# Parking Sensor Technology Performance Evaluation

## June 2, 2014

# Executive Summary

As part of the SF*park* pilot, the SFMTA used a network of in-ground parking sensors in 8,200 on-street parking spaces. The sensors used for the SF*park* pilot were provided by StreetSmart Technologies (now known as Fybr). These sensors utilized a magnetometer to detect when vehicles entered and exited a space. The primary purposes of these sensors were to measure parking occupancy for calculating demand-responsive rate adjustments and to provide real-time parking availability data that the SFMTA provided to the public. Additional uses included measuring parking behavior to evaluate the SF*park* pilot projects including a test of guided parking enforcement.

This document describes the technology utilized for the SF*park* pilot, the issues that arose during the pilot, how the SFMTA measured parking sensor performance, and the results of these performance metrics for the magnetometer sensors as well as for four newer technologies.

This evaluation covers findings relating to the sensor data used for SF*park*, managing sensor data, and the possible uses of sensors in the future.

### SUMMARIZED FINDINGS REGARDING THE SENSOR DATA USED FOR THE SF*PARK* PILOT

- **Parking sensors have provided a wealth of data for analysis.** The magnetometer-based sensors provided by StreetSmart met the primarily needs of the SF*park* pilot. However, parking sensors are a nascent technology and the SF*park* pilot served as a learning opportunity for both the SFMTA and sensor providers. The deployment also provided the SFMTA with an unprecedented dataset measuring parking behavior for nearly three years in SF*park* areas. The agency has used this data both to operate and evaluate the SF*park* pilot as well as to support other parking and transportation analyses.
- **Parking sensors have successfully provided reliable data for occupancy rates.** The occupancy accuracy test involves field surveyors validating whether or not spaces are occupied. This test measures performance of calculating occupancy rates (i.e., how many spaces are occupied out of total available spaces). Relatively strong occupancy accuracy scores (averaging 86% through 2012) indicate that the sensor data can reliably support occupancy calculations – this is the principal metric for the SFMTA's parking management goals.
- **Parking sensor networks can achieve low latency and support real-time applications.** The SFMTA included timestamps within the sensor transmissions to measure how quickly the sensor network could detect vehicles and provide the SFMTA data. The parking sensor network used for the SF*park* pilot achieved strong scores for latency, with the majority of all transmissions being received by the SFMTA within 30 seconds of detection. Low latency is required for applications such as real-time parking availability data and guided enforcement.
- **The SFMTA chose not to use parking sensor data to support turnover/length of stay calculations.** The turnover accuracy/timeliness test involves field surveyors capturing when and where vehicles leave a space. Detailed field verification of this data revealed that sensors can over

count or undercount the number of sessions while still yielding a rather high accuracy rate for occupancy. This occurs because the sensors may falsely detect or miss a car parking or leaving a space during a period of occupancy. For example, one vehicle may be parked in a space for 60 minutes, but sensors may detect this as three parking sessions lasting 20 minutes each. As a result, the SFMTA chose not to use data from these sensors to calculate turnover or length of stay metrics.

## SUMMARIZED FINDINGS RELATED TO SENSOR DATA MANAGEMENT

- **Operational control of sensor data feeds is critical.** Once the sensor network became operational, the SFMTA discovered the need to develop processes to closely monitor data transmissions from the vendor. This was necessary to ensure the completeness of the dataset. Regardless of the vendor's own quality control processes, the SFMTA found it necessary to independently monitor and verify quality. The SFMTA worked with the vendor to identify and address issues.
- **Field issues can complicate vehicle detection.** High levels of electromagnetic interference from overhead wires, underground utilities, and other sources made it more difficult than expected for the magnetometer sensors to properly detect vehicles. The nature of the interference varied significantly by district, block, and in some cases, by parking space. During three years of operation, interference remained pervasive and unpredictable. While the vendor made some strides in filtering out some of the noise via software upgrades to the sensors, these software changes also reduced battery life of the sensors.
- **In-ground sensors involve substantial asset management in the field.** The SFMTA and StreetSmart attempted to plan sensor installation to avoid major street construction projects and excavation of sensors. However, timelines for construction projects sometimes changed, and other agencies, utilities, and vendors performed work in the street without notifying the SFMTA so some sensors were paved over or otherwise destroyed without notification. Coordination improved over time as other agencies and private contractors became familiar with sensors in the street and better adhered to City procedures for notifications. Any future installation of in-ground sensors will require careful coordination and planning with existing City processes.
- **Performance measurement should be tied to how sensor data will be used.** The SFMTA used multiple methods of measuring parking sensor performance. The agency collected data using two contractually mandated methodologies over time and developed two additional methods to further analyze performance. In some cases, results varied considerably across methodologies. To interpret results and properly assess performance, the performance measurement tools should be linked to how the data will be applied for analysis and operations.

## SUMMARIZED FINDINGS FOR CONSIDERING THE USE OF SENSORS IN THE FUTURE

- **New sensor technologies can be more accurate and support more applications.** Since deploying of the StreetSmart sensors early in 2011, several newer vendors and technologies have emerged. The SFMTA conducted trials of these new technologies alongside the existing sensors. Newer sensors, particularly those using radar and infrared technologies, have demonstrated improved accuracy that may be able to more reliably support additional metrics and applications such as turnover and length of stay calculations. However, the results of these small-scale trials should not be extrapolated to a larger deployment which presents additional challenges.

- **Future deployments should start small.** The SF*park* pilot deployment was geographically expansive, and the majority of sensors were installed in a few months. This pushed the limits of this new technology since sensors need to be carefully tuned to their surrounding environment. In any future installations, the agency should start with one district with perhapss no more than 1,000 spaces and potentially reevaluate deployment plans on an incremental basis.
- **The SFMTA should consider what applications it may have for sensor data in the future.** In evaluating whether or not the SFMTA should use parking sensors in the future, the agency should consider not only cost, but how it will use the data and the expected benefits. For example, providing real-time parking availability to the public requires sensor data that can support accurate occupancy rate calculations, but not necessary accurate turnover calculations. The SFMTA's needs for the data should be clear, and the agency should clearly define performance standards and measurements that are tied to these applications.

## Introduction

As part of the SF*park* pilot, the SFMTA used a network of in-ground parking sensors in 8,200 on-street parking spaces. Sensors were provided by StreetSmart Technologies and utilized a magnetometer to detect vehicles. The primary purposes of these sensors were to measure parking occupancy for calculating demand-responsive rate adjustments and to generate real-time parking availability data that the SFMTA provided to the public. Additional important uses included measuring parking behavior for the evaluation of SF*park* and supporting a test of guided parking enforcement.

The installation of on-street parking sensors for SF*park* was the first large scale installation of this technology in a major North American city. The SF*park* pilot served as a learning opportunity for both the SFMTA and sensor providers.

This document describes the technology utilized for the SF*park* pilot, issues that arose during the pilot, how the SFMTA measured parking sensor performance, and the results of these performance metrics for the magnetometer sensors as well as for four newer technologies.

## SF*park* pilot deployment

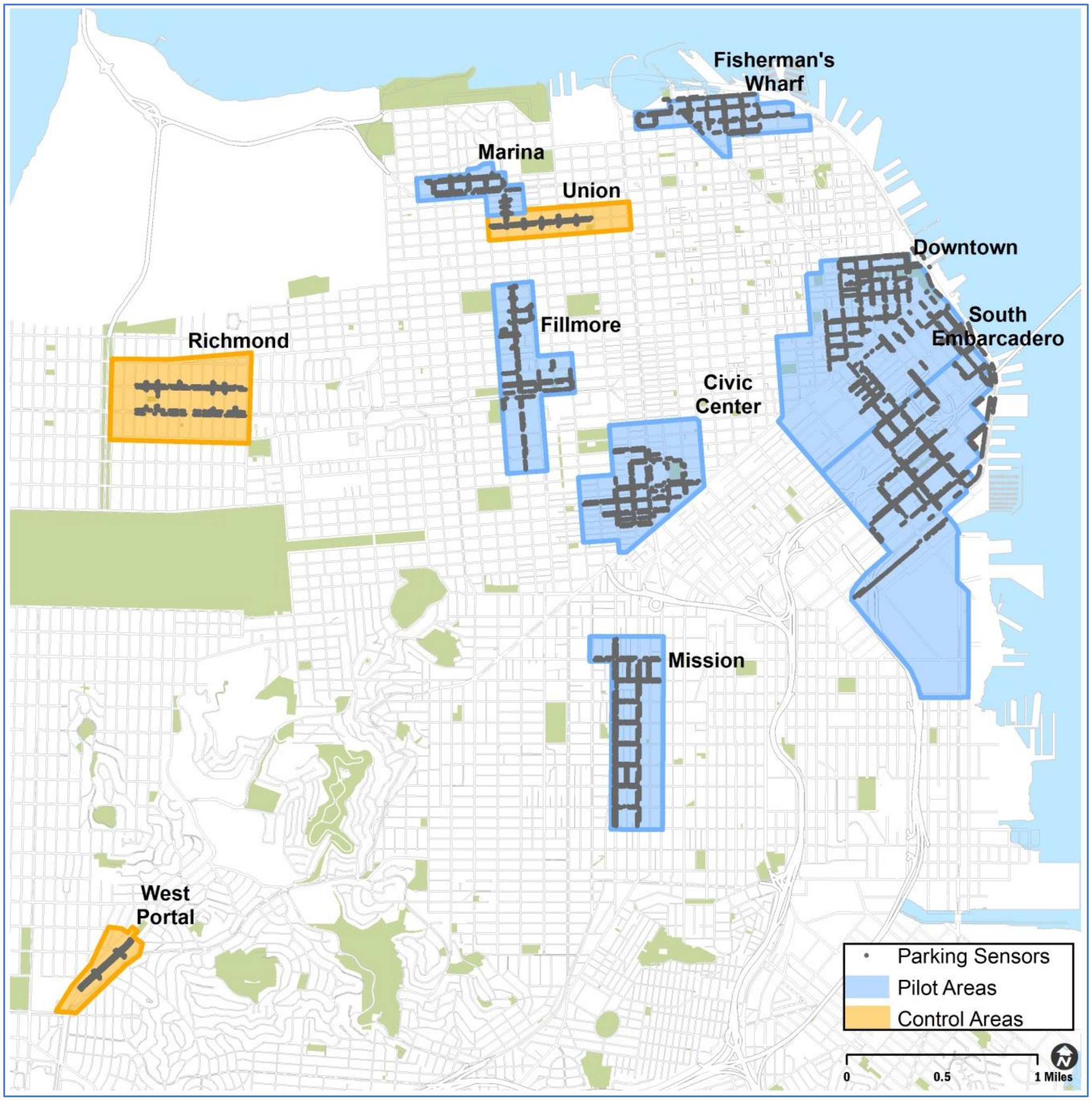
Parking sensors for the SF*park* pilot deployment were provided by StreetSmart Technologies (SST). StreetSmart's parking sensor is a wireless, in-ground device that that detects the presence or absence of large metallic objects using a magnetometer. The sensors send transmissions to the SFMTA back-end system when a vehicle enters a space (session start or SS) or leaves a space (session end or SE). The sensor network also sent a set of other messages as necessary to reflect operational status.[1] These transmissions were conveyed through a network of about 400 pole-mounted networking devices that comprise an ultra-low powered mesh network. This network was optimized to provide high accuracy and low latency. On average, about 250,000 transmissions were sent per day.

The SFMTA paid for the installation of the sensors and a monthly per-space fee to receive data. StreetSmart owned, operated, and maintained the network and equipment. The average installation cost was $330 per space. Monthly fees were tied to performance and varied over time; however, on average, the SFMTA paid about $10 per space per month.

The parking sensor network for SF*park* includes over 8,200 spaces in ten Parking Management Districts (PMDs), shown on the following page. Every metered space in San Francisco is physically marked and assigned a unique identifier. Valid data from all PMDs is available starting on April 1, 2011. In 2013, sensor battery life began to degrade, and transmissions from control areas ceased on June 30, 2013. Data from the rest of the pilot areas ceased on December 31, 2013. This timeframe was generally consistent with the SFMTA's expectations.

[1] See the SF*park* parking sensor data guide for more details.

**SF*park* Sensor Deployment**




## Field issues

A number of unexpected field issues posed challenges for the deployment of on-street parking sensors for the SF*park* pilot:

- **Noise from overhead lines and other sources.** Once the sensor network was deployed, StreetSmart noticed high levels of electromagnetic interference (or "noise") in many areas. 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 electricity junction boxes underground transformers. The nature of the noise varied significantly by PMD, block, and in some cases, parking spaces. These parking sensors were ultra-low power devices, so noise degraded their ability to detect vehicles correctly. While SST developed various hardware and software solutions to overcome noise, including placing two sensors in nearly half of all parking spaces, sensor accuracy varied more than expected.

- **Early battery degradation.** The batteries in StreetSmart sensors were originally intended to last about five years. Specialized software designed to filter out some of the AC and DC noise reduced this estimate to three years. While the three-year expectation was generally met, some sensors started to require battery replacements in late 2012 and early 2013, about one year earlier than expected. Due to resource constraints, not all sensors with depleted batteries could be replaced, and the SFMTA prioritized replacements in spaces that were part of demand-responsive rate adjustments. The SFMTA took other corrective actions within its internal asset management system to filter out data from sensors with depleted batteries.
- **Street construction**. To the extent possible, the SFMTA attempted to make sure StreetSmart removed sensors prior to street paving and other street construction. The SFMTA coordinated internally and with the San Francisco Department of Public Works. However, not all construction work can be coordinated, and there are other agencies, utilities, and vendors that perform work in the street. These projects often disrupt operations of other City infrastructure such as parking meters; however, tools and processes are being developed to better coordinate work. Some sensors were paved over or otherwise destroyed without notification, but coordination improved over time as other agencies and private contractors became familiar with the presence of sensors in the street.

The SF*park* deployment was geographically expansive, and the majority of sensors were installed in a few months. This schedule pushed the limits of this new technology because sensors need to be carefully tuned to their surrounding environment. In any future installations, the agency should start with one district with no more than around 1,000 spaces and be prepared to reevaluate deployment plans on an incremental basis.

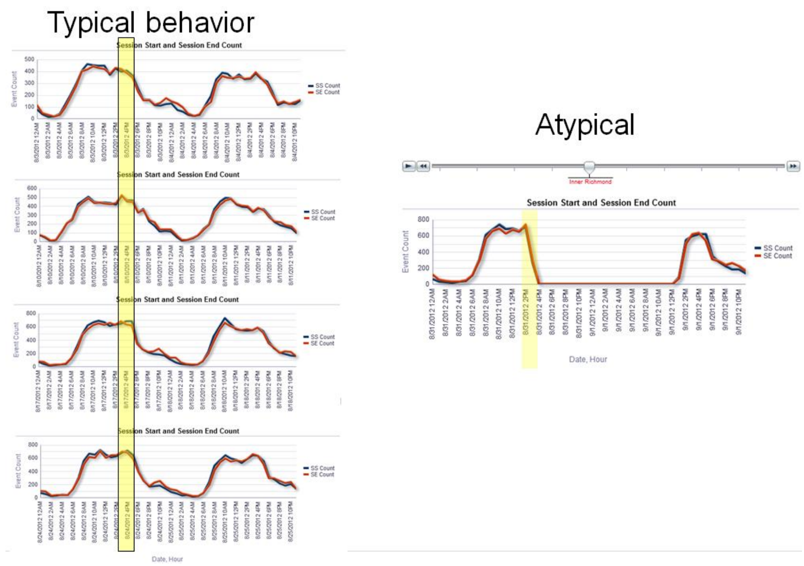
### Operational control over real-time data transmissions

Once the sensor network became operational, the SFMTA discovered the need to closely monitor data transmissions from the vendor once the system went live. This was necessary to ensure that data for all spaces was successfully being transmitted. The SFMTA employed the three following methods to ensure data was properly flowing:

1. **Check to see that each space sends a message at least once a day.** While some vehicles may be parked in a space for more than 24 hours, most spaces have more than one parking session per day. Receiving no messages from a sensor on a day can indicate a problem.

2. **Keep track of spaces that haven't sent a message for more than three days.** Most spaces that did not report on one day tended to report again within two or three days. The SFMTA monitored spaces that have not reported for more than three days, and conducted periodic field checks. Long periods of non-reporting often indicated that a sensor had been destroyed or blocked due to long-term construction.

3. **Compare current levels of data flow to historical profiles.** For each district, the SFMTA created an hourly profile to define a typical level of transmissions based on historical data. An alerting system was implemented to notify project managers if actual levels fell significantly below the typical threshold. The figure below illustrates this concept, and how a below-normal level of transmissions predicted an oncoming outage.




No single method of operational control – nor the combination of all three – could definitively indicate a data transmission problem. However, the SFMTA used this information to direct further investigation into potential issues and resolve them with the vendor as quickly as possible. Regardless of the vendor's own quality control processes, the SFMTA found it necessary to independently monitor and verify data quality.

## Performance measures

The SFMTA utilized four measures for assessing sensor performance:

1. Occupancy accuracy
2. Turnover accuracy/timeliness
3. Parking session accuracy
4. Latency

The occupancy accuracy and turnover accuracy/timeliness tests were based on contractually-mandated methodologies. These contractual tests were referred to as the "accuracy test" and the "timeliness test," respectively, and the SFMTA prorated monthly fees based on the results of these tests. The SFMTA developed the additional two methods over the course of the pilot to further analyze performance. In assessing overall performance, the SFMTA found it necessary to tie these methodologies to how the agency uses the data for operations and analysis. The following table shows how the SFMTA linked performance methodologies to applications of sensor data (and renamed some tests appropriately) to evaluate parking sensor technology.[2]

| | **Application of data** | | | | |
|---|---|---|---|---|---|
| **Performance measures** | Real-time data | Occupancy rate analysis | Turnover/ session count analysis | Length of stay analysis | **Notes** |
| Occupancy accuracy | **X** | **X** | | | Easy to gather large samples, but only related to a snapshot in time and can be accurate by chance. |
| Turnover accuracy/ timeliness | | | **X** | | More closely tied to raw sensor data, but difficult to collect large samples. |
| Parking session accuracy | | **X*** | **X*** | **X** | Provides detailed information, but labor-intensive to collect and evaluate. |
| Latency | **X** | | | | Low latency is necessary for real-time applications. |

*While the SFMTA did not use parking session accuracy to inform occupancy rate analysis and turnover analysis for this report, data from these tests could support this use.

## Occupancy accuracy

The occupancy accuracy test measures how reliably sensors accurately report the status of a parking space. Field observations record whether each space is vacant or occupied, which is then compared to data from the sensor data feed. The results indicate how often the sensors accurately reflect whether or not a space is vacant or occupied.

### STRENGTHS AND LIMITATIONS

Field observations can be collected from any space at any time, and thus large samples are easy to gather.

However, because the occupancy accuracy observations are essentially a snapshot in time, the occupancy test does not reflect whether any single sensor was correct over a sustained period of time.

[2] More detailed methodologies are available in Appendix A.

The occupancy accuracy score does not measure how accurately the sensors reflect parking turnover. Additionally, because a space can only be one of two states (i.e., vacant or occupied), sensors can be accurate 50 percent of the time based on chance alone.

#### APPLICATIONS

The occupancy accuracy scores have several practical applications. They indicate the quality and reliability of the real-time availability feed. The occupancy accuracy scores also provide guidance for the use of sensor data in any occupancy rate analysis and in some enforcement-related analyses.

### Turnover accuracy/timeliness

The turnover accuracy/timeliness test measures how reliably and how quickly the sensors detect parking events (session start or session end). For this test, a field surveyor observes where and when vehicles enter (SS) or leave (SE) a space. The evaluation of each observation consists of two portions:

1. The turnover accuracy portion measures whether the sensor sends a correct event for each observed parking event.
2. The timeliness portion measures how quickly the sensor network gets that message to the SFMTA server.

#### STRENGTHS AND LIMITATIONS

The turnover accuracy/timeliness test is more closely tied to the raw SS and SE event data sent to the SFMTA.

The test captures how well sensors report what is observed on the street, but it does not measure the incidents of false positives, which is when a sensor reports an event that did not actually occur. Additionally, field observations can only be gathered when a vehicle enters or exits a space. This makes collecting large samples of observations more difficult.

#### APPLICATIONS

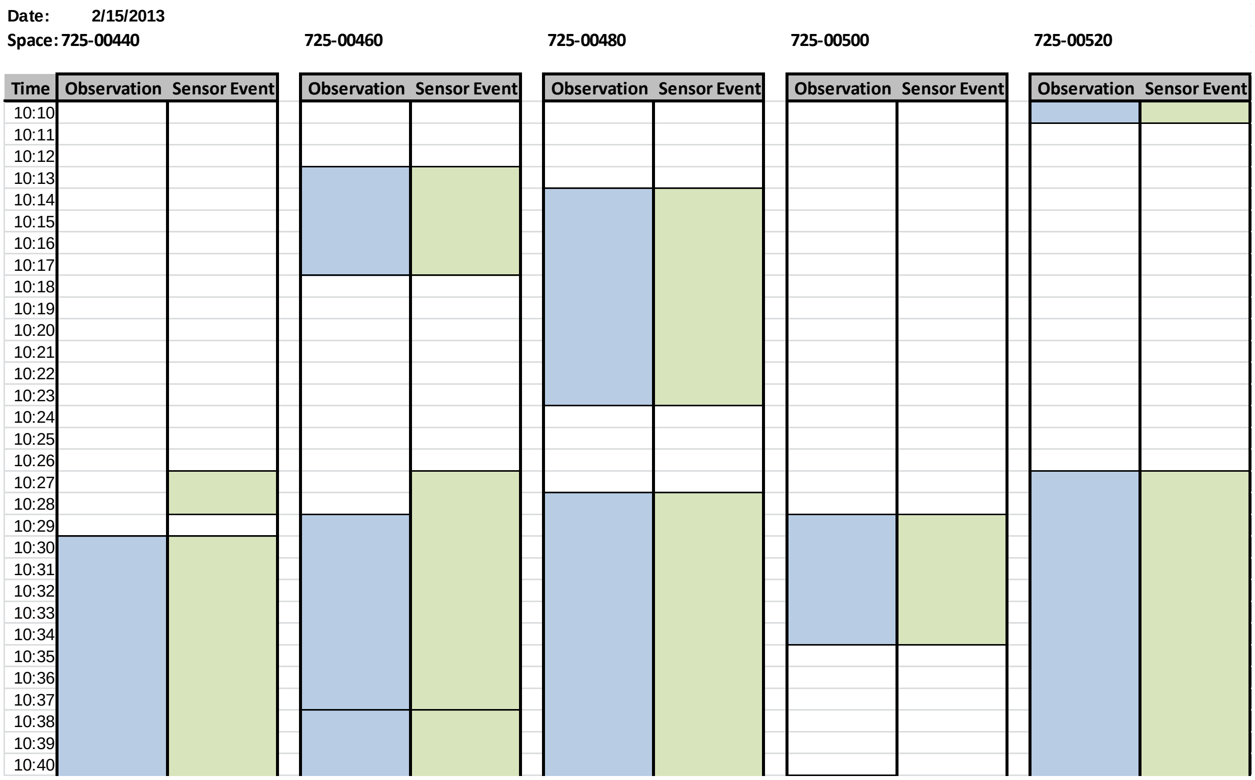
The turnover accuracy/timeliness test provides useful information on the accuracy of data for turnover analyses. The timeliness portion of the test may not be necessary in future applications; if the data feed contains the necessary elements, the latency test can measure the timeliness of data in a more comprehensive way so long as timestamps are periodically validated.

### Parking session accuracy

The SFMTA developed the parking session accuracy test to more comprehensively measure how well sensor events represented actual parking sessions on the street.

### STRENGTHS AND LIMITATIONS

This test is more rigorous than the previous two methods. The figure below illustrates how the parking session accuracy test compares field observations to the sensor feed across five parking spaces, with observed parking events in blue on the left and reported sensor events on the right in green:




However, the parking session accuracy test requires continuous observation of spaces and is therefore labor-intensive and costly. The test has a small sample size and minimal geographic variability. While the test does record false positives, or parking events that the sensors report that do not actually happen, this occurrence is not completely captured in the existing metrics.

### APPLICATIONS

The parking session accuracy test gives the most comprehensive view of how the sensors report what is happening on the ground. The measure of the percent of observed sessions that have a corresponding reported sensor event informs how useful the sensor data is for length of stay analyses. This also has implications for enforcement applications. The parking session accuracy test can also be used to measure the accuracy of turnover and occupancy rates (see Appendix B).

## Latency

The latency test measures how long it takes for a SS or SE that happens on the street to be communicated, processed, and received by the SFMTA back-end system. The latency test is a simple calculation using two fields in the parking sensor data feed: the event time, or the time that the sensor determined that the event occurred, and the transmission received time, or the time that the SFMTA's system received the transmission.

### LIMITATIONS

The latency score does not account for sensor accuracy.

### APPLICATIONS

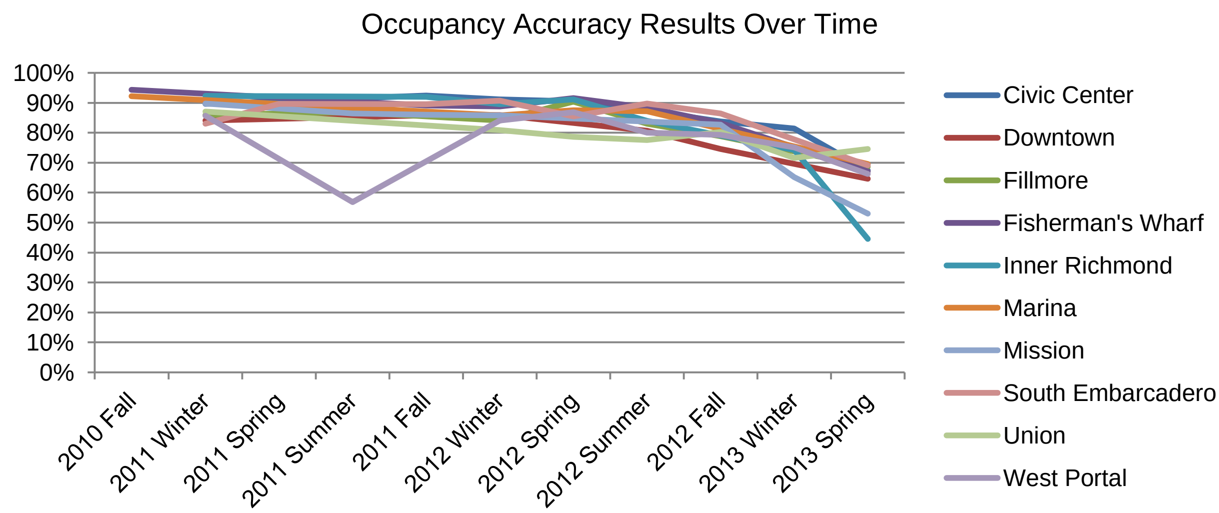
The latency scores indicate how quickly data can be fed to real-time applications. This includes real-time parking availability feeds and real-time guided enforcement.

The following sections describe the results of all four of these tests as applied to the deployment of 8,200 sensors for the SF*park* pilot as well as four newer sensor technologies.

## Results from SF*park* pilot deployment

### Occupancy accuracy

Occupancy scores varied over time and by district. Until early 2013, the overall average occupancy accuracy was 86%. The scores started to decrease at the end of 2012 and into 2013. The average accuracy score was 68% in 2013, bringing the overall average over all years to 82%. The chart below outlines the occupancy accuracy results over time by PMD.

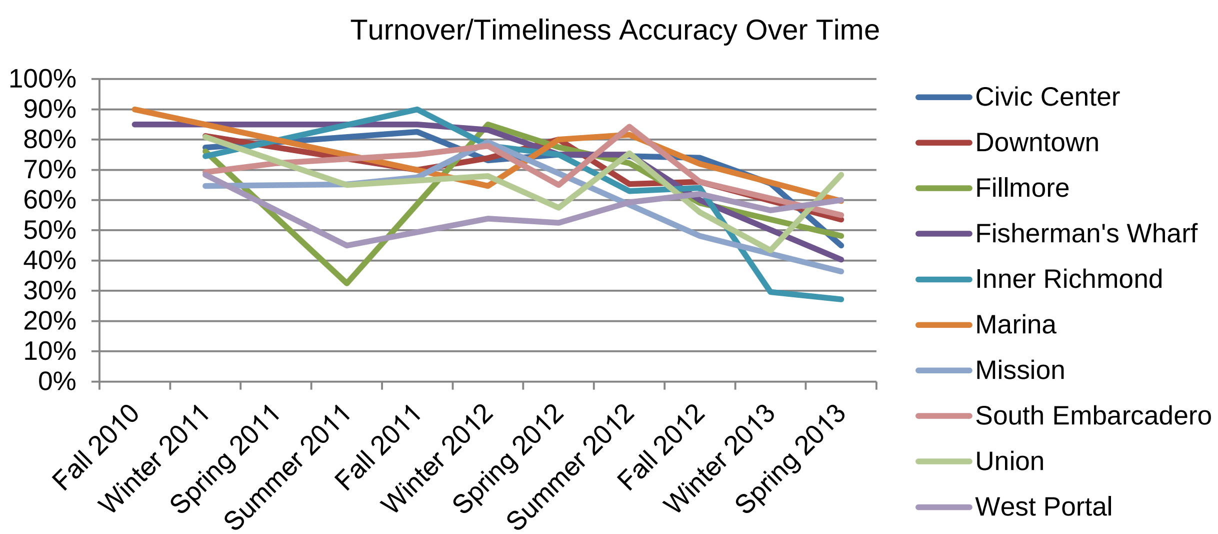



Early battery failures are likely the primary cause for the decline in performance beginning in Fall 2012. Additional explanatory reasons for variations in performance (including the drop in accuracy for West Portal in 2011) include the nature of environmental interference and their changes over time. While the vendor developed various solutions to overcome noise, noise remained pervasive and unpredictable and was known to affect sensors differently in certain times and areas.

Additionally, the combined effects of noise, battery failures, and other field issues such as degrading network communication could have contributed to declining scores. Although improvements were made in one area (e.g., noise), challenges arose in another (e.g., network performance). To the extent possible, the SFMTA tracked known spaces with consistently erroneous data and filtered them out of real-time applications and historical analyses. These adjustments are not reflected in the results of the occupancy accuracy test.

### Turnover accuracy/timeliness

The turnover accuracy/timeliness test measures the percent of observed parking sessions that had a corresponding sensor event in the data feed. These scores evaluate the sensors' ability to correctly identify when cars park or pull out of spaces. The average overall score for events received within 180 seconds of the recorded observation is 67%. The turnover accuracy/timeliness scores varied significantly by area and over time. The chart below illustrates the turnover accuracy/timeliness scores for 180 seconds over time by PMD.




Like occupancy accuracy, turnover accuracy/timeliness scores slowly declined over time. However, there is also greater variation in these results as compared to occupancy accuracy. In addition to the possible reasons for degrading performance mentioned previously, low and variable turnover accuracy/timeliness scores may be due to the smaller sample size for this test. Since only a minimum of 40 observations are required for this test (compared to 450 for occupancy accuracy), errors are more significant in the overall result.

This test was initially referred to as the "timeliness test" in the contract, and it was intended to measure latency rather than accuracy. The common occurrence of missed sessions (meaning a car was parked in a space but not detected by the sensor) was not anticipated. The numerous missed detections reduce the accuracy of the turnover counts. The strong latency scores, outlined later in this document, indicate that the vast majority of the events not captured within this 180 window were not received later; rather, they are missed detections, or instances where a car parked in a space and was not recorded by the sensor. Similar to the occupancy accuracy test, operational adjustments made to account for known sensors with recurring issues are not reflected in these results.

### Parking session accuracy

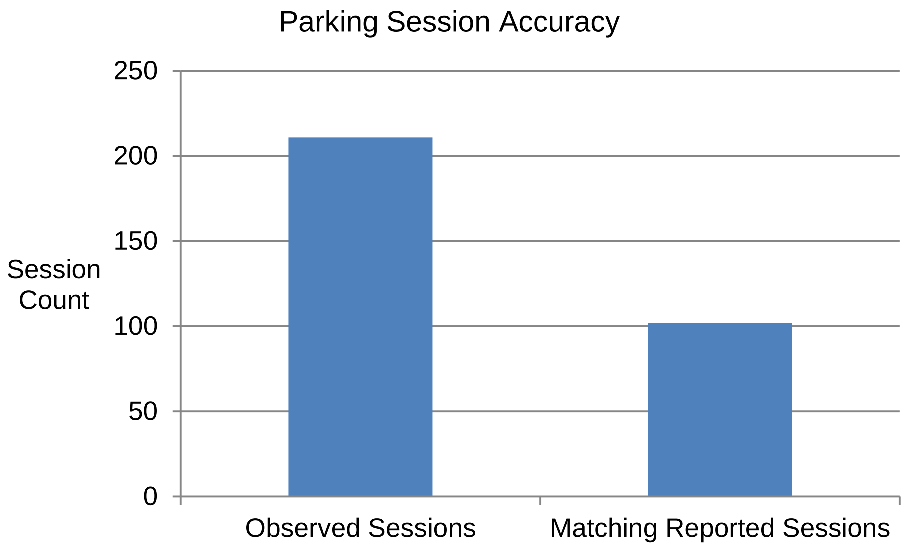
The SFMTA performed several field tests to verify how well sensor events represented actual sessions, both to get a more robust picture of how sensors were functioning as well as to better understand how turnover accuracy scores can be lower than occupancy accuracy scores.

A parking session accuracy test calculates how often the sensors correctly track cars pulling into a space and measuring their duration of stay. This metric compares the total number of observed sessions to the number of matching sessions reported by the sensor. A matching session is a reported sensor session that both:

1. Begins at the same time as the observed session, and
2. Lasts for the same amount of time as the observed session.

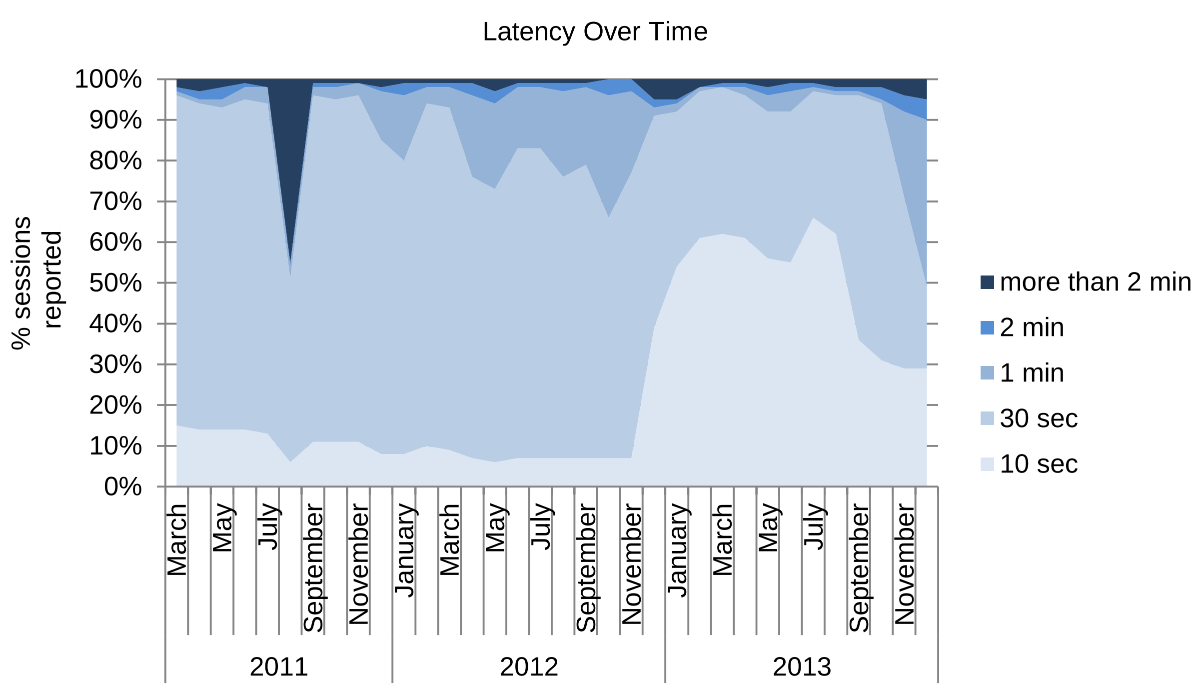
For both the start time and the duration, the SFMTA uses a three-minute margin of error when measuring performance. The final score is the number of reported sessions that started at the correct time and reported an accurate length of stay over the total number of sessions observed.

Collecting actual session and length of stay data is a resource-intensive process. Using the methodology described above, the SFMTA monitored parking spaces in four-hour periods in three neighborhoods on seven different days. This effort yielded data for 211 parking sessions and found that only 102 sessions were reported accurately. This means that sensors accurately represented the start and end of a parking session – with no interruptions in between – only half of the time.




### Latency

The latency scores show that the SFMTA server receives the vast majority of all parking events within one minute of the sensor recording a parking event.




Over the course of the pilot:

- 97% of all messages were to the server within 3 minutes,

- 95% were received within one minute, and
- 87% were received within 30 seconds

Apart from a service outage in the summer of 2011, the vast majority messages were received within 30 or less. In late 2012, StreetSmart deployed improvements to the sensor network that significantly increased the share of events arriving within 10 seconds or less.

## Conclusions

This set of complementary tests outline how useful the sensor data are for various applications. Occupancy accuracy scores (averaging 86% through 2012 and 82% including 2013) indicate that the sensor data can reliably support occupancy calculations.[3] Occupancy is the SFMTA's principal metric for parking management, and the sensors support this need. Paired with strong latency scores, the SFMTA concluded that the existing technology supported SF*park*'s demand-responsive rate adjustments and real-time availability feed.

Aggregating data over time (e.g., hour) and geography (e.g., blockface or block) can also reduce the effect of sensor error. The SFMTA performs most analyses – including the implementation of SF*park* rate adjustments – with hourly data at the block level. Additionally, the SF*park* real-time availability feed provided data at the blockface level.

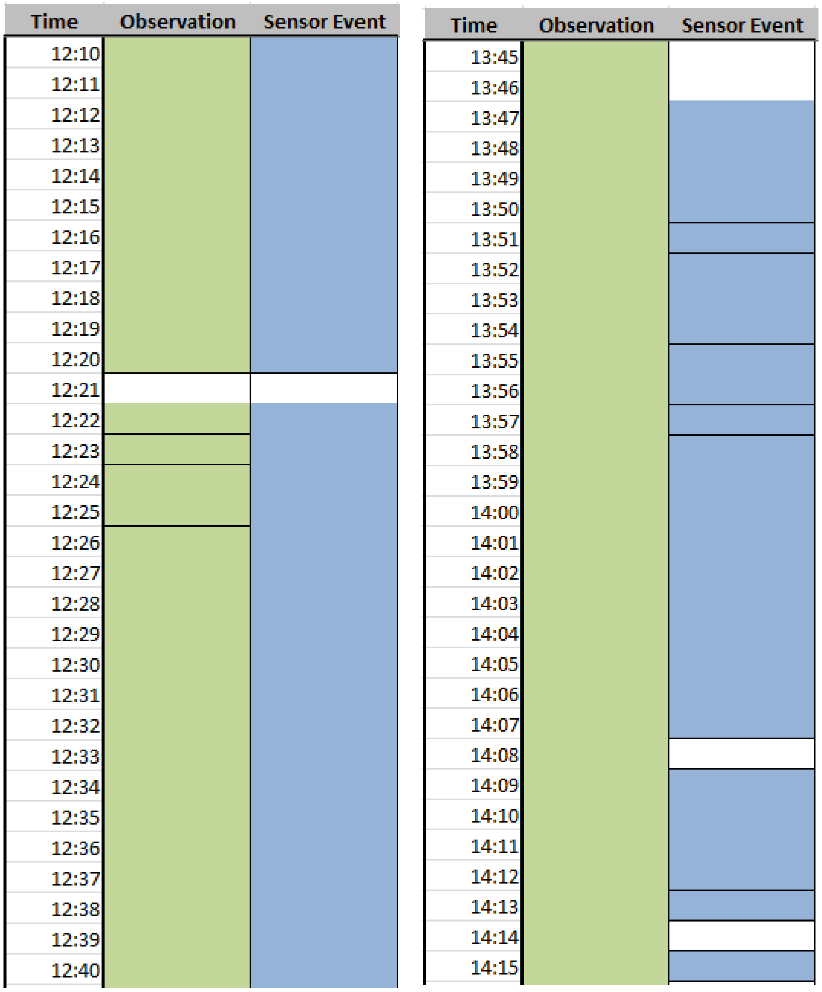
However, much lower turnover accuracy/timeliness scores suggest that the data should not be used for turnover or length of stay calculations. Results from these tests were highly variable, and the parking session accuracy tests revealed that sensors can over count or undercount the number of sessions while still yielding a rather high accuracy rate for occupancy.

This occurs because the sensors may falsely detect or miss a car parking or leaving a space change during a period of occupancy. For example, one vehicle may be parked in a space for 60 minutes, but sensors may detect this as three parking sessions lasting 20 minutes each. The reverse is also possible; three vehicles may have parked one after another in the same space for 20 minutes each, but the sensors may have missed the quick turnover and incorrectly reflected one continuous hour-long session.

An example of this is illustrated below, with time to the minute in the first column, observations in the second, and reported sensor events in the third. Minutes that are in color (green for observations and blue for sensors) mean that a car was parked during that minute, and the horizontal black lines indicate when either the observer or the sensor indicated that a car left and the parking session ended. The example on the left shows a period of time when there were several cars parked in a space over 30 minutes, but the sensor only reported two cars. The example on the right shows a period of time when

[3] The SF*park* parking sensor data guide provides more detail on how the SFMTA calculates occupancy rates using sensor data.

there was only one car parked the entire time but the sensor reported nine cars over 30 minutes (and four minutes without any car).




Even with a small sample size of turnover accuracy/timeliness surveys, the high variation of the results indicate that counting total number of sessions and measuring their duration would not be accurate. As a result, the SFMTA has chosen not to use parking sensor data to support these metrics.

## New technologies

Since the launch of SF*park* in April 2011, newer sensor technologies have emerged from multiple providers. The SFMTA tested four new sensor technologies using the same performance metrics applied to the larger network.

The SFMTA chose two primary test sites for these new sensors: Fillmore and West Portal. Both sites are within existing SF*park* areas so the SFMTA could compare the test sensors with the original StreetSmart sensors to the extent possible. The sites were selected because they also have relatively high levels of electromagnetic interference which posed challenges for existing magnetometer-based sensors. They were also good test sites because they are busy commercial streets with high turnover. Fillmore has parallel spaces, while West Portal tests sensors in angled parking spaces. Additionally, the West Portal test site is located in very close proximity to a device that feeds overhead lines for light rail vehicles – this has been known to generate levels of interference that have not been found elsewhere in the deployment of parking sensors in San Francisco. The SFMTA prioritized testing in these locations, but in some cases found it necessary to install sensors for testing in other locations.

### Trial vendors and technologies

Most test sensors systems were in a pre-production state, meaning that hardware and software were still very much in development.[4] Where possible, the SFMTA attempted to place test technologies in the same parking spaces at the same time.

| Sensor technology | Vendor | Dates tested | Streets tested | Number of spaces tested |
|---|---|---|---|---|
| Radar/magnetometer | Fybr[5] | Fall 2013 | West Portal, Clement | 29 |
| Radar | Sensys | Spring 2013 | West Portal, Fillmore | 36 |
| Infrared | Car Parking Technologies (CPT) | Spring 2013 | West Portal, Fillmore | 20 |
| Image recognition | Cysen | Summer 2012 | West Portal, Fillmore, Valencia, Balboa | 55 |

To evaluate these technologies and vendors, the SFMTA utilized the same four tests previously outlined in this document. All efforts were made to ensure fairness and consistency among vendors. Each vendor

[4] For instance, one vendor indicated that they would install sensors differently within the space in future deployments, another vendor implemented network changes midway through the trial, and another progressed through multiple software iterations.
[5] In 2013, StreetSmart changed its name to Fybr and developed a new sensor product.

was required to provide data via the same XML data protocol as StreetSmart in the SF*park* pilot.[6] The SFMTA conducted all field tests with the same methodology and resources as it did for StreetSmart, with small revisions to account for the smaller sample size.

## Testing Results

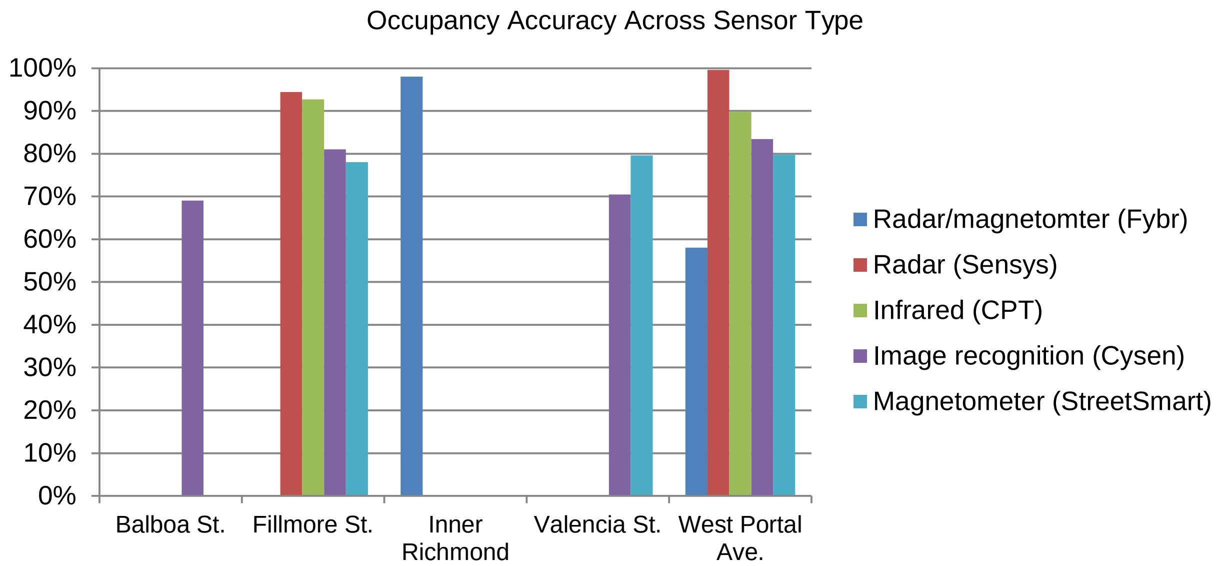
Existing StreetSmart scores for all the applicable spaces are provided for reference. See Appendix D for all results.

### OCCUPANCY ACCURACY

The following table summarizes the average of all occupancy accuracy tests:

| Sensor technology (vendor) | Occupancy accuracy |
| --- | --- |
| Radar/magnetometer (Fybr) | 78% |
| Radar (Sensys) | 98% |
| Infrared (CPT) | 92% |
| Image recognition (Cysen) | 77% |
| Magnetometer (StreetSmart) | 81% |

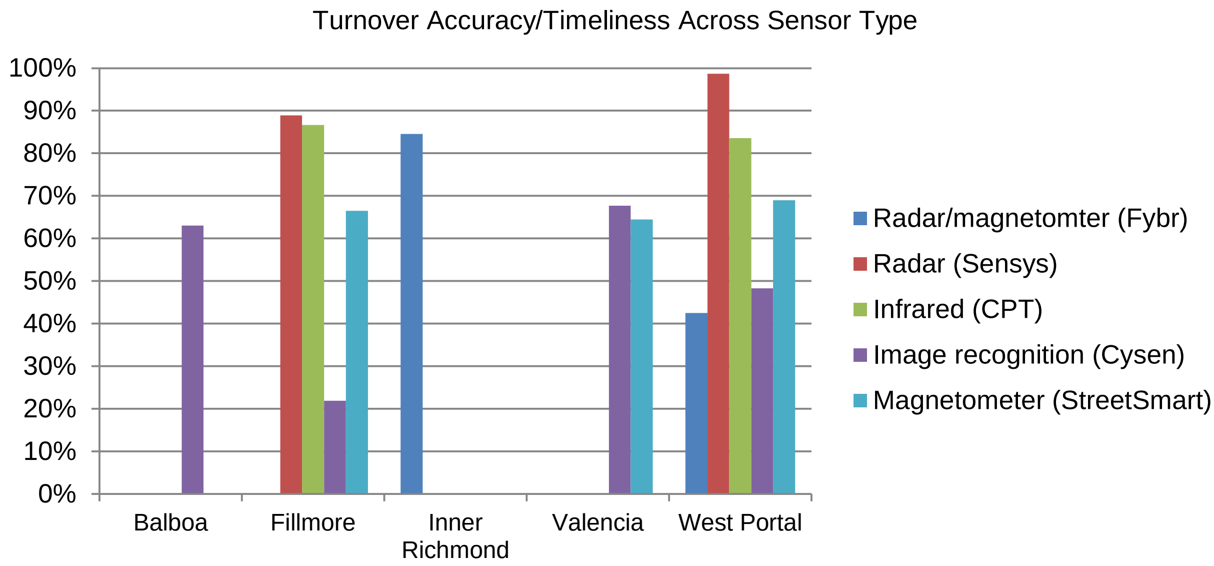
[6] See the SF*park* parking sensor data feed specification for more details.




## TURNOVER ACCURACY/TIMELINESS

The following table shows the average results of all turnover accuracy/timeliness tests by sensor technology.

| Sensor technology (vendor) | Percent of events detected & received within: | | |
|---|---|---|---|
| | **60 seconds** | **120 seconds** | **180 seconds** |
| Radar/magnetometer (Fybr) | 60% | 63% | 64% |
| Radar (Sensys) | 91% | 95% | 96% |
| Infrared (CPT) | 73% | 86% | 86% |
| Image recognition (Cysen) | 32% | 47% | 52% |
| Magnetometer (StreetSmart) | 64% | 67% | 68% |




## PARKING SESSION ACCURACY

The following table shows the average results of all parking session accuracy tests by sensor technology.

| Sensor technology (vendor) | Observed sessions | Accurately reported sessions | % Sessions matched and accurately reflected |
|---|---|---|---|
| Radar/magnetometer (Fybr) | 131 | 95 | 73% |
| Radar (Sensys) | 97 | 70 | 72% |
| Infrared (CPT) | 58 | 43 | 74% |
| Image recognition (Cysen) | 85 | 39 | 46% |
| Magnetometer (StreetSmart) | 211 | 102 | 48% |

### LATENCY

The table below has the combined latency results for March and April 2013.[7,8]

| | | Percent of events received within (cumulative) | | | | | |
|---|---|---|---|---|---|---|---|
| **Sensor technology (vendor)** | **Events** | **10 sec** | **30 sec** | **1 min** | **2 min** | **3 min** | **> 3 min** |
| Radar/magnetometer (Fybr) | 684,659 | 73% | 98% | 99% | 99% | 99% | 100% |
| Radar (Sensys) | 210,215 | 43% | 61% | 96% | 98% | 99% | 100% |
| Infrared (CPT) | 112,956 | 3% | 46% | 89% | 94% | 94% | 100% |
| Magnetometer (StreetSmart) | 14,254,355 | 60% | 95% | 97% | 99% | 99% | 100% |

## Conclusions from trials

Radar and infrared-based sensors performed consistently well in every method of performance measurement, with radar sensors scoring very high in both the occupancy and turnover/timeliness accuracy tests. Radar/magnetometer sensors scored well at the Clement Street test site in the Inner Richmond, but did not perform as well in West Portal where electromagnetic interference is very strong.

While image recognition sensors did not score highly, some of the poor performance can be attributed to the design of the sensor. While each of the other sensors tested were installed in each space, the image recognition system utilized a single camera panning across the survey area so that each space was not continuously monitored.

Overall, newer sensors have demonstrated improved accuracy that may be able to more reliability support additional metrics and applications such as turnover and length of stay calculations. However, the scale of these trials was relatively small, and a larger deployment would be likely to encounter some unforeseen issues.

[7] The Cysen image recognition system utilized a sampling methodology; spaces were not monitored continuously. This led to timestamp values in the data feed that did not support a useful latency calculation.

[8] Data from the magnetometer/radar (Fybr) test was taken during December 2013 and January 2014 to coincide with when other evaluation data was collected.

## Conclusion

The SF*park* pilot was intended to test various parking policies and technologies, including an evaluation of how well these technologies support the SFMTA's policy goals. The magnetometer-based sensors provided by StreetSmart met the primary needs of the SF*park* pilot by quickly providing data that can be used for occupancy calculations. The deployment also provided the SFMTA with an unprecedented dataset measuring parking behavior for nearly three years in SF*park* areas. The agency has used this data both to operate and evaluate the SF*park* pilot as well as to support other parking and transportation analyses.

However, parking sensors are a nascent technology, and the SF*park* pilot served as a learning opportunity for both the SFMTA and sensor providers. Electromagnetic interference and other field issues complicated vehicle detection and reduced battery life. Managing parking sensors also requires asset management, operational control, and proactively coordinating with other organizations that perform work in the street.

The SFMTA also tested a variety of newer sensor technologies, with some promising results. While the outcome of small-scale trials should not be extrapolated to automatically apply to a larger deployment, the newer technologies have demonstrated improved accuracy that may support a wider range of applications.

In evaluating whether or not the SFMTA should pursue parking sensors in the future, the agency should consider not only cost, but how it will use the data. For example, providing real-time parking availability to the public requires sensor data that can support accurate occupancy rate calculations, but not necessarily accurate turnover calculations. The SFMTA's needs for the data should be clear, and the agency should clearly define performance standards and measurements that are tied to these applications.

# Appendix A: Field test methodologies

### ACCURACY TEST

For an occupancy accuracy test, a field observer surveys 450 parking spaces in a single parking management district (PMD). The observer stops at each parking space and notes the time, the Post ID, and the status of the space (vacant or occupied). If a vehicle is abnormally parked (facing in the wrong direction, too close to or far from the curb, or parked between two marked spaces) or the space is occupied by something other than a car (as defined by having four wheels and being less than 30 feet in length), the field observer skips the space and does not record an observation. The observations are compared against data from the sensor data feed, and the occupancy accuracy score is the percent of observations that the sensor correctly reported as either vacant or occupied. For example, in a test of 450 spaces, if the sensors were correct in 420 of the observations, the occupancy accuracy would be 93%.

### TIMELINESS TEST

In the turnover accuracy/timeliness test, a field observer walks around a single PMD over the course of a day to record parking events. The observer watches for cars that are pulling either into or out of a parking space. Once the parking event is complete (i.e., the car fully stops within the space while parking or has completely cleared the space while pulling out), the observer records the time, the Post ID, and whether the parking event was a session start (SS) or a session end (SE).

These SS/SE observations are then compared to data from the sensor feed. For every observed parking event, the SFMTA looks at all events reported by the sensor sent 30 seconds before and 180 seconds after the observed time. Of the remaining messages, this test selects the event that happened within the least amount of time of the observed event. If the event type matches (session end or session start), that observation is a pass. In the event of a pass, this test also scores the amount of time between when the parking event was observed and when the matched sensor event occurred, with categories of one minute, two minutes, and three minutes. For example, an observed session start at 11:15:00 with a corresponding message from the sensor reporting a session start at 11:16:30 would be a pass for occurring within three minutes and two minutes but not within one minute of the observed time.

### PARKING SESSION ACCURACY

The parking session accuracy test is an observation of every parking event across five to seven adjacent parking spaces over approximately four-hours. The SFMTA has used two different approaches to collect this data:

- **In-person observations**: A field observer spends four hours observing five parking spaces. The observer records every session start and session end across each of the five spaces.
- **Camera observations**: A field observer sets up an iPhone in a parked car where the phone's camera can capture at least five parking spaces. Using a time lapse photography app, the

camera takes a photo every 15 seconds and puts a time stamp (with the date and the time to the seconds) on the photo.

The observations, recorded as a series of session starts and session ends, are then compared to the corresponding sensor feed for each Post ID. The parking session accuracy test generates several metrics: the percent of session starts that occurred that were correctly identified by the sensor, the percent of these sessions that reported a length of stay within three minutes of the observed length of stay, and the difference between the total number of sessions over the course of the test as observed and as reported by the sensor. Additionally, the parking session accuracy test generates a measure of what percent of the time the sensor accurately reflected the status of the parking space. More specifically, of the time that the sensor is incorrect, the parking session accuracy test identifies the percent of time that a sensor over reports (says a space is occupied when it is vacant) and under reports (says a space is vacant when it occupied).

The chart below illustrates the observations against the sensor feed for each space in the test area.

## Appendix B: Parking Session Accuracy: Occupancy Metric

Another metric from the parking session accuracy test, similar to the occupancy accuracy test, is the percent of time that the sensor reported the correct status (occupied versus vacant). This score tallies each minute according to whether the sensor agrees with the observation. This process resembles how the SFMTA processes parking sensor data, albeit it at the minute, and not second, level. The parking session accuracy test also takes a closer look at the instances where the sensor is not correct. The table below outlines the scores of seven parking session accuracy tests. Overall, sensor accuracy is skewed by underreporting. In other words, sensors are much more likely to report that a space is empty when it is full than they are to report that a space is full when it is empty.

| Date | Location | % Accurate | % Over | % Under | Observed | Reported |
|---|---|---|---|---|---|---|
| 1/26/2012 | Fillmore | 93% | 2% | 98% | 18 | 32 |
| 1/27/2012 | West Portal | 81% | 7% | 93% | 11 | 12 |
| 1/31/2012 | Mission | 96% | 2% | 98% | 20 | 17 |
| 3/30/2012 | West Portal | 95% | 29% | 71% | 47 | 48 |
| 2/15/2013 | West Portal | 74% | 32% | 68% | 39 | 80 |
| 4/5/2013 | Fillmore | 72% | 1% | 99% | 17 | 13 |
| 5/6/2013 | Fillmore | 73% | 2% | 98% | 41 | 37 |
| **Average** | | **83%** | **11%** | **89%** | **28** | **34** |

# Appendix C: Vendor trial test results

**Technology:** Infrared
**Vendor:** CPT

| Location and date | Accuracy | Timeliness - % within 60 sec | Timeliness - % within 120 sec | Timeliness - % within 180 sec |
|---|---|---|---|---|
| **Fillmore** | **93%** | **73%** | **87%** | **87%** |
| 3/15/2013 | 95% | 73% | 85% | 85% |
| 4/8/2013 | 92% | 68% | 86% | 86% |
| 4/24/2013 | 91% | 77% | 89% | 89% |
| **West Portal** | **90%** | **75%** | **84%** | **84%** |
| 3/18/2013 | 90% | 75% | 84% | 84% |
| **Average** | **92%** | **73%** | **86%** | **86%** |

**Technology:** Image recognition
**Vendor:** Cysen

| Location and date | Accuracy | Timeliness - % within 60 sec | Timeliness - % within 120 sec | Timeliness - % within 180 sec |
|---|---|---|---|---|
| **Balboa** | **69%** | **39%** | **62%** | **63%** |
| 6/7/2012 | 69% | 39% | 71% | 74% |
| 6/22/2012 | 69% | 40% | 52% | 52% |
| **Fillmore** | **81%** | **3%** | **15%** | **22%** |
| 5/15/2012 | 81% | 3% | 15% | 22% |
| **Valencia** | **71%** | **55%** | **68%** | **68%** |
| 6/25/2012 | 71% | 55% | 68% | 68% |
| **West Portal** | **83%** | **29%** | **41%** | **48%** |
| 5/21/2012 | 83% | 19% | 24% | 33% |
| 5/23/2012 | 87% | 24% | 45% | 55% |
| 6/4/2012 | 81% | 44% | 54% | 57% |
| **Average** | **77%** | **32%** | **47%** | **52%** |

**Technology:** Radar
**Vendor:** Sensys

| Location and date | Accuracy | Timeliness - % within 60 sec | Timeliness - % within 120 sec | Timeliness - % within 180 sec |
|---|---|---|---|---|
| **Fillmore** | **94%** | **75%** | **87%** | **89%** |
| 4/8/2013 | 96% | 76% | 92% | 95% |
| 4/24/2013 | 93% | 74% | 83% | 83% |
| **West Portal** | **100%** | **97%** | **99%** | **99%** |
| 2/12/2013 | 100% | 95% | 97% | 97% |
| 2/13/2013 | 100% | 98% | 100% | 100% |
| 2/26/2013 | 98% | 93% | 97% | 97% |
| 2/27/2013 | 100% | 100% | 100% | 100% |
| 3/18/2013 | 100% | 99% | 100% | 100% |

| | | | | |
|---|---|---|---|---|
| **Average** | **98%** | **91%** | **95%** | **96%** |

**Technology:** Magnetometer
**Vendor:** StreetSmart

| Location and date | Accuracy | Timeliness - % within 60 sec | Timeliness - % within 120 sec | Timeliness - % within 180 sec |
|---|---|---|---|---|
| **Fillmore** | **78%** | **64%** | **66%** | **67%** |
| 5/15/2012 | 85% | 59% | 60% | 62% |
| 3/15/2013 | 78% | 55% | 55% | 55% |
| 4/8/2013 | 72% | 71% | 71% | 73% |
| 4/24/2013 | 77% | 71% | 77% | 77% |
| **Valencia** | **80%** | **65%** | **65%** | **65%** |
| 6/25/2012 | 80% | 65% | 65% | 65% |
| **West Portal** | **83%** | **63%** | **68%** | **69%** |
| 5/21/2012 | 92% | 53% | 58% | 60% |
| 5/23/2012 | 87% | 52% | 59% | 59% |
| 6/4/2012 | 97% | 69% | 74% | 75% |
| 2/12/2013 | 74% | 70% | 73% | 75% |
| 2/13/2013 | 67% | 74% | 75% | 77% |
| **Average** | **81%** | **64%** | **67%** | **68%** |

**Technology:** Radar/Magnetometer
**Vendor:** Fybr

| Location and date | Accuracy | Timeliness - % within 60 sec | Timeliness - % within 120 sec | Timeliness - % within 180 sec |
|---|---|---|---|---|
| **Inner Richmond** | **98%** | **83%** | **84%** | **85%** |
| 12/10/2013 | 99% | 83% | 84% | 85% |
| 12/11/2013 | 96% | 83% | 84% | 84% |
| **West Portal** | **58%** | **37%** | **42%** | **43%** |
| 12/12/2013 | 59% | 36% | 38% | 39% |
| 12/13/2013 | 56% | 37% | 46% | 46% |

# Appendix D: StreetSmart test results

## Occupancy Accuracy Scores

### CIVIC CENTER

| Date | Score |
|---|---|
| 1/26/11 | 87% |
| 3/9/11 | 89% |
| 3/22/11 | 93% |
| 11/1/11 | 92% |
| 1/18/12 | 91% |
| 3/23/12 | 90% |
| 5/3/12 | 91% |
| 8/2/12 | 87% |
| 10/8/12 | 84% |
| 1/2/13 | 81% |
| 4/16/13 | 67% |

### DOWNTOWN

| Date | Score |
|---|---|
| 2/2/11 | 79% |
| 2/10/11 | 85% |
| 3/23/11 | 88% |
| 11/30/11 | 86% |
| 1/11/12 | 86% |
| 3/5/12 | 86% |
| 6/1/12 | 80% |
| 8/3/12 | 81% |
| 10/1/12 | 84% |
| 12/26/12 | 65% |
| 4/9/13 | 65% |

### FILLMORE

| Date | Score |
|---|---|
| 1/20/11 | 84% |
| 3/21/11 | 88% |
| 9/8/11 | 87% |
| 1/5/12 | 84% |
| 3/1/12 | 84% |
| 5/1/12 | 90% |
| 8/10/12 | 83% |
| 10/10/12 | 80% |
| 12/18/12 | 77% |
| 5/7/13 | 69% |

### FISHERMAN'S WHARF

| Date | Score |
|---|---|
| 12/14/10 | 94% |
| 10/19/11 | 89% |
| 1/25/12 | 89% |
| 3/16/12 | 89% |
| 5/17/12 | 92% |
| 8/13/12 | 88% |
| 10/12/12 | 90% |
| 12/21/12 | 77% |
| 4/22/13 | 67% |

### INNER RICHMOND

| Date | Score |
|---|---|
| 1/27/11 | 93% |
| 3/11/11 | 92% |
| 11/3/11 | 92% |
| 1/26/12 | 86% |
| 3/13/12 | 93% |
| 5/10/12 | 91% |
| 8/21/12 | 84% |
| 10/23/12 | 79% |
| 1/9/13 | 74% |
| 5/3/13 | 45% |

### MARINA

| Date | Score |
|---|---|
| 12/27/10 | 92% |
| 11/28/11 | 87% |
| 1/30/12 | 86% |
| 3/14/12 | 86% |
| 5/14/12 | 88% |
| 8/6/12 | 87% |
| 10/16/12 | 90% |
| 12/19/12 | 73% |
| 4/25/13 | 70% |

### MISSION

| Date | Score |
|---|---|
| 1/18/11 | 89% |
| 3/16/11 | 90% |
| 7/21/11 | 86% |
| 12/5/11 | 86% |
| 1/20/12 | 86% |
| 10/26/12 | 81% |
| 12/20/12 | 84% |
| 1/16/13 | 65% |
| 4/18/13 | 53% |

### SOUTH EMBARCADERO

| Date | Score |
|---|---|
| 1/31/11 | 90% |
| 3/15/11 | 76% |
| 4/20/11 | 90% |
| 11/7/11 | 90% |
| 1/13/12 | 91% |
| 3/21/12 | 87% |
| 5/28/12 | 84% |
| 8/28/12 | 90% |
| 10/4/12 | 91% |
| 12/28/12 | 82% |
| 4/12/13 | 69% |

### UNION

| Date | Score |
|---|---|
| 1/14/11 | 87% |
| 3/25/11 | 87% |
| 1/9/12 | 85% |
| 3/12/12 | 77% |
| 5/24/12 | 79% |
| 8/16/12 | 78% |
| 10/18/12 | 80% |
| 1/7/13 | 72% |
| 4/29/13 | 75% |

### WEST PORTAL

| Date | Score |
|---|---|
| 2/15/11 | 85% |
| 3/28/11 | 86% |
| 9/6/11 | 57% |
| 1/4/12 | 81% |
| 3/8/12 | 87% |
| 5/7/12 | 87% |
| 8/24/12 | 80% |
| 10/22/12 | 79% |
| 1/14/13 | 75% |
| 5/1/13 | 66% |

## Turnover Accuracy/Timeliness Scores

### CIVIC CENTER

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/10/2011 | 76% | 76% | 73% |
| 3/22/2011 | 78% | 78% | 78% |
| 10/31/2011 | 83% | 80% | 75% |
| 1/19/2012 | 71% | 70% | 66% |
| 3/26/2012 | 75% | 75% | 75% |
| 5/4/2012 | 75% | 75% | 75% |
| 10/9/2012 | 74% | 74% | 70% |
| 1/3/2013 | 65% | 62% | 60% |
| 4/16/2013 | 45% | 45% | 42% |

### DOWNTOWN

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/24/2011 | 81% | 79% | 74% |
| 12/2/2011 | 70% | 68% | 50% |
| 1/12/2012 | 73% | 73% | 71% |
| 3/6/2012 | 75% | 73% | 73% |
| 6/5/2012 | 80% | 80% | 80% |
| 8/8/2012 | 65% | 65% | 59% |
| 10/2/2012 | 84% | 84% | 78% |
| 12/28/2012 | 48% | 46% | 44% |
| 4/9/2013 | 54% | 54% | 52% |

### FILLMORE

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 1/6/2011 | 78% | 78% | 78% |
| 3/21/2011 | 75% | 73% | 72% |
| 9/9/2011 | 33% | 33% | 30% |
| 3/2/2012 | 85% | 85% | 85% |
| 5/2/2012 | 78% | 75% | 70% |
| 8/14/2012 | 72% | 72% | 72% |
| 10/11/2012 | 72% | 72% | 66% |
| 12/18/2012 | 46% | 46% | 40% |
| 5/7/2013 | 48% | 48% | 43% |

### FISHERMAN'S WHARF

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 12/15/2010 | 85% | 85% | 85% |
| 10/20/2011 | 85% | 85% | 83% |
| 1/24/2012 | 89% | 89% | 87% |
| 3/19/2012 | 78% | 78% | 78% |
| 5/22/2012 | 75% | 75% | 48% |
| 8/15/2012 | 75% | 73% | 73% |
| 10/15/2012 | 86% | 86% | 84% |
| 12/24/2012 | 34% | 32% | 32% |
| 4/22/2013 | 40% | 40% | 33% |

### INNER RICHMOND

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/14/2011 | 75% | 75% | 75% |
| 11/2/2011 | 90% | 90% | 90% |
| 1/27/2012 | 78% | 78% | 78% |
| 5/11/2012 | 75% | 75% | 70% |
| 8/23/2012 | 63% | 63% | 61% |
| 10/25/2012 | 64% | 64% | 62% |
| 1/11/2013 | 30% | 24% | 20% |
| 5/3/2013 | 27% | 27% | 27% |

## MARINA

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 12/28/2010 | 90% | 90% | 88% |
| 11/29/2011 | 70% | 70% | 70% |
| 1/31/2012 | 64% | 64% | 60% |
| 3/15/2012 | 65% | 63% | 63% |
| 5/17/2012 | 80% | 75% | 60% |
| 8/7/2012 | 82% | 82% | 80% |
| 10/17/2012 | 72% | 72% | 72% |
| 4/25/2013 | 60% | 60% | 60% |

## MISSION

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/16/2011 | 65% | 65% | 65% |
| 7/20/2011 | 65% | 65% | 65% |
| 12/6/2011 | 68% | 68% | 68% |
| 1/23/2012 | 79% | 77% | 71% |
| 10/29/2012 | 55% | 53% | 49% |
| 12/20/2012 | 42% | 42% | 38% |
| 4/18/2013 | 36% | 36% | 35% |

## SOUTH EMBARCADERO

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/17/2011 | 69% | 67% | 63% |
| 4/21/2011 | 72% | 70% | 70% |
| 11/8/2011 | 75% | 75% | 68% |
| 1/16/2012 | 81% | 81% | 81% |
| 3/22/2012 | 75% | 75% | 60% |
| 5/29/2012 | 65% | 63% | 53% |
| 8/29/2012 | 84% | 84% | 81% |
| 10/5/2012 | 62% | 62% | 56% |
| 12/31/2012 | 70% | 70% | 68% |
| 4/12/2013 | 55% | 53% | 50% |

### UNION

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/25/2011 | 81% | 81% | 81% |
| 9/12/2011 | 65% | 65% | 65% |
| 1/10/2012 | 73% | 73% | 73% |
| 3/14/2012 | 63% | 63% | 63% |
| 5/25/2012 | 58% | 58% | 58% |
| 8/20/2012 | 75% | 75% | 75% |
| 10/19/2012 | 56% | 56% | 50% |
| 1/8/2013 | 43% | 38% | 28% |
| 4/29/2013 | 68% | 65% | 65% |

### WEST PORTAL

| Date | % w/in 180 seconds | % w/in 120 seconds | % w/in 60 seconds |
|---|---|---|---|
| 3/28/2011 | 68% | 67% | 65% |
| 9/6/2011 | 45% | 43% | 40% |
| 1/3/2012 | 53% | 53% | 46% |
| 3/9/2012 | 55% | 55% | 48% |
| 5/9/2012 | 53% | 48% | 48% |
| 8/27/2012 | 59% | 56% | 37% |
| 10/23/2012 | 62% | 60% | 56% |
| 1/15/2013 | 57% | 57% | 51% |
| 5/1/2013 | 60% | 60% | 60% |

## Appendix E: Sensor vendor contractual history for SF*park* pilot

For the SF*park* pilot projects, Serco, a government services provider, was the SFMTA's prime contractor for delivering SF*park*. For services or goods it could not provide, Serco conducted all necessary procurements to deliver the pilot projects. In 2009, Serco conducted a Request for Proposal (RFP) process to procure parking sensors, using product specifications and performance standards provided by the SFMTA. Several companies responded to that RFP, including ACS who teamed with Streetline Networks as its subcontractor. During that competitive process, the ACS/Streetline team scored significantly higher than other respondents and was selected to provide parking sensors for all SF*park* pilot areas.

The SFMTA and Serco encountered serious issues with ACS/Streetline in 2010 that caused significant project delay. These included contractor installation issues that led to consistently missed deadlines, low and highly variable occupancy accuracy scores, and high latency. The SFMTA and Serco teams worked with ACS/Streetline to help to resolve challenges with parking sensors, which further delayed the project and, as time passed, posed significant risks to the successful launch of the SF*park* project.

In light of growing installation delays, persistent data accuracy and latency issues that meant non-compliance with contractual performance standards, and ACS/Streetline's continuing challenges when attempting to resolve these issues, other possible parking sensor providers were investigated as one part of an overall risk management plan. StreetSmart was identified as an alternative sensor subcontractor, and a small-scale trial of StreetSmart equipment in June 2010 yielded promising results. Serco then put in place a modification to its subcontract with ACS to replace most Streetline sensors with StreetSmart sensors.

However, after several months of negotiation ACS and Streetline could not reach an agreement on the terms of this contractual modification, which led ACS to terminate its subcontract with Streetline in October 2010. Because the Streetline system did not meet the contractual criteria for acceptance, Serco and the SFMTA made no payments to ACS for data or equipment from Streetline. As a result, the SFMTA and Serco utilized StreetSmart sensors for the entire scope of the SF*park* pilot.