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PILOTING SIDEWALK DELIVERY ROBOTS IN PITTSBURGH, MIAMI-DADE COUNTY, DETROIT, AND SAN JOSÉ: KNIGHT AUTONOMOUS VEHICLE INITIATIVE



URBANISM NEXT CENTER



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The Knight Autonomous Vehicle (AV) Initiative is a multi-year collaborative effort between the Urbanism Next Center at the University of Oregon, Cityfi, the cities of Detroit, Pittsburgh, and San José, and Miami-Dade County to pilot and learn about automated mobility technologies today to shape the future of deployment tomorrow. It is generously funded by the Knight Foundation.

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All photos provided courtesy of Kiwibot unless otherwise indicated.

Urbanism Next Center

The Urbanism Next Center at the University of Oregon conducts research and convenes partners from around the world to understand the impacts of new mobility, e-commerce, urban delivery, and autonomous vehicles on the built environment. Going beyond these emerging technologies, we explore the possible implications on equity, health, safety, the economy, and the environment to inform decision-making that supports community goals. Urbanism Next brings together experts from a wide range of disciplines including planning, design, development, business, and law and works with the public, private, and academic sectors to help create positive outcomes from the impending changes and challenges confronting our cities.

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EXECUTIVE SUMMARY

The Knight Autonomous Vehicle (AV) Initiative is a multi-year collaborative effort between the Urbanism Next Center at the University of Oregon, Cityfi, the cities of Detroit, Pittsburgh, and San José, and Miami-Dade County (the “cohort”) to pilot and learn about automated mobility technologies today to shape the future of deployment tomorrow.

The four jurisdictions had originally planned to test passenger AV pilots but due to both the Covid-19 pandemic and changes in the AV market, these were substituted for automated delivery pilots. With this transition, the cohort partnered with Kiwibot to learn more about a new technology—sidewalk delivery robots. Through this partnership, Kiwibot tested different use cases and collaborated on community engagement opportunities in each locale. Given the proliferation of bills being passed by state legislatures legalizing deployment of personal delivery devices (PDDs) or sidewalk robots, and the increased delivery demand due to the pandemic, the pilots were well timed to be able to meaningfully inform the cohort cities about the potential benefits and challenges of sidewalk delivery robots.

The PDDs primarily were used for food and goods delivery from local restaurants and stores to residents who chose to participate. Three key objectives for the pilots were established:

1. **Learn about PDD technology and understand the technical issues, opportunities, and challenges.**
2. **Educate and engage with community members about this technology to better understand how the application of it can best align with community needs.**
3. **Work with private sector companies testing these products to identify challenges and opportunities, with the goal of ultimately delivering positive societal outcomes for community members.**

This report provides an overview of the pilot design in each locale, presents key findings, and offers a set of recommendations based on the cohort’s experiences. Pilots are often time-intensive and challenging to pull off, but they also provide valuable learnings, and these pilots were no exception. Here are our top five takeaways:

- **Events and demonstrations were the best ways to engage community members and onboard them into a new experience.** Cohort staff felt that the most valuable engagement came from events and demonstrations where community members were able to directly interact with the technology. These opportunities gave residents the ability to experience the technology on their own terms, such as through the partnership with Veggjelution in San José where interested participants could opt in to receiving a delivery by sidewalk robot. These kinds of low-stakes engagement opportunities are important and illuminating.
- **Pilots should test with low-stakes deliveries.** Given the challenges discovered throughout the pilots, such as navigating large intersections and other issues in the built environment, this technology is not ready to fulfill essential community needs. Opt-in models where the person receiving the delivery is not dependent on

the success and timeliness of the delivery for essential services is the responsible way to deploy these technologies at this stage of development.

- **Partner selection—technology providers and local partner businesses—is crucial to success.**

The relative size and maturity of an AV and new mobility business may impact willingness to collaborate, with newer start-ups more willing to collaborate and engage with cities than larger and more advanced companies. Kiwibot was a willing and enthusiastic partner, but they lacked

expertise in some areas at the outset of the pilots, such as in their understanding of infrastructure conditions and associated data. Kiwibot worked to improve their products over the course of the pilots, but their lack of experience presented challenges for the cohort at times. Additionally, Kiwibot and cohort staff discovered that it is more difficult to bring local, small businesses into these pilots without long timeframes and significant support to help onboard the local businesses with incorporating the new technology.



A community liaison receives an order during a demo in Miami-Dade County.

- **There is value in city-level control while business models and technologies are maturing but not yet ready to scale.** Robots had a difficult time navigating the built environment in some places, particularly in areas with wide intersections or poor sidewalk conditions. They also had a limited delivery range, which was one reason it proved difficult to formulate partnerships with local businesses. Cities benefit from being able to have local control while the built environment issues with this technology are being resolved and the business models are being refined. At this point, it would be challenging to enact flexible and enforceable enough state-level rules given the numerous implementation issues.
- **A cohort model adds value and leverage.** Having the four cohort locales pilot the same technology simultaneously with the same private sector partner enabled staff to share learnings and resources in real-time. They collaborated on memorandums of understanding (MOUs), data sharing agreements, and engagement materials. By working together, they were also able to make collective demands of Kiwibot that they may not have been able to do on their own. At the same time, Kiwibot gained valuable insights from cohort staff, such as the types of infrastructure data that are most valuable to local agencies.

SECTION 1: BACKGROUND AND OBJECTIVES

The Knight Autonomous Vehicle (AV) Initiative is a multi-year collaborative effort between the Urbanism Next Center at the University of Oregon, Cityfi, the cities of Detroit, Pittsburgh, and San José, and Miami-Dade County to pilot and learn about automated mobility technologies today to shape the future of deployment tomorrow. Automation has the potential to have major impacts on cities, both positive and negative. AVs in particular could increase safety and help reduce pollution and parking demand, but they could increase congestion and, due to their costs and their potential impacts on transit, make our existing transportation system even more inequitable than it already is. While the timeline for the mass deployment and adoption of AVs is uncertain, cities need to plan for AVs before they arrive to take advantage of the best they have to offer, instead of realizing the worst.

For this reason, the Knight Foundation awarded grant funding to four locales (the “cohort”), selected for being on the leading edge of autonomous innovation, to support their efforts in preparing for autonomous vehicles:

- **Detroit**, home of the U.S. auto industry and nearby Mcity in Ann Arbor, a purpose-built test track for AVs;
- **Pittsburgh**, home of Carnegie Mellon’s Argo AI Center for Autonomous Vehicle Research, with a growing list of AV testers on its streets;
- **San José**, the heart of Silicon Valley, and ground zero for technology companies developing AVs like Waymo, AutoX, and Zoox; and
- **Miami-Dade County**, a welcome testing ground for AVs given its copious amounts of sunshine and its openness to technology with the Ford City of Tomorrow Challenge.



Robot on the sidewalk in front of the Paper Moon Café in Downtown San José with people crowded around the restaurant.

At the outset of the Knight AV Initiative in September 2018, all four jurisdictions had passenger AV pilot projects in development, and the purpose of the Knight funding was to support engagement efforts to ensure community voices were centered in the conversations about AVs. For a host of reasons—including the start of the COVID-19 pandemic in early 2020—plans changed and the pilots involving passenger AVs were halted.

By late 2020, discussions about the future of automated mobility had shifted to automated delivery, propelled both by the increasing demand for delivery in response to COVID-19 and the proliferation of bills being passed by state legislatures legalizing deployment of personal delivery devices (PDDs) or sidewalk robots. Members of the cohort were concerned about the speed with which these bills were being passed given how much was unknown about their operations and potential impacts, and they felt pressure to develop operating permits without a sufficient understanding of the technology. As a result, the cohort decided it would be worthwhile to pilot sidewalk

robots in order to learn more about the technology, including its potential benefits and challenges.

The pilot design process began in late 2020 with exploratory conversations with a variety of delivery operators that had been testing and/or deploying devices in the U.S. A key determining factor in vendor selection was the operator's willingness and capacity to run simultaneous pilots in all four locales in collaboration with the cohort—this significantly constrained the number of potential partners. PDD operator Kiwibot was selected as the private sector partner because of their willingness to take on the task of running simultaneous pilots, as well as to test a variety of different use cases in support of positive societal outcomes in collaboration with cohort staff.

The pilots ran for approximately three to six months between June and December 2021, depending on the locale, with a maximum of 10 robots operating in each place. The robots were operated semi-autonomously and were primarily controlled by remote operators. A Kiwibot representative was physically located in each of the cohort communities for the duration of the pilot to oversee day-to-day operations. While specifics varied in each locale, the PDDs were used for food and goods delivery from local restaurants and stores to participating individuals in the general public.

PILOT OBJECTIVES AND KEY QUESTIONS

The cohort established three key objectives for the collective pilot efforts, along with a set of key questions related to each objective:

Objective 1: Learn about PDD technology and understand the technical issues, opportunities and challenges.

Key Questions:

- Can robots be deployed on sidewalks without creating safety or accessibility issues for other users?
- What infrastructure/conditions are required in order for the robots to operate? (E.g., curb cuts, sidewalk width, street connectivity, etc.)
- Given the current state of the technology, can robots be used to support deliveries from small, locally-owned businesses?

Objective 2: Educate and engage with community members about this technology to better understand how the application of it can best align with community needs.

Key Questions:

- What are initial reactions/responses from community members?
- What concerns do community members have?
- Can robots potentially fill unmet needs that community members have?

Objective 3: Work with private sector companies testing these products to identify challenges and opportunities, with the goal of ultimately delivering positive societal outcomes for community members.

Key Questions:

- What value do local agencies derive from partnering with private sector partners on pilots and vice versa?

The next section of this report provides additional details about each pilot by locale, including deployment area and use cases, and a summary of the engagement activities conducted specific to each locale. (In addition to the engagement activities described, Kiwibot also ran its own “Love Date Robots” marketing campaign to introduce the robots to the public.)

Following the pilot details, we discuss our key findings from the various pilots and offer recommendations for both public and private sector entities interested in pursuing similar or related efforts.

Robots operate on a closed street during a farmer's market event in San José.



SECTION 2: OVERVIEW OF PILOTS BY LOCALE

SAN JOSÉ, CA

San José was the only cohort community that Kiwibot had operated in prior to the start of the pilot. (They operated for approximately six months in 2020.) Because of their previous deployment there, they had already mapped parts of Downtown San José and had established a relationship with a local business, the Paper Moon Cafe. The City of San José and Kiwibot signed an operating agreement in June 2021, enabling a formal launch of the pilot. Paper Moon Cafe was the first use case piloted with deliveries beginning in June, and other use cases were added before the pilot ended in December. To identify other potential use cases city staff conducted outreach to 15 local organizations and nonprofits prior to the start of the pilot and ultimately partnered with Veggielution to supplement the use cases identified by Kiwibot.

USE CASES

- Veggielution Urban Farm in East San José to deliver **farm boxes to low-income residents**.
- Paper Moon Cafe in Downtown San José to test **food and beverage deliveries** to neighborhood residents.
- A pop-up Community Hub next door the Paper Moon Cafe to deliver **small, non-perishable items** such as snacks and t-shirts to neighborhood residents.
- Delivery of **goods** from the Westfield Valley Fair Mall.

ENGAGEMENT EFFORTS

- **Events:** City staff attended community events, such as the weekly farmer's market and a cinema in the park event, throughout the course of the pilot along with the local Kiwibot representative overseeing robot operations. Kiwibot brought one to two robots to each event so that community members could experience the technology in controlled settings. Both city and Kiwibot staffers used the opportunities to speak with community members to gauge their reactions to the technology and discussions were held in both English and Spanish.
- **Partnership with a Local University:** City staff partnered with a professor at San José State University (SJSU) to work with a class of graduate planning students to gather additional findings about stakeholders' views of the robots and how community members interacted with the robots. Students enrolled in the class participated in different research activities including: stakeholder interviews with groups such as the San José Silicon Valley Chapter of the Federation of the Blind, the San José Chapter of California Walks, the San José Downtown Association, the San José Residents Association, and others; interviews with community members; field observations of the robots in operation; and intercept surveys of pedestrians in areas where robots were operating. City staff, in conjunction with Urbanism Next, devised the tools the students used to conduct research to ensure they aligned with the key

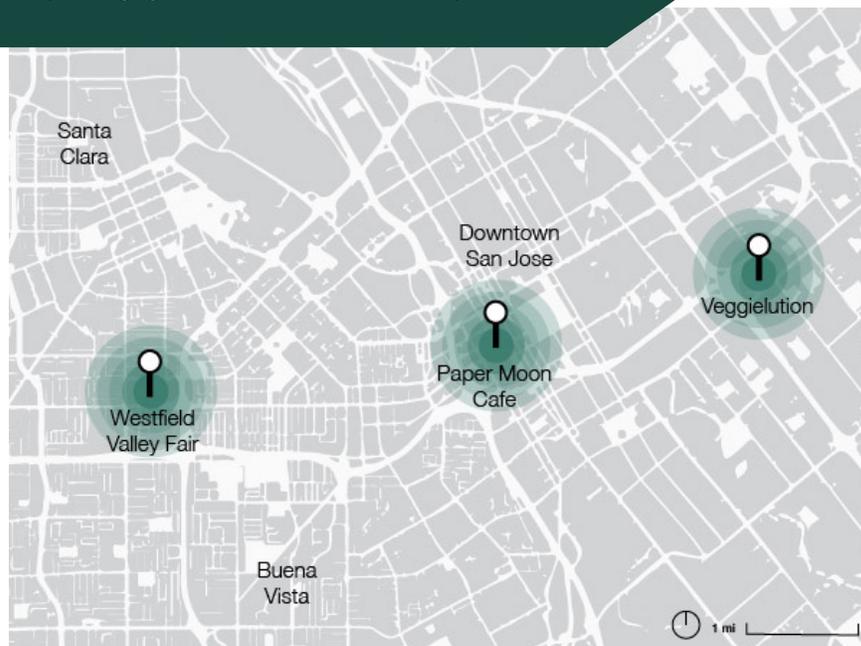
questions of the pilot. At the end of the term, students presented their findings to city staff and other members of the AV cohort.¹

- **Interviews with Delivery Recipients:** The nonprofit Veggielution offered a subset of program participants the option of receiving their farm box via robot delivery in lieu of picking it up. Deliveries were then scheduled to those who expressed interest. Veggielution staff conducted follow-up interviews with program participants who received a delivery via a robot to discuss the experience, and the anonymized findings were shared with City of San José staff.
- **Interactive City Website:** A pilot specific website page was established on the city's digital engagement platform, Move San José, with information about the pilot and a link to a survey that people could fill out to provide feedback on it. (Information was available in both English and Spanish.)

¹ Associate Professor Serena Alexander who was overseeing the SJSU class published a summary of the class findings in May 2022 called "Robots Among Us: An Analysis of Community Perspectives toward Sidewalk Delivery Robots in the City of San José," available at: <https://transweb.sjsu.edu/sites/default/files/2203-Alexander-Perspective-Sidewalk-Delivery-Robots.pdf>.

BY THE NUMBERS: SAN JOSE DEPLOYMENT AREA

- 91 Simulated orders/deliveries (e.g., generated by Kiwibot staff to use for testing/mapping)
- 143 Orders/deliveries to customers
- 1,553 Miles driven by the robots during the pilot
- 7 Community events attended by city and Kiwibot staff
- 80 Intercept surveys conducted by SJSU students
- 20 Interviews with community members conducted by SJSU students
- 12 Hours of robot field observations by SJSU students
- ~530 People engaged over the course of the pilot



Map of San José deployment areas

PITTSBURGH, PA

In November 2020, the State of Pennsylvania passed Senate Bill 1199 legalizing the operations of personal delivery devices on sidewalks across the state. In response, the Pennsylvania Department of Transportation (PennDOT) devised a two-phase authorization process outlining the requirements that operators who want to deploy anywhere in the state must follow.² During Phase 1 (0-180 days), PennDOT requires a PDD operator to remain within 30 feet of a robot at all times. After 180 days, a PDD company can automatically transition to Phase 2, eliminating the 30-foot requirement.

PennDOT granted Phase 1 authorization to Kiwibot in late June 2021, which enabled Kiwibot to begin mapping the Bloomfield neighborhood and conducting outreach to local businesses, after the area was identified as an ideal location for the pilot due to its diverse demographics, wide sidewalks on commercial streets, and high concentration of locally-owned businesses. (The City of Pittsburgh Department of Mobility and Infrastructure (DOMI) also issued an operating permit to Kiwibot that outlined additional expectations.) Because only one Kiwibot staff person was located in Pittsburgh during the pilot and they had to stay within 30 feet of the robot at all times, they were limited in their ability to do deliveries during Phase 1. PennDOT granted early authorization for Kiwibot to transition to Phase 2 after 90 days, and Kiwibot began making deliveries in September. The pilot wrapped in mid-December.

USE CASES

- Delivery of **prepared food** from Taquito's Food Truck in the Bloomfield area to neighborhood residents.
- Delivery of **personal and household items** from Wilson's Pharmacy in Bloomfield to neighborhood residents, excluding prescription or over-the-counter drugs.
- Delivery of **children's books** from Carnegie Library of Pittsburgh in Lawrenceville to local residents.

ENGAGEMENT EFFORTS

- **Partnership with a Resident Community Organization:** DOMI staff partnered with the Bloomfield Development Corporation (BDC), a Resident Community Organization (RCO) serving the Bloomfield neighborhood. DOMI staff met biweekly with BDC representatives during the course of the pilot, and BDC organized two virtual community meetings. During these meetings, the community provided input on the pilot and made specific asks of DOMI and Kiwibot, including an FAQ about the pilot and more information about Kiwibot's privacy policies.
- **Steering Committee:** To guide the development of the pilot, DOMI staff established a pilot steering committee. Members of the committee included representatives from BDC, local Bloomfield residents, other city staff, and faculty from Carnegie Mellon University.

² More information about Pennsylvania Department of Transportation's guidelines for Personal Delivery Devices available at: <https://www.pennndot.pa.gov/Doing-Business/PDD/Pages/default.aspx>

- **Events and Demos:** DOMI staff, in conjunction with the local Kiwibot representative, attended three local events over the course of the pilot, including the Bloomfield Saturday Market, the Lawrenceville Farmers' Market, and a youth event organized by the Carnegie Library. Additionally, demos were organized with advisory committees and an after-school program in the Garfield neighborhood to provide community members opportunities to interact with the robots.
- **Coordination with a Local University:** DOMI staff coordinated with research faculty at Carnegie Mellon University (CMU) to make them aware of the pilot and discuss potential research opportunities. Faculty conducted field observations of the robots during the course of the pilot and published a short paper in 2022.³
- **Meetings with Stakeholder Advisory Groups:** DOMI staff held regular meetings during the course of the pilot with the Shared and Autonomous Advisory Committee and the Pittsburgh AV Testers Group, convened by DOMI to discuss the state of technology and deployment in the Pittsburgh area.
- **Interactive City Website:** A pilot specific website page was established on the city's digital engagement platform, EngagePGH, with information about the pilot and a link to a survey that people could fill out to provide feedback on it.

³ "Sharing the Sidewalk: Analyzing Autonomous Delivery Robot Interactions with Pedestrians" by David Weinberg, Healy Dwyer, Sarah Fox, and Nikolas Martelaro is available at: https://drive.google.com/file/d/1sOgr6TJsxRyhZB_jQjE688U90jITXK3Z/view.

Children sit facing robots in a closed lot during an event at the Lawrenceville Farmers' Market in Pittsburgh.



BY THE NUMBERS: BLOOMFIELD DEPLOYMENT AREA

- 972 Simulated orders/deliveries (e.g., generated by Kiwibot staff to use for testing/mapping)
- 5 Orders/deliveries to customers (4 completed, 1 canceled)
- 992 Miles driven by robots during the pilot
- 2 Virtual community events held with a combined total of ~140 people in attendance
- 5 Events attended/demos organized
- 300 Visits to EngagePGH webpage
- ~660 People engaged over the course of the pilot



Map of Pittsburgh deployment areas

MIAMI-DADE COUNTY, FL

The State of Florida passed a bill in 2017 authorizing the operation of PDDs, allowing PDD operators to legally deploy prior to the pilot. Miami-Dade County (MDC) and Kiwibot signed an operating agreement in June 2021 and the pilot officially launched in July. The pilot ran for six months, ending in December 2021..

In addition to running the PDD pilot with Kiwibot, MDC also partnered with Ford City:One and the Urban Health Partnership (UHP) as part of a separate effort focused on identifying mobility challenges faced by Miami-Dade residents. This work occurred concurrent with the PDD pilot, and the purpose was to improve MDC's understanding of the unique mobility needs, behaviors, and assets of Miami-Dade County residents. Ford City:One was responsible for developing "mobility personas" and UHP was responsible for developing a network of community liaisons (CLs) from key communities around Miami-Dade to support the work of MDC and Ford City:One and conduct engagement with residents in 11 targeted neighborhoods. (Community liaisons interact with community members on behalf of an organization and provide/gather info.) UHP hired and trained a total of 13 community liaisons as part of this effort.

USE CASES

- Delivery of **prepared food** from Pepito's in the Downtown Miami / Brickell area.

ENGAGEMENT EFFORTS

- **Demos:** In collaboration with UHP and Kiwibot, Miami-Dade County organized a series of demonstration events with the network of community liaisons in October and November 2021. Over the course of three separate days, CLs visited the Brickell neighborhood to experience Kiwibot demonstrations, which included speaking with Kiwibot staff and placing orders for delivery. After the demonstrations, CLs shared their feedback with Kiwibot staff as well as with UHP staff via one-on-one calls. CLs were also tasked with conducting neighborhood outreach to share information and collect impressions on the pilot, gather ideas for use cases, and to encourage people to take the New Mobility Survey conducted by Ford City:One.
- **Events:** Kiwibot staff participated in a community event in the Little Havana neighborhood.

BY THE NUMBERS: BRICKELL DEPLOYMENT AREA

- **1,528** Simulated orders/deliveries (e.g., generated by Kiwibot staff to use for testing/mapping)
- **44** Orders/deliveries to customers
- **1,422** Miles driven by the robots during the pilot
- **2** Demo events with community liaisons
- **1** Community event attended by Kiwibot staff
- **~1,550** People engaged over the course of the pilot (including outreach done by the CLs)



Map of Miami-Dade deployment areas

DETROIT, MI

Unlike the other three pilots, the Detroit pilot was overseen by a technology incubator, Newlab, rather than by local government staff due to staff capacity issues at the City during pilot development. Newlab already had a presence in Detroit because they had partnered with Ford's Michigan Central to develop an "Accessible Streets Studio" and had selected Kiwibot to participate in the Studio. As a result of this set of circumstances, Newlab oversaw the Kiwibot pilot in Detroit with some support from city staff. The pilot ran for three months between October and December 2021—a delay in the City's permitting process limited the length of the pilot.

USE CASES

- Delivery of **prepared food** from Bobcat Bonnie's and The Goblin in the Corktown area.

ENGAGEMENT EFFORTS

- **Events:** Kiwibot staff attended several local events, including the Detroit Harvest Festival, the Sunday brunch market at Valade Park, and community events held at Roosevelt Park over the course of the pilot.
- **Meetings with Stakeholders:** Kiwibot staff presented to the Corktown Business Association, and they visited the Detroit Hispanic Development Corporation where they spoke with local students about robotics.

BY THE NUMBERS: CORKTOWN DEPLOYMENT AREA

- 400 Simulated orders/deliveries (e.g., generated by Kiwibot staff to use for testing/mapping)
- 12 Orders/deliveries to customers
- 450 Miles driven by the robots during the pilot
- 1 Demo event held
- 3 Community events attended by Kiwibot staff
- 1 Stakeholder meeting
- ~1,000 People engaged over the course of the pilot



Map of Detroit deployment areas

SECTION 3: METHODS

Urbanism Next staff participated in weekly meetings with the cohort, Kiwibot, Newlab, Ford City:One and UHP between May and October 2021 to track the development of the pilots and conducted mid-pilot interviews in October 2021, as well as end-of-pilot interviews in April/May 2022. Whenever possible, Urbanism Next staff attended virtual events during the pilots, including community meetings in Pittsburgh, presentations by SJSU students, and workshops facilitated by Ford City:One and UHP. To develop the findings included in this report, we reviewed all the materials shared by the cohort and other pilot partners, as well as weekly meeting notes.

Limitations

- Urbanism Next staff were not physically based in any of the cohort locales and we were limited in our ability to travel due to the ongoing pandemic, so we had to rely on data shared by the cohort, weekly meetings, and interviews to develop our findings.
- Although each locale was piloting the same technology, staff capacity to oversee the pilots varied from place to place. This resulted in inconsistent data collection efforts across the cohort, with more information being available about some of the pilots and less about others.
- Only a handful of people submitted survey responses via the San José and Pittsburgh city websites, and the sample sizes were too small to be statistically significant. Because of the small sample size and the potential for bias in the sampling strategy, we are not presenting any summary statistics in this report.
- There were only ~200 real orders/deliveries made during the pilots across all locales, which was less than anticipated. The low number of orders limits the conclusions we can draw about service operations and outcomes. As a result, the majority of the findings are process-oriented.



Robot on the sidewalk in front of Bobcat Bonnie's restaurant in Corktown, Detroit.

SECTION 4: KEY FINDINGS

OBJECTIVE 1

Learn about PDD technology and understand the technical issues, opportunities and challenges.

Key Question: Can robots be deployed on sidewalks without creating safety or accessibility issues for other users?

- Pedestrian safety was a critical concern for the cohort, and Kivibot provided operations reports during weekly calls with staff. **There were no reported safety incidents with pedestrians during the course of the pilot, but the robots did encounter issues crossing streets** with drivers in vehicles hitting the robots on several occasions, particularly in situations where drivers were making a right-hand turn.
- In their observations of the robots in San José, SJSU students did not report any incidences of a robot hitting a pedestrian, animal, or other object, but they did observe 12 incidences of a robot getting stuck, and three incidences of a robot tipping over. **Situations where a robot has gotten stuck or is unable to move can create accessibility issues for pedestrians and other sidewalk users.** Both SJSU students and CMU students/faculty in Pittsburgh observed situations where pedestrians assisted robots that had gotten stuck, but they also noted that some pedestrians exhibited hesitation around the robots because they were uncertain about how the robots would respond and/or move. In their paper summarizing their findings, Weinberg et al. (CMU) suggest that **refined auditory and visual signals could improve interactions between pedestrians and robots.**



A robot tries to navigate a sidewalk in Pittsburgh that has overgrown foliage and other sidewalk obstructions.

Key Question: What infrastructure/conditions are required for the robots to operate? (E.g., curb cuts, sidewalk width, street connectivity, etc.)

- **At a minimum, we observed the following infrastructure/conditions are required for robot operation:**
 - » Continuous, paved sidewalks
 - » Unobstructed sidewalks and curb cuts
 - » Sufficient sidewalk width
 - » Pedestrian crossings that do not require pushing a crosswalk button

- » Smooth pavement
 - » Robot connectivity to remote operator
 - » Well-functioning stormwater system
- Kiwibot **did not operate the robots in heavy rain or snow**, choosing to operate only in mild weather conditions. This proved limiting in Pittsburgh, Detroit, and Miami-Dade since all three experienced variable weather during the pilots.
 - In Pittsburgh, Kiwibot mapped the Garfield neighborhood but noted that there were places the robot could not operate due to infrastructure limitations such as cracked sidewalks, etc. Robots were also unable to operate if there were sidewalk obstructions such as overgrown trees or bushes or if cars were parked blocking the sidewalk, etc. **It is important to note that—first and foremost—these situations currently create challenges for people in wheelchairs and others with mobility limitations.** As a result of the infrastructure challenges in that neighborhood, Kiwibot determined that they would not be able to offer delivery service there.
 - In Detroit, **the robots had trouble getting across an intersection on Michigan Ave. during the pedestrian signal because** the traffic light did not allow enough time for the robot to cross this wide street. (This may also be a limitation of the technology and the positioning of the cameras as well. They are being remotely operated at all times and operators may have line of sight issues with being able to clearly see traffic and crossing signals). The robot could not clear the intersection before the light turned again, and as a result, it appeared to be running the signal. Kiwibot had to change its routing to avoid crossing Michigan Ave. because of this issue. **Again, it is important to note that this may be an issue for pedestrians**



Robot crossing in a crosswalk on a wide road in Detroit with oncoming traffic.

as well who are not able to clear the intersection during the pedestrian signal. Operationally, this may mean that robots have to take less direct routes as a way of dealing with infrastructure and condition limitations.

- In San José, **complex intersections were also difficult for the robots to cross.** Kiwibot made deliveries from the Valley Fair Mall. One three way intersection had a pedestrian crossing signal in the middle island, which the robot could not activate.

Key Question: Can robots be used to support deliveries from small, locally-owned businesses?

- **One of the biggest challenges Kiwibot faced during the pilot was establishing small business use cases.** Developing a market with participating businesses and a robust customer base takes time, marketing resources, well-designed technology, and more. There were issues with onboarding restaurants, integrating technology platforms, and ensuring that there was enough demand for delivery to support the service. For example, some of the businesses Kiwibot partnered with during the pilot did not have delivery as an option previously and/or did not have a well-established online presence, so getting them set up for delivery was complicated. As a result, Kiwibot determined during the pilot that working with small, local businesses was difficult and ultimately not yet scalable.
- Aside from the other challenges and limitations of working with small businesses, **Kiwibot's delivery radius of 1-1.5 miles substantially limited the potential customer base.** These factors contributed to the limited number of real deliveries that were made during the pilots.

OBJECTIVE 2

Educate and engage with community members about this technology to better understand how the application of it can best align with community needs.

Key Question: What are initial reactions/responses from community members?

- **Curiosity was a common initial reaction** from many of the community members that were engaged throughout the course of the pilot, as reported in the weekly calls with city staff. The SJSU students who conducted intercept surveys and community interviews corroborated this, suggesting that many people expressed positive initial reactions to the robots. They noted that when people were asked to describe their first reactions, many people used terms such as “surprised” and “curious.” “Cute” was also a common term that people used to describe the robots.



Complicated intersections near the Valley Fair Mall in San José were difficult for the robots to cross. (Google Maps screenshot)

"Yeah, at first, I thought they were kind of funny looking. They're like, a little bit cute, you know? And my first thought was, how does it know if there's anything in front of it? Like, what if it runs into something and I was concerned about that, but I think the idea is really cool."

- San José community member comment to SJSU students

- **Children, in particular, enjoyed interacting with the robots.** During the follow-up calls with Veggielution program participants in San José who received a delivery, many people mentioned how much their kids enjoyed getting to see and experience the robots.

"We liked everything, it was a fun moment for the kids and eye-opening to the way modern technology is advancing."

- Veggielution delivery recipient

"I liked that the kids were amazed by it, they had a fun experience and it was nice to have vegetables delivered for free."

- Veggielution delivery recipient

- While curiosity was a common initial reaction, **the responses were mixed and others expressed a disinterest in seeing robots on city streets.** During the first virtual community meeting in Pittsburgh, many people voiced concerns about the deployment of robots and expressed displeasure with the pilot. Others noted that they did not see the utility of the robots.

"Don't want robots, will take away jobs, but most significantly, I just don't feel a need for it - I'd prefer to walk or trust a human to get me food in one piece."

- Comment submitted through EngagePGH

"I'd rather see people come to my door, not a robot."

- San José community member comment to SJSU students

- **Many stakeholder groups involved in exploratory discussions about potential use cases expressed an appreciation for being invited to participate in discussions about new technology,** even if the use cases did not come to pass. City staff in San José noted this after conducting 15+ exploratory conversations with local organizations and nonprofits, as did city staff in Detroit after Kiwibot spoke with members of the Corktown Business Association. Community liaisons in Miami-Dade also expressed their excitement to see the technology up close during the demonstration event.

Key Question: What concerns do community members have?

- **The most commonly cited concerns community members expressed were about safety, privacy, vandalism/theft, and impacts on jobs.** People also questioned the practicality of the service, how accessible it is to people who are either not familiar with technology or do not have smartphones, and how it might impact people with disabilities.

"I am concerned that in the future, this technology will take over people's jobs and people will be out of work. It's not clear how this technology can or will be used."
- Veggielution delivery recipient

"I always wonder if somebody's going to attack the robot or abuse the robot. So it seems sort of defenseless out there. You know, just kind of slowly creeping around the streets. And so I guess that's one thing I think about, but I love the idea of being able to have deliveries that don't require cars and gas."
- San José community member comment to SJSU students

"Lack of infrastructure for safe operation. Broken delivery robots will be a blight all over the city. Road and sidewalk hazard. And finally, a target of theft or acts of mindless vandalism. Like we see today with the electric scooter rentals."
- Comment submitted through Move San José

"My only concerns involve their reliability, I think it's definitely worth a try but since they are unsupervised I'm not sure how they respond to getting stuck or if someone tries to steal one."
- San José community member comment to SJSU students

- **A good outcome of the pilot and the community engagement is that Kiwibot updated its data privacy policy as a result of discussions with community members in Pittsburgh.** The Bloomfield Development Corporation said they would not support the pilot unless Kiwibot responded to the concerns raised by community members, which proved to be effective.
- A stakeholder with the San José Federation of the Blind interviewed by SJSU students **questioned the usability of the robots for people with limited or no sight:**

“So with a sighted user, if you get within 20 yards of the robot, it’s highly likely that user will see the robot and can navigate toward it...and complete the transaction. So with a blind user, right? I mean, you could be five feet away and not realize that you’re near the robot. If it doesn’t make a certain sound or you don’t hear it or you know, you don’t know exactly where its location is.”

Key Question: Can robots potentially fill unmet needs that community members have?

- **People identified potential benefits the robots could have**, such as reducing car traffic, which would have positive environmental impacts. **In terms of ways that robots can be used to fill unmet needs**, some community members mentioned the potential to support people who are homebound by delivering necessities such as meals, medicines, or basic goods. Some of the community liaisons in Miami-Dade noted that robots could potentially make a lunch break more enjoyable by eliminating time spent traveling or waiting in line to get a meal.

“There is an advantage because a delivery robot keeps people from having to leave the house and this could be beneficial for people who have difficulty doing that, especially in a pandemic it may help prevent so many people from having to go to stores and possibly get sick/encounter other dangers.”
- Veggielution delivery recipient

- **If the robots can deliver items that otherwise would not have had a delivery option, they might be able to fill an unmet need.** For instance, all of the Veggielution delivery recipients noted that they would be interested to receive a delivery in the future and many mentioned the convenience of not having to pick up their produce box. In that instance, if robot delivery had not been an option they would have had to pick up the items themselves.

“Yes, it was good because I have unreliable transportation so this was a secure way to receive the box.”
- Veggielution recipient

- In situations where other delivery options are available, however, people may be less likely to choose robot delivery. While people noted the potential benefits of the service and some expressed interest in trying it for the novelty factor, **some people noted that they could not see using it regularly due to the limited delivery range, as well as the limited storage capacity.**

OBJECTIVE 3

Work with private sector companies testing these products to identify challenges and opportunities, with the goal of ultimately delivering positive societal outcomes for community members.

Key Question: What value do local agencies derive from partnering with private sector partners on pilots and vice versa?

- **Doing the pilots enabled cohort staff to develop an understanding of the state of the technology that they would not otherwise have had and to cut through some of the hype.** At the outset of the pilot, cohort staff felt a sense of urgency around sidewalk delivery robots and thought they would need to prepare a permitting process by the end of the pilot. Seeing the technology up close and experiencing some of the difficulties in deployment and scaling helped cohort staff determine that more piloting is needed and that they have more time to develop processes before sidewalk delivery robots are ubiquitous on city streets.



A child sits in front of a robot during a community event in San José.

- **Kiwibot staff reported getting substantial value from partnering with the cohort.** They gained insights about the types of infrastructure data that are most valuable to local agencies, and they were able to test small business use cases and refine their business model. At the outset of the pilot, Kiwibot was interested in working with small businesses but over the course of the pilots they developed a better understanding of the challenges associated with that business model. Based on their experiences with the pilots, Kiwibot began to investigate a business model based on using robots to collect infrastructure data that could be valuable to cities. During a cohort-wide meeting, cohort staff laid out what types of data they wanted and the formats needed to make the data usable. This level of access to cohort staff proved valuable for Kiwibot.
- **Cohort staff learned a lot about designing and managing pilots in partnership with early-stage testers.** On the one hand, Kiwibot was a willing and enthusiastic partner who agreed to work collaboratively with the cohort and without their partnership, the pilots would not have happened. On the other hand, they lacked expertise in key areas and were not always able to deliver on promises made. For instance, Kiwibot provided cohort staff with a data dashboard with information about deliveries, robot operations, and the quality of the local infrastructure, but there were serious functionality issues with the dashboard that were unable to be resolved before the pilots ended.

Street Scouting



Screenshot of Kiwibot data dashboard for Pittsburgh.

- **Both Kiwibot staff and cohort staff gained an understanding of the amount of work it takes on both sides to pull off a truly collaborative partnership.** Cohort staff and Kiwibot staff met weekly during the pilots, regularly attended events together, and were in consistent communication throughout the process. Given the amount of work involved, there was some disappointment on the part of the cohort staff that the pilots did not yield more quantifiable results. The number of deliveries were minimal, in part because working with small businesses proved to be more difficult than anticipated, and questions about the quality and accuracy of infrastructure data collected by Kiwibot remained at the end of the pilots.
- **Doing a pilot in Pittsburgh enabled both city staff and Kiwibot to test out the new PDD permitting process that was enacted by the Pennsylvania Department of Transportation and identify issues to address.** For instance, per PennDOT's process, a requirement of Phase 1 is for a human to stay within 30 feet of the robot for the first 90 days, but there is no guidance on the minimum number of robots that need to be in operation in Phase I or any requirements around allowable jumps in scale. As currently written, an operator could have one robot out with one human for the first 90 days and then they could deploy 100 robots after 90 days with no humans nearby. DOMI staff were able to flag this as a potential issue for PennDOT to consider moving forward. Kiwibot also benefited from partnering with the City because city staff helped them navigate the process with PennDOT—this proved particularly beneficial as Kiwibot was the first company to go through this permitting process. If they had just applied for a permit directly from PennDOT without the City's support, they would have had to navigate the process on their own.

SECTION 5: RECOMMENDATIONS

Here we offer our top five takeaways, following by a set of recommendations for both public and private sector entities interested in pursuing similar or related efforts.

TOP FIVE TAKEAWAYS

- **Events and demonstrations were the best ways to engage community members and onboard them into a new experience.** Cohort staff felt that the most valuable engagement came from events and demonstrations where community members were able to directly interact with the technology. These opportunities gave residents the ability to experience the technology on their own terms, such as through the partnership with Veggielution in San José where interested participants could opt in to receiving a delivery by sidewalk robot. These kinds of low-stakes engagement opportunities are important and illuminating.
- **Pilots should test with low-stakes deliveries.** Given the challenges discovered throughout the pilots, such as navigating large intersections and other issues in the built environment, this technology is not ready to fulfill essential community needs. Opt-in models where the person receiving the delivery is not dependent on the success and timeliness of the delivery for essential services is the responsible way to deploy these technologies at this stage of development.
- **Partner selection—technology providers and local partner businesses—is crucial to success.** The relative size and maturity of an AV and new mobility business may impact willingness to collaborate, with newer start-ups more willing to collaborate and engage with cities than larger and more advanced companies. Kiwibot was a willing and enthusiastic partner, but they lacked expertise in some areas at the outset of the pilots, such as in their understanding of infrastructure conditions and associated data. Kiwibot worked to improve their products over the course of the pilots, but their lack of experience presented challenges for the cohort at times. Additionally, Kiwibot and cohort staff discovered that it is more difficult to bring local, small businesses into these pilots without long timeframes and significant support to help onboard the local businesses with incorporating the new technology.
- **There is value in city-level control while business models and technologies are maturing but not yet ready to scale.** Robots had a difficult time navigating the built environment in some places, particularly in areas with wide intersections or poor sidewalk conditions. They also had a limited delivery range, which was one reason it proved difficult to formulate partnerships with local businesses. Cities benefit from being able to have local control while the built environment issues with this technology are being resolved and the business models are being refined. At this point, it would be challenging to enact flexible and enforceable enough state-level rules given the numerous implementation issues.
- **A cohort model adds value and leverage.** Having the four cohort locales pilot the same technology simultaneously with the same private sector partner enabled staff to share learnings and resources in real-time. They collaborated on MOUs, data sharing agreements, and engagement materials. By working together, they were also able to make collective asks of Kiwibot that they may not have been able to do on their own. At the same time, Kiwibot gained valuable insights from cohort staff, such as the types of infrastructure data that are most valuable to local agencies.

PLANNING A PILOT

- **Set clear expectations of roles and responsibilities, discuss contingencies during the planning stages, and have a plan for what happens at the end.** Both cohort staff as well as Kiwibot staff expressed that if they could go back to the beginning, they would have been more clear about who was responsible for what, such as who was expected to identify local businesses with whom to partner. They also wished they had had more contingency planning conversations given the experimental nature of the pilots. For instance, it proved to be very difficult to set up deliveries with small businesses as originally intended. Because Kiwibot was receiving funding from the cohort to test different use cases, there was an expectation that if one use case did not work out another would be identified, but there was a lack of clarity on who was responsible for identifying new or additional use cases. Additionally, an MOU or operating agreement should have a clear wrap-up plan. Some of the MOUs had ambiguous endings, which created unnecessary confusion.
- **Create a reasonable scope of work that can be carried out in the allotted time frame.** Some members of the cohort suggested that they tried to accomplish too much by tackling multiple use cases and deployment areas. In retrospect, they wished they had been more limited in the initial scope and had taken a phased approach. They could have extended and/or expanded the scope as they learned more about the technology and if/when certain milestones were reached.
- **Demo events and pilots have different benefits— it is important to think about what needs to be accomplished when deciding which to pursue.** Members of the cohort felt that some of the pilot objectives could have been accomplished with short demos rather than a 6-month pilot. They could have tested the technology without trying to set up partnerships with local restaurants, which proved to be more difficult than anticipated. Six months was not a long enough timeframe to integrate with local businesses and restaurants, establish a new delivery service, and establish a customer base, but key demos that provided opportunities for community engagement and staff learning could have been accomplished in fewer than six months.
- **Think outside of the box and stay flexible.** When thinking about possible use cases to test during the pilot, members of the cohort reached out to a wide variety of stakeholders to discuss if/how sidewalk delivery robots could be put to use to support their work. These conversations generated some creative ideas and led to new partnerships, such as with Veggielution, that likely otherwise would have not been established if the public and private sectors had not been working together.



Two people pull out their cell phones to take a picture of a robot operating on the sidewalk on Liberty Ave. in Pittsburgh.

- Plan a demo event for staff during the pilot planning stages whenever possible.** Because of the circumstances with COVID-19 during the early planning stages, most members of the cohort had not seen the delivery robots up close before the pilots began. In retrospect, this would have been beneficial because it would have helped staff know what questions to ask of Kiwibot during the planning stages. Members of the cohort wished they had asked more questions about the conditions the robots could operate in and what Kiwibot's process was for onboarding new restaurants. They also wished they had had a better understanding of the robot's technical specifications and constraints. In the end, Kiwibot promised more than they could deliver during the pilot given the state of the technology, as well as ongoing challenges due to COVID-19. Building a team for in-field operations proved more expensive and challenging for Kiwibot than anticipated, for example. A demo event for staff may have helped both parties identify the questions they needed to ask of each other.
- To get the most value out of a pilot as possible, have a dedicated staff person who can attend events and be involved in the day-to-day operations.** Cohort staff who were able to focus more of their time and energy on the pilot were able to glean more value from it. For instance, staff in San José and Pittsburgh said that if they had relied solely on what Kiwibot was reporting when they went to events, their understanding of public opinion would be fairly limited.



Community liaisons receiving an order during a demonstration event in the Brickell area of Miami.

CONDUCTING OUTREACH AND ENGAGEMENT

- Reach out to stakeholders as early as possible.** Staff in San José conducted a number of stakeholder interviews with local organizations and nonprofits and had many good conversations. That outreach ultimately led to the partnership with Veggielution, which enabled the city to test the delivery of farm boxes to low-income families who expressed interest in participating in the pilot. Delivering only to people who opted in may have biased the findings, but we explicitly did not want to test a new technology on this population without their express buy-in.
- Engage local universities.** Partnerships with San José State University and Carnegie Mellon University enabled city staff to do more than they could have done on their own, and provided learning opportunities for local students.

- **Plan to have public and private sector staff attend community events together.** There were many instances where members of the cohort attended local events along with Kiwibot staff, which was beneficial in many ways. Kiwibot staff could answer technical questions about the robots while cohort staff could speak to the larger pilot objectives. These events also enabled cohort staff and Kiwibot staff to deepen their working relationships and build trust, and to convey a mutual commitment to engaging with community.
- **Consider a community liaison model whenever possible.** Staff with Miami-Dade County expressed a high level of satisfaction with the work done by UHP to hire and train community liaisons who live in the neighborhoods Miami-Dade is serving. Miami-Dade plans to make this a new model of engagement for the County.

BUILDING ORGANIZATIONAL UNDERSTANDING

- **Ensure there is a way for learnings to be shared across teams/departments to maximize the value of a pilot.** The staff involved with the pilots learned a lot about the state of the technology, but all the cohort members agreed that there are no organizational processes in place that enable them to share their learnings with other teams and/or departments. As a result, all of those learnings largely live with just the one to two people directly involved with the pilot and that knowledge is easily lost during staff transitions. To prepare for a future with more automated mobility technologies, there need to be more opportunities for important learnings to be shared. Staff in Miami-Dade suggested that short, easy-to-digest documents and/or presentations that could be passed on to other agencies/ departments would be useful.
- **Engage other jurisdictions as well as other teams/departments.** In Detroit, robots had a difficult time making it across Michigan Ave. before the light turned red, which indicates that a longer pedestrian crossing may be needed to better accommodate pedestrians. However, Michigan Ave. is managed by the Michigan Department of Transportation (MDO) rather than the City of Detroit. Learnings like this one get lost if the right people are not involved in the conversations.
- **Be open to strategically testing new technologies.** The people sitting in leadership positions in a public agency make a big difference in the approach the agency takes to new, emerging, and/or automated mobility, and finding the right balance is key. Cohort staff said that it is important to have people in leadership positions who foster a culture of innovation and willingness to test or pilot new technology but who also do not move too fast. Extreme approaches on either end of the spectrum—saying only “yes” or only “no” to new technology—will not set an agency up for success in the long run. Ultimately, there is value in doing thoughtful testing or piloting to help agencies prepare for automated mobility technologies.

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Five robots lined up on a sidewalk in Brickell.





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