The Exploratory Advanced Research Program

EXPLORATORY ADVANCED RESEARCH

The Impact of Automated Transit, Pedestrian, and Bicycling Facilities on Urban Travel Patterns

SUMMARY REPORT

U.S. Department of Transportation
Federal Highway Administration

Foreword

Full usage of rapid transit systems that serve major urban areas can reduce road congestion and greenhouse gas emissions. One obstacle to greater use of available rapid transit systems is the distance between the rapid transit station and the traveler's origin or destination, termed the *last-mile problem*. To address the last-mile problem, the investigators of this research project, sponsored by the Federal Highway Administration's Exploratory Advanced Research Program, asked whether the use of rapid transit might be increased by implementing an automated, high-frequency community shuttle service to the transit station and improving urban design near the stations to accommodate pedestrians and cyclists. The investigators surveyed residents of four metropolitan Chicago neighborhoods, all served by rapid transit but differing in levels of population density and affluence. By drawing on the survey data and by using agent- and activity-based modeling developed by the research team, the investigators found that a significant shift of commuters from automobiles to rapid transit might be achieved with implementation of the potential shuttle service and design improvements. The investigators also explored how perceptions of cost, safety, and time affect travelers' choice of mode.

Replication of this study, validation of its forecasts, and refinement of the research models are now needed to understand significant shifts in travel and mode choice. Although the deployment of automated vehicles is approaching technological feasibility, research is also needed to understand and address associated public policy and institutional issues, particularly with regard to public transit applications. The results of this project suggest that further research is indeed warranted.

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16. Abstract

Researchers conducted a survey in four metropolitan Chicago neighborhoods served by commuter rail to explore how residents' travel preferences might change with the potential addition of (1) an automated community transit (shuttle) service to and from the station and (2) a package of streetscape improvements to facilitate walking and bicycling to the station. The neighborhoods differ in levels of population density, current rail use, land use, and affluence. By using a telephone and mail survey to determine residents' current travel patterns and preferences with the potential improvements, agent-based modeling, and activity-based modeling, the researchers forecast a possible overall decrease in car use of 39 percent and an increase in commuter rail use of 34 percent with the improvements. The shuttle service produced greater changes in lower density neighborhoods, with forecast of transit use doubling in the lowest density neighborhood. Travelers' perceptions of cost, time, and safety are explored, and the differences among communities' responses to the improvements and their implications for the relative effectiveness of each potential improvement are discussed. This report summarizes the Exploratory Advanced Research Program project "Effects of Automated Transit and Pedestrian/Bicycling Facilities on Urban Travel Patterns." The final project report is available at https://taubmancollege.umich.edu/faculty/faculty-publications/effects-automated-transit-pedestrian-and-bicycling-facilities-urban.

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Introduction

This report summarizes the results of a Federal Highway Administration (FHWA) Exploratory Advanced Research (EAR) Program research project that explored the potential of a hypothetical driverless vehicle to improve access to and use of available rapid-transit rail service. The distance between a traveler's origin or destination and the nearest public transit station is often time-consuming, inconvenient, or unsafe to travel and may discourage potential transit riders from using the system. This distance, known as the "last-mile problem," impedes full usage of existing transit systems, particularly in outlying suburban and exurban areas.

Walking, cycling, driving or being driven, or riding a station feeder bus line are the usual options for reaching the nearest station. In some public transit systems, community shuttle buses or vans supplement existing feeder bus lines to improve residents' access to commuter rail stations, but the challenge in providing community shuttles is the high cost of labor, fuel, and equipment, particularly in neighborhoods with low population density. In these areas, the cost per rider for shuttle service can be prohibitively high, whether in the form of rider fares or tax-supported subsidies. Automated vehicles would eliminate the cost of operator labor from this equation, possibly lowering costs sufficiently to make high-frequency service feasible and offering a solution to the last-mile problem. Recent rapid advances in automated vehicle technology have brought the driverless vehicle within reach, potentially within the next decade for low-speed neighborhood travel.

> The full final report of this project, *Effects of Automated Transit, Pedestrian, and Bicycling Facilities on Urban Travel Patterns* (September 2013), is available on the University of Michigan Web site: https://taubmancollege.umich.edu/faculty/faculty-publications/effects-automated-transit-pedestrian-and-bicycling-facilities-urban.

Whether the availability of an innovative transit shuttle service would be incentive enough to attract large numbers of people to public transit is an open question, however. In this project, the University of Michigan and the University of Illinois at Chicago conducted an initial inquiry into the potential impact of three types of neighborhood improvements on residents' use of transit:

- Automated, high-frequency community shuttle service to and from commuter rail stations.
- Cycling facilities.
- Urban design improvements in the vicinity of the transit station to facilitate walking and cycling.

The researchers also explored the effect of changes in the costs of parking and driving on public transit use.

This project was not a feasibility study; rather, the research design was a "best-case" approach to help assess whether the concept of using automated vehicles as transit shuttles holds promise for further research and development. The project's purpose was to inform discussions on policy choices regarding this option. Of specific interest was the relative capacity of the potential improvements to generate changes in travel behavior, that is, to shift trips from automobile to other modes of transportation and to increase use of regional public transit based on improved station access.

The best-case assumptions for the research included no congestion on local streets, no limitations due to weather or nighttime conditions, and unrestricted ability to alter rights-of-way to make transit and environmental improvements. Because the researchers examined whether the frequency and quality of service deemed possible with automated neighborhood shuttles might increase transit use and did not evaluate the feasibility, practicability, or acceptability of deploying the shuttles, the driverless aspect of the shuttles was not discussed with the research participants.

The study had several related elements:

- A literature review to identify urban design improvements shown to have a positive effect in promoting multimodal travel.
- An inventory and selection of sites and station approaches in four metropolitan Chicago neighborhoods, including mapping a 1.5-mi (2.4-km) buffer zone around the selected station by using geographical information system data (rights of way, land use, and census data).
- Preparation of photographs and illustrations of station approaches and potential improvements.
- A mail and telephone survey of households located within about 1.5 mi (2.4 km) of the station.
- Simulations using activity-based and agent-based modeling.

The research focused on four Chicago-area neighborhoods—Evanston, Skokie, Pilsen, and Cicero, Illinois. All are first-ring suburbs or, in the case of Pilsen, within Chicago city limits, and all are served by Chicago Transit Authority (CTA) rapid transit lines with capacity for increased use. The researchers selected the neighborhoods to represent different combinations of housing density and affluence, as shown in table 1.

Table 1. Neighborhood selection scheme.

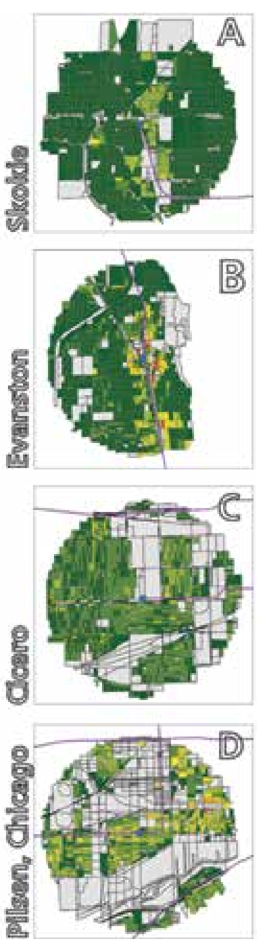
	Lower Income	Higher Income
More Auto-Oriented	Cicero	Skokie
Less Auto-Oriented	Pilsen	Evanston

The following sections discuss the characteristics of the four neighborhoods and transit stations and the neighborhood improvements that were the basis for the research.

The Study Neighborhoods and Transit Stations

The research team selected the four neighborhoods in the study to represent two broad conditions of land-use mix and population density and two broad conditions of household income to ensure that the research findings could be generalized to a variety of urban conditions. Each neighborhood was served by at least one CTA station, with service frequencies in the range of 7 to 15 minutes. See figure 1 for the location and housing density of each neighborhood.

Within each neighborhood, the research team selected a transit station and mapped a buffer zone of 1.5-mi (2.4-km) radius around it. This zone provided the population for the simulations. Within the buffer zone, the researchers chose two smaller focus areas within 0.5 mi (0.8 km) of the station, A and B, on which to base the project's survey. The A and B focus areas surround two different approaches to the CTA station to facilitate planning, designing, and illustrating the potential improvements. Each station approach included a street intersection close to the station that became the site of the transit, cycling, and urban design improvements that were described and illustrated in survey materials. An example of a land-use map with buffer zone and focus area demarcated is



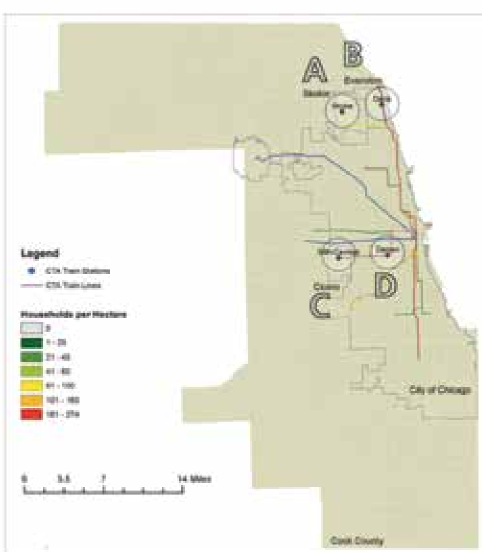


Figure 1. Locations and household density of the four metropolitan Chicago neighborhoods on which the study was based.

Figure 2. Land-use map of the buffer zone centered around Pilsen's Hoyne/Damen transit station. [NOTE: The highlighted area contains the A and B focus areas included in the survey, and the station area improvement sites are marked "01" and "02."]

shown in figure 2, with the two approaches numbered "01" and "02." The following sections provide a brief description of each neighborhood. The research team obtained the neighborhood demographic information from publicly available sources and survey responses.

Village of Skokie

The Skokie/Morton Grove neighborhood, served by the Yellow Line, is an area with predominantly low-density residential land use and socioeconomic composition of primarily middle-to-high income, ranking high on measures of suburban living quality. The area has a complete street network, although some fragmentation is introduced by highways and railroads. The Skokie station offers connections with four bus lines, indoor bike parking, and a park-and-ride facility, and it also serves as the Greyhound bus terminal. Service frequency varies between 10 and 15 minutes during weekdays from 5 a.m. to 11:15 p.m. On weekends, frequency is every 15 minutes between 6:30 a.m. and 11:15 p.m. There are no other stations within the buffer zone around the station, and residents are highly dependent on cars for transportation.

Skokie Demographics

Average family size, 3 members

Vehicles per household, 1.5–2.5

Current travel mode share to Chicago's inner central area: Train, 39.5%, Bicycle, 0.6%, Bus, 1.7%, Driving, 58.1%

Town of Evanston

Evanston, served by the Purple Line, is a mixed-use area with a socioeconomic composition of primarily middle-to-high income. Evanston has a fully connected street network. The focus area covers both low-density residential areas toward the south and a more mixed-use and high-density downtown area around the Davis station, a downtown stop on the Purple Line that was selected for the study. Service frequency varies from 7 to 14 minutes. The station offers connections with seven bus lines and was one of four test sites for the Active Transit Station Signs program, which provides real-time transit and traffic message signs that display travel time, next departing train, delay, fare, and other CTA-programmed information. The buffer zone around the CTA Davis station includes six other stations on the Purple Line as well as a Metra commuter rail stop. The two focus areas selected were a residential neighborhood and a residential neighborhood with an institutional anchor.

Evanston Demographics

Average family size, 3–3.5 members

Vehicles per household, 1.0–2.0

Average annual family income, $75,000 (northwest subarea, $55,000)

Current travel mode share to Chicago's inner central area: Train, 65.4%, Bicycle, 2.3%, Bus, 1.8%, Driving, 30.5%

Town of Cicero

Cicero, served by CTA's Pink Line, is an area with predominantly residential land use and a socioeconomic composition of low-to-middle income. Like Pilsen, Cicero is fragmented by industrial sites, but its residential areas are lower in density. The focus CTA station, 54th/Cermak, is the last stop on the Pink Line and offers connections with five bus lines, indoor bike parking, and a park-and-ride facility. Service frequency varies from 7.5 to 15 minutes. The focus area is dominantly residential and excludes the industrial areas and the higher income neighborhoods to the west. The surroundings of the 54th/Cermak station are more residential compared with those of the three other stations located in the buffer zone.

Neighborhood of Pilsen

Located in the lower west side of Chicago and served by the CTA Pink and Blue Lines, Pilsen is a mixed-use area with a socioeconomic composition of low-to-middle income. Pilsen has high-density residential areas and large industrial areas traversed only by major arterial roads. The focus CTA station in Pilsen, Hoyne/Damen on the Pink Line, has indoor bike parking and connects with two CTA bus lines. Service frequency varies from 8 to 15 minutes. The buffer zone around the station includes five other stations on the Pink Line and one on the Blue Line. An industrial area on the south and a university-related area of development in the northeast were not part of the focus area.

Cicero Demographics

Average family size, 3.5–4 members

Vehicles per household, 2.0–2.5

Average annual family income

- Near station, $45,000–$55,000
- Toward the east, >$75,000
- Toward the west, <$45,000

Current travel mode share to Chicago's inner central area: Train, 32.0%, Bicycle, 2.3%, Bus, 9.8%, Driving, 56%

Pilsen Demographics

Average family size, 3.5–4 members

Vehicles per household:

- Near station, 0–1.0
- Not near station, 1.0–1.5

Average annual family income, $45,000 (northeast subarea, $65,000–$75,000)

Current travel mode share to Chicago's inner central area: Train, 24.6%, Bicycle, 4.8%, Bus, 32.6%, Driving, 38.0%

Potential Improvements Described in the Survey

The researchers designed potential transportation (shuttle and biking facilities) and urban design (streetscape changes) improvements for each station approach (two for each transit station), and they described and illustrated the improvement changes in materials that were distributed in the neighborhood surveys. For each approach, seven illustrations were prepared that showed:

- The streetscape with no changes.
- The streetscape as it would be changed by transportation (shuttle and cycling) improvements at three levels of use (e.g., current level of users, a few more users, and a lot more users).
- The streetscape as it would be changed with both the transportation improvements and additional streetscape features, also at three levels of use.

The transportation and streetscape design improvements are described in the following sections.

Transportation Improvements

The primary hypothesis in the study was that an automated high-frequency community shuttle service would increase transit use and reduce driving. The shuttle vehicle would circulate frequently through the neighborhood, delivering passengers to and from the regional rail station, on a fixed route and a fixed schedule. Illustrations in the survey materials showed the shuttle vehicle near spacious, covered transit stops with seating.

Bicycle facilities were the second transportation improvement and included well-marked, dedicated bicycle lanes; bicycle traffic signals; and bicycle stands. Illustrations in the survey showed the brightly colored bicycle lanes located, where possible, between the street curb and parked cars.

Design Improvements

The design elements illustrated in the survey materials target safety, density of users, and attractiveness of surroundings to users near the station. Some of the elements that have been shown to increase use of alternatives to driving include the presence of pedestrians, shops and businesses, benches and other places to sit, a friend or neighbor using the same route, and traffic control devices that aid pedestrians.(1) For bicyclists, bicycle lanes, bicycle signals, and bike racks near public transit are important.(2,3,4) Transit riders value sheltered, well-lit waiting areas and safe access to vehicles.(5,6) Although diversity of land use and density of the built environment have also been shown to improve walkability, this research was focused on assessing environmental improvements that did not require changes in land use; therefore, no alterations to the built environment were shown in the illustrations.

The improvements illustrated in the community survey included the shuttle and bicycle facilities described previously and an assortment of streetscape features: widened and brightened sidewalks, pedestrian crosswalks, a generous tree canopy and continuous plantings, signs, public art, magazine and newspaper dispensing boxes, trashcans, light poles, and sign posts. The survey illustrations also represented different levels of use with the addition of pedestrians, cyclists, and transit users in the vicinity of the intersections. For an example, see the illustrations prepared for Site 2 at the Hoyne/Damen station in Pilsen in figure 3. A photograph of the unchanged area is shown first. Three images follow with transportation improvements (shuttle vehicle and bicycle facilities) at increasing levels of use. The final three images show both the transportation and the urban design improvements at increasing levels of use.

Figure 3. Example of the illustrated improvements. [Note: The seven graphics depict site 2, the Damen Avenue approach to Pilsen's Hoyne/Damen CTA station.]

Methods

The research team used three analytical approaches in the study: a mail and telephone survey; activity-based modeling of respondents' choice of travel modes, based on the survey results; and agent-based modeling of commuters and their preferences regarding cost, travel time, and safety considerations. The agent-based model, calibrated with data from the four neighborhoods, was developed by first using parameters from the travel behavior literature and then incorporating parameters from the study's activity-based model. Commuters in the model choose transportation options based on their preferences, characteristics of the environment, and the travel modes available to them.

Household Survey

The research team conducted a survey of at least 150 respondents in each of the four neighborhoods. Respondents lived within 1.5 mi (2.4 km) and worked within 3 mi (4.8 km) of a CTA rail station. The research team designed the household survey to collect information about the household, the respondent's current travel behavior, mode preferences under the potential transportation and design improvements, and perceptions of mode cost, convenience, time, and safety.

Staff from the Survey Research Laboratory at the University of Illinois at Chicago used a multimode design for the household survey. The staff used address-based sampling from the Delivery Sequence File constructed by the U.S. Post Office to obtain an initial 7,700 addresses within the A and B focus areas of the four neighborhoods. The staff divided sampling equally among the neighborhoods, and carried out recruitment in eight repetitions of the same experimental conditions during March–April 2012. Because of the low responses in Cicero, Pilsen, and Skokie, the survey staff added an additional 8,998 addresses in those neighborhoods in two additional samplings, with recruitment occurring during May–June and December 2012. Thus, 16,698 households received the initial recruitment contact.

The team conducted the survey in three steps:

1. Recruitment mailing to random sample:
   - Advance letter describing the survey and inviting participation.
   - Response form and postage-paid return envelope.
2. Study packet mailing to eligible respondents:
   - Cover letter and consent information form.
   - Travel diary covering 1 day, to be completed on a randomly assigned weekday.
   - Booklet containing seven color images illustrating the status quo and potential improvements (customized to the address of the respondent) accompanied by six worksheets to be used in the telephone interview.
3. Telephone interview (30 minutes):
   - To elicit the respondent's modal preferences through a process of completing the six illustrated survey worksheets and to elicit perceptions of cost, safety, quickness, and convenience.

The recruitment mailing asked for participation in the study and offered a cash incentive to eligible respondents who completed the written survey and the followup telephone interview. Anyone living in the household and over the age of 18 who spoke either English or Spanish (interviews and survey materials were available in either language) was eligible to return the response form, which asked whether the respondent works or goes to school outside the home, his or her work or school address, and how many times during the week the person travels to his or her nearest CTA rail station or within a half-mile (0.8 km) of that station.

The survey team used a screening process to eliminate respondents who did not work or go to school outside the home, did not travel at least once a week to their CTA rail station area, or did not work or attend school within 3 mi (4.8 km) of the CTA system. The team sent the survey study packet containing the travel diary and booklet only to respondents deemed eligible. At least 1 day after the date assigned to the respondent to complete the travel diary, the survey team telephoned to conduct the followup interview.

The overall returns to the recruitment mailings were 10.1 percent, and the final participation rate—respondents who completed the telephone interview—was 3.8 percent and ranged from 2.0 percent in Cicero to 9.2 percent in Evanston.

Travel Diary

The travel diary centered on the respondent's travels on a randomly selected weekday. The questionnaire devoted three pages to the main tour of the day (e.g., the series of trip segments between home and a destination or from a destination to home), with up to three segments, and contained space to add additional tours. Questions involved destination, travel times, travel modes, length of trip, and number of stops. The travel mode options offered were private vehicle as driver, private vehicle as passenger, bus, train, walking, cycling, and car-sharing. Questions also included any costs for parking or highway tolls.

Survey Booklet and Telephone Interview

The telephone interview had four parts:

- Collecting information about the household.
- Collecting the travel diary entries, which represented the respondent's current travel behavior.
- Gathering the respondent's perceptions of the safety, convenience, quickness, and cost of the main trip with and without potential improvements.
- Recording the respondent's travel preferences under the six potential levels of transportation and design improvements.

The survey booklet that was mailed as part of the study packet contained six worksheets covering the transit station approach with which the respondent's address was associated. Each worksheet was illustrated with one of six "improved" scenarios (a sample is shown in figure 4). These worksheets were completed one by one during the telephone interviews, which were conducted by using CASES, the Computer-Assisted Survey Execution System Program, version 5.4.[7] The interviewer supplied travel times and costs for each travel mode based on the times, starting point, and destination data for the main trip in the respondent's travel diary. Survey software generated the values for the interviewer. The interviewer then asked the respondent to reflect on the worksheet information and image and select the mode of transportation that they would prefer to use for the trip recorded in the diary.

Limitations of the Survey

Although the survey team sent the initial recruitment mailing to a random sample within the defined geographic areas, the survey respondents were a self-selected sample, and their participation likely reflects a greater interest in transit, cycling, and walking as alternatives to driving than that of the general population. As a result, the survey results cannot be used to make population inferences. The assumed positive bias, however, is in line with the mission of the study, which was to estimate a best-case scenario for the community shuttle.

CTA Station Hoyne/Damen (Pilsen, Chicago)

Intersection of W Cullerton St and S Damen Av.

WORKSHEET #1

The interviewer will give you values to fill in this worksheet. These are the choices you'd have available to you for a trip in the new environment we've sketched in image #1. Please think about how you might get to your current destination in this new environment.

	Drive	Community Transit Bus to CTA Station/Station Area	Walk to CTA Station or Station Area	Cycle to CTA Station or Station Area	Cycle to your destination
Time to the station	N/A	BOX A _______ minutes	BOX B ________minutes	BOX C ________minutes	N/A
CTA travel time (station to station NOT including wait time)	N/A	BOX D _______ minutes	BOX D ________minutes	BOX D ________minutes	N/A
Parking Cost	BOX E $_________	N/A	N/A	N/A	N/A
Community Transit Fare	N/A	Free	Free	Free	N/A
CTA Frequency	N/A	BOX F Every _______minutes	BOX F Every _______minutes	BOX F Every ______ minutes	N/A
CTA Fare	N/A	$2.25	$2.25	$2.25	N/A
Community Transit vehicle frequency	N/A	BOX G every ______ minutes within a half block of your house	N/A	N/A	N/A
Total door-to-door time	BOX H _____ minutes	BOX I ______ minutes	BOX J _______ minutes	BOX K ________ minutes	BOX L ____ minutes

Survey Research Laboratory, University of Illinois at Chicago

A Transportation Improvements
Current level of users

Figure 4. Sample worksheet with illustration of transportation improvements at the West Cullerton Street and South Damen Avenue approach to Pilsen's Hoyne/Damen CTA Station.

Modeling and Simulations

Data from the neighborhood surveys were the basis of the activity-based model. The survey incorporated both the respondents' current travel patterns and their stated preferences after potential implementation of the improvements, as described and illustrated in the survey materials. The stated preference portion of the data was used to estimate an activity-based model of mode choice. Utilities from this model were then used to revise initial parameters used in the agent-based model. In this way, the empirical estimation of the activity-based model was combined with the capacity of the agent-based model to simulate changes over time.

In the stated-preference survey, respondents chose from five travel modes:

- Drive.
- Community shuttle to the transit station.
- Walk to the transit station.
- Cycle to the transit station.
- Cycle to destination.

Information presented about the travel options included travel time to the CTA station by shuttle, time between shuttles, driving time to the destination, parking cost at the destination, CTA train frequency, station-to-station travel time, and fare. Some variables changed according to the residential location of the respondent but did not vary among the hypothetical scenarios. These variables included: walk time to the CTA station, cycle time to the CTA station, cycle time to the destination, CTA travel time from station to station, and CTA train frequency. The respondents' actual choices were compared against their stated preferences.

A permanent link to the agent-based last mile commuter behavioral model is available at www.openabm.org/model/4055/version/1/view http://www.openabm.org/model/4055/version/1/view. The model is built on NetLogo 5.0.2 and works on multiple operating systems.

The research team built a prototype agent-based model to represent commuters living within a 1.5-mi (2.4-km) radius of a transit station in their neighborhood and work or study in the downtown area, making transit a feasible commuting choice. As part of a larger metropolitan area, commuters have a choice of various transportation modes, and they base their decisions on their preference for travel time, transportation cost, and perceived safety. The neighborhoods, commuting modes, and parameters were modeled after the four Chicago neighborhoods in the study. The agent-based model incorporated parameters from the activity-based model, and the simulations were run on this integrated model.

Results

Results from the integrated model showed that the presence of the community transit and urban-design improvements had a marked effect on the sample population. Modeling with and without community transit and a set of urban amenities resulted in noticeable reductions in driving, as shown in figure 5. The decrease in the percentage of travelers who drove cars on their commuting trips varied between 7 percent and 29 percent, with the largest percentage-point reductions seen in the more auto-oriented areas of Cicero (16 percent) and Skokie (29 percent). Auto-use reductions were also significantly lower in areas with greater transit use to begin with; specifically Pilsen (8 percent) and Evanston (7 percent). The increase in the percentage of travelers who used the train varied between 9 percent and 28 percent, with more auto-oriented Skokie (28 percent) and Cicero (23 percent) exceeding the denser Pilsen (12 percent) and Evanston (9 percent). CTA mode shares among the modeled population increased from 24 percent to 52 percent in Skokie, 46 percent to 55 percent in Evanston, 52 percent to 75 percent in Cicero, and 52 percent to 64 percent in Pilsen. Across all neighborhoods, the results indicated that community transit might possibly decrease car use for these trips from the current 36 percent to 22 percent and increase CTA share from its current 50 percent to 67 percent. Community transit was shown to produce the greatest change in the lower density areas of Skokie and Cicero.

Running the model with and without community transit for each neighborhood shows that adding shuttles can lead to noticeable reductions in driving.

Differences by Land-Use Density

One of the most robust findings in the project was that the community shuttle produced greater change in the lower density areas of Skokie and Cicero. These less dense neighborhoods were more sensitive to higher parking costs, streetscape improvements, and the shuttle service than were the denser and more pedestrian-oriented neighborhoods (Pilsen and Evanston). Results from the stated-preference survey questions suggest that the shift from car to transit would be even greater if supported by policy changes that affect the cost of driving.

In contrast, where environments are more urban in character with walkable neighborhoods, more accessible transit, and higher parking costs, fewer gains may be realized with a community shuttle. For example, Evanston was the least responsive to the shuttle service—bus service to its CTA and Metra stations is already quite good. The higher density in central Evanston would also explain why the community shuttle service and street improvements seem to serve different populations: Shuttles would likely target residents living further away but close to shuttle routes, whereas streetscape improvements target commuters who have to spend more time walking across the neighborhood. As a result, the effects of applying each policy independently add up in the combination scenario.

Differences by Improvements

The first level of improvements represented in the survey was the community shuttle with a bicycle lane; the shifts in respondents' mode choices occurred at this level. The second level of improvements, urban design improvements with the shuttle and bicycle facilities, showed minimal further shifts.

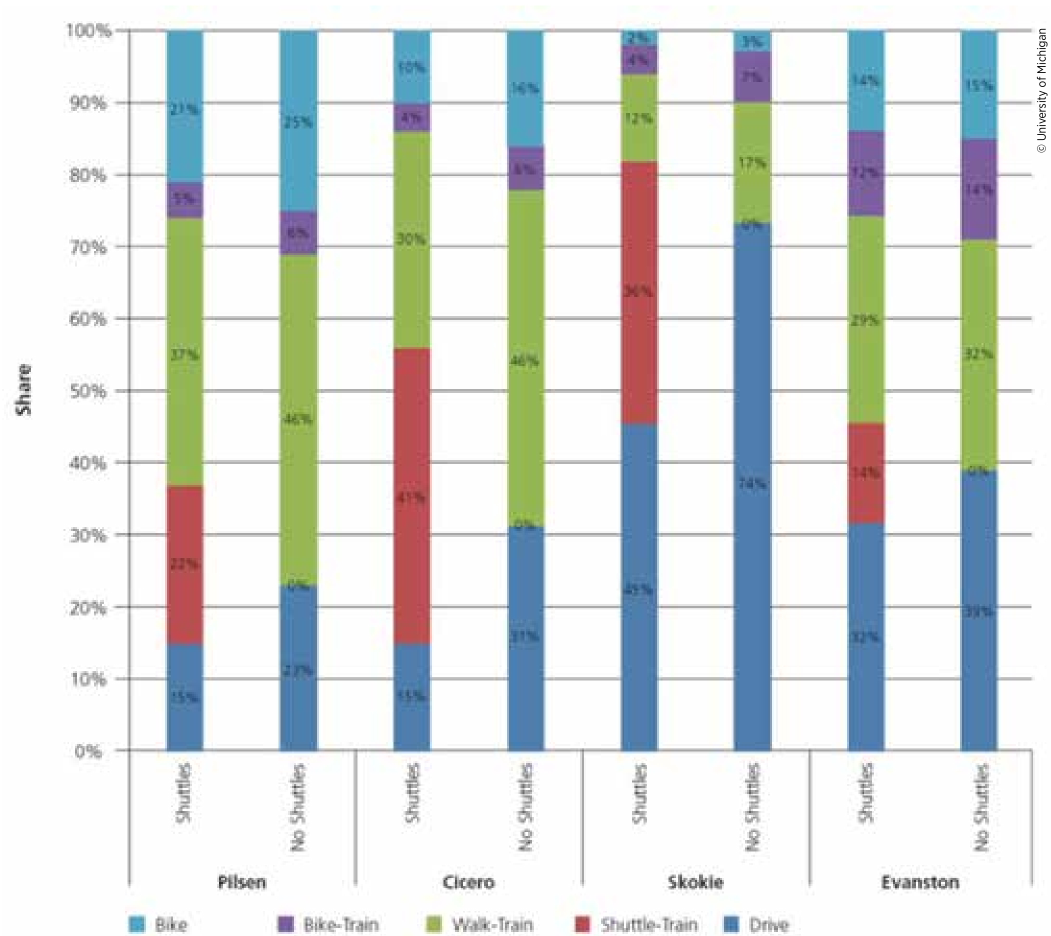


Figure 5. Combined model results using the neighborhood best fit coefficients comparing and testing the effect of community transit.

Extensive urban design improvements beyond the bike lane were tested, and none of them had a measurable impact on mode choice in the study. As a result, although there is support in the mode-choice literature for the potential of urban design improvements to reduce driving, this research did not generate additional empirical evidence for that hypothesis. Streetscape improvements tended to support transit use for residences closer to train stations. Results from the activity-based model suggest that of the design variables, the frequency of the shuttle service had the greatest influence on its use.

Differences by Level of Use

The researchers also asked whether the presence of pedestrians, cyclists, and other transit users in greater numbers would affect traveler's perceptions and shift mode choices to transit. Three levels of use were represented in the survey images for the transportation and urban design improvements. This hypothesis was tested in agent-based and activity-based modeling, and neither found an effect.

Conclusions and Recommendations

The purpose of this EAR Program project was to aid in an assessment of whether automated vehicle technologies deployed as community shuttles to transit stations hold promise for further research and development. The research was conducted within a best-case framework and adopted best-case assumptions. The research team explored the potential of transportation and urban streetscape improvements to increase transit use within cities and suburban neighborhoods without significant changes to the built environment. The specific improvements included an automated high-frequency, fixed-route community shuttle serving the transit station; bicycle lanes, paths, racks, and signals; and streetscape changes, such as more trees, wider sidewalks, and better lighting. The project used three forms of analysis—survey research, activity-based modeling, and agent-based modeling—as a check against one another and ultimately combined them into a single model to explore the impact of the potential improvements.

The project results suggest that high-frequency transit shuttles could trigger significant shifts from driving to public transit. Shifts to public transit may be larger in low-density neighborhoods that are more automobile-oriented and in neighborhoods where bus service is unavailable, unreliable, or infrequent. Streetscape improvements targeting areas near transit stops may reinforce these shifts, as may policies that modify other aspects of travel. The strong response to cycling improvements in particular suggests that there is considerable growth potential for this mode with installation of the appropriate facilities.

The research suggests that greater shifts can be expected in urban and close-in suburban neighborhoods that are less transit-oriented.

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About the EAR Program

Federal legislation establishes an Exploratory Advanced Research (EAR) Program to address longer-term, higher-risk, breakthrough research with the potential for dramatic long-term improvements to transportation systems—improvements in planning, building, renewing, and operating safe, congestion-free, and environmentally sound transportation facilities. The Federal Highway Administration's (FHWA) EAR Program secures broad scientific participation and extensive coverage of advanced ideas and new technologies through stakeholder engagement, topic identification, and sponsored research.

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