SFpark

Roadway Sensor Data Guide

June 25, 2014

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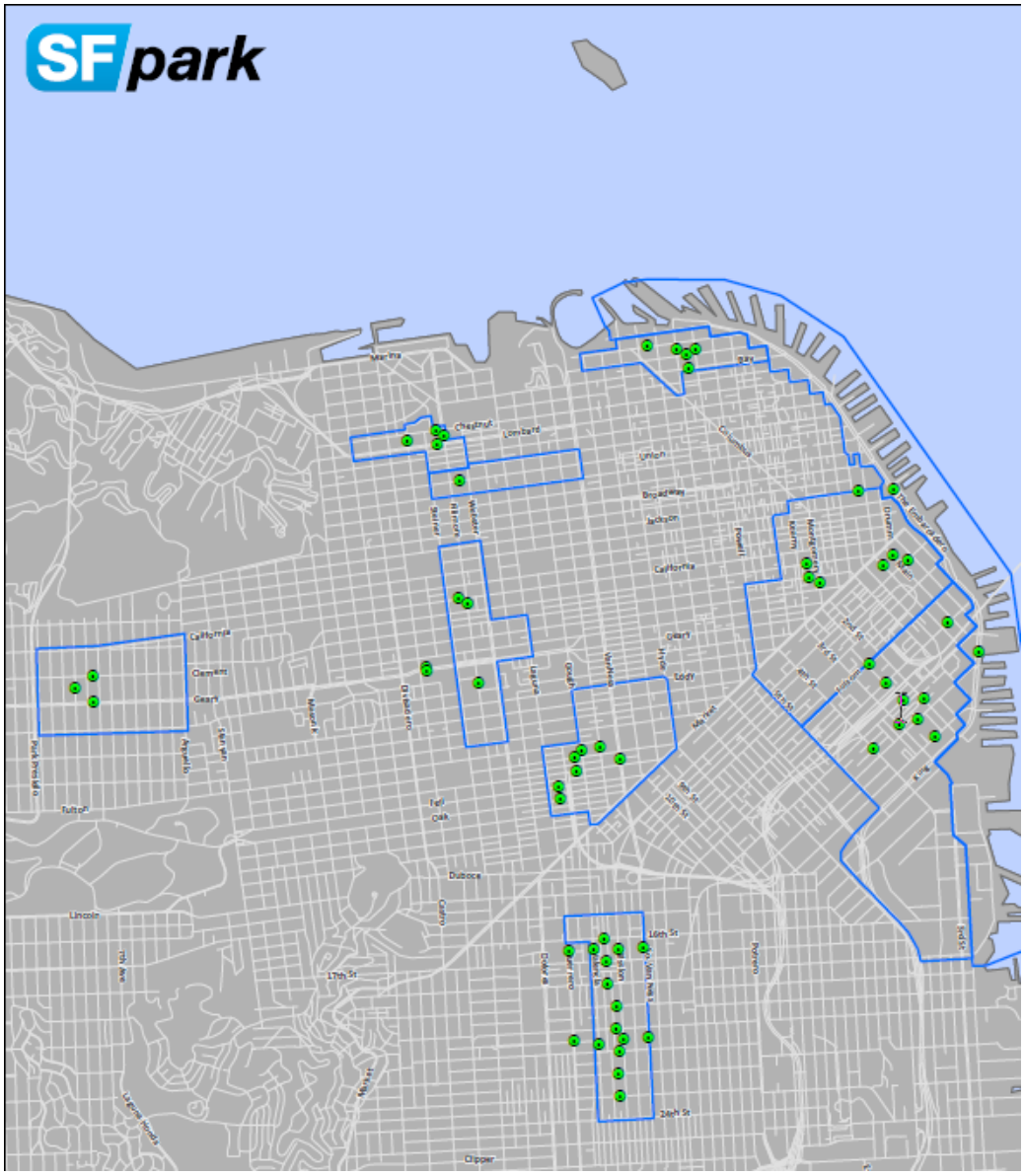
1 Introduction

In an attempt to understand the impact of SF*park* on vehicular traffic, Sensys roadway sensors were installed in and around SF*park* pilot and control areas, as shown in Figure 1 below. These roadway sensors captured four metrics: vehicle count, average speed, median speed, and vehicle occupancy (i.e., traffic density) to help evaluate the programs impact on vehicle traffic.

Figure 1. Roadway Sensors in SF*park* Pilot and Control Areas



1.1 Timeline

As of March 2011, roadway sensors installed at 56 locations throughout the SF*park* pilot and control areas began providing continuous data in 15 minute intervals, 24 hours per day, through May of 2013.

It was initially thought that the sensors would provide a continuous data stream that could be analyzed throughout the year. Ultimately this was not the case due to various outages, technological and environmental, which are discussed in the Data Validation section. These issues have necessitated extensive usability analyses of the data.

1.2 Availability of Data

This data guide supports three roadway sensor datasets: the 15 minute data as transmitted from Sensys from March 2011 through May 2013, a usability analysis worksheet prepared by SF*park* staff, and a worksheet containing aggregated speed data for locations meeting at least a 30% usability threshold.

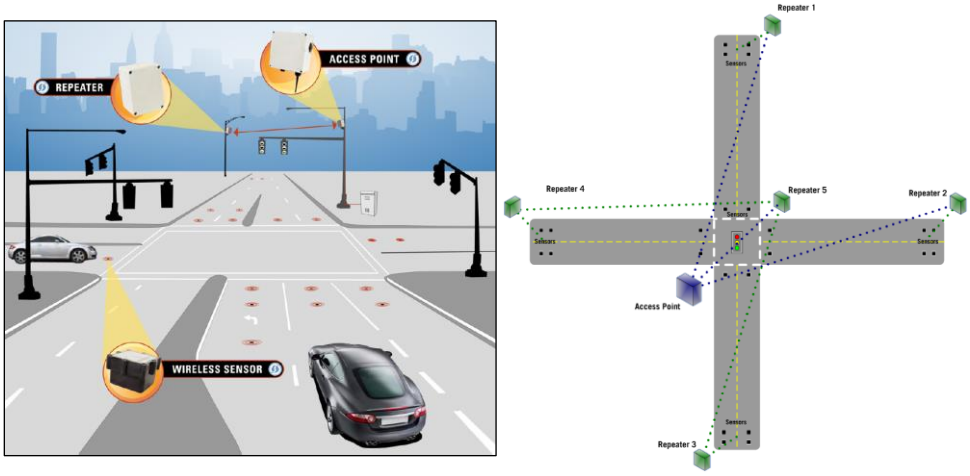
For all data requests and related inquiries, please contact info@sfpark.org and put "SFpark evaluation data request" in the subject line.

Roadway Sensor file names, formats and sizes are as follows:

- File name: SFpark_RoadwaySensorData_CompleteDataset_20112013.csv
- Microsoft Excel Comma Separated Values File (.csv)
- File size: 678 MB

2 Roadway sensor equipment overview

Sensys roadway sensors capture raw traffic data which is then sent to the Sensys sensor management system via a network of pole-mounted repeaters and access points. The Sensys sensor management system processes the raw data, aggregating it into 15 minute intervals.



Standard components for a Sensys roadway sensor installation

2.1 Roadway Sensors

Sensys's sensor is a wireless self-powered device embedded into travel lanes. Roadway sensors are installed in pairs, one leading sensor and one trailing sensor, in each travel lane on a street.

Roadway sensor installation process

As these sensors work in tandem to detect the presence and movement of vehicles, this data is communicated to the sensor management system to calculate various metrics.

The diagram below shows the position of the equipment associated with this location and the configuration of the leading and trailing sensors are (e.g., in the westbound lane on 21st St. number one represents the leading sensor, number two represents the trailing sensor.).

2.2 Access Point

Sensys access points relay sensor data to the Sensys sensor management system through a cellular communications band (850, 900, 1800 or 1900 Mhz), depending on the cellular carrier. Access points are mounted on a pole generally with a direct line of sight to either the roadway sensors or a repeater that is within the direct line of sight of the roadway sensors.

2.3 Repeaters

Repeaters are used in locations where direct communication between the roadway sensors and the access point are unreliable due to environmental conditions. Repeaters are installed on poles that are within range of both the sensors and access point.

2.4 Equipment inventory

At full deployment there were 56 locations with sensors throughout in the City. Across those locations were 46 access points, 62 repeaters, and 346 sensors. As of March 2011 roadway sensor distribution throughout the SF*park* pilot and control areas was as follows:

Parking Management District	Roadway Sensor Locations
Downtown	5
South Embarcadero	10
Civic Center	7
Mission	16
Fillmore	5
Fisherman's Wharf	5
Marina	4
Union	1
Inner Richmond	3
West Portal	0
Total	**56**

It was initially thought that the sensors would provide a continuous data stream that could be analyzed throughout the year. Ultimately this was not the case due to various outages, technological and environmental, which are discussed in the Data Validation section.

2.5 Format and content

The Sensys sensor management system uses the raw roadway sensor data to calculate the four metrics (occupancy, volume, median speed, and average speed) at 15 minute intervals. The results are compiled into a daily CSV file for each access point and are retrieved by the SF*park* servers. Daily reports contain 96 data points per travel lane (four 15 minute intervals per hour, 24 hours per day). An excerpt is shown below:

timestamp	APEG	lane	occupancy(%)	volume	speed_med(mph)	speed_avg(mph)	lane	occupancy(%)	volume	speed_med(mph)	speed_avg(mph)	lane	occupancy(%)	volume	speed_med(mph)	speed_avg(mph)
5/11/2011 0:15	apeg43	NB1	1.09	23	29	30.3	NB2	2.48	53	30	31.4	NB3	1.24	23	30	28.6
5/11/2011 0:30	apeg43	NB1	0.68	15	32	33.1	NB2	2.06	44	31	32.1	NB3	1.22	25	29	28.4
5/11/2011 0:45	apeg43	NB1	0.76	16	29	23.3	NB2	1.28	29	31	34.6	NB3	0.79	18	33	31.8
5/11/2011 1:00	apeg43	NB1	-1	-1	30	28	NB2	1.38	30	31	33.9	NB3	-1	-1	31	28.9
5/11/2011 1:15	apeg43	NB1	0.49	9	24	27.8	NB2	1.53	31	29	29.3	NB3	1.1	22	31	30.5
5/11/2011 1:30	apeg43	NB1	0.68	14	24	26.9	NB2	1.17	24	31	28.1	NB3	0.69	15	31	29
5/11/2011 1:45	apeg43	NB1	0.73	14	23	26.3	NB2	0.92	20	32	31.6	NB3	0.54	11	32	31.3
5/11/2011 2:00	apeg43	NB1	0.58	12	29	32.1	NB2	1.18	25	30	31.8	NB3	0.78	16	32	32.3
5/11/2011 2:15	apeg43	NB1	0.22	6	31	28.5	NB2	1.03	22	32	31.4	NB3	0.79	18	32	32
5/11/2011 2:30	apeg43	NB1	0.31	7	31	36.9	NB2	0.86	17	29	30.6	NB3	0.44	9	30	28.2
5/11/2011 2:45	apeg43	NB1	0.42	9	32	29.9	NB2	1.33	25	33	30.7	NB3	0.85	11	27	23
5/11/2011 3:00	apeg43	NB1	0.57	5	19	19.4	NB2	0.64	15	32	31.5	NB3	1.11	13	20	20.1
5/11/2011 3:15	apeg43	NB1	0.33	8	29	25.3	NB2	0.73	14	32	32.4	NB3	0.38	7	30	26.8
5/11/2011 3:30	apeg43	NB1	0.38	6	20	16	NB2	1.13	22	30	32.1	NB3	0.38	6	28	27.4
5/11/2011 3:45	apeg43	NB1	0.1	2	33	33.4	NB2	0.91	14	30	35.3	NB3	0.19	4	23	25.4
5/11/2011 4:00	apeg43	NB1	0.68	12	23	27	NB2	0.57	15	33	27.3	NB3	0.54	9	27	28
5/11/2011 4:15	apeg43	NB1	1.12	16	20	23.3	NB2	1.42	29	32	33.9	NB3	0.38	8	28	26.4
5/11/2011 4:30	apeg43	NB1	0.48	7	18	20.6	NB2	1.43	22	31	30.3	NB3	0.43	8	28	31.3
5/11/2011 4:45	apeg43	NB1	0.61	13	30	29.2	NB2	1.4	33	32	31.3	NB3	0.63	12	35	33.3
5/11/2011 5:00	apeg43	NB1	0.98	16	29	31.7	NB2	2.27	40	30	31.8	NB3	0.86	16	28	29.8
5/11/2011 5:15	apeg43	NB1	0.97	19	22	26.7	NB2	2.53	43	29	30.4	NB3	1.54	28	29	27
5/11/2011 5:30	apeg43	NB1	1.58	29	27	28.7	NB2	3.1	62	30	32.8	NB3	1.89	34	32	30.2
5/11/2011 5:45	apeg43	NB1	2.99	52	26	29.6	NB2	4.57	74	29	30.1	NB3	3.12	53	28	29
5/11/2011 6:00	apeg43	NB1	2.69	50	23	28.8	NB2	4.09	74	29	27.3	NB3	2.93	48	28	30.1

2.6 Dataset definitions

- timestamp: Identifies each 15 minute period
- APEG: Identifies which access point the data relates to
- lane: Identified which travel lane the data relates to
- occupancy(%): Percentage of time a car was detected above a the sensors (traffic density)
- volume: 15 minute vehicle count
- speed_med(mph): 15 minute median speed
- speed_avg(mph): 15 minute average speed

2.7 Additional information

The figure below shows a sample equipment diagram in the Civic Center pilot area. The squares numbered one through ten represent roadway sensors in travel lanes, R1 and R2 represent repeaters,

LOCATION DESCRIPTIONS	AP	RP	SENSORS	LOC#	AP ID	SNAPS ID	Proxy ID	IP Address	TCP/HTTP port	RF	Color Code	RP	RP	Dot LOC	Sensor LOC	Sensor ID	RF
GROVE @ OCTAVIA / GOUGH GOUGH @ FULTON / GROVE	1	2	10	CC-2	6340	23	30	192.168.3.102	10340 20340	10	3A	R1		7	EB-1L	0F52	8
												10 / 8 - 1		8	EB-1T	0F39	
												17F6		9	WB-1L	1094	
														10	WB-1T	1047	
				CC-3								R2		1	SB-1L	0FB9	9
												10 / 9 - 0		2	SB-1T	0F19	
												17C7		3	SB-2L	0F32	
														4	SB-2T	1043	
														5	SB-3L	0FE5	
														6	SB-3T	1045	

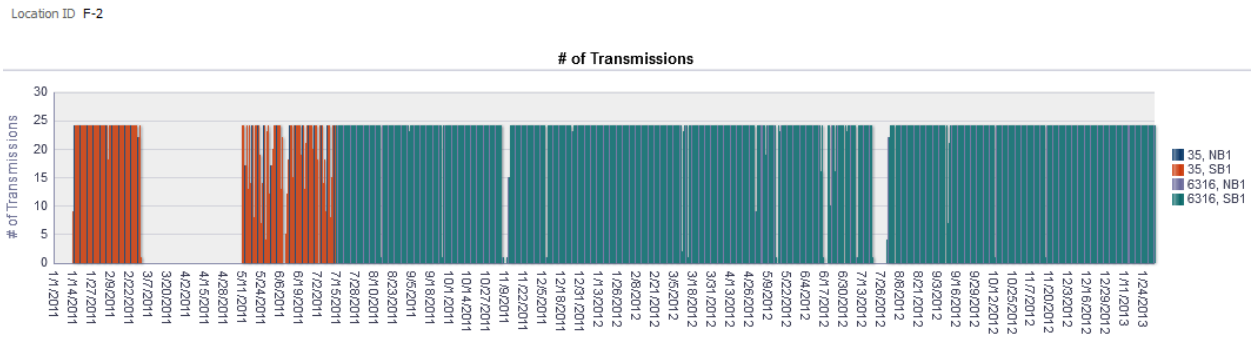
and “AP” represents the access point location. The table at the bottom identifies the sensors 1 through 6 as being associated with location ID CC-3 and sensors 7 through 10 as being associated with location ID CC-2. All data is analyzed at the travel lane level, by location ID level. As a result, if a significant amount of data for one travel lane is missing, that location ID will not be used for evaluation purposes.

3 Business rules

Based on the format and quality of the raw data, the SFMTA performed four important transformations to the data prior to analysis.

3.1 Access Point ID (APEG) change

For the purposes of identifying access points Sensys assigned each unit a unique numerical value. During 2011 Sensys unexpectedly changed from two digit to four digit APEG numbers. This change was not communicated by the vendor and was not discovered until the data was loaded into the SF*park* data warehouse. To address this issue, Sensys provided information for SF*park* staff to create a matrix to link the old two digit IDs to the new four digit IDs for each APEG. This was necessary to associate the data at both the old and new IDs to provide a complete dataset.



Total number of data transmissions at a location after linking its old APEG (35) with its new APEG (6316)

3.2 Error code data

In cases where the sensors could not confidently provide data for a 15 minute interval, a value of “-1” was recorded, as shown in the table below. In order to use the data for analysis, SF*park* staff converted all the “-1” data to “<null>.”

timestamp	APEG	lane	occupancy(%)	volume	speed_med(mph)	speed_avg(mph)	lane	occupancy(%)	volume	speed_med(mph)	speed_avg(mph)
5/11/2011 0:15	apeg38	EB1	0.88	12	20	20.9	EB2	0.11	1	-1	-1
5/11/2011 0:30	apeg38	EB1	0.34	4	23	21.4	EB2	0.05	1	21	37.1
5/11/2011 0:45	apeg38	EB1	0.74	8	22	19.5	EB2	0.15	1	18	15.9
5/11/2011 1:00	apeg38	EB1	1.07	9	19	22.4	EB2	0.22	3	12	13.1
5/11/2011 1:15	apeg38	EB1	0.42	5	27	21.2	EB2	0.09	1	19	19.6
5/11/2011 1:30	apeg38	EB1	0.31	4	25	25.7	EB2	0	0	-1	19.4
5/11/2011 1:45	apeg38	EB1	0.05	1	27	27.1	EB2	0	0	-1	19.4
5/11/2011 2:00	apeg38	EB1	0.21	4	27	22.7	EB2	0	0	-1	19.4
5/11/2011 2:15	apeg38	EB1	0.34	5	23	24.4	EB2	0	0	-1	19.4
5/11/2011 2:30	apeg38	EB1	0.46	6	25	21.3	EB2	0	0	-1	19.4

3.3 Lane name/Location ID association

For the purposes of the evaluation, it was necessary to associate the lane level metrics provided by the Sensys sensors to each of the 56 location IDs. When practical, Sensys covered as many locations IDs as possible with a single access point. The SFMTA used equipment diagrams (example below) to associate travel lane data with location IDs. For example, the WB1 and EB1 data to location CC-2 on Grove St and SB1, SB2, and SB3 to location CC-3 on Gough St.

LOCATION DESCRIPTIONS	AP	RP	SENSORS	LOC#	AP ID	SNAPS ID	Proxy ID	IP Address	TCP/HTTP port	RF	Color Code	RP	RP	Dot LOC	Sensor LOC	Sensor ID	RF
GROVE @ OCTAVIA / GOUGH	1	2	10	CC-2	6340	23	30	192.168.3.102	10340 20340	10	3A	R1		7	EB-1L	0F52	8
GOUGH @ FULTON / GROVE												10 / 8 - 1		8	EB-1T	0F39	
												17F6		9	WB-1L	1094	
														10	WB-1T	1047	
				CC-3								R2		1	SB-1L	0FB9	9
												10 / 9 - 0		2	SB-1T	0F19	
												17C7		3	SB-2L	0F32	
														4	SB-2T	1043	
														5	SB-3L	0FE5	
														6	SB-3T	1045	

4 Glossary

Access Point – A wireless device the links sensors to the Sensys database.

APEG – The unique four digit number that identifies each access point.

Location ID – A location ID is made up of a number of lanes at a single location.

Repeater – A wireless that assists sensors in communicating with APEG when they may be on the fringe of the APEG's coverage area.

SNAPS ID – The unique two digit number that was replaced by APEG for identifying access points.

Lane – The lowest level that data from the roadway sensors is provided to SF*park* at. Each lane is made up two sensors, a leading and trailing sensor, which are used to calculate the four metrics.

5 Appendix A: Location maps

SFpark_DataGuide_RoadwaySensor_APPENDIX_A_LocationMaps_08302013.pdf