City of Philadelphia

REPORT

SMART LOADING ZONES TO SMART GRANT FUNDED PROJECTS

KEY FINDINGS FROM THE PILOT PROJECT AND NEXT STEPS USING SMART GRANT FUNDS

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SUBMITTED BY

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EXECUTIVE SUMMARY

Project Name:	Smart Loading Zones Pilot Project
Partners:	Smart Cities team, OTIS, Streets Department, PPA
Pilot Period:	October 2022 – November 2023
Go Live:	October 17th, 2022
Enforcement Live:	November 1st, 2022
Closeout:	April 15th, 2023
Pilot Coverage:	21 active zones (2771 curb feet)

Project Objectives:

- Test technologies that enable digital curb space management
- Measure and monitor curb activity at loading zones.
- Develop a strategy for future use of technologies to digitize curb management.

Outcomes:

1. Highly granular curb data—assets, regulations, and activity—was collected and analyzed digitally, which would otherwise not have been possible.
2. The operational success of digital management of curb space was showcased.
3. New practices were developed to improve data privacy standards and procurement practices for pilot projects.
4. An evidence-backed pivot in strategy to digitize curb space management was developed.

Key Findings:

1. Manual inspection-based enforcement may be highly inefficient.
2. On average, the bookings and the enforcement scans could only capture 2% of curb activity.
3. Commercial loading makes up a small fraction of the loading activity.
4. Average dwelling times were more than time limits under current regulations.
5. Curb use and demand vary heavily by policy type.
6. CDS can be challenging to use for tracking non-compliant events.
7. The observed adoption rate of the app was approximately 1.97%.

Strategic Pivot:

1. Reorient from the “loading zone user” to the “right-of-way user.”
2. Compliance must be ubiquitous.
3. CDS must be extended to cover the entire Right-of-Way.

INTRODUCTION

The City of Philadelphia's Smart Cities team, in partnership with the Streets Department and Philadelphia Parking Authority, conducted a 6-month pilot project called Smart Loading Zones Pilot Project (the Pilot project). Sidewalk Labs (a Google company) was awarded the contract to provide such technologies and support the physical deployment in the Center City area. The Pilot project initially targeted 21 block faces where the curb spaces were already designated as "loading," with most restricted to commercial vehicles only.

The main objective of the Pilot project was to deploy and test leading-edge technologies that could enable City-wide digital curb space management in the near future. A total of five key technologies were tested. These technologies generated highly specific data about curb use by type of vehicle, booking capture rates, enforcement patterns, driver engagements, and loading activity. To use this data for evaluation, 5 of the 21 zones were monitored and analyzed using video recordings to develop baseline data. Data from these five baseline zones was compared to mid-deployment periods to assess the impact of the technologies. The Pilot project also provided the City with digitized mapping of all curb assets and regulations in Center City, University City and along South Street.

The Pilot project successfully demonstrated that curbs can be managed digitally. A new data set of all curbside assets and regulations was generated for the entire Center City, University City, and the South Street commercial areas. More importantly, it proved that digital tools could deliver regulatory changes to all curb users in real time. Two of the Smart Loading Zones initially selected for deployment had to be moved after input from local stakeholders on that block, and this change took only a few minutes to implement. Lastly, the Pilot project demonstrated that manual enforcement is highly inefficient, and a camera or sensor-based enforcement is the only way to ensure most curb users comply with posted regulations. Due to this project's "pilot" format, all operations had to be shut down by the end of the term in mid-April.

The focus on "loading" activity was too narrow for the City's broader adoption of the solutions. It allowed the Smart Cities team to evaluate various technologies' technical feasibility successfully. But it also kept most managers in partner agencies and most of large delivery companies from adopting these technologies since it did not solve most of their daily challenges. In March 2023, before the Pilot project was closed out, the Smart Cities team helped the Streets Department win an award for $2 million for a project that broadens the focus of digital management from "loading zone users" to "all right-of-way users."

USERS: THE CUSTOMER AND THE PARTNERS

The Pilot project's goal was to deploy and evaluate technologies that could enable City-wide digital management of curb space. But before we discuss the technologies we tested, it is important to define who was the customer (receiving services), the partners engaged in curb management (providing services), and the problems they have within the current system. The evaluation in this document is based on assessing how much, if at all, each customer could seek a solution for their specific problems through the technologies deployed in the Pilot project.

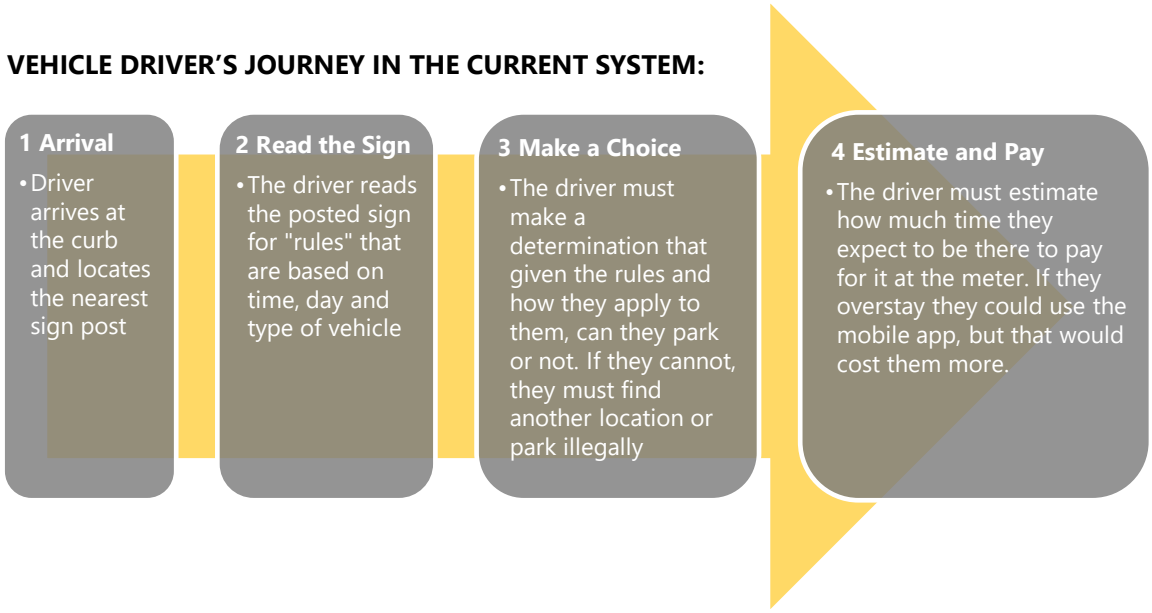
USER (ROLE)	USER NEED	USER CHALLENGE / PROBLEM
Vehicle Driver (the customer)	Use a loading zone quickly, safely and in compliance with regulations	Time and space constraints of finding and using a loading zone may be prioritized over compliance with posted regulations. There is lack of real-time discovery of available spaces and ability to pay-per-use.
Parking Enforcement Officers and the Agency (partner)	Enforce curb regulations by issuing citations to anyone parked illegally	Manual inspections are limited to how many times an officer can pass by a curb space over their service period in a day and by the low probability of driver parking illegally exactly when the officer is inspecting.
Streets Department Managers (partner)	Set curb regulations, issue street closures and study the use and allocation of curb space	Curb regulations are a narrow segment of the challenges faced within the realm of right-of-way management and lack of data prevents managers plan or regulate efficiently.

The City of Philadelphia has always regulated and enforced curb regulations through "analog" methods like posted signages. Vehicle drivers must navigate the information on signs to determine if they are allowed to park or not. But the digital tools allow the vehicle drivers to skip this step entirely. Of the three users, Pilot project focused heavily on the customer's or the vehicle driver's needs by providing the following services.:

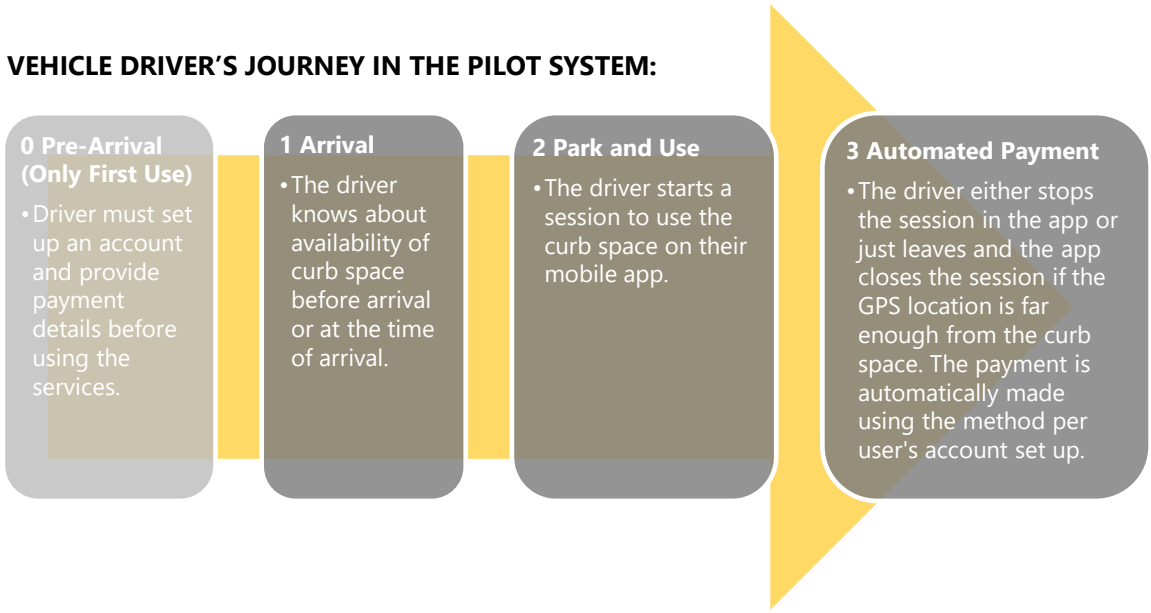
1. **Discovery and Reservation:** Ability to discover the real time availability of Smart Loading Zones (curb spaces) and the ability to book or reserve them for up to 15 mins if they were within ½ mile distance of that zone.
2. **Enhanced Enforcement:** If a booked loading zone was occupied for someone else, the user was able to inform the parking enforcement officers of illegal parking through the mobile app and seek another zone near the site.
3. **Convenient and Pay-per-use Payment:** A vehicle driver could either set up an individual account or a "Fleet account" to pay for smart loading zones using common

payment methods. Fleet accounts allowed fleet managers to pay for multiple vehicles through a single payment set up. Most importantly, unlike traditional metered parking payments where someone pays upfront for expected curb use time, the Pilot project allowed vehicle drivers to pay only for the time they used the curb per minute of use.

VEHICLE DRIVER'S JOURNEY IN THE CURRENT SYSTEM:



VEHICLE DRIVER'S JOURNEY IN THE PILOT SYSTEM:



TECHNOLOGIES TESTED

Through the Pilot project, the Smart Cities team deployed five different technologies that worked together to allow digital management of curb spaces designated as "Smart Loading Zones."

1. **Curb Data Specification (CDS)**: This technology is an API specification (Application Programming Interface – it's a type of blueprint for two computer programs to communicate with each other digitally). It was created by Open Mobility Foundation (OMF) in partnership with many cities (including the City of Philadelphia) and allowed us a way to turn analog regulations posted on signs along the curbs into pieces of digital information packets that can be transmitted over internet and understood by a computer or a smart phone using web or mobile applications. This technology complements traditional GIS-based data management and is not intended to replace it. This pilot project was one of the first projects in US to use CDS.

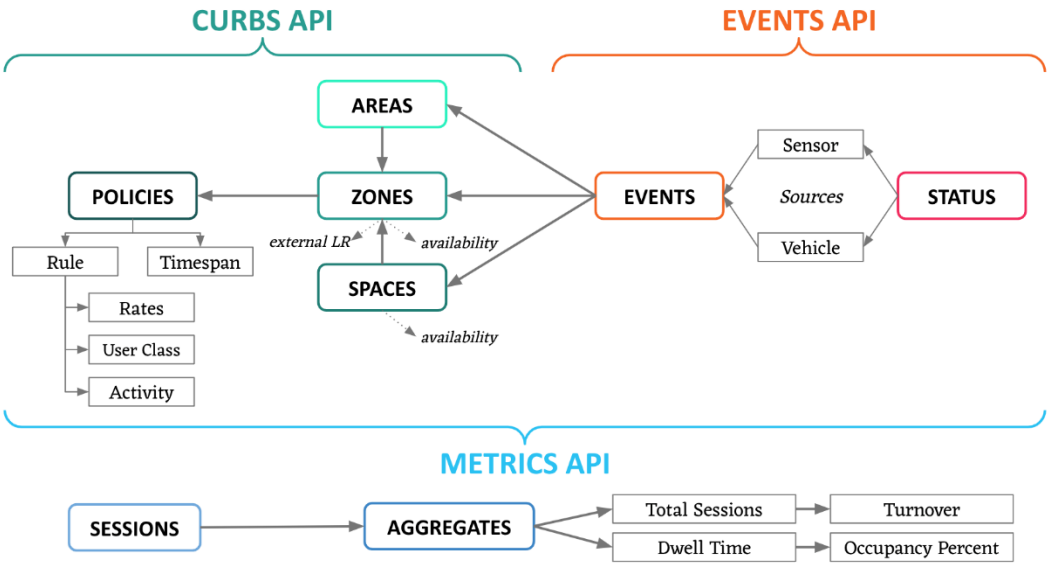


Fig. 1 Curb Data Specification API structure. It's a blueprint for the City to digitally publish curb regulations, gather use data and track defined metrics while protecting user privacy. Source: Open Mobility Foundation

2. **Driver App**: This was a mobile phone application that anyone could download from the App Store (Google or Apple). Users could sign up by providing their contact information, vehicle details, and payment information. Once signed up, users could look up "available" Smart Loading Zones near their destination using their phone and "reserve" it for use. The curb regulations were digitized for the

entire Center City using the Curb Data Specification (CDS) and were being used through this application to make it accessible to users looking to book a zone.

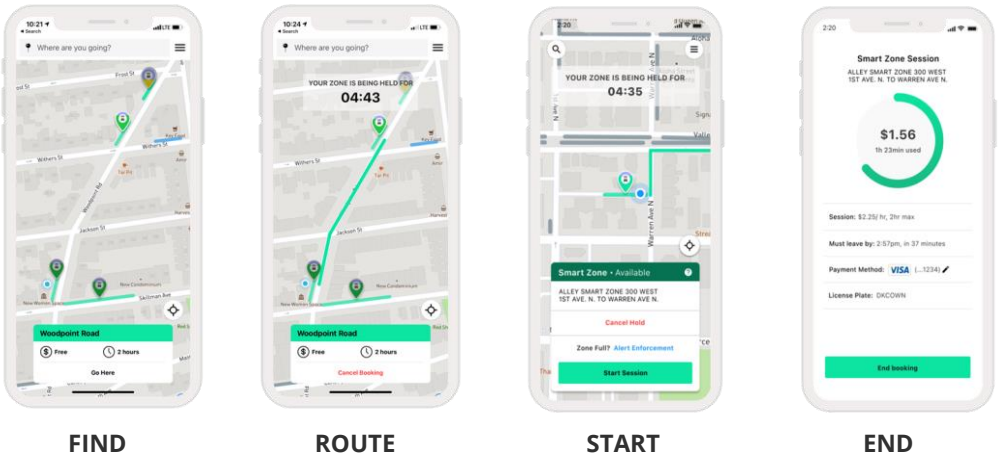


Fig. 2 A mobile app for drivers that enabled routing and reservation services for Smart Loading Zones

3. **Fleet Management App**: This was a web application (designed to be used on a desktop or laptop in a web browser). The purpose of this app was to allow Fleet managers to manage multiple vehicles using their license plate numbers through a single Fleet account and pay for all those vehicles through a single payment method (ACH or card on file). The drivers would still use the Driver App to reserve the zones but were not required to pay individually if they were part of a Fleet booking.

4. **Inspector App**: This was a mobile application installed on all devices used by Parking Enforcement Officers (PEOs). It was used to check whether a vehicle in a Smart Loading Zone was authorized to be there. The PEOs would also receive notifications from users using the Driver App if someone was in a reserved zone and the driver alerted enforcement about it.

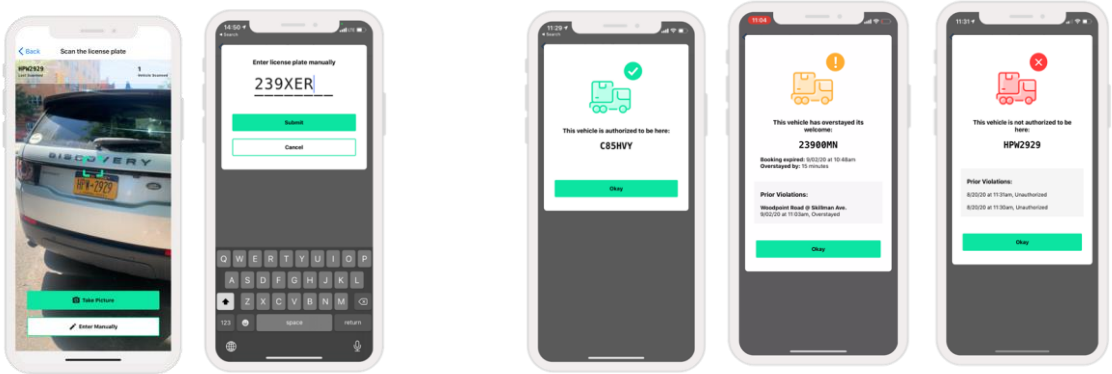


Fig. 3 A mobile app for Parking Enforcement Officers

5. **Smart Zone Dashboard**: This was a web application (designed to be used on a desktop or laptop in a web browser). This application allowed City and PPA staff members to view the regulations digitized on a map, edit any regulations digitally, and post those changes to be used by other users on other applications in real-time. It also provided a way for the City and PPA users to see aggregated metrics such as occupancy data and revenue collections by time or make projections for use and revenue for specific zones.

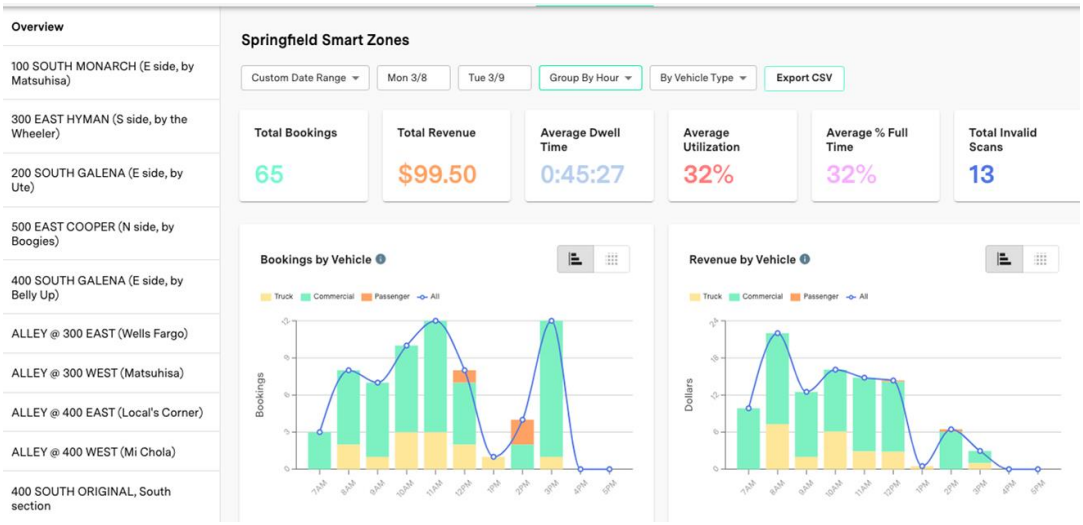


Fig. 4 Smart Zone Dashboard

Other than the five key technologies listed above, the Pilot project also tested two other technologies but did not end up using them due to operational reasons as described below:

a. **Collector App**: This mobile app allows digitization of all regulations along a block face in less than 10 minutes using a combination of augmented reality and GPS. It allowed anyone with minimal training to use the app and digitize regulations by clicking pictures of posted signs or street furniture (like fire hydrants). This application was not used because Google's team had already digitized the entire Center City area using this application before the project began. These digitized regulations and images generated were shared with the City as part of the project. The project team used the Smart Zone Dashboard to update existing zones to Smart Zones for the Pilot project to become operational.

b. **Parking Sensors**: These low-cost sensors would stick to the asphalt using glue. The purpose was to test whether we could avoid solutions that traditionally used core drilling into asphalt by using this adhesive-based installation. The initial tests failed to stay in place for longer than the first few weeks and were removed from the pilot stage evaluation.

DEPLOYMENT OUTCOMES

The Pilot project was deployed at 21 active Smart Zones within the southeastern quadrant of the City's Center City area. The Pilot project went live for public use on October 17th, 2022, but the enforcement through issuance of parking violations went live on November 1st, 2022. All users were notified of the planned project closeout in early April 2022 and the project was closed out for public use on April 15th, 2022. The map below shows Smart Zone locations, policies at each zone, and designated numbers that were used on the physical signages at the zone.

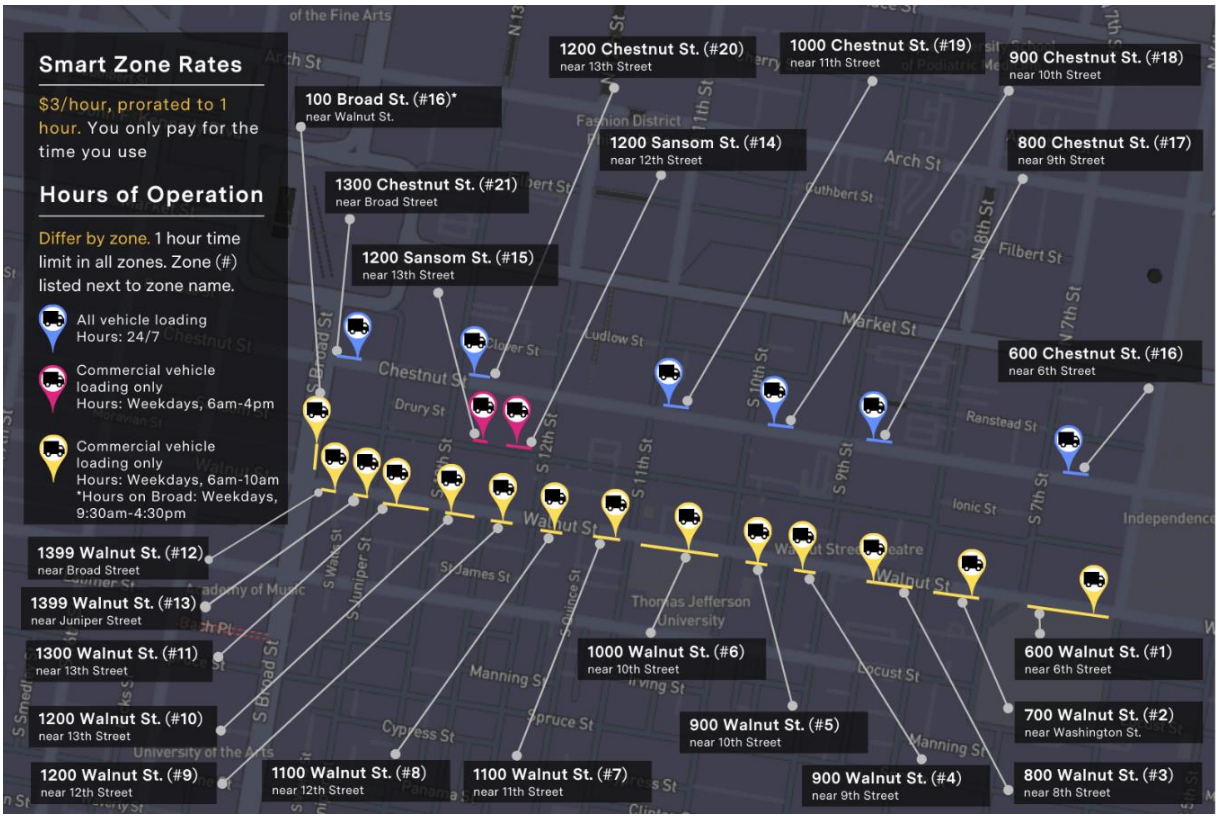


Fig. 5 Map of Smart Loading Zone Deployment showing zone numbers (#) and regulations by color.

Throughout the Pilot project, the project team learned and documented key lessons while attempting to digitize a traditional analog operation. These lessons were critical to ensuring that the Pilot project was operationally stable and minimized risk for all stakeholders while allowing the test deployment of an array of complex technologies and generating value for the City and its residents.

1. **Contractual Privacy Controls:**

   One of the primary concerns for the project team in testing such invasive technologies was preventing any misuse of personally identifiable information. Several steps were taken to ensure such data is handled in accordance with

industry best practices. Through a first-of-its-kind contractual requirement, the City required the vendor involved in the Pilot project to be contractually bound to delete any personally identifiable data within 6 months of concluding the Pilot project. The vendor complied with this requirement and submitted a written confirmation for the same.

2. **Establishing Baseline Zones for Evaluation:**

   To establish a baseline for evaluation, 5 of the 21 Smart Zones (zone #2, #8, #15, #19, #21 – per the map above) were closely monitored before deployment and halfway into the Pilot to understand user behavior, enforcement patterns and any impacts the technology might have. These baseline zones were monitored using 60 hour video recordings, and the recorded feed was analyzed thoroughly across several metrics.

3. **Digital Inventory of Curb Regulations:**

   The first success of the Pilot project was generating an inventory of curbside assets and associated regulations using the curb data specification (CDS) and developing a way to visualize them for operational use. The data topology used here had two separate data sets, one for assets (*for instance, the location of a fire hydrant) and the second for regulations as applicable along the parking lane (for instance, a no-parking zone within 15 ft on either side of the fire hydrant*). Such a detailed and interconnected inventory allowed the project team a viable "base map" to select from and designate areas at existing loading zones with minimal regulatory changes.

4. **Digitizing Physical Infrastructure for the Pilot:**

   To minimize regulatory changes and to align with existing usage patterns while introducing digital tools, the project team decided use existing regulations at existing loading zones. The team identified and designated 21 Smart Zones for the Pilot project within two weeks of the launch and deployed the signages, cameras, and sensors within a month of the launch. The sites were identified using quantitative methods to enable a comparative evaluation between different types of types of policies.

5. **Rapidly Adapting to Changes Digitally:**

   An opportunity to test the efficiency of a digital system came up early in the Pilot project when project team was able to accommodate feedback from two local community partners in near real-time using deployed technologies. The community partners did not want this Pilot deployed on their block for hyper-local operational reasons. A Smart Zone at 600 Chestnut Street and another one between 7th and 8th Street on Sansom Street had to be moved quickly. To

accommodate the requests, the project team closed off bookings to those zones within minutes of receiving the request using the Smart Zone Dashboard. This was the first operational success that showcased how "digital regulations" can be implemented in near real-time for all users. The physical removal of signage took at least two more days, and by them, the project team could find alternate sites and relocate these two zones.

6. **Highly Granular Operational Curb Data in CDS format:**

The project team captured very granular data about the usage and operations of the Smart Zones and its analysis to develop several key findings. Over the course of 6 months of the Pilot project, 1446 drivers signed up, and **4508 bookings** were made. Over **280** enforcement officers were trained over 10 sessions, and **5977 enforcement scans** occurred. Each booking and scan were logged in a format compliant with CDS (Curb Data Specification). **8 fleet operators** signed up for fleet accounts and were able to manage multiple bookings through a single payment method. Based on user feedback, over 15 major and minor changes were made to the technologies during the Pilot deployment.

7. **Closeout**

The Pilot project was closed out per the contract within 6 months of launch without attempting to continue for several reasons. Among them was the lack of automated enforcement features within the technology suite and a narrow operational definition of our target user. The technology suite was more incentive-based than penalty-driven and, with a lack of automated enforcement capabilities, resulted in very low compliance rates. Furthermore, the target users for this Pilot project were the vehicle drivers trying to use a loading zone. Operationally, this cohort of users was a very small fraction of all right-of-way users with high dependency on others sharing the right-of-way.

Fig. 6

Signages that were deployed at each zone through the Pilot project.

KEY FINDINGS

The Pilot project was the City's first attempt to test leading-edge technologies in digitizing curb space management. It was not an attempt at conducting traditional workflows more efficiently but an entirely new way of doing business. Several successes and failures provided data-backed lessons that would not otherwise have been possible to uncover. The following insights are based on the Pilot's highly granular operations data, usage data, and video collected in selected zones.

1. **Manual inspection-based enforcement may be highly inefficient.**
    a. Based on a match between scans and recorded arrival activity at the baseline zone, manual enforcement was able to capture **less than 2% of the daily vehicle arrivals** in these baseline zones. In other words, for every 100 vehicles that used a Smart Zone, an enforcement officer could only scan the license plates of 2 vehicles in a day.
    b. Of the vehicles that did receive a scan by the enforcement officer, **89%** of such vehicles were an **unauthorized user** in the Smart Zone.
    c. 24/7 all-vehicle zones along Chestnut Street received most of the enforcement scans (**84% of all scans**), even though the number of bookings along Sansom Street was about the same as bookings along nearby zones on Chestnut Street.
    d. On average, about 618 daily arrivals were recorded at baseline zones, but only 11 scans occurred.
    e. **Zone #15** (1200 Sansom Street), a *commercial loading-only zone, had nearly the same number* of bookings as **Zone #17** (800 Chestnut Street), a *24/7 all-vehicle zone*.
    f. There were **1,644 uses of the "call for enforcement" feature** during the pilot, the majority of which were in the Chestnut Street zones.
2. **Bookings (and Enforcement Scans) captured only 2% of the overall curb activity.**
    a. When data from bookings are compared to baseline zones, it is evident that bookings captured only ~**2% of all activity** at the Smart Zones.
    b. **~2%** is also the **enforcement capture rate** at these zones.
    c. Only those many people chose to use the zones legally as the number of people who would have been checked for compliance by an officer. People somehow minimized their risk while adopting illegal behaviors and did not increase the risk they would otherwise have to take in other spaces.

3. **The commercial loading activity is a small fraction of curb activity.**
    a. Based on analysis of baseline zones, **private non-TNC vehicles** made up over **80%** and **TNC vehicles** made up over **8%** of all arrivals. These patterns were consistent before and through the Pilot deployment.
    b. Of all 4508 bookings, 30% were commercial vehicles, and 70% were private vehicles. However, for baseline zones, commercial loading vehicles only

made up 12% of all vehicles, and **loading events** only made up **2% of all events** at the curb.

c. At baseline zones, stopping, pickup-drop-off, and regular parking made up 19%, 30%, and 47%, respectively.

4. **Avg dwell time per booking at most Smart Zones was more than the maximum allowed time limit at each zone.**
    a. At **7 of the 15** Smart Zones with a *1-hour limit policy*, average dwell time exceeded this limit. For **Zone #12** (1399 Walnut Street), it exceeded the limit by about 20 mins.
    b. At **all 5** Smart Zones with a *20-minute limit policy, the average dwell time exceeded this limit by 10 to 15 minute*s.
    c. Since drivers were not allowed to rebook the same zone within 30 minutes of their last session, many requested a policy change and a convenient way to go beyond the limit.

5. **Curb use and demand of zones varied heavily by policy type.**
    a. **Zones #1-#12** (along Walnut Street) received a total of 453 bookings, peaking between 8 a.m. and 9 a.m.
    b. **Zones #14 and #15** (along Sansom Street) received a total of 599 bookings, peaking between 12 p.m. and 1 p.m.
    c. **Zones #13, #17-#21** (along Chestnut Street) received 3447 bookings, peaking between 1 p.m. and 2 p.m.

6. **Tracking non-compliance events using Curb Data Specification (CDS) was challenging.**
    a. CDS was a good tool for mapping, visualizing, and evaluating curb policies and use data. However, the project team found it challenging to capture non-compliant use, such as illegal parking, within this format due to the lack of coverage of lanes adjacent to the parking lane.
    b. The project team could not decouple asset location on sidewalks from regulations data applicable in the parking lane.

STRATEGIC PIVOT

Based on key lessons from the data and the deployment of this Pilot project and insights from other efforts underway across different agencies in the City, the project team recommended and sought funding based on the following changes in strategy to digitize curb space management.

1. **Transition from a "loading zones user" to a "right-of-way user":**
    a. A *loading zone user* is a vehicle driver trying to access short-term parking space for a **parking** event, presumably for loading activities like moving materials, pick-ups, and drop-offs, or delivery of packages or food. But a *right-of-way user* is anyone traversing a part of the right-of-way, which includes loading zones and other curb spaces and would like to use a portion of the right-of-way for a specific amount of time for a specific purpose permissible by regulations. Besides a parking event, a *right-of-way user* could request the City for a **street closure** event of a specific section of a specific lane for a specific amount of time.
    b. From a programmatic lens, a **parking** event can be seen as a subset or a type of **street closure** event. Both these events functionally assign the use of a portion of the right-of-way to an individual for a specific period per specific policies or regulations, preventing anyone else from using it for that period. Changing target users to a broader cohort (the right-of-way user) will provide a more robust technology solution with fewer resources.
    c. Broadening the focus of digitization efforts also provides an incentive for technology providers to consider a larger addressable market while keeping marginal costs low since the same solution could be extended from curb management to other sections, such as the sidewalk and travel lanes.

2. **To ensure compliance, enforcement should be ubiquitous:**
    a. As discussed earlier, manual inspection-based enforcement may not be able to capture even a small fraction of all curb activity. Introducing automated camera-based enforcement will allow a nearly 100% capture rate and ensure much higher compliance rates than we saw in the Pilot project.
    b. One method for delivering the citation to the vehicle's registered owner is to mail the notice of violation, as is done in some municipalities in Pennsylvania, such as Pittsburgh and Reading, and as outlined in the recently introduced Bill No. 24106300 in Philadelphia City Council.
    c. Congested streets in urban downtowns may be a major concern for cities, but they make up a small fraction of operations for any major delivery company. Camera-based enforcement ensures lesser adoption costs for large delivery companies that cannot justify making broad technology

changes to the specific hand-held devices used by their staff to cover operational challenges in downtowns.

3. **Extend Curb Data Specification (CDS) to cover the entire Right-of-Way (ROW):**
    a. Application Programming Interfaces or APIs are predefined methods or communication protocols that allow one computer to communicate with another seamlessly. Curb Data Specification or CDS is such a blueprint that, if deployed, allows the regulator (a city) to digitally communicate curb space regulations to anyone using the curb for parking or loading activity without having them "read" posted signages to determine if they can park.
    b. Curb Data Specification is a great tool for cities to start using digital tools to publish curb regulations and gather usage data operationally meaningfully while preserving all users' privacy. But it is just the first step and is limited to the curb space. CDS enables the spatial granularity or resolution to capture and manage curb data that matches our operational needs. But this spatial granularity must be extended to the entire ROW, even if the target use is limited to curb space, because regulations and events associated with the curb space usually spill onto the sidewalk or adjacent travel or bike lanes.

SMART GRANT FUNDED PROJECTS

To test and implement a part of the pivot in the strategy described above and to continue efforts to digitize the management of the curb and the right-of-way, the Smart Cities team applied for and won a $2M grant award through the **SMART (Strengthening Mobility and Revolutionizing Transportation) Grant** program by US DOT on behalf of the Streets Department. With an additional $1M match fund from the City, this award provides the needed capital for the Smart Cities team to procure, develop, deploy, and evaluate the technologies to manage the entire right-of-way digitally. The funds will be used to procure the following five discrete technology solutions and develop a cohesive approach to digital right-of-way management.

1. **Data Topology and Process Mapping** *(Professional Services)*:
   Managing the right-of-way digitally requires codifying and creating a digital twin of the right-of-way assets and regulations at a spatial granularity level that meets the City's and its partners' operational needs. This project will support the development of such a data topology or structure that extends CDS to the ROW and complements existing Street Centerline data used by the City. It will also support the mapping of data for a pilot area and process mapping to establish which processes lead to a change in access to ROW by the public. The effort to map these processes will provide a high-level view of which systems or processes must be integrated into a digital ROW management system.

2. **Smart Right-of-Way (ROW) Software** *(Software Product)*:
   The City will procure a software product to inventory, ingest, manage, and publish the ROW policies and regulations digitally. This proof-of-concept deployment will manage the pilot area and leverage the data topology developed in the previous project. The software product will have internal-facing applications as well as public-facing applications. The public-facing applications will integrate with several City and partner agency applications per operational needs. The software product will allow the data to be managed at the spatial granularity of per lane, per foot, per unit time.

3. **Transit Signal Priority** *(Software Product)*:
   Through this project, the City will procure and test leading-edge cloud-based transit signal priority solutions. Buses are a critical part of the City’s ROW and surface transportation system. This project will improve transit services and potentially integrate them into a broader digitized ROW management system.

4. **E-Ink Digital Signages** *(Hardware & Services)*:
   Assuming the ROW Software above enables publishing regulations digitally through an API (Application Programming Interface), this project will procure digital signages that use E-Ink display technology and deploy them in the pilot area to provide only the relevant information for curb or ROW users.

5. **Signal Controllers** *(Hardware & Services)*:
   The City will use its matching funds to procure and deploy modern signal controllers at 40 intersections that fall within the pilot area for this project. These new controllers will enable digital and adaptive control of signal timings and support other modern traffic management applications.

The SMART grant funding was the first grant award the City of Philadelphia received through the Bipartisan Infrastructure Legislation (BIL) federal funds and one of the first direct grants from USDOT to the City's Streets Department. The grant agreement for this award was also unique in that it clearly prohibited specific uses from being funded using this award and required the City and any vendors receiving these funds to comply with new procurement terms.

As per federal law, the funds **cannot be used** to procure *License Plate Recognition* (LPR) technologies or any kind of enforcement activity. Furthermore, the new terms the awardees must pass on to any potential vendor paid using these funds made it challenging for the City to use existing procurement processes. The Smart Cities team worked with the Law Department and other partner agencies to develop methods and protocols to comply with these new contractual terms and is currently underway to complete the procurement process.