What Location Factors did Highly Utilized DC Fast Chargers have in Common?

May 2015

Key Conclusions

- The most highly utilized direct current (DC) fast chargers (DCFCs) in The EV Project were located in the metropolitan areas of Seattle and San Francisco.
- The metropolitan areas of San Francisco and Seattle represent two of the top five U.S. sales markets for the Nissan Leaf.
- The top 10% of the most highly utilized DCFCs in The EV Project averaged 40 fast charges per week.
- The most utilized DCFC stations were located along major commuter routes within the major metropolitan areas.
- Many of the highly utilized DCFCs were located near or associated with high-tech employers.

Introduction

The EV Project deployed over 100 DCFCs using the CHAdeMO charging standard.[1] This option for fast charge capability was included on all Nissan Leaf vehicles that participated in The EV Project.

The EV Project's plan for deployment of DCFCs included some located within metropolitan areas of The EV Project and some located on transportation corridors between metropolitan areas. The latter were intended to enable Leaf drivers to extend their travel range and move between metropolitan areas. This was most extensively done in Tennessee, where there are distinct population centers separated by miles of highway, passing primarily through rural areas.

The distribution, by state, of DCFCs deployed in The EV Project is shown in Figure 1. DCFCs were deployed in the California markets of The EV Project as follows: 30 in San Francisco and 5 each in Los Angeles and San Diego.

Data Analyzed

Data analyzed for this paper included DCFC use data collected by the Blink network and transmitted to the Advanced Vehicle Testing Activity at Idaho National Laboratory (INL). INL's data experts then qualified and aggregated data for reporting. DCFC utilization data includes all charging operations, not just those from vehicles that were part of The EV Project.

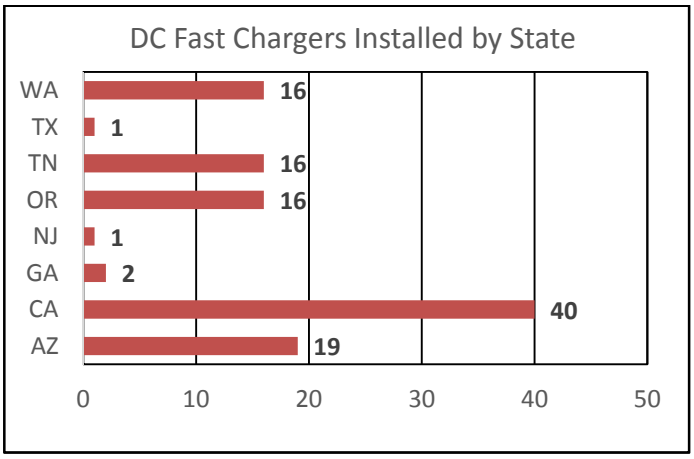


Figure 1. Deployment of DCFCs by state.

This report analyzed DCFC utilization over the final 6 months of 2013, including charge events and energy dispensed per DCFC. During this period, over 30,000 charge events and 275,000 kWhs of electrical energy were delivered from The EV Project's DCFCs.

In order to determine what effect location had on use of DCFCs, the most utilized stations were mapped and their locations examined for distance to local attractions, large employers, and transportation routes.

Analyses Performed

The top 20 most utilized DCFC stations in The EV Project are listed in Table A1 of Appendix A. The top 12 most utilized DCFCs in The EV Project were located in the Seattle (seven DCFC) and San Francisco (five DCFC) markets. Based on the average number of charge events per week, the Blink DCFC at Evernote in Redwood City, California was used most frequently at 66.5 charge events per week over the last 6 months of 2013.

Because DCFCs in Seattle and San Francisco represent the top 12 sites and 70% of the top 20 most utilized stations, analysis focused on location-based factors that contributed to the high utilization of these DCFCs. Figure B1 of Appendix B shows all of DCFC stations in San Francisco and Seattle that had an average of more than three charge events per week. This figure also shows significant variation in DCFC utilization within these two markets. San Francisco DCFC utilization ranged from 66.5 to only 4.3 charge events per week. While the metropolitan Seattle area had utilization ranging from 58.85 to 3.77 charge events per week.

Figures 2 and 3 (also included in larger format in Appendix B as Figures B2 and B3) show the geographic relationship between the DCFCs in the San Francisco and Seattle markets. The figures represent DCFC use with the height of the bars.

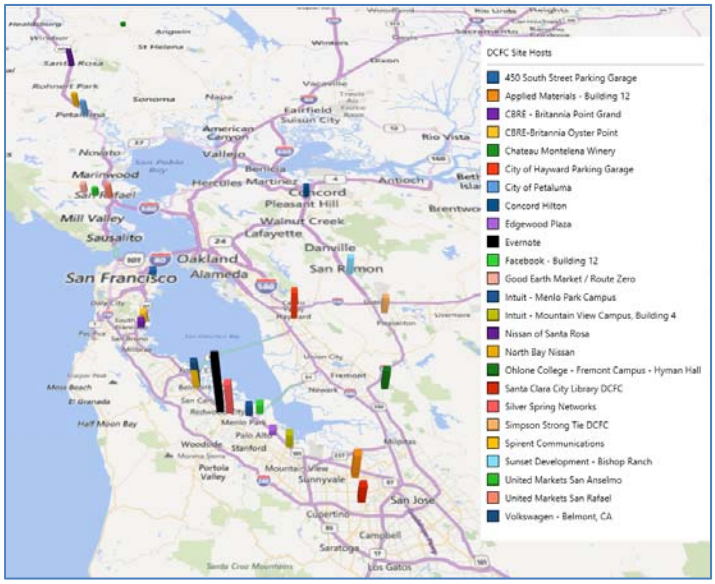


Figure 2. DCFC use in San Francisco market.

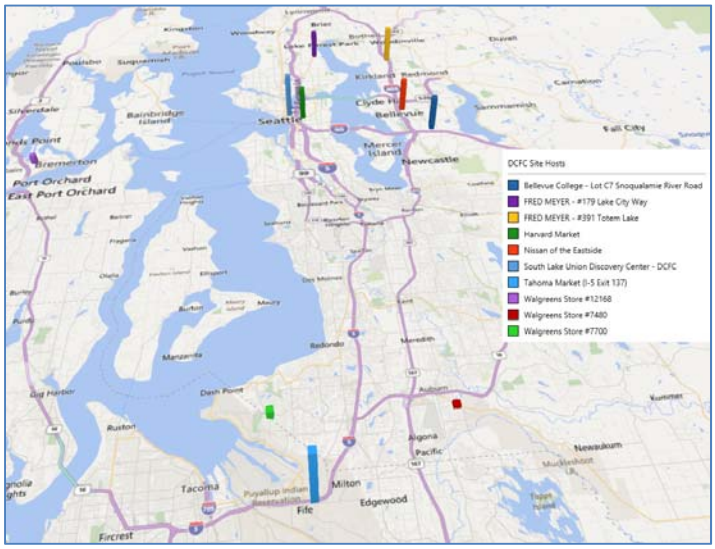


Figure 3. DCFC use in Seattle market.

Analysis of these highly utilized locations was performed using annual average daily traffic and the location of the DCFC station relative to the nearest major transportation route. Figure 4 shows an example of this for the most frequently used DCFC, which was at Evernote in Redwood City, California. The Evernote site is near a major junction of the Bayshore Freeway (US-101) and is associated with the highly compensated workforce of a high-tech employer.

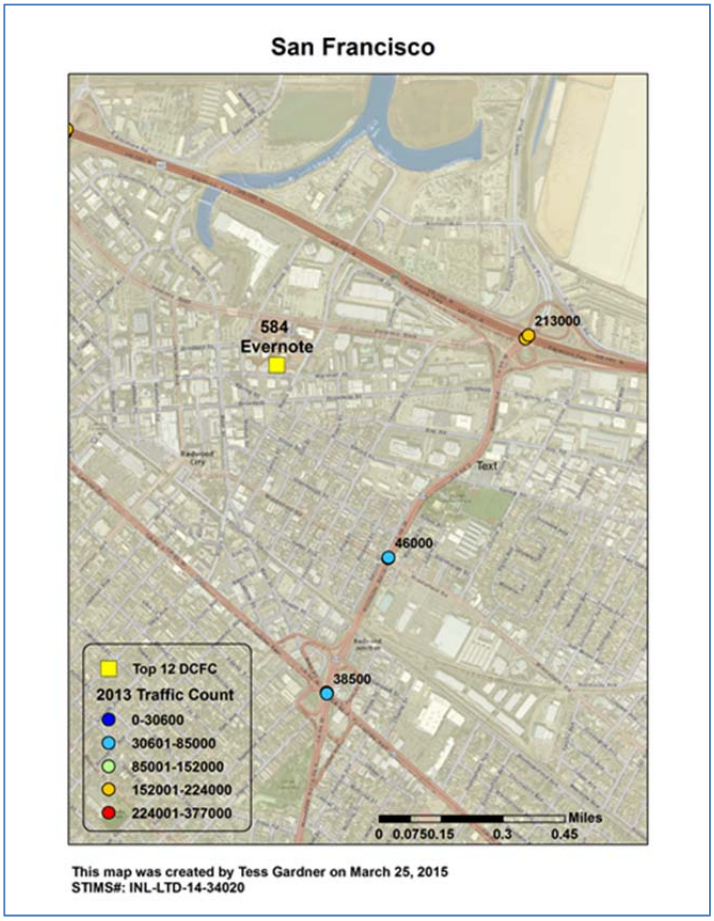


Figure 4. Geographic information system map of DCFC and annual average daily traffic for 2013.

Discussion of Results

In addition to being the first (i.e., San Francisco) and fourth (i.e., Seattle) largest markets for sales of the Nissan Leaf in 2013, three location-based characteristics are associated with the highest utilized DCFCs in these markets:

1. Close proximity to popular commuter routes
2. Close proximity to or direct association with a highly compensated workforce
3. DCFC located in an obviously publicly accessible venue.

Near Busy Transportation Routes

The proximity to popular commuter routes appears to have the greatest influence on DCFC popularity, because it was a feature that was common amongst most of the high-use stations. Table A2 lists the top 12 DCFCs and the average daily traffic that was within half a mile of the DCFC station. Nine of the twelve stations are located near very significant transportation routes. The majority of these transportation

routes are located within the urban areas they serve. The exception is the second most frequently used station at Tahoma Market in Fife, Washington. This station is more accurately described as being outside the urban Seattle area and more likely acts as a range extending or connecting station between metropolitan areas. It is located adjacent to Junction 137 on highly travelled Interstate 5, as seen in Figure 5.

Typically, DCFCs located adjacent to highways between metropolitan areas were not used as often as those located adjacent to commuter routes within a metropolitan area.

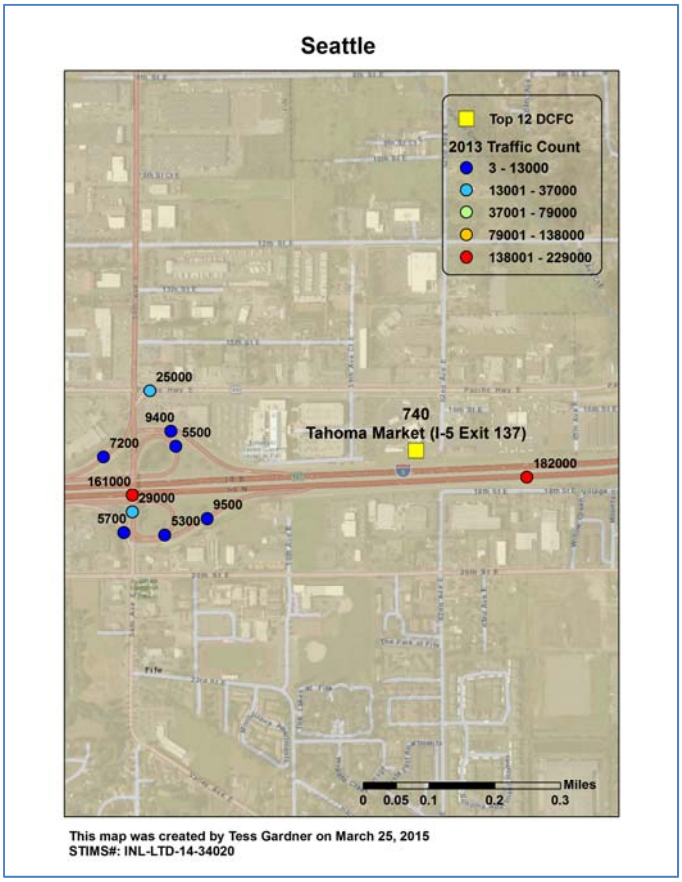


Figure 5. Geographic information system map of DCFCs and annual average daily traffic for 2013.

Near Employers with Highly Compensated Workforce

Another factor that appears to influence utilization is the location of the DCFC near the campus of high-tech businesses, which typically have a highly compensated workforce. This is likely due to the matching demographics between employees of high-tech businesses and electric vehicle purchasers as highlighted in a paper published by Experian Automotive in April 2014.[2] In addition to being used as a workplace charger, these DCFCs also benefit from a very local population of electric vehicle drivers accessing the stations for public use.

However, installations on high-tech campuses near commuter routes is not a guarantee of high utilization (as can be seen in the map showing DCFC locations in Figure A3). Facebook, Intuit, and Spirent Technologies are all high-tech companies with a highly compensated workforce and DCFC stations similarly located adjacent to the same Bayshore Freeway as the Evernote DCFC. Utilization of these stations is not as high as it is for others along the Bayshore Freeway. One factor that likely keeps these stations from being used as much as the others along the Bayshore Freeway is is the existance of a free DCFC at a Nissan Technology Center that is located within a 10-minute walk (per comments on Plugshare.com) from Spirent Technologies.

Easily Accessible Location

Finally, simple and easy access to the DCFC station is an important factor for frequent utilization. Among the highest used sites are those that are clearly accessible to the public. Two-thirds of the top 20 most utilized sites are found in public parking garages and parking lots at public venues like shopping centers and community colleges.

Although Facebook's DCFC is available to the public, it is inside a large employee parking lot (as seen in bird's eye view shown in Appendix B, Figure B4) and may be perceived as less welcoming to passing EV drivers.

Conclusions

The first observation that must be made about highly utilized DCFCs in The EV Project is that they are located in two very successful markets for the Nissan Leaf. Without a significant population of "fast-chargeable" plug-in electric vehicles, high utilization cannot be achieved.

Regarding the location of the most highly utilized DCFCs in The EV Project, there is a greater likelihood that a DCFC will be highly utilized if its location exhibits all of the following location-based characteristics:

- Within a half mile of a major commuter route
- On or near the campus of a company with a highly compensated workforce, where it can function as both workplace and publicly accessible
- It is in a welcoming location (i.e., not too closely associated with the host).

About The EV Project

The EV Project was the largest plug-in electric vehicle infrastructure demonstration project in the world, equally

funded by the U.S. Department of Energy (DOE) through the American Recovery and Reinvestment Act and private sector partners. The EV Project deployed over 12,000 alternating current Level 2 charging stations for residential and commercial use and over 100 dual-port DCFCs in 17 U.S. regions. Approximately 8,300 Nissan LEAFs™, Chevrolet Volts, and Smart ForTwo Electric Drive vehicles were enrolled in the project.

Project participants gave written consent for EV Project researchers to collect and analyze[1] data from their vehicles and/or charging units. Data collected from the vehicles and charging infrastructure represented almost 125 million miles of driving and 4 million charging events. The data collection phase of The EV Project ran from January 1, 2011, through December 31, 2013. INL is responsible for analyzing the data and publishing summary reports, technical papers, and lessons learned on vehicle and charging unit use.

Company Profile

INL is one of DOE's 10 multi-program national laboratories. The laboratory performs work in each of DOE's strategic goal areas: energy, national security, science, and the environment. INL is the nation's leading center for nuclear energy research and development. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance.

For more information, visit avt.inl.gov/evproject.shtml and avt.inl.gov/chargepoint.shtml.

References

1. CHAdeMO Association http://www.chademo.com/wp/.
2. Experian Automotive, "Consumers purchasing an electric vehicle are younger and more affluent than those buying a hybrid," April 22, 2014 https://www.experianplc.com/media/news/2014/experian-automotive-consumers-purchasing-an-electric-vehicle-are-younger-and-more-affluent/.

Appendix A, Tables

Most Utilized DCFCs by Charge Events per Week

Table A1. Report from data supplied by Blink network from July 1 through December 31, 2013 (source – Advance Vehicle Testing Activity at INL).

Charge Events per Week	Host	Street Address	City	State	ZIP	EV Project Market
66.50	Evernote	305 Walnut St.	Redwood City	CA	94063	San Francisco
58.85	Tahoma Market (I-5 Exit 137)	6006 Pacific Highway East	Fife	WA	98424	Seattle
43.90	South Lake Union Discovery Center - DCFC	101 Westlake Ave N	Seattle	WA	98109	Seattle
37.93	FRED MEYER - #391 Totem Lake	12221 120th Ave NE	Kirkland	WA	98034	Seattle
36.48	Silver Spring Networks	585 Broadway Street	Redwood City	CA	94063	San Francisco
35.19	Bellevue College - Lot C7 Snoqualamie River Road	3036 Snoqualamie River Road	Bellevue	WA	98005	Seattle
34.58	Nissan of the Eastside	11815 NE 8th Ave	Bellevue	WA	98005	Seattle
33.21	Harvard Market	1401 Broadway	Seattle	WA	98122	Seattle
31.16	City of Hayward Parking Garage	777 B Street	Hayward	CA	94541	San Francisco
30.32	Volkswagen - Belmont CA	500 Clipper Drive	Belmont	CA	94002	San Francisco
29.94	Applied Materials - Building 12	3225 Oakmead Village Drive	Santa Clara	CA	95051	San Francisco
28.68	FRED MEYER - #179 Lake City Way	13000 Lake City Way NE	Seattle	WA	98125	Seattle
26.90	FRED MEYER - #661 Sunset	22075 NW Imbrie Drive	Hillsboro	OR	97124	Oregon
25.15	Clackamas Town Center	11900 SE 82nd Ave	Happy Valley	OR	97086	Oregon
23.36	South Coast Air Quality Management District	21865 Copley Dr	Diamond Bar	CA	91765	Los Angeles
22.90	FRED MEYER - #375 Tigard	11565 SW Pacific Highway	Tigard	OR	97223	Oregon
22.52	FRED MEYER - #090 East Salem	3740 Market NE	Salem	OR	97301	Oregon
22.45	Ohlone College - Fremont Campus - Hyman Hall	43600 Mission Blvd	Fremont	CA	94539	San Francisco
21.57	Santa Clara City Library DCFC	2635 Homestead Drive	Santa Clara	CA	95051	San Francisco
20.81	Linear City Development LLC - Mateo Street	662 Mateo Street	Los Angeles	CA	90021	Los Angeles

Annual Average Daily Traffic near the Most Utilized DCFCs

Table A2. Report from data supplied by Blink network from July 1 through December 31, 2013 (source – Advance Vehicle Testing Activity at INL).

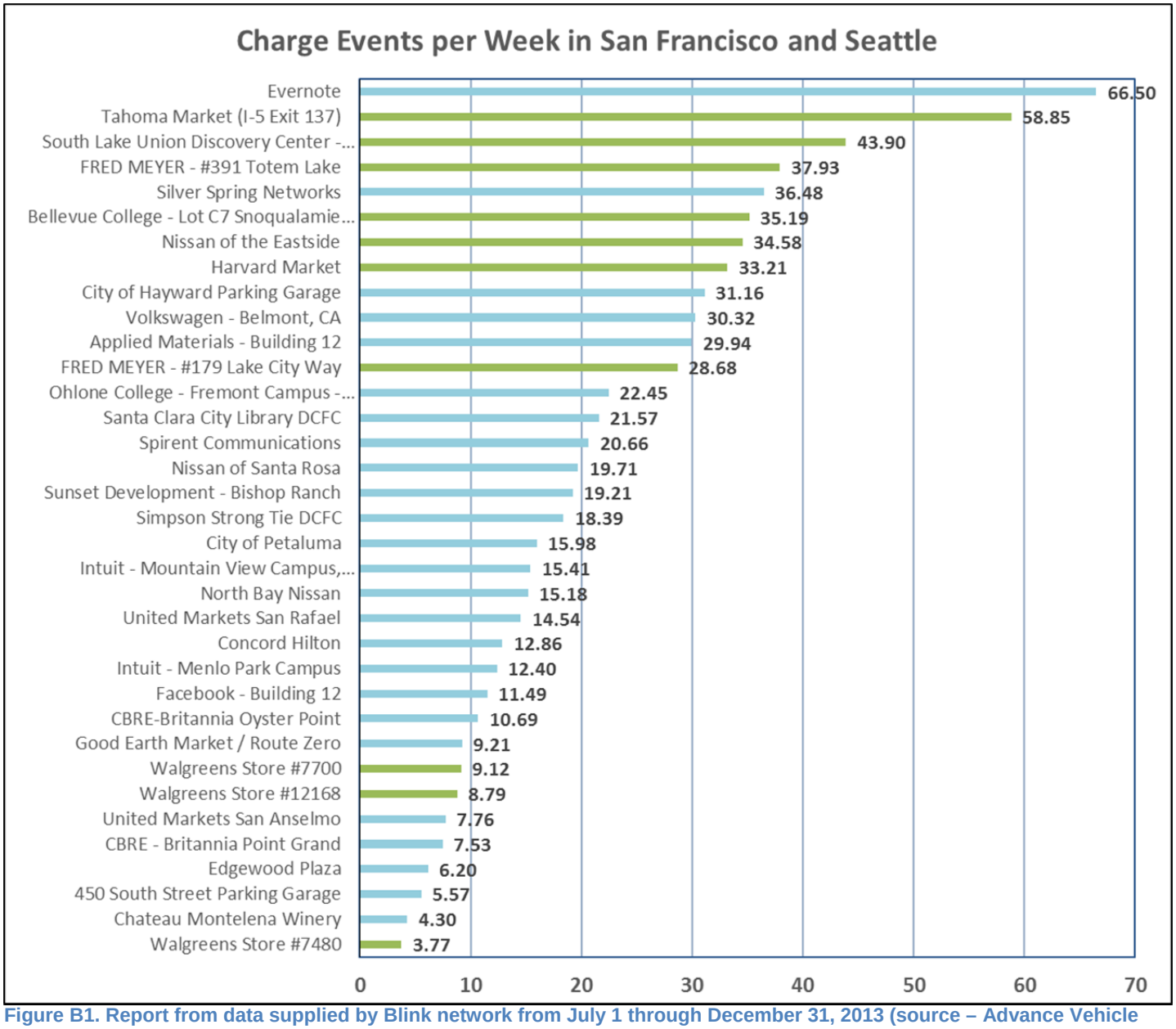
Charge Events per Week	Host	Street Address	City	State	Nearest AADT
66.50	Evernote	305 Walnut St.	Redwood City	CA	**213,000**
58.85	Tahoma Market (I-5 Exit 137)	6006 Pacific Highway East	Fife	WA	**182,000**
43.90	South Lake Union Discovery Center - DCFC	101 Westlake Ave N	Seattle	WA	**206,000**
37.93	FRED MEYER - #391 Totem Lake	12221 120th Ave NE	Kirkland	WA	**129,000**
36.48	Silver Spring Networks	585 Broadway Street	Redwood City	CA	**213,000**
35.19	Bellevue College - Lot C7 Snoqualamie River Road	3036 Snoqualamie River Road	Bellevue	WA	**16,000**
34.58	Nissan of the Eastside	11815 NE 8th Ave	Bellevue	WA	**164,000**
33.21	Harvard Market	1401 Broadway	Seattle	WA	**206,000**
31.16	City of Hayward Parking Garage	777 B Street	Hayward	CA	**37,000**
30.32	Volkswagen - Belmont CA	500 Clipper Drive	Belmont	CA	**229,000**
29.94	Applied Materials - Building 12	3225 Oakmead Village Drive	Santa Clara	CA	**191,000**
28.68	FRED MEYER - #179 Lake City Way	13000 Lake City Way NE	Seattle	WA	**34,000**

Utilization of DCFC in the San Francisco and Seattle Market Areas

Table A3. Report from data supplied by Blink network from July 1 through December 31, 2013 (source – Advance Vehicle Testing Activity at INL).

Host Name	Address	City	Stat	ZIP	Charge Events per Week
Evernote	305 Walnut St.	Redwood City	CA	94063	66.50
Tahoma Market (I-5 Exit 137)	6006 Pacific Highway East	Fife	WA	98424	58.85
South Lake Union Discovery Center - DCFC	101 Westlake Ave N	Seattle	WA	98109	43.90
FRED MEYER - #391 Totem Lake	12221 120th Ave NE	Kirkland	WA	98034	37.93
Silver Spring Networks	585 Broadway Street	Redwood City	CA	94063	36.48
Bellevue College - Lot C7 Snoqualamie River Road	3036 Snoqualamie River Road	Bellevue	WA	98005	35.19
Nissan of the Eastside	11815 NE 8th Ave	Bellevue	WA	98005	34.58
Harvard Market	1401 Broadway	Seattle	WA	98122	33.21
City of Hayward Parking Garage	777 B Street	Hayward	CA	94541	31.16
Volkswagen - Belmont, CA	500 Clipper Drive	Belmont	CA	94002	30.32
Applied Materials - Building 12	3225 Oakmead Village Drive	Santa Clara	CA	95051	29.94
FRED MEYER - #179 Lake City Way	13000 Lake City Way NE	Seattle	WA	98125	28.68
Ohlone College - Fremont Campus - Hyman Hall	43600 Mission Blvd	Fremont	CA	94539	22.45
Santa Clara City Library DCFC	2635 Homestead Drive	Santa Clara	CA	95051	21.57
Spirent Communications	1325 Borregas Avenue	Sunnyvale	CA	94089	20.66
Nissan of Santa Rosa	1275 Santa Rosa Ave.	Santa Rosa	CA	95404	19.71
Sunset Development - Bishop Ranch	2430 Camino Ramon	San Ramon	CA	94583	19.21
Simpson Strong Tie DCFC	5956 West Las Positas Boulevard	Pleasanton	CA	94588	18.39
City of Petaluma	210 Lakeville Street	Petaluma	CA	94952	15.98
Intuit - Mountain View Campus, Building 4	2500 Garcia Ave.	Mountain View	CA	94043	15.41
North Bay Nissan	1250 Auto Center Drive	Petaluma	CA	94952	15.18
United Markets San Rafael	515 Third St.	San Rafael	CA	94901	14.54
Concord Hilton	1970 Diamond Blvd.	Concord	CA	94520	12.86
Intuit - Menlo Park Campus	180 Jefferson Drive	Menlo Park	CA	94025	12.40
Facebook - Building 12	1601 Willow Rd.	Menlo Park	CA	94025	11.49
CBRE-Britannia Oyster Point	1110 Veterans Parking Garage	South San Francisco	CA	94080	10.69
Good Earth Market / Route Zero	720 Center Blvd.	Fairfax	CA	94930	9.21
Walgreens Store #7700	34008 HOYT RD SW	FEDERAL WAY	WA	98023	9.12
Walgreens Store #12168	3929 KITSAP WAY	BREMERTON	WA	98312	8.79
United Markets San Anselmo	100 Red Hill Rd.	San Anselmo	CA	94960	7.76
CBRE - Britannia Point Grand	280 E Grand Ave	South San Francisco	CA	94080	7.53
Edgewood Plaza	2050 Channing Way	Palo Alto	CA	94303	6.20
450 South Street Parking Garage	450 South Street	San Francisco	CA	94158	5.57
Chateau Montelena Winery	1429 Tubbs Lane	Calistoga	CA	94515	4.30
Walgreens Store #7480	1701 AUBURN WAY S	AUBURN	WA	98002	3.77

Appendix B,
Figures



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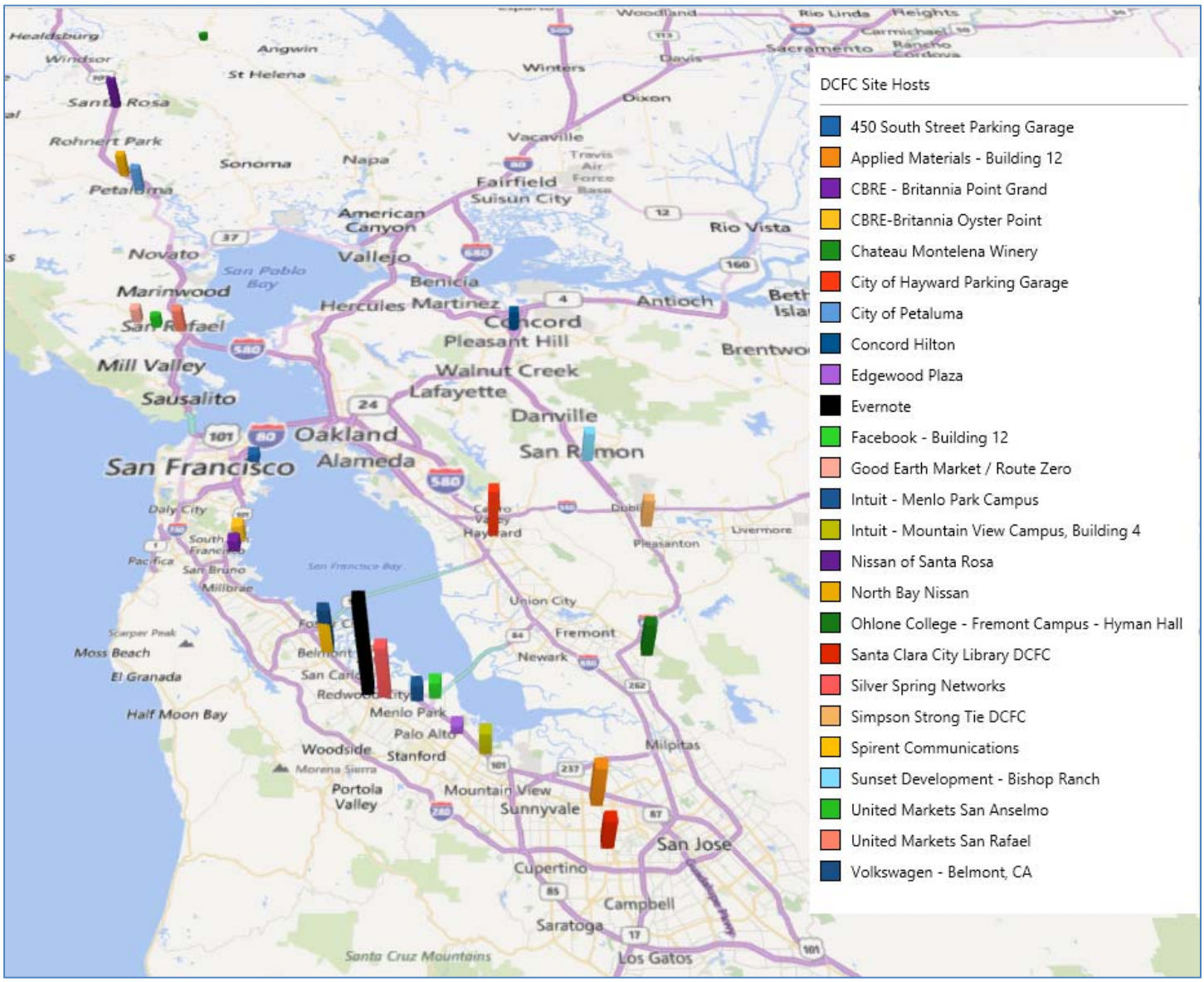

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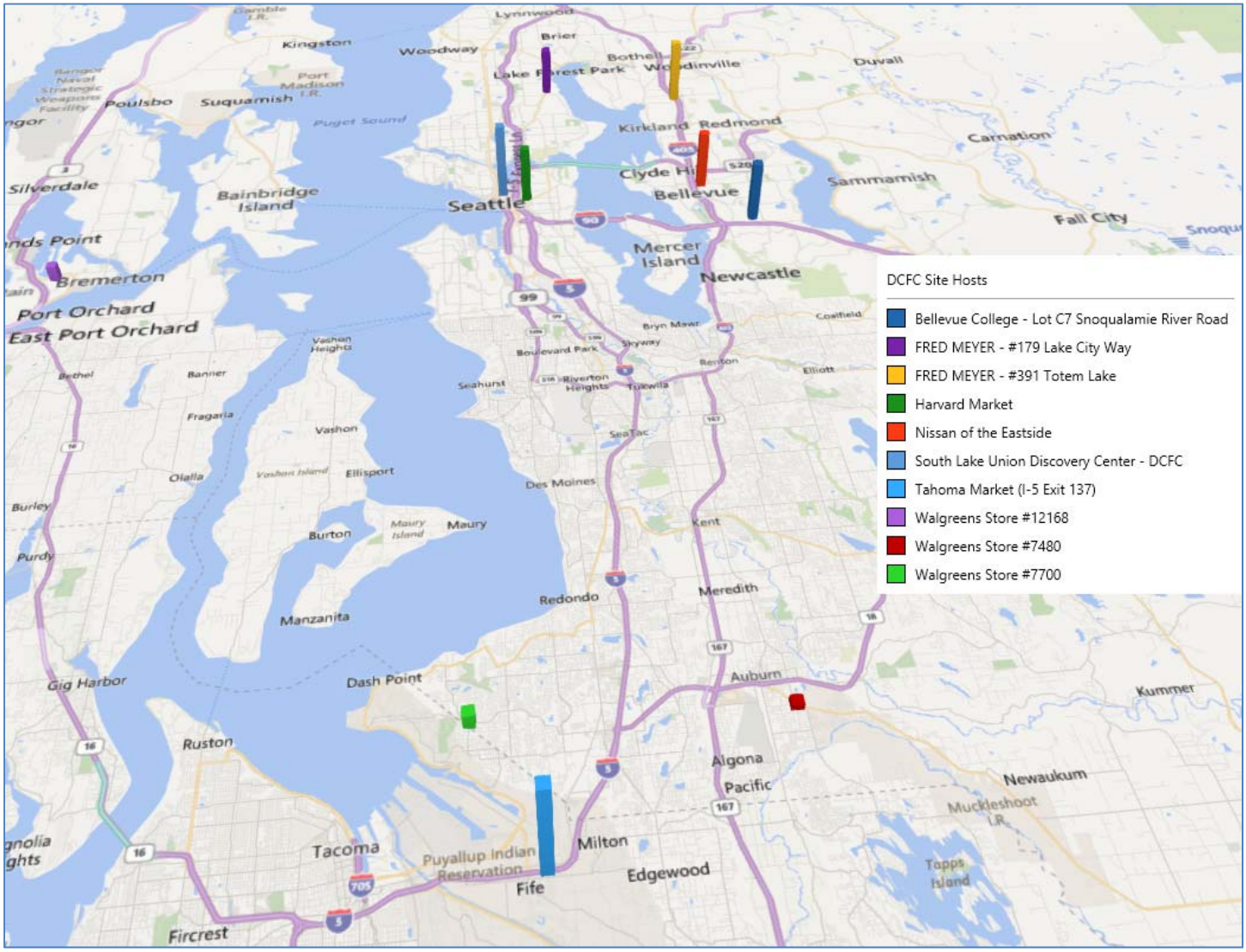

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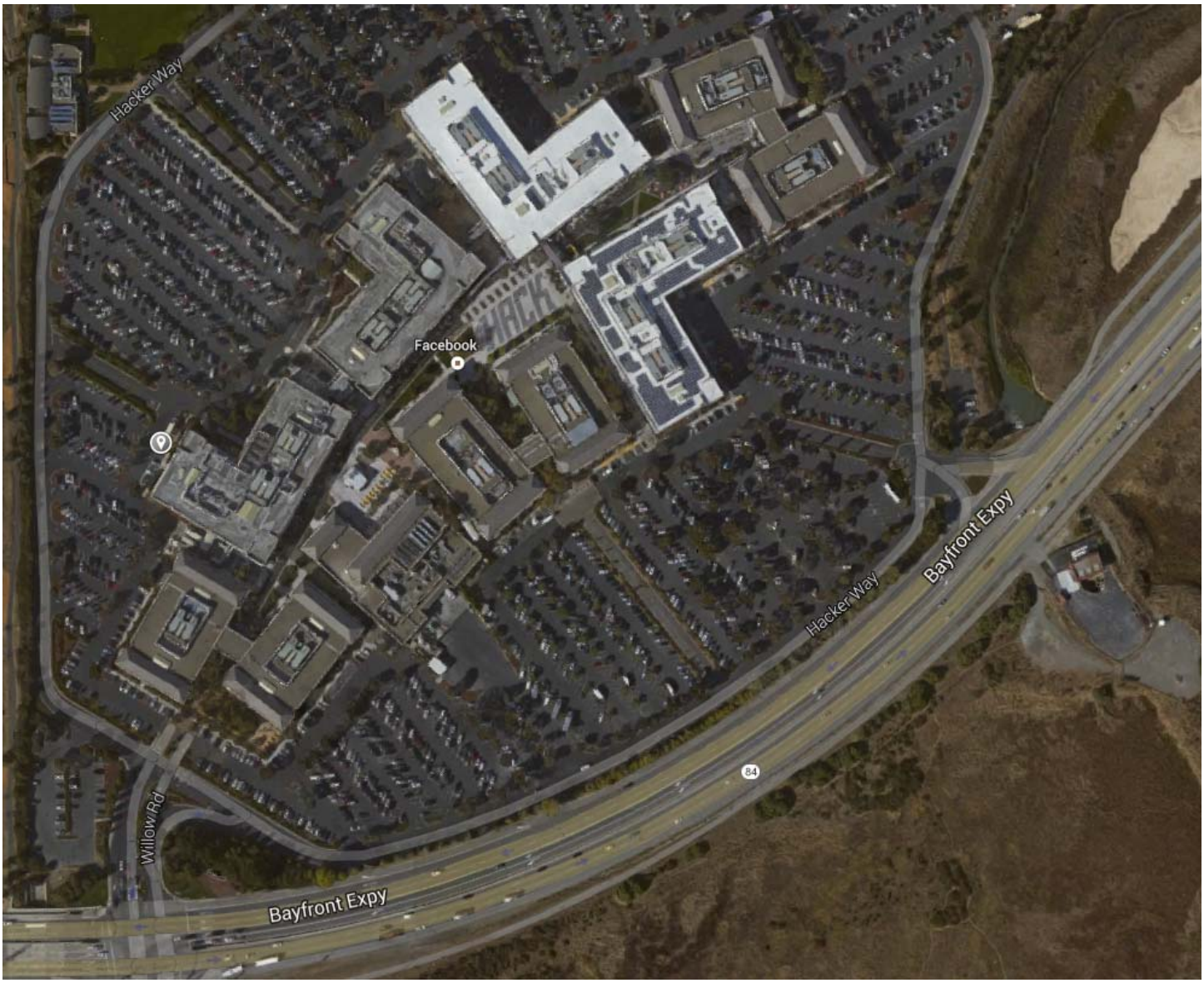

Figure B4. Google Earth view of Facebook campus at 12 Hacker Way, Menlo Park, California. DCFC located at circle marker on left side of photo.