2021
Personal Delivery Device
Final Pilot Evaluation

May 2022

Table of Contents

Executive Summary

About the Pilot

In July 2021, the Pittsburgh Department of Mobility & Infrastructure (DOMI) launched a six-month personal delivery device (PDD) pilot ("Pilot") with 1 vendor and 10 PDDs in a 1.5 square mile radius in the Bloomfield, Lawrenceville, and Garfield neighborhoods. The Pilot aimed to better understand what role PDDs play as a potential delivery option in Pittsburgh; the operational challenges PDDs present and the ways they can be mitigated; and how effectively PDD vendors can operate while promoting increased delivery options and access for everyone. The Pilot concluded on December 15, 2021 and this report reflects the learnings from throughout its duration.

Pilot Overview

Pennsylvania Senate Bill 1199/Act 106

On October 20, 2020, the Pennsylvania Legislature passed Senate Bill 1199, authorizing and defining personal delivery devices. On November 1, 2020, the bill became law without the Governor's signature. SB 1199 includes PDDs under the definition of "pedestrian" and defines a PDD as a ground delivery device manufactured for transporting cargo or goods, operated by a driving system that allows remote or autonomous operation, or both, and weighs less than 550 pounds without cargo.

The bill provides PennDOT with general and sole authority over PDDs and preempts local authority over PDDs except in instances where the local authority determines, after consultation with the PDD operator, that operation of the PDD constitutes a hazard. This law limits the City's ability to oversee or regulate PDDs on city streets and sidewalks. However, DOMI worked with community members and stakeholders to submit comments to PennDOT while the department developed policies governing the authorization of PDDs.

On January 30, 2021, SB 1199 went into effect and PennDOT published its "[Personal Delivery Device (PDD) Operations Policy](#)" and began accepting applications from companies seeking to operate PDDs in Pennsylvania.

Pilot Planning

After SB 1199 went into effect and PennDOT published its PDD Operations Policy, DOMI knew it was critical for leadership and staff to learn more about this emerging technology and the implications this shift in delivery services could have on our public space. The City already had grant funding from the Knight Foundation to focus on community-driven automated or "self-driving" technology pilots, along with other grant cities (San Jose, Detroit, and Miami-Dade County).

DOMI staff recommended using the Knight Foundation funding to launch a PDD pilot aimed at better understanding what role PDDs play as a potential delivery option in Pittsburgh; the operational challenges PDDs present and the ways they can be mitigated; and how effectively PDD vendors can operate while promoting increased delivery options and access for everyone. DOMI staff began outreach to Registered Community Organizations (RCOs) and Business Improvement Districts (BIDs) to identify a willing community partner to assist with shaping the pilot and facilitating community engagement.

Following conversations with a number of RCOs and BIDs, the Bloomfield neighborhood was identified as an ideal location for this pilot, in part due to its diverse demographics, wide sidewalks on commercial streets, engaged community group, and high number of small, locally

owned businesses. After conversations with additional communities and local businesses, the pilot area was later expanded into portions of Garfield and Lawrenceville.

With support from the Knight Foundation and collaboration with the other grant cities (San Jose, Detroit, and Miami-Dade County), Kiwibot was selected as the PDD provider for this pilot. Kiwibot was selected in part because of its small, slow, remotely operated PDDs, its willingness to have a collaborative relationship with municipalities, share data, and participate in public engagement alongside City staff.

After identifying an ideal location and willing provider, DOMI proposed the pilot concept to the community at virtual meetings hosted by Bloomfield Development Corporation (BDC) in April and June 2021. During these meetings, the community provided input on the proposed pilot, which led to the implementation of an emergency response plan, the EngagePGH page, and an FAQ. More information on the community meetings can be found on the EngagePGH project page as well as on Bloomfield Development Corporation's website.

Pilot Launch

In July 2021, the Pittsburgh Department of Mobility & Infrastructure (DOMI) launched a six-month personal delivery device (PDD) pilot ("Pilot") with 1 vendor and 10 PDDs in a 1.5 square mile radius in the Bloomfield, Lawrenceville, and Garfield neighborhoods.

The Pilot took a phased approach, as required by PennDOT, with only 1 or 2 robots initially operating to do mapping with a human supervisor within 30 feet of the device and available to answer questions from residents and visitors who passed by or interacted with the robot. Kiwibot then gradually began operating more robots in the public space. In September 2021, Kiwibot was granted authorization from PennDOT to begin operating remotely ("Phase 2"), without the requirement of a human supervisor staying within 30 feet of the robot. After Kiwibot was authorized to enter Phase 2 of operations, it began offering deliveries for local businesses at no cost to the business or customer.
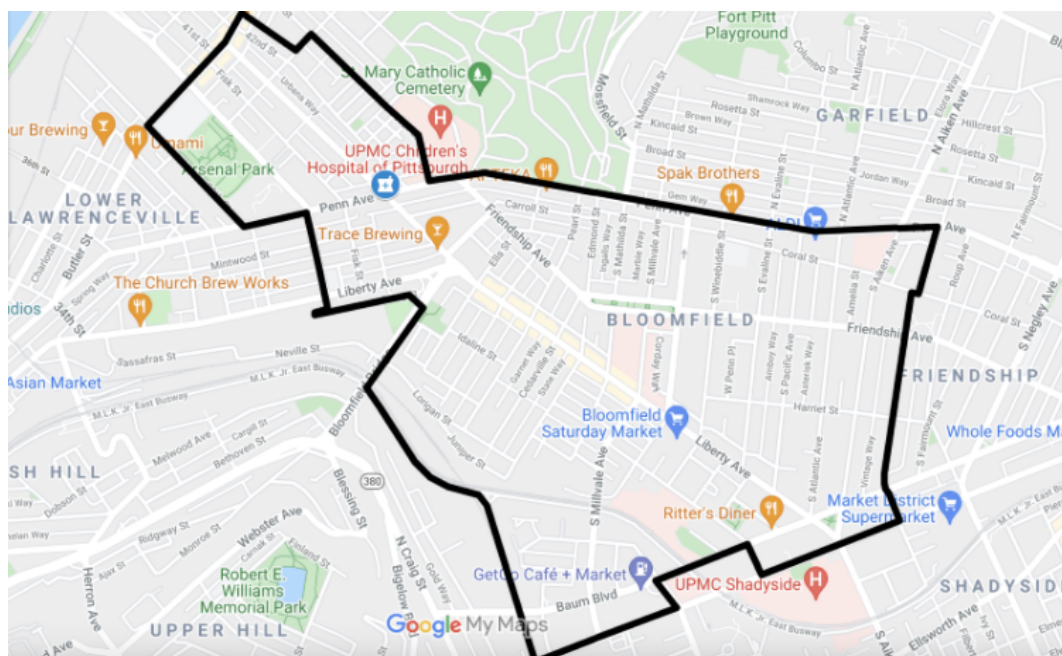
Local Partners

During the Pilot, DOMI and Kiwibot partnered with local businesses and non-profit organizations to offer deliveries using the robots. Access to the dashboard was provided after the NDA was signed. The following are those local businesses and non-profits and the use cases being explored:

- **Carnegie Library of Pittsburgh**

    - Delivered books and educational materials to youth

- **Wilson's Pharmacy**

    - Delivered over-the-counter goods and medications to customers, with a focus on seniors and customers with travel limitations

- **Taquitos**

    - Individual meal deliveries to customers

- **Assemble**

    - Hosted public demos and education sessions with the public

- **Carnegie Mellon University**

    - Performed observational research study on Kiwibot rollout

The business and non-profit organization partners were selected, in part, because they provided an essential service to the community and were either locally owned and operated or not-for-profit. Kiwibot also worked with the Center for Victims to introduce the delivery robots to service animals who may encounter the Kiwibot robots or future providers in the public space.

PDD Operations and Deliveries

Operations

Month	Miles (operations)	Miles (mapping)	Miles (demo)	Total Miles	Avg. Miles per week
July	29.59	46.24	13.25	89.08	22.27
August	55.49	38.80	0.48	94.77	23.69
Sept	212.96	21.05	7.39	241.40	60.35
October	42.90	0.00	0.00	42.90	42.90
November	236	12	1	249	62.25
December	116	0	4	120	60

*Note a significant increase during September, due in part to the fact that Kiwibot was permitted to begin operating in Phase 2, allowing several more robots to operate at a given time.

Orders

Month	Simulated Orders	Real Orders
July	31	0
August	59	0
Sept	215	3
October	41	0
November	655	6
December	399	0

Simulated orders are orders artificially created by Kiwibot in order to provide social interactions between robots and pedestrians. The City of Pittsburgh was interested in the insights provided by these interactions and they were also used in CMU's observational research study. A delivery robot travels from a origin point to a destination point in the operating area, but there is no real customer or cargo involved.

*Note after the pilot there have been some issues with the dashboard data consistency. All figures from October through December have been taken from the Pittsburgh dashboard after the pilot's termination. While some figures have been inconsistent they aren't far enough away to change DOMI's position so the recommendations from DOMI remain the same. Kiwibot would also like to note that PennDOT did not approve continued mapping in other networks despite Kiwibot meeting its requirements during phase one of operations.

Safety and Compliance

Internal Incidents (reported by Kiwibot) **-** issues that occur during operations related to the software, cameras, sensors, connectivity, etc.

Examples include signal latency, software and hardware issues, command issues, and navigation issues (e.g., robot gets stuck).

Month	Internal Incidents
July	30
August	17
Sept	74
October	84
November	97
December	32

*Note a significant increase during September, due in part to the fact that Kiwibot was permitted to begin operating in Phase 2, allowing several more robots to operate at a given time.

External Incidents (reported by Kiwibot) - issues or events that occur involving third parties

Examples include crashes with vehicles or pedestrians, vandalism, and 3rd party damage to the robot.

Month	External Incidents
July	0
August	0
Sept	7
October	7
November	3
December	0

*Details of External Incidents can be found in Appendix A.

3-1-1 Service Requests - Only one 3-1-1 request has been received during the pilot period. The submitter stated a concern for friends that are blind or have low vision and that they felt uncomfortable with the robot on the sidewalk and felt as if the robot would have run into them if they did not move aside when approaching the robot on a sidewalk.

Community Outreach

Pre pilot launch:

- Feb - April 2021 - Biweekly meetings between DOMI and BDC
- April & June 2021 - Two open community meetings hosted by BDC
- June 2021 - Launched EngagePGH website

Post pilot launch:
- Ongoing   - On-street engagements during operations
- Ongoing   - Visited areas outside of the operating area with the robots
- 07/31/2021 - Attended Bloomfield Saturday Market
- 08/17/2021 - Convened Steering Committee
- 08/28/2021 - Attended a youth event hosted by the Carnegie Library
- 09/14/2021 - Demo with Steering Committee
- 09/21/2021 - Attended Lawrenceville Farmers' Market
- 11/2021   - Five demos/education sessions held over the course of the month with Assemble in Garfield
- 12/15/2021 - Carnegie Mellon releases results of observation surveys of robot/pedestrian interactions
- 03/30/2022 - Convened Final Steering Committee

Learnings

General

- Residents and community member organizations value the opportunity to be part of the conversation around emerging mobility technologies. There is value in early community conversations and pilots around new technologies. Communities working together will be better prepared for emerging technologies, including personal delivery devices.

Learnings by Key Research Questions

- **Can PDDs be deployed on sidewalks without creating safety or accessibility issues for other users?**

  DOMI, PennDOT, and Kiwibot have not determined exactly what makes for a safe operating environment but have identified a number of metrics (number of complaints filed, number of reported device related injuries or fatalities, perception of safety).]As shown in the previous section of this report, there were few complaints and no reported injuries during the Pilot.

  The limited number of PDDs (never more than 10) operating at any one time made it difficult to determine how many PDDs can operate at the same time proximate to each other and still operate safely. The robots operated in a small area and documented the interactions and impressions in those neighborhoods but more sample data is needed to draw an accurate conclusion.

  According to a recent report about PDDs by the Pedestrian and Bicycle Information Center, "...wheelchair users require a corridor at least three feet wide for passage. They also need four feet of lateral space plus additional room to maneuver; therefore, with PDDs allowed to share and potentially block sidewalk space, communities will need to consider ways to expand and ensure passable spaces (six to eight feet wide) and access points such as doorways and curb cuts." This report also noted that, unlike robots used in warehouses and industrial settings, there are no safety features like bumpers, power buttons, or bars to grab to right PDDs that have tipped over or to manually stop them. While the company that caused controversy over this issue was Starship and Kiwibot has operated according to Pennsylvania's regulations for PDDs on sidewalks, the issue of sidewalk space has the potential to be a sensitive issue.

- **What's the necessary infrastructure/conditions for PDDs to operate? (e.g. curb cuts, sidewalk widths, street connectivity, etc.)**

  During the pilot, we observed the following requirements for operation:
  - Curb cuts (unobstructed)
  - Street crossing that does not require pushing a crosswalk button
  - Clear path with a minimum width (undetermined at this point)
  - Relatively smooth pavement
  - Robot connectivity to remote operator
  - Well-functioning storm water system
  - Clear weather (little to no rain or snow)

  It is worth noting that most of the necessary infrastructure required for PDDs to operate are also necessary for human pedestrians to safely and comfortably navigate the public space.

  Kiwibot did map the Garfield neighborhood in Phase 1 of operations; however, Kiwibot noted that there are many places in Garfield that the robot cannot operate due to infrastructure limitations such as cracked sidewalks, lack of sidewalks, etc. Kiwibot also can't operate if there are things blocking the sidewalk such as overgrown trees or bushes or if cars are parked blocking the sidewalk, etc.

- **Can the Pilot (and future pilots) cover their costs or will they need subsidies to operate in the future?**

  PDDs are most likely to be successful in high density areas with high income earners. Subsidies (paid for by government or non-profits) may be necessary in lower density locations or to lower income populations.

  Specific to this pilot, Kiwibot could not cover its costs. For a variety of reasons related to Pittsburgh's layout including topography and distance between business and delivery location there was minimal demand for the service in the Pilot use cases. This is not to say there may not be demand elsewhere; for instance, Kiwibot believes that demand exists in the business-to-business (B2B) market but in the areas tested Pittsburgh lacked the density required for PDD delivery service.

  The Pilot use cases were not sustainable beyond the life of the Pilot and there is no future funding secured to cover the full operational costs of the service, as there has not been enough demand. However, Kiwibot has expressed interest in a B2B or university partnership to continue operations in Pittsburgh and other locations in Pennsylvania.

- **Who adopts PDDs and why?**

  Kiwibot and other PDD operators are still exploring use cases. These markets may be evolving, especially as communities continue to respond to the Covid-19 pandemic and new variants. However, during this pilot deliveries and survey responses were minimal.

- **Can PDDs meet a defined community need?**

  At the start of the pilot, Kiwibot found that less than 30% of local businesses in Pittsburgh have their own ordering platform and therefore depend on third parties for deliveries. Those third parties rarely, if ever, share customer data and often charge extensive fees to drive volume.

  The use cases deployed during the Pilot period did not meet the delivery needs of small businesses or add a true value to residents. Due to low demand for deliveries, only small numbers of meals, goods, medication, and books were delivered by the PDDs.

- **How accessible is the technology to target users? Are there identified barriers to use?**

  Use of the PDD delivery service was very low throughout the Pilot. The surveying and outreach did not determine whether low delivery numbers are due to lack of demand for the service or potential customers being unaware of the pilot service.

  Similar to the previous question, the pilot highlighted the difficulty for small businesses and nonprofits to adopt a new technology or service, particularly for a limited pilot period. It remains unclear whether there was a lack of demand from customers or whether the barriers small businesses and nonprofits face in marketing and modernizing inventory tracking, result in lack of awareness of the delivery service and ease of use for customers, thus, lack of demand.

  For this delivery service to be successful and meaningful to small businesses and nonprofits, it seems that PDD operators will either 1) have to provide significant infrastructure and technical assistance to bring small businesses and nonprofits on board in a way that sets them up for success, or 2) partner primarily with large companies that have the staff, skills, and resources to integrate new technologies and services into their business models.

City of Pittsburgh Comments and Recommendations

Learnings on PDD Deployments

- **PDDs need increased demand and presence high-traffic areas in order to scale**

  During the planning stage, PDDs were seen as a potential option for local delivery for businesses and the Knight Foundation provided financial support to pilot this potential solution. Early during the planning period, there was high community interest and concern, and notable press coverage regarding the PDD pilot; however, over time DOMI observed a decrease in community interest and press coverage. In theory, PDDs would be ideal for local, last-mile delivery, but in reality only a small fraction of local businesses involved perform deliveries and an even smaller number of those deliveries occur locally in that last mile. This pilot demonstrated that for PDD delivery services to generate enough revenue to be sustainable, PDD providers will need to launch in places with a higher density of customers in the last mile.

- **Partner integration is a major hurdle for deployment**

  In their research, Kiwibot found that only 30 percent of local businesses in Pittsburgh had some form of ordering platform. In order for the Kiwibot platform to work flawlessly digital inventory systems are necessary in order to know what each business has in stock. Ideally, an online ordering platform for handling transactions would also be in place. For some participating businesses, delays in service launch and lack of demand occurred in part because the business had no digital inventory system in place, meaning there was no way to know how much of a given item was available. While there was integration between Kiwibot and the Shopify platform for purchases delivered by PDDs, there were still communication issues between platforms for participants and Kiwibot. Even when there was a system in place, other issues arose such as outsourcing website management to a third party created difficulty with communication between platforms. In future deployments DOMI would recommend more time be spent working with the small businesses to provide resources and support for a digital inventory system, as well as improved communication between both partners and the customer base.

- **PennDOT's Permitting Process remains an area of concern**

  During their first phase of operation, companies are permitted by PennDOT to deploy PDDs as long as they have an operator within 30 feet and in view of the device. The ratio during this time is also kept at one operator to one device. After the initial phase, operators are no longer required to have line of sight of the device and are able to operate several at once, with the limit being fairly high.

  Reviews should be put in place to determine if the service provider has adequately performed to the desired expectations before entering "phase 2" of operations..

Recommendations

- **Data Privacy is a concern for the public, Data Privacy Policies should be issued to address this concern**

  After public meetings and engagement with community organizations where data privacy concerns were raised, DOMI requested Kiwibot's data privacy policy. Upon learning that Kiwibot did not have a public-facing data privacy policy, DOMI required a policy to be drafted and published by Kiwibot before operations continued. Kiwibot complied in a reasonable time period and that policy is published on Kiwibot's website.

  This highlights the importance of community engagement and feedback loops to provide opportunities for the public to raise concerns to DOMI as the city is learning about new technology and services. In this case, community feedback resulted in a material policy implementation for a company who's operating in several jurisdictions.

  Additionally, it is a reminder to DOMI and all local governments that we can't assume young, start-up companies have all of the necessary formal policies in place. The willingness of public and private sectors to coordinate and share learnings can result in improved policies and services.

  For future deployments, it is recommended that a company's data privacy policy is reviewed by both PennDOT and DOMI before an operator is authorized to deploy. Further, any authorized entities should be required to publish their data privacy policy before any PDDs begin operating in public space.

- **Quality Assurance Measures Need Improvement**

One key component of this pilot was Kiwibot's commitment to providing DOMI and the public with data on travel and delivery times, number of orders, internal and external incidents, as well as infrastructure conditions, such as curb ramp condition, sidewalk condition, sidewalk obstructions, intersection/crossing, lighting and visibility.

Though this data component is a new service Kiwibot is exploring and some issues were anticipated, overall the dashboard never got to a usable state and the data's accuracy was too unreliable for DOMI to use or to share with the public. It is worth noting though, that the overall plan for the pilot changed mid-way through and with that focus changing there was a movement away from the end goal of deliveries to the goal of insights from public interaction.

With this shift Kiwibot had difficulty conducting quality assurance measures that ensured accuracy of the data the Kiwibots were collecting. For this pilot, DOMI's higher priority was learning from the PDD operations in the public space, as opposed to the data collection; however, the data was a secondary benefit that DOMI was excited to have through this pilot, but which never came to fruition.

For future pilots, DOMI should refrain from partnering with a company for a service or relying on secondary benefits a company promises until the company has adequately proved its service is accurate and reliable. There was still benefit in understanding user interaction and how PDD deployments work even if these weren't the initial intent of the pilot. Kiwibot was able to develop an MVP during the pilot and is currently finalizing a product in partnership with another city that will then be available to other cities as a paid service.

Appendix A

Description of External Incidents

09/02/2021 - A robot was vandalized by 2 pedestrians who blocked its path, picked up the robot and threw it on its side in the grass. The robot did not seem to have suffered any obvious damage. Kiwibot staff responded to the scene and spoke with pedestrians who did not provide a specific reason for interfering with the robot.

09/13/2021 - A robot was kicked by a pedestrian. The robot did not appear to have suffered any obvious damage. Kiwibot staff responded to the scene and spoke with the pedestrian after the person tried to kick the robot a second time. No clear reason provided for kicking the robot other than dislike of the technology.

09/14/2021 - A pedestrian picked up a robot and threw it near a dumpster. The flag of the robot was broken as well as the screen and internal components. Kiwibot did not catch the person in time to discuss.

09/21/2021 - A robot turned a corner around a table at the entrance of the Lawrenceville Farmers Market and ran into the leg and foot of a patron. Neither DOMI or Kiwibot staff witnessed the impact, but immediately responded to the incident. The person who was impacted assured no injury resulted and did not seek to file a written statement or formal report to DOMI. DOMI alerted Lawrenceville United and Lawrenceville Corporation of the incident that evening.

09/23/2021 - A pedestrian kicked a robot and kept walking. Kiwibot staff identified the person after receiving a description of the individual by the remote supervisor but did not proceed to engage with the person. The robot did not suffer any obvious damage.

09/29/2021 - At the intersection of N. Evaline Street and Penn Avenue (a marked intersection with traffic signals), a robot was crossing Penn Ave in the marked crosswalk with a "walk" signal. A motor vehicle on N. Evaline Street made a left onto Penn Avenue, with a green light, but failed to yield to the robot crossing the intersection. The vehicle hit the robot but continued down Penn Ave. A Kiwibot staff member was just around the corner and responded quickly to remove the robot from the intersection before any conflict or obstruction arose. The robot was inoperable, suffering internal damage; external case scratching; and motor, wheel, and hub damage.

09/30/2021 - A pedestrian kicked a robot and kept walking. The robot did not tip over but the internal component was damaged and required minor repairs.

10/01/2021: Pedestrians attempted to steal the flag from a robot. Flag was broken and required replacement.

10/01/2021 - Three pedestrians intentionally stood in front of the robot blocking it. One person kicked the robot and the entire group kept walking. Robot did not suffer any obvious damage.

10/08/2021 - Pedestrian picked up a traffic cone and placed it on top of the robot. Robot did not suffer any obvious damage.

10/12/2021 - Pedestrian flipped over the robot. Flag broke and required replacement. Robot did not suffer any other obvious damage.

10/19/2021 - A person driving a car pulled over, came out of the car, and kicked the bot. They then kept driving. Robot did not suffer any obvious damage.

11/04/2021 - The robot was awaiting to get a simulated order. A pedestrian walked towards the robot and did graffiti on the lid. The message of the graffiti was "420 DOT GOV". Robot did not suffer any significant damage. On-site team socialized with the pedestrian about the pilot and the goals of it.

11/07/2021 - The robot was navigating and an individual riding a bike kicked it. Robot did not suffer any significant damage.

11/16/2021 - The robot was navigating and an individual kicked the robot. Flag broke and required replacement. Robot did not suffer any other obvious damage.

Service Request

09/24/2021 - Pedestrian was almost run over by the robot today. Person voiced concerns about a visually impaired friend interacting with robots and requested a follow-up call to discuss the matter. Several attempts were made to contact the individual for a follow-up conversation without any response.