Transit accessibility and autonomous technology in Eau Claire

Traffic and Operations Safety Lab & State Smart Transportation Initiative

University of Wisconsin-Madison

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Executive summary

This report describes work conducted by researchers at the University of Wisconsin-Madison in early 2019, with guidance from an advisory panel representing the City of Eau Claire, Eau Claire Transit, the West Central Wisconsin Regional Planning Commission, the Eau Claire Transit Commission, the Eau Claire Area Chamber of Commerce, and the University of Wisconsin-Eau Claire.

There are three main aims of this study: 1) to model future transit and land use scenarios, 2) to gauge the community's perspectives on transit and emerging autonomous vehicle (AV) technologies, and 3) to understand the emerging role of AV technologies. Here are the key findings:

- New transit service, particularly to currently underserved areas, could have a major impact on people's access to jobs and other opportunities, but this potential accessibility depends largely on concentrating future development in central locations near transit.
- Most survey respondents believe transit is mainly for people with limited travel options and do not use transit because they find it inconvenient or not flexible enough to meet their needs. They generally welcome new vehicle technologies but currently they are not as comfortable with advanced automation, particularly if it means transit vehicles would not have operators on board.
- Increased transit vehicle autonomy can be expected over the long term, but probably not without operators continuing to play important roles. In the near term, Eau Claire can improve safety and efficiency, while growing acceptance of these technologies among everyone, by incorporating more automated functions on vehicles and considering ideal locations—controlled, low-speed environments—for autonomous-shuttle pilot programs.

Part 1. Transit scenario analysis

Our research team worked with project advisors to pinpoint two potential transit service improvements, which may or may not incorporate AV technologies, and develop a range of potential land use scenarios. We then modeled the outcomes of these scenarios in terms of their impacts on access to jobs throughout the city.

The advanced accessibility analyses in this study are an improvement over more conventional performance metrics. The main goal of a transportation system is connecting people to key destinations such as work, school, stores, and services. And yet we often rely on proxy metrics to understand how well those systems are performing. Proxy metrics often answer questions like: How fast does traffic move during rush hour? Where do buses run and how often do they arrive on time? These are important questions to ask, but they don't paint a complete picture.

Instead, the metrics reported in this study answer the question: How easily can people reach key destinations by transit, from anywhere in the city, at different times of the day? This method incorporates a broad range of data, including information about where buses run and how often, how fast they travel, whether there are walking connections to bus stops, and the distribution of different land uses including homes, jobs, and other points of interest (POIs).

The results of our analyses can be shown in maps (Figure 1) or described using summary statistics. For instance, our baseline analysis shows that the average household in the study area shown can reach 25,900 jobs by transit within a typical commute time, based on the available service during the morning commute period (7-9 AM). The map shows that someone could reach more than 35,000 jobs from the city center, but fewer than 25,000 jobs if they are not near a major bus route. This includes the time it takes to walk to and from the nearest bus stop.

These reported metrics give a higher value to jobs with short travel times and decreasing values as travel times increase. This is done using *travel time decay functions* derived from the 2017 National Household Travel Survey. We know, for instance, that almost all transit commuters travel at least 10 minutes to work, 70 percent travel at least 30 minutes, and 50 percent travel 45 minutes or more. Therefore, a job 10 minutes away counts as a full job, a job 30 minutes away counts as 0.7 jobs, and so on. These values typically differ depending on travel mode (e.g., driving versus transit) and trip purpose (work versus non-work).

Access to jobs is a frequently used accessibility metric, partly because commute trips are a common focus of transportation planning, and because job centers are often important activity centers that provide other goods and services. However, we can report accessibility metrics based on other land uses. In this report, we also provide analyses in terms of access to hospitals.

This approach lets us evaluate not only current accessibility, but also the impacts of changes in transit service. For example, we can evaluate accessibility during the night period, when the buses do not run and jobs can only be accessed by walking (Figure 2), and we can evaluate which neighborhoods are most affected by late night transit frequency (Figure 3). In some areas, there is a difference of 12,000 or more jobs that can be reached during peak morning period versus at night.

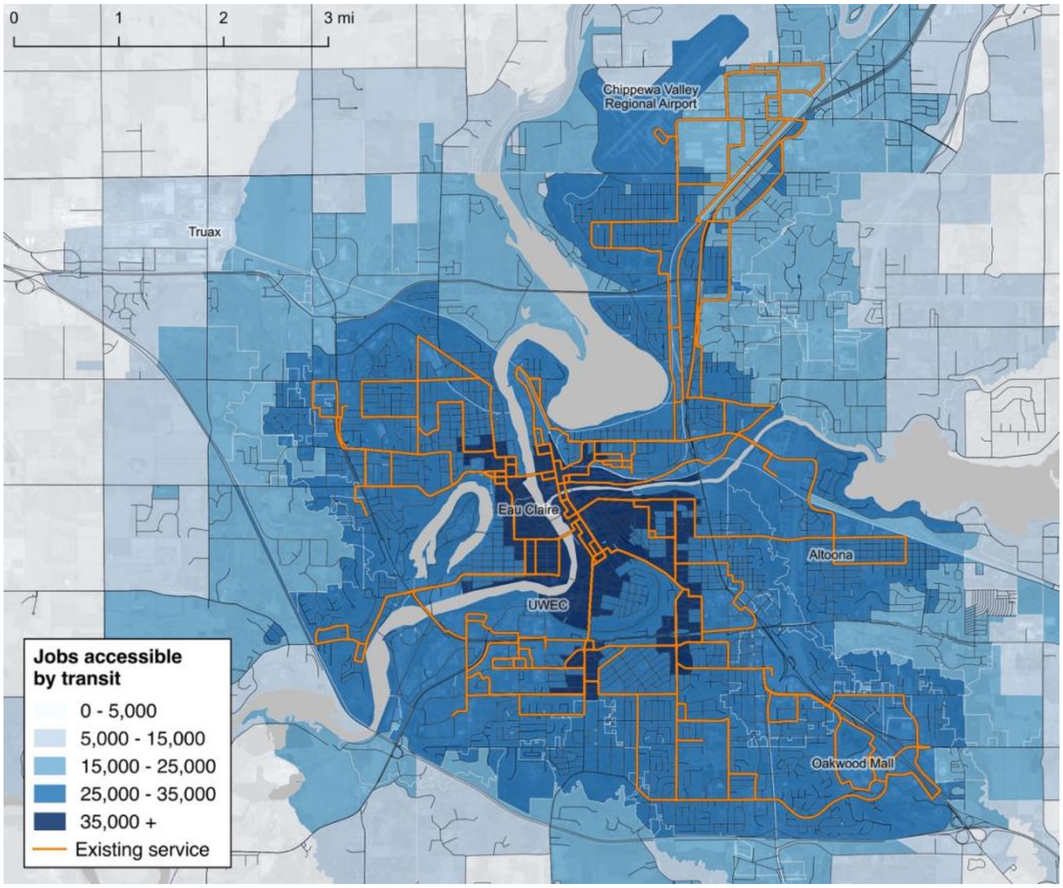


Figure 1. Current access to jobs by transit during the morning period (7-9 AM)

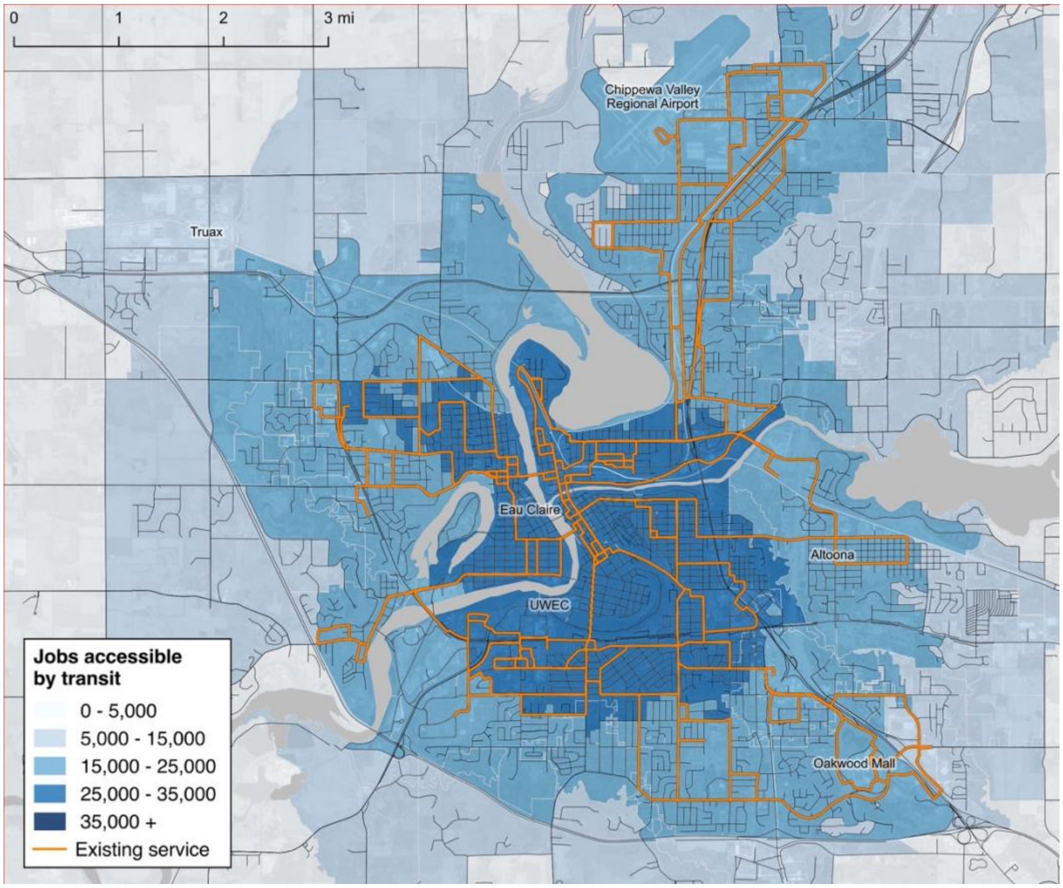


Figure 2. Current access to jobs by transit during the night period

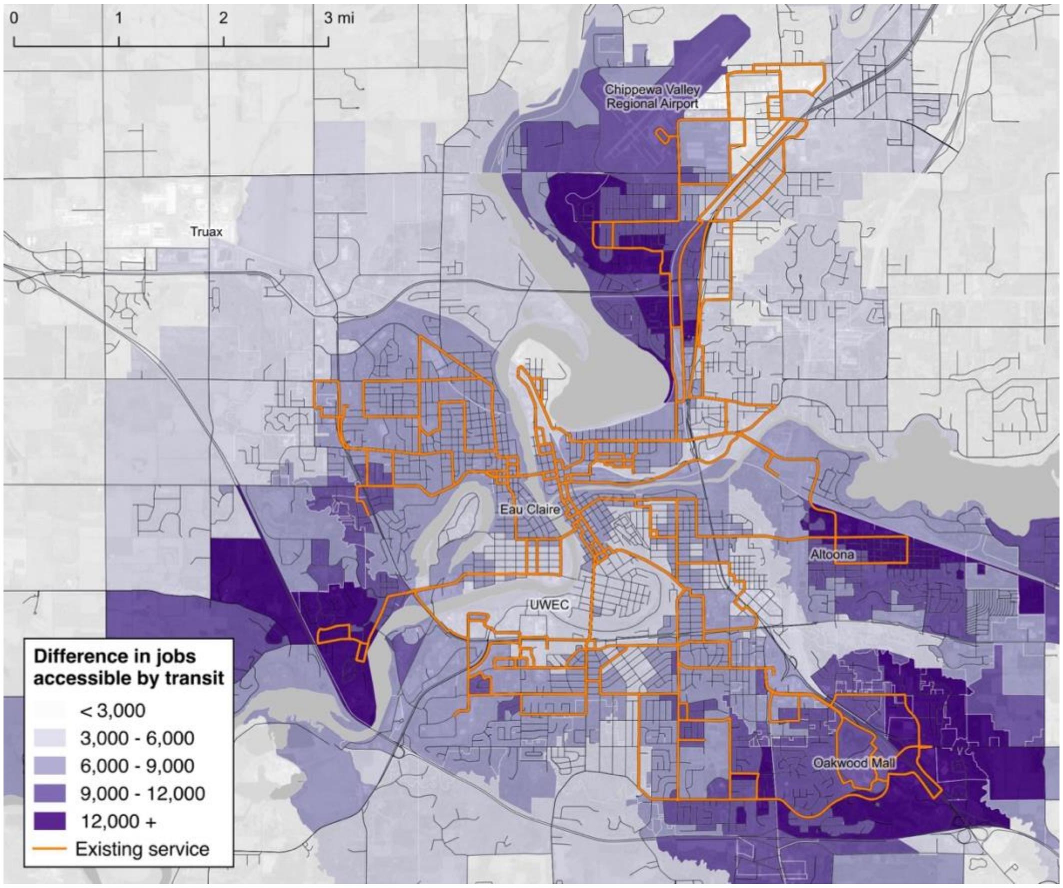


Figure 3. Difference in access to jobs by transit between the morning and night period

Scenarios

For this study, we used accessibility analysis to evaluate several future scenarios, developed with input and feedback from our advisory panel. These scenarios include two possible new transit lines (depicted in Figure 5 and Figure 6) and a variety of land use patterns, described below.

Transit option 1: Downtown Circulator

The proposed Downtown Circulator runs in a "figure eight" pattern starting at the downtown transfer center heading north; west on East Madison St.; south on 5th Ave.; east on Water St.; south on State St.; west on Clairemont Ave. following existing bus routes past Sacred Heart Hospital; east on Menomonie St. and Water St.; and returning to the transfer center. This service would run with an assumed 15-minute frequency.

Transit option 2: Gateway Loop

The proposed Gateway Loop serves the Gateway Industrial Park area north of Highway 312. It begins at the downtown transfer center heading north; west on East Madison St.; north along 3rd St., Truax Blvd., and Jefferson Rd.; west on County Line Rd.; south on Venture Dr. and North Clairemont Ave.; east on Truax Blvd.; and returning to the transfer Center along the same initial route. This service would run with an assumed 30-minute frequency.

Land use scenarios

Our team, working with the advisory panel, developed four future land use scenarios. Each scenario assumes the city of Eau Claire and its immediate surrounding areas, including Altoona, will add a combined 5,859 households by 2030, according to the most recent plans (Table 1) and 9,374 jobs based on the current regional ratio of 1.6 jobs per household.

Table 1. Population and housing estimates and 2030 Plan projections

Municipality		**2010 Census**	**2016 ACS (base)**	**2030 Plan (projected)**	**2030 Plan (added)**
Eau Claire	Population	65,931	67,654	78,400	10,746
	Households	26,803	27,234	32,671	5,437
Altoona	Population	6,706	7,193	7,612	NA
	Households	2,883	2,876	3,298	422

In developing future land use scenarios, we first estimated the maximum potential capacity of every Census block in the study area based on the following information:

- Zoning districts;
- Current housing and jobs densities by zoning district;
- Assessment records indicating undeveloped parcels;
- Current plans for up-zoning and redevelopment;
- Additional input from the advisory panel.

We then allocated the projected new housing and jobs to Census blocks, up to their maximum capacity, based on the following rules for each of four land use scenarios:

- ***Land use scenario 1: Transit-oriented development (TOD).*** New growth is added starting with the most transit-accessible block based on current transit service and then to additional blocks in decreasing order of transit accessibility (Figure 4).
- ***Land use scenario 2: Non-TOD.*** New growth is added starting with the least transit-accessible block based on current transit service and then to additional blocks in increasing order of transit accessibility.
- ***Land use scenario 3: Random growth.*** New growth is added randomly to blocks.
- ***Land use scenario 4: Gateway TOD.*** New growth is added starting with the most transit-accessible block, but with additional Gateway Loop service considered. This scenario increases growth within the Gateway Industrial Park area but does not represent its maximum growth capacity.

Accurate land use forecasts were beyond the scope of this study, so the block-level details of each scenario should not be a major focus of the work. Instead, these scenarios should be thought of as general cases, which may be useful for gauging a wide range of possible outcomes under various extremes. All of the land use scenarios are depicted in Appendix A.

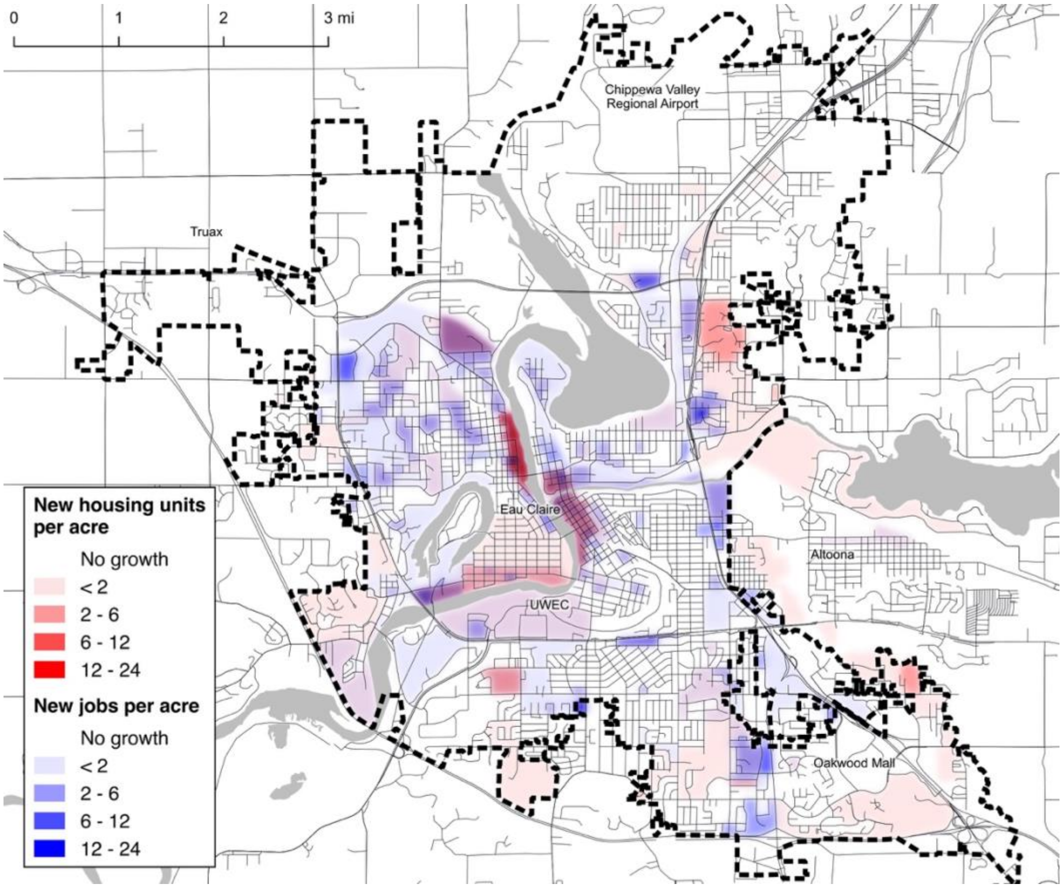


Figure 4. Projected growth for TOD scenario

Model results

The results of our accessibility analyses based on various combinations of transit and land use scenarios are shown in Table 2. Unless stated otherwise, the results are based on conditions during the typical morning period. These findings are useful for understanding the relative benefits of different transit investments compared to, or in combination with, different land use patterns. For instance, the average household experiences a 1.0 to 1.6 percent increase in access to jobs from the Downtown Circulator and Gateway Loop, respectively. As shown in Figure 5 and Figure 6, however, these benefits are concentrated in different areas. It is worth noting that while the magnitude of the impacts from the Downtown Circulator appear smaller, there are higher concentrations of households in the affected areas.

Table 2. Access to jobs by transit (weighted sum of jobs based on travel time decay function and morning period travel times, unless stated otherwise)

	All households			Low-income households		
Scenario	**Avg.**	**Total change**	**Percent change**	**Avg.**	**Total change**	**Percent change**
Existing service	25,930	0	0.0%	27,680	0	0.0%
Existing service (night)	19,330	-6,600	-25.5%	20,870	-6,810	-24.6%
Downtown Circulator	26,180	250	1.0%	27,980	300	1.1%
Gateway Loop	26,340	410	1.6%	28,080	400	1.4%
Existing service / TOD	31,360	5,430	20.9%	32,620	4,940	17.8%
Existing service / Non-TOD	27,140	1,210	4.7%	30,520	2,840	10.3%
Existing service / Random growth	29,490	3,560	13.7%	31,580	3,900	14.1%
Existing service / Gateway TOD	31,000	5,070	19.6%	32,700	5,020	18.1%
Downtown Circ. / TOD	31,340	5,410	20.9%	32,630	4,950	17.9%
Downtown Circ. / Non-TOD	27,190	1,260	4.9%	30,580	2,900	10.5%
Downtown Circ. / Random growth	29,460	3,530	13.6%	31,560	3,880	14.0%
Downtown Circ. / Gateway TOD	30,900	4,970	19.2%	32,610	4,930	17.8%
Gateway Loop / TOD	31,480	5,550	21.4%	32,720	5,040	18.2%
Gateway Loop / Non-TOD	27,780	1,850	7.1%	30,900	3,220	11.6%
Gateway Loop / Random growth	29,730	3,800	14.7%	31,710	4,030	14.6%
Gateway Loop / Gateway TOD	31,540	5,610	21.6%	33,130	5,450	19.7%

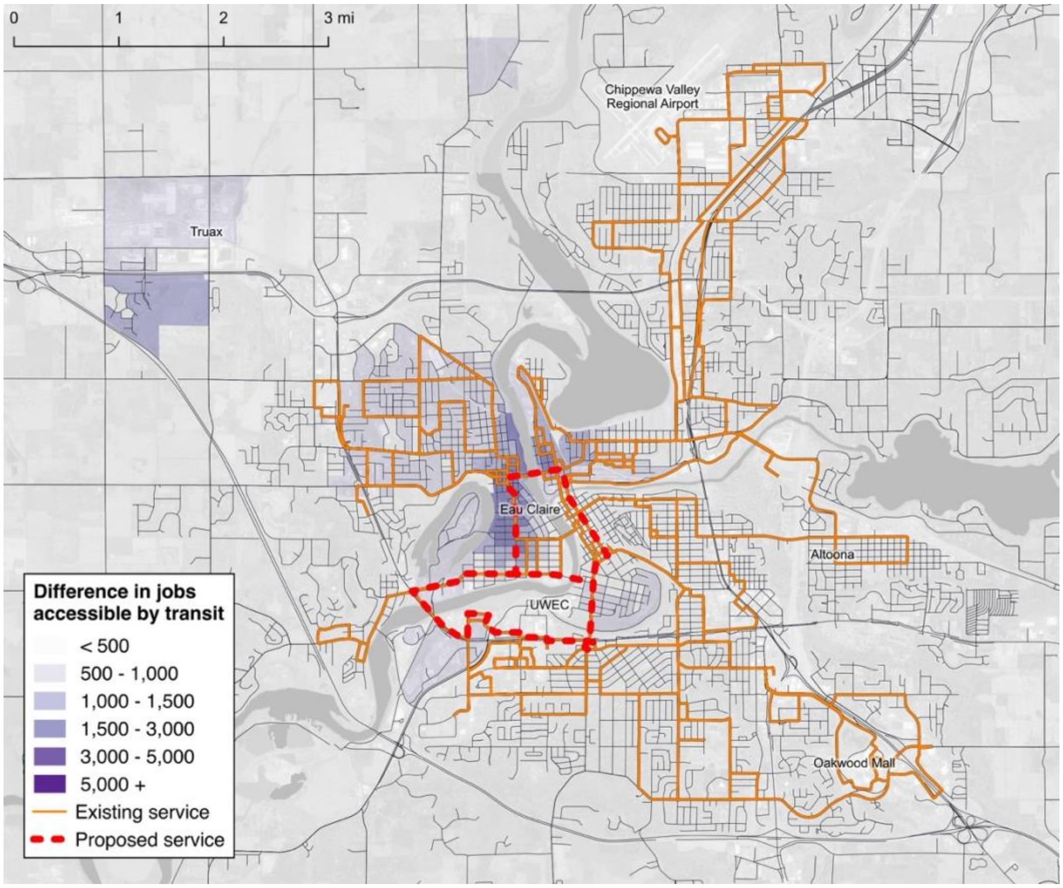


Figure 5. Increase in access to jobs from Downtown Circulator

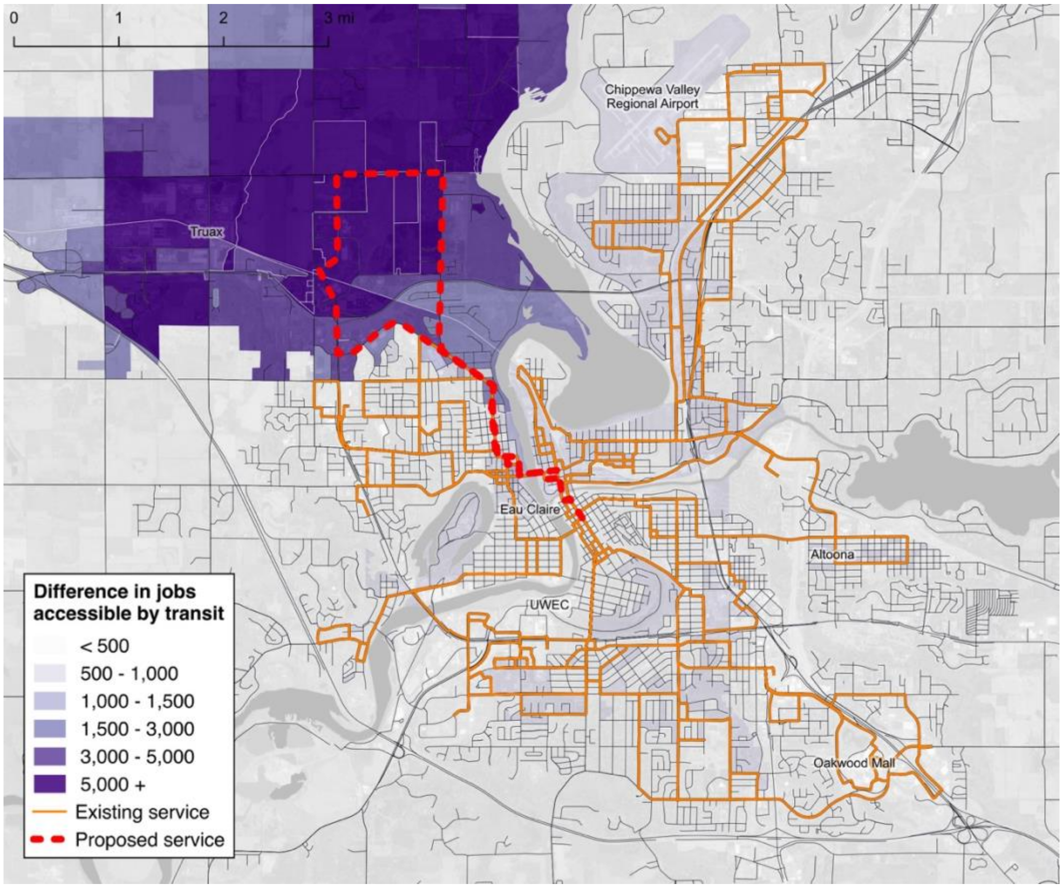


Figure 6. Increase in access to jobs from Gateway Loop

Even without changes in transit service, future development has a large effect on access to jobs. Under the TOD scenario, the average household accessibility increases by 21 percent (Figure 7), which is due to the clustering of households and jobs in more central, transit-oriented locations. The average household accessibility also increases under the non-TOD scenario, but only by five percent.

The largest overall increases of around 22 percent are achieved through TOD in combination with the Gateway Loop transit line, with most of the benefit coming from development patterns. The Gateway Loop only increases accessibility by 15 percent under random growth and seven percent under non-TOD growth.

Note there is a small amount of random variation in these models, resulting in somewhat counterintuitive findings such as a marginally lower accessibility increase with the Downtown Circulator under the random growth scenario than without it (13.7 percent versus 13.6 percent).

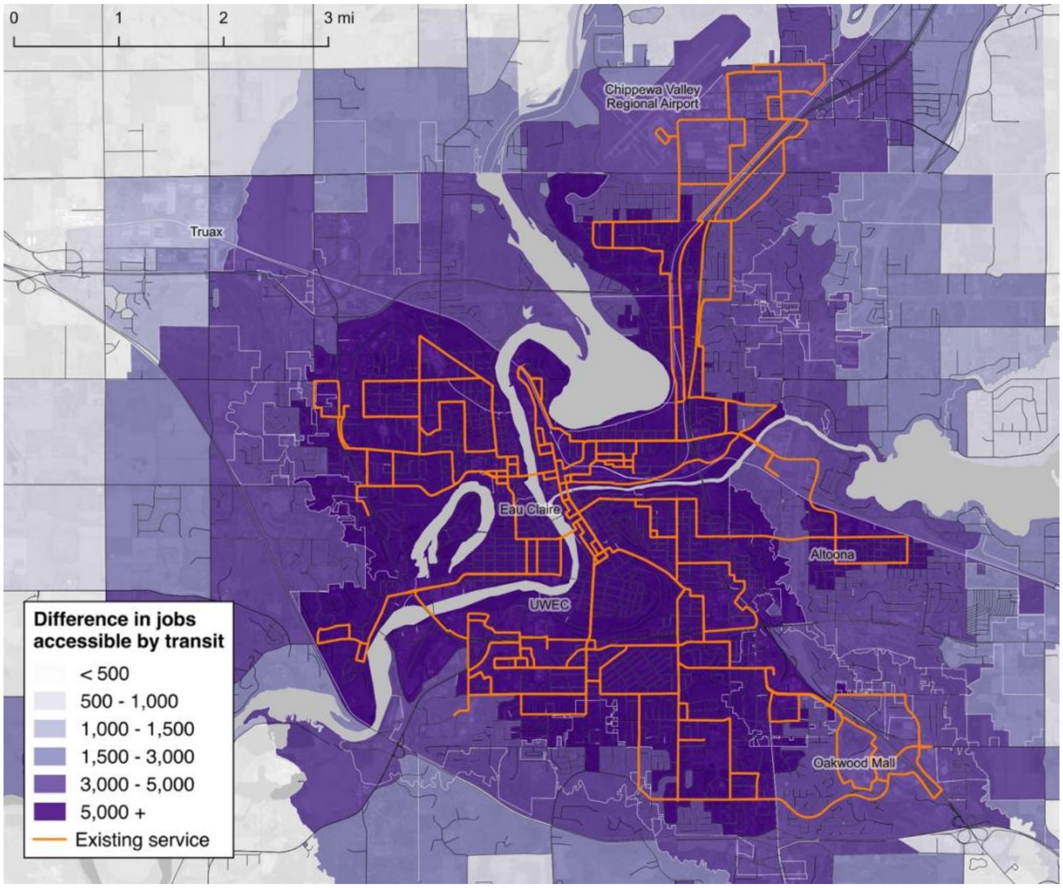


Figure 7. Increase in access to jobs from transit oriented-development (TOD)

Table 2 also provides the results of our accessibility analyses in terms of the average low-income household (annual incomes under $45,000), which leads to somewhat different results than the analysis for the general population. For instance, the average increase from the Downtown Circulator is somewhat larger, while the increase from the Gateway Loop is smaller, bringing them more in line with each other. The non-TOD growth scenarios generally have larger positive effects on *existing* low-income households, but this does not account for the locations of *future* low-income households, the decentralization of which could have considerable negative impacts.

Non-work accessibility

Accessibility metrics can be used to interpret access to other destinations than jobs. For example, the popular website, WalkScore.com, provides accessibility metrics in terms of walking access to restaurants, coffee shops, stores, schools, parks, and other destinations, expressed as a score of up to 100 total points.

For this study—based on input from the advisory panel—we also evaluated transit accessibility in terms of access to hospitals, which provide a critical service to the Eau Claire community and serve as major job centers. The results are reported in terms of travel time to the nearest hospital. As shown in Figure 8, there are some differences from the aforementioned access to jobs metrics, but the general patterns are remarkably similar.

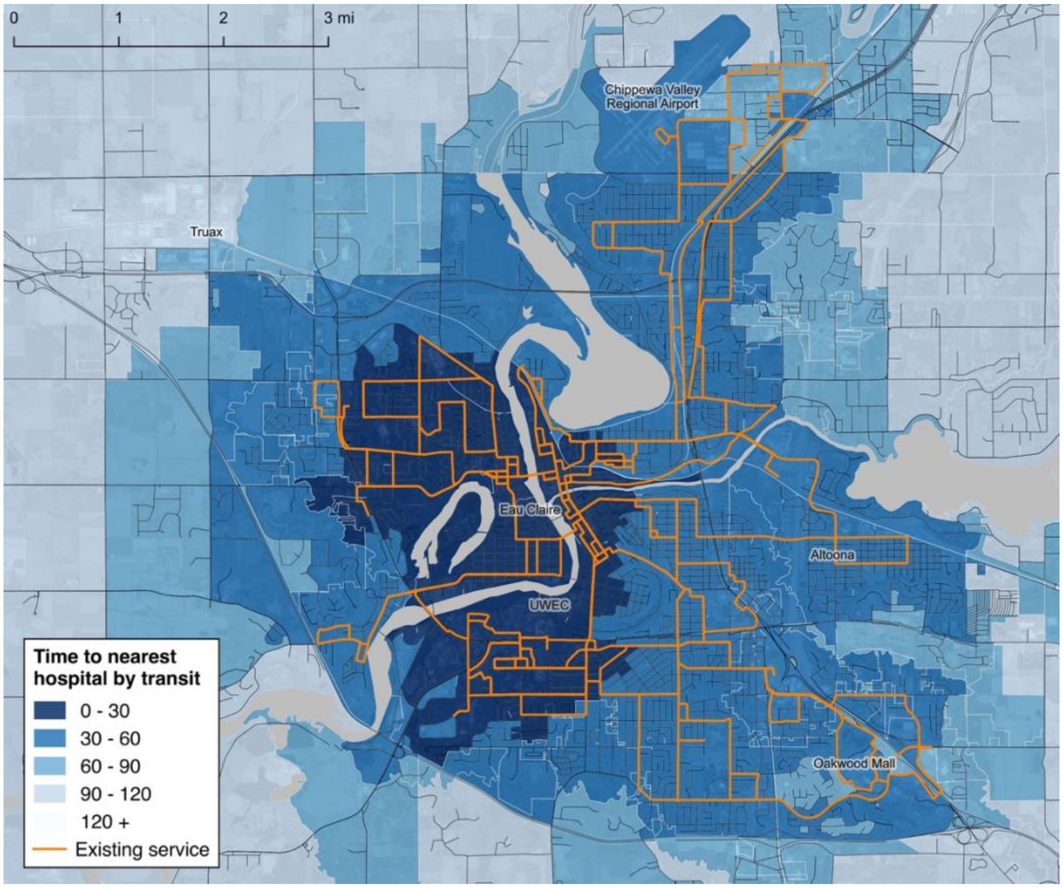


Figure 8. Time to nearest hospital by transit during morning period (minutes)

Table 3 provides summary statistics for access to hospitals by transit, based on the two transit options, and a comparison to access by driving based on road speeds during the peak morning period. In this case, the travel time to the nearest hospital decreases by 3.6 percent with the Downtown Circulator, compared to 1.0 percent with the Gateway Loop. These travel times, which are around 50 minutes, are still considerably longer than travel times by driving, which is 7.5 minutes.

Table 3. Time to nearest hospital (minutes)

	All households			Low-income households		
Scenario	**Avg.**	**Total change**	**Percent change**	**Avg.**	**Total change**	**Percent change**
Existing transit service	51.6	0	0.0%	46.2	0	0.0%
Downtown Circulator	49.8	-2	-3.6%	44.4	-2	-3.9%
Gateway Loop	51.1	0	-1.0%	45.8	0	-0.8%
By driving in peak AM traffic	7.5	-44	-85.5%	6.8	-39	-85.3%

Part 2. Public perceptions in Eau Claire

Our team carried out a public survey to understand how well the City of Eau Claire's public transportation system serves the community, the role that emerging technologies like automated driving could play, and how to better plan for the future. Data were collected on the following five topics:

- Exposure and opinions about vehicle automation and driving assistance technologies.
- Transit usage.
- Travel habits.
- Attitudes towards technologies, driving, and transit.
- Demographic information.

The online survey was administered from April 16th to June 10th, 2019. It was shared through the Eau Claire Transit website, mailing lists for the Chamber of Commerce and UW-Eau Claire, and an article in the local news outlet, Volume One. In total, 290 responses were received, of which 217 were complete and were analyzed for this report.

The survey results indicate that the respondents are well-exposed to information about autonomous vehicles and driving assistance technologies. They generally welcome vehicle automation and driving assistance technologies but are still unsure about the future of vehicles equipped with more of these technologies, especially options with which they may not be familiar. Most of the respondents have access to private vehicles and are content relying on them. Transit was not one of the most popular daily travel modes, with the common reasons being "not convenient" and "not flexible" for their needs. While most respondents felt transit was generally safe, they also felt transit is primarily for people without access to other transportation modes, including driving, walking, and biking. People are uncertain about the safety benefits of adding automation technologies to transit. At the current stage, they still prefer having a human operator, even if transit vehicles were automated. Key findings for each of the five topics are presented below.

Detailed survey findings

Travel habits

The travel habit questions provide information about household vehicle ownership, commute pattern, and mode choice. Over 95 percent of the respondents have one or more personal vehicles in their household, and the average is 2.8 vehicles per household. Most of the respondents (over 85 percent) regularly commute to work using any mode, with 66 percent of the respondents commuting five times per week. Over 60 percent of the respondents have a commute shorter than five miles, and most of the respondents (75 percent) have commute time of less than 20 minutes. Driving a personal vehicle was the primary mode for 71 percent of surveyed commuters and personal vehicles accounted for 86 percent for non-work trips. Transit was the primary mode for eight percent of commute trips and three percent of other trips.

About 70 percent of the respondents never use transit. The average respondent uses public transit less than once per week (0.91). The top three concerns in using transit for the respondents were lack of convenience, lack of flexibility, and poor access.

Exposure and opinions about vehicle automation and driving assistance technologies

In terms of vehicle automation and driving assistance technologies, 94 percent of the respondents have heard of autonomous vehicles, and 90 percent of the respondents have a vehicle with one or more driving assistance technologies. The most common technologies the respondents have on their vehicles are cruise control, blind spot detection/warning, and lane departure avoidance. In general, the respondents are happy about those driving assistance technologies. Over three quarters (77 percent) of the respondents would like more driving assistance technologies on their next car purchase.

Attitudes towards technologies, driving, and transit

The attitudinal questions cover three aspects: technologies, driving, and transit. The following five-point Likert scale was used for each question: 1) strongly agree, 2) agree, 3) neither agree nor disagree, 4) disagree, and 5) strongly disagree. The responses to questions about technologies imply that the respondents are both interested and excited about new technologies—about 70 percent agreed or strongly agreed with statements about each—but are generally more reserved when making their decisions to spend money on such new technologies. Many respondents enjoy driving and feel safer driving themselves than when driven by others (about 60 percent for each). From the responses to transit questions, the survey found that the respondents prefer using a personal vehicle to taking transit. The respondents generally feel comfortable and safe when taking transit (about 60 percent agree or strongly agree), but about half of them believe that people only take transit due to lack of access to other modes of transportation. In written comments, some respondents expressed greater interest in improving overall bus service, including increased service and transit-priority lanes, before moving toward advanced technologies.

A considerable proportion of the respondents (40 percent) are unsure whether driving assistance technologies will improve bus safety; another 30 percent are positive and 16 percent are negative. Over three-quarters of the respondents have concerns about taking a fully automated transit vehicle with no human operator onboard, with 48 percent of the respondents not feeling comfortable riding such a vehicle, and 28 percent of the respondents unsure about it. However, in the case of a mostly-automated transit vehicle with a human operator onboard, most respondents (over 70 percent) would feel comfortable taking it.

Demographic information

Among the respondents, 43 percent are UW-Eau Claire employees or students. UW-Eau Claire is one of the largest employers (with over 1,000 employees) and the largest public higher education institution (with over 10,000 students) in the city of Eau Claire (with a population of around 65,000). The respondents are well distributed across all age groups, with slightly more respondents from the 25-34 age group than the others. There were roughly twice as many female respondents than male respondents; four percent self-described or chose not to specify their gender. The respondents have a variety of occupations. Most of the respondents (96 percent) have a valid driver license. Most of the respondents (94 percent) received some college education or higher. The average household size was 2.48 people and 74 percent of the respondents do not have young kids (< 12 years old) in their household. The respondents are mostly from ZIP codes 54701 (53 percent), 54703 (26 percent), and 54720 (5 percent), which cover the central Eau Claire area, as shown in Figure 9.

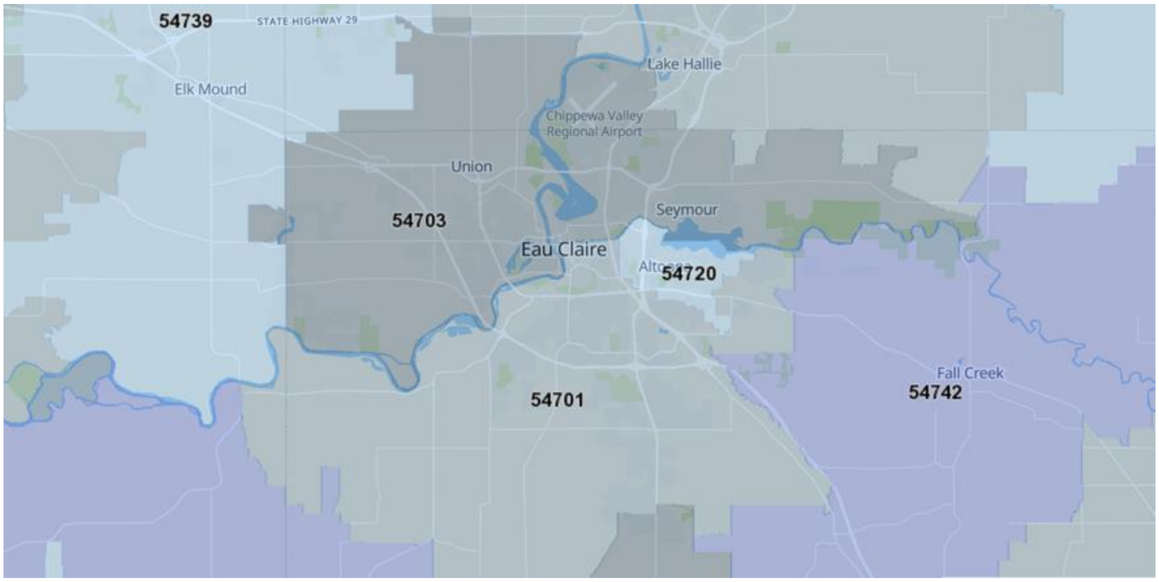


Figure 9. Local zip codes (source: https://www.unitedstateszipcodes.org/)

Part 3. Autonomous vehicle technologies

AVs have the potential to transform transit services by improving level of service, safety, sustainability, and ridership while lowering operating costs. These technologies have been deployed, not just in transit vehicles, at test sites and for pilot projects in Arizona, Denver, Michigan, Nevada, Ohio, Texas, and Utah. Pilots are also expected in California, Florida, and New York, among other places.

The technologies have advanced considerably over the past 50 years, but their implementation in vehicles still faces challenges:

- Meeting requirements of the “Buy American Act,” mandated by FTA.
- Labor agreements.
- Perceived risks, in terms of operating cost and liability.
- Industry and public acceptance of new technologies.
- Safety testing.
- ADA requirements.
- State and local regulations.

Nonetheless, transit agencies that are prepared to integrate AVs into transit services will be better positioned to harness the positive impacts of this disruptive technology and minimize its possible negative impacts. Agencies will need to develop AV-related policies with respect to service planning, safety assurance, workforce development and training, and other areas. The following sections describe key considerations in several areas, drawing largely on research for the National Cooperative Highway Research Program (NCHRP) project 20-102(02): Impacts of Laws and Regulations on CV and AV Technology Introduction in Transit Operations.

AV transit deployment scenarios

The timeline for expected deployment of AV technologies is unclear, but the advancements will certainly be incremental. The following deployment scenarios provide likely ranges for technological readiness of different features, but these timelines do not necessarily coincide with timelines to gain user trust or acceptance and to implement the necessary policies, laws, regulations in place before widespread adoption in the public transit industry.

- Near-term (5-10 years): Deployment within controlled environments and/or at lower operating speeds. Potential examples include exclusive transitways such as bus rapid transit (BRT) routes with operator onboard or driverless shuttles in campus settings.
- Medium-term (10-15 years): Deployment with or without an operator in high occupancy vehicle (HOV) lanes or managed lanes, in exclusive transitways (such as BRT), and for first- and last-mile connectivity on city roads with mixed traffic.
- Long-term (15-30+ years): Technically feasible to operate automated vehicles within fully automated transit systems in full compliance with Americans with Disabilities Act (ADA) requirements.

Table 4. Potential deployment timeline based on NCHRP 20-102(02)

Functionality	**2020**	**2025**	**2030**	**2035**	**2050**
Warnings, safety enhancements, station approach and docking, and self-driving in controlled environments (e.g., campus) at low speeds.					
Some automated functions (e.g., platooning) and precision maneuvering in controlled environments.					
Self-driving in managed lanes and transitways, between stations.					
Self-driving in managed lanes and transitways or in mixed traffic at low speeds.					
Self-driving in mixed traffic at all speeds.					

The near-term deployment of partially autonomous transit vehicles could also have important implications for infrastructure and other facilities:

- Increased numbers of bus stops and shelters to accommodate more customized trips to new locations.
- Transition zones to let vehicles change between automation and manual control.
- Larger loading areas to accommodate platooning vehicles.
- Updated maintenance facilities.

Workforce deployment

The successful deployment of AV technologies in transit systems requires the support of and collaboration with the transit workforce. Human operators play a crucial role in transit services, beyond just driving the vehicles. They are essential for communicating with passengers and assisting disabled passengers in entering and exiting vehicles. Additionally, they address occasional passenger behavior problems. There is no current outlook in the near- to medium-term that does not require a human operator aboard vehicles for certain tasks.

Lower levels of automation, expected in the short-term, are essentially integration of multiple driver assistance systems and do not impact the workforce as such. In the medium-to-long term, deployment of highly automated vehicles would impact the nature of involvement of a human operator in the driving task. As such, drivers will be most directly affected by this. Transit agencies will need to prepare to retrain drivers to be situationally aware while not necessarily driving a vehicle. Drivers will need to be prepared to take control of the vehicle if the situation warrants. In addition, drivers will need to continue to play their role of passenger assistance. In the long-term, where a human operator is not required for vehicle operation at all, the role of vehicle operators will likely transition to a remote-monitor or remote-pilot role. This could raise new challenges in meeting passenger assistance needs.

Safety assurance

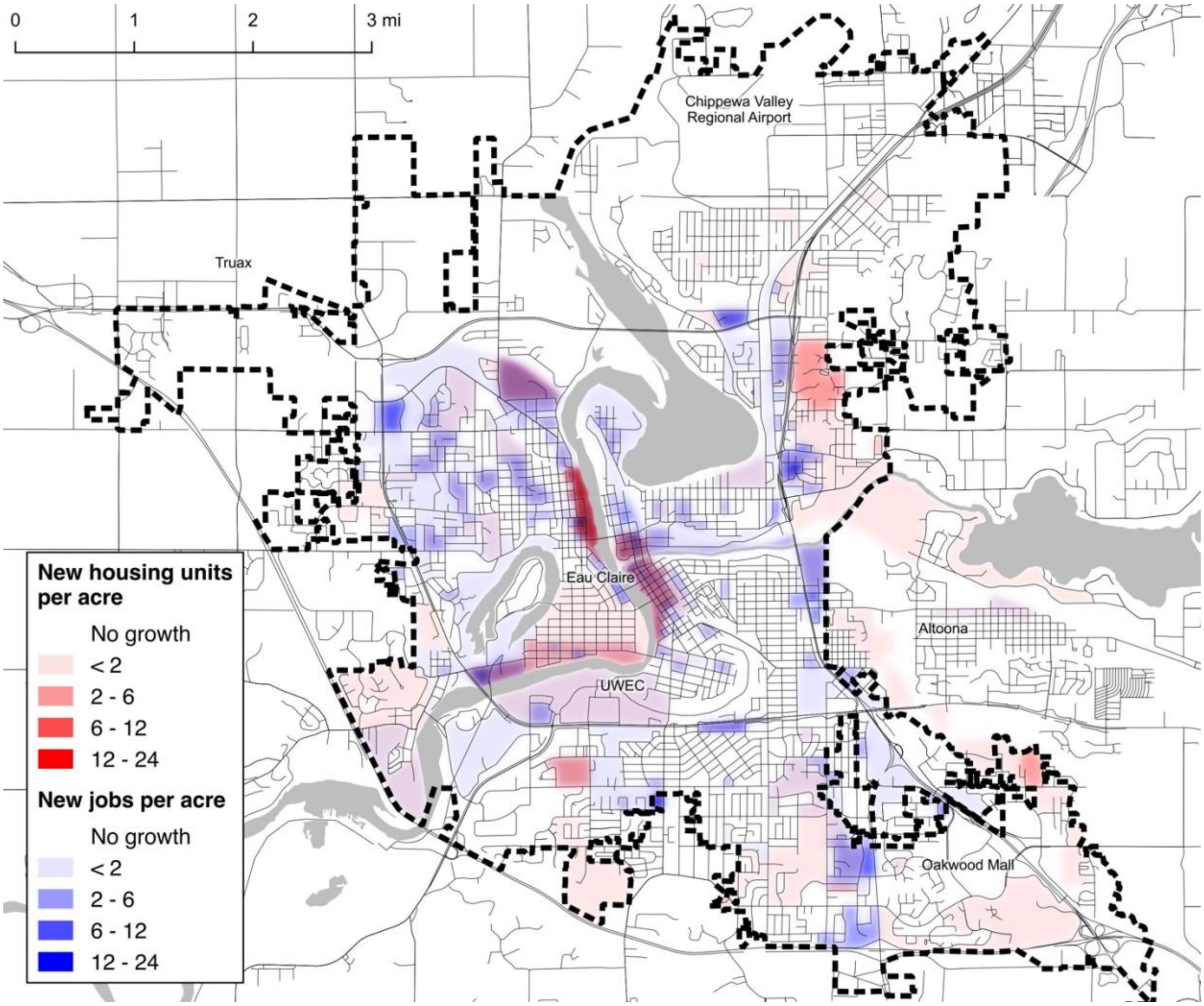
Vehicle safety and general safety in transit operations will continue to be monitored and regulated by federal and state governments. While AV technologies are generally thought of as bringing important safety improvements compared to human drivers, local agencies may need to make additional safety considerations for AVs:

- Conform with federal and state laws and set local regulations where necessary.
- Become more aware of these technologies and particularly how to continually ensure protections against computer vulnerabilities.
- Identify the appropriate operations, safety, and customer service roles and policies for staff as non-drivers.

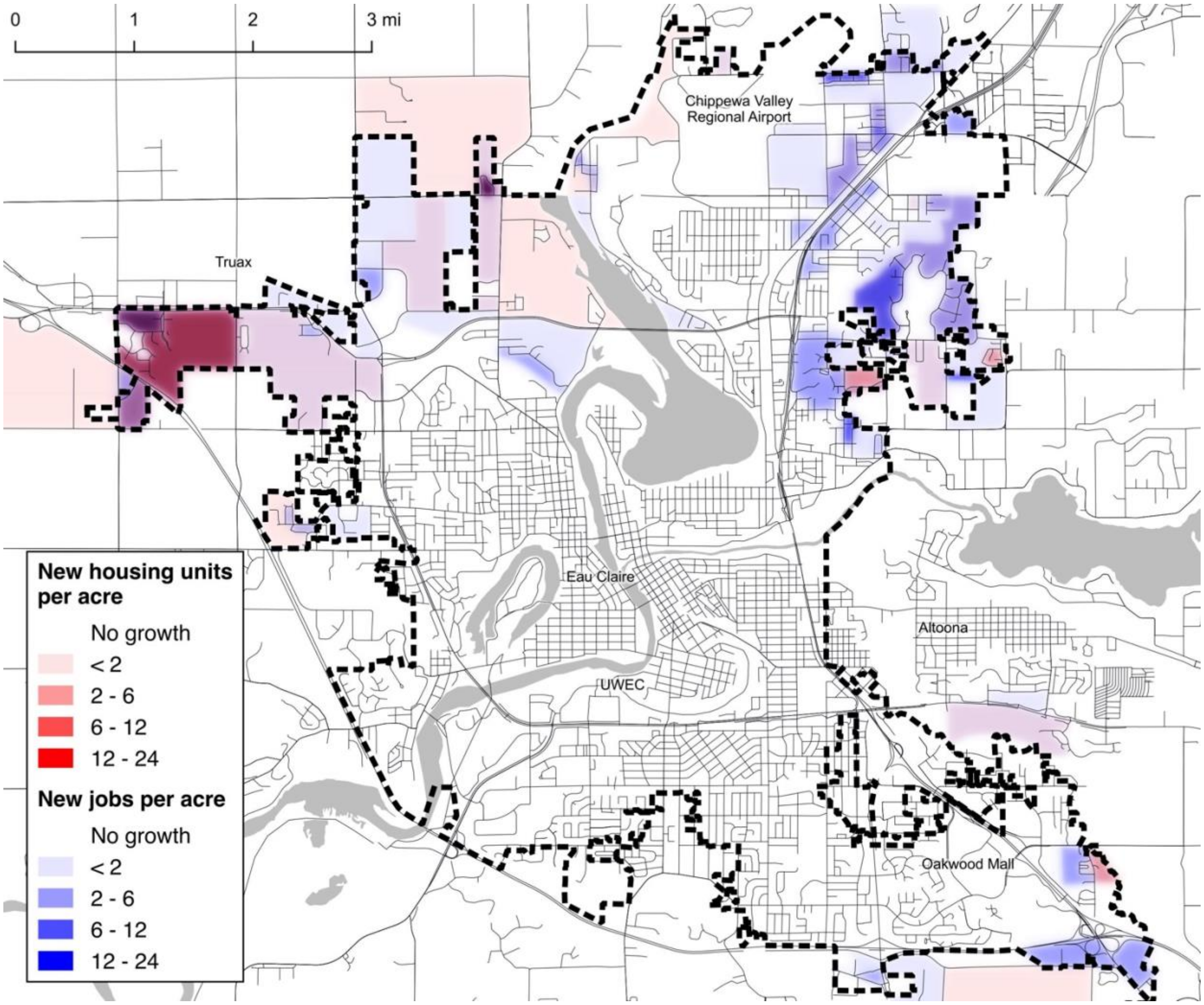
Developing trust in automated transit system requires a comprehensive safety assurance approach that integrates “vehicle-focused” functional safety methodologies as well as “system-focused” methodologies. In addition, a crucial component to be considered and incorporated into design, testing, and deployment is the role of the human operator in automated transit systems. While transit agencies may have their own safety assurance systems in place, this topic is typically governed by federal and state regulations.

Appendix A. Land use scenarios

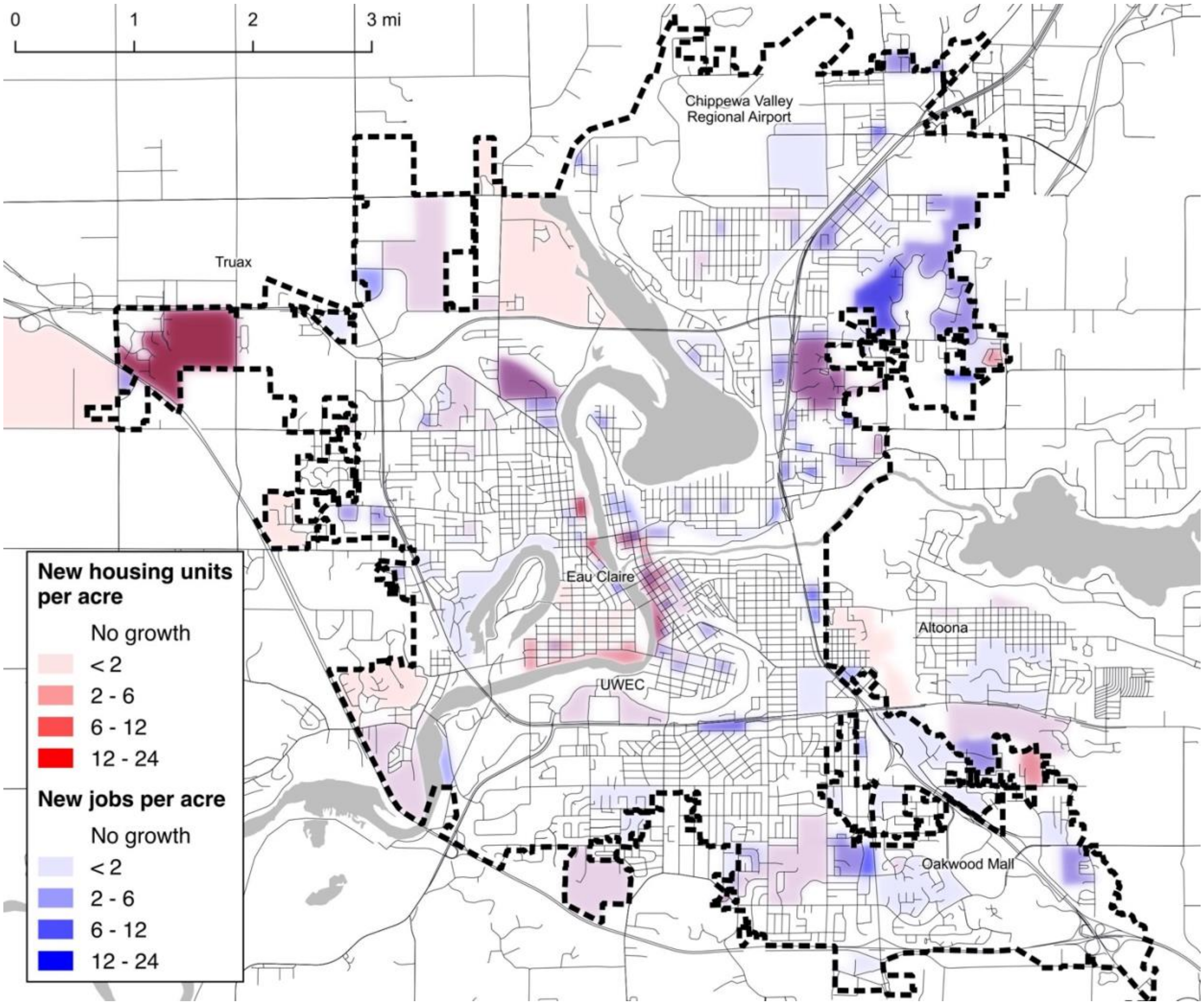
Land use scenario 1: Transit-oriented development (TOD)



Land use scenario 2: Non-TOD



Land use scenario 3: Random growth



Land use scenario 4: Gateway TOD