Parking Sensor Data Guide

September 4, 2013

Table of Contents

1   Introduction

This document describes how transactional parking sensor data is collected and processed for analysis in the SFMTA's SF*park* data warehouse, particularly for the purpose of conducting demand-responsive rate adjustments. Additionally, it explains the assumptions and decisions made when interpreting and analyzing the data. The document concludes with a guide to be used in conjunction with block-level hourly occupancy data.

1.1   Timeline

Parking sensors began transmitting data in real time starting in March/April of 2011 and continue to submit data through to the date of this data guide.

1.2   Availability of Data

This data guide supports the use of block level hourly occupancy and meter rate data. The complete hourly occupancy dataset is available as a .csv file and includes all hourly block level occupancy data as well as rate adjustment data from April 2011 through July 2013. A data dictionary can be found in section 9 of this document.

For all data requests and related inquiries, please contact info@sfpark.org and put "SFpark evaluation data request" in the subject line.

The name, format and size of the data file are as follows:

- ○   File name: SFpark_ ParkingSensorData_HourlyOccupancy_20112013.csv
- ○   File format: 2010 MS Office Comma Separated Values File
- ○   File size: 1.163 GB

2   Parking sensor equipment overview

StreetSmart Technologies provides parking sensors for SF*park*. StreetSmart's sensor is an in-ground and self-powered wireless device. The sensors send data to the StreetSmart sensor management system via a network of pole-mounted repeaters and gateways. The StreetSmart servers then transmit the data to the SF*park* data warehouse.

2.1   Parking Sensors

The StreetSmart sensor, or "puck," is a device designed to detect the presence of a vehicle in a parking space. It measures 4" in diameter and 1.2" in height, is made of glass filled nylon, and is powered by two AA lithium batteries.
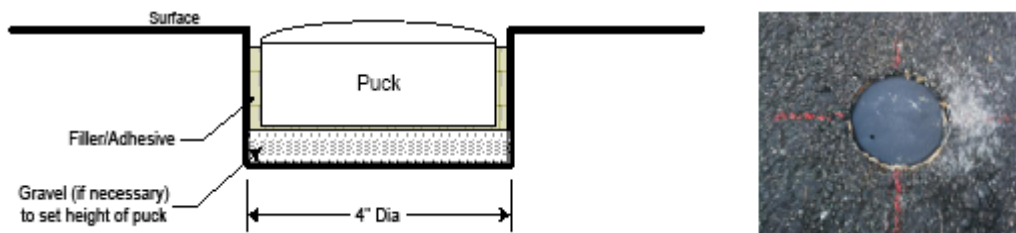
The sensors detect vehicles primarily with a magnetometer that senses the presence of large metal objects. Sensors detect electromagnetic changes along three axes; this area can be thought of as a spherical zone with roughly a three foot radius. During installation, sensors are calibrated to their surrounding environment and "trained" to determine when there is a vehicle present or not. Each sensor has the computing ability to determine the space's status. Sensors look for about ten seconds of stability after a change of status before making a determination that a vehicle has either arrived or departed.

2.2   Repeater

Sensors do not communicate directly with the back-end system. Rather, sensors communicate to repeaters, which then relay data to gateways. Communication to and from the repeaters are in the 902-928Mhz ISM (Industrial, Scientific, Medical) band. The StreetSmart repeater weights about nine pounds, is a solar-powered device, and is mounted eight to fifteen feet above the ground.
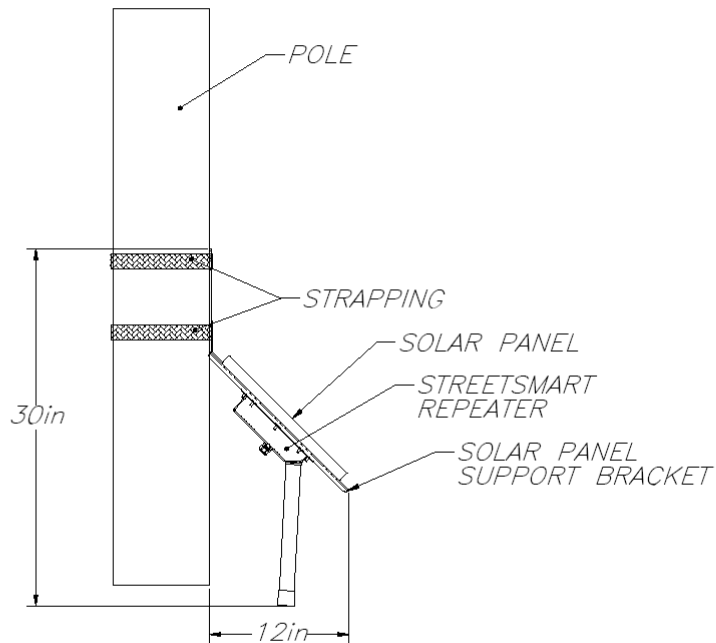
2.3 Gateway

StreetSmart gateways relay sensor data from the repeaters to the StreetSmart back-end system in the standard GSM cellular communications band (850, 900, 1800 or 1900 Mhz). Two gateway models have been used. Both weigh about fifteen pounds, are solar powered, and are mounted eight to fifteen feet above the ground. StreetSmart employs redundancy in network deployment so that each sensor has multiple paths to send data. If a gateway goes out of service temporarily, sensors are typically able to send data through the backup gateway.

Type 1 Gateway:

POLE

STREETSMART GATEWAY

SOLAR PANEL

STRAPPING

SOLAR PANEL SUPPORT BRACKET

24in

15in

Type 2 Gateway:

GATEWAY SUPPORT BRACKET

STREETSMART GATEWAY

POLE

STRAPPING

SOLAR PANEL

SOLAR PANEL SUPPORT BRACKET

28in

10in

⌀ 4in

CIRCLE LESS, LIVE MORE
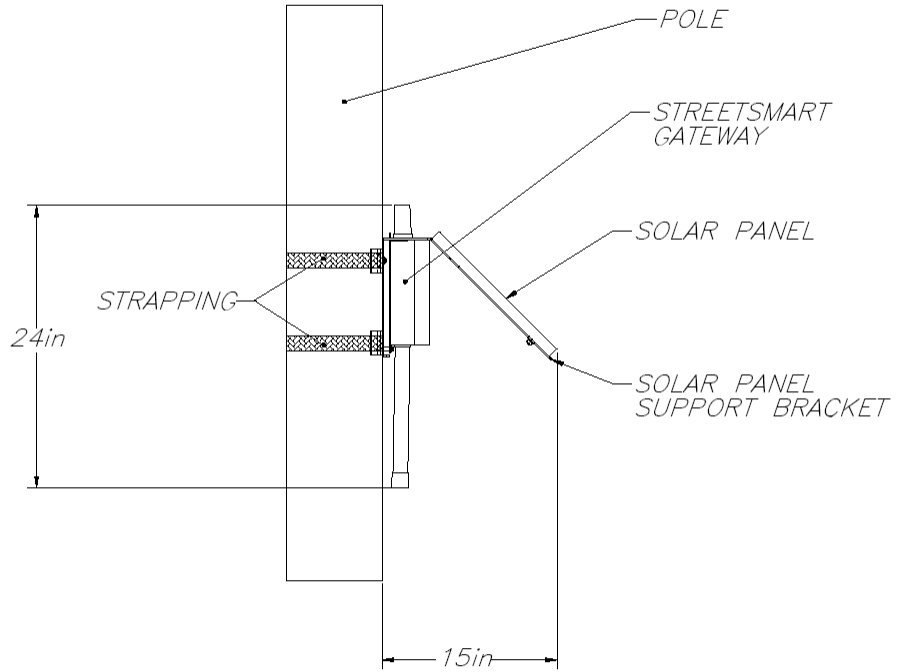
SFMTA
Municipal Transportation Agency
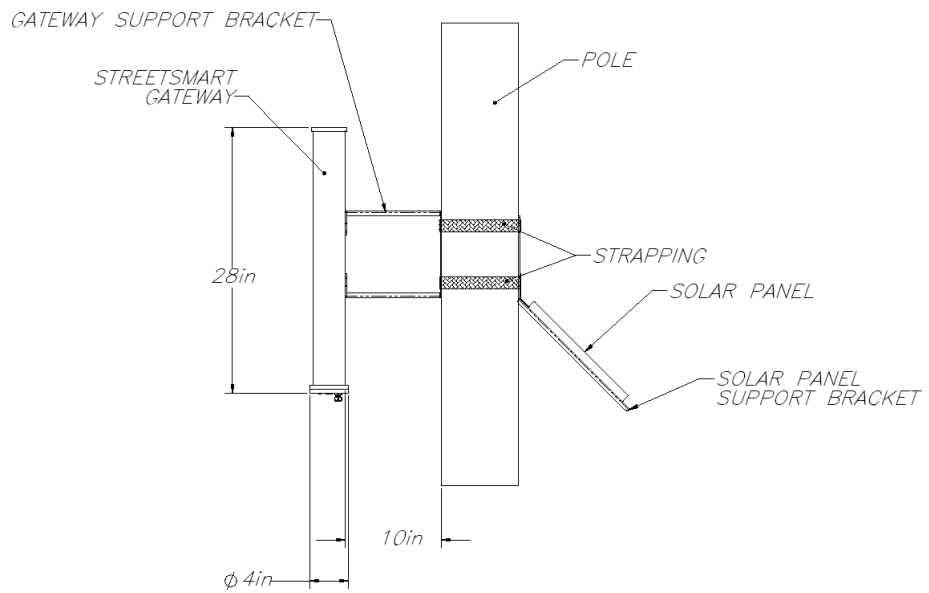
2.4 Installation

The following diagram shows where sensors are installed in parallel and angled parking spaces. One or two sensors may be installed, depending on the location and levels of external electromagnetic noise. The primary sensor is always located towards the front of the space. If needed, a secondary sensor is installed behind the primary sensor.
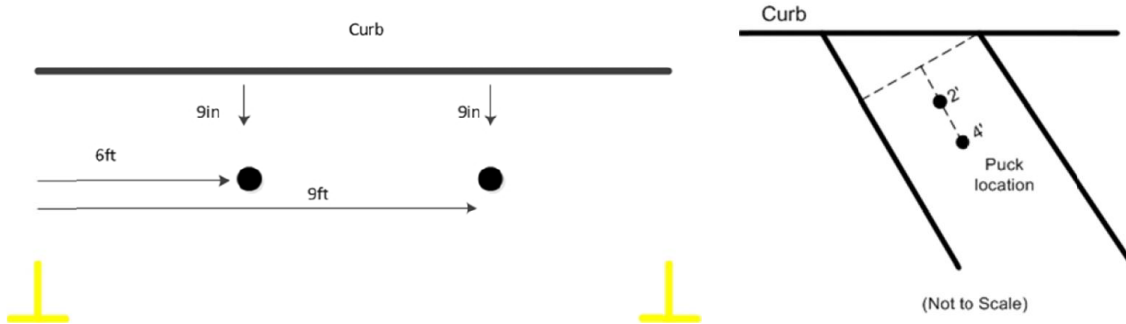
2.5 Equipment inventory

The parking sensor network for SF*park* includes over 8,200 spaces. The following table shows the total number of sensors, repeaters, and gateways deployed for SF*park*.

Area	Spaces with sensors	Total number of sensors	Repeaters	Gateways
Downtown	1,795	2,575	98	13
South Embarcadero	1,663	2,331	65	11
Civic Center	914	1,348	39	5
Mission	1035	1578	26	6
Fillmore	739	1161	40	7
Fisherman's Wharf	652	777	26	3
Marina	400	616	17	5
Union	262	485	9	2
Richmond	528	585	19	3
West Portal	240	461	7	3
Total	**8,228**	**11,917**	**346**	**58**

As an example, the following map shows how this equipment has been deployed in the Fillmore pilot area:
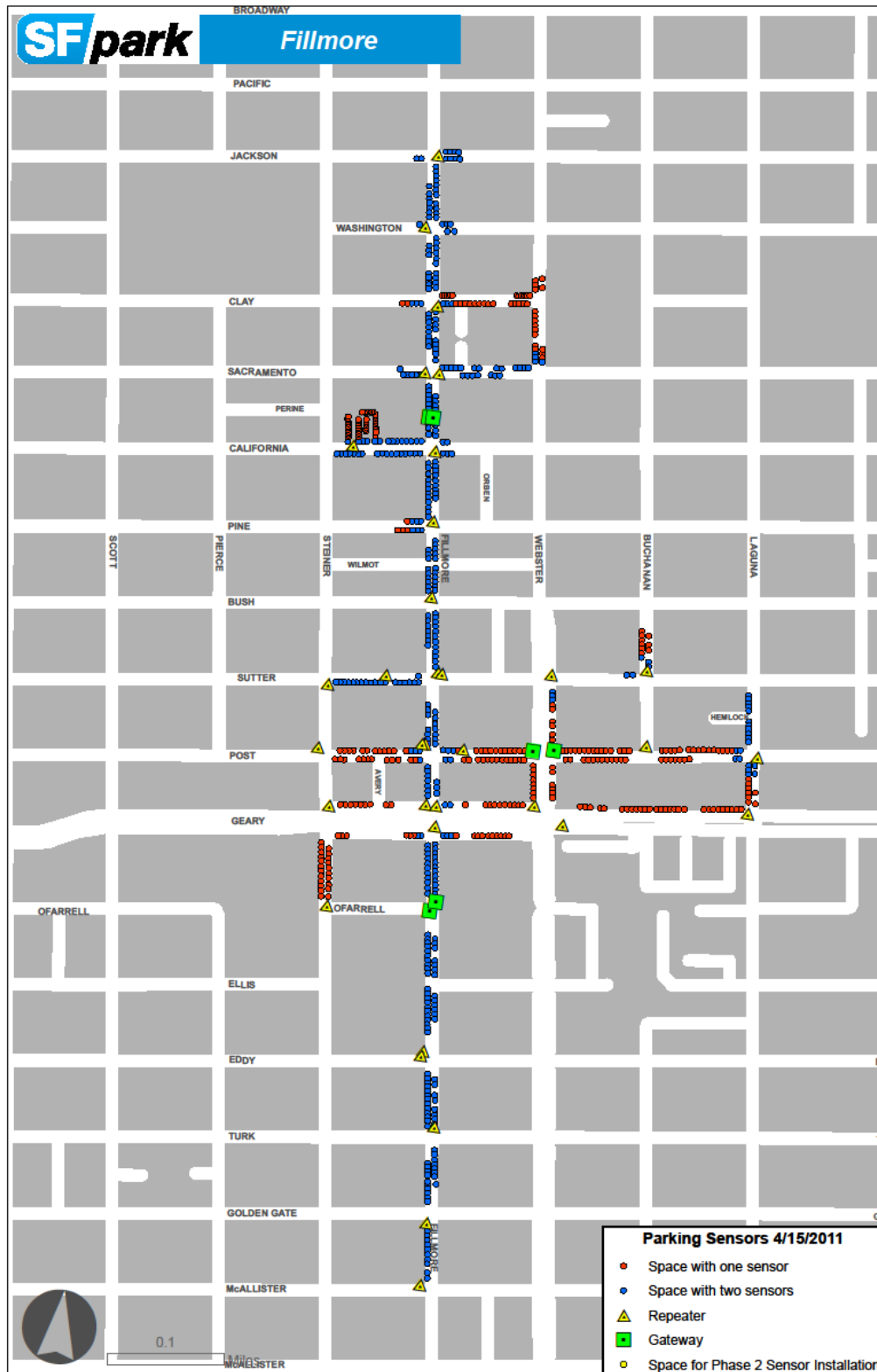
3   Data availability dates

3.1   Installation schedule

During initial sensor deployment planning, the SFMTA identified about 8,200 spaces for parking sensors. Sensors were installed over three installation phases:

- **Phase 1:** About 7,000 spaces were installed and started sending data prior to the formal launch of SF*park* in April 2011. The other 1,200 spaces were delayed due to coordination with street paving and other excavation projects.
- **Phase 2:** About 1,000 of these 1,200 were installed in the summer of 2011.
- **Phase 3:** The remaining 200 were installed in the spring of 2012.

The following table shows the dates that reliable data started being loaded into the SF*park* data warehouse by area and installation phase. The SFMTA verified accuracy using contractually defined standards and methodologies.

At any given time, a small share of spaces (generally less than five percent) may be (or were) unavailable due to construction projects. Additionally, some parking spaces are permanently converted to other uses than vehicle parking such as travel lanes, parklets, and bike parking. Sensors from these spaces are removed and reinstalled at other spaces on an ongoing basis.

Area	Phase 1		Phase 2		Phase 3		Total Spaces
	Spaces Installed	Data Start Date	Spaces Installed	Data Start Date	Spaces Installed	Data Start Date	
Downtown	1,508	04/01/11	187	12/05/11	100	07/16/12	1,795
South Embarcadero	1,231	04/01/11	431	11/22/11	1	07/16/12	1,663
Civic Center	747	04/01/11	79	11/02/11	88	07/24/12	914
Mission	860	04/01/11	175	12/07/11			1,035
Fillmore	739	04/01/11					739
Fisherman's Wharf	584	04/01/11	66	11/02/11	2	07/16/12	652
Marina	336	04/01/11	64	11/29/11			400
Union	262	04/01/11					262
Richmond	527	04/01/11	1	11/07/11			528
West Portal	240	04/01/11					240
Total	**7,034**		**1,003**		**191**		**8,228**

4 Field issues encountered

4.1 Electromagnetic interference

During field trials in San Francisco, StreetSmart noticed higher than expected levels of electromagnetic interference (or "noise") in many areas. The levels of noise were higher than encountered in other cities where the vendor had deployed before. The sources of this noise were found to be (1) direct current from the overhead lines that power Muni trolley buses and light rail vehicles, and (2) alternating current from a variety of utility-related facilities such as PG&E junction boxes. This noise degrades the sensors' ability to detect vehicles correctly. The vendor developed various hardware and software solutions to overcome noise, although sensor accuracy varies more than expected. However, noise remains pervasive and unpredictable and can affect sensors differently in certain times and areas.

4.2 Early battery failures

The batteries in StreetSmart sensors were intended to last about five years. Specialized software designed to filter out some of the AC and DC noise reduced expected life to three years. However, some sensor batteries started to fail in late 2012 and early 2013, about one year earlier than expected. The geographical distribution of battery failures is seemingly random; they are not clustered according to any discernible pattern and are difficult to predict.

StreetSmart started to observe approximately battery failures about a few hundred sensors per month (out of 12,000 total sensors) in November 2012. Since replacement units and resources to replace them were limited, the SFMTA asked StreetSmart to prioritize replacing failed sensors at parking spaces that either were (1) part of the rate adjustment process, or (2) in the Richmond or Union control areas. These represented about 5,100 spaces out of the 8,200 total spaces in the SF*park* sensor network.

A failed sensor battery triggers a "sensor down," or SD, transmission to the SF*park* data warehouse. As a result, the amount of occupancy data lost due to failures can be tracked by measuring total unknown time (see Section 8 for more detail). Since unknown time is taken out of the occupancy equation, the failures themselves do not erroneously affect occupancy calculations for rate adjustments.

Due to early battery failures and dwindling replacement sensor stock, the SFMTA stopped receiving data from the control areas (i.e., Richmond, Union, and West Portal) on August 1, 2013. This allowed functioning equipment to be redeployed to the pilot areas to support the availability feed and rate adjustments after the evaluation data collection period was over.

4.3 Street construction

To the extent possible, the SFMTA removed sensors prior to street paving and other street construction. The SFMTA coordinated internally and with the San Francisco Department of Public Works' Five Year

Plan. However, not all construction work can be coordinated, and there are other agencies, utilities, and vendors that perform work in the street. While the SFMTA is developing tools and processes to better coordinate work, these projects often disrupt operations of other City infrastructure (e.g., parking meters, on-street car sharing spaces). Due to the difficulty of coordinating work, some sensors have been paved over or otherwise destroyed without notification.

The SFMTA installed some replacements for paved-over sensors, and some sensors were removed before repaving, but much work remains to be done. As of August 2013, about 850 spaces need sensors reinstalled due to construction.

A large construction project starting in March 2012 led to removing sensors from about 40 percent of the spaces in the Mission pilot area. See Section 9 for more details.

5   Data feed specifications

All SF*park* XML data feed specifications were developed to be vendor-neutral; all sensor vendors must communicate with the SF*park* data warehouse using the following events and rules.[1] This section summarizes the key elements of the parking sensor data feed. For additional information, see the SF*park* parking sensor data feed specification.

---

[1] Even though SF*park* relied entirely on one sensor vendor, the SFMTA worked with multiple vendors to test various technical approaches (see the Parking Sensor Technology Performance Report for more details).

5.1 Key sensor data feed elements

Element Name	Data Type	Description
VENDOR_ID	PosIntegerType	Unique vendor identifier
TRANSMISSION_ID	PosIntegerType	Transmission number generated by vendor for the message, assigned in ascending order by event time w/in sensor ID.
TRANSMISSION_DATETIME	DATE/TIME	Date and time of transmission of the message e.g. "2010-02-11 14:32:22"
EVENT_TYPE	ENUMERATION	One of five event types: SS, SE, SD, SU, or HB
PS_ID	PosIntegerType	Unique identifier for the parking space
SENSOR_ID	STRING	Post ID of the space where the sensors have been installed.
EVENT_TIME	PosIntegerType	Date and time of the sensor event e.g. "2010-02-11 14:32:22"

5.2 Parking events

The sensors send (via the repeater and gateway) the SF*park* data warehouse five types of events: two communicate parking status and three communicate operational status.

- **Session Start (SS).** A vehicle has arrived in the parking space and has started a new parking session.
- **Session End (SE).** A vehicle has departed from the parking space and has completed a parking session.
- **Sensor Down (SD).** The sensing and communication ability of the sensor or sensors in a space have been determined to be faulty and has entered a period of irrevocable outage.
- **Sensor Up (SU).** The sensor has been brought online and is ready for service.
- **Heartbeat (HB).** This message is a positive affirmation of a sensor's operational status. This message is sent once per day per sensored space.

5.3 Tow away filter

The SFMTA provides the sensor vendor with a list of Post IDs and corresponding times where peak-hour tow away regulations are enforced. No events are sent during the tow away period.

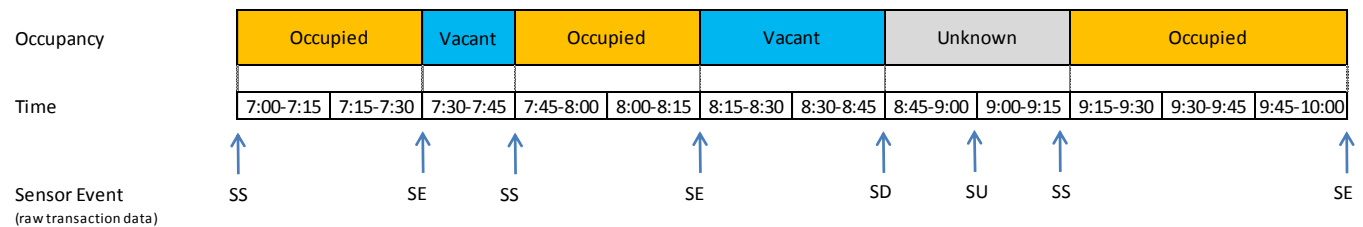# 6   Data interpretation and aggregation

This section shows how transactional parking sensor data is interpreted and aggregated.

6.1 Occupancy status changes

The underlying logic is that the status of a space changes once a new event is received. A parking space can have one of three mutually exclusive statuses:

- **Occupied.** A space is occupied by a vehicle. This status follows a SS event.
- **Vacant.** A space is available. This status follows a SE event.
- **Unknown.** Status cannot be determined to be vacant or occupied. This status follows SD and SU events. Generally, less than 5 percent of total time.

The following figure describes how the SFMTA interprets of events into occupancy status durations. The 15-miunte periods are simplified for illustration purposes; the system actually stores the start/end of statuses to the second.

Occupancy	Occupied		Vacant	Occupied		Vacant		Unknown		Occupied		
Time	7:00-7:15	7:15-7:30	7:30-7:45	7:45-8:00	8:00-8:15	8:15-8:30	8:30-8:45	8:45-9:00	9:00-9:15	9:15-9:30	9:30-9:45	9:45-10:00
Sensor Event (raw transaction data)	SS		SE	SS		SE		SD	SU	SS		SE

6.2 Availability feed vs. historical data for analysis

Parking sensors feed the SF*park* public availability API for on-street spaces and the California/Steiner off-street lot. Generally, latency for events is less than 60 seconds and uptime is above 99 percent. This generally translates to accuracy and reliability for the availability service that is on par with the historical data for analysis.

However, occasional cellular outages, network problems, and other issues on the StreetSmart sensor management system can significantly increase latency for some events arriving at the SF*park* data warehouse. Greater delay reduces the accuracy of the public availability API. But since the events eventually arrive (generally within a few hours), they are included in the data interpretation and aggregation process and thus all analyses on parking sensor data.

Additionally, statuses of "unknown" are reflected as occupied for purposes of the public availability API.

7   Business rules

The SFMTA made the following assumptions in processing data and determinations regarding data quality.

7.1   Assume parking spaces are vacant immediately following the end of a tow away period

Due to the tow away filter, the status of a space immediately following the end of a tow away period cannot be easily determined. However, the SFMTA preliminarily assumes that spaces are, by default, vacant because:

- Tow away periods are heavily enforced.
- It would be difficult for a vehicle to park in a space while it is an active travel lane.
- Even assuming a certain share of drivers park in spaces before tow away periods are legally over, the majority of spaces are still likely to be vacant.

This is only a preliminary assumption; the status of a space can be retroactively updated with an event within three hours of the end of the tow away period. For instance, given a space with a tow away period ending at 6:00pm, if a sensor sent an SE event at 8:50pm, then the space's status from 6:00-8:50pm would be updated to occupied. If a SS was received at 8:50pm, or if there were no events between 6:00 and 9:00pm, then the status remains vacant.

This filter only applies to data for historical analysis, not the availability API.

7.2   Reject duplicate or conflicting events

Some events are erroneously sent for the same parking space and for the same exact event time as another event. These events may be duplicates of an existing event (e.g., two SS events at the same exact time) or may conflict with existing events (e.g., SS and SE event at the same time). The only difference may be that one event was received later than the other. In these cases, the SFMTA considers the first event received, based on transmission time, as the actual status. StreetSmart has noted that this is more common from spaces with two sensors due to some messages from the secondary sensor to slip through the logical filters.

7.3   Measure occupancy at hourly increments

While parking sensors are designed to detect changes at the second level, the SFMTA processes and stores occupancy data for every hour at each parking space.

During the design of the data warehouse, the SFMTA considered calculating occupancy on a minute-by-minute basis; however, this approach would have significantly multiplied the capacity (and therefore resources) required to store this amount of data (since this would necessitate that all of the many data sets in the system, such as meter payment statuses, be stored at that level as well). Additionally, the wealth of data produced by generating occupancy at the hour level only already provides more than sufficient amount of data for rate adjustments and analysis. As a result, the SFMTA determined that the cost of storing occupancy at the minute level outweighed the benefit of this data for analysis.

Additionally, the accuracy of occupancy rates, as measured by the SFMTA's occupancy accuracy test, are generally between 85 and 90 percent when aggregated over a few hours and a few hundred parking spaces. The SFMTA recommends aggregating data over time (e.g., hour) and geography (e.g., blockface or block) since averaging the more granular data will reduce the effect of sensor error.

The SFMTA implements rate adjustments performs most analyses – including the implementation of SF*park* rate adjustments – with hourly data at the block level.

7.4   Do not use sensor data for turnover and length of stay metrics

The SFMTA performed field studies to validate the accuracy of sensor data for measuring session counts and length of stay. These included the turnover accuracy/timeliness and length of stay accuracy tests (see the Parking Sensor Technology Performance Report for more details). Results from the turnover accuracy timeliness tests varied significantly (between 30 and 90 percent), and the length of stay accuracy tests yielded an overall score of 51 percent.

Due to the high amount of resources involved in collecting this data in the field, sample sizes for both tests were small. Additionally, StreetSmart has indicated that the causes and effects of the underlying technical issues vary significantly by location. And although StreetSmart has continued to improve their network since the initial installation, other issues have arisen (e.g., early battery failures).

Sensor performance has varied over time and geography in a way that is not predictable or systemic. Additionally, the root causes of the issue are not well known. The results from limited field surveys do not inspire confidence in the accuracy of the data for turnover and length of stay analyses. As a result, the SFMTA has chosen not to use the sensor data to support these metrics.

7.5   Do not use data from West Portal for analysis

Since the installation of parking sensors in 2010/2011, StreetSmart has had the most difficultly with sensor performance in West Portal. This is primarily due to the electromagnetic interference caused by overhead wires that power the Muni light rail vehicles. While many SF*park* areas have overhead wires, West Portal is the only area with surface level light rail, which generates substantially more interference. Additionally, SST has noted that there are other causes for performance issues throughout the SF*park* areas, and that the nature of these issues they vary by area, sometimes on a block by block basis. The conditions in West Portal have created a perfect storm for sensor performance.

The SFMTA has made West Portal the lowest priority area for addressing performance issues for the following reasons:

- The relative importance of other control areas
- No other evaluation survey data (e.g., parking search time, intercept surveys)
- No viable traffic or transit data is available for West Portal
- The vendor's limited resources to address issues

As sensor batteries started to fail in late 2012, and given limited replacement stock, the SFMTA instructed StreetSmart to not replace any sensors in West Portal. This further reduces the utility of data from West Portal.

Considering the issues mentioned above and the questionable accuracy of data from West Portal overall, the SFMTA has excluded data from West Portal.

7.6   For rate adjustments, exclude blocks if the sample size falls below 50 percent

Sensors were installed in every metered space and send continuous data, so it was expected that there would be no need to consider sampling. However, construction projects leading to the physical removal of sensors and early battery failures reduce the number of spaces from which the SFMTA receives data, in spite of some spaces actually being available for parking. Rather than having data from 100 percent of available spaces, the SFMTA started to receive data from a smaller sample of the total population of spaces on each block.

The SFMTA determined that the sample size for each block must be at least 50 percent, and removed a block from the rate adjustment process if either of the following conditions were met:

1. Fewer than 50 percent of the spaces on a block have sensors installed
2. Unknown time on a block exceeds 50 percent for the period of analysis

8   Occupancy measure definitions

8.1   Occupancy rates are calculated using units of time.

Occupancy status durations are the basis for calculating parking occupancy rates. Because status durations are in units of seconds, occupancy rates are calculated as:

$$\frac{\text{Total occupied seconds}}{\text{Total vacant seconds + total occupied seconds}}$$

For instance, if a parking space is occupied for 2,520 seconds of an hour, its occupancy is 2,520/3,600 = 70 percent occupied.

Since unknown statuses indicate periods when SF*park* cannot determine the status of the space (i.e., it is neither vacant nor occupied), the occupancy calculation excludes unknown time from the denominator of calculation. The sum of all vacant, occupied, and unknown time for a parking space over the course of one hour will always equal 3,600 seconds.

Occupancy rates are only be calculated on whole hour increments (e.g., 9am-12pm is based on totals of the 9am, 10am & 11am hours).

8.2   Occupancy measure definitions

In order to account for the complexity and variety of meter operating schedules and restrictions in San Francisco, the SFMTA calculates four distinct occupancy measures. Each measure filters out available time based on the goals for analysis. For each measure, a rate for occupied, vacant and unknown status durations can be calculated. For the purposes of illustration, this section will only describe occupied statuses.

- **Total occupancy.** This calculates the overall percent of time the space(s) were occupied over the period selected.
    - No filtering is made based on meter operating hours or restrictions.
    - Total occupancy is the only measure that can span a 24-hour period.
- **Operational occupancy.** This calculates the overall percent of time the space(s) were occupied during the period selected during operational hours.
    - Filters are applied for meter operating schedules. If a space is metered from 9am-6pm, then occupancy can only be calculated for those hours. No operational occupancy rates would be calculated outside of those hours.
    - Filters are also applied within operating hours during periods that the meters may not be in operation. This includes street sweeping, peak period tow away times, and temporary

loading zones (e.g., a metered space is an unmetered white curb loading zone between 11am-1pm).

- For example, if a metered space is operational from 9am-6pm but is in peak-period tow away lane from 4-6pm, then operational occupancy is only calculated from 9am-4pm.

- **General metered parking (GMP) occupancy.** A subset of operational occupancy that only includes time that metered spaces are available for general parking by the public.

  - Includes time that metered spaces are available to the general public. Generally includes gray cap (available to all drivers) and green cap metered spaces (available to all drivers but for short periods only, generally a 30 minute time limit).

  - Excludes street sweeping, peak period tow away times, and temporary loading zones (e.g., a metered space is an unmetered white curb loading zone between 11am-1pm).

  - Excludes periods that metered spaces are restricted for commercial loading (yellow and red cap).

  - Includes periods that yellow (commercial loading vehicles only) and red cap (six-wheeled commercial loading vehicles only) spaces are not restricted for commercial loading and available for parking by the general public. For example, if a meter is restricted for commercial loading from 9am-2pm, then it may be available for general metered parking from 2pm-6pm.

  - This is the occupancy metric used for calculating rate adjustments.

- **Commercial occupancy.** A subset of operational occupancy that only includes time that metered spaces that are restricted for commercial loading.

  - Only includes periods that metered spaces are restricted for commercial loading.

  - This includes yellow cap (commercial loading) and red cap (6-wheeled commercial loading) spaces.

  - Excludes street sweeping, peak period tow away times, and temporary loading zones (e.g., a metered space is an unmetered white curb loading zone between 11am-1pm).

The following figure shows how meter operating schedules and a variety of alternate schedules and restrictions will contribute to the various occupancy measures. The example is designed to illustrate the complexity of schedules and restrictions; however, the typical metered parking space does not have as many restrictions and alternate schedules.

Occupancy Measures									**Commercial Occupancy**				**GMP Occupancy**										
									Operational Occupancy				**Operational Occupancy**										
											Total Occupancy												
Meter operating schedules and parking restrictions								**Street Sweeping - No Parking**	**Commercial loading**		**White zone -- unmetered loading zone**		**General Metered Parking**		**Peak Hour Towaway zone - No parking**								
											Meter Operational Hours												
Time (hours)	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12pm

9 Hourly occupancy and rate data

This section is a guide to be used in conjunction with block-level hourly occupancy data.

9.1 Hourly Occupancy and Rates Data Dictionary

The Hourly Occupancy and Rates data file has a row for every block for every hour. For more explanation on occupancy rates and measures, see Section 8. The table below explains the columns for this file.

FIELD NAME	DEFINITION	CALCULATION
BLOCK_ID	Unique ID assigned to each block	First 3 digits refer to the street, and last 2 are the block number
STREET_NAME	Name of street	
BLOCK_NUM	Block number	
STREET_BLOCK	Street name followed by block number	Corresponds to BLOCK_ID
AREA_TYPE	Pilot or Control	Defined by PMD
PM_DISTRICT_NAME	Name of Parking Management District	
RATE	Hourly rate for parking spaces on that block	Generated through rate adjustment process
RATE_TYPE	Hourly (H) and Base (B): an internal distinction that does not impact analysis and can be considered "normal" Special Event rate (S) is a different rate in effect during special events at specific locations, and would likely be separated out for analysis	Assigned according to time and location
START_TIME_DT	Month, Day, Year, Hour, Minute, and Second of start of hour	
TOTAL_TIME	Total time, or the sum of seconds across all spaces on that block during that hour, which is the sum of occupied time, vacant time, and unknown time	number of spaces * 3600, or TOTAL_OCCUPIED TIME + TOTAL_VACANT_TIME + TOTAL_UNKNOWN TIME
TOTAL_OCCUPIED_TIME	Total occupied time, or the sum of seconds across all spaces on that block during that hour when a spot was occupied	Sum of occupied seconds of all spaces *3600
TOTAL_VACANT_TIME	Total vacant time, or the sum of seconds across all spaces on that block during that hour when a spot was vacant	Sum of vacant seconds of all sensors *3600
TOTAL_UNKNOWN_TIME	Total unknown time, or the sum of seconds across all spaces on that block during that hour when a spot was unknown	Sum of unknown seconds of all spaces *3600

	(primarily due to sensor down time,* but also including time during towaway)	
OP_TIME	Operating time, or the sum of seconds across all spaces on that block during that hour when meters are in operation according to the operating schedule (this is also the sum of general metered parking time and commercial time)	Sum of operational time of all spaces * 3600, or GMP_TIME + COMM_TIME, or OP_OCCUPIED_TIME + OP_VACANT_TIME + OP_UNKNOWN_TIME
OP_OCCUPIED_TIME	Operating occupied time, or the sum of seconds across all spaces on that block during that hour when a spot was occupied and operating	Sum of operating occupied seconds of all spaces * 3600
OP_VACANT_TIME	Operating vacant time, or the sum of seconds across all spaces on that block during that hour when a spot was vacant and operating	Sum of operating vacant seconds of all spaces * 3600
OP_UNKNOWN_TIME	Operational unknown time, or the sum of seconds across all spaces on that block during that hour when a spot was vacant	Sum of operating unknown seconds of all spaces * 3600
NONOP_TIME*	Non-operating time, or the sum of seconds across all spaces on that block during that hour when meters are not in operation according to the operating schedule, including towaway time (this does NOT include broken meters)	Sum of non-operational time of all spaces * 3600, or NONOP_OCCUPIED_TIME + NONOP_VACANT_TIME + NONOP_UNKNOWN_TIME
NONOP_OCCUPIED_TIME	Non-operating occupied time, or the sum of seconds across all spaces on that block during that hour when a spot was occupied and not operating	Sum of non-operating occupied seconds of all spaces * 3600
NONOP_VACANT_TIME	Non-operating vacant time, or the sum of seconds across all spaces on that block during that hour when a spot was vacant and not operating	Sum of non-operating vacant seconds of all spaces * 3600
NONOP_UNKNOWN_TIME	Non-operational unknown time, or the sum of seconds across all spaces on that block during that hour when a spot was unknown and not operating	Sum of non-operating unknown seconds of all spaces * 3600
GMP_TIME	General metered parking time, or the sum of seconds across all spaces on that block during that hour when metered parking is open to all vehicles	Sum of GMP time of all spaces * 3600, or GMP_OCCUPIED_TIME + GMP_VACANT_TIME + GMP_UNKNOWN_TIME
GMP_OCCUPIED_TIME	GMP occupied time, or the sum of seconds across all spaces	Sum of GMP occupied seconds

	on that block during that hour when a spot was occupied and open to all vehicles	of all spaces * 3600
GMP_VACANT_TIME	GMP vacant time, or the sum of seconds across all spaces on that block during that hour when a spot was vacant and open to all vehicles	Sum of GMP vacant seconds of all spaces * 3600
GMP_UNKNOWN_TIME	GMP unknown time, or the sum of seconds across all spaces on that block during that hour when a spot was unknown and open to all vehicles	Sum of GMP unknown seconds of all spaces * 3600
COMM_TIME	Commercial time, or the sum of seconds across all spaces on that block during that hour when metered parking is restricted to commercial vehicles only	Sum of commercial time of all spaces * 3600, or COMM_OCCUPIED_TIME + COMM_VACANT_TIME + COMM_UNKNOWN_TIME
COMM_OCCUPIED_TIME	Commercial occupied time, or the sum of seconds across all spaces on that block during that hour when a spot was occupied and restricted to commercial vehicles only	Sum of Commercial occupied seconds of all spaces * 3600
COMM_VACANT_TIME	Commercial vacant time, or the sum of seconds across all spaces on that block during that hour when a spot was vacant and restricted to commercial vehicles only	Sum of Commercial vacant seconds of all spaces * 3600
COMM_UNKNOWN_TIME	Commercial unknown time, or the sum of seconds across all spaces on that block during that hour when a spot was unknown and restricted to commercial vehicles only	Sum of Commercial unknown seconds of all spaces * 3600

* Sensor down-time increased towards the end of 2012 due to battery failures.

Removal and reinstallation of sensors over the SF*park* pilot period affects the number of sensors on block, therefore the time calculations outlined above. A change in total time on a block over time is likely due to a different number of sensors.

9.2   Data and rate adjustment timeline

SF*park* hourly occupancy and rates data are available starting in April of 2011. The SFMTA exempts meter payments on Christmas, Thanksgiving, and New Year's Day. All other days have rates in effect.

There was a sensor outage for the week of December 10, 2012 to December 17, 2012. The data from this outage was not recoverable, and there is no usable data for that week. While there may have been some stray events reported by the sensors during that time that result in occupancy figures in the data

file, these should be discarded for analysis. While the sensors had other outages from 2011 to 2013, this period was the only outage where data was not recoverable.

The rates in the hourly occupancy and rates data document change according to the SF*park* rate change schedule, outlined below. The implementation dates of the first four rate changes were staggered to allow the SFMTA to verify the accurate implementation of the rate adjustments.

Rate Adjustment	Reference Date	Implementation Date
1	8/11/11	7/21/11 – 8/11/11
2	10/11/11	10/11/11 & 10/18/11
3	12/13/11	12/13/11 & 12/20/11
4	2/14/12	2/13/12 & 2/28/12
5	3/28/12	3/28/12
6	5/8/12	5/8/12
7	8/29/12	8/29/12
8	10/31/12	10/31/12
9	1/16/13	1/16/13
10	4/3/13	4/3/13

9.3   Generating rate adjustments from occupancy data

Rate adjustments are calculated based on hourly occupancy calculations. The lower occupancy limit is inclusive, and the upper limit is exclusive (except for values of 100 percent). The table below outlines the rules that define the relationship between occupancy and rate adjustments.

From Occupancy	To Occupancy	Change Amount
>= 0%	< 30%	$ -0.50
>= 30%	< 60%	$ -0.25
>= 60%	< 80%	$ 0.00
>= 80%	=< 100%	$ 0.25

9.4   Blocks and Rate Adjustments

Over the course of the SF*park* pilot project, some blocks were added to, and in some cases removed, from the rate adjustment due to several reasons, outlined below:

- **No parking sensors**. Without occupancy data, the SFMTA cannot conduct a rate adjustment.

- **Block is in the Port jurisdiction.** Several blocks are subject to the Port's pricing policies. To date, there has not been a SF*park* rate adjustment at spaces on Port property.

- **No Smart Meter**. Without smart meters that can receive wireless transmissions, the SFMTA cannot easily adjust rates.

- **Install Phase**. See Section 3.1 for more details. 1,200 of the 8,200 spaces with sensors were installed in either summer 2011 or early 2012, and they may be included in later rate adjustments

- **Insufficient Block Coverage**. Over time, some sensors have been removed due to construction or otherwise rendered inoperable. Starting with rate adjustment #3, the SFMTA added a rule to require that at least 50% of the sensors on a block must be functioning to be included in a rate adjustment. In the rate adjustment datasets from the SF*park* website, blocks with insufficient block coverage are included but do not list occupancy data or a rate change.

For example:

- Fell Street blocks (unit, 100, 200, and 300) were delayed due to street paving and a later installation of smart meters.

			Rate Adjustment # and ID										
			1	2	3	4	5	6	7	8	9	10	
Block ID	PMD	Street Block	201108	201110	201112	201202	201203	201204	201208	201210	201301	201303	Total RA
41100	Civic Center	FELL ST 0	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4
41101	Civic Center	FELL ST 100	No	No	No	No	No	No	No	Yes	Yes	Yes	3
41102	Civic Center	FELL ST 200	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4
41103	Civic Center	FELL ST 300	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4

- Larkin blocks (unit, 100, 200) were excluded from rate adjustments due to insufficient block coverage for some time, but sensors were reinstalled so these blocks were included again in later adjustments.

			Rate Adjustment # and ID										
			1	2	3	4	5	6	7	8	9	10	
Block ID	PMD	Street Blo	201108	201110	201112	201202	201203	201204	201208	201210	201301	201303	Total RA
54200	Civic Cent	LARKIN ST	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
54201	Civic Cent	LARKIN ST	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	6
54202	Civic Cent	LARKIN ST	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8

Appendix A is an excel file that lists which blocks were included in each of the 10 Rate Adjustments.

The following is a list of all of the blocks that participated in all ten of the rate adjustments in SF*park*'s pilot project.

Civic Center

FRANKLIN ST 100
FRANKLIN ST 200
FRANKLIN ST 300
FRANKLIN ST 400
FRANKLIN ST 500
GOLDEN GATE AVE 600
GOLDEN GATE AVE 700
GOUGH ST 200
GOUGH ST 300
GOUGH ST 400
GROVE ST 0
HAYES ST 0
HAYES ST 100
HAYES ST 300
HAYES ST 400
HAYES ST 500
HICKORY ST 0
HICKORY ST 100
LARKIN ST 0
LECH WALESA ST 0

MCALLISTER ST 300
MCALLISTER ST 400
MCALLISTER ST 500
OAK ST 0
OAK ST 100
POLK ST 0
POLK ST 100
POLK ST 300
REDWOOD ST 100
VAN NESS AVE 0
VAN NESS AVE 100
VAN NESS AVE 200
VAN NESS AVE 300
VAN NESS AVE 400
VAN NESS AVE 500

Downtown

01ST ST 200
02ND ST 200
BATTERY ST 400

BATTERY ST 500
CLAY ST 100
CLAY ST 300
CLAY ST 400
CLAY ST 500
DAVIS ST 300
DRUMM ST 300
JACKSON ST 0
JACKSON ST 100
JACKSON ST 200
JACKSON ST 400
MARKET ST 0
MERCHANT ST 400
MISSION ST 0
MISSION ST 600
MONTGOMERY ST 700
NATOMA ST 100
SANSOME ST 500
SANSOME ST 600
STEUART ST 0
STEUART ST 100
TEHAMA ST 100

WASHINGTON ST 0
WASHINGTON ST 100
WASHINGTON ST 200
WASHINGTON ST 300
WASHINGTON ST 400
WASHINGTON ST 500

Fillmore

BUCHANAN ST 1800
California and Steiner Lot
CALIFORNIA ST 2300
CALIFORNIA ST 2400
CLAY ST 2400
CLAY ST 2500
FILLMORE ST 1000
FILLMORE ST 1100
FILLMORE ST 1200
FILLMORE ST 1300
FILLMORE ST 1400
FILLMORE ST 1500

FILLMORE ST 1600
FILLMORE ST 1700
FILLMORE ST 1800
FILLMORE ST 1900
FILLMORE ST 2000
FILLMORE ST 2100
FILLMORE ST 2200
FILLMORE ST 2300
FILLMORE ST 2400
GEARY BLVD 1500
GEARY BLVD 1600
GEARY BLVD 1700
GEARY BLVD 1800
JACKSON ST 2300
JACKSON ST 2400
LAGUNA ST 1500
LAGUNA ST 1600
PINE ST 2300
POST ST 1600
POST ST 1700
POST ST 1800
POST ST 1900
SACRAMENTO ST 2400
SACRAMENTO ST 2500
STEINER ST 1500
SUTTER ST 1800
SUTTER ST 2000
WASHINGTON ST 2400
WASHINGTON ST 2500
WEBSTER ST 1500
WEBSTER ST 1600
WEBSTER ST 2100
WEBSTER ST 2200

Fisherman's Wharf

BAY ST 300
BAY ST 500
BEACH ST 200
BEACH ST 300
BEACH ST 400
BEACH ST 500
BEACH ST 600
BEACH ST 700
BEACH ST 800
COLUMBUS AVE 1200
COLUMBUS AVE 1300
HYDE ST 2800
LARKIN ST 3000
LEAVENWORTH ST 2700
LEAVENWORTH ST 2800
MASON ST 2300
MASON ST 2400
MASON ST 2500
NORTH POINT ST 300
NORTH POINT ST 400
NORTH POINT ST 500
NORTH POINT ST 900
POLK ST 3100
POWELL ST 2300
POWELL ST 2400

Marina

AVILA ST 0
CHESTNUT ST 2000
CHESTNUT ST 2100
CHESTNUT ST 2200
CHESTNUT ST 2300
CHESTNUT ST 2400

DIVISADERO ST 3200
FILLMORE ST 3300
LOMBARD ST 2000
LOMBARD ST 2100
LOMBARD ST 2200
LOMBARD ST 2300
LOMBARD ST 2400
MALLORCA WAY 0
PIERCE ST 3200
PIERCE ST 3300
SCOTT ST 3200
SCOTT ST 3300
STEINER ST 3300

Mission

16TH ST 3000
16TH ST 3100
18TH ST 3400
21ST ST 3200
22ND ST 3200
23RD ST 3300
BARTLETT ST 0
VALENCIA ST 1000
VALENCIA ST 1100
VALENCIA ST 1200
VALENCIA ST 400
VALENCIA ST 500
VALENCIA ST 600
VALENCIA ST 700
VALENCIA ST 800
VALENCIA ST 900

South Embarcadero

01ST ST 300
02ND ST 300
02ND ST 400
02ND ST 500
02ND ST 600
02ND ST 700
03RD ST 300
03RD ST 400
03RD ST 500
03RD ST 600
03RD ST 700
04TH ST 600
BRANNAN ST 200
BRANNAN ST 300
BRANNAN ST 400
BRANNAN ST 500
BRYANT ST 300
BRYANT ST 400
BRYANT ST 500
FOLSOM ST 0
FOLSOM ST 600
HARRISON ST 0
HARRISON ST 100
HARRISON ST 500
KING ST 100
MAIN ST 300
SPEAR ST 300
TOWNSEND ST 0
TOWNSEND ST 100
TOWNSEND ST 200

Notes for special blocks:

- Montgomery 600 – The 600 block of Montgomery Street shows up in some of the earlier rate adjustment spreadsheets. However, this block is all commercial meters at all operation hours, so there are no GMP hours on which to base rate adjustments. This block should be excluded from analysis.

- Townsend 300 – The 300 block of Townsend Street originally had seven spaces with sensors and shows up in some of the earlier rate adjustment spreadsheets. After the seven sensors were installed, more meters were added to the block, resulting in a block with over 40 metered spaces. After the new meters were added, the seven sensors were insufficient to calculate sensor-based rate adjustment per

CIRCLE LESS, LIVE MORE

SFMTA
Municipal Transportation Agency

SF*park* policy across the entire block. The rates have subsequently been based on manual surveys. This block should be excluded from analysis.

10 Appendix A: List of blocks included in rate adjustments 1-10

See Excel file:

SFpark Parking Sensor Data Guide_APPENDIX A_List of Blocks by Rate Adjustment_2013-08-30.xlsx