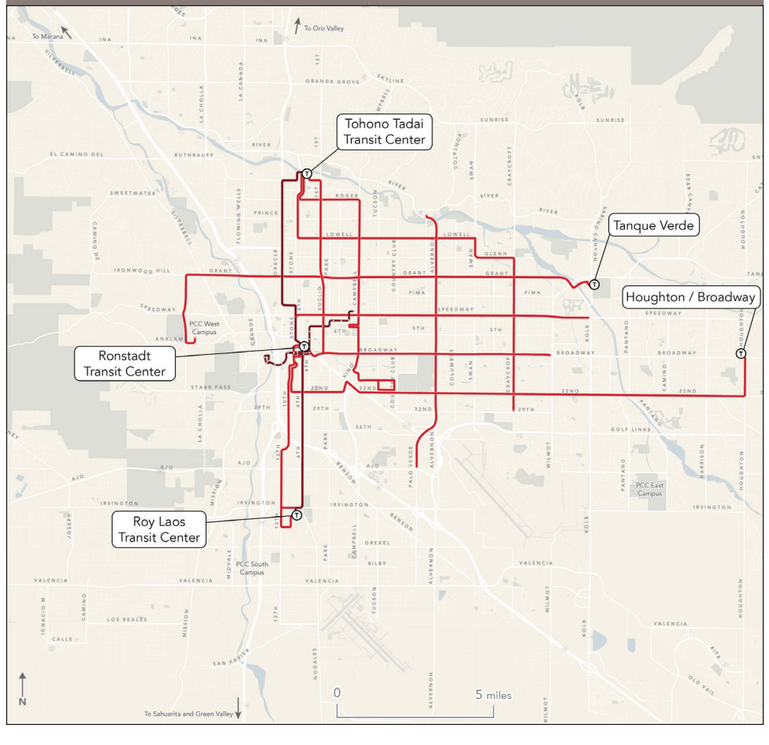
The maps below show the extent of the Frequent Transit Network (FTN) only. Routes that operate less than every 15 minutes on weekdays are not shown, but would still operate. The point of these maps is to show the planned expansion of the FTN over time in this plan.

Map Legend

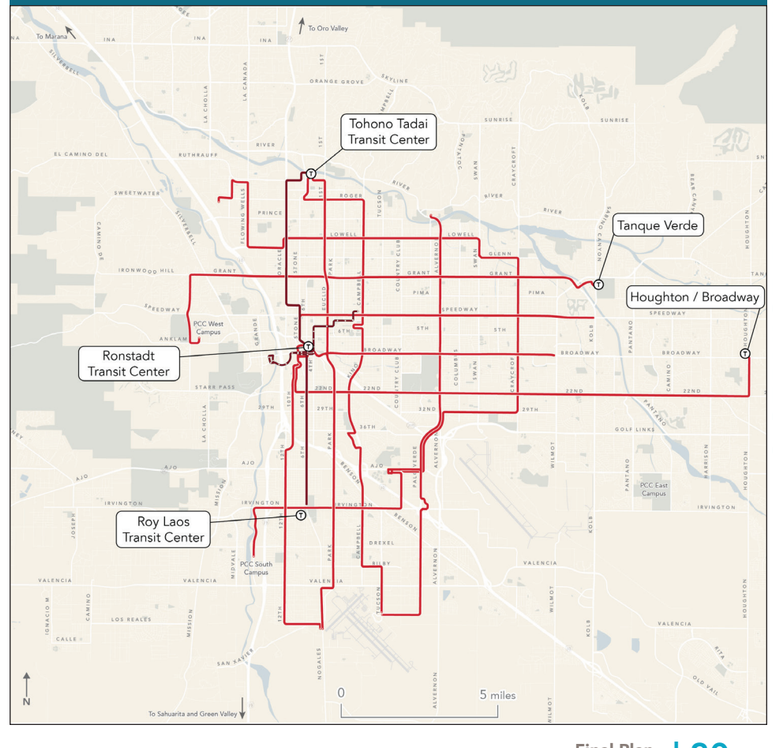
A bus comes every...

- 10 minutes
- 15 minutes

Existing - Frequent Transit Network



Phase 2 (within 5 years) - Frequent Transit Network



Long Term FTN Improvements

Within ten to twenty years, anyone in the core areas of the Tucson metropolitan area would be able to reach frequent service in any direction within a 10 minute walk. Frequent routes would be spaced on a consistent 1 x 1 mile grid in most of Tucson.

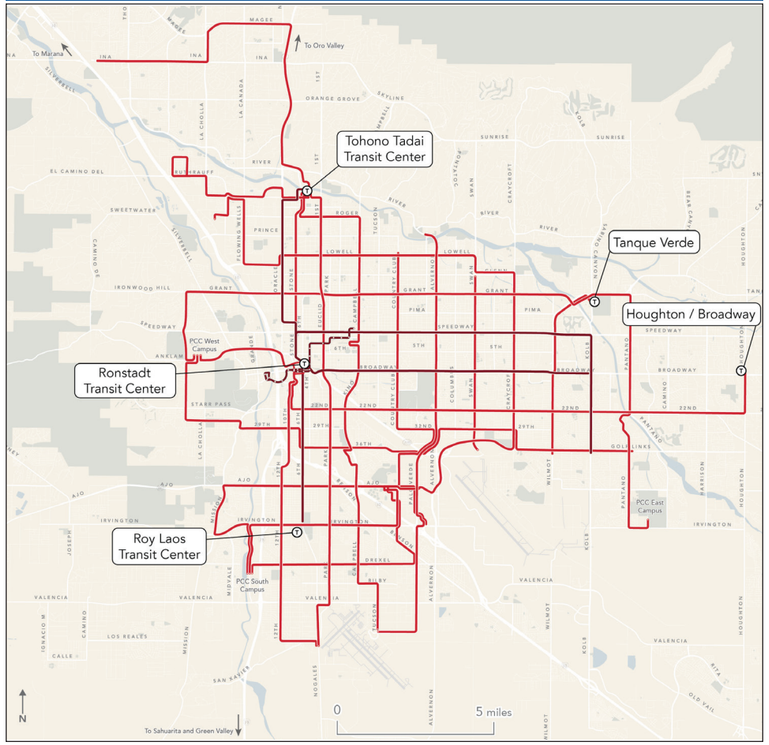
Furthermore, frequent routes would extend to all parts of the region developed in a relatively dense, linear and continuous fashion. This would include more frequent routes on the south side, in Flowing Wells, on the outer east side, and in Casas Adobes.

How to Read the Map on this Page

The map below shows the extent of the Frequent Transit Network (FTN) only, ten to twenty years from the beginning of this plan. Routes that operate less than every 15 minutes on weekdays are not shown, but would still operate. The point of this maps is to show the planned expansion of the FTN over time in this plan.

Map Legend
A bus comes every...
10 minutes
15 minutes

Long Term (within 10-20 years) - Frequent Transit Network



JARRETT WALKER + ASSOCIATES

Service Strategy No. 4: Targeted Expansions in the Suburbs

Why Expand Suburban Service?

This plan dedicates the majority of service expansions to core areas of the region, where investments in additional service are most likely to make transit convenient to large numbers of people and generate significant new ridership, while making efficient use of public funds.

Nevertheless, this plan has considered all parts of the greater Tucson region, and recommends service expansions in certain suburban areas that show either of the following conditions:

- Expected demand for transit service is likely to grow over the next twenty years. These areas may in the very long term become more similar to the core of the region.
- Local demographics suggest extremely high levels of need for service. Factors like age, income and car ownership levels suggest a high proportion of the people living in these areas need a public transportation service, even if we do not expect that service to ever generate high ridership, or even ridership comparable to existing core services.

Public feedback on the Draft Plan suggests that suburban residents tend to place much higher value on improvements to suburban service than urban residents. Nearly 40% of suburban respondents to the online and in-person survey carried out in September 2019 indicated that the initially proposed medium-term service improvements were not enough. **As a result, several improvements originally intended for the long-term (in ten to twenty years) have now been placed in Phase 2, within five years of plan funding.**

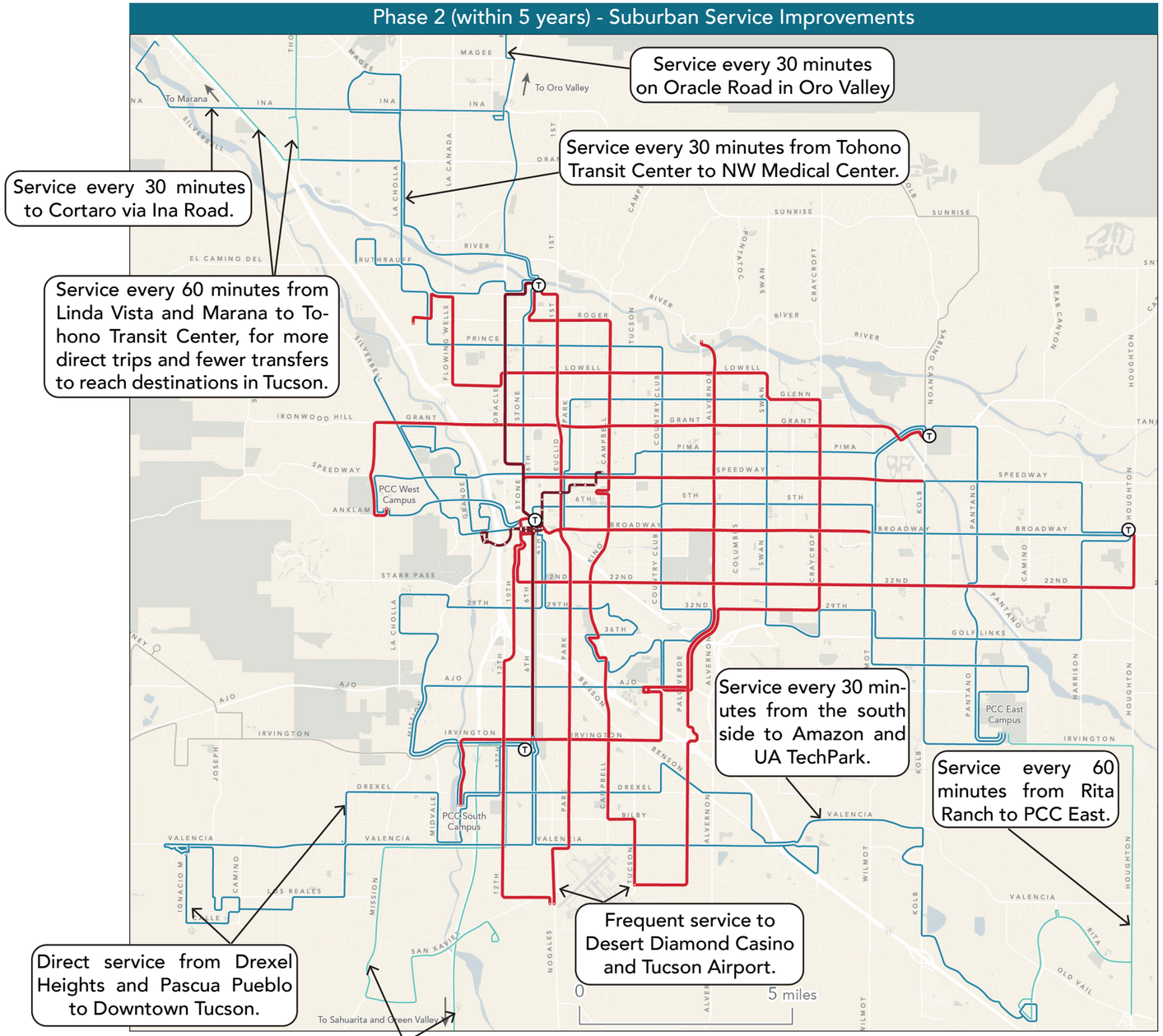
Medium Term Suburban Improvements

Proposed improvements to suburban service in the first five years of this plan are indicated on the map to the right. This map shows the typical frequency of transit service on weekdays. Frequency is indicated by line color, as shown in the legend below.

Map Legend

A bus comes every...

- 10 minutes
- 15 minutes
- 30 minutes
- 60 minutes



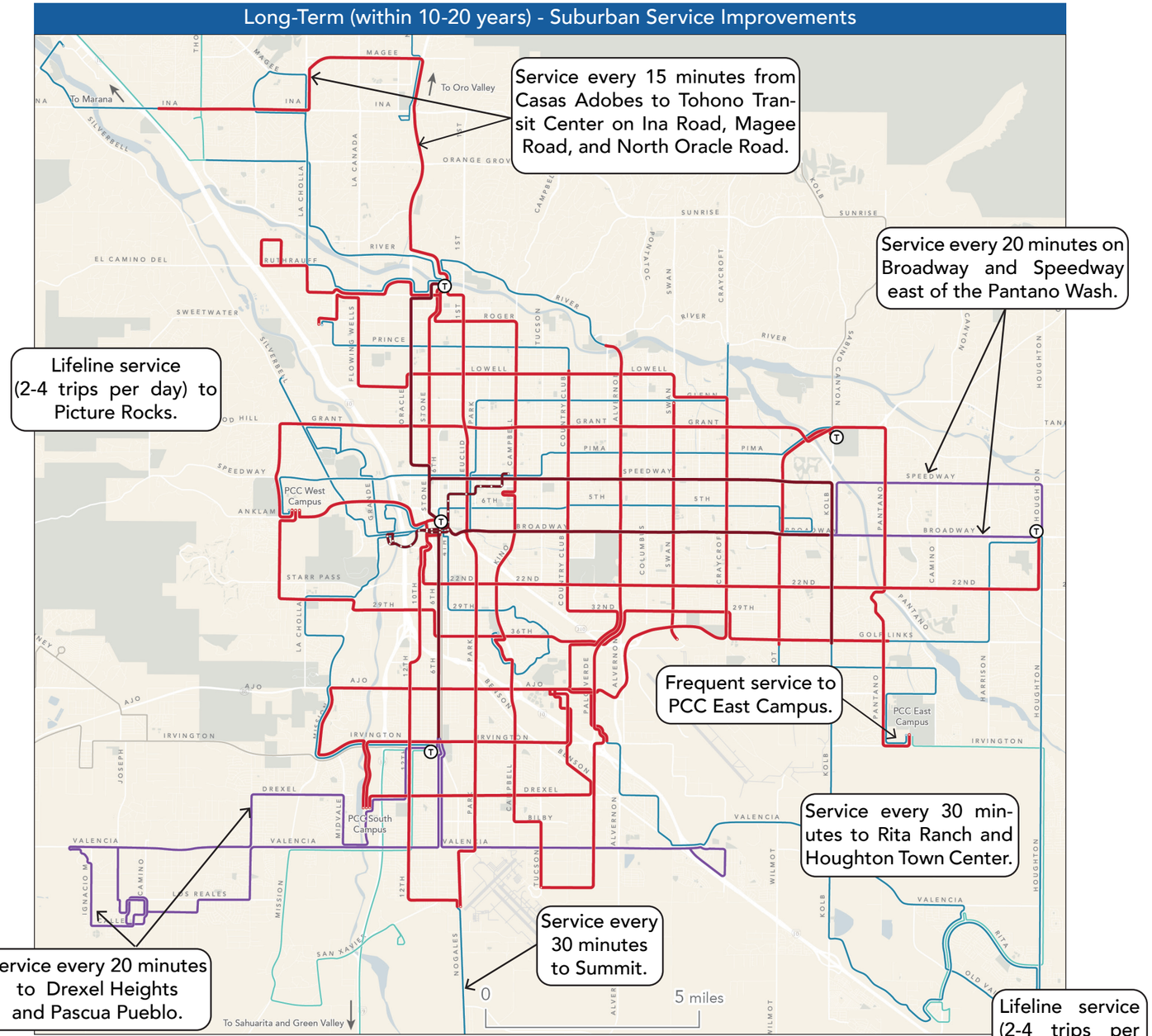
Long Term Suburban Improvements

Proposed improvements to suburban service within ten to twenty years of the beginning of this plan are indicated on the map to the right. This map shows the typical frequency of transit service on weekdays. Frequency is indicated by line color, as shown in the legend below.

Map Legend

A bus comes every...

- 10 minutes
- 15 minutes
- 30 minutes
- 60 minutes



Medium Term Network (within 5 years): Detailed Map

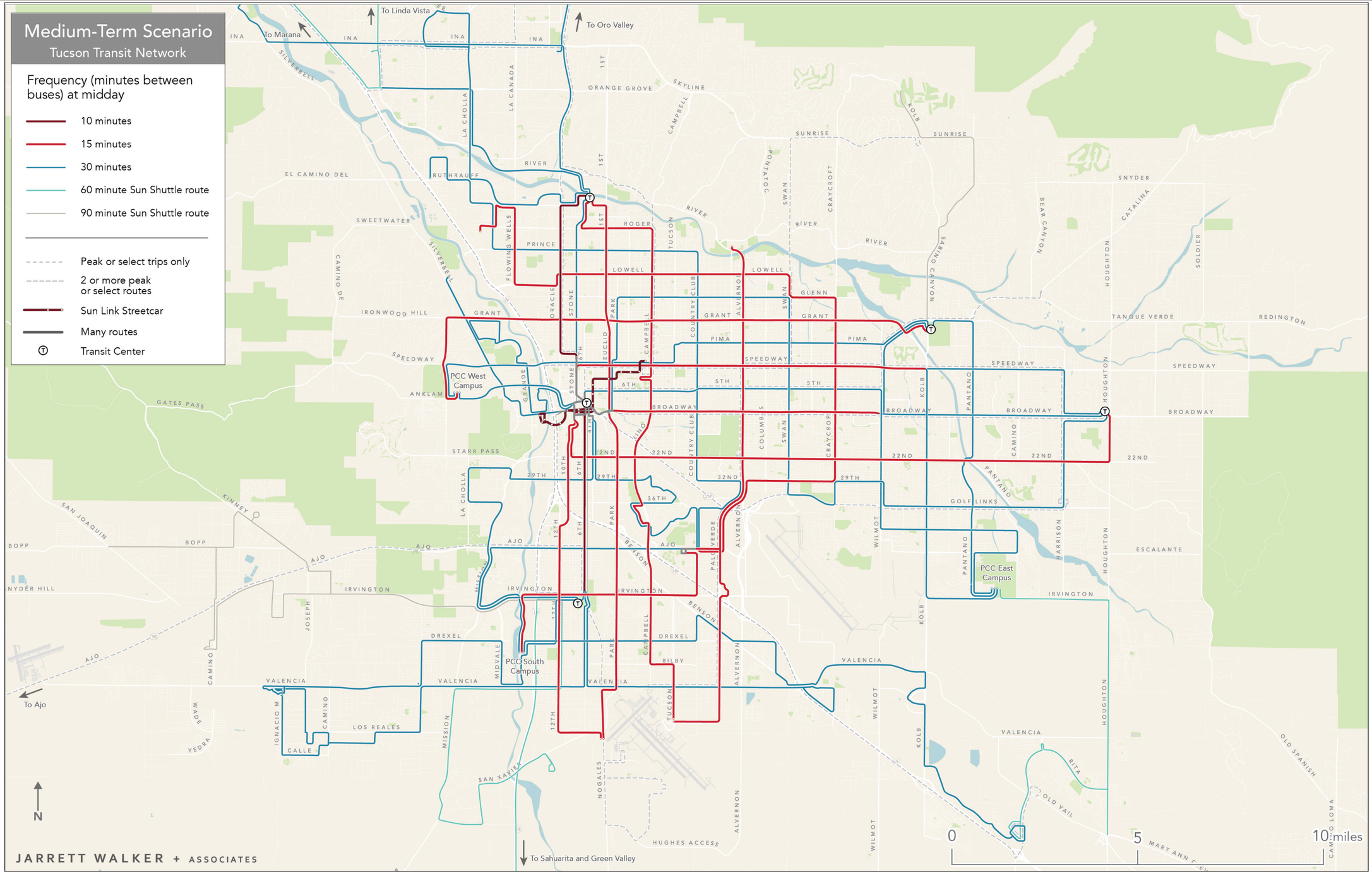


Figure 21: Detailed map of proposed medium term improvements to the Tucson transit network.

Please note:

1. This map shows the intended location and frequency of Sun Tran and Sun Shuttle in five years after funding, assuming this plan is adopted. Certain details, like exact route numbers and end of line locations, may evolve over time. All service changes would be subject to public comment before taking place.

2. This map does not show Sun Tran Express service in detail, because this long-range plan does not address these routes (100X and 200X series). Any future changes to these routes would also be subject to public comment.

Long Term Network (within 10-20 years): Detailed Map

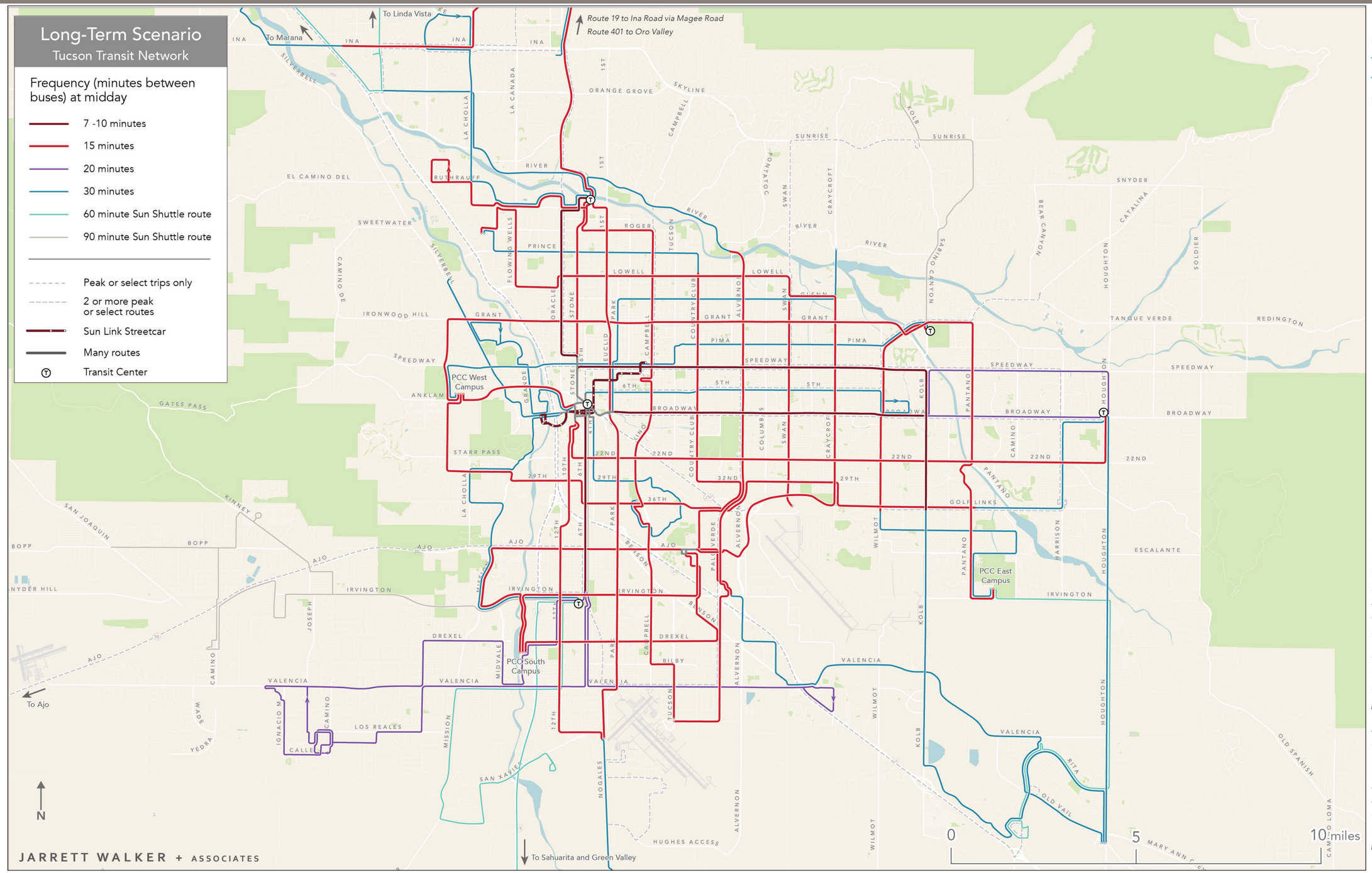


Figure 22: Detailed map of proposed long term improvements to the Tucson transit network.

Please note:

1. This map shows the intended location and frequency of Sun Tran and Sun Shuttle, 10 to 20 years after plan adoption. Certain details, like exact route numbers and end of line locations, may evolve over time. All service changes would be subject to public comment before taking place.

2. This map does not show Sun Tran Express service in detail, because this long-range plan does not address these routes (100X and 200X series). Any future changes to these routes would also be subject to public comment.

3 Capital Element: Improving Speeds, Reliability and Comfort

Why include capital investments in this plan?

Purpose

Capital investments can serve many different purposes. Some investments—such as maintenance facilities—may enlarge the agency's capacity to provide service. Others, such as stations, enhance customer experience, comfort, and safety. Yet other investments may accomplish both goals; for example, signal priority at intersections increases trip speed and reliability while freeing up buses to provide more service.

One thing is clear: without the proper equipment and infrastructure, it's not possible to run transit service at all, and any improvements will be highly constrained. So to make the most of the operating investments described in Chapter 2, it makes sense to envision a broad plan of capital improvements that would:

- **Provide a higher level of safety, security and dignity** for transit users, through improvements to vehicles, technology, stops, stations and facilities.
- **Improve capacity, speed and reliability** for faster travel, to plan for higher ridership, and to lower the unit costs of providing service.

Who's involved?

PAG, the Regional Transportation Authority (RTA), the City of Tucson, and other local and tribal governments all have a role in the transit experience for existing and future transit users.

Sun Tran, Sun Link and Sun Shuttle are responsible for providing stops, service information and the transit service itself. But much of the infrastructure that enables customers to safely and comfortably access transit and allows transit vehicles to maintain reliable and on-time performance belongs to local government.

Although this plan does not take a specific position on who should purchase, own or maintain any specific element of infrastructure, we have assumed that:

- Transit vehicles, vehicle technology, stops and stations are the responsibility of the service operators.
- Other transit-supporting elements in the right-of-way like sidewalks, intersection traffic control, and the layout of streets and roads in general are responsibilities of local government (or tribal government on tribal lands).

Existing Assets

The region has a long history of capital investments supporting the regional transit network. Some of the most visible results include:

- **The Sun Link modern streetcar** in 2014, representing a nearly $200 million investment in fixed-route, high-capacity transit in downtown Tucson. Sun Link comprises four miles of guideway, eight vehicles, and a dedicated maintenance facility.
- **Transit Centers and Park-and-Ride facilities** including the Rondstadt, Roy Laos, and Tohono Tadai transit centers and several park-and-ride facilities that are staffed and feature enhanced amenities such as sheltered stops, lighting and restrooms.
- A network of **over two thousand bus stops**, ranging from unmarked flag stops to high amenity Sun Link stations that feature shelters, off-board fare purchase stations and real-time arrival information. In all, nearly half of Sun Tran's stations have shelters in place—an important amenity in a city where the average daytime temperatures regularly exceed 100 degrees Fahrenheit in the summer.
- New **maintenance facilities** provide space for over 250 buses, a significant expansion over the old Price Center. Sun Van, the region's complementary paratransit network, operates another dedicated maintenance facility. And in conjunction with the City of Tucson, Sun Tran opened a compressed natural gas (CNG) facility, enabling operation of low-emission transit vehicles.

The City of Tucson's Transit Asset Management Plan (TAMP), completed in 2019, lists major capital assets owned by Sun Tran and related entities along with their maintenance needs. The TAMP estimates that to maintain its current facilities and assets, Sun Tran and its partners will need to invest $79 million over the next four years to sustain a state of good repair.

These costs are already taken into account in existing financial plans[1]. The further improvements described in this chapter are proposed new costs, above and beyond prior plans.

1 Capital costs from the TAMP are understood to be already taken into account. However, expanding the capital assets of Sun Tran will also increase the annual cost of keeping the system in a state of good repair. Going forward, it will be important to balance the needs of ongoing maintenance costs against the service and capital expansion programs described in this document.

What improvements are included?

This plan recommends nearly $300 million in additional capital spending over the long-term planning horizon. The elements included are intended to work in concert with the service improvements described in Chapter Two, and include:

- Purchase of additional new alternative fuel vehicles to accommodate expanded service;
- An expanded bench and shelter program, putting improved facilities at 99% of boarding locations, including all new stops required by new service;
- Sun Link-style stations (bench, shelter, lighting, off-board payment, and real-time arrival) at 100 Frequent Network stops;
- Ten new mobility hubs and two new transit centers;
- Intersection treatments at the top 200 intersections in the region; and
- Installation of an Automatic Vehicle Locator/Automatic Passenger Counter/Computer-Aided Dispatch system on every bus in the fleet.

The improvements described in this chapter are organized in three phases:

- **Phase 1 improvements** correspond to a significant increase in service delivery over the first two years of this plan. The majority of infrastructure investments over this phase support direct service delivery including vehicles and technology.
- **Phase 2 improvements** are envisioned within two to five years of plan funding. These should be implemented concurrently with the expansion of the Frequent Transit Network. They include a further expansion in the transit fleet, and additional right of way and stop/station improvements in the busiest parts of the network and/or areas where the introduction of frequent service requires substantial infrastructure upgrades.
- **Phase 3 improvements** are envisioned within five to ten years, and represent the final supporting elements of the medium term network. This phase includes the bulk of improvements to stops, stations, and right-of way to improve the efficiency and capacity of the network.
- **Long term improvements** are envisioned within ten to twenty years, corresponding with long term network plans.

Initial improvements are focused largely on purchasing new vehicles and upgrading vehicle technology, while later items include significant improvements to stops and stations and right-of-way in addition to substantial new bus purchases. A summary of the expenses envisioned throughout each phase of improvements can be found in Figure 23.

In practice, capital expenses occur continuously and are required to expand services or maintain a service standard. Buses have a typical operating life of 12 years; shelters and stations require installation and maintenance, and emergent traffic congestion may cause certain routes to become slower over time, necessitating changes to signals, right-of-way or other roadway features.

Within the timeline envisioned for each phase, capital expenses will need to be balanced against available resources and expansions in service. Some capital expenses may be required as a direct result of specific service changes, such as vehicle purchases necessary to meet expanded fleet needs; others may reflect agency goals as expressed by the public, such as an expanded shelter program.

Planning for capital costs is challenging, particularly for items that require engineering, design and construction. The estimates outlined in this document include a significant contingency to allow for uncertainties in site-specific conditions, professional service needs, and overall level of investment decisions.

Improvement Type[1]	Phase 1 *(Years 1 - 2)*	Phase 2 *(Years 3 - 5)*	Phase 3 *(Years 5-10)*	Long Term *(Years 11-20)*	Total
Vehicles	$60.8 million			$143 million	$204 million
Technology	$13 million			$7.7 million	$21 million
Stops and Stations	$4.7 million	$14.7 million	$86 million	$102 million	$207 million
Speed and Reliability	$2.1 million	$6.7 million	$20 million	$41 million	$70 million
Total	**$80.3 million**	**$21.4 million**	**$106 million**	**$294 million**	**$502 million**

1 All costs listed in this chapter are in dollars estimated based on year of expenditure and include contingency, management, and permitting estimated at 40 percent of a planning-level estimate of hard costs (with the exception of vehicles, where we calculate a contingency in case of switch to electric propulsion). This type of contingency is necessary because many of the items in this plan require design and construction, both of which require significant contingencies for unforeseen circumstances.

Figure 23: Capital Cost Summary by Phase. All dollar costs in this table are estimated based on year of expenditure, assuming Year 1 is 2023.

Service levels drive capital investments.

Focus Improvements on More Frequent Routes

The service element of this plan (described in Chapter 2) distinguishes between routes on the Frequent Transit Network, standard Sun Tran bus service, and infrequent Sun Shuttle service.

Detailed maps showing existing and proposed service frequencies by day and time are provided in Chapter 2. The table below summarizes the types of service proposed by tier as a function of their intended daytime and evening frequencies.

By focusing capital investments on higher service tiers and higher-ridership stations, this capital element of the plan seeks to prioritize the needs of the highest numbers of existing and potential riders.

Multi-Agency Approach

Transit-supportive improvements also extend beyond the immediate assets of Sun Tran, Sun Link and Sun Shuttle. Projects led by local governments may include pedestrian and bicycle infrastructure, land development, traffic operations and more.

The planning, funding, and implementation of truly multimodal transportation projects requires coordination between agencies The region, therefore, must take advantage of opportunities to show how transit-supportive improvements enhance the travel experience for existing and future riders and other travelers who share the roads, sidewalks and urban trails on and around transit facilities.

In some cases, it may be possible to fund or finance capital investments with the help of Federal Transit Administration (FTA) resources. This is especially true of bulk vehicle purchases. In developing funding sources for the elements of this plan, regional planners and decision-makers should carefully consider which elements of this plan might qualify for state or federal resources.

Service Tiers	Frequency	Description	Typical Capital Needs
Frequent Transit Network (FTN) Tier 1 (Sun Link, Sun Tran)	Daytime: 7-10 minutes; Evening: 15-30 minutes.	A new service category; representing service on South 6th/Oracle in the medium term, but also Broadway, Speedway, and Sun Link in the long term.	Vehicles, stops and stations, right-of-way improvements, technology.
FTN Tier 2 (Sun Tran)	Daytime: 15 minutes; Evening: 30 minutes.	Similar to existing frequent service, but seven days a week and with more consistent evening service.	Vehicles, stops and stations, right-of-way improvements, technology.
Standard Service (Sun Tran)	Daytime: 30 minutes; Evening: 30-60 minutes.	Comparable to existing 30-minute service, but with expanded weekend service. In the long term, 30-minute evening service as well.	Vehicles, stops, technology.
Suburban Service (Sun Shuttle)	Daytime: 60-90 minutes.	Similar to current Sun Shuttle service, but with some improvements of 90-minute routes to 60-minute routes over time.	Vehicles, stops, technology.
Suburban Dial-a-Ride (Sun Shuttle)	On demand.	Existing Oro Valley and Sahuarita/Green Valley Dial-a-Ride. In the long term, new areas may be served.	Vehicles, technology.
Intertown Service (Sun Shuttle)	1 - 2 trips per day.	Existing service to Ajo and Why. In the long term, new areas may be served (e.g. Picture Rocks, Vail).	Vehicles, stops, technology.

Figure 24: Proposed Service Levels and related capital requirements.

Types of Proposed Capital Improvements

As shown in Figure 25, this chapter outlines four major types of capital costs associated with improvements to transit service, as well as opportunities for partnership and coordination with both private and public entities.

In the following pages, each type of capital improvement is described in the following manner:

- A **general description** of the nature and importance of the capital project type,
- A review of **existing conditions** in Tucson,
- An **estimate of unit costs** for capital projects, or suggestions for partnerships, and
- A recommended **phasing plan** for implementation.

The phased implementation described in this chapter provides preliminary recommendations for capital investment in the context of the phase and service tiers described in this and preceding sections.

However, as time proceeds, capital projects of various types identified for implementation in a specific phase may be prioritized by certain "triggers." For example, if congestion causes vehicle speeds to decrease, right-of-way improvements might take precedence over the program to improve stops and stations. Or if ridership along a certain route increases substantially, upgraded stations or rolling stock might be a higher priority instead.

This report estimates unit costs using national databases (such as the Federal Transit Administration's Capital Cost Database), published reports (such as those of the Victoria Transportation Policy Institute and the National Highway Cooperative Research Program), and peer agency capital planning programs.

Improvement Type	Description
 **Vehicles**	Purchase of new alternative fuel transit vehicles. Primarily envisioned as purchases of new 40-foot and 60-foot buses using Compressed Natural Gas (CNG) power plants; however, the marginal cost of purchasing electric vehicles instead of CNG is included as a contingency.
 **Stops and Stations**	Purchase or upgrade of boarding and alighting facilities. These range from a simple "sign and sidewalk" facility to staffed transit centers.
 **Right-of-Way**	Signals, lane markings, signal priority and other improvements to streets and intersections that give transit vehicles priority or improve traffic flow around transit service.
 **Technology**	Investments that facilitate more efficient operations and better passenger information. Includes Automatic Passenger Counters (APC), Automatic Vehicle Locators (AVL), fare collection technologies, and vehicle interfaces with signal priority systems.

Figure 25: Summary table showing the four types of capital improvements in this plan.

Capital Improvement Type No. 1: Vehicles

General Description

Transit buses serve as the workhorses of most urban transit fleets. These vary in size, propulsion and additional features; unit costs vary accordingly.

Forty-foot buses are typical in Tucson, though 60-foot articulated buses are frequently found in service on high volume routes in other cities.

Shorter vehicles (such as 30-foot buses or smaller "cutaways") can negotiate tighter streets and parking lots more easily, making them appropriate for on-demand, curb-to-curb service, and may incur less wear-and-tear on city streets. However, their operating costs are not substantially cheaper than 40-foot vehicles, making their use in fixed-route operations unusual in urban transit fleets[1].

Transit vehicles can be powered by diesel or biodiesel fuel, electricity (supplied by a hybrid diesel engine, battery or overhead wire), compressed natural gas (CNG), or other source. Lower-emissions vehicles have advantages for local air quality and climate change, but they are usually more expensive to purchase and typically require specialized fueling and maintenance facilities.

Depending on agency specifications, vehicles may have specialized accommodations for level platform boarding, onboard bicycle storage, multi-door boarding, off-board fare payment, Wifi or other amenities.[2] Vehicles specialized for "express" service may feature more comfortable seats, luggage storage, or bathrooms. Though all contemporary transit vehicles are accessible by customers utilizing wheelchairs, specialized paratransit vehicles are smaller and optimized for curb-to-curb, on-demand service.

Existing Fleet

Sun Tran, Sun Van and Sun Link currently operate a mix of transit buses, paratransit vehicles (including cutaway buses, minivans, and automobiles), and streetcars, as shown in Figure 26.[3]

Sun Tran operates a CNG fueling facility, allowing it to operate CNG-powered buses; all transit buses purchased since 2014 (68 vehicles in total) have used CNG power plants. Buses purchased prior to 2014 are typically biodiesel or hybrid diesel. Paratransit and support vehicles are powered by gasoline, and Sun Link modern streetcars receive electricity from overhead wires.

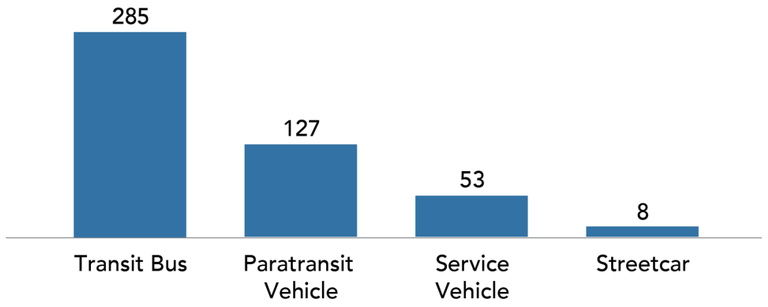


Figure 26: Sun Tran and Sun Link combined existing vehicle fleet.

How much does a bus cost?

Given the volume of new transit vehicles purchased every year by transit agencies across the United States, vehicle capital costs are widely known. In general, a larger bus is more expensive than a smaller bus, and a bus operating on cleaner fuel is more expensive than the equivalent diesel bus, as shown in Figure 27.

The purchase of new vehicles is usually subsidized through Federal Transit Agency (FTA) grant programs, such as 5307 (Urbanized Area Formula Grants) or 5339 (Bus and Bus Facilities). Federal funding can cover up to 80% of new vehicle purchase costs. Nevertheless, purchase of new vehicles is expensive, especially considering buses typically have a 10- to 12- year service life.

Given Sun Tran's existing fleet and the City of Tucson's commitment to piloting the use of electric buses (supported in part by a federal grant), it is likely that new vehicles will use either CNG or battery electric propulsion. CNG buses are comparable in cost to diesel hybrid on a per-bus basis, but have substantially lower emissions and fuel costs than hybrid diesel vehicles. Electric buses are more expensive, but produce virtually no emissions.

The typical 40-foot CNG bus costs approximately $630,000 in 2020 dollars, compared to $820,000 for a 40-foot electric bus. The typical 60-foot CNG bus costs approximately $935,000 in 2020 dollars, compared to $1.31 million for a 60-foot electric bus.

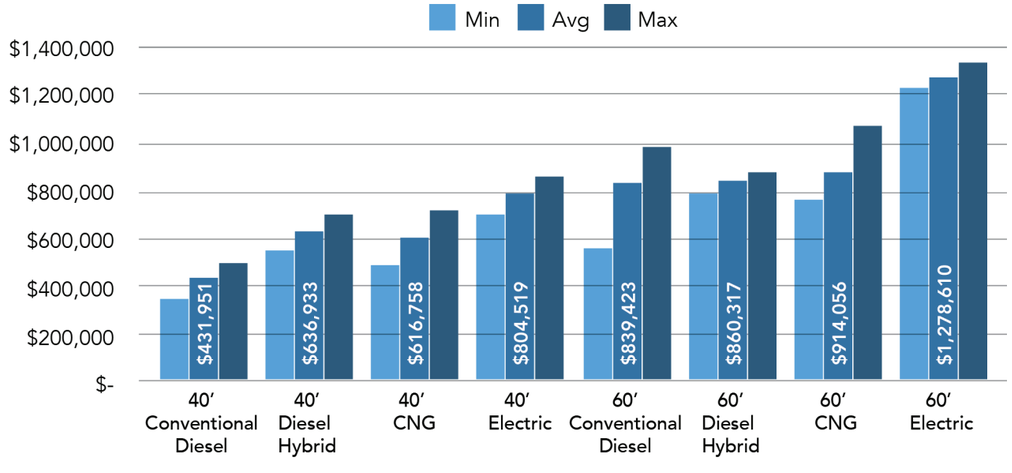


Figure 27: Typical unit costs for new transit buses in the US by size and fuel type (2020 dollars).

1 Operating costs are mostly composed of payroll for operators and maintenance staff, so they are not as different from one type of transit vehicle to another as the difference in vehicle size would intuitively suggest.

2 Specialized technologies that have both on- and off-board components (e.g. fare payment, vehicle locators, and the like) are discussed in the Technology subsection of this chapter.

3 City of Tucson Transit Asset Management Plan (2019).

Phasing Plan

Medium Term

In the first two years of this plan, Sun Tran would need to purchase up to 70 additional 40-foot vehicles. These new vehicles would serve two purposes:

- Approximately half of the vehicles would be purchased to account for additional annual in-service miles starting in Phase 1, when evening and weekend service levels would increase. These vehicles are not critical for operations. However, if these vehicles are not purchased early on they would most likely need to be purchased later, and at a higher price, as early replacement for vehicles in Sun Tran's existing fleet.
- The other half of new purchased vehicles would be to support the higher peak vehicle requirement once all Frequent Transit Network (FTN) improvements have been made in Phase 2. Because the lead time on bulk bus purchases is in the range of two years, the purchase of these vehicles must be initiated in Phase 1.

On most routes improving from 30-minute to 15-minute service, frequency increases would likely provide sufficient passenger capacity without requiring larger vehicles.

Long Term

In the second decade of this plan, Sun Tran would need to purchase up to 124 additional buses to accommodate the significant increase in the number of frequent routes, including **up to 17 new 60-foot buses** for FTN Tier 1 routes, where service would be available every 7 to 10 minutes (e.g. on N Oracle Road, S. 6th Ave, Broadway and Speedway).

As in the medium term, fleet purchase requirements would stem from two sources. First, the peak vehicle requirement (the number of vehicles required to provide service during the busiest part of the day) determines number of vehicles needed in the fleet, with a 10 percent spare vehicle margin. Next, the increase in overall vehicle usage over existing levels due to extra service during off-peak operations requires increasing the number of vehicles in the fleet to account for extra wear and tear on vehicles, to avoid needing early replacement.

As noted earlier, base costs assume purchase of CNG vehicles, with the marginal cost of purchasing new electric vehicles included as a contingency.

Why aren't any streetcar purchases included?

In developing this plan, we considered whether any new streetcar purchases would be needed to accommodate long-term increases in Sun Link service. In the end, we decided not to include any streetcar purchases for the following reasons:

- The peak streetcar requirement would not increase.
- FTA guidelines typically call for 25-year life spans for rail vehicles, plus ten years following refurbishment.
- Tucson streetcars see relatively light duty compared to other systems, were purchased relatively recently (2013) and are likely to last longer than 25 years. In other words, the existing streetcar fleet is likely to last beyond the time horizon of this plan.
- For reference, San Francisco streetcars which see a high level of activity are typically replaced every 30 to 35 years.

Rolling Stock Phasing Plan (2020 Dollars)

Vehicle Type	Unit Cost *(2020 dollars)*	Phase 1 *(Years 1-2)*	Phases 2 & 3 *(Years 3-10)*	Long Term *(Years 11-20)*	Total Cost
40 Foot CNG	$630 000	70 vehicles $47.6 million	N/A	107 vehicles $89.5 million	$137 million
60 Foot CNG	$934 000	N/A	N/A	17 vehicles $21.1 million	$21.1 million
Contingency for electric vehicles		$13.2 million	N/A	$32.5 million	$45.7 million
Total		**$60.8 million**		**$143 million**	**$204 million**

Figure 28: Recommended medium and long term transit bus purchases, to match the service levels recommended in Chapter 2. Except for unit costs provided in 2020 dollars, all dollar costs in this table estimated based on year of expenditure, assuming Year 1 is 2023.

Capital Improvement Type No. 2: Vehicle Technology

General Description

In public transit, use of technology can improve the customer's experience both directly, by providing real-time arrival and trip planning information, and indirectly, by allowing agencies to better manage service to meet customer needs.

Automatic Vehicle Location (AVL) Systems produce real-time data on system performance, tracking transit vehicles using Global Positioning System (GPS) data. This enhances information available to riders at stations and on mobile phone applications.

An AVL system consists of several components working together:

- Dispatching software (Computer-Aided Dispatch, or CAD) is the central technology, allowing interface between the scheduling platform and the rest of the system.
- In-vehicle hardware contains both GPS systems and communications equipment for the operator to interact with the CAD system.
- Prediction engines estimate the time it will take for a vehicle to arrive at the station; this is typically licensed annually.
- Customer interfaces, like signs and audio announcements, or software, as well as web sites, mobile applications and text message. These have their own costs of development, licensing and installation.
- Additional connections to other onboard technologies, such as Automatic Passenger Counters (APCs), the interface between vehicles and Transit Signal Priority systems, internal or external cameras, operator communication systems and fare collection.

APCs facilitate improved collection of passenger boarding data using infrared lights above the doorways to a vehicle. These lights determine whether a person is entering or exiting a vehicle. These counters allow operators to acquire better ridership data and optimize service planning accordingly.

Off-board fare collection units and mobile ticketing allow passengers to purchase tickets and provide proof of payment either before they board or by using their mobile phones. Off-board fare systems (machines at stations) allow cash-paying customers to board at the same pace as mobile or prepaid customers, greatly decreasing dwell time at stations. Finally, off-board fare collection allows for all-door boarding, an even larger factor in reducing dwell times.

Existing Conditions

Sun Tran does not currently offer an agency-sponsored real time arrival system outside of its Sun Link vehicle system. Although AVL systems are available on some Sun Tran vehicles, there is no agency-wide implementation that is able to provide both comprehensive operational data and real-time passenger information.

What do technology improvements cost?

While the cost of the technology involved has decreased over time, AVL implementations include substantial costs with respect to software development, installation/labor costs and licensing.

A 2008 TCRP report suggests a per-vehicle cost of around $17,000, with a base cost of around $2.5 million.[1] However, recent procurements suggest AVL/CAD systems actually typically costs $25,000 to $50,000 per vehicle, including multiyear licensing of software components.[2] This plan estimates an average cost of just over $33,000 per vehicle.

AVL systems may also include interfaces with other technologies, including Automatic Passenger Counters (APCs) and ticketing software. Often, these items are procured together (especially AVL and APC systems) to reduce costs of installation and software licensing. Licensing, support, and maintenance of software contracts alone can range from $200,000 to $500,000 per year.

As vehicle automation becomes more prevalent—ranging from existing driver-assist technologies to fully automated vehicles—these systems will become less of a matter of retrofitting existing fleets and more of a matter of procuring vehicles already equipped with the appropriate ITS suite. However, these products undoubtedly will require external maintenance and licensing contracts, shifting the cost burden from one-time capital purchase to a recurring "subscription" model. However, the costs and benefits of switching to fully automated vehicles remain highly speculative, and so they are not included in this plan.

Phasing Plan

As AVL/APC systems are one of the cornerstones of modern transit networks and tightly linked to the transit fleet, implementation of a combined system is recommended in Phase 1, during the first two years of the plan. As the fleet expands, additional costs in the form of hardware and licensing/maintenance agreements may be incurred, as well as the installation of the appropriate AVL/APC system in each new bus.

1 http://www.trb.org/Publications/Blurbs/159906.aspx

2 AVL/APC systems are typically installed by a small handful of vendors under fixed-price contracts whose pricing is proprietary and generally redacted from publicly available documents. While all-inclusive systems are common, separating components—e.g., the AVL/CAD system from the prediction engine—can result in a system that is more economical or tailored to an agency, albeit one with more vendors (and accordingly, RFPs to issue).

Technology	Unit Cost *(2020 dollars)*	Phase 1 *(Years 1 - 2)*	Phases 2 & 3 *(Years 3 - 10)*	Long Term *(Years 11 - 20)*	Total Cost
AVL/APC System	$33 300	253 vehicles $9.0 million	N/A	124 vehicles $5.5 million	$14.5 million
Contingency	40%	$3.7 million	N/A	$2.2 million	$6 million
Total		**$13 million**		**$7.7 million**	**$21 million**

Figure 29: Technology Phasing Plan (2020 Dollars). Except for unit costs provided in 2020 dollars, all dollar costs in this table estimated based on year of expenditure, assuming Year 1 is 2023.

Capital Improvement Type No. 3: Stops and Stations

General Description

Stops and stations play a critical role in public transit operations. Ranging from unmarked "flag stops" to fully developed transit centers, these facilities serve as the public's first and last experience with transit service.

Basic station accommodations are governed by the Americans with Disabilities Act (ADA) and the US Department of Transportation (DOT) standards.[4] New, altered, or relocated bus stops must have a minimum paved area of eight by five feet, connect to streets, sidewalks, or pedestrian paths, and meet certain other requirements of slope and accessibility. There are more stringent regulations for light rail and BRT station areas.[5]

Beyond meeting accessibility requirements, bus stops and stations have few consistent requirements from one place to another. For the purposes of matching amenities to service levels and to aid in consistently estimating costs, this plan distinguishes six station types, shown in Figure 30.

Station Types Used in This Plan

Station Typologies	 Basic Stop	 Improved Stop	 Enhanced Stop	 Premium Station	 Mobility Hub	 Transit Center
Signage provides basic wayfinding, branding and other information.	●	●	●	●	●	●
Sidewalks provide an accessible place to wait as well as connections to destinations.	○ [1]	●	●	●	●	●
Shelters keep passengers out of the elements.		○	●	●	●	●
Lighting provides comfort and security at night.			○ [2]	●	●	●
Real-time information provides estimates of vehicle arrival times and service advisories.				●	●	●
Curb space for taxis, ridehailing, bike, and scooter share; enhanced or secured bicycle parking.					●	●
Passenger amenities include wifi, access to retail kiosks or vending machines, and/or restrooms.					●	●
Staff help provide customer service, provide security, and educate riders.						●

1 Ideally, all stops and stations will have access to sidewalk facilities. However, these costs are not included in the cost of stops or stations beyond the average cost of an ADA-accessible concrete pad. Coordination within the City of Tucson and other jurisdictions will be necessary to implement any sidewalk improvements for better access to and from bus stops in unimproved areas.

2 Costs for lighting can vary considerably depending on implementation and availability of electricity. The average costs used in this document reflect implementation of lighting where feasible.

Figure 30: Stop and station classification, from a basic stop to a fully developed transit center where many bus routes meet.

4 For more information on accessible station requirements, see FTA Circular C 4710.1 (https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/Final_FTA_ADA_Circular_C_4710.1.pdf).

5 Though there is little technical difference between the terms "stop" and "station", the former is normally applied to standard bus service while the latter refers to higher-amenity facilities typically found along Bus Rapid Transit and rail lines.

Existing Conditions

Many current stops in Sun Tran's service area have facilities below the standards of even a "Basic Stop" as defined on the previous page: they lack even a sidewalk or concrete pad. In many cases, the stop's location may preclude such facilities (for example, there might be insufficient right-of-way to meet ADA standards) or the lack of connecting city infrastructure like sidewalks would make the installation of a concrete pad awkward.

Sun Tran's shelter program has now installed at least a bench or a shelter at the majority of stops in the system. Nevertheless, one third of existing bus stop have neither a shelter nor a bench, just over half of existing bus stops do not have a shelter, and two thirds of existing bus stops do not have a bench. Other amenities inconsistently provided include garbage cans (51% of stops), information posts (46%), lighting (20%), and display cases for information (17%).

Though shelters are distributed relatively evenly across the service area, there is a clear disparity in benches between areas north and south of I-10. Areas south of I-10 have dramatically fewer benches, and substantially fewer sidewalks, bus pads, and other basic pedestrian/curb infrastructure. In other words, these areas have worse starting conditions, and the average installation costs of even basic stop facilities will cost more in these areas.

Sun Tran operates three transit centers, each of which functions as a major transfer center, customer service location, and in the case of the Tohono Tadai and Laos facilities, a park and ride lot.[1]

Sun Link's nineteen transit stations have shelters, benches, real-time arrival information, and other high-quality passenger amenities.

1 The agency also operates or provides access to 23 other park and ride locations; these are discussed in the Parking subsection of this chapter.

	No Bench	Bench
No Shelter	766 (33%)	454 (20%)
Shelter	777 (33%)	333 (14%)[1]

1 Of the 333 stops in the database with both a bench and a shelter, 29 are located at a transit center.

Figure 31: Presence of shelters and benches at Sun Tran stops.

What do stop and station upgrades cost?

The cost to install or upgrade stops and stations increases as more amenities are involved:

- An FTA-standard minimum bus stop can often be installed for less than $500
- An "enhanced stop" featuring both bench and shelter on ADA-approved pavement, typically costs approximately $20,000-$25,000.
- A complete transit center can reach into the millions.

However, these numbers are just averages; **the actual costs associated with specific individual stops and stations are site-specific and vary widely.** Connecting a station to the surrounding sidewalk network requires the existence of a sidewalk network; at between $50 and $100 per linear foot, installing of a quarter mile of sidewalks can easily add $100,000 to the construction cost of even a basic transit stop.

Because of these significant uncertainties and the potentially complex engineering and construction processes that they reflect, this plan adds a 40% contingency to the total costs of bus stops.

Interaction with the Pedestrian and Bicycle Environment

Other elements of pedestrian-friendly design, including pedestrian countdown signals, additional in-street signage, and high-visibility crosswalks make the journey to transit a safer and more enjoyable experience. Bicycle and pedestrian access should be considered as necessary capital improvements to maximize station area potential.

Sidewalk construction (as well as the installation of bike lanes and other multimodal features) is an extremely common area of cooperation between agencies.

However, partnership with local governments and other public entities is not the only avenue available for funding improvements. Bus stops are often required as part of the conditional use permitting process for new major developments, mitigating their net public costs.

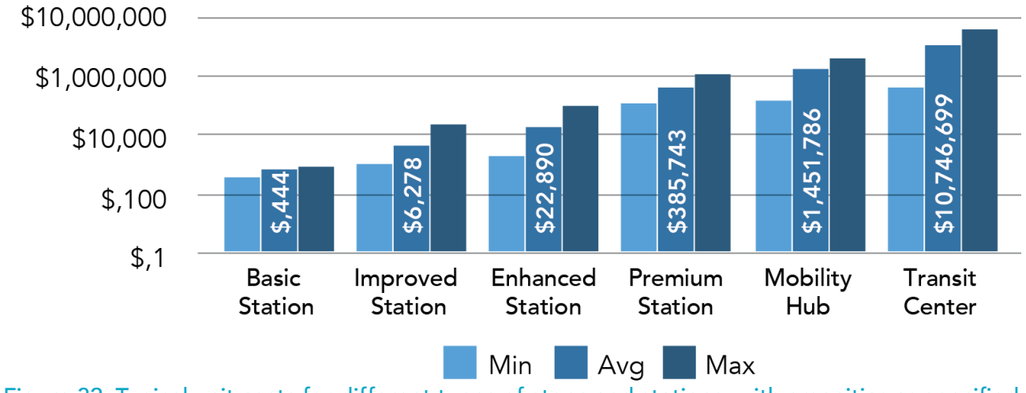


Figure 32: Typical unit costs for different types of stops and stations, with amenities as specified in Figure 25 (in 2020 dollars).

Phasing Plan - Stops and Stations

Station area goals should be easily articulated and tightly linked to both service levels and performance metrics. For example:

- Sun Tran would require that Improved Stops be installed to correspond to a certain percentage of boardings. This ensures investment in areas with high ridership that are likely to maintain transit service even through service changes, reducing the risk of investing along routes whose alignments may change in the future due to low ridership.
- High-frequency routes are easy targets. For example, Sun Tran may decide that all Frequent Transit Network Tier 1 routes should have enhanced or premium stations as part of its long-term plan.
- Endpoints of FTN Tier 1 and Tier 2 routes, major transfer areas, educational facilities, or major activity centers are excellent candidates for mobility hubs and transit centers. Since the goal of a mobility hub is to enhance first-mile/last-mile and pedestrian and bicycle connections, their locations should be conducive to connecting with other transportation modes.

Further requirements—such as describing the quality of stops in front of every hospital, or school, or senior center—can be added as needed.

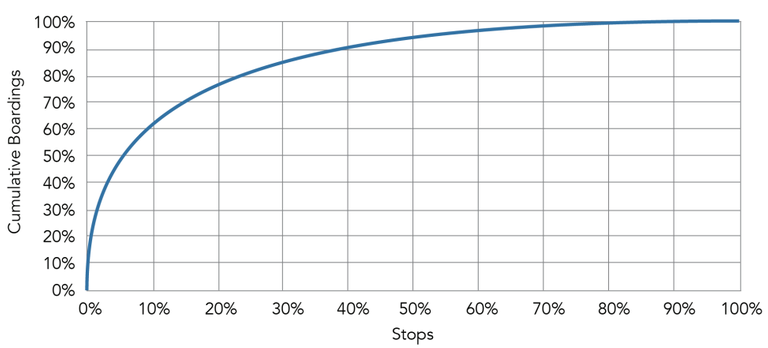


Figure 34: Distribution of Boardings at Sun Tran Stops (March 2019)

The costs laid out in Figure 33 assume the following investments in bus stops and stations, based on existing stop locations:

- **Basic Stops or better at all existing and new stops**.
- **Improved Stops or better serving 99% of boardings,** or approximately 75% of all existing stops.
- **Enhanced Stops at all stops on the Frequent Transit Network,** i.e. where the bus comes every 15 minutes or better.
- **Premium Stations (i.e. comparable to current Sun Link stations) at a total of 100 locations**. These would likely target one or more of the FTN Tier 1 routes (North Oracle Road, South 6th Ave, Broadway, Speedway).
- **A total of 10 mobility hubs and two new transit centers.** The exact location of these highly improved stations for multiple routes remains to be determined. Some likely locations based on the long-term network map include the vicinities of:
  - » Desert Diamond Casino in southern Tucson.
  - » Houghton Town Center in southeast Tucson.
  - » PCC East, West and Desert Vista (South) campuses.
  - » Tucson International Airport.
  - » Thornydale Plaza in Casas Adobes.

Facility Type[1]	Unit Cost *(2020 dollars)*	Phases 1 & 2 *(Years 1 - 5)*	Phase 3 *(Years 5-10)*	Long Term *(Years 11-20)*	Total Cost
Basic Stop	$440	227 stops $120 000	680 stops $380 000	194 stops $130 000	$630 000
Improved Stop	$6 420	54 stops $390 000	161 stops $1.3 million	78 stops $730 000	$2.4 million
Enhanced Stop	$23 400	231 stops $6.1 million	692 stops $20.1 million	455 stops $15.6 million	$41.8 million
Premium Station	$394 000	13 stations $5.6 million	37 stations $18.4 million	50 stations $28.9 million	$52.9 million
Mobility Hub	$1.48 million	1 hub $1.7 million	4 hubs $7.4 million	5 hubs $10.9 million	$20 million
Transit Center	$11.0 million	N/A	1 center $13.7 million	1 center $16.1 million	$29.8 million
Contingency	40%	$5.5 million	$24.5 million	$29.0 million	$59 million
Total		**$19.4 million**	**$85.8 million**	**$101.4 million**	**$207 million**

1 These high-level estimates assume that stations having either a bench or a shelter meet ADA paving requirements, and that all "basic" stops (those having neither shelter or no bench) will require concrete pads. It further counts stops having either a bench or a shelter—but not both—as "improved" stops.

Figure 33: Stops and Stations Phasing Plan. Except for unit costs provided in 2020 dollars, all dollar costs in this table estimated based on year of expenditure, assuming Year 1 is 2023.

Capital Improvement Type No. 4: Speed and Reliability

General Description

At its most basic, transit does not require much more than a bus and places for it to stop. However, investment beyond these two components can substantially improve both capacity and the quality of the passenger experience.

Modifications to street and road layouts (like dedicated lanes, queue jumps, signal priority and others) can help transit vehicles avoid congestion. These can improve the speed and reliability of travel by transit, and they also reduce the cost of providing service. There are two main approaches to speed and reliability improvements:

- **Spot treatments in many locations to relieve chokepoints.** Identifying problem locations throughout the system can help prioritize high-return and low-cost investments that result in significant savings in operations, while also increasing rider satisfaction and experience throughout the region.
- **Corridor improvements in support of a "rapid" bus, BRT or light rail.** Strategic and coordinated investment in partially or fully dedicated right-of-way, priority at intersections, and improvements to vehicles and stations along one specific route can serve markets of significant customer demand. These corridors are supported by investments in distinct stations, dedicated guideways, signal priority, fare collection systems and entail considerable capital investment into a single route.

Focusing on spot treatments at problem locations can provide benefits like ease of implementation, lower costs, and improving service on multiple routes at the same time. Corridor improvements can provide an opportunity for revitalization and placemaking beyond the transit-specific amenity. As described on page 19, this plan takes the position that spot improvements are more conducive to regional mobility improvements than the intense focus on one or two BRT or streetcar projects.

Figure 35 describes some of the most common types of transit speed and reliability improvements. The NACTO Transit Street design guide contains detailed descriptions of individual transit elements that can be implemented on a project-by-project basis.[1] TCRP Report 118, published in 2007, remains a definitive (if slightly dated) reference for costs and efficacy of TSP, queue jumps, running-way enhancements, and other treatments.[2]

Types of Speed and Reliability Improvements	
Dedicated Lanes	Fully-separated busways can have an enormous impact on travel time and reliability. Typically, the obstacles to implementation are political; transit agencies must convince the public and politicians that the loss of either a travel lane or parking lane is worth the (considerable) increase in capacity and reliability. Capital costs vary substantially, based on degree of separation, whether new right-of-way is required, and other factors. Short segments of dedicated lanes are, from a capital standpoint, little more than paint, but can have still-substantial positive impact on transit operations. In addition to improving reliability in problem sections, transit-only lanes help promote transit as a viable, visible form of transportation. Peak hour-only bus lanes can provide a compromise on limited streetscapes, leaving more space for curbside parking or mixed travel outside of peak travel periods.
Queue Jumps	Intersection treatments like queue jumps allow transit vehicles to bypass the "line" of waiting traffic at an intersection, e.g. by allowing buses to use a turn lane to proceed straight through an intersection. Typically implemented in conjunction with transit signal priority.
Transit Signal Priority	Often installed as part of an intersection treatment like a queue jump; allows transit vehicles to cross intersections sooner by allowing direct communication between traffic signals and transit vehicles. This is accomplished either through a dedicated transit signal phase, or green signals that remain lit longer when a transit vehicle is near.
Curb Extensions	Curb extensions typically replace on-street parking with a wider sidewalk, avoiding the need for the transit vehicle to pull out of the flow of traffic to accommodate passengers and reducing dwell times. They also increase the space available for streetscaping, including general pedestrian amenities such as benches and business activities. Contrast this approach with bus pullouts (where transit vehicles leave the flow of traffic during boarding and alighting activity), which improve traffic flow at the expense of transit operations.

Figure 35: Types of Speed and Reliability Improvements

Existing Conditions

The region does not currently operate any fixed-guideway transit other than the Sun Link streetcar, which operates in mixed traffic with limited priority treatments downtown. Buses generally operate in mixed traffic with no special or priority accommodations.

Past plans, like PAG's 2009 and 2017 High Capacity Transit Plans both suggest additional investment in either BRT or streetcar corridors. The broad expansion of the Frequent Transit Network in this plan suggests that resources should be set aside for spot improvements in many locations, allowing for transit speed and reliability improvements to be enjoyed by more people in more locations.

1 https://nacto.org/publication/transit-street-design-guide/

2 https://nacto.org/docs/usdg/tcrp118brt_practitioners_kittleson.pdf

What do speed and reliability improvements cost?

The capital costs associated with these elements vary based on the type of intervention, and can be costly, especially when land purchases are necessary.

Actual implementation will require the active cooperation of the facility owner (in most cases the City of Tucson). According to our analysis of current unit costs:

- Basic lane striping changes can be accomplished for approximately $2,600 per lane-mile, if no new right-of-way is purchased. The cost of lane striping is otherwise primarily the political will necessary to reallocate road space from cars and trucks to transit.
- Transit Signal Priority (TSP) systems cost an average of just over $17,000 per intersection. However, this cost varies as a function of the complexity of the specific intersection involved.
- Curb extensions cost an average of just over $64,000 per location, though the cost varies considerably depending on the size of the new raised concrete area.
- Queue jumps, which often require right-of-way reallocation, tend to be more expensive, averaging about $300,000 per intersection.

According to PAG's 2017 High Capacity Transit Implementation Plan (HCTIP), the capital cost of BRT corridors envisioned to date in Tucson is in the range of $30 million to $40 million. So at a similar level of cost to several miles of BRT, it would be possible to improve bus flow at hundreds of intersections, install high quality shelters across its network, and improve both the visibility and performance of the entire network rather than a single route.

There are a number of advantages to implementing a series of smaller projects over a single large project: it is easier to achieve geographic equity; it is easier to see which projects work well and modify capital spending accordingly; more work can be done quickly and in-house; and it allows the agency to tout the usability and vitality of the system as a whole rather than improving the image of just a few routes.

On the other hand, smaller projects have some difficulties—they requires more dedicated staff, and may require "packaging" of projects to show large-scale results and obtain political support.

Phasing Plan

This plan assumes that right-of-way improvements, like bus stop improvements, would be implemented as spot improvements in many locations. The total level of investments for both the medium- and long-term plans represent the capital outlay equivalent to a relatively small-scale BRT project—about $70 million—distributed over the entire network (see Figure 37).

Determining where these investments occur should be linked to observable metrics, such as passenger-hours of delay. It is likely that most of the improvements included will be distributed on FTN Tier 1 and Tier 2 routes, though strategic placement (e.g. transfers, common stops) will enhance operations on all routes.

Ultimately, since many of these projects have a higher political than capital cost, crafting a metrics-based "story" to communicate the systemwide return on investment is a critical component of this strategy.

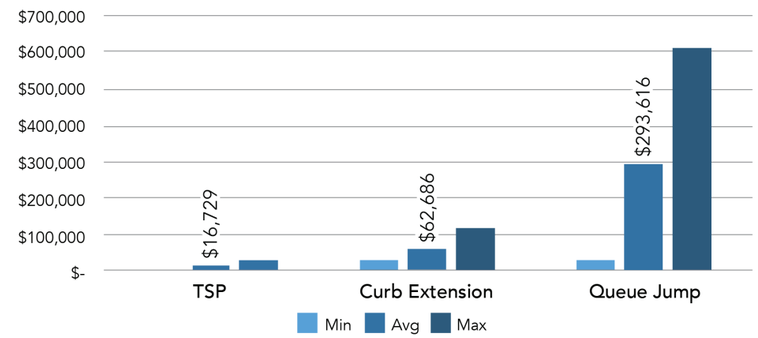


Figure 36: Typical unit costs for right-of-way improvements.

Improvement Type	Unit Cost *(2020 dollars)*	Phases 1 & 2 *(Years 1 - 5)*	Phase 3 *(Years 5-10)*	Long Term *(Years 11-20)*	Total Cost
Lane Striping	$2 600	8 miles $25 000	17 miles $55 000	25 miles $95 000	$175 000
Transit Signal Priority	$17 100	33 intersections $650 000	67 intersections $1.4 million	100 intersections $2.5 million	$4.6 million
Curb Extensions	$64 100	N/A	N/A	50 locations $4.7 million	$4.7 million
Queue Jumps	$300 000	16 intersections $5.6 million	34 intersections $12.5 million	50 intersections $22 million	$40 million
Contingency	40%	$2.5 million	$5.6 million	$11.7 million	$20 million
Total		**$8.8 million**	**$20 million**	**$41 million**	**$70 million**

Figure 37: Speed and Reliability Improvements Phasing Plan. Except for unit costs provided in 2020 dollars, all dollar costs in this table estimated based on year of expenditure, assuming Year 1 is 2023.

Other Capital Improvement Considerations

Park and Ride Facilities

Park-and-ride facilities combine some aspects of high-volume transit stops with structured or surface parking facilities.

Park-and-ride facilities are most often associated with "express" style service, where commuters use transit to bypass congested freeways (especially in conjunction with managed, tolled, or other transit-advantaged lanes), save the wear or expense of driving personal vehicles, avoid paid parking in the urban core, or simply use the "free time" spent on transit to read, work, or sleep.

Park-and-ride facilities range in complexity from unpaved lots and a basic station to full-fledged transit centers of their own. In a regional context, park-and-ride facilities might be the link between services from several transit providers.

There are currently 25 designated park-and-ride facilities in the Tucson region. Ten are owned and operated by local jurisdictions, including two which are located at transit centers. The remainder include agreements with churches, community colleges and other facilities. Some facilities, such as the Houghton Road lot, include substantial amenities, including driver restrooms, lighting, and bicycle facilities. Others are more spartan in their implementation.

Parking structures are extremely expensive to construct. Two separate national surveys identified per-space costs of basic structured parking facilities at between $15,000 and $29,000, depending on the city; local requirements, customer amenities, and costs of financing, permitting, and planning can drive these costs even higher (though public entities with access to public land may see reductions in total costs).[1]

Surface lots typically cost one-quarter to one-half of structured lots on a per-space basis. Annual operating costs can vary dramatically as well, especially if parking is staffed. The cheapest parking is often an agreement with a public facility, place of worship, or shopping center. These agreements often take advantage of little used parking facilities, especially for locations whose peak activity times are on the weekends.

Because this plan does not explicitly deal with future changes to the peak express route system (Sun Tran routes in the 100X and 200X series), it does not include any proposals for specific additional park-and-ride facilities.

However, new mobility hubs or transit centers in outlying locations (see page 46) may be well paired with parking for passengers coming from outer suburban and exurban locations. In these cases, Sun Tran and partner agencies should prioritize agreements with local private-sector or publicly owned facilities to provide parking.

Maintenance Facilities

Maintenance facilities are another critical component of transit operations. The capacity, location, and special equipment at maintenance facilities can all influence operations and capital expenditures. Large maintenance facilities have some advantages of scale, but multiple facilities can reduce costs of deadheading.

The City of Tucson's LEED Gold certified Northwest Bus Facility houses the majority of Tucson's capacity for transit storage and maintenance. The facility has the capacity to maintain up to 250 buses.

The City of Tucson also owns and operates the Price maintenance facility, with a capacity of 150 vehicles, bringing the total system capacity to 400. Based on the peak vehicle requirements of even the long-term plan, no new maintenance facilities should be required by this plan.

However, should battery electric vehicles become a significant part of the fleet, the cost maintenance and charging infrastructure to support them should be considered. **Note that although this plan includes a contingency for the added cost of purchasing new electric vehicles instead of CNG, it does not include the cost of all related maintenance and charging equipment.**

The City of Tucson operates specialized facilities for its Sun Link and Sun Van programs; this plan does not anticipate additional capacity requirements at these facilities.

1 Victoria Transportation Policy Institute (2019). Transportation Cost and Benefit Analysis II – Parking Costs. http://www.vtpi.org/tca/tca0504.pdf

4 Outcomes: Faster Travel and More Freedom

How do we measure improved outcomes?

This chapter reports on three different ways of measuring the performance of the proposed medium- and long-term improvements to the transit network.

These measurements are not forecasts, and they do not rely on any assumptions about how culture, technology, prices or other factors will change in the next few years.

Instead, we measure distance to service, travel times, and the most recent data on population and jobs to give an idea of how well each scenario would serve people living and working in the Tucson region. We calculate all of these outcomes at three key times:

- **Weekdays at Noon.** This compares the level of service experienced by the majority of transit trips today. This is because people take most of their trips during the daytime, and most bus routes in Tucson do not require peak frequency increases.
- **Weekday Evenings at 9 p.m.** This compares the level of service experienced by people who try to use transit in the evenings. Except for a few select routes, nearly all existing evening service runs only once an hour. Evening service also currently ends at 10 p.m. on Saturdays and 9 p.m. on Sundays (but would continue until midnight under this plan).
- **Sundays at Noon.** This represents the baseline for weekend service. Like on weekday evenings, nearly all existing Sunday service runs only once an hour. Yet most people travel around town on weekends as well as weekdays, and many people need to travel on weekends due to nontraditional work schedules.

We compare existing service to the service that would be available in the following time frames:

- **End of Phase 1: 2 years from plan funding.**
  - » This is particularly useful for comparing evening and weekend service outcomes. However, weekday daytime service would not change in Phase 1.
- **End of Phase 2: 5 years from plan funding.**
  - » This is the time frame at which all medium term service improvements would be in place.
  - » Further speed and reliability improvements in Phase 3 would then continue to improve transit performance in the period from 6 to 10 years from plan funding. However, the exact level of impact from those improvements remains speculative at this stage of planning. See page 10 and Chapter 3 for a summary of the intended improvements in Phase 3.
- **Long Term: 10 to 20 years from plan funding.**
  - » In this time frame, all of the service improvements included in this plan would be in place. As a result, this is when we would realize the most benefits.

Measure no. 1: Proximity

The first measure reported is very simple: **How many residents and jobs are near transit?**

Specifically, we measure how many people and jobs would be located within half a mile of a bus stop in each scenario. This does not tell us whether people will find transit useful, only that it is available nearby.

To provide some idea of usefulness, we distinguish between how many people and jobs are near frequent service (every 15 minutes or better), service every 20 to 30 minutes, or any service at all.

A quarter of a mile is a distance often used to determine whether someone is "close enough" to transit; however, many people are willing to walk farther to reach more frequent service. Since the improvements to the transit network are largely focused around expanding the frequent network, we focus on the number of people and jobs within half a mile of service in this report.

Measure no. 2: Travel Time Maps (Isochrones)

To understand the benefits of a network change, consider this simple question: **Where could I get to, in a reasonable amount of time, from where I am?**

If you can get to more places in that amount of time, you will have more opportunities, and your life may well feel more free.

The travel time maps in this chapter cover how far one could travel in 45 minutes, on weekdays and Sundays, from five representative locations in and near Tucson, representing different quadrants:

- Downtown Tucson (Congress St & 6th Ave)
- South: VA Hospital (Ajo Way & South 6th Ave)
- North: Tucson Mall (Wetmore Road & North Oracle Road)
- East: Park Place (East Broadway Blvd between Wilmot Road and Craycroft Road)
- West: Pima Community College - West Campus (West Anklam Road & N Greasewood Road)

Of course, different types of trips lead to different needs and expectations about what a reasonable amount of travel time may be. 45 minutes door-to-door might make sense for a commute to a full-time job, but it's a little long to go to the grocery store. And for less frequent trips, just being able to get there may have value, even if it takes up to an hour.

Ultimately, we use 45 minutes as our reference travel time because it represents an amount of time that many people would consider travelling at least once per day, including many people who are used to driving most places.

To illustrate how isochrones work, the example provided on this page shows how many more areas, jobs and residents would be reachable from the Tucson Spectrum shopping mall at the end of Phase 2, compared to existing service. This example shows that:

- Providing frequent service at this location would improve transit accessibility to and from this location at all times.
- Gains are strongest in the daytime, when service on the route serving this location and service on connecting routes (e.g on South 6th Ave, South 12th Ave, Park Ave) would be the most frequent.

We provide comparable 45 minute travel time maps for 19 different locations in Appendix A to this report.

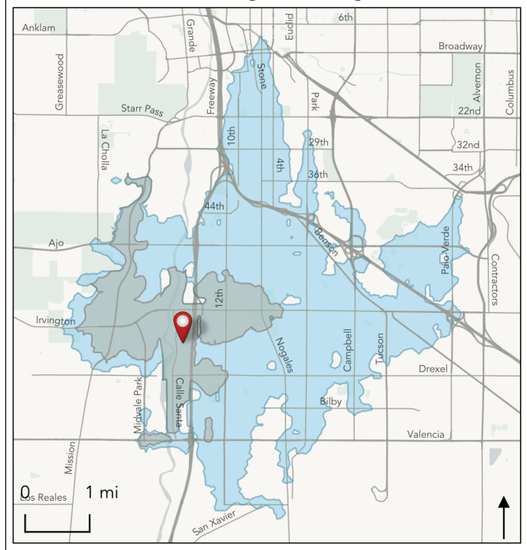
Example - 45-minute Travel Time Map
Improvements by the End of Phase 2 (within 5 years)

How far can I travel from

Tucson Spectrum

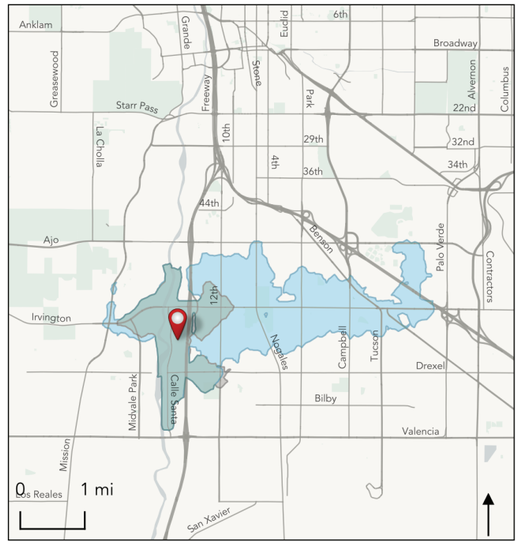
in **45 minutes** during...

Weekday Middays



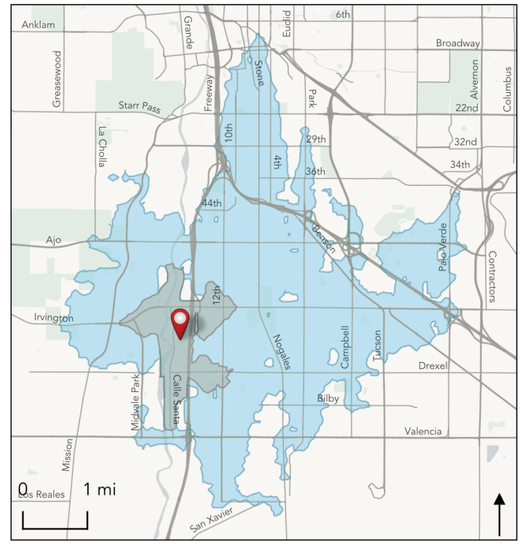
Residential Access	Job Access
+405%	+805%

Weekday Evenings



Residential Access	Job Access
+250%	+120%

Sunday Middays



Residential Access	Job Access
+900%	+975%

Measure no. 3: Access to Opportunity

One of the primary functions of transit is to provide access to jobs. And, because retail and services also account for jobs, access to jobs is also a good indicator of the usefulness of transit for many other purposes.

So, we ask the question: **Can we design a transit network that helps more people access more jobs (and other opportunities) by transit, in less time?**

To answer this question, we first measure how far a person could go in 45 minutes on transit (door-to-door, including walking, waiting, riding, and any necessary transfers) from anywhere in the Tucson region, and then calculate how many jobs are located in that area.

The process is illustrated in Figure 38. It essentially consists in creating a 45 minute travel time map from everywhere in Tucson, and then using each location's results to show which areas have the most access to jobs, and which areas would have the most to gain from proposed improvements.

We use jobs as a proxy for overall economic and social opportunity because data on jobs is readily available from the U.S. Census Longitudinal Employer Household Dynamics (LEHD) dataset. But jobs are also a good indicator of many opportunities beyond employment. Think of all the useful places you may need to go in a week: schools, restaurants, shopping centers, medical facilities, community centers, and many other such locations are also places of employment, often located near other places of employment.

How This Plan Expands Access to Opportunity: An Example from the South Side

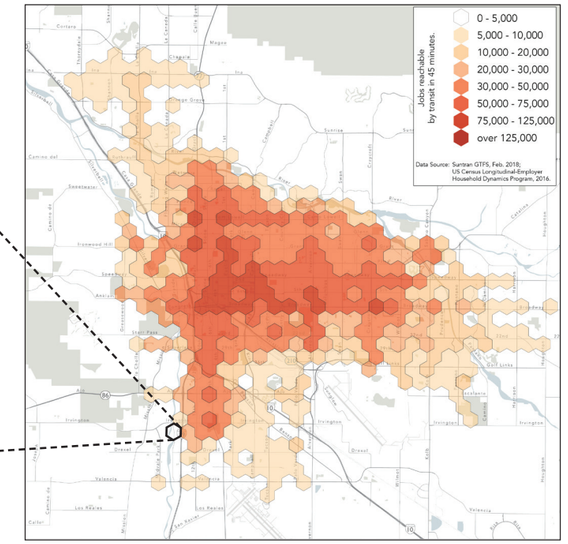
Isochrone Analysis shows how far you can go from a given location in a reasonable amount of time, as an area on a map. We can calculate the number of people and jobs in this area.

Access Analysis shows the results of running an isochrone from anywhere in the region. The color of each hexagon indicates how many jobs are accessible for trips starting in that area.

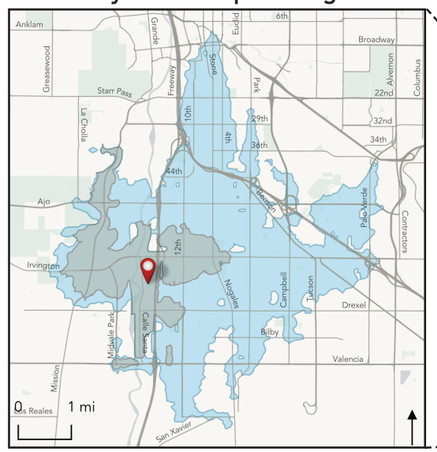
1. Where can I get to in 45 minutes on transit, door-to-door? *(includes walking and waiting)*

3,200 jobs accessible in 45 minutes

2. How much opportunity does that represent?



3. How many more places could I reach in 45 minutes, within 2-5 years of this plan being funded?



+28,300 more jobs accessible in 45 minutes

4. How much more opportunity does that represent?

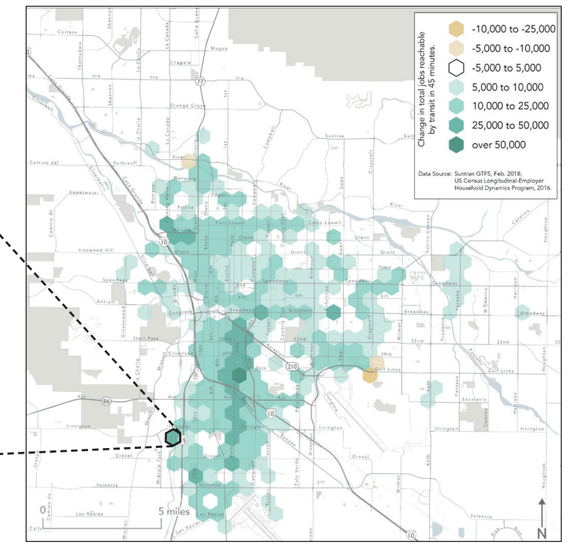


Figure 38: These maps show how we measure the access to opportunity provided by the existing transit network, and the change made possible by the improvements proposed in this plan.

Phase 1: Proximity to Transit

Phase 1 of this plan, to be implemented in the first two years following funding, boils down to two key improvements:

- Evening service every 30 minute or better on all FTN routes.
- Consistent daytime service levels, seven days a week.

The bar charts at right show that this is achieved:

- The percentage of Pima County residents near evening service every 30 minutes or better would go from 16% to 26% of the population.
- The percentage of Pima County jobs near evening service every 30 minutes or better would go from 38% to 51%.
- The percentage of Pima County residents near transit service every 15 minutes or better on Sundays would go from 0% to 26%.
- The percentage of Pima County jobs near transit service every 15 minutes or better on Sundays would go from 0% to 51%.

This suggests transit service would become slightly more useful in the evenings, and significantly more useful on weekends. The travel time maps and job access analysis shown on the following pages confirm this.

Figure 39: Percentage of Pima County residents near transit service at different frequencies, existing vs. Phase 1. Phase 1 would bring improvements to evenings and weekends.

Phase 1: Access to Opportunity

Transit service, even at high frequency, is not enough to attract riders. Transit needs to go *where* people want to go. To describe the kind of freedom available on a complete and connected network, we ask: **how many useful places could you reach in a reasonable amount of time, from anywhere else?**

There's no perfect definition of "useful places": different things are useful to different people. But we can calculate something useful to many people: access to jobs.

- Access to many jobs means more people can access their job by transit. In the long term, how well a transit network provides access to jobs impacts what jobs people will take.
- Job locations often have other useful features. Shopping centers, medical offices, and schools are all employers in themselves, in addition to the services they provide. Calculating access to jobs helps us understand opportunity more broadly.
- In other words, **more access means more opportunity.**

The average wait for a bus that comes every 15 minutes is 7.5 minutes. If a transfer between two such routes is required to get from to A to B, then the average total wait time is twice as long, or 15 minutes[1].

As a result, even a connected network of relatively frequent bus routes can only take you so many places in 30 minutes or less. The benefits of the connected network become clearest for people willing to travel for slightly longer.

In 45 minutes, a connected network of transit lines coming every 15 minutes can allow you to reach 5 to 7 miles in any direction, door-to-door. In many parts of Tucson, that's enough to reach several of the region's major job and activity centers.

So improving weekend service to feature as many frequent routes as on weekdays turns out to have a very significant impact.

- For the average Tucson region resident, job access by transit in 45 minutes would more than double (+113%) on Sundays.
- The positive impact is roughly similar between the general population and low-income and minority populations. However, existing weekday service inequities (less service on the south side) would not be solved in Phase 1.

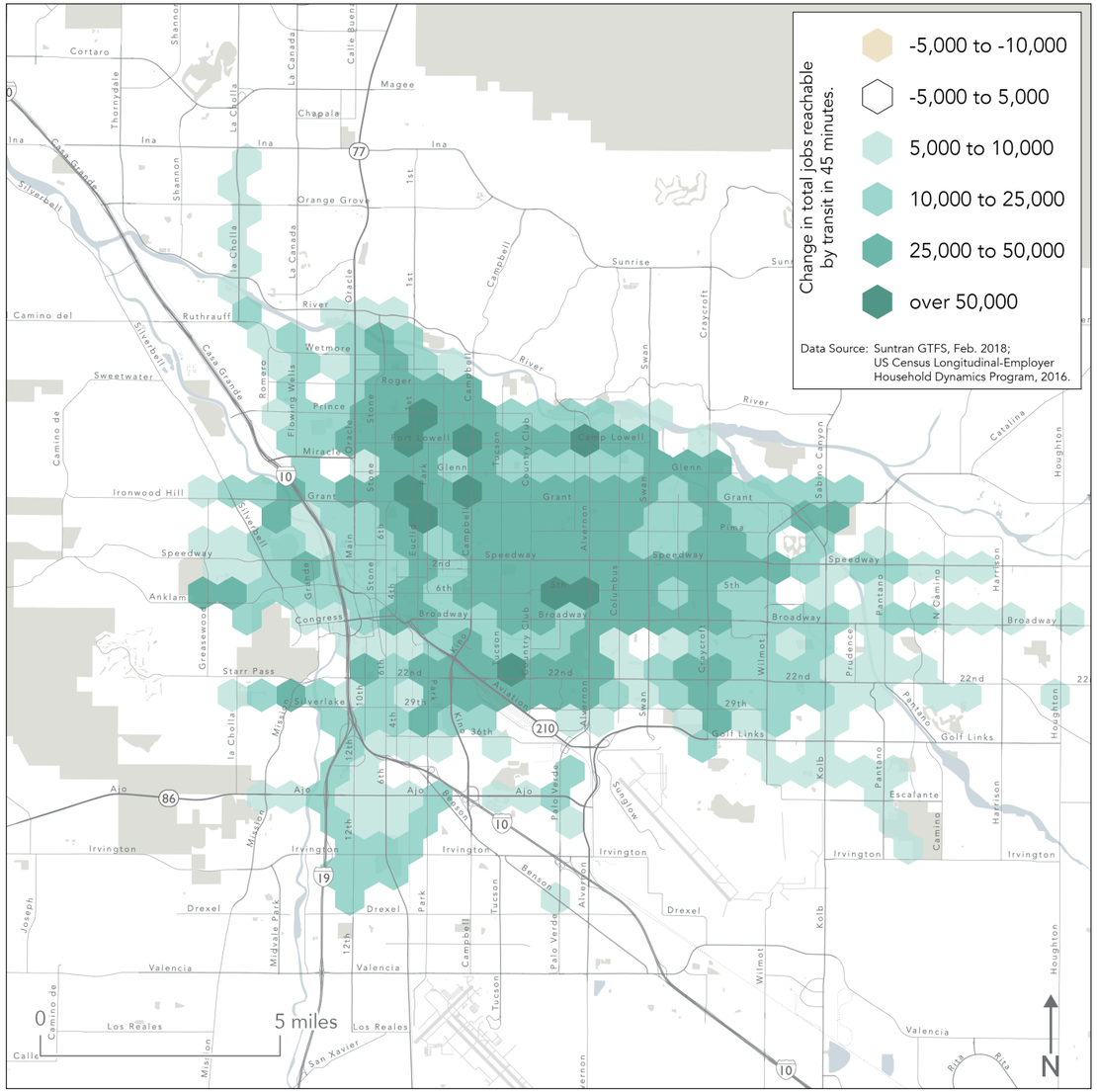
Job Access Change - Sundays, Phase 1 (within 2 years)

Under this transit network overall job access in 45 minutes would change by...

+113% for All Residents

+109% for Minority Residents

+113% for Low-income Residents



1 On any trip, you may be lucky and catch your bus right on time, but you may also have just missed a bus, so "on average" you're likely to wait half the time between any two buses.

Phase 1 evening service improvements would also be helpful in improving access to opportunity, but they would be far less noticeable.

- For the average Tucson region resident, job access by transit in 45 minutes would increase by only 9% on Sundays.
- Positive impacts would be concentrated on streets that currently have frequent service in the daytime, but hourly service after 7 PM: 22nd Street, Craycroft Road, Fort Lowell Road, Campbell Ave, and parts of Grant Road. Those streets would now receive service every 30 minutes in the evening.
- Due to the relatively long average wait for service every 30 minutes (average wait = 15 minutes), this would increase the number of places one might be able to reach in bus ride on a single vehicle, but it would not have a significant impact on evening trips that require transfers.

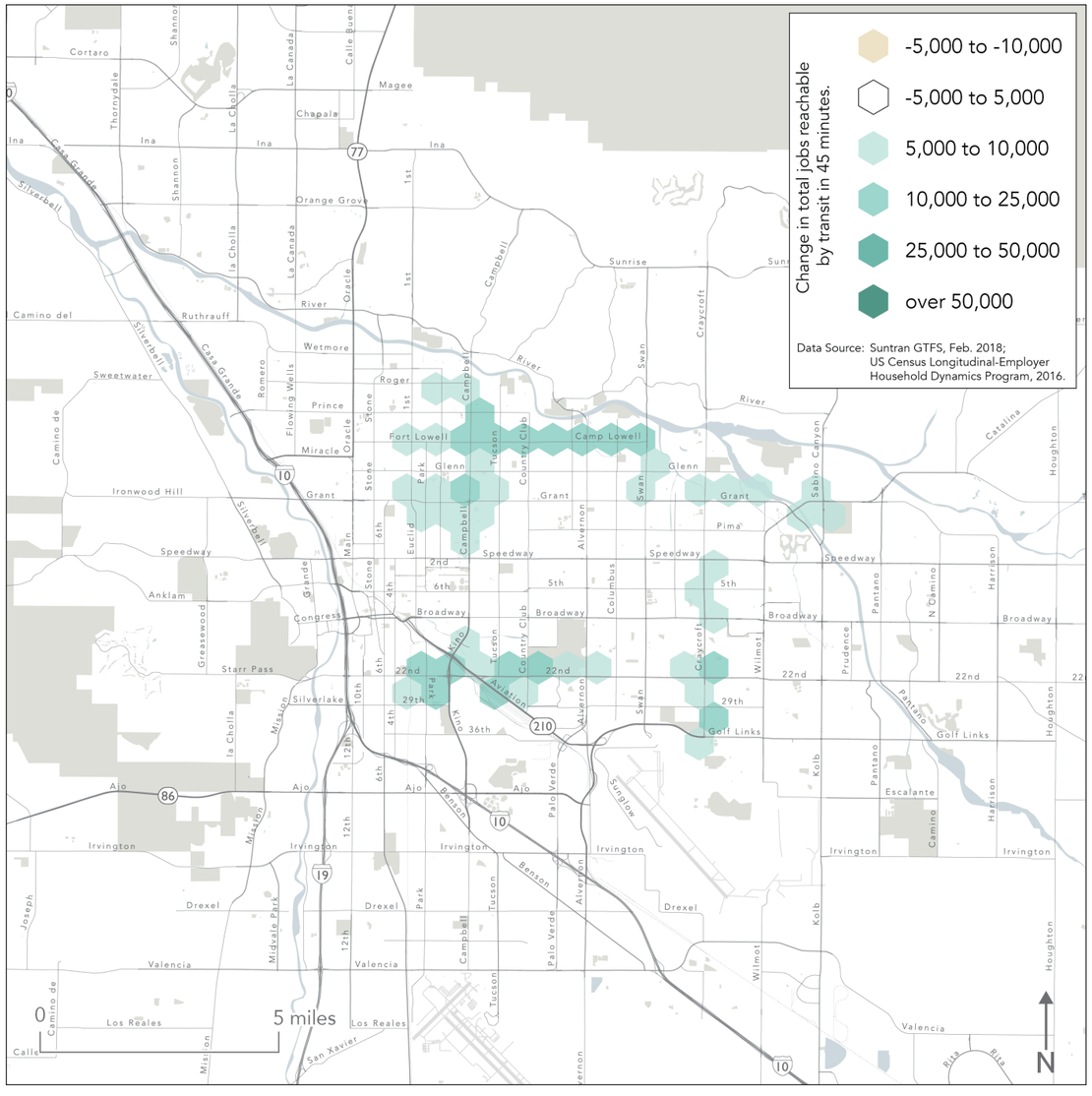
Job Access Change - Evenings, Phase 1 (within 2 years)

Under this transit network overall job access in 45 minutes would change by...

+9% **for All Residents**

+8% **for Minority Residents**

+7% **for Low-income Residents**



Phase 1: 45-minute Travel Time Maps

Downtown Tucson

In Phase 1, the following improvements would be evident:

- On weekday evenings, service between Downtown and points on 22nd Street would improve. Route 7 (22nd Street) is currently the only FTN route that serves downtown with service only every 60 minutes after 7 p.m.
- On Sundays, travel to and from Downtown by transit would improve in all directions, essentially becoming as convenient as on a weekday.

45-minute Travel Time Map

Improvements by the End of Phase 1 (within 2 years)

How far can I travel from

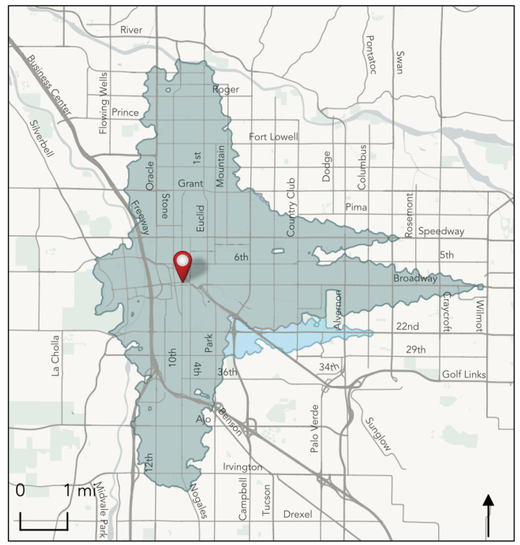
Tucson Downtown

in **45 minutes** during...

Weekday Middays

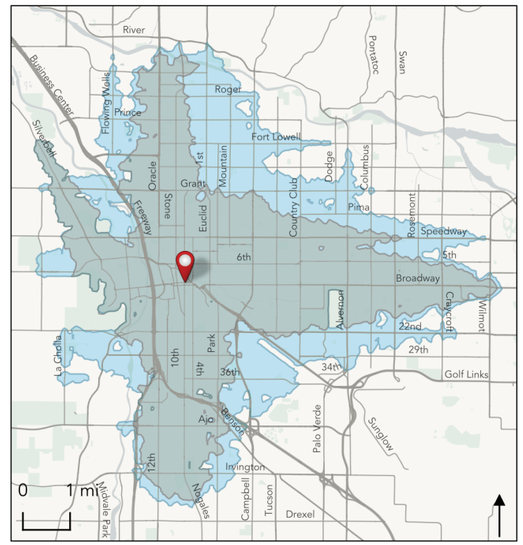
Residential Access	Job Access
+0%	+0%

Weekday Evenings



Residential Access	Job Access
+5%	+0%

Sunday Middays



Residential Access	Job Access
+90%	+35%

South Side - VA Hospital

In Phase 1, the following improvements would be evident:

- On Sundays, travel to and from the VA Hospital would improve in all directions.
  - » North and southbound trips would improve because Route 18 (South 6th Ave) would operate every 10 minutes, as on weekdays.
  - » East and westbound trips would improve because the Route 11 (Alvernon) branch on Ajo Way would operate every 30 minutes, and because services connecting to Route 18 (e.g. Route 7 on 22nd Street, Route 8 on Broadway) would also operate frequently on weekends.

45-minute Travel Time Map

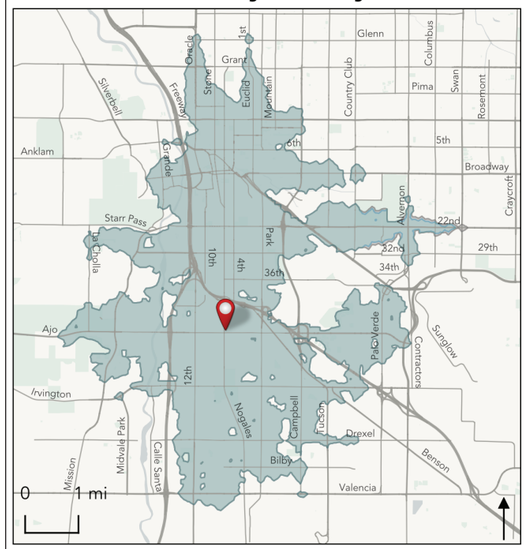
Improvements by the End of Phase 1 (within 2 years)

How far can I travel from

VA Hospital

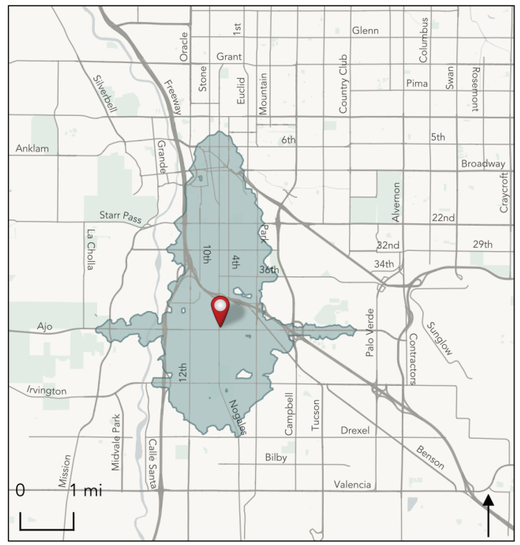
in **45 minutes** during...

Weekday Middays



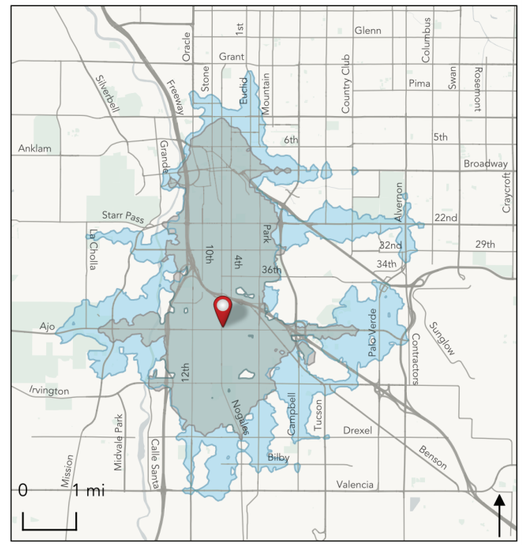
Residential Access	Job Access
+0%	+0%

Weekday Evenings



Residential Access	Job Access
0%	0%

Sunday Middays



Residential Access	Job Access
+100%	+35%

North Side - Tucson Mall

In Phase 1, the following improvements would be evident:

- On evenings, travel between Tucson Mall and locations on Campbell Ave (Route 15) and Fort Lowell Road (Route 34) would improve, as those routes' frequency would increase from every 60 minutes to every 30 minutes.
- On Sundays, travel to and from Tucson Mall would improve in all directions, as weekend frequencies on all the routes feeding into this location, and all routes feeding into transfers to Route 16 (Oracle) would now match weekday frequencies.

45-minute Travel Time Map

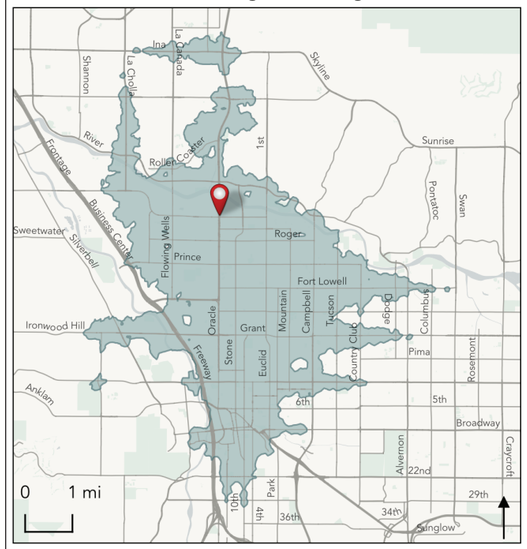
Improvements by the End of Phase 1 (within 2 years)

How far can I travel from

Wetmore & Oracle

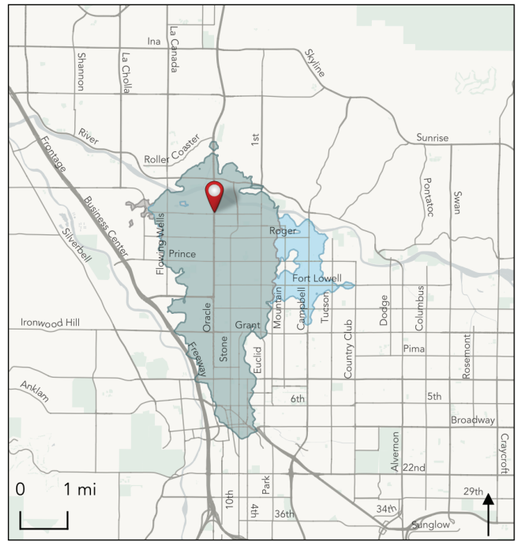
in **45 minutes** during...

Weekday Middays



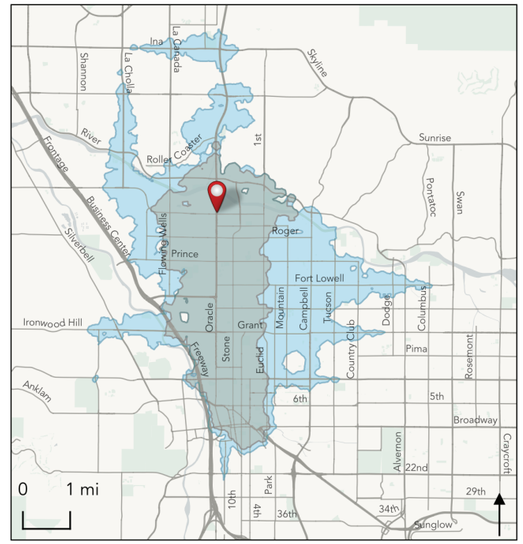
Residential Access	Job Access
+0%	+0%

Weekday Evenings



Residential Access	Job Access
+15%	+10%

Sunday Middays



Residential Access	Job Access
+95%	+65%

East Side - Park Place

In Phase 1, the following improvements would be evident:

- On evenings, there would be no significant difference, as Route 8 (Broadway) already operates every 30 minutes after 7 p.m.
- On Sundays, travel to and from Park Place would improve both from:
  - » Direct but infrequent routes, such as the outer parts of Route 8 on Wilmot Road and outer Broadway.
  - » Routes that require transfers, but would continue to operate frequently on the weekend, such as Route 11 (Alvernon) and Route 34 (Craycroft/Fort Lowell).

45-minute Travel Time Map

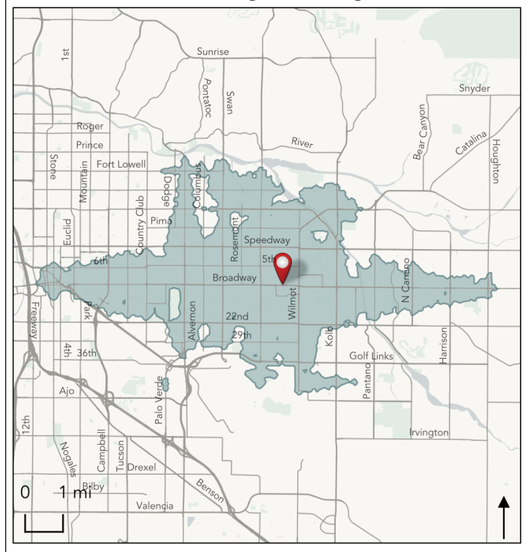
Improvements by the End of Phase 1 (within 2 years)

How far can I travel from

Park Place

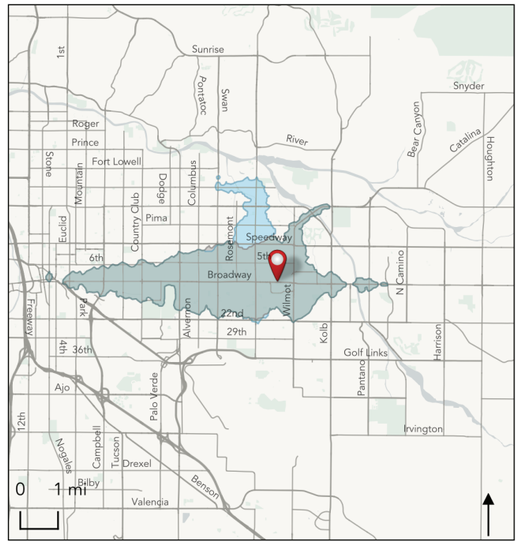
in **45 minutes** during...

Weekday Middays



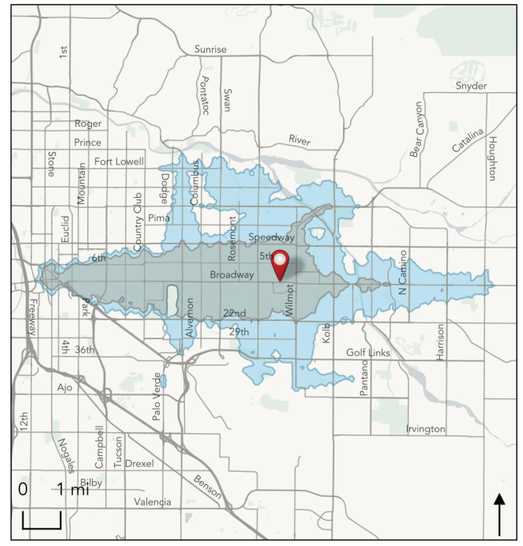
Residential Access	Job Access
+0%	+0%

Weekday Evenings



Residential Access	Job Access
+15%	+15%

Sunday Middays



Residential Access	Job Access
+150%	+60%

West Side - PCC West

In Phase 1, the following improvements would be evident:

- On evenings, the increase in service on Route 9 (Grant) from every 60 minutes to every 30 minutes would make the transit connection between PCC West and North Tucson much more useful.
- On Sundays, travel to and from PCC West would improve even more, as Route 9 would operate every 15 minutes instead of every 60 minutes, and other west side routes to Downtown would operate every 30 minutes instead of every 60 minutes.

45-minute Travel Time Map

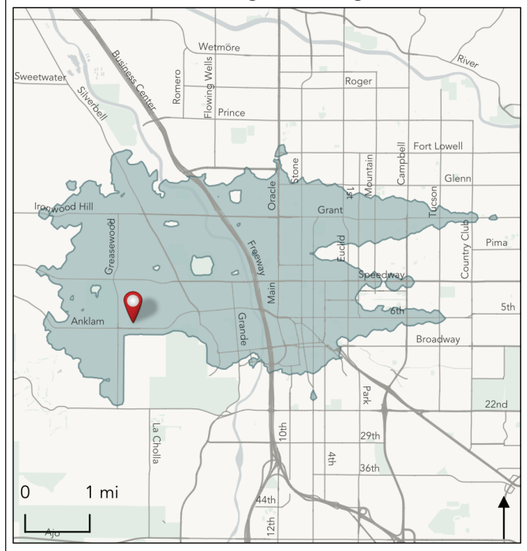
Improvements by the End of Phase 1 (within 2 years)

How far can I travel from

PCC West Campus

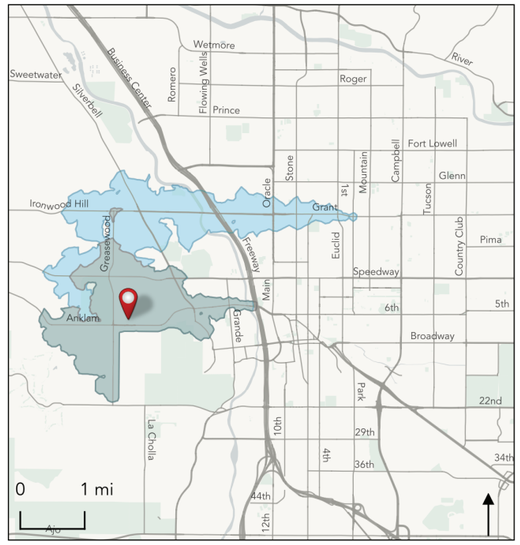
in **45 minutes** during...

Weekday Middays



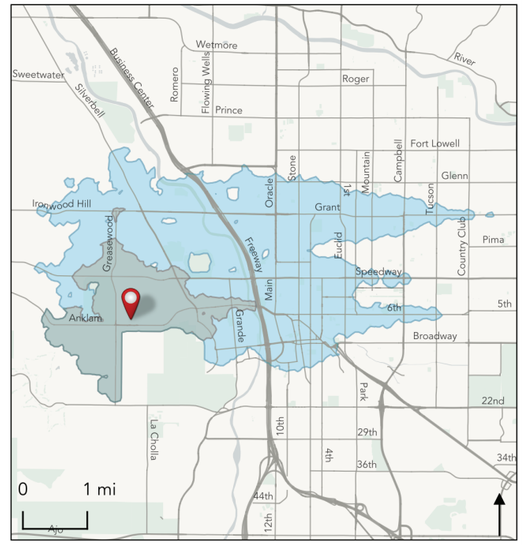
Residential Access	Job Access
+0%	+0%

Weekday Evenings



Residential Access	Job Access
+95%	+515%

Sunday Middays



Residential Access	Job Access
+430%	+5,955%

Phase 2: Proximity to Transit

Phase 2 of this plan, to be implemented in two to five years following funding, boils down to two key improvements:

- Expansion of the Frequent Transit Network (FTN) to large parts of the south side and Flowing Wells, seven days a week.
- A corresponding increase in the number of locations near evening service every 30 minute or better.
- Targeted expansion of some suburban services as described on page 32.

The bar charts at right show what is achieved in terms of people and jobs being closer to transit. Compared to existing service:

- The percentage of Pima County residents near service every 15 minutes or better would go from 26% to 35% on weekdays, and from 0% to 35% on weekends.
- The percentage of Pima County jobs near service every 15 minutes or better would go from 51% to 59% on weekdays; and from 0% to 59% on weekends.
- The percentage of Pima County residents near evening service every 30 minutes or better would go from 16% to 34%.
- The percentage of Pima County jobs near evening service every 30 minutes or better would go from 38% to 59%.
- The percentage of Pima County residents near any fixed-route transit service would increase from 57% to 62%. This likely reflects the suburban expansions.
- The percentage of Pima County jobs near any fixed-route transit service would increase from 76% to 80%.

All of this suggests transit service would become significantly more useful to many people at all times of the day and week. The travel time maps and job access analysis shown on the following pages confirm this.

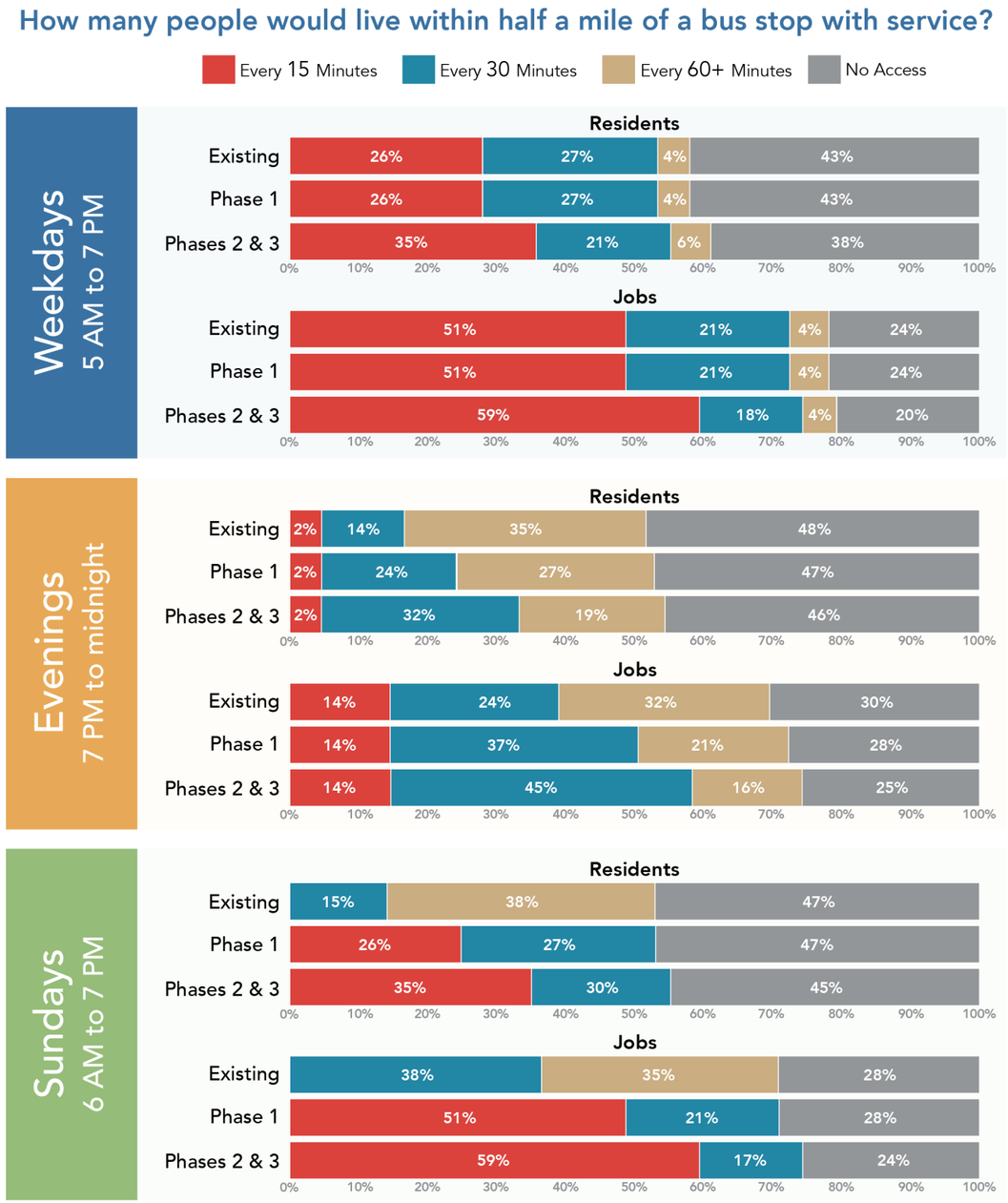


Figure 40: Percentage of Pima County residents near transit service at different frequencies, existing vs. Phase 1 and Phases 2/3. Phase 2 would restructure the network and significantly expand frequent service. Phase 3 would entail capital improvements, so there would be very limited change in the number of people near service.

Phase 2: Access to Opportunity

The expansion of the FTN in Phase 2 would represent a significant network restructuring with massive positive impacts on access to opportunity by transit at almost all times of the day and week.

As a result of these improvements, the transit network would become potentially far more useful to far more people, which is likely to significantly increase systemwide ridership.

- Compared to existing service, for the average Tucson region resident, job access by transit in 45 minutes would improve by:
  - » **+23% on weekdays**
  - » **+25% on evenings**
  - » **+171% on Sundays**. In other words, job access by transit would nearly triple on Sundays.
- The positive impact of these improvements would be broadly distributed geographically and demographically:
  - » Because the strongest improvements in this phase would target the south side and Flowing Wells, the positive job access impacts we measure would be slightly higher for low-income residents and noticeably higher for minority residents.
  - » Although the strongest positive impacts would be felt on the south side, nearly all areas west of I-10/I-19 and east of Craycroft Road would experience a substantial increase in the usefulness of transit.

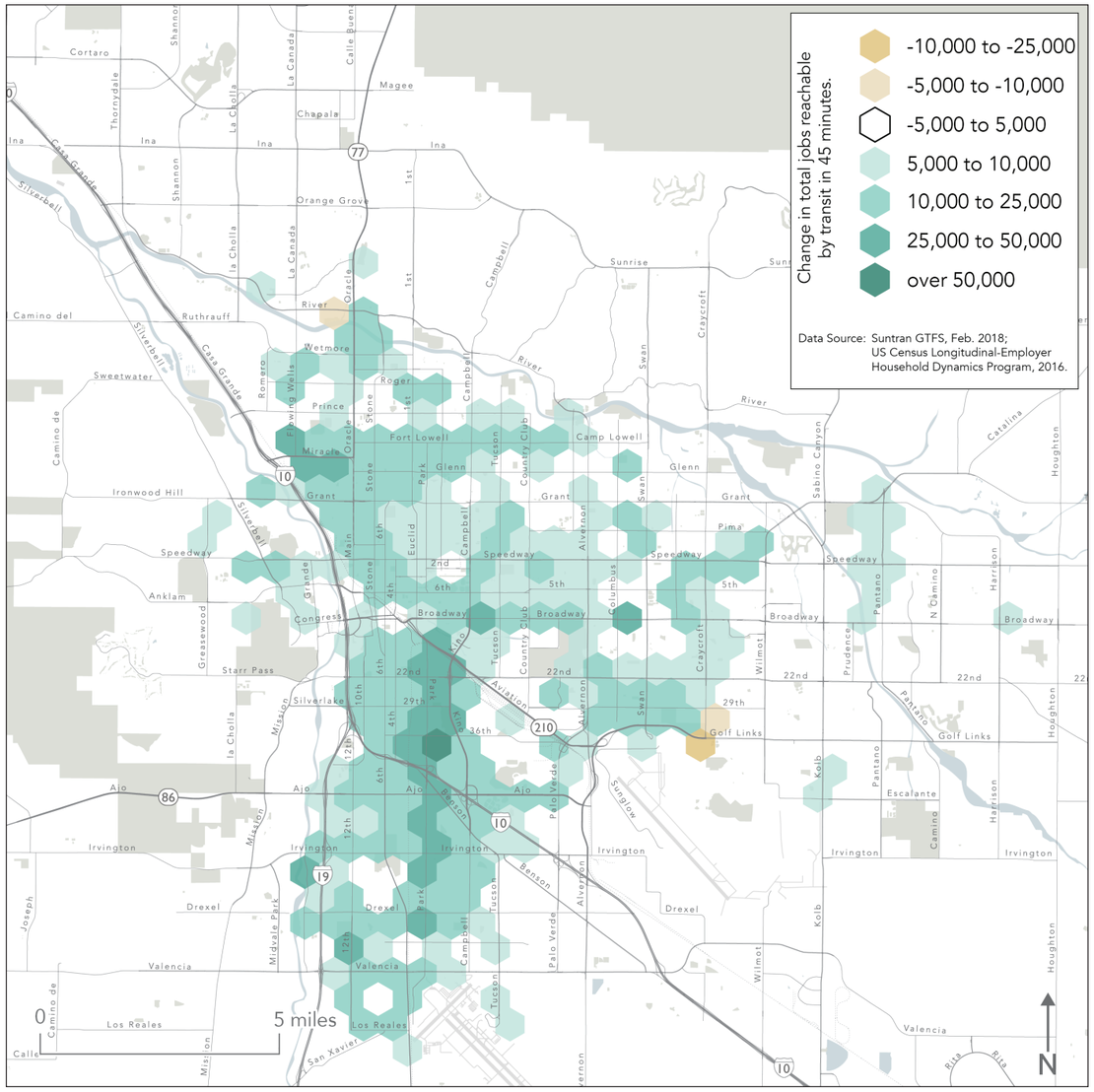
Job Access Change - Weekdays, Phase 2 (within 5 years)

Under this transit network overall job access in 45 minutes would change by...

+23% for All Residents

+29% for Minority Residents

+25% for Low-income Residents



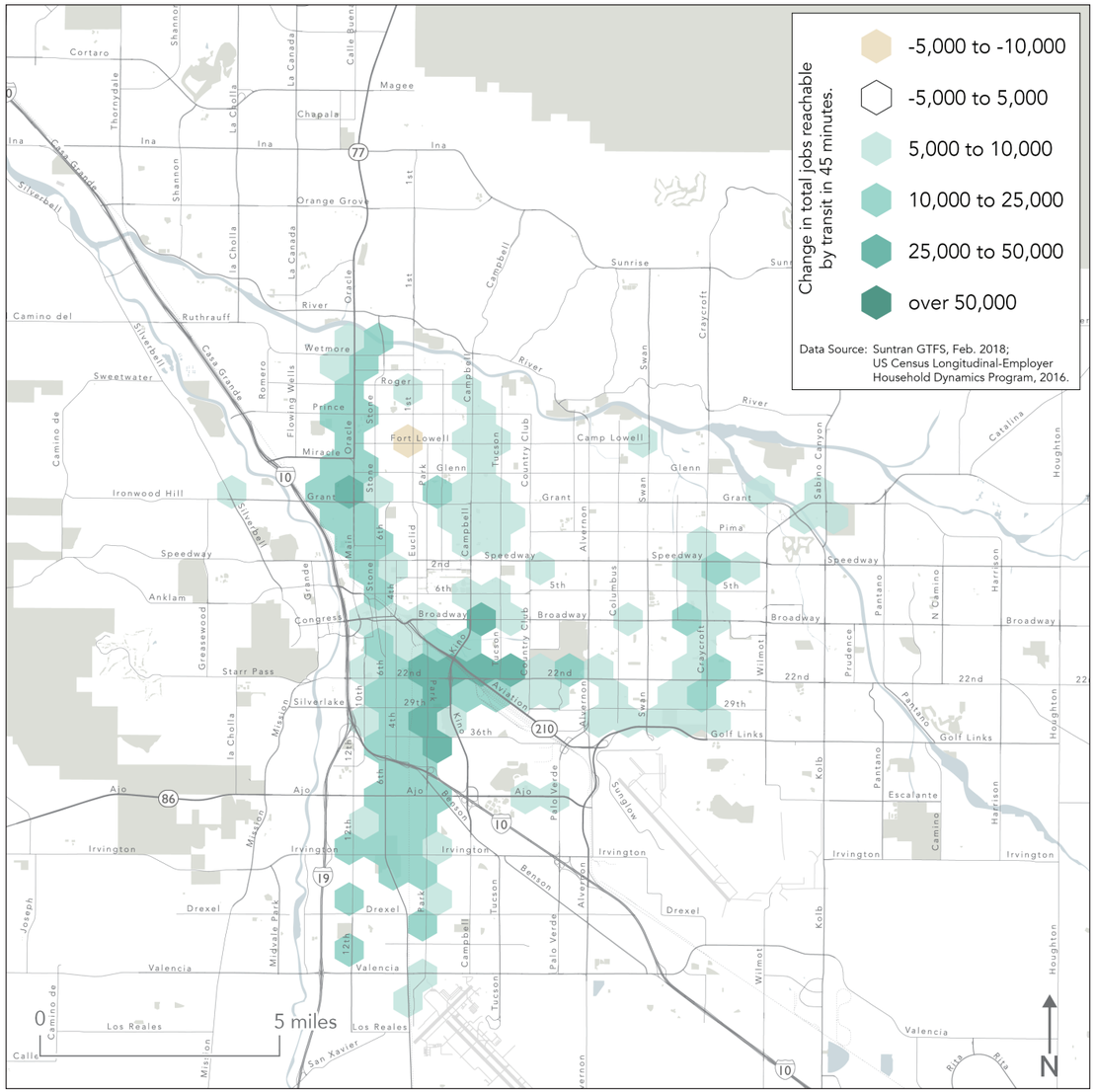
Job Access Change - Evenings, Phase 2 (within 5 years)

Under this transit network overall job access in 45 minutes would change by...

+25% for All Residents

+32% for Minority Residents

+28% for Low-income Residents



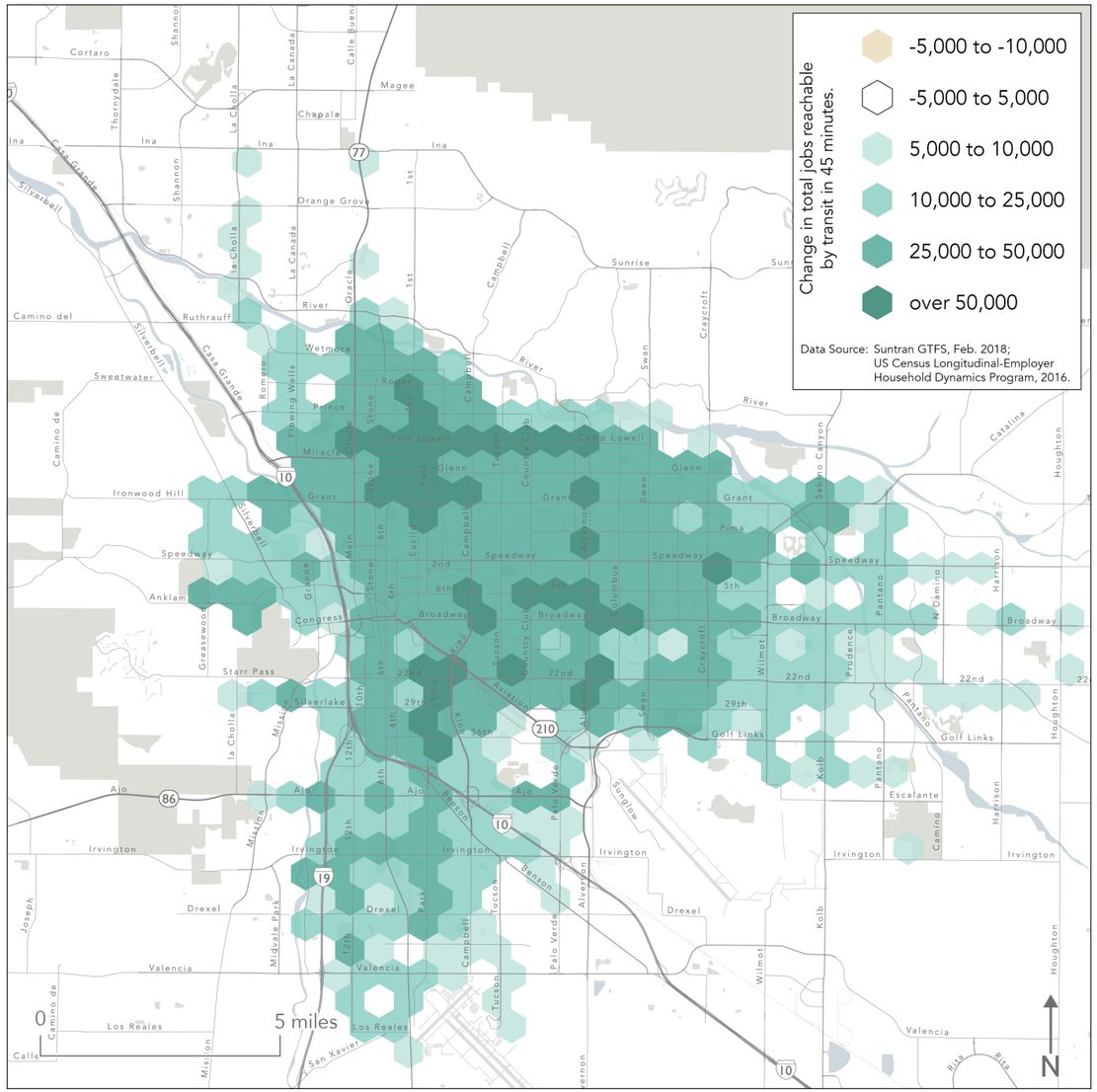
Job Access Change - Sundays, Phase 2 (within 5 years)

Under this transit network overall job access in 45 minutes would change by...

+171% for All Residents

+193% for Minority Residents

+175% for Low-income Residents



Phase 2: 45-minute Travel Time Maps

Downtown Tucson

In Phase 2, the following improvements would be evident:

- On weekdays, the biggest improvements in travel to and from Downtown come from the south side, particularly between Irvington Road and Valencia Road, along Park Ave and South 12th Ave.
- On weekday evenings, there is generally relatively marginal improvement in access to Downtown by transit, compared to existing service. This is because all of the evening services that already operate every 30 minutes or better come out of Downtown.
- On Sundays, travel to and from Downtown by transit would improve in all directions, essentially becoming as convenient as on a weekday, with the addition of further improvements on the south side.

45-minute Travel Time Map

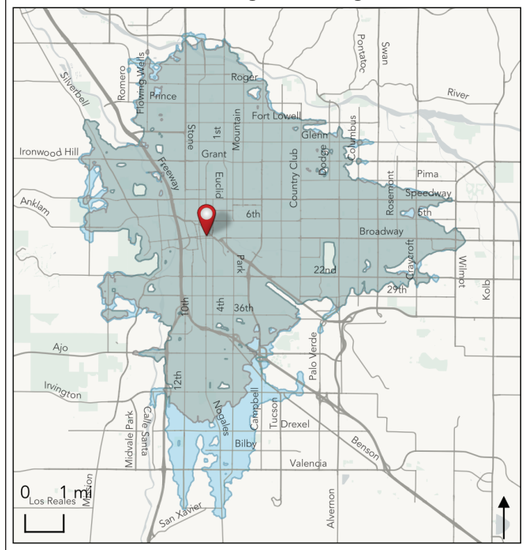
Improvements by the End of Phase 2 (within 5 years)

How far can I travel from

Tucson Downtown

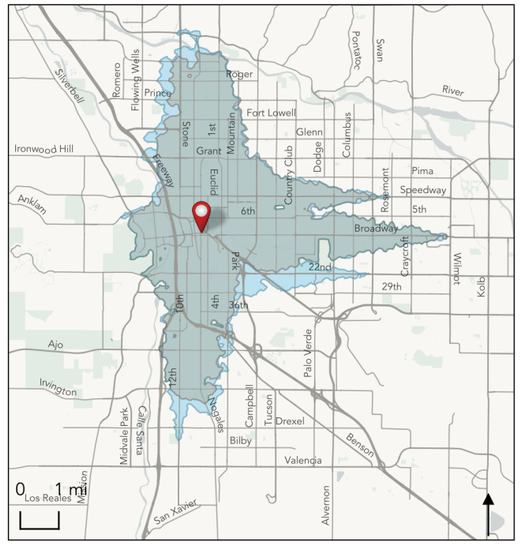
in **45 minutes** during...

Weekday Middays



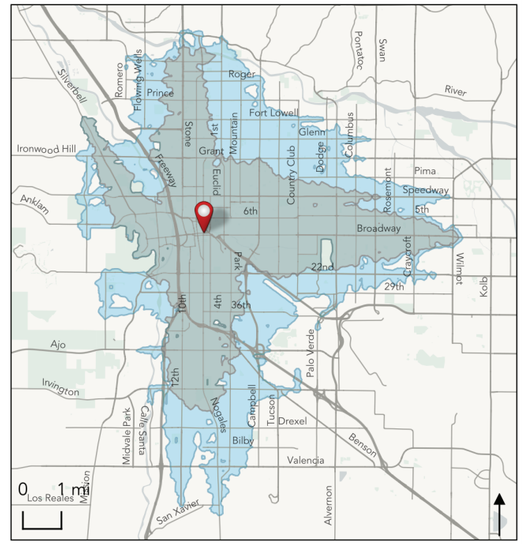
Residential Access	Job Access
+15%	+5%

Weekday Evenings



Residential Access	Job Access
+10%	+10%

Sunday Middays



Residential Access	Job Access
+130%	+45%

South Side - VA Hospital

In Phase 2, the following improvements would be evident:

- Weekday access to the VA Hospital would improve from the north, south and west, thanks to:
  - » Direct travel with no transfers from South 6th Avenue to North Oracle Road and to areas along Valencia Road.
  - » Improved transfer connections from frequent service on South 6th Avenue to other frequent services, such as a new frequent cross-town route on Irvington Road.
- Direct travel between South 6th Avenue and North Oracle Road is also the source of improved evening access to the VA Hospital from the north side.
- On Sundays, travel to and from the VA Hospital by transit would improve in all directions, essentially becoming as convenient as on a weekday, with the addition of improved connections to the north, south and west.
- At the same time, restructuring the frequent network to extend to the south side would inevitably have negative impacts on a limited number of specific trips. On the weekday map, we can see that access to the VA from Alvernon Road would take longer, because achieving frequent north-south service on Palo Verde Road would mean that Route 11 could no longer split between one branch on Ajo Way and one branch on Palo Verde.

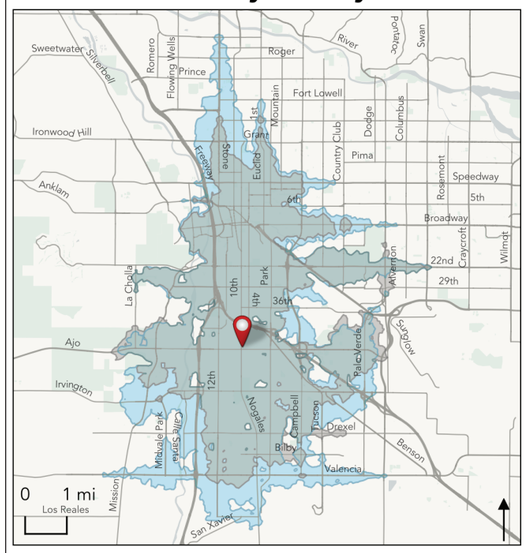
45-minute Travel Time Map
Improvements by the End of Phase 2 (within 5 years)

How far can I travel from

VA Hospital

in **45 minutes** during...

Weekday Middays

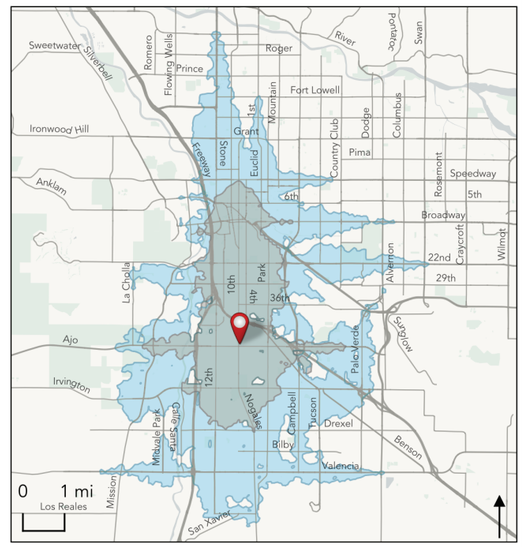


Residential Access	Job Access
+35%	+20%

Weekday Evenings

Residential Access	Job Access
+60%	+35%

Sunday Middays



Residential Access	Job Access
+270%	+90%

North Side - Tucson Mall

In Phase 2, the following improvements would be evident:

- Continuing service from North Oracle Road directly to South 6th Avenue with no transfers downtown would significantly increase access to Tucson Mall from the south side. This would be true at all days and times.
  - » However, this new connection would also requiring terminating Route 16 at Tohono Tadai Transit Center. As a result, service to Oracle Road north of Tohono Tadai would likely be placed on Route 19, causing some existing transit trips to become less convenient.
- On evenings, travel between Tucson Mall and locations on Campbell Ave (Route 15) would also improve, for similar reasons as in Phase 1.
- On Sundays, travel to and from Tucson Mall would improve in all directions.

45-minute Travel Time Map

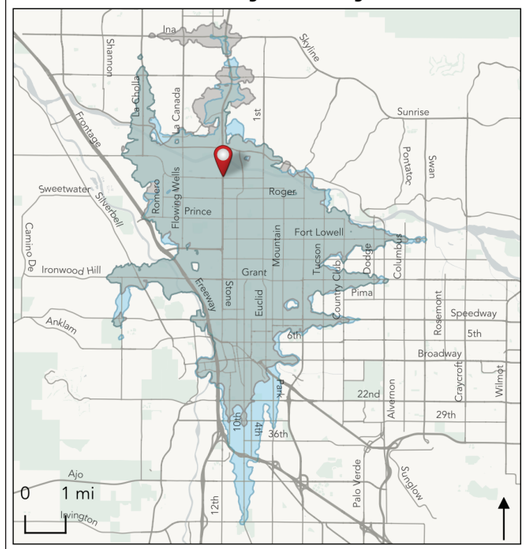
Improvements by the End of Phase 2 (within 5 years)

How far can I travel from

Wetmore & Oracle

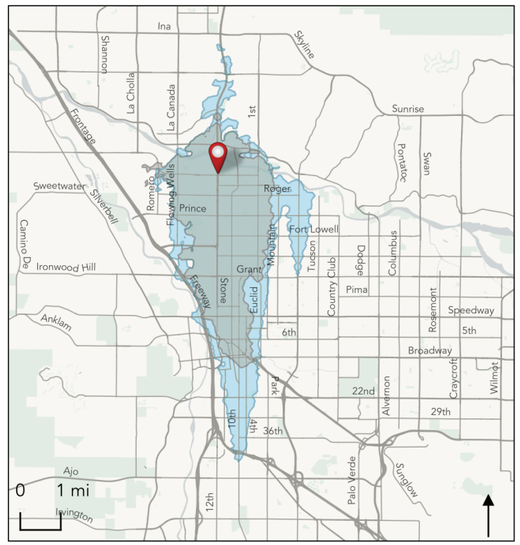
in **45 minutes** during...

Weekday Middays



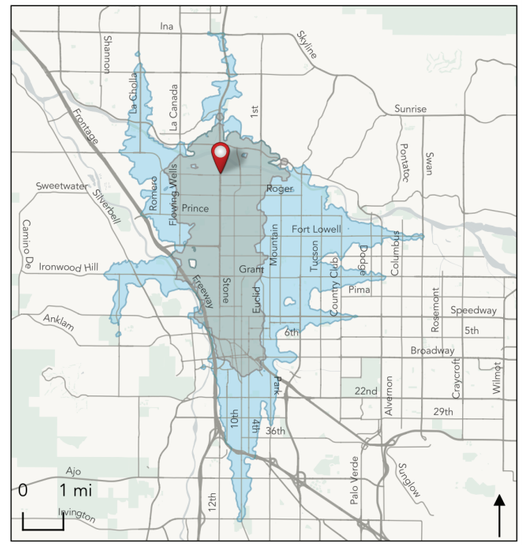
Residential Access	Job Access
+10%	+5%

Weekday Evenings



Residential Access	Job Access
+50%	+60%

Sunday Middays



Residential Access	Job Access
+170%	+110%

East Side - Park Place

In Phase 2, the following improvements would be evident:

- Weekday and evening improvements would be limited, largely because Park Place already is located along some of the most frequent transit routes in Tucson.
- On Sundays, travel to and from Park Place would improve similarly to Phase 1, along:
  - » Direct but infrequent routes, such as outer Broadway and Wilmot Road.
  - » North-south routes that require transfers, but would continue to operate frequently on the weekend, such as Route 11 (Alvernon) and Route 34 (Craycroft/Fort Lowell), or even less frequent routes that would continue to operate every 30 minutes on weekends, such as service on Swan Road.

45-minute Travel Time Map

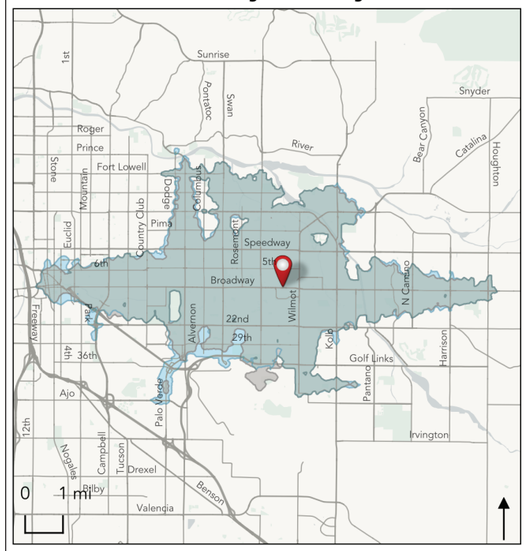
Improvements by the End of Phase 2 (within 5 years)

How far can I travel from

Park Place

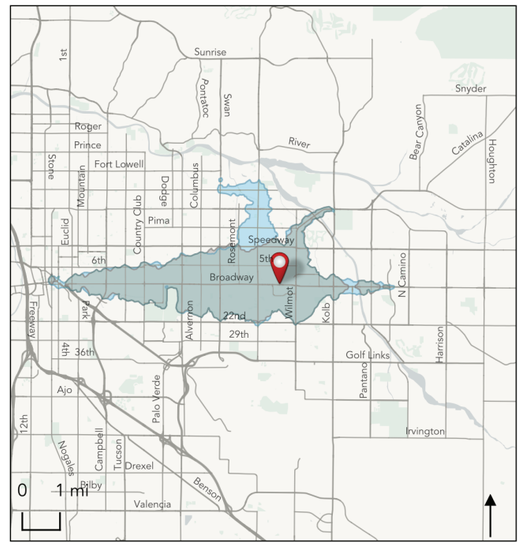
in **45 minutes** during...

Weekday Middays



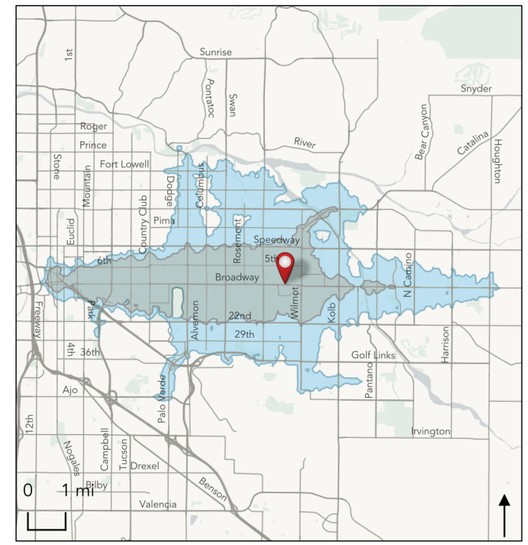
Residential Access	Job Access
+5%	+5%

Weekday Evenings



Residential Access	Job Access
+20%	+20%

Sunday Middays



Residential Access	Job Access
+175%	+75%

West Side - PCC West

In Phase 2, the following improvements would be evident:

- On weekdays, there would be slight improvements in connectivity to the south side.
- On evenings, similar to Phase 1, the increase in service on Route 9 (Grant) from every 60 minutes to every 30 minutes would make the transit connection between PCC West and North Tucson much more useful.
- On Sundays, similar to Phase 1, travel to and from PCC West would improve even more, as Route 9 would operate every 15 minutes instead of every 60 minutes, and other west side routes to Downtown would operate every 30 minutes instead of every 60 minutes.

45-minute Travel Time Map

Improvements by the End of Phase 2 (within 5 years)

How far can I travel from

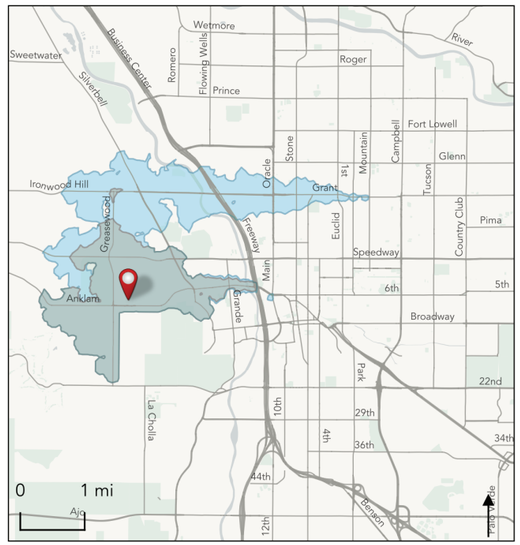
PCC West Campus

in **45 minutes** during...

Weekday Middays

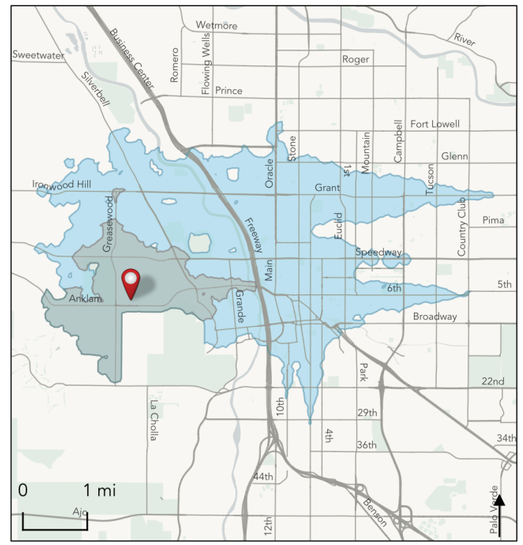
Residential Access	Job Access
+10%	+5%

Weekday Evenings



Residential Access	Job Access
+105%	+565%

Sunday Middays



Residential Access	Job Access
+480%	+6,135%

Long Term: Proximity to Transit

In the second decade of this plan, the following significant additional service improvements would take place:

- Further expansion of the Frequent Transit Network (FTN), such that most of Tucson is covered by a 1 x 1 mile grid of frequent bus routes.
- A further corresponding increase in the number of locations near evening service every 30 minutes or better.
- Additional service (including 7- to 10-minute weekday and weekend service, and 15-minute weekend service) on Tier 1 FTN routes, including North Oracle Road, South 6th Ave, Broadway Blvd, Speedway Blvd and the Sun Link streetcar.
- Further targeted expansion of some suburban services as described on page 33.

The bar charts at right show what is achieved in terms of people and jobs being closer to transit. Compared to service achieved in the medium term:

- The percentage of Pima County residents near service every 15 minutes or better would go from 35% to 46% on weekdays and on weekends.
- The percentage of Pima County jobs near service every 15 minutes or better would go from 59% to 68% on weekdays and on weekends.
- The percentage of Pima County residents near evening service every 15 minutes or better would go from 2% to 13%. The percentage of Pima County residents near evening service every 30 minutes or better would go from 34% to 57%.
- The percentage of Pima County jobs near evening service every 15 minutes or better would go from 14% to 35%. The percentage of Pima County jobs near evening service every 30 minutes or better would go from 59% to 78%.
- The percentage of Pima County residents near any fixed-route transit service would increase from 62% to 64%.
- The percentage of Pima County jobs near any fixed-route transit service would go from 80% to 82%.

All of this suggests transit service would become significantly more useful, compared to the medium term, especially in the evenings. The travel time maps and job access analysis shown on the following pages confirm this.

How many people would live within half a mile of a bus stop with service?

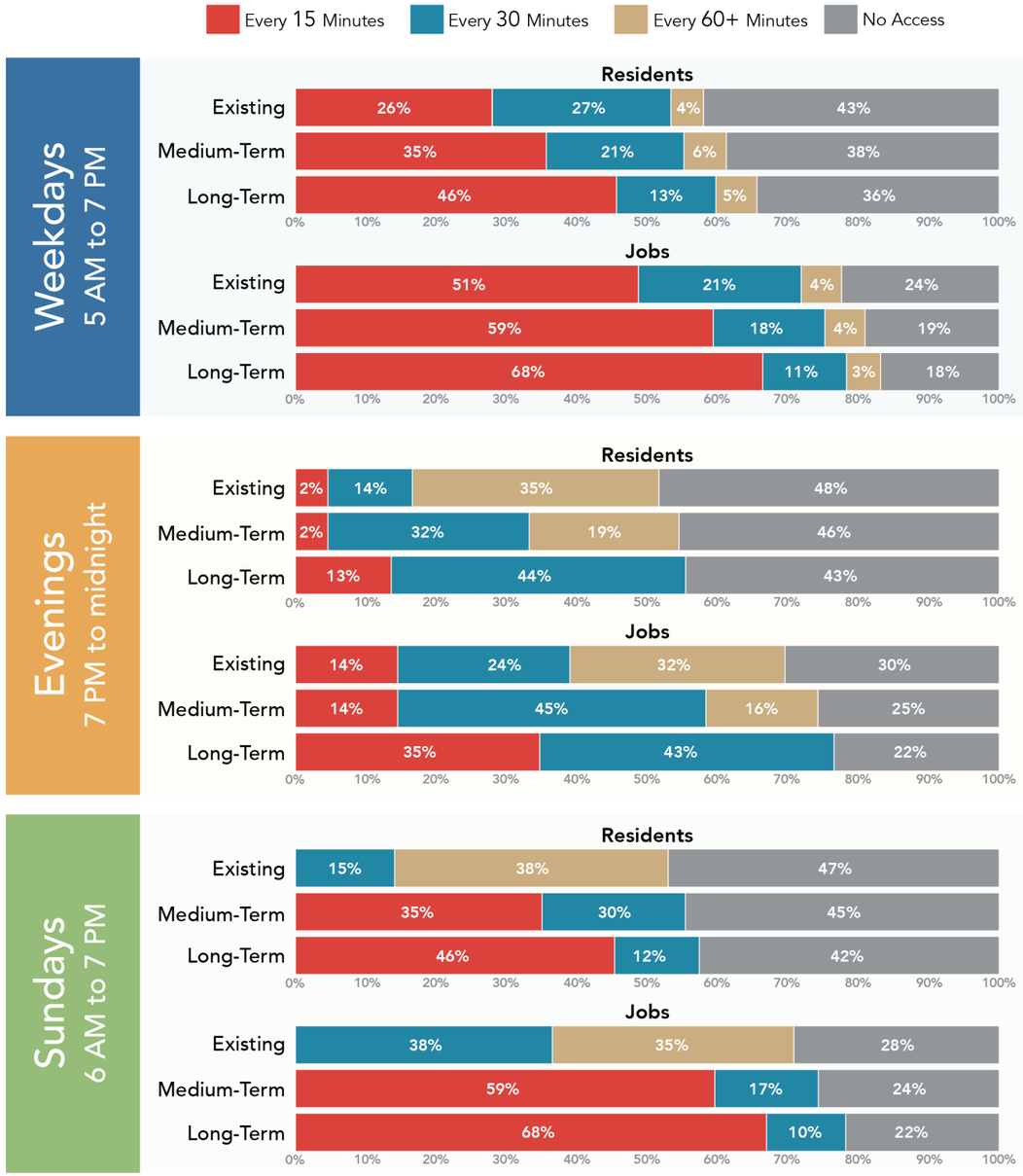


Figure 41: Percentage of Pima County residents near transit service at different frequencies, existing vs. Phase 1 and Phases 2/3. Phase 3 would restructure the network and significantly expand frequent service.

Long Term: Access to Opportunity

As in Phases 1 and 2, the best measure of how much these improvements would improve transit for people in the Tucson region is calculating the change in the number of jobs accessible in a reasonable amount of time using the transit system.

Through the analysis illustrated on this page and next we find that after long-term service improvements, **in 45 minutes on transit** (door-to-door, including time spent walking, waiting and in vehicle), **the average resident of the Tucson region could access:**

- **+50% more jobs on weekdays** than today, more than twice as much benefit as in the medium term
- **+91% more jobs in the evening** than today, more than three times as much benefit as in the medium term
- **+229% more jobs on Sundays** than today, or about a third more benefit as in the medium term.

Both the proximity and access benefits described above would be more geographically spread out than in the medium term. In particular, the long-term improvements would start bringing significant improvements in transit to areas:

- On the outer east side, especially between Craycroft Road and Pantano Road.
- On much of the west side between I-10/I-19 and Greasewood Road
- Along La Cholla Road, Oracle Road and Ina and Magee Roads north of the Rillito river.

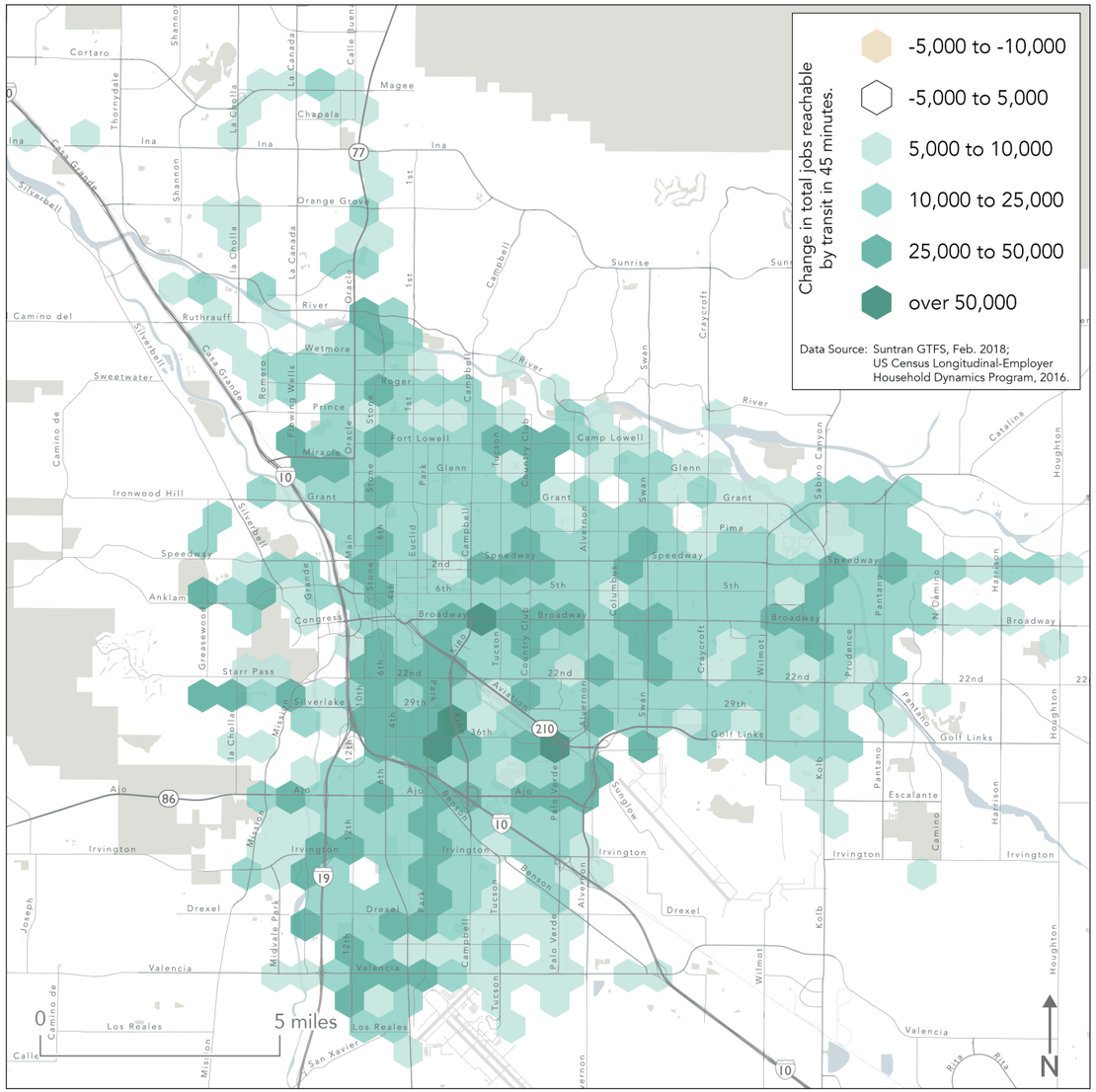
Job Access Change - Weekdays, Long Term (within 10 to 20 years)

Under this transit network overall job access in 45 minutes would change by...

+50% **for All Residents**

+58% **for Minority Residents**

+50% **for Low-income Residents**



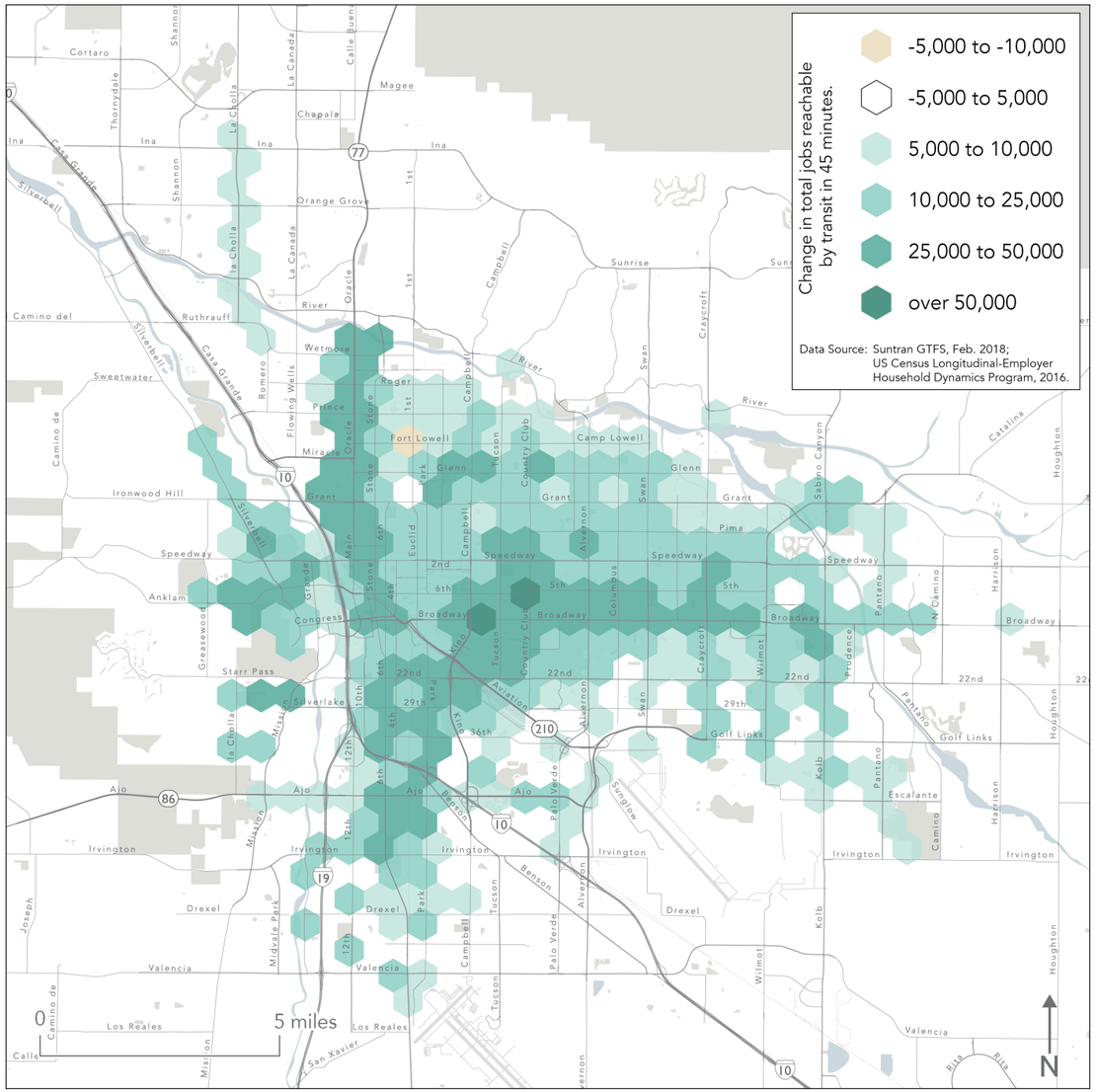
Job Access Change - Evenings, Long Term (within 10 to 20 years)

Under this transit network overall job access in 45 minutes would change by...

+91% for All Residents

+97% for Minority Residents

+89% for Low-income Residents



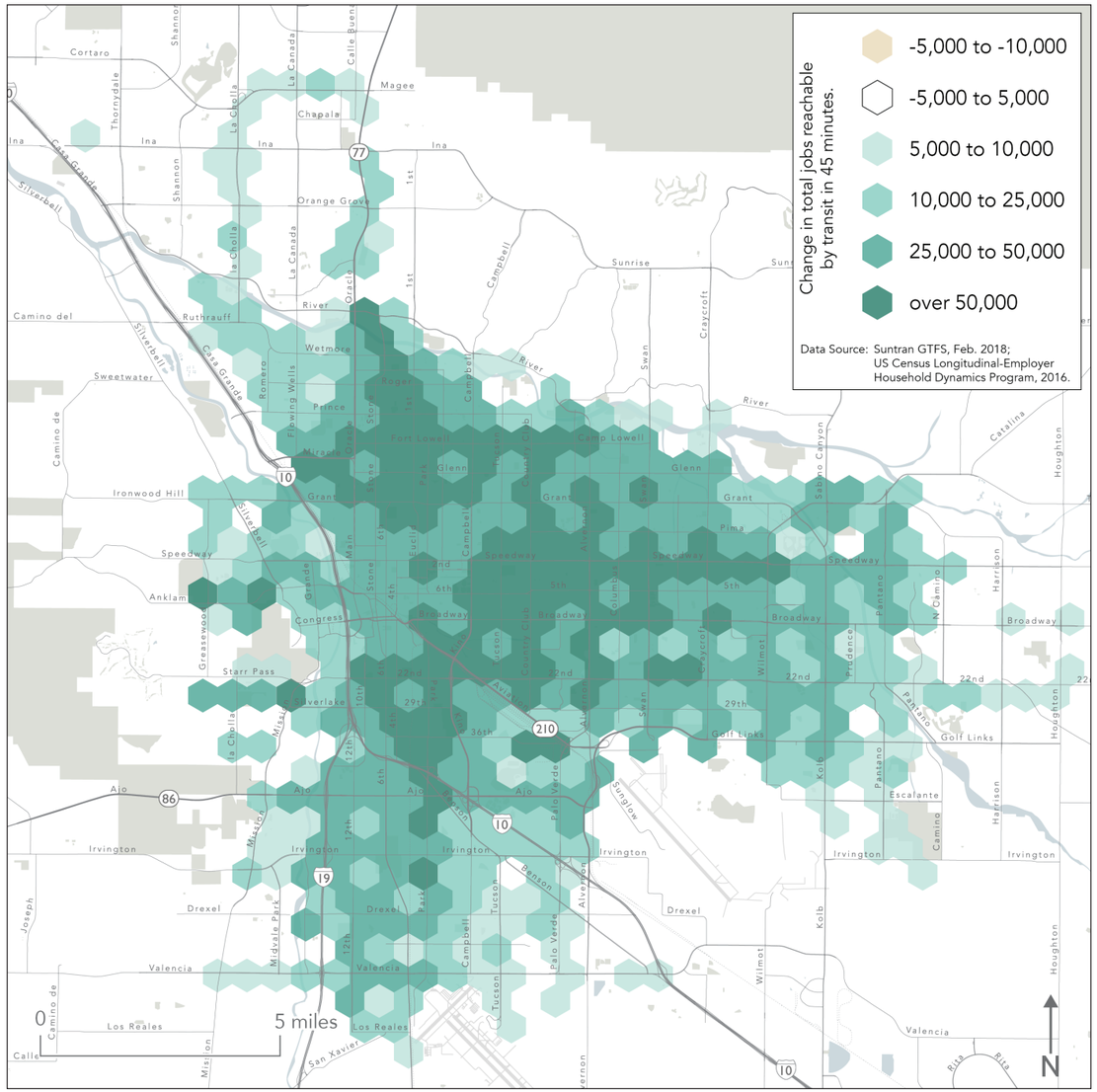
Job Access Change - Sundays, Long Term (within 10 to 20 years)

Under this transit network overall job access in 45 minutes would change by...

+229% for All Residents

+243% for Minority Residents

+232% for Low-income Residents



Long Term: 45-minute Travel Time Maps

Downtown Tucson

In the long term, the proposed increases in service, and in particular the expansion of the Frequent Transit Network (FTN) and increased evening frequency on FTN tier 1 routes, would mean that access to Downtown by transit would improve significantly at all days and times.

45-minute Travel Time Map

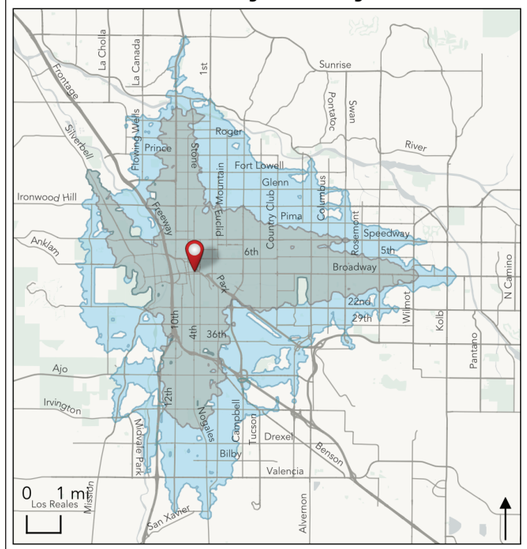
Long-Term Improvements (within 10 to 20 years)

How far can I travel from

Tucson Downtown

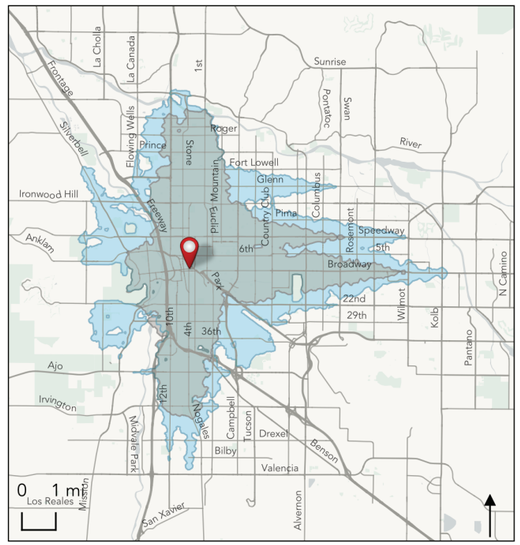
in **45 minutes** during...

Weekday Middays



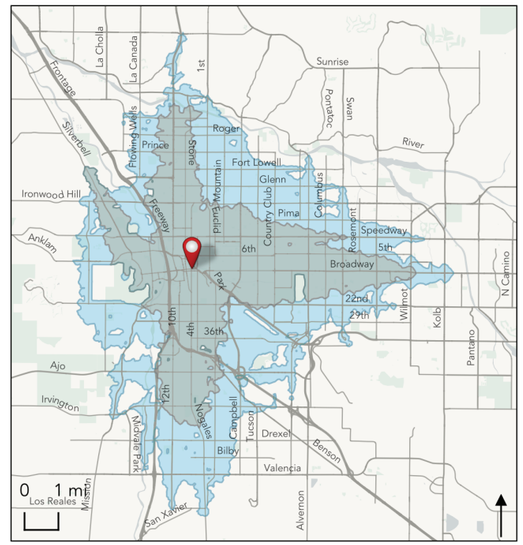
Residential Access	Job Access
+30%	+15%

Weekday Evenings



Residential Access	Job Access
+60%	+35%

Sunday Middays



Residential Access	Job Access
+165%	+60%

South Side - VA Hospital

As with Downtown, long-term improvements would enable increased frequent service to the VA Hospital from all directions, significantly increasing access to and from this location at all days and times.

45-minute Travel Time Map

Long-Term Improvements (within 10 to 20 years)

How far can I travel from

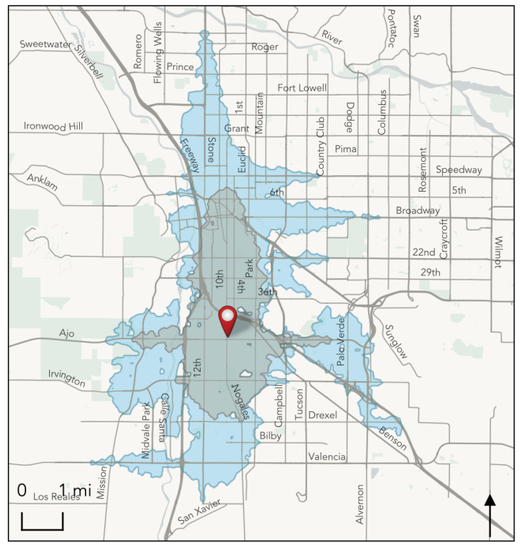
VA Hospital

in **45 minutes** during...

Weekday Middays

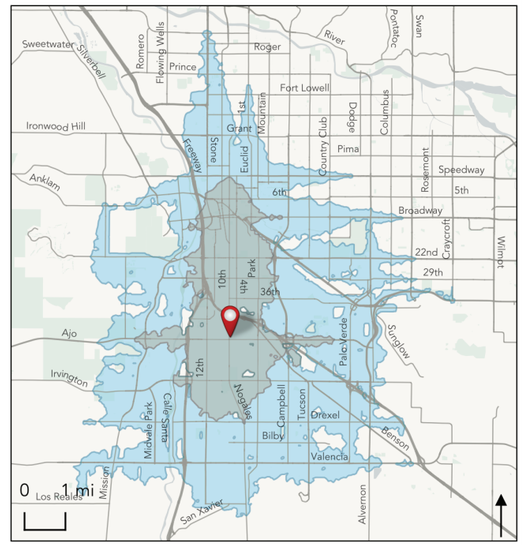
Residential Access	Job Access
+75%	+35%

Weekday Evenings



Residential Access	Job Access
+215%	+90%

Sunday Middays



Residential Access	Job Access
+405%	+120%

North Side - Tucson Mall

In the long-term, access to Tucson Mall would increase significantly, even beyond the increases visible in Phase 2 (see page 67). In particular:

- Increased evening frequencies on North Oracle Road (linking to South 6th Ave) would further improve access from the south side.
- FTN expansion to more parts of Flowing Wells would improve access coming from the east at all days and times.

45-minute Travel Time Map

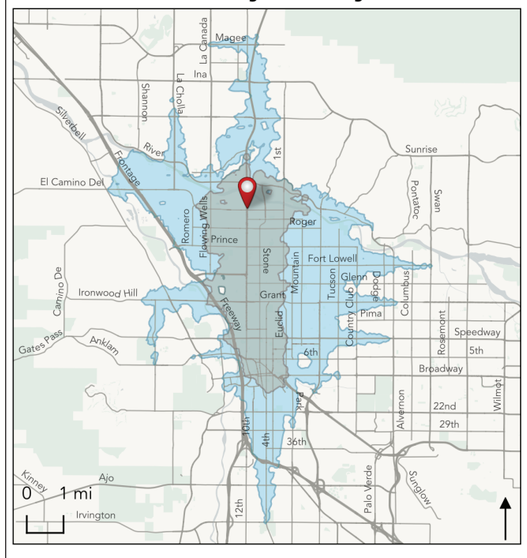
Long-Term Improvements (within 10 to 20 years)

How far can I travel from

Wetmore & Oracle

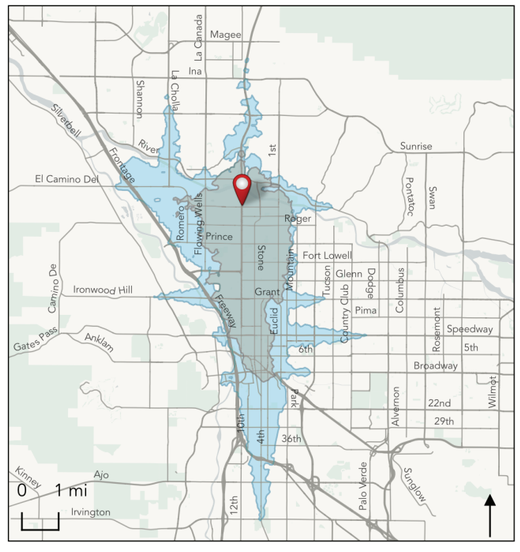
in **45 minutes** during...

Weekday Middays



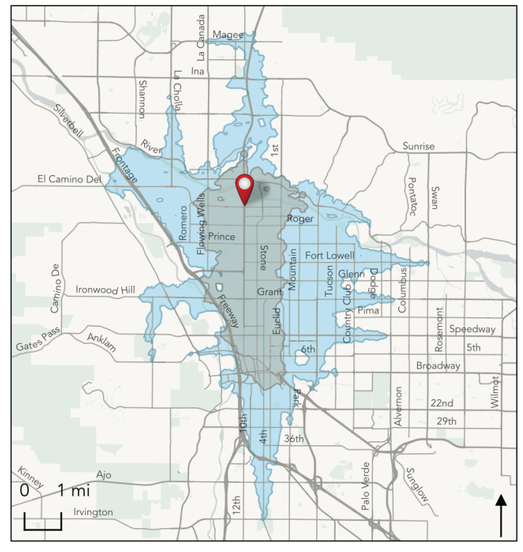
Residential Access	Job Access
+25%	+15%

Weekday Evenings



Residential Access	Job Access
+115%	+135%

Sunday Middays



Residential Access	Job Access
+215%	+130%

East Side - Park Place

Major long-term improvements that would positively affect access to and from Park Place include:

- Additional weekday, evening and weekend frequency on Broadway Boulevard, which could also be reinforced with a faster "rapid" type service. This improves access in all directions, because it also means that trips requiring transfers to north-south routes would be faster.
- A direct connection every 20 minutes with outer parts of Speedway Boulevard would improve access eastward.

45-minute Travel Time Map

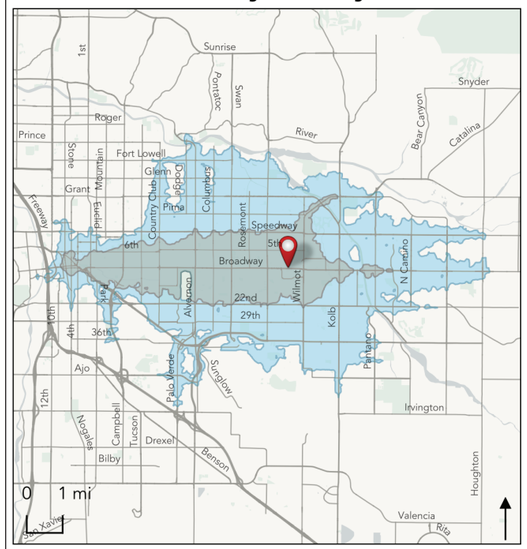
Long-Term Improvements (within 10 to 20 years)

How far can I travel from

Park Place

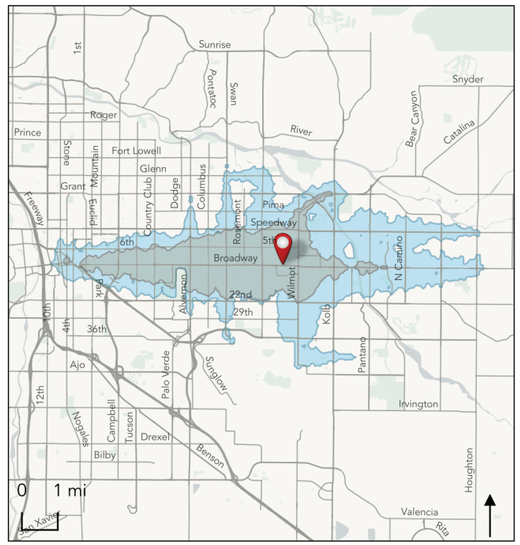
in **45 minutes** during...

Weekday Middays



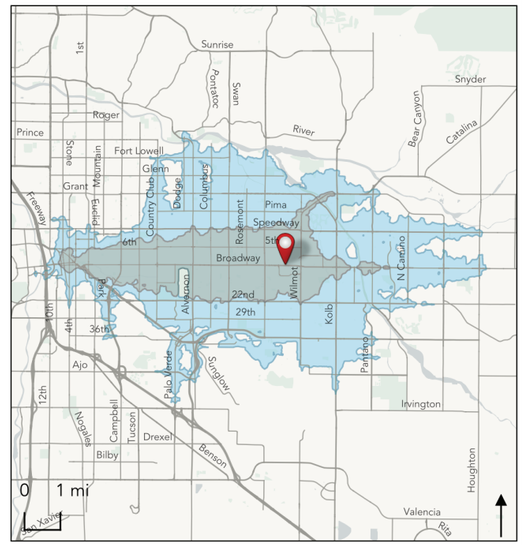
Residential Access	Job Access
+55%	+30%

Weekday Evenings



Residential Access	Job Access
+195%	+130%

Sunday Middays



Residential Access	Job Access
+300%	+130%

West Side - PCC West

When compared to improvements in Phase 2 (see page 69), the major added improvement in the long-term is a direct frequent connection between PCC West and the south side via Star Pass Road and 26th Street. This would significantly further expand the area accessible to PCC West by transit.

45-minute Travel Time Map

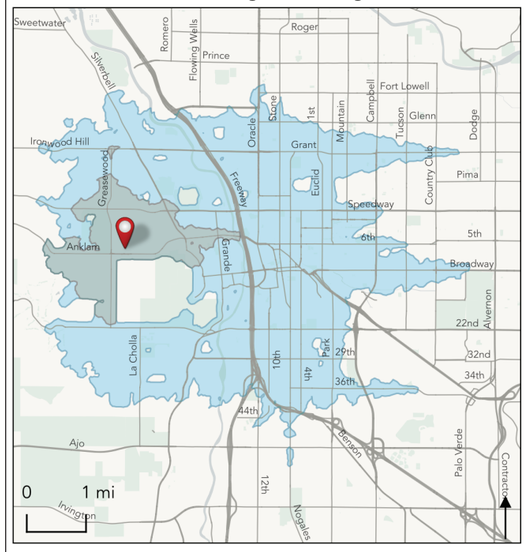
Long-Term Improvements (within 10 to 20 years)

How far can I travel from

PCC West Campus

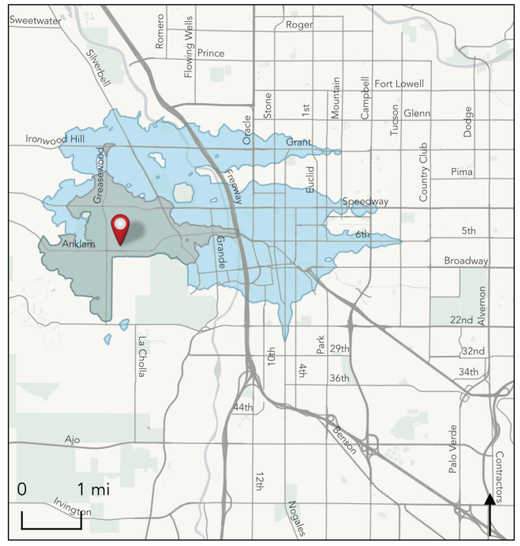
in **45 minutes** during...

Weekday Middays



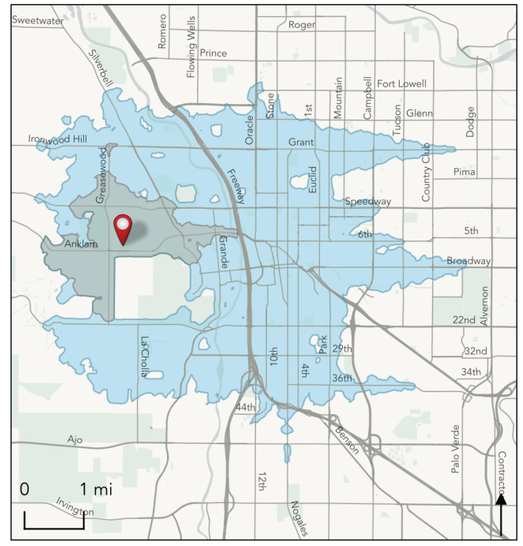
Residential Access	Job Access
+55%	+25%

Weekday Evenings



Residential Access	Job Access
+345%	+5,685%

Sunday Middays



Residential Access	Job Access
+750%	+7,725%

Summary of Outcomes: Why make this investment?

As explained on page 20, this is an expensive plan. But it is far less expensive when compared to the alternatives: ever more auto-oriented growth, leading to even longer travel times and even more expensive road and highway projects. Furthermore, as we have seen in this last chapter, this plan comes with considerable benefits.

By making transit a viable option for many more trips, implementing this plan would considerably reduce growth in traffic congestion, air pollution, and greenhouse gas emissions. At the same time, it would empower great numbers of people with limited transportation options to access vastly more opportunities than they can today, and could even attract new economic opportunities to the region.

The following is a summary of the key measures of transit-specific benefits measured in this chapter.

More People Near Better Transit

The proposed network would ensure that far more people and jobs would be located within a 1/2 mile of frequent service, with a bus coming every 15 minutes or better.

- **Today: 28% of Pima County residents** (57% of Tucson residents) are near the Frequent Transit Network (FTN).
- **Within 5 years of funding: 35% of Pima County residents** (69% of Tucson residents) would be near the FTN.
- **Within 10 to 20 years of funding: 46% of Pima County residents** (85% of Tucson residents) would be near the FTN.

These improvement wouldn't be limited to any one class or type of people, and the benefits would be even more striking among low-income and minority populations with higher transit needs:

- Non-white residents of Pima County living near frequent service would increase from 31% today, to:
  - » 43% within 5 years of funding.
  - » 55% within 10 to 20 years of funding.
- Low-income residents of Pima County living near frequent service would increase from 42% today, to:
  - » 54% within 5 years of funding
  - » 67% within 10 to 20 years of funding.

Faster Travel and More Access to Opportunity

The expansion of the frequent network to many more places would mean that the average resident in the Tucson region would be able to reach:

- **Within 5 years of funding: +23% more jobs on weekdays** in 45 minutes door-to-door.
- **Within 10 to 20 years of funding: +50% more jobs on weekdays** in 45 minutes door-to-door.

Extending evening service would allow the average resident in the Tucson region to reach:

- **Within 2 years of funding: +9% more jobs on weekdays** in 45 minutes door-to-door.
- **Within 5 years of funding: +25% more jobs on weekdays** in 45 minutes door-to-door.
- **Within 10 to 20 years of funding: +91% more jobs on weekdays** in 45 minutes door-to-door.

Extending Sun Tran weekend service levels to match weekdays would allow the average resident in the Tucson region to reach:

- **Within 2 years of funding: +113% more jobs on Sundays** in 45 minutes door-to-door.
- **Within 5 years of funding: +170% more jobs on Sundays** in 45 minutes door-to-door.
- **Within 10 to 20 years of funding: +228% more jobs on Sundays** in 45 minutes door-to-door.

All of these positive impacts would be felt at similar or slightly higher levels among low-income and minority populations.

Glossary

Glossary

Access	The number of jobs or residents reachable from a starting location by transit and walking. Access is often calculated for many starting points in a network, based on some assumed travel-time "budget," and summarized on a map.
Arterial road	A high-capacity through road.
Circulator	Circulator is often used to describe a service that provides transit coverage to a low-density area, because the travel paths that result are so often circular in shape. In some places a circulator is also operated downtown. Large circular transit routes that offer high speed or high frequency and serve high-demand areas, however, are generally referred to as loops.
Commuter express service	An FTA designation that distinguishes between fixed routes that must be supplemented by paratransit, and fixed routes that may not. From the FTA's website: "Commuter bus service means fixed route bus service, characterized by service predominantly in one direction during peak periods, limited stops, use of multi-ride tickets, and routes of extended length, usually between the central business district and outlying suburbs. Commuter bus service may also include other service, characterized by a limited route structure, limited stops, and a coordinated relationship to another mode of transportation." http://www.fta.dot.gov/12876_3906.html
Connection	A connection or transfer takes place when a person uses two transit vehicles to make a trip.
Coverage	Coverage can refer to the amount of geographic space, the proportion of people or the proportion of jobs that are within a certain distance of transit service. An assumption about how far people will walk to a given transit service—often ranging from 1/4 to 1/2 mile—must be made in order to estimate coverage.
Deadhead hours	The time a vehicle spends between the garage and the start or end of revenue service, or between the end of a trip on one route and the beginning of a trip on another route.
Dial-a-ride	Demand response service, usually requires booking a day in advance, over the phone.
Express	Express can have a range of meanings when applied to transit. It most often describes a route with a long non-stop segment. It can also be used to describe a route with wide stop spacing and overall faster speeds, though that is more commonly called a rapid.
Farebox recovery	Farebox recovery is a measure of how much of a transit system, network or route's operating cost is recovered through fares.
Feeder	A local route that connects or feeds into a radial route. Low-frequency feeders sometimes pulse so that transferring is more convenient
Fixed-route transit	Fixed-route transit describes any transit service that is operated on the same predictable route. In contrast, paratransit and demand-responsive service may always or often follow different routes for each vehicle trip, as they serve different customers and their trips.
Frequency	Frequency is often expressed in minutes, i.e. a service that comes every 15 minutes has "15-minute frequency." A more technical term for frequency is headway.
Grid Network	A network of routes that intersect all over the city. Grid networks are best suited for places with many activity centers, as opposed to radial networks, where most people are traveling to a central location. Grid networks require high-frequency to make transfers short, reliable and convenient.
Headway	Headway is the time between successive trips at a stop, a more technical transit term for frequency. A service that comes every 15 minutes can be said to have a "15-minute headway."
Investment	Service or revenue hours per capita, a measure of the relative level of transit service.
Isochrone	An illustration to help visualize where someone can go from a location, in a certain amount of time, using transit or by walking.
Land use	Land use describes the way a parcel of land is being used, for example as commercial, industrial or multi-family residential. Land use descriptions can be general or very specific. Land use is distinct from zoning, as land may be rezoned under existing uses and buildings long before changes to its use take place.
Layover	Time for driver breaks between trips. Usually included in revenue hours. Unlike recovery time, layover time sometimes cannot be skipped even when a bus is behind schedule.
Longline	Some routes have a more frequent inner segment and a less frequent outer segment. At the end of the inner segment, some buses turn around and come back, while others continue on to a more distant turnaround point. The outer, less-frequent segment is often called the "longline," though technically the longline is the longest path that buses on that route travel, and its length is the inner segment plus the outer segment. The inner segment is called the "shortline."
Microtransit	Demand response service, like dial-a-ride, but usually distinguished by same day or instant booking, often with an app.
Mobility	Mobility is generally used to express the ease with which people can move from place to place. It is distinct from access, which describes the extent to which people can meet their needs nearby. In some places, people have high access (they are able to meet all of their needs without traveling very far or at all) and low mobility (because traveling long distances is difficult or slow). In other places, mobility is high and access is low.
Mode share	Mode share is a technical term for the percentage of a population that uses a particular mode (e.g. transit, walking, driving) for traveling. Mode share information in the U.S. is generally reported for commute trips.
National Transit Database	The National Transit Database is a federal clearinghouse of general information about transit in the U.S. and information specific to each transit agency. Agencies of a certain size are required to submit financial and performance data to the NTD each year. https://www.transit.dot.gov/ntd/

Glossary

One-seat-ride	A trip that requires boarding only one transit vehicle (no transfers).
Paratransit	Paratransit is a transit service that provides on-demand, curb-to-curb travel for people with disabilities, per the American's with Disabilities Act. It is required by this U.S. law to be provided to people who have a disability that prevents them from using fixed-route transit service, within three quarters of a mile of fixed-route transit, during all times when fixed-route transit is operating.
Peak	In some places, two peaks of travel (and transit) demand take place each day: in the morning and afternoon, as people travel to and from work and school. However, in many places travel demand peaks only once, in the midday or afternoon, as service shifts change and students leave school.
Peak-only	A transit service that is peak-only operates only during the morning and afternoon travel peaks.
Productivity	The word productivity is often used in transit to describe the number of people served per unit of cost. Productivity can be expressed for an entire transit system, a subset of the system, individual lines or even for segments of lines.
Pulse	A pulse takes place when two or more transit services arrive together at the same place at the same time, so that their passengers may transfer among them with minimal waiting.
Radial	A route or network design where most routes go to and from a central point (typically a downtown). As opposed to a grid network.
Rapid	Rapid can have a range of meanings when applied to transit. It most often describes a route with wider stop spacing and overall faster speed.
Recovery time	Extra time between trips to make up for a delay. Unlike layover, which is a driver's break time, recovery time can be cut short so that the next trip can depart on-time.
Relevance	Boardings per capita, a measure of how relevant transit is to the population it serves.
Revenue hours	The time a transit vehicle and its operator spend out in public, available to passengers and (potentially) collecting revenue. Usually includes layover and recovery time, but excludes deadhead.
Ride check	The National Transit Database requires that transit agencies regularly sample all of their services to collect ridership and on-time performance information. This is often performed using surveyors on transit vehicles, though increasingly it is performed by automated counters and GPS devices on transit vehicles. It is sometimes called a ride check.
Ridership	Ridership refers informally to the number of boardings or trips taken on a transit system or a particular transit service.
Shortline	Some routes have a more frequent inner segment and a less frequent outer segment. At the end of the inner segment, some buses turn around and come back, while others continue on to a more distant turnaround point. The outer, less-frequent segment is often called the "longline," though technically the longline is the longest path that buses on that route travel, and its length is the inner segment plus the outer segment. The inner segment is called the "shortline."
Span	The span of a transit service is the number of hours it operates during the day, e.g. a service that runs from 6:00 a.m. to 11:30 p.m. would have a 17.5-hour span. Span can also describe the number of days per week and per year that a service is operated.
Street connectivity	The degree to which streets connect to one another, and multiple paths exist between any two points, is described as that place's connectivity. Areas with many cul de sacs or loops and few through routes have low connectivity; areas with grid-like street patterns have high connectivity. Low connectivity discourages trips by slower modes (such as walking or bicycling), and presents challenges for transit routing.
Transfer	When a person uses more than one transit vehicle to make a trip, they transfer in between vehicles. This is also often called a connection.
Transit dependency	If a person has a severe need for transit, due to a disability or lack of access to an automobile, they are often referred to as transit dependent. However, transit dependency is in fact a spectrum, not a category. People with disabilities and people without their own cars may have access to rides or taxis, but the extent to which they use those rides may depend on the availability and quality of transit service.
Transit orientation	As with transit dependency, transit orientation is a spectrum, not a category. People who are living or working around areas with higher activity densities, in places where walking to transit is safe and appealing, or who do not have easy access to an automobile may have some degree of transit orientation. Transit orientation can exist among poor and affluent populations alike.
Tripper	A tripper is a special type of transit service that makes only a few trips or a single trip each day. Transit agencies often send one or more trippers to relieve crowding on certain routes, or to provide direct service where none exists at other hours. Trippers often run at the start and end of school days or work shifts.
Vehicle hours	The time during which a transit vehicle is away from the garage, whether providing revenue service (represented by "revenue hours"), driving between the garage and the start or end of service (represented by "deadhead hours") or in layover and recovery time.