megacity logistics lab
reinventig large scale urban supply chain systems

MIT Center for Transportation & Logistics

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Collecting an visualizing urban and corporate information

last mile

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1. Executive Summary

LastMile is an initiative from the MIT Megacity Logistics Lab to provide visualizations to both public and private entities on complex urban logistics data. Currently, Last Mile focuses on two sets of information relevant to inform logistic operations in large cities around the world: urban logistics data (KM2) and transactional delivery data (Loopa).

KM2 contains information from megacities in the world based on single square kilometer areas. As a part of an "urban logistics atlas" of different cities, it visualizes detailed logistics, retail and urban form information of chosen square kilometers. These visualizations inform factors that affect urban last-mile delivery performance in these regions.

The second component of the Last Mile initiative is Loopa. It enables companies to quickly visualize key indicators of large amounts of urban delivery transactional data through intuitive geographical navigation.

2. The megacity challenges

Megacities are cities or major urban areas with populations over 10 million inhabitants.
Most megacities are commonly located in developing nations and rapidly emerging markets. These cities will continue to expand both in population and area growth. Thirty-one megacities around the world represent almost 15% of the global GDP and are expected to increase to 20% of the global GDP in the next 10 years.

Population densities in emerging markets like Mumbai can be as high as 20,000 inhabitants per square kilometer. This density is more than double than that of London or Manhattan. In these cities, development is rapid which places stress on existing transportation infrastructure that is commonly already overtaxed for resident mobility. As a result, businesses operating in these cities face many logistical challenges.

On top of the stressed transit systems, freight activity adds significant traffic disruption in the transportation network. Many of these cities are not equipped well to serve both the mobility of residents and the freight movement that serves the growing population. To satisfy the magnitude of orders in these areas, many ad-hoc practices and local knowledge are adapted to the complex urban setting.

Due to geographical proximity for easy accessibility, many small stores, or nanostores, serve the needs of urban residents. These nanostores are common in large cities.

As the population grows, so does the quantity of nanostores. Each nanostore requires specific deliveries on a given timeframe that a logistics provide must abide by. At the same time, to reduce traffic in urban areas, many municipalities are putting regulation in place that limits traffic in the urban core. Some regulations include limiting of freight movement during peak hours, parking restrictions, and road pricing. Given the number of nanostores in megacities, regulatory constraints, and infrastructural challenges, logistics systems operating in megacities need additional information to make choices before planning logistics operations. To operate more efficiently, some issues they may account for are the location of distribution centers, different vehicles used for deliveries, delivery timing, route plans, and others.

A major limitation of logistics systems in emerging markets is the lack of technologies informing operations. Many urban logistics systems rely solely on the truck, the driver, and their mobile phone without any other technological support. This provides very little information on all sides of the equation – the distribution center, the driver, and the receiving customers. Given the aforementioned challenges in urban logistics, the Megacities Logistics Lab developed two platforms that help both businesses and policymakers visualize the last mile of the supply chain, in order to make better decisions in real time operations, logistic plans, as well as long term urban planning.

There are 31 megacities that represent almost 15% of the global GDP and is expected to increase between 15% and 20% in the next 10 years.

3. Last mile

The LastMile initiative was motivated to respond to the growing urban complexities previously illustrated. The purpose of the LastMile is to visualize detailed contextual information that influences logistics operations directly.

The data Last Mile represents allows users to better understand context specific information visually. Last mile is made up of two different platforms: KM2 and Loopa.

4. Km2

The objective of KM2 is to display key information for square kilometer areas in large cities around the world. The visualization provides representations of each sq km through freight deliveries, street traffic flow, flow disruptions, and characterization of stores

Project development

Team

Under the supervision of the MIT Megacity Logistics Lab research staff, the initial data collection was conducted by a team of MIT undergraduate students who traveled abroad to major cities to collection data to inform this project. Students from other universities joined and supported the project during field observations. The software platform was designed by a team of students from Monterrey Tech in Mexico.

Data collection design

The first step was to decide on relevant data and collection strategies. Building from existing literature review, policy reports, and workshops hosted by the MIT Megacity Logistics Lab with businesses around the world, several key characteristics of the urban context were selected. To facilitate standard data collection, manuals and templates were designed to ensure both the consistency of the data but also the ability to open up data collection widely.GPS tracking devices were employed for data collection to accurately map the selected areas.

The data collection protocol was validated and refined with a pilot study in the Greater Boston metropolitan area (Massachusetts, USA). The pilot data is also included in the KM2 platform.

The following are the chosen data collection categories:

Shop inventory

The shop inventory captures all the shops in the selected square kilometer of a given city. This inventory defines the stores requiring good delivery. To define each store geographically, GPS tracks show the location of the shops in the chosen area.

Roads and regulations

This category describes the transit infrastructure and regulation in the city as they relate to logistics systems. This includes the regulations of road usage, freight vehicle parking area, loading/unloading zones, etc

Traffic count

Traffic count sample data describes the flow of vehicles within a focus street of the square kilometer. Observations of the traffic flow are represented at different times of the day on different days of the week to capture variability.

Delivery tracking

Delivery tracking captures the actual delivery operation, including locations, distance traveled, type of products, and equipment use.

Disruptive violations

This category describes disruptions in the traffic flow by both freight vehicles and other sources, including a measure of the severity.

Shop inventory

Roads and regulations


Traffic count

Delivery Tracking

Disruptive violations

Data collection

The cities (Figure 4.1) included in the first stage of the project are:

- Beijing
- Bogotá
- Boston
- Kuala Lumpur
- Madrid
- Mexico City
- Santiago de Chile
- São Paulo
- Rio de Janeiro

The 3-week data collection schedule included three days for a full inventory of shops, roads and regulations, and contextual observations for each square kilometer area. The remaining data was collected on a block that represented the most significant portion of freight and traffic activities in the square kilometer. Seven days of delivery tracking, as well as three days of traffic count and disruption observation were scheduled.

Figure 4.1 Square kilometers in which data collection has already been developed

Software Platform

Basics

To build the visualization from the data generated by the collection team, a Content Management System (CMS) allows users to upload the information collected directly to a database. The database works using PostgreSQL. This system was built using Ruby on Rails.

Features

The system allows each user to select the square kilometer and specific blocks and pair them with GPS tracks so that it can be easily visualized. Users can upload context-specific information about the city (Figure 4.2).

To provide ease of accessibility and use, an icon denotes every piece of data collected. To guarantee consistency and scalability, all data is loaded in CSV format, following a pre-defined standard with automatic error checking prior to database upload (Figure 4.3)

Name	Mexico City
Time Zone	Mexico City
Language	Please select
Population	8840000
Pop. Density	6000
Area(km2)	1485
US Exchange rate	13.3
GDP(USD)	1153000000000
Big Mac Index	2.9

Figure 4.2 Context of the megacity

Mexico City - km2

Name	Tracks	Traffic	T. Dis	S. Data	P. Res	Shops	Deliveries	
Zócalo	0	0	0	0	0	0	0	

Figure 4.3 CMS Interface

Data visualization

All the vast and complex information gathered from each square kilometer is summarized in a small set of visual displays, designed to allow fast and intuitive understanding of the area. Drill down capabilities allow users to gain further insights of specific elements of the urban space. (Figure 4.4)

Future work

KM2 began with these initial cities but will be expanded to include other major cities around the world and multiple square kilometers within a city. The first stage was initiated by MIT students in six different cities in the world, while a team from Monterrey Tech developed the technology backbone including the visual display.

KM2 is designed for many users to use and submit data that informs Last Mile operations in major cities around the world, using standardized templates and detailed manuals. This project requires collaboration from outside users to grow and further develop into a useful tool that will allow private and public sector stakeholders to compare different areas of megacities.

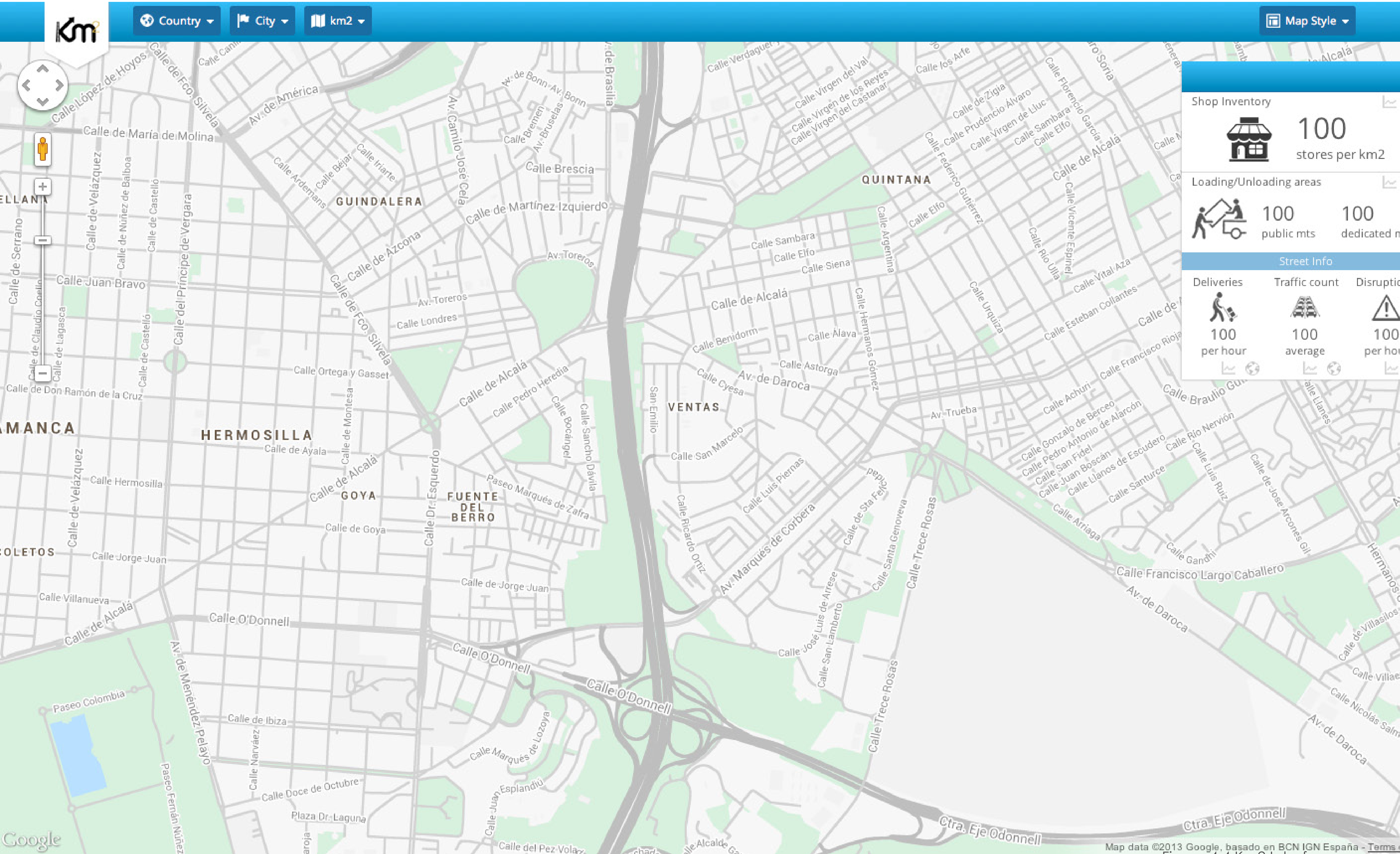
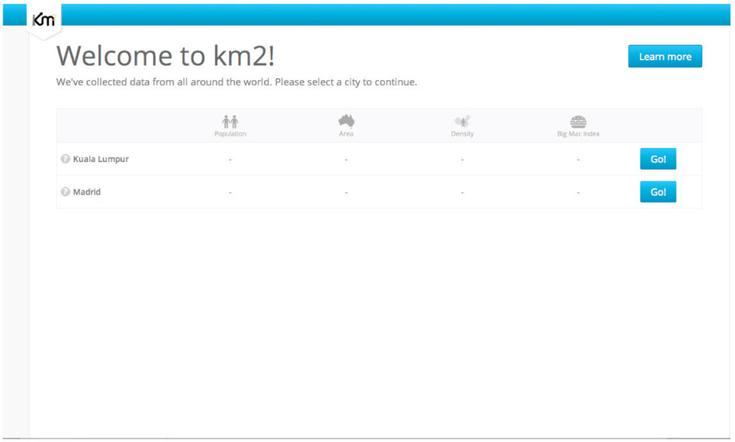
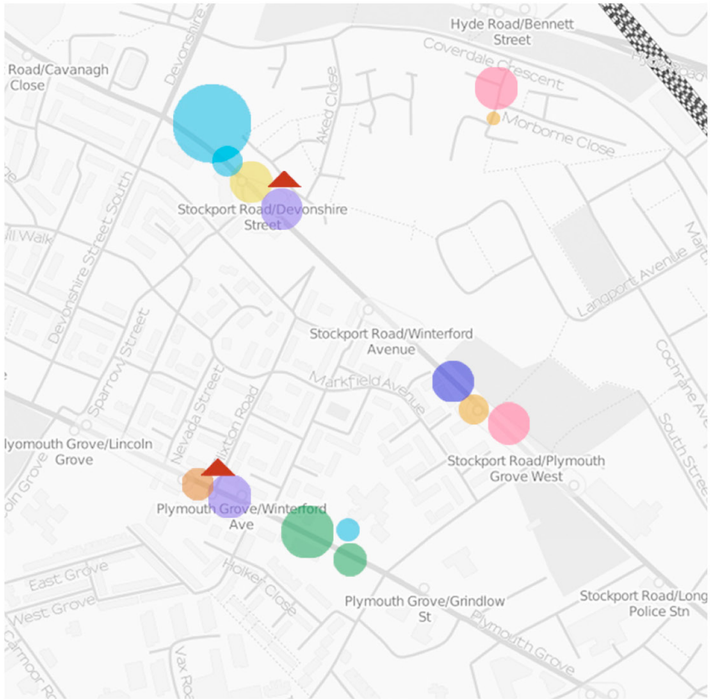


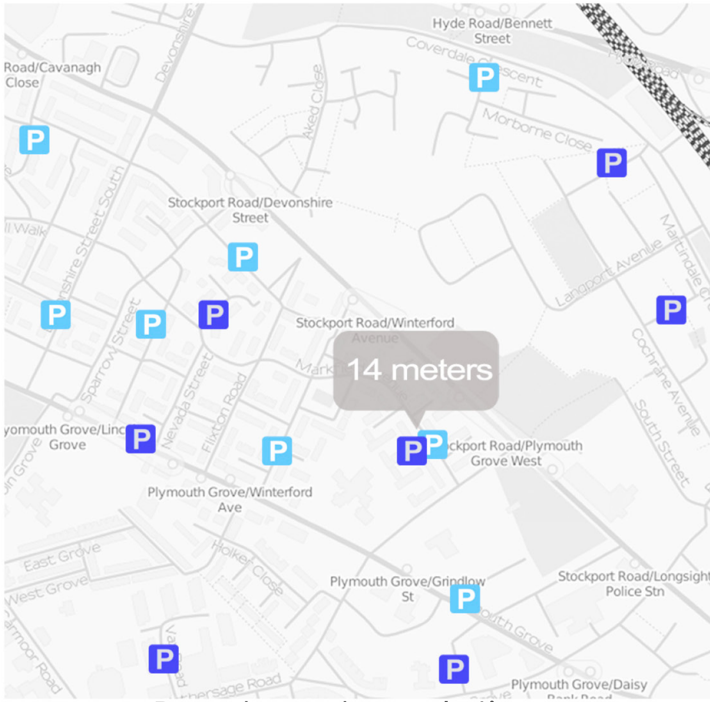
Figure 4.4 Km2 Interface



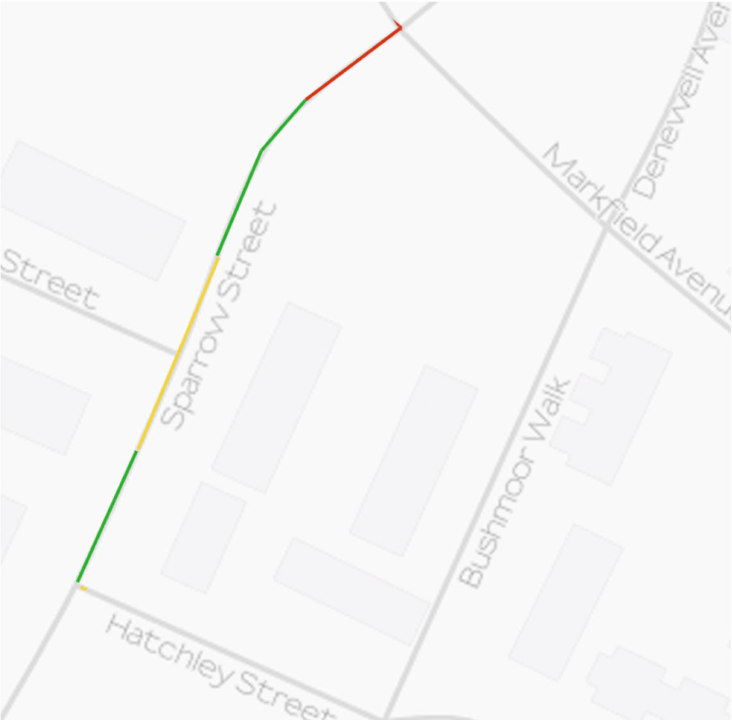
General Information



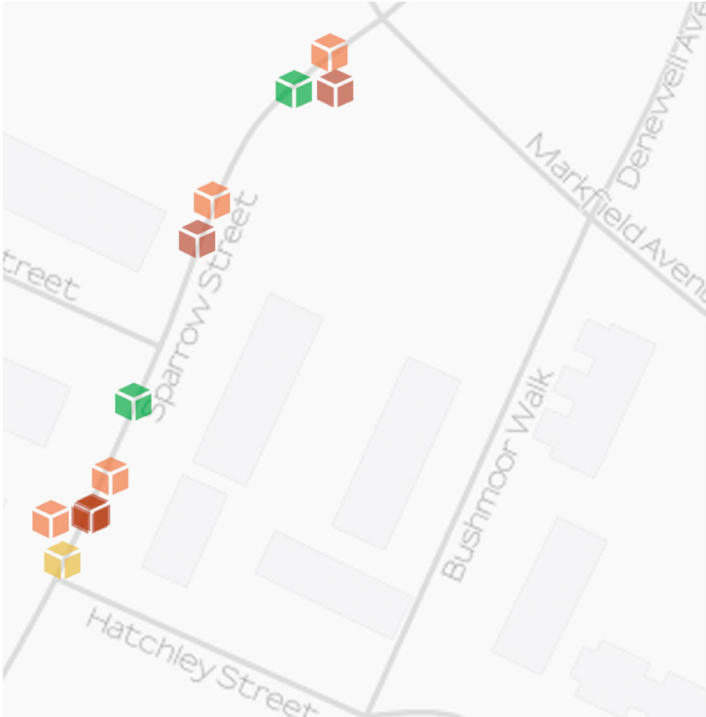
Shop inventory



Roads and regulations



Traffic count



Delivery tracking

Disruptive violations

5. Loopa

The objective of Loopa is to allow companies to quickly visualize key indicators of large amounts of urban delivery transactional data through intuitive geographical navigation.

As opposed to open-ended data collection for KM2, Loopa is designed to leverage structured data combined with public urban data to visualize logistics operations in the city context.

The first case study for Loopa was a Colombia based candy distribution company.

Project development

Received data for test case

The data from the Colombian based company included 21 months of deliveries. The data includes customers, products, and quantities ordered. The data also included the exact location of the customers in the city of Bogota. To manage this information, a PostgreSQL database was created.

Information processing

In order to display the information geographically, the urban area was divided into square kilometer quadrants: Bogota has an extension of 23 km by 34 km for a total of 782 squared kilometers. Each square kilometer was identified by one geospatial "degrees" of latitude and longitude.

Transactional data is then mapped to each square kilometer and summarized in a set of CSV files as follows:

- Customers per square kilometer per month
- Products per square kilometer per month
- Customers per square kilometer per week
- Products per square kilometer per week
- Customers ABC classification
- Products ABC classification

User Interface

The display of the information and the key informaThe user interface is designed for the best representation of information visually. The website was created using javascript, D3 and NVD3. (Figure 5.5)

The aggregate data is represented on a map divided by square kilometer quadrants. Each of the quadrants is active, so clicking on any of them will display information about it.

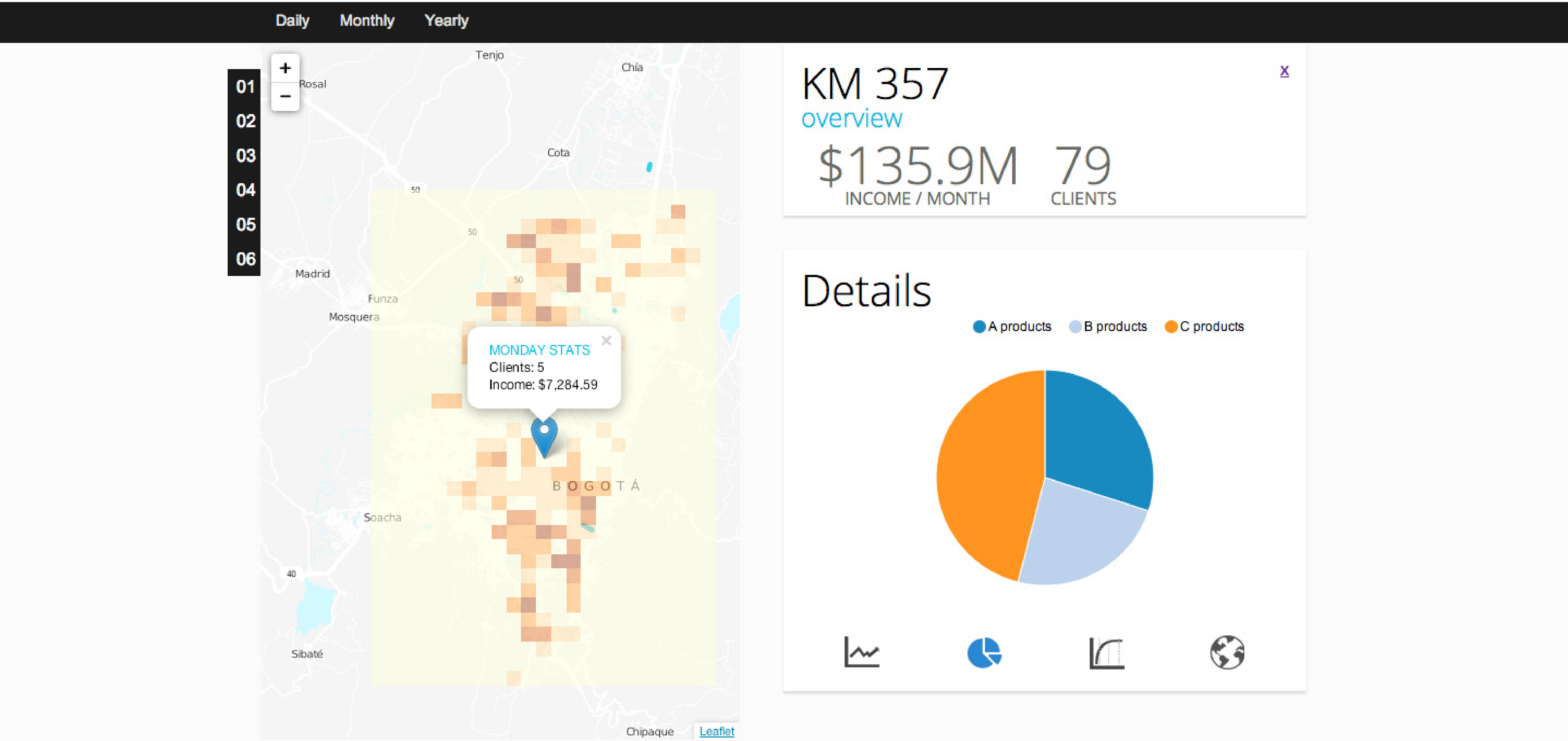
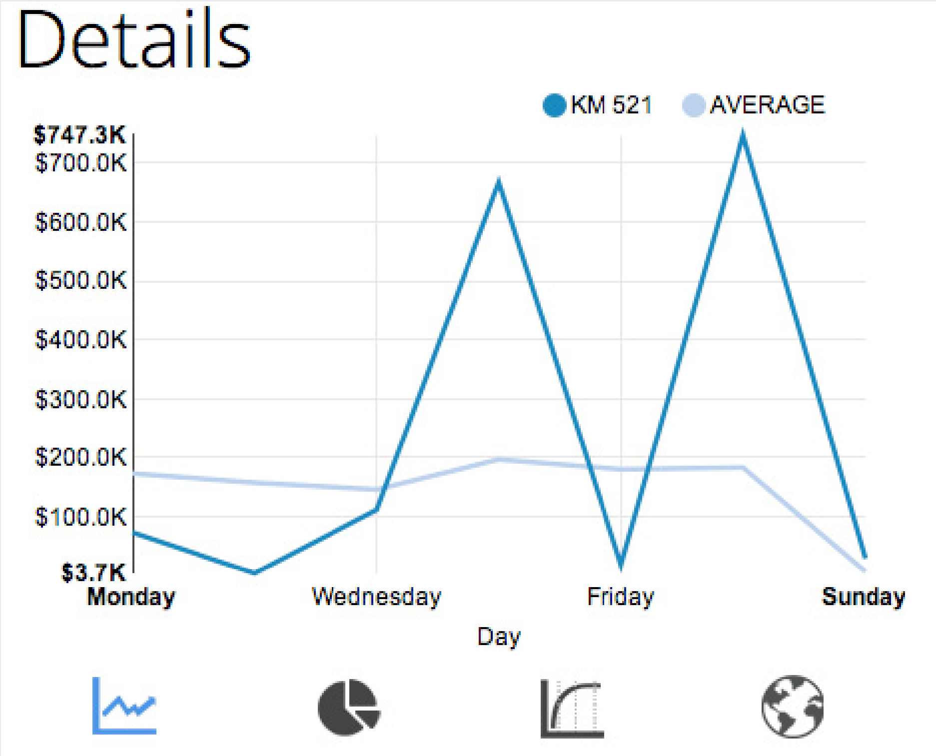
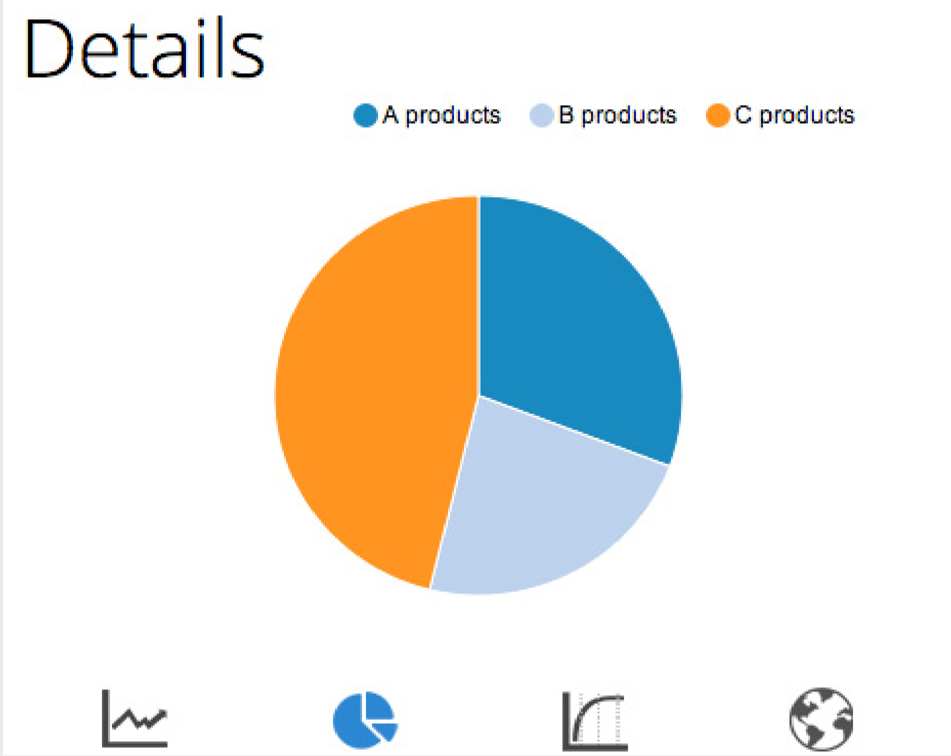
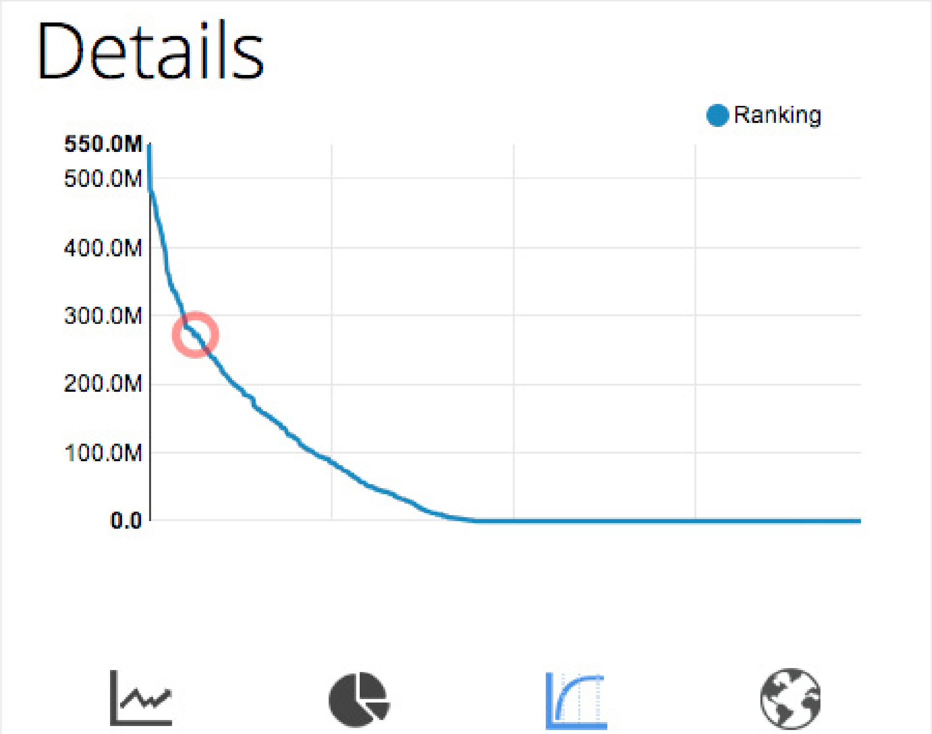
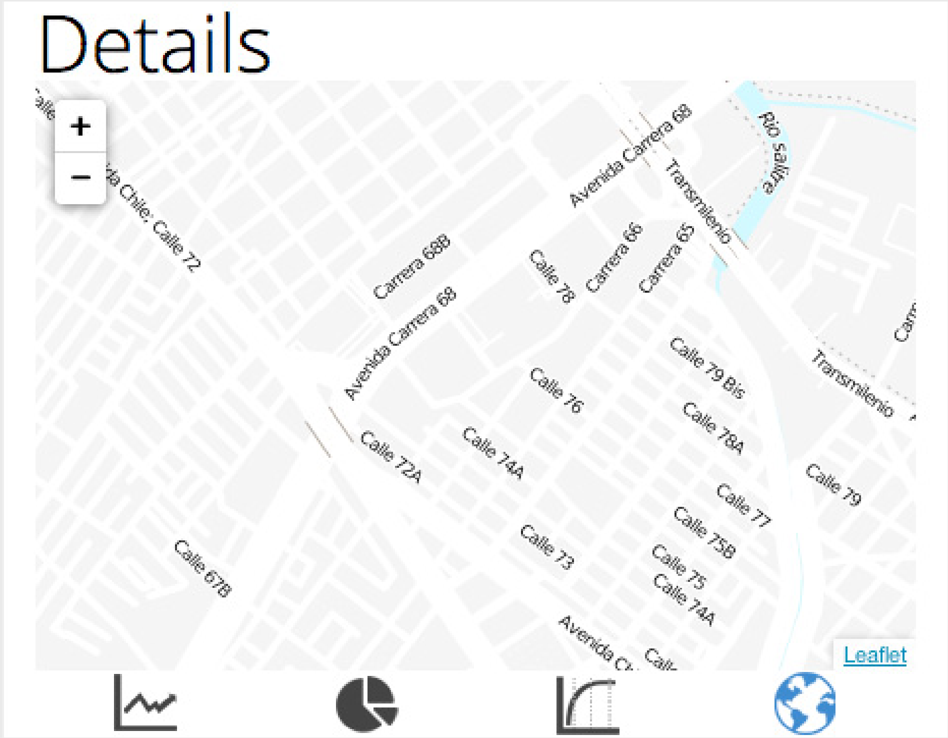


Figure 5.1 Loopa Interface


Details
KM 521
AVERAGE
$747.3K
$700.0K
$600.0K
$500.0K
$400.0K
$300.0K
$200.0K
$100.0K
$3.7K
Monday
Wednesday
Friday
Sunday
Day


Details
A products
B products
C products


Details
Ranking
550.0M
500.0M
400.0M
300.0M
200.0M
100.0M
0.0


Details
+
−
Avenida Carrera 68
Transmilenio
Carrera 68B
Carrera 68
Avenida Carrera 68
Calle 78
Carrera 66
Carrera 65
Calle 79 Bis
Calle 76
Calle 78A
Calle 72A
Calle 74A
Calle 77
Calle 79
Transmilenio
Calle 75B
Calle 73
Calle 75
Calle 74A
Calle 67B
Leaflet

On the left side of the display, the day of the week can be selected. This feature is useful to display the behavior of the deliveries and the customers throughout a given week. This information can be observed in terms of income or active customers. (Figure 5.2)

Information about each urban quadrant is also presented through graphs and lists that can be selected using the intuitive menus on the right side of the screen. This information includes:

- ABC classification for the customers inside the selected quadrant
- List of customers inside the quadrant
- Income generated by customer through time (all the months), for each individual customer inside the quadrant
- ABC classification for the products sold inside the quadrant
- List of products sold in the quadrant
- Income generated by the products sold
- Income generated per day of week inside the quadrant versus the average
- Ranking of the quadrant, by the percentage of the income it generates.

The menu also displays a smaller version of the map. This shows the exact location of each customer within the square kilometer. This allows the user to drill down to more detailed information, to select specific visualization from the map, and to explore multiple dimensions.

Future Work

This is the first release of Loopa and, as KM2, it is designed for growth. The Loopa platform is capable of holding information from many different companies and visualize them in at a square kilometer level, regardless of the geographical location of the city.

The intention of Loopa is to create a base of information about logistics operations on a large scale in cities around the world. This information can help companies' better plan for last mile operations, tailored to local urban demand patterns.

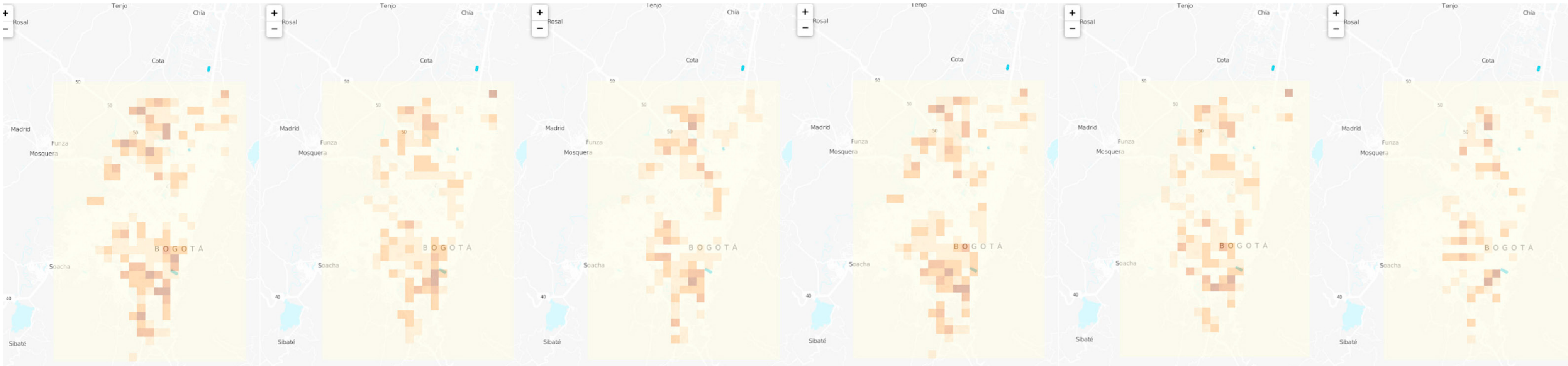


Figure 5.2 The visualization changes according to the day of the week

6. Conclusions

This report summarizes the first iteration of the Last Mile initiative for data visualization in large urban areas. This includes two major web platforms: KM2 and Loopa.

Both projects have the potential to provide important information about logistics operations in cities and how they are constrained by existing land use. There are significant implications for logisticians and urban planners intending to answer the problem of urban factors in freight movements, and vice-versa. Both projects are set to grow and evolve to accomplish their objectives and provide strategic information about last mile operations in major cities.

Future work at the MIT Megacity Logistics Lab will focus on expanding the breadth of data in KM2 and to refine existing visual displays for both KM2 and Loopa.

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