Transit Bus Fleet Size

Utility Bus and Truck Working Council

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Topic

What happens when you get into big deployment of buses - how does the onsite infrastructure differ when you have a 100- bus depot versus a 10-bus depot?

Manual Chargers

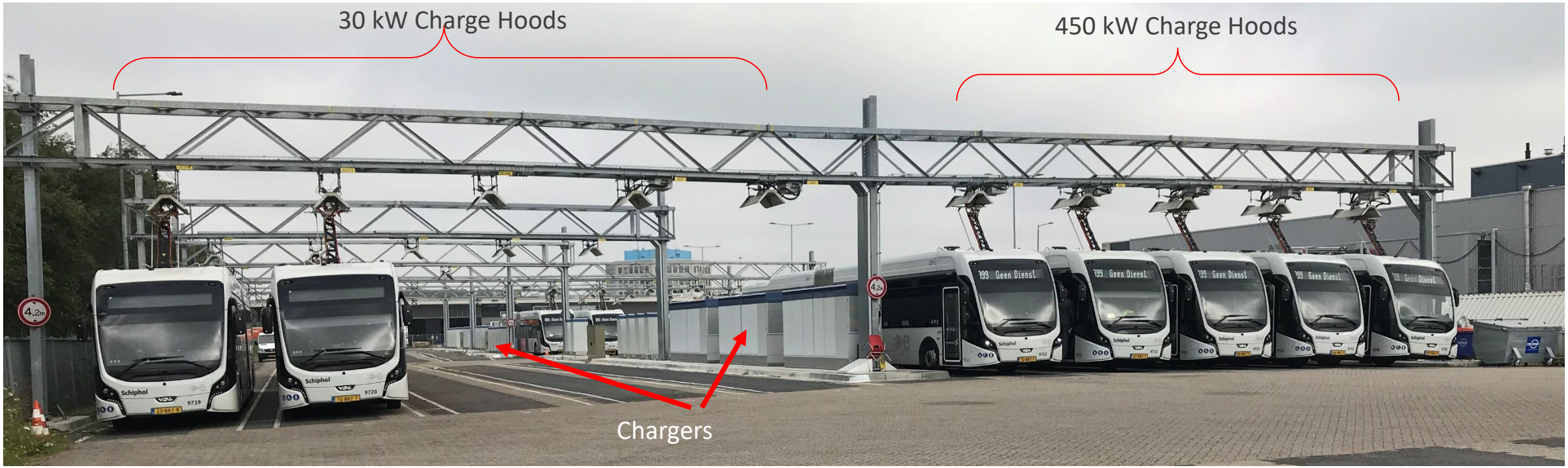
- With a small fleet of transit buses, all that is needed in the depot are manually-connected DC chargers
- Facilities may have enough excess power to provide for the needs of a small fleet

50 kW Chargers

60 kW Chargers

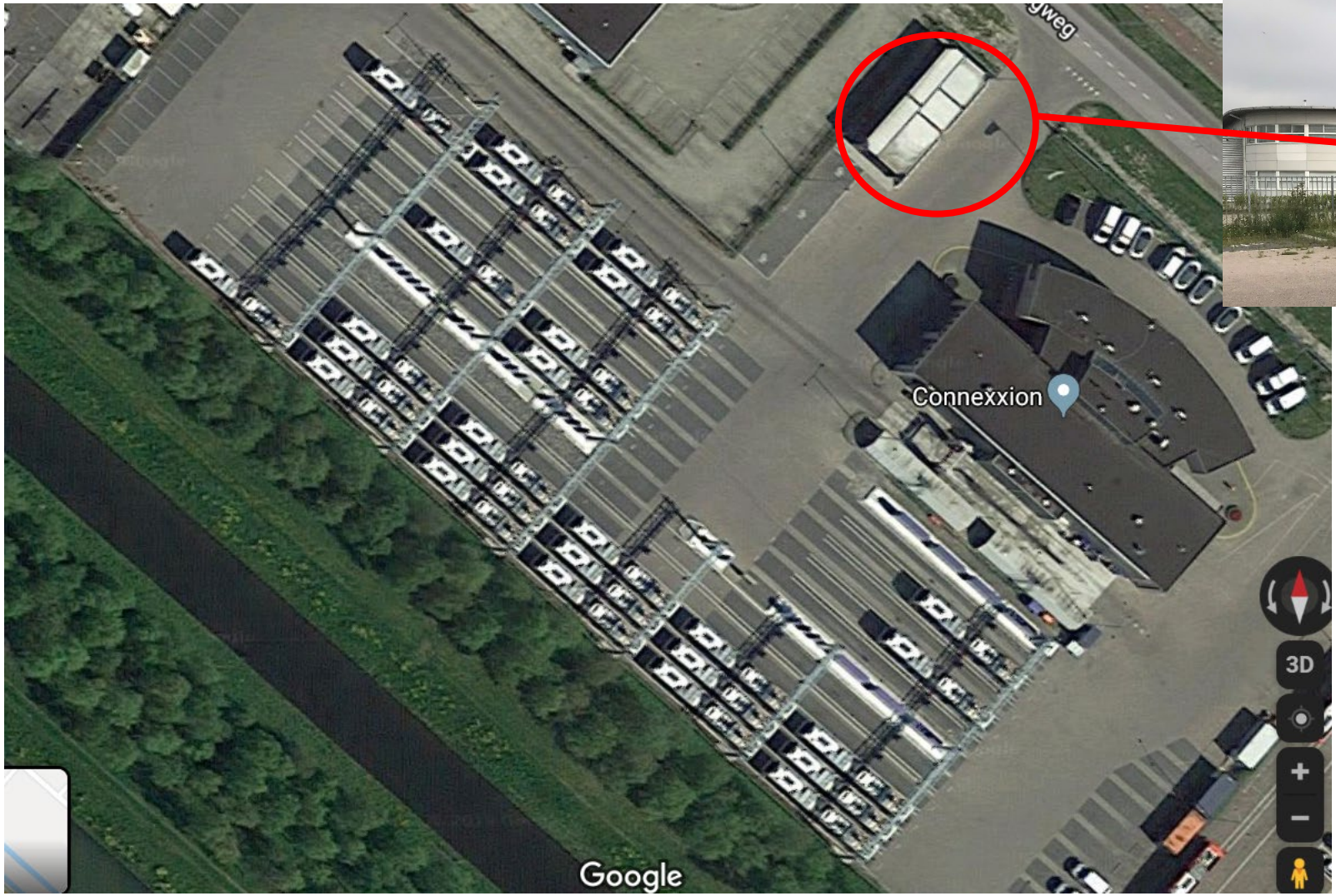
- Dedicated spaces for Buses with chargers are used
- Chargers can be floor-mounted, wall-mounted, or ceiling-mounted
- Cable management is required

Schiphol Airport All-Electric Transit Bus Fleet



- 100 x 60-foot Transit Buses (VDL)
- 13 MW installed Power
- 84 x 30 kW Charging Hoods
- 23 x 450 kW Opportunity Charging Hoods
- 2 x 25 kW Mobile Chargers in the Workshop
- Two Outside Depots
- Five Opportunity Charging sites
- Full Operation with 24/7 Service

Schiphol Depot 1 of 2



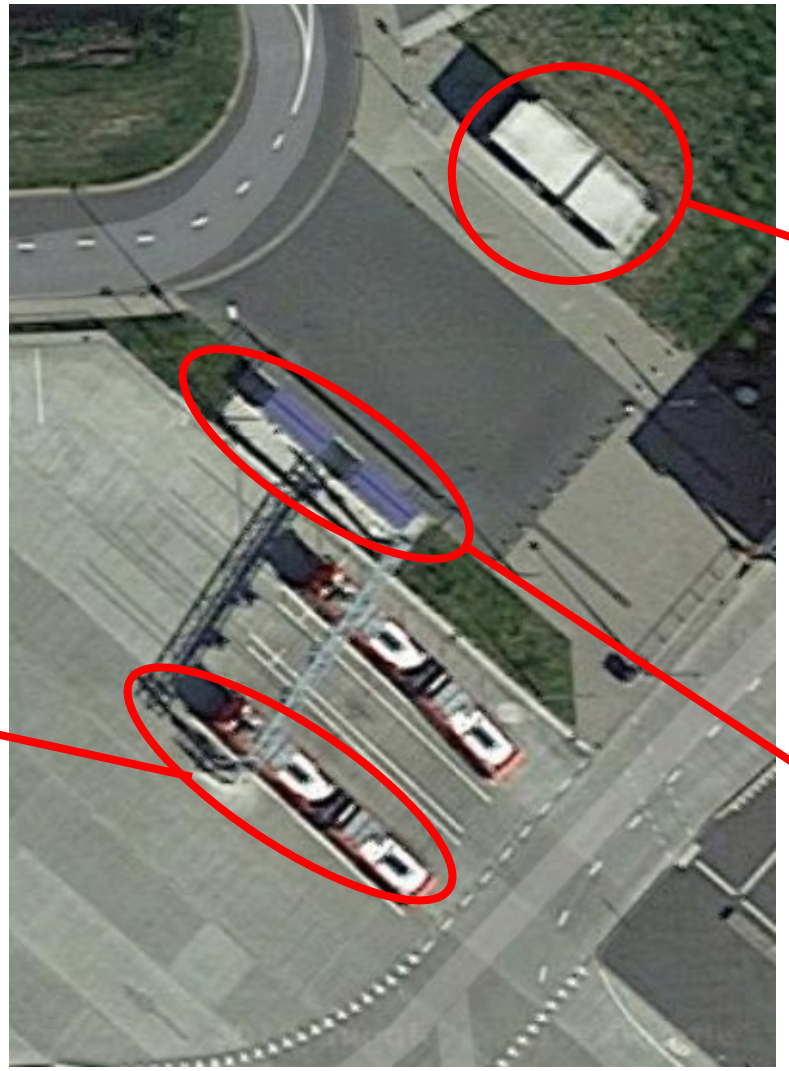
Five Independent transformers for resilience

Forty Eight 30 kW Charge Hoods

Five 450 kW Charge Hoods

Total: ~4 MW

Schiphol Opportunity Charging 1



2 x > 900 kVA Transformers
Independent for resilience

4 x 450 kW Chargers

Total: ~2 MW

Proterra Rendering of a 60 kW Depot

A rendering of a bank of 60 kW Proterra chargers. Image courtesy: Proterra

Together...Shaping the Future of Electricity

Questions

Given a site, what is the available power at the site?

Should a depot site energy have its own meter and account instead of integrating the energy with the existing building?

What do you do for resilience?

What are the voltage levels for utility transformers?

Should DCaaS be deployed?

Example- 100 Buses

	100 Bus Depot and On-route Charging			
	Cross Rail J-3105-1		Bus-Up J-3105-2	
	Automatic Depot Charging	Manual Depot Charging	Automatic Depot Charging	Manual Depot Charging
Incremental # of Passengers	1	1	Neutral	Neutral
# of Pantographs	80	10	80	10
Moving Parts on Bus	None	None	Yes	Yes
Moving Parts on Infrastructure	Yes	Yes	None	None
Affect of Breakdown of Pantograph	Few Buses	Many Buses	Few Buses	Many Buses

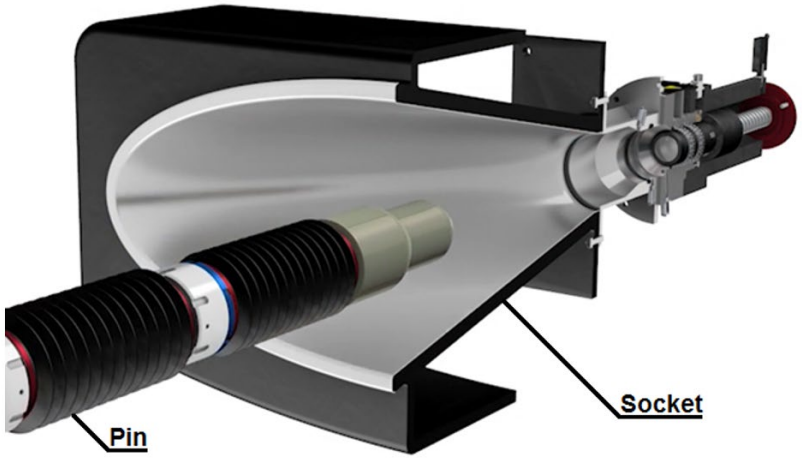
J-3105 Sub-Document Definition

J-3105-1

Infrastructure-mounted Cross Rail Connection

J-3105-2

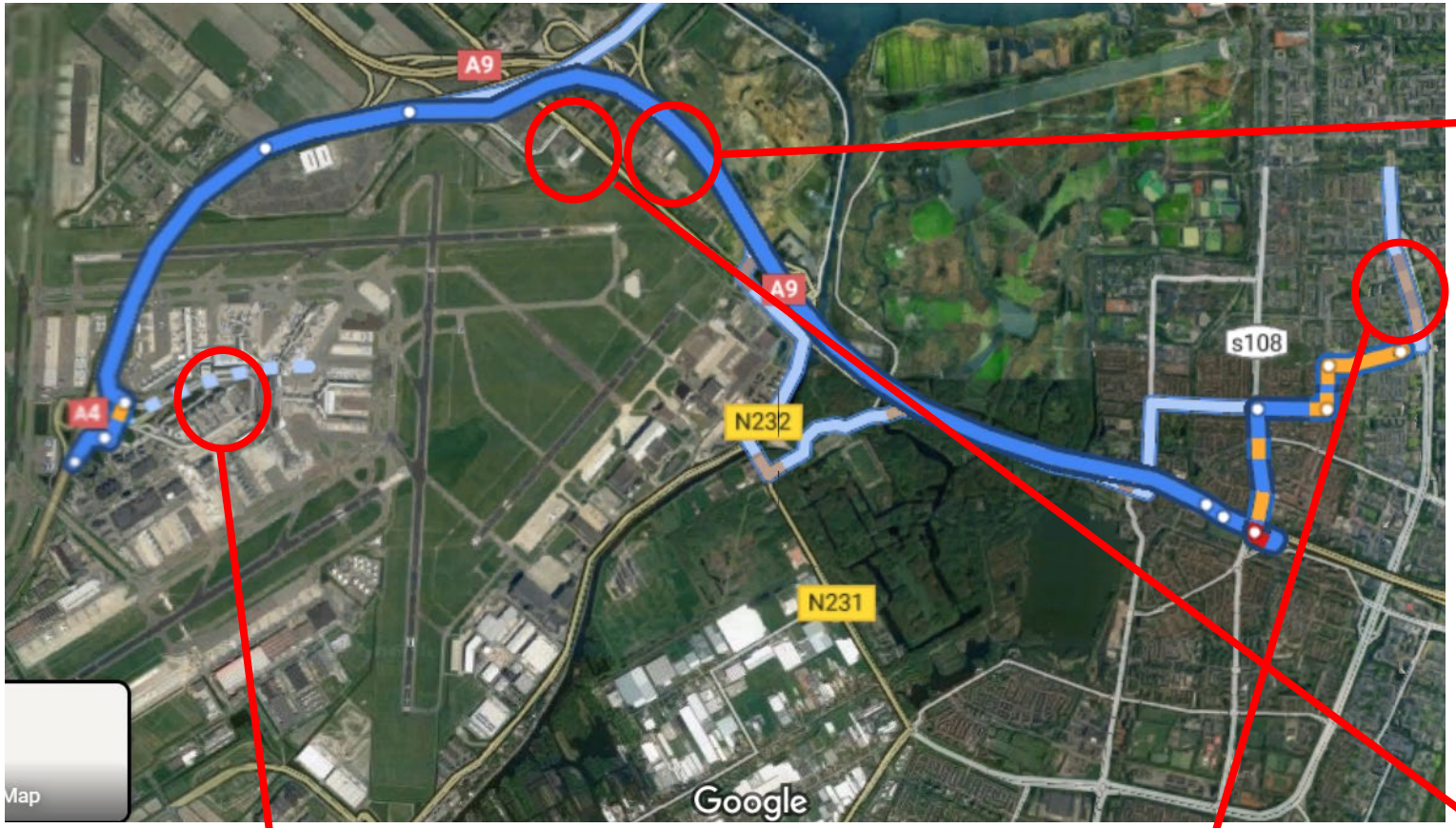
Vehicle-mounted Pantograph Connection

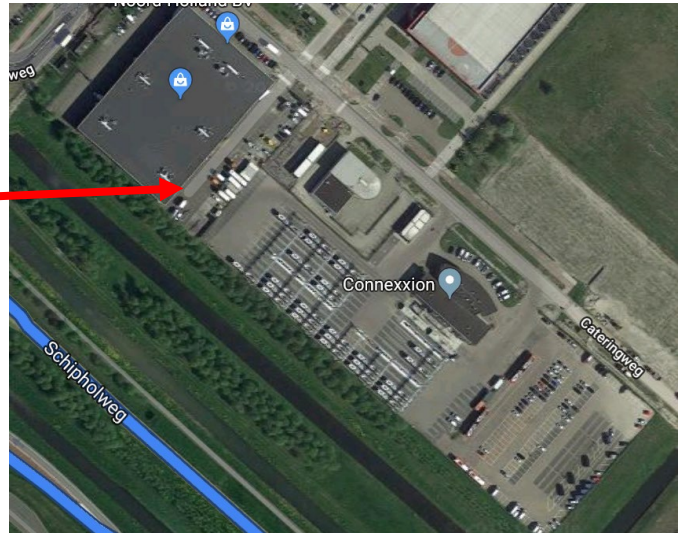


J-3105-3

Enclosed Pin and Socket Connection

Schiphol Airport, Amsterdam





Depot 1

On-Route Charging 1

On-Route Charging 2

Depot 2

Eindhoven Opportunity Charging

43 All-Electric Buses with Automatic Depot Charging Indoors

Heliox and VDL initial deployment

Heliox and VDL headquarters and manufacturing is near Eindhoven

Chile

285 All-electric Buses in Santiago, Chile

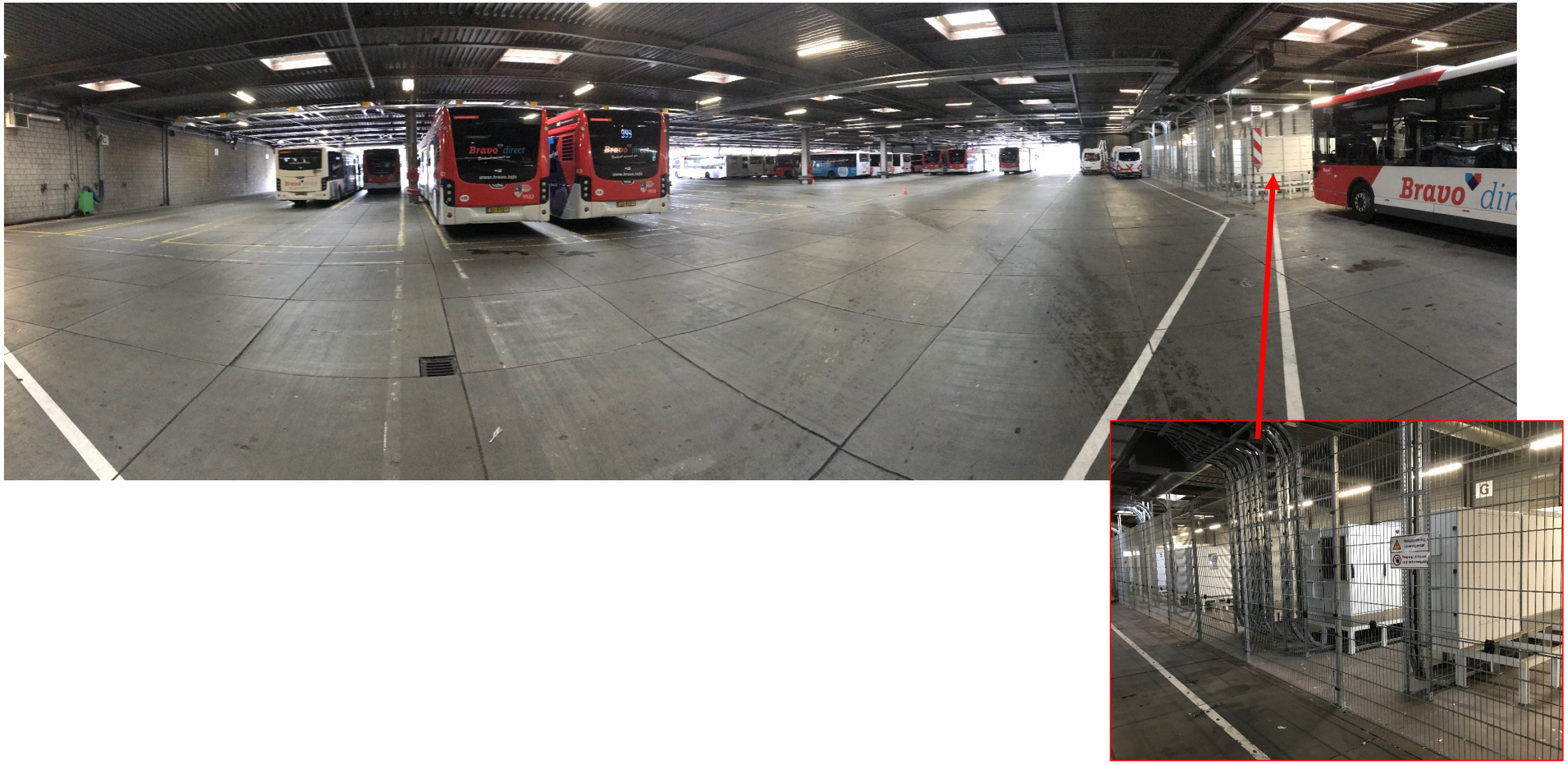
Schiphol Opportunity Charging 1

UL Listed DC Chargers

50 kW $62k

450 kW $333k

Eindhoven Indoors Depot



Schiphol Opportunity Charging 1

Eindhoven Opportunity Charging Alignment

Operator aligns the yellow line on the bus floor with the white line on the street

Eindhoven Opportunity Charging

On-route chargers are located at the depot and the Eindhoven Airport

A bumper on the pavement stops the bus for the alignment with the hood.

Eindhoven Indoors Depot

Charger Cabinets are up off the floor to easily get the power in and out.

Power is routed in conduit to the ceiling and then to each charging hood

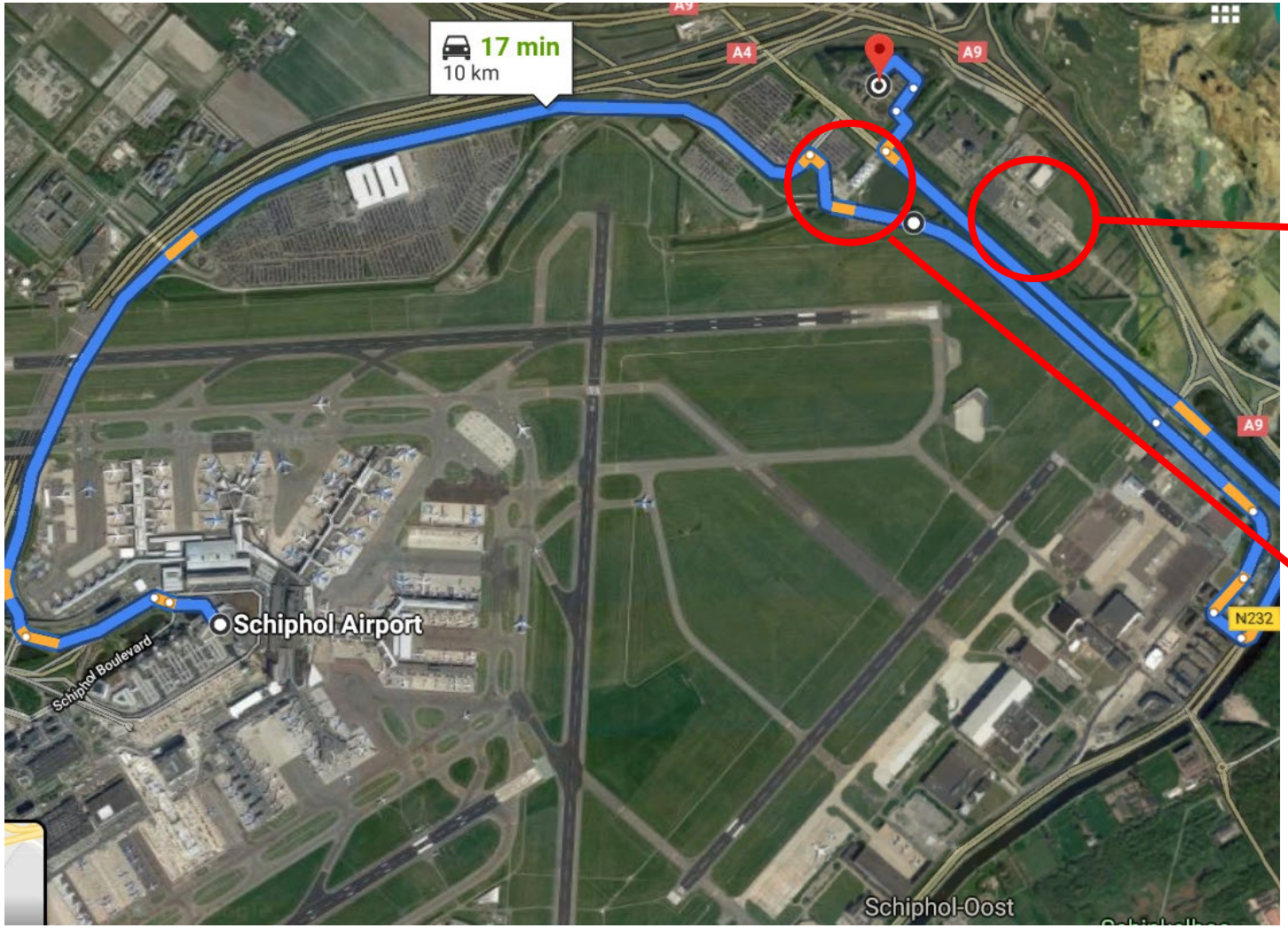
Summary

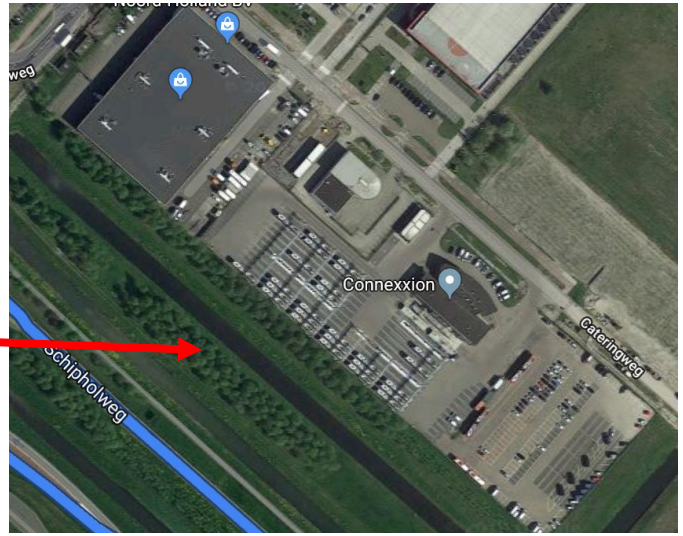
- Before starting to plan, engage the proper city departments that have a stake in the program including the utility
- Plan the need for adequate electric capacity
- Locate the depot where there is a potential for electricity and decide indoors or outdoors
- Consider Automatic connections, manual connections can be made, but hanging cables will provide an untidy site and not provide smooth handling for the operators.
- Select the automated connection that best provides for your needs

Backup

Grand Avenue Depot Electrical Room and Panels

Schiphol Airport, Amsterdam





Depot

On-Route Charging

Electric Bus Fleet Demonstration and Data Collection

Sites can be field approved by Underwriters Laboratories (UL) or others. If the components for the site are not UL qualified, then UL can do a field approval of the site. UL comes to the site and performs the characteristic tests subscribed by the requirements.

Organizational entities were gathered for the NYC program including the New York City Transit (NYCT), Bridges and Tunnels, NY State Department of Transportation (NYDOT), New York City Department of Transportation (NYCDOT), Hudson River Park, New Flyer, Black and Veatch, and Ciocchini Design. Much coordination had to occur between departments. One large delay was having a plan from the NYDOT for traffic control during construction. Evidently, the requirements went back and forth between departments causing a sizable delay.

During the planning process, it is necessary to determine the designated dedicated parking spaces for the buses to be charged. Chargers can be overhead, on a nearby wall, or floor-mounted near each parking place. Chargers can be located between or near several buses for effective utilization. It is important to determine whether the operator/personnel plugs in the charger or an automated charging system is warranted.

The automated charging system could be the same system used on-route. Currently, there are three automated charging systems defined with a common set of requirements.

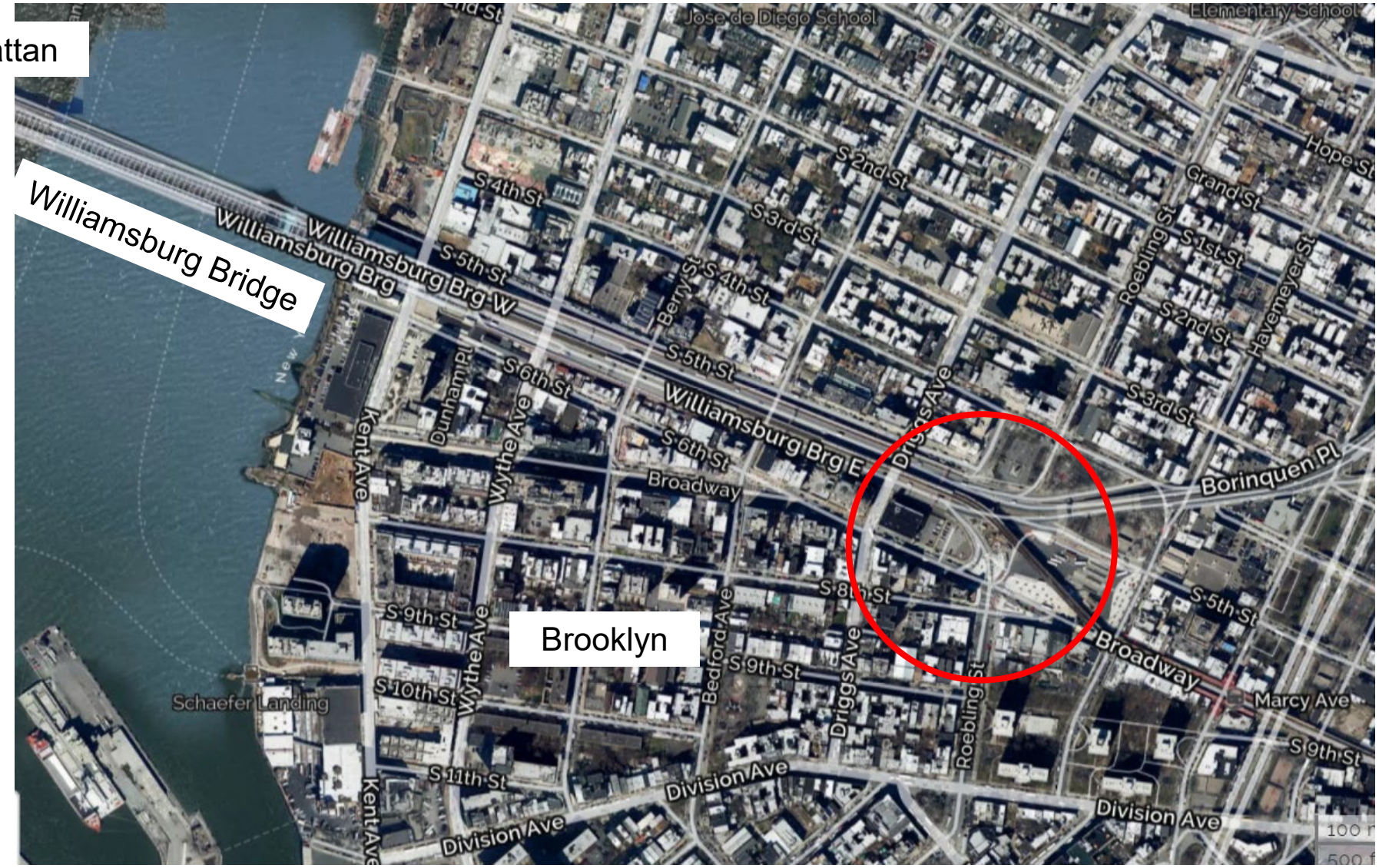
Consideration needs to be made regarding the power conduit. The conduit can be placed underground or overhead. The underground type is more esthetically pleasing but it cost more to either drill under the ground or dig up streets and lay asphalt or concrete over. The overhead version can more easily be put up but esthetically it is not as pleasing. If the system is automated and on public streets it may be wise to have a more esthetically pleasing system. If the chargers are in a depot, the conduit can be run on existing walls or overhead. The system is less expensive.

Proterra Buses in Brooklyn

- 5 Proterra buses (440 kWh) capable of charging with two chargers at a time (100 kW)
- Blade On-Route* Charging System (500 kW) at terminal near the Williamsburg Bridge in Brooklyn
- Six 50 kW DC Chargers (Tritium) located at the Grand Avenue Depot in Queens

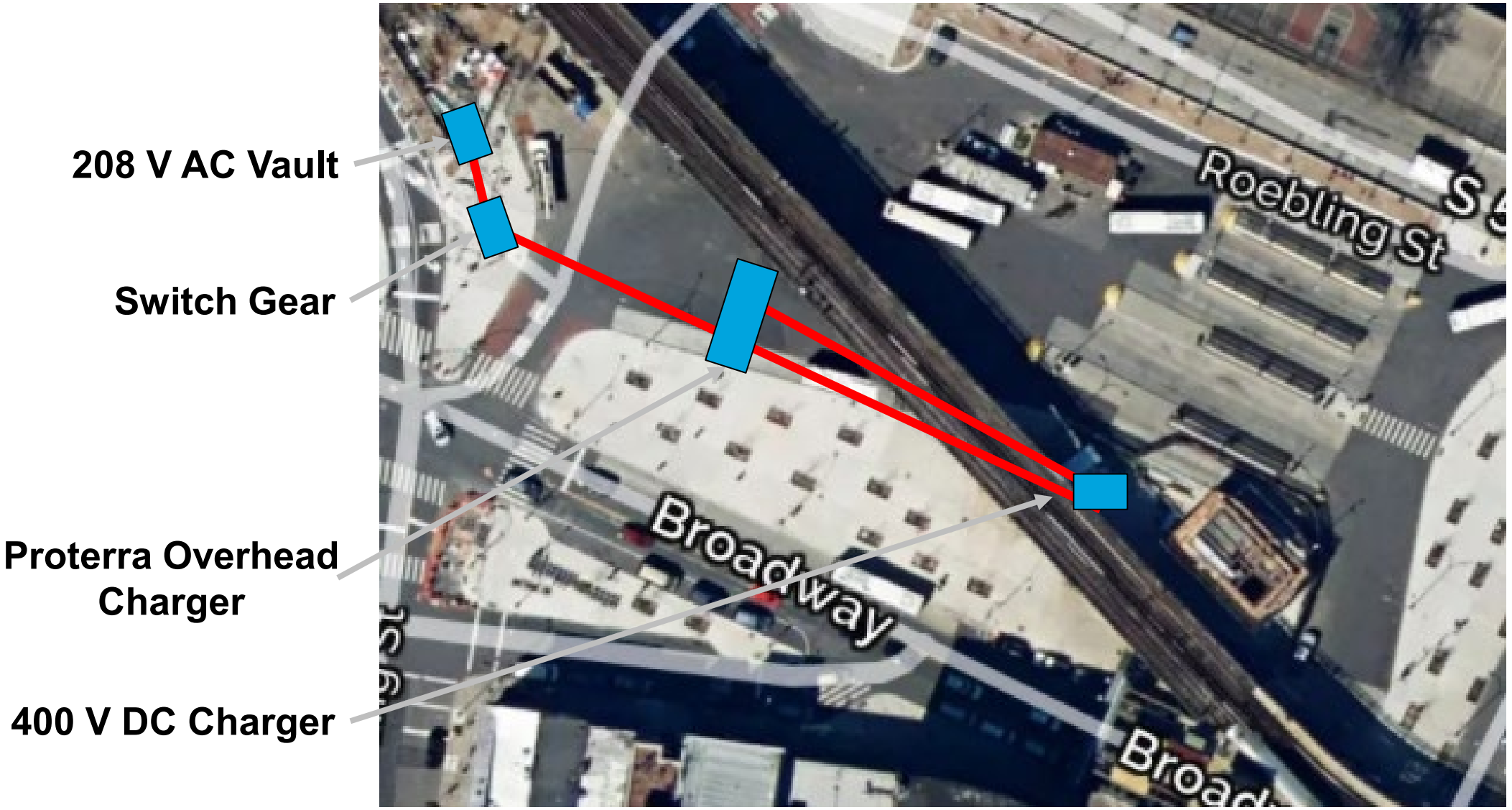
* Per Proterra, the Blade system has been eliminated from the SAE J3105 Recommended Practice

Location for the Proterra Overhead Charger



Plan was for 2 routes (B32 and B39), however, multiple routes are being used as the need arises.

Williamsburg Terminal Layout



Proterra Bus at Williamsburg Terminal in Brooklyn

400 V DC Charger

Manhattan Routes (M42 and M50) along 42nd Street- New Flyer

West Side started in Charging in December 2018

Pole is on Driver side

East Side started in Charging in January 2019

Pole is on passenger side

Cross Section of a NYC Street

Understand the Ground Below

Power
Cable
Water
Steam
Gas
Forgotten

Transportation

Sewage

Geology

Deep Water

MJ Quill Depot- Manhattan

~280 buses at the MJ Quill Depot

5 New Flyer Electric buses are housed

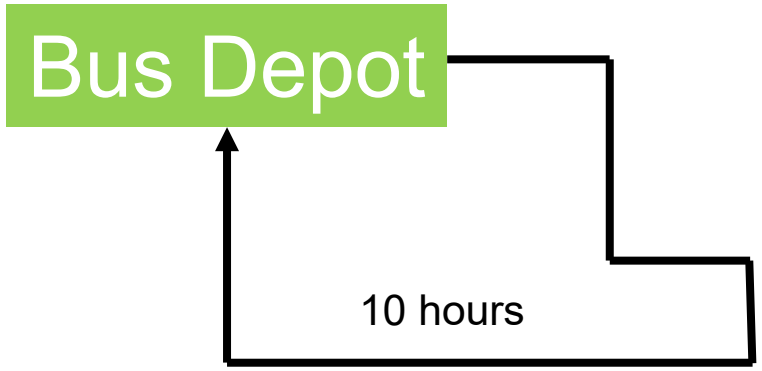
15 more buses have been ordered and to be placed at Quill

Two 60 kW chargers (Siemens) and 8 more being added on the roof

Operational Data

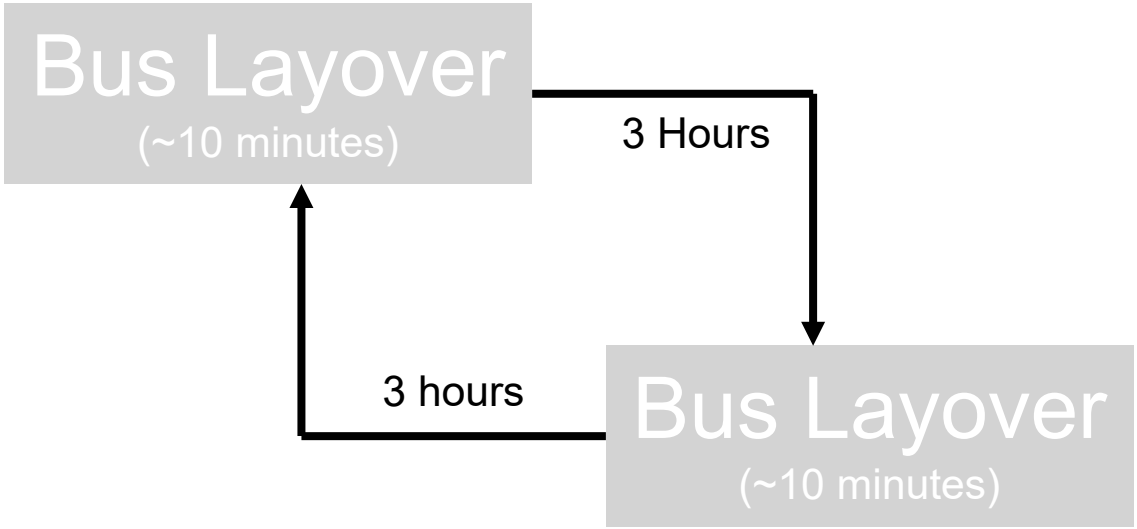
Technology Differences Evaluated

Slow Charge (50 to 100 kW)



- Charges at Depot
- Range of 10 hours
- ~ 4 to 7 hours to charge overnight
- Proterra

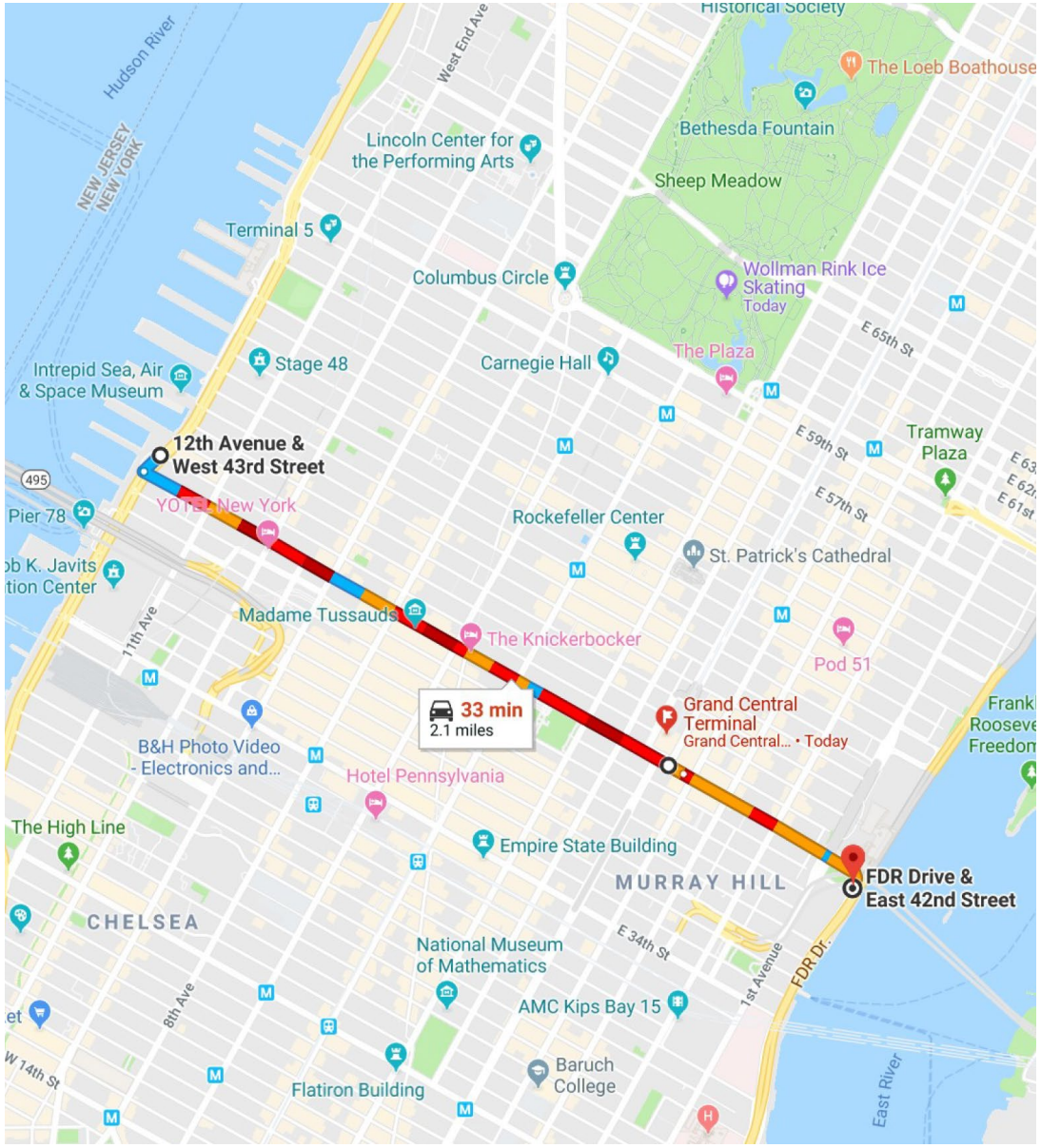
Fast Charge (350 kW)



- Charges at Bus Layover
- Range of 3 hours
- ~ 10 minutes to charge
- New Flyer

Sample New York City Routes: Manhattan

M42



- New Flyer buses
- MJ Quill depot on Manhattan

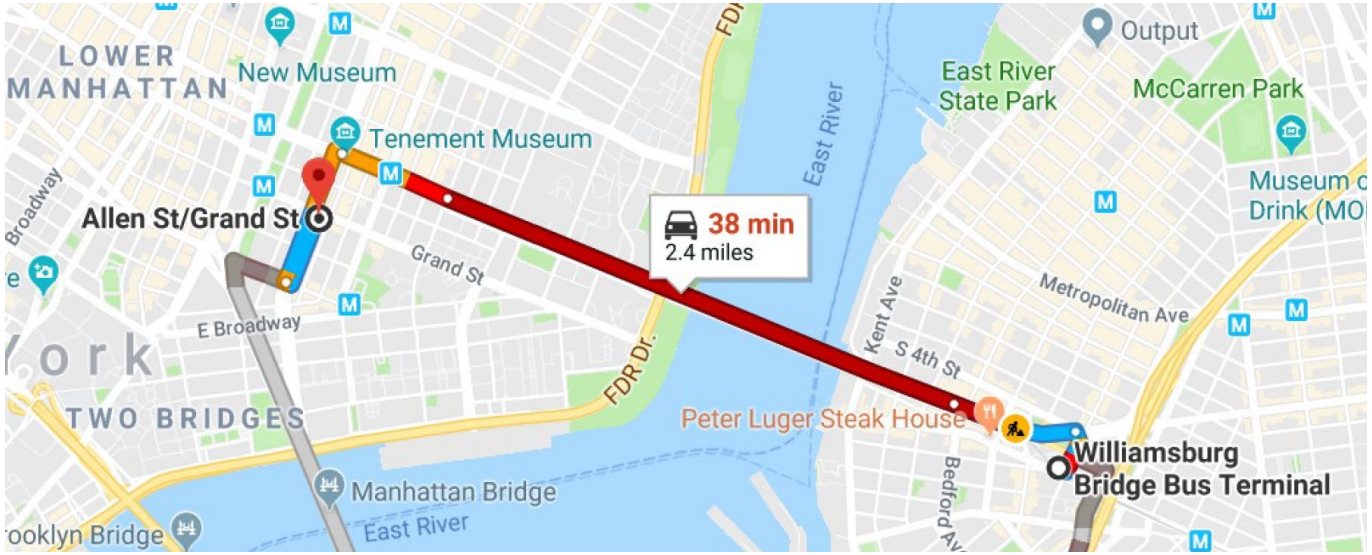
- NYCT is currently operating the buses conservatively

From Google Maps
Approximately noon on Thurs 11/15/2018.

Sample Routes: Brooklyn/Queens

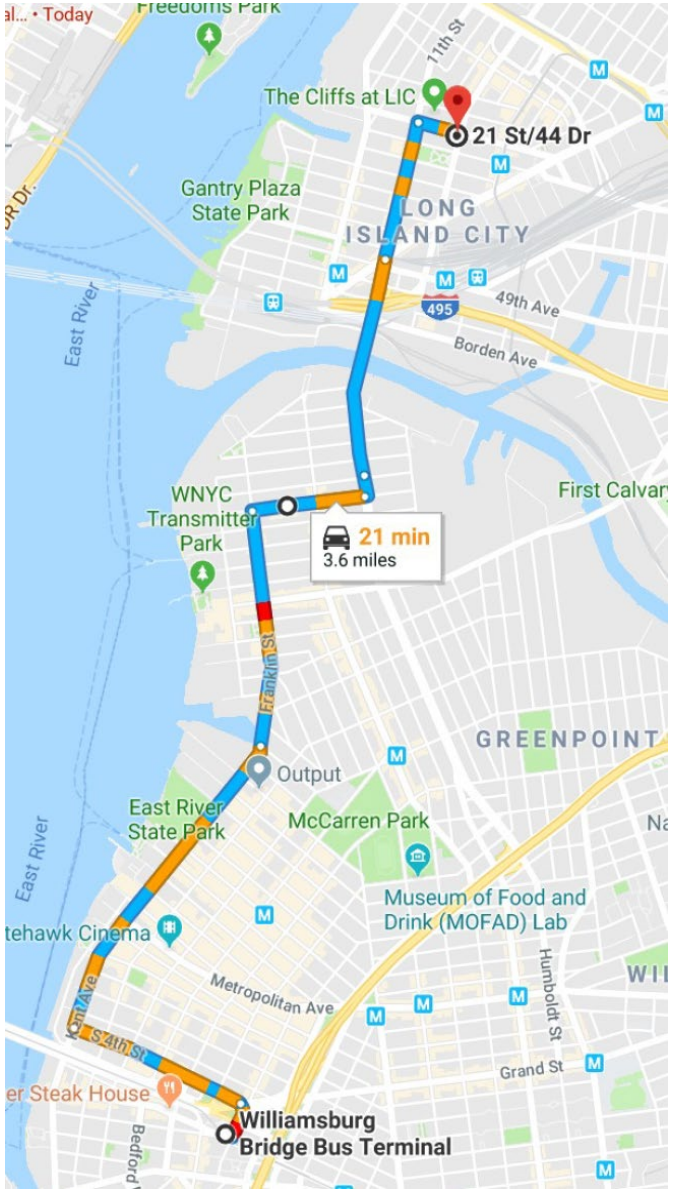
- Proterra buses
- Grand Ave depot in Brooklyn
- NYCT has operated Proterra buses on all routes out of Grand Ave

B39



From Google Maps
Approximately noon on Thurs 11/15/2018.

B32



Driving Data Summary

	Number of Drive Events	Total Distance (miles)	Operating Time (hours)
New Flyer	7,083	23,000	6,716
Proterra	1,019 *	32,347	3,780 *
Total	**8,102**	**55,348**	**10,497**

New Flyer data from 2/1/2018 to 11/30/2018

Proterra data from 12/26/2017 to 11/28/2018

*** Proterra data does not include long dwells**

- Many short New Flyer events
- Four Proterra buses have been out of service since mid-August. One other was in service until the end of November.
- Proterra data is missing long dwell periods

Driving Data Summary

	Number of Drive Events	Total Distance (miles)	Operating Time (hours)	Overall Average Speed (mph)	Moving Average Speed (mph)
New Flyer	7,083	23,000	6,716	3.16	7.20
Proterra	1,019 *	32,347	3,780 *	8.89 *	9.81
Total	**8,102**	**55,348**	**10,497**	**5.22**	**8.60**

New Flyer data from 2/1/2018 to 11/30/2018

Proterra data from 12/26/2017 to 11/28/2018

*** Proterra data does not include long dwells**

Driving Data Summary

	Number of Drive Events	Total Distance (miles)	Operating Time (hours)	Overall Average Speed (mph)	Moving Average Speed (mph)	Total Energy Consumed (kWh)	Energy Consumption (kWh/mi)
New Flyer	7,083	23,000	6,716	3.16	7.20	78,896	3.72
Proterra	1,019*	32,347	3,780*	8.89*	9.81	89,481*	2.66*
Total	**8,102**	**55,348**	**10,497**	**5.22**	**8.60**	**168,378**	**3.07**

New Flyer data from 2/1/2018 to 11/30/2018

Proterra data from 12/26/2017 to 11/28/2018

*** Proterra data does not include long dwells**

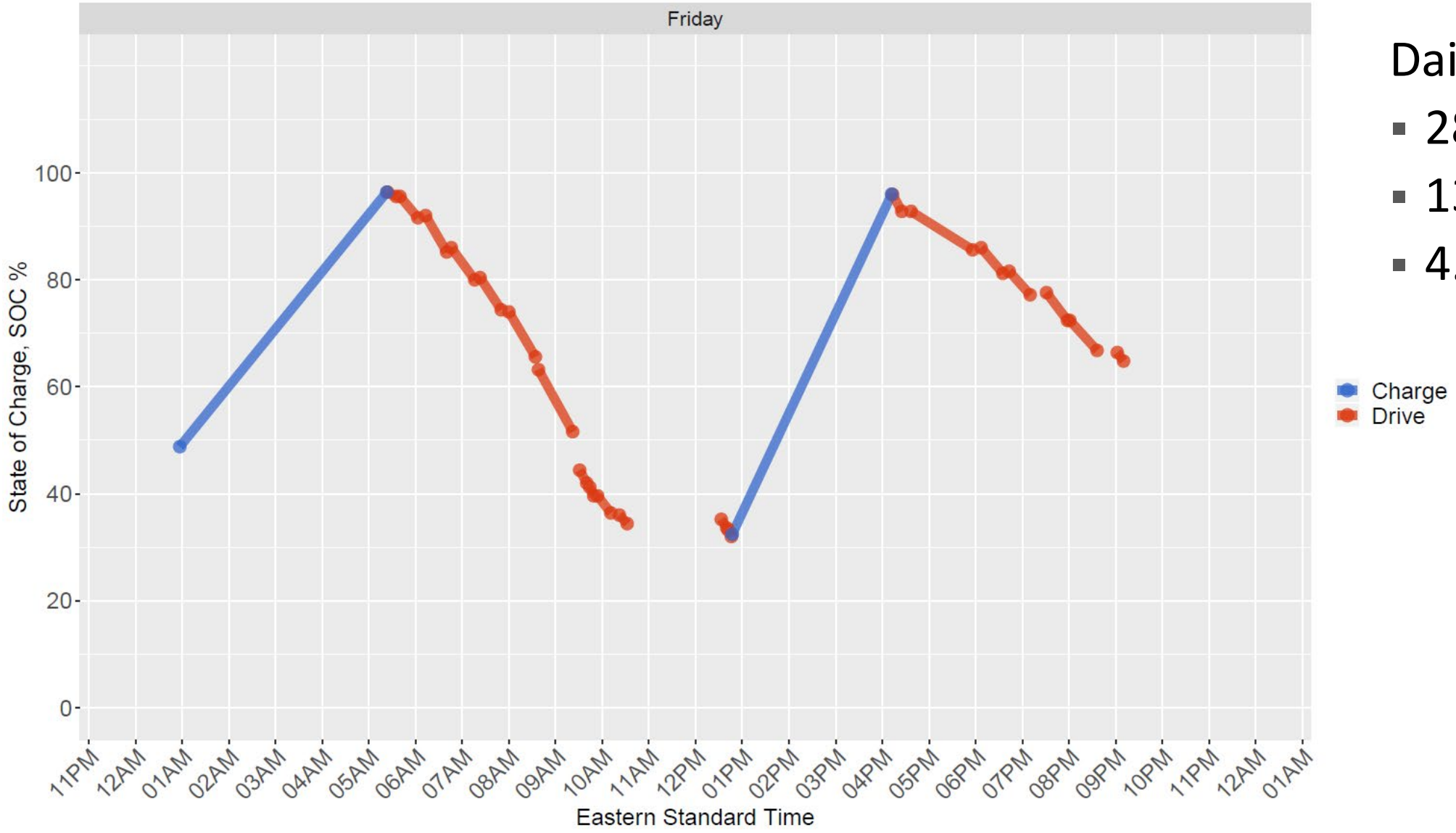
Charging Data Summary

	Number of Depot Charge Events	Total Duration (hours)	Active Charging Time (hours)
New Flyer	2,127	5,362	3,239
Proterra	1,118	4,047	2,284
Total	**3,245**	**9,409**	**5,523**

New Flyer data from 2/1/2018 to 11/30/2018

Proterra data from 12/26/2017 to 11/28/2018

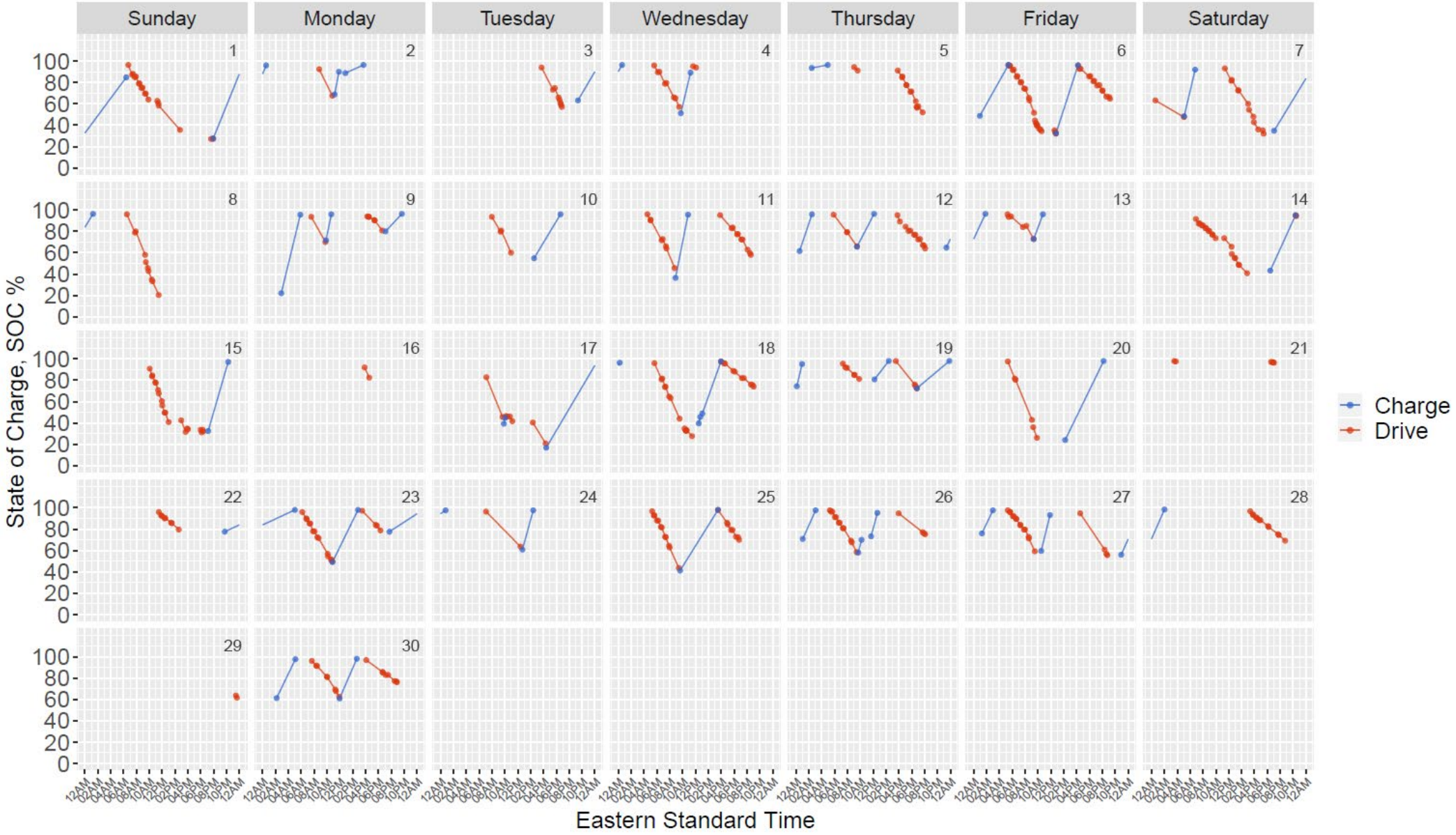
Example Battery SOC History: New Flyer Bus #11, 4/6/2018



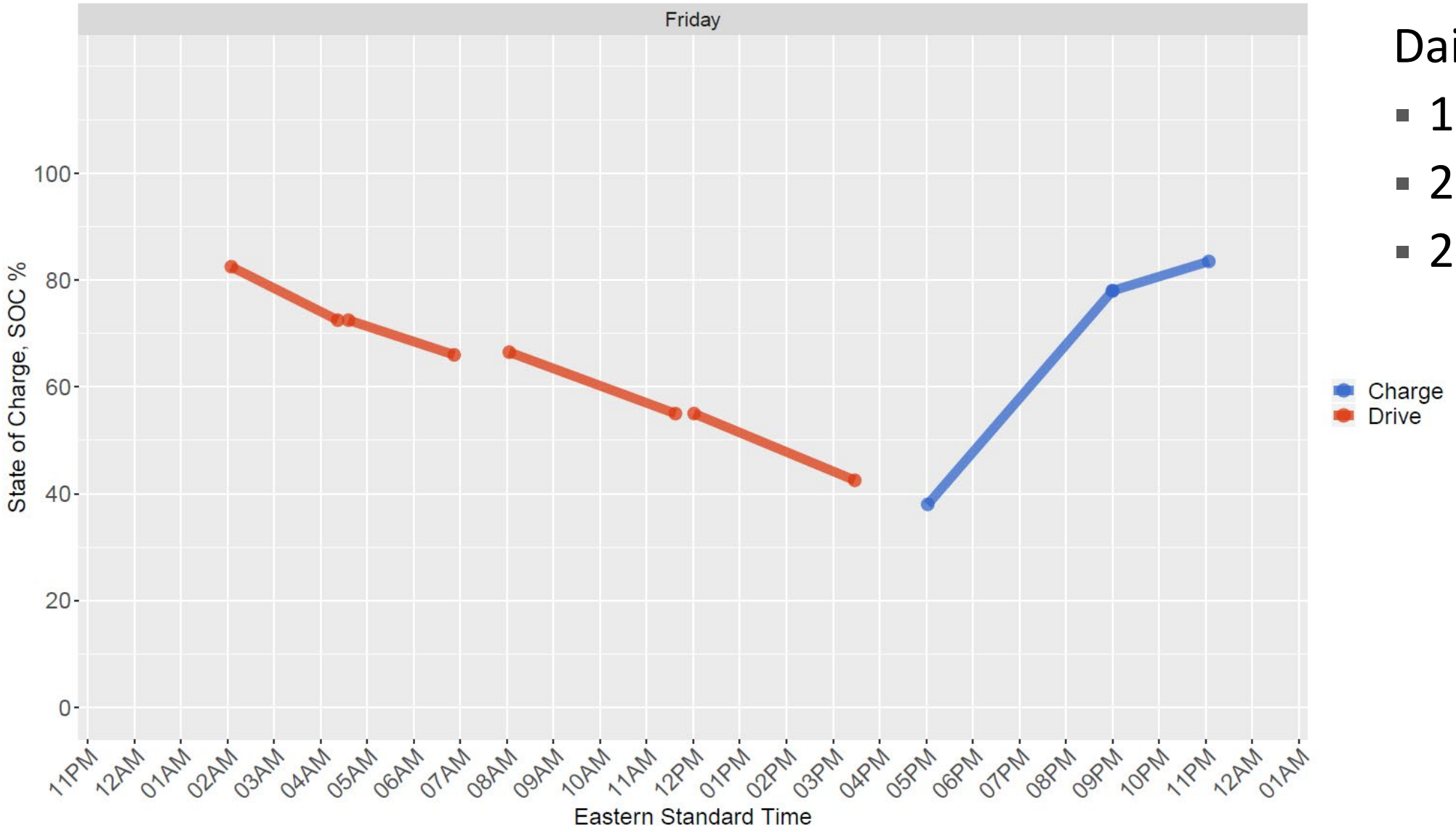
Daily totals:

- 28 miles
- 130.8 kWh
- 4.7 kWh/mile

Example Battery SOC History: New Flyer Bus #11, April 2018



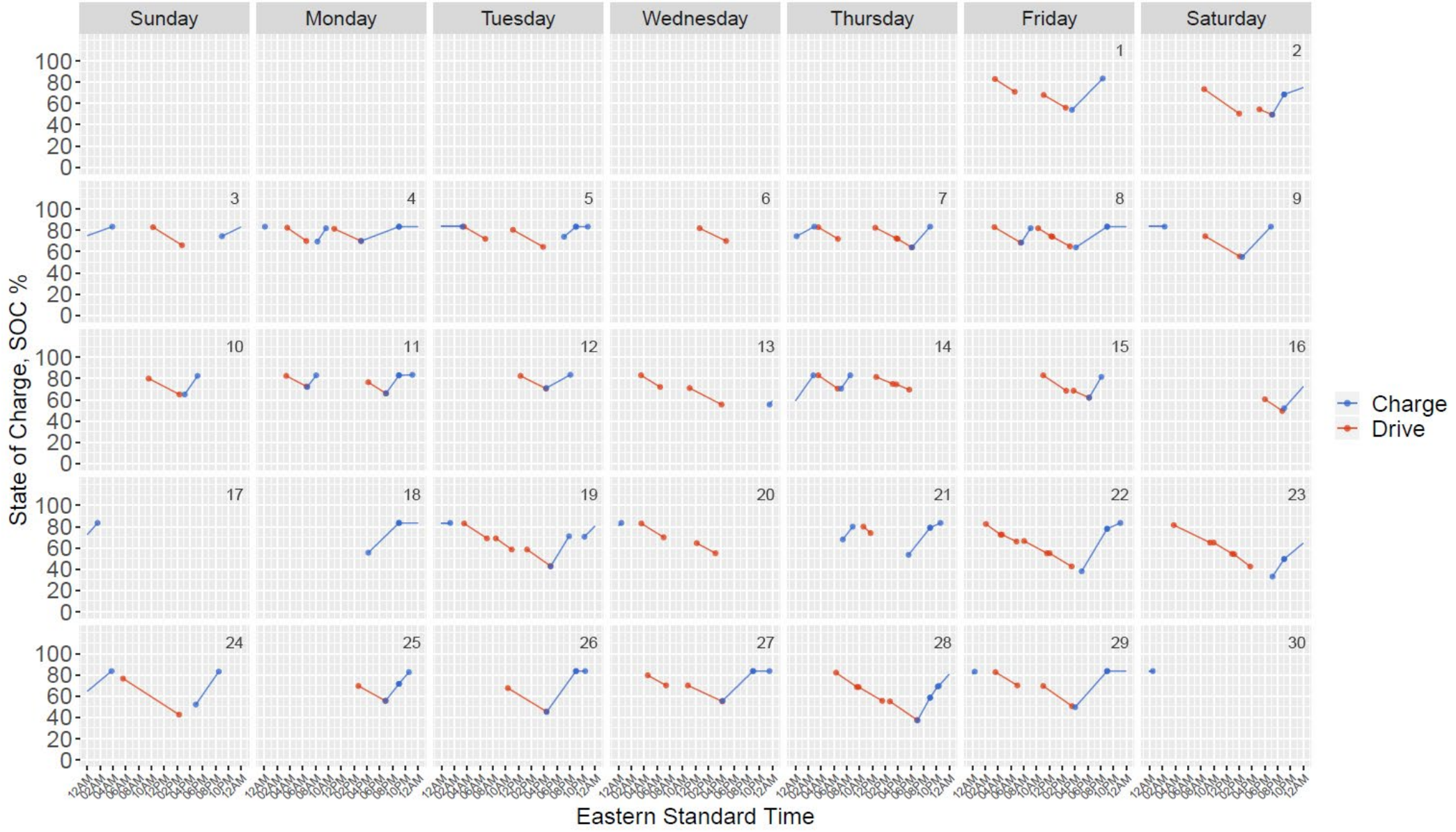
Example Battery SOC History: Proterra Bus #16, 6/22/2018



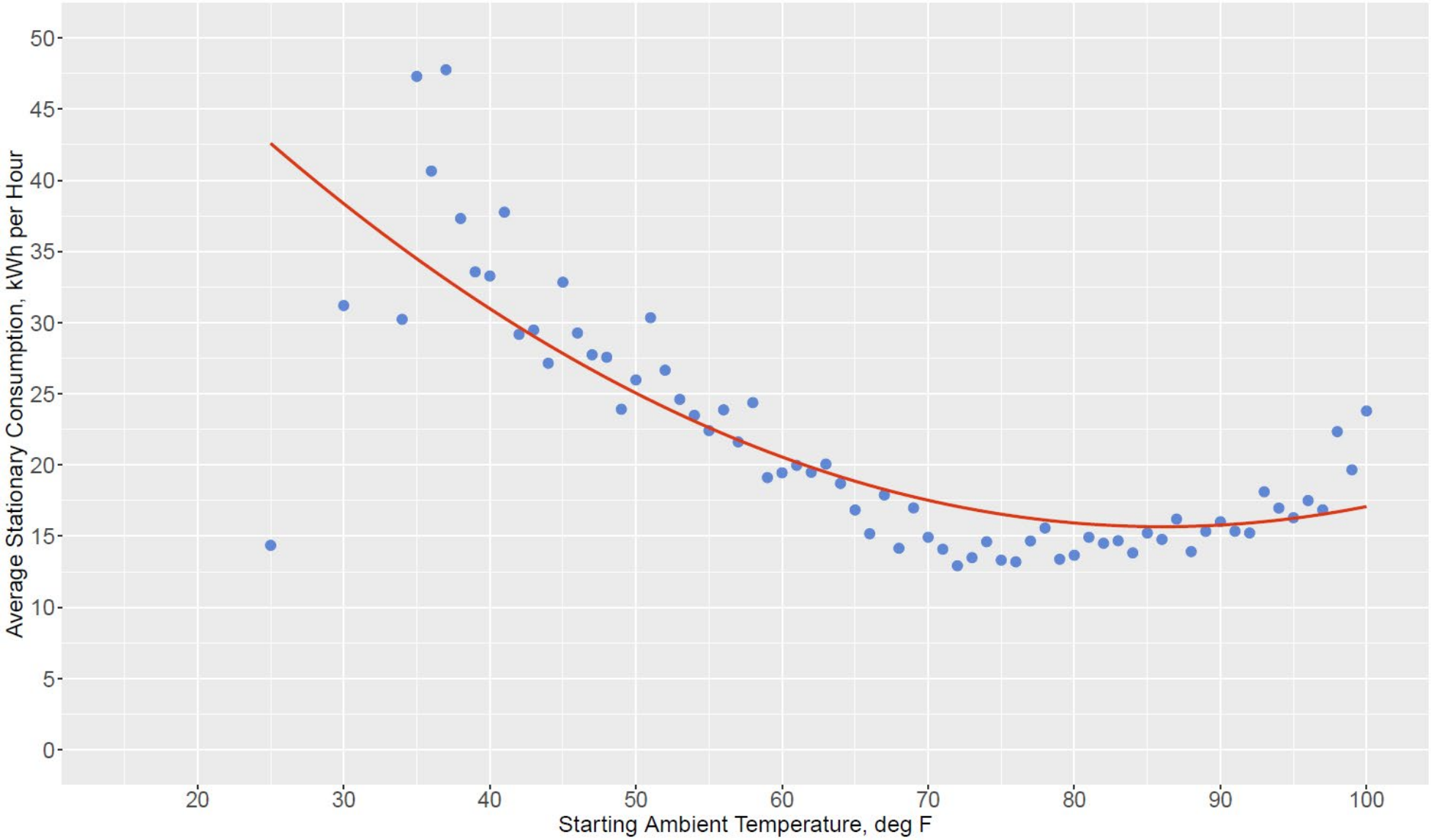
Daily totals:

- 107.6 miles
- 281.2 kWh
- 2.6 kWh/mile

Example Battery SOC History: Proterra Bus #16, June 2018



Ambient Temperature Impact: New Flyer Fleet



Lessons Learned

- The initial on-route charger set the template for the others
- Power at the on-route sites was:
  - Insufficient at the Williamsburg Terminal (New power was pulled and a new Transformer in a new Vault)
  - West Side had excess of 280 kW (Charge limited to 280 kW)
  - East Side had excess of 500 kW
- Establish stakeholders early and engage
  - DOTs, Landowners, Road Commissions, Designers, Fleet Managers, Facility personnel, etc.
- Consider Road conditions- Ramp angles, Crowns

Summary

- Program started on time missing only 2 of the three on-route chargers (last 2 charging now)
- Buses have been collecting data since January 2018 (more than 55,000 miles and charging more than 170 MWh)
- Big Battery/ Slow Charge and Little Battery/ Fast Charge is being evaluated
- Data is being evaluated for performance, charging statistics, economics, etc.
- Need to determine how to electrify a bus depot for 100 or more buses in the future

Electric School Bus Program Funding

Funding for this project is divided over the three-year life of the project.

Site Hosts

Minimum of $50,000/year (who already have or plan to deploy an electric school bus) = $150,000 total. Additional scope may be added per the host.

Collaborators

$25,000/year for (who will not deploy an electric school bus) = $75,000 total

Investigating lease options at additional cost

This project qualifies for tailored collaboration (TC) or self-directed funding (SDF).

If you are already hosting a school bus fleet, EPRI could assist with the data analysis, assist in steering the project, and provide technical information to collect. Comparison data would be available with environmental, performance, and route schedules. It would be reported in this supplemental report and the funders would also have the data results from the other hosts involved.

Electric School Bus Program

- Supplement Still Available: HECO (host), NYPA, and NC Coop
- Hawaiian Electric one Type D Electric School bus will be placed into 3 different school districts over three years
  - Bus is currently being ordered
  - Plans are to begin on school route next school year (August 2019)
  - Data will be collected and analyzed

- This project will demonstrate and/or analyze:
  - the ability to adequately serve various driving distances, terrains, charging schedules, and school programs,
  - the ability batteries to provide grid services specifically supporting the integration of renewable generation,
  - the ability batteries to be charged at times other than during the system peak,
  - incentives and savings of TOU rate tariffs,
  - needs of charging infrastructure,
  - cost/benefits of operations.

Electric School Bus programs are getting attention

Together...Shaping the Future of Electricity

Backup

2017 Electric Transportation Supplemental Project Urban electric bus fleet demonstration and data collection

Objective

- Identify what utilities can do to encourage electric bus adoption by identify and quantifying the key installation and operational issues for a fleet of electric buses
- Attempts to help answer:
  - What is required to deploy a fleet of plug-in electric buses?
  - What are the costs?
  - How can this scale?

Value

- Supports utilities in developing and prioritizing plans to encourage electric bus adoption
- Increased grid utilization
- Lower environmental impact of transportation sector

Price

- $180k host/$90k collaborator, qualifies for TC and SDF

Contact

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  (248) 421-7124

2017 Electric Transportation Supplemental Project
Urban electric bus fleet demonstration and data collection

1. Phase 1 (Design and implementation of Host 10 bus pilot)
   a. Map out the technical requirements needed to charge up to 5 plug-in electric buses at a single depot
   b. Assist host utilities in setting up bus depot charging for up to 5 buses
   c. Assist host utilities in integrating depot charging into building energy management systems, if possible
   d. Assist host utilities in in setting up on-route charging for up to 10 buses
   e. Collect data on bus usage, performance, energy consumption, power, etc.
   f. Collect financial data related to energy and power (energy as well as capacity charges), installation, operation and other costs
   g. Map out a technical glide path for increasing number of buses within a facility
   h. Identify load reduction opportunities to offset or minimize increased charger loads
   i. Define facility characteristics compatible with lowest cost first adoption strategies

2. Phase 2 (100 bus pilot)
   a. Repeat Phase 1 by modeling a use case of 100 buses
   b. Provide an Excel Spreadsheet Calculator as a Planning Tool

3. Produce briefings and technical report of findings

Road way dig up

Several Brooklyn streets had to be trenched about 1/3 mile to bury the required cable for 208 V AC power to the charging site

MJ Quill Depot- 50 kW Chargers

New York City Electric Transit Buses

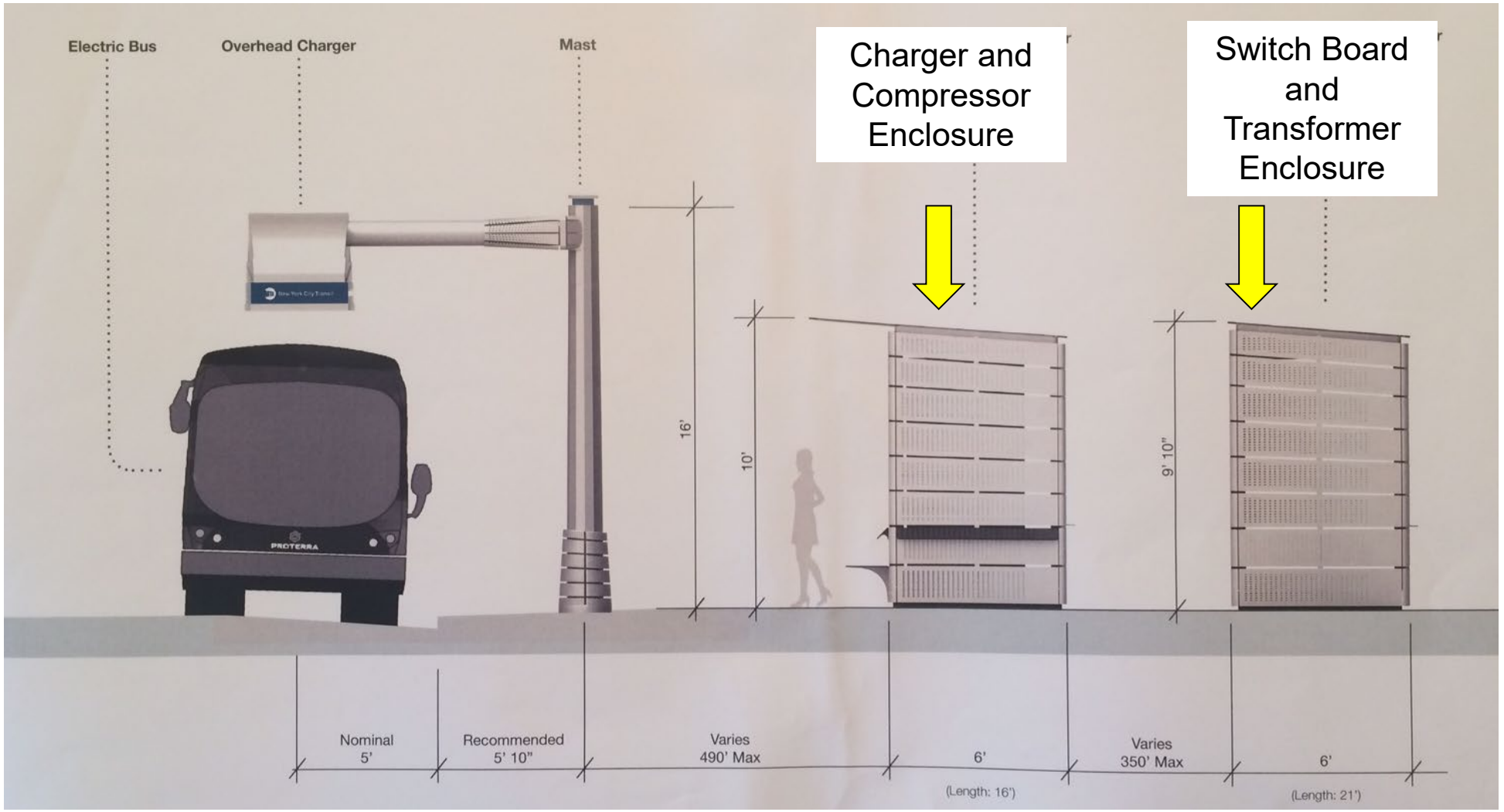
Type	Mfg	Charging Power	# Buses	Location
Overhead/Depot	New Flyer	350 kW; 50 kW	5	NYC/Manhattan
Overhead/Depot	Proterra	500 kW; 50 kW	5	NYC/Brooklyn

- Background
  - In North America, ~51 fleets with 683+ electric buses on road by 2021
- Project overview and status
  - Depot and on-route charging are being evaluated along with battery sizing
  - NYC has 10 electric transit buses running in Manhattan and Brooklyn
  - Driven more than 55k miles since January 2018 (Proterra and New Flyer)
  - Installed 3 automated on-route chargers (350 kW and 500 kW) and 8 depot chargers (50 kW)
  - Data has being collected and analyzed
- Expect to complete the analysis and write report in Q2 2019 with learnings
  - Early coordination of departments and design is critical - (Transit Fleet, State DOT, City DOT, Parks, Bridges and Tunnels, etc.)

Many Transit agencies are deploying

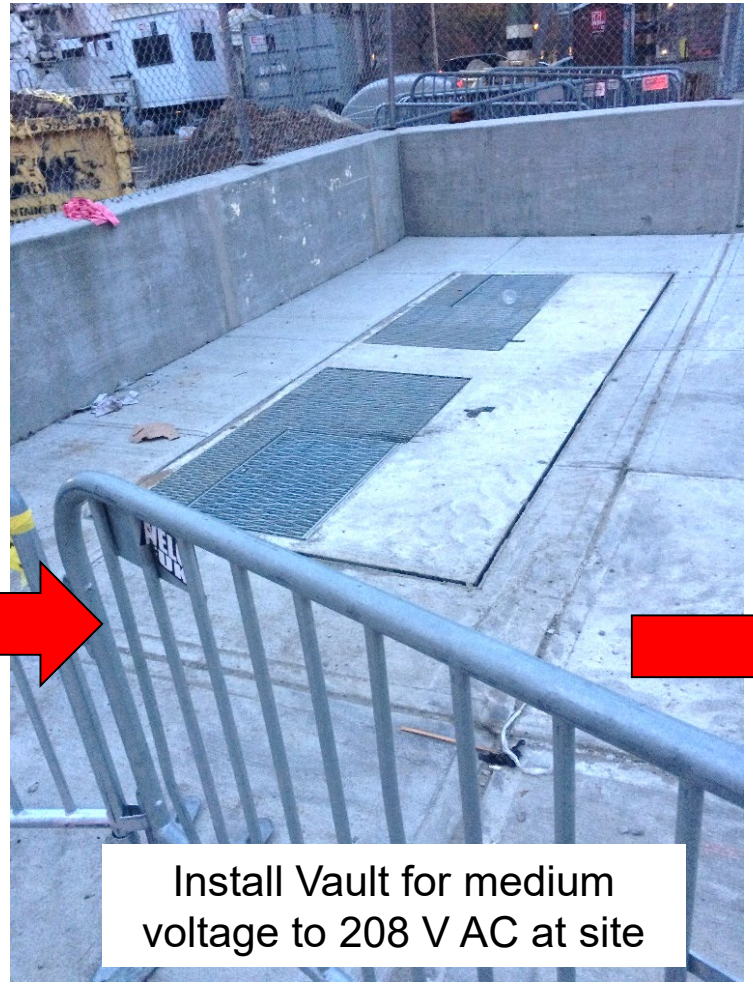
Together...Shaping the Future of Electricity

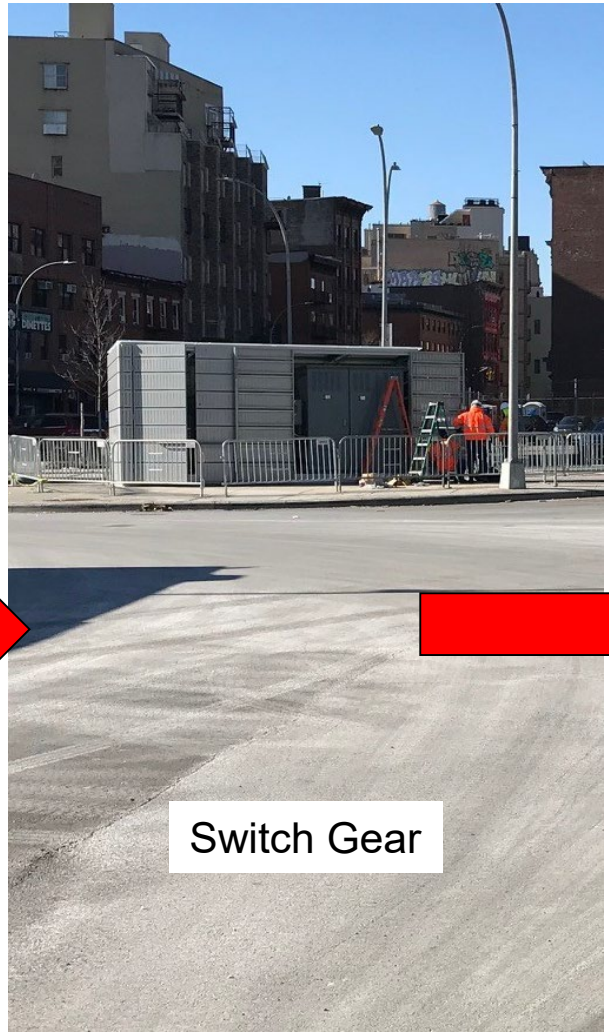
Charging Equipment located near the sight



Two different enclosures with benches will be located on the street near the overhead charging unit. One shall contain the transformers and switch gear and the other will contain the DC Charger.

Williamsburg Terminal in the Brooklyn





Williamsburg Terminal in the Brooklyn

400 V DC Charger

Williamsburg Terminal

Several Brooklyn streets had to be trenched about 1/3 mile to bury the required cable for 208 V AC power to the charging site