

LA Metro EV Bus Yard Simulation

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WenChun “Annie” Wang

Agenda

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- Project Overview
- Why Simulate Why Anylogic
- Simulation Model Scope
- Site Concepts & Model Scenarios
- Parameters
- Results & Insights
- Q & A

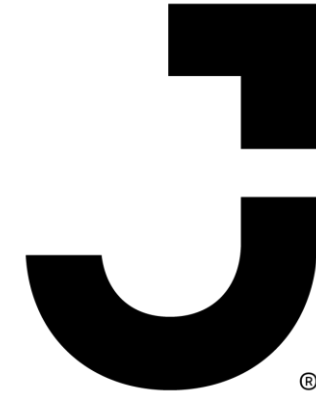
About the Presenter

- Annie Wang is an **analytics** and **engineering consulting** professional with over 20 years of experience and a background in Industrial Engineering.
- Her expertise includes **simulation modeling** and **semiconductor fab design**, with industry experience spanning aerospace, energy, engineering services, healthcare, manufacturing, transportation, semiconductors, and software R&D.
- Having worked across the United States and **globally**, she is known for effectively **communicating** with stakeholders from diverse cultures and technical backgrounds.
- A lifelong **simulation enthusiast**, Annie views simulation as both a profession and a hobby.
- Outside of work, she is passionate about **public health issues**, enjoys exploring local cuisines as a devoted **foodie**, and can be seen traveling the world with her alter ego and travel buddy, **Allie**, the alligator.



About Jacobs

- A **global Professional Services company** that plans, designs and delivers complex infrastructure, advanced technologies and critical systems that support how people live, work and move.
- **Challenging today** is our response to the increasing complexity our world is experiencing.
- **Reinventing tomorrow** is our promise and an invitation to raise the bar in everything we do.
- Industries, including:
 - Semiconductors (where I currently belong)
 - Manufacturing, Agriculture, Energy/Battery, Transportation/Ports, Mining (a sample of where I have engaged)
 - and many more



Project Overview

- Location: **LA Metro** Bus divisions in **Carson** Div 7 and **West Hollywood** Div 18.
- Goal: Support LA Metro's transition to a zero-emission fleet of around 2,000 electric buses. Carson and West Hollywood accounts for about **500 buses**.
- Timeline: Scheduled for completion before the **2028** Olympic and Paralympic Games in Los Angeles.
- Key Features: Overhead charging systems, upgraded electrical distribution, and smart energy management tools.

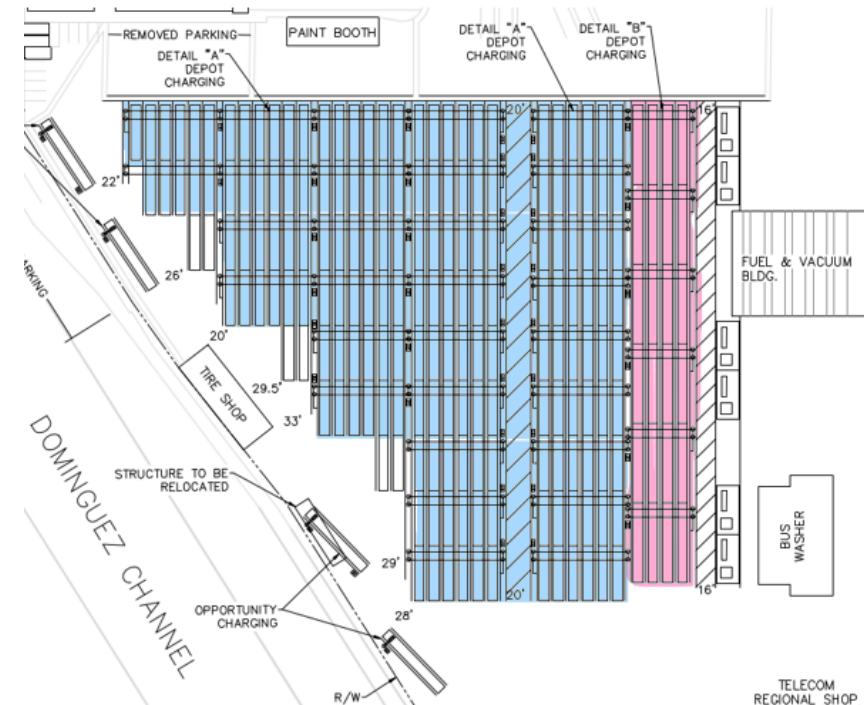
Current Operation - CNG Buses

- Fuel & Vacuum (1)
 - CNG refuel only takes a few minutes
- Clean/Wash (2)
- Park (3)



Future Operation – Electric Buses

- Unchanged Vacuum and Clean/Wash needs
- Charging instead of Fueling
 - Takes much longer
 - Is done at the parking spots
 - 60ft bus – pink spots
 - 40ft bus – blue spots



Why Simulate Why Anylogic

- Provide direction on **charging spot to bus ratio**
- Identify potential **bottlenecks**
- **Visualizing** how charging operations will work within the physical yard space
- Test for quantity of missed outbound buses (pass/fail) for each concept/scenario.
- **Manpower** requirements
- **Energy curves or power demand profiles** that are grounded in actual charging spot utilization/occupancy.
- Inform **future iterations** of layout development, as well as different charger architectures.

Model Scope

The Outside

The Jacobs-developed Fleetmax software utilizes GTFS data, environmental considerations, vehicle parameters, and other assumptions through years of fleet analyses.

The route model focuses on the ability to meet service, as well as provide in and out timestamps and state of charge.



Pull in time
Pull out time
State of charge

The Inside

Developed using Agent Based and Discrete Event Simulation methodologies, the Yard Simulation is an Anylogic model that enables what-if analysis, and optimization of the yard operations.

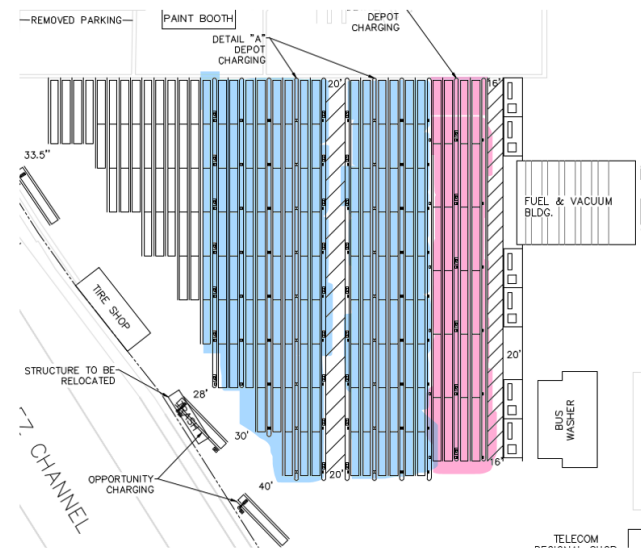
The Yard Simulation provides key insights to the effects of yard layouts, charger power levels, power sharing architectures, yard energy demand, and manpower

Depot Charge and Fast Charge Explained

- Depot Charge
 - 1 charger (480kw/hour) supplying 4 spots
 - Dynamic power sharing
 - Charging rate is higher when less buses are connected
- Fast Charge
 - Charging rate as high as 250 – 350 kw/hour at each spot
 - Charging rate variable dependent on the bus level of charge

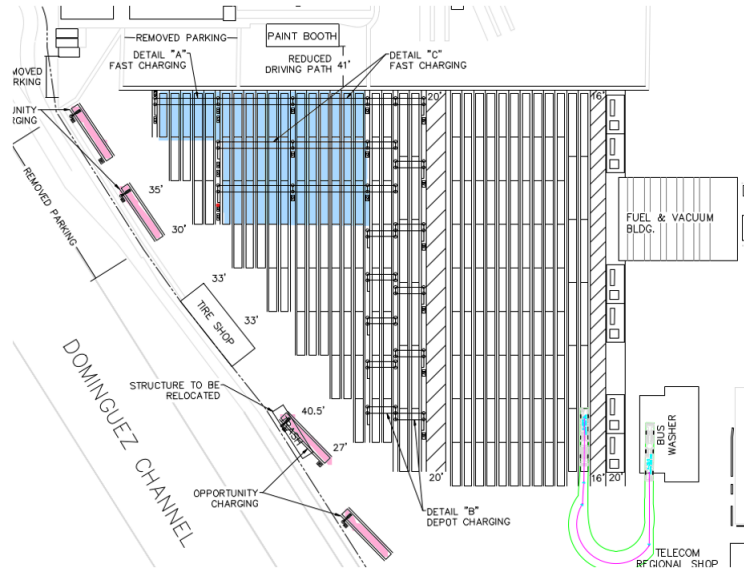
Site Concept & Model Scenarios - West Hollywood Div 18

Depot Charge Regular



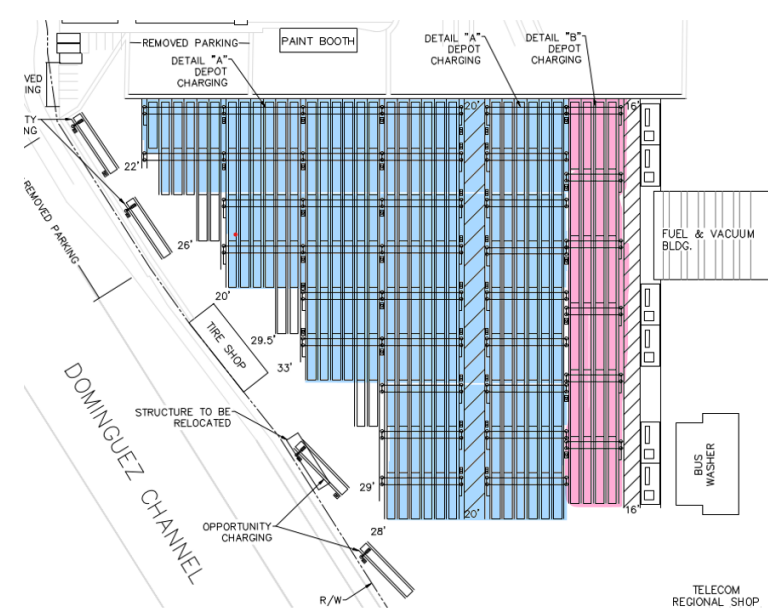
Charge Spot:
40ft: 124
60ft: 24

Fast Charge



Charge Spot:
40ft: 24
60ft: 12

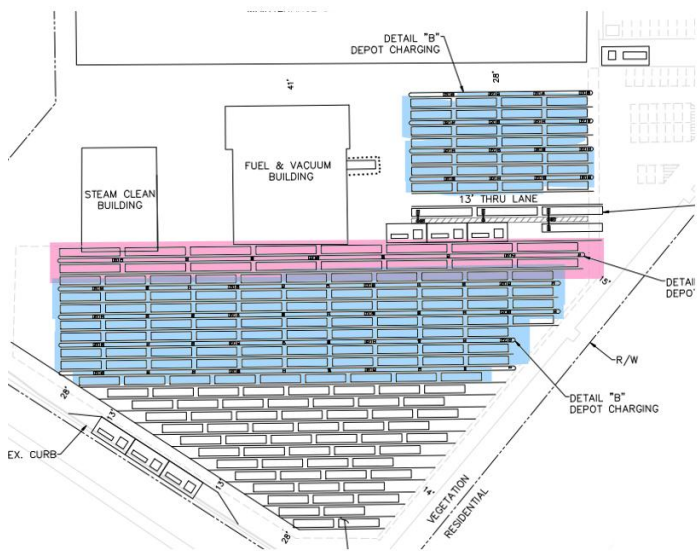
Depot Charge Full



Charge Spot:
40ft: 179
60ft: 24

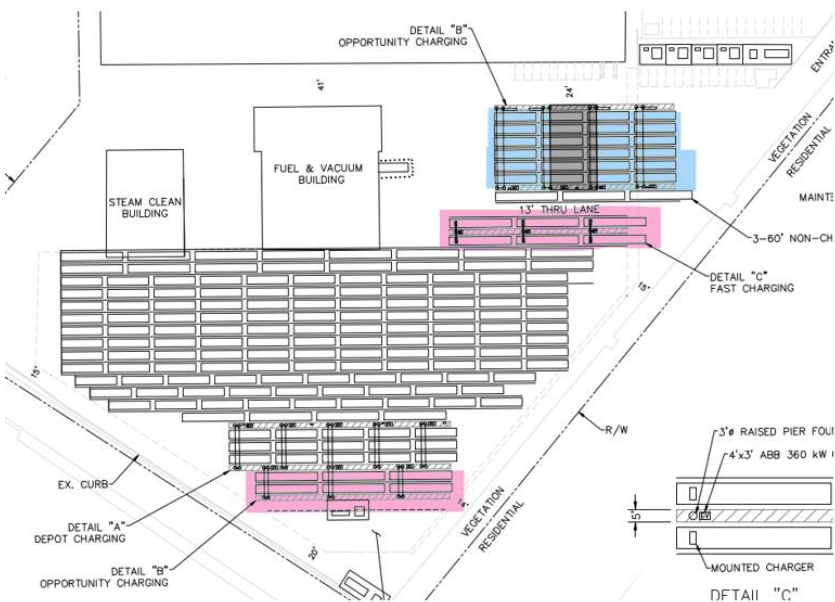
Site Concept & Model Scenarios - Carson Div 7

Depot Charge Regular



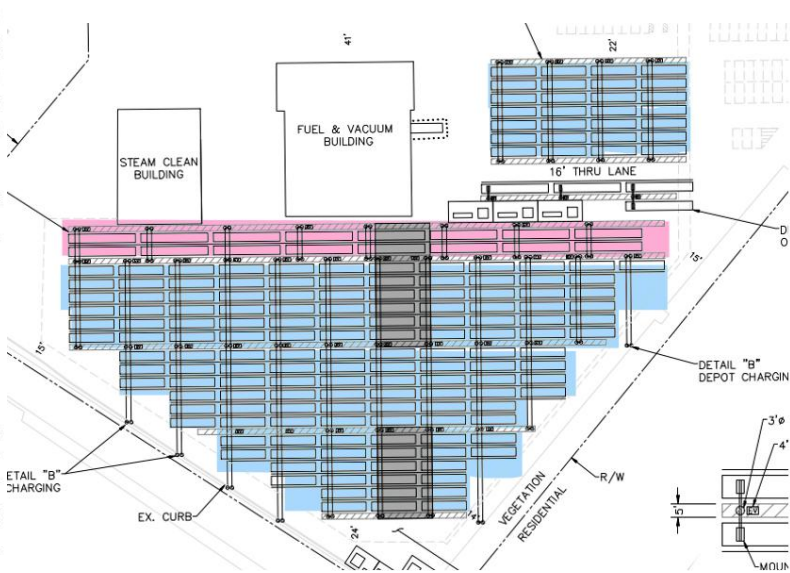
Charge Spot:
40ft: 111
60ft: 16

Fast Charge



Charge Spot:
40ft: 24
60ft: 12

Depot Charge Full



Charge Spot:
40ft: 170
60ft: 16

Model Process Steps

Depot Charge Regular

- Enter
- Charge
- Vacuum
- Wash/Clean
- Park
- Exit

Fast Charge

- Enter
- Charge
- Vacuum
- Wash/Clean
- Park
- Exit

Depot Charge Full

- Enter
- Vacuum
- Wash/Clean
- Charge & Park in Place
- Exit

Model Assumptions

- Each bus must go through each process step in order specified.
- Inbound and outbound schedule and initial, final state of charge defined by Fleetmax output.
- A scenario is considered “Working” if the inbound schedule of buses is adequate to supply the outbound schedule, or Zero missed outbound
- Buses are processed in each step FIFO – First In First Out
- Space always available for bus to queue before process step
- Access to charging spot
 - Limited by effects of lane structure
 - The most left lane, most forward spot will be occupied first

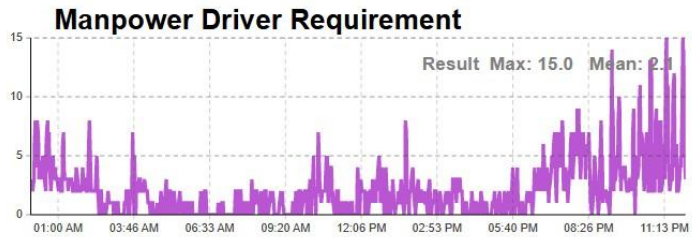
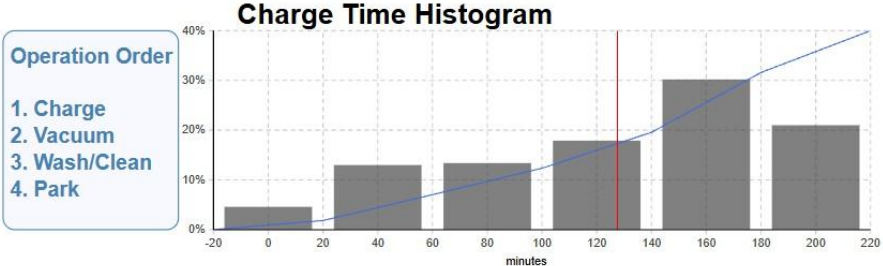
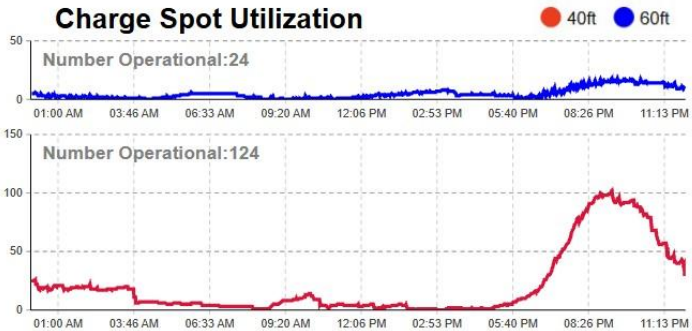
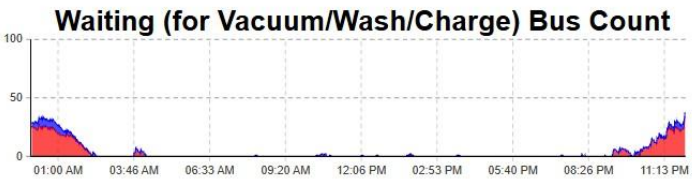
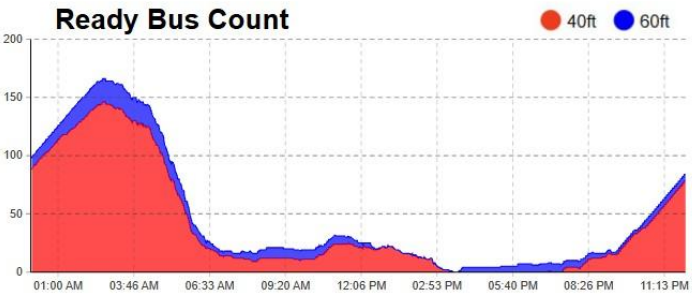
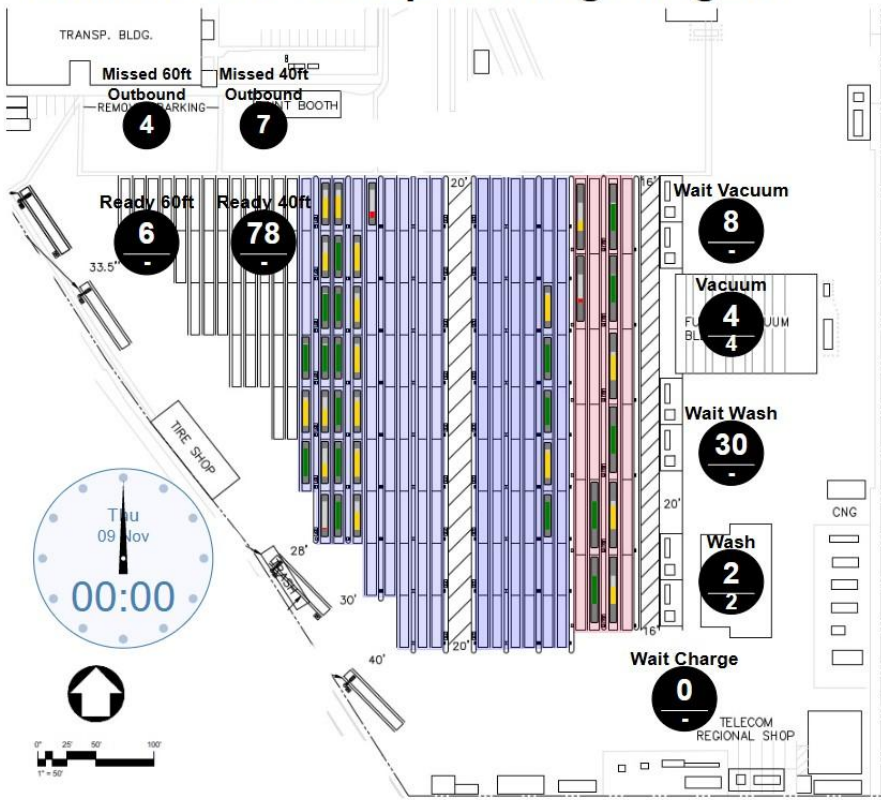
Model Parameters

- Simulation Duration: 1 day with warm up period
- Bus Speed Limit: 10 MPH
- Vacuum Time: ~ 5 min, 4 Spots Shared
- Wash/Clean Time: ~ 4 min, 2 Spots Shared
- Connect/Disconnect Time: ~ 3 min each
- Initial and Final State of Charge for buses:
 - Based on Fleetmax data, “check in” SOC, and it’s next “check out” SOC.
- Div 18 Fleetmax Daily Blocks/Bus Count
 - 40ft: $219/174 = 1.26$
 - 60ft: $43/27 = 1.59$
- Div 7 Fleetmax Daily Blocks/Bus Count
 - 40ft: $205/145 = 1.41$
 - 60ft: $34/24 = 1.42$

Model Demo

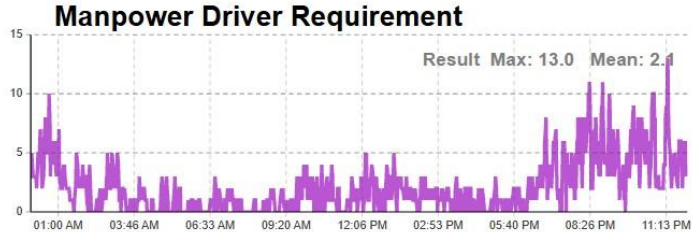
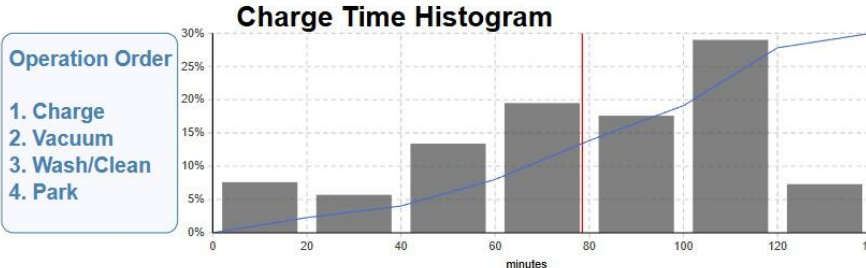
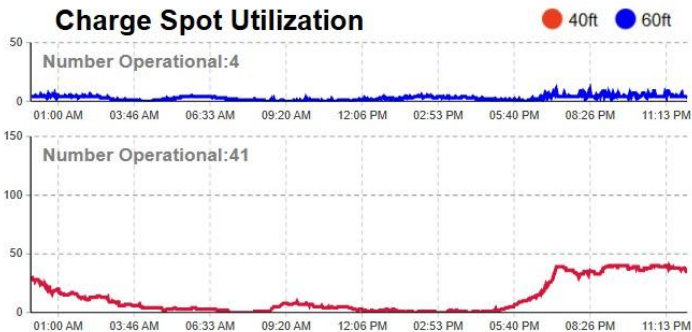
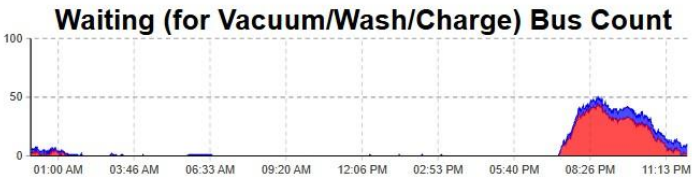
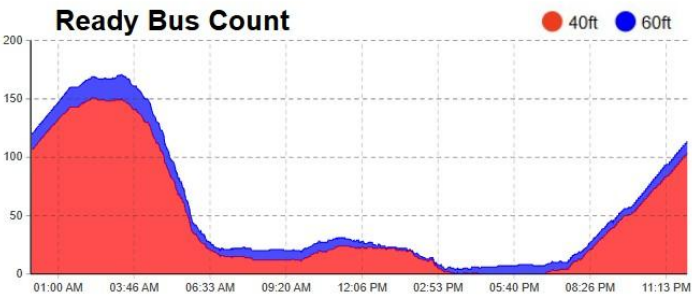
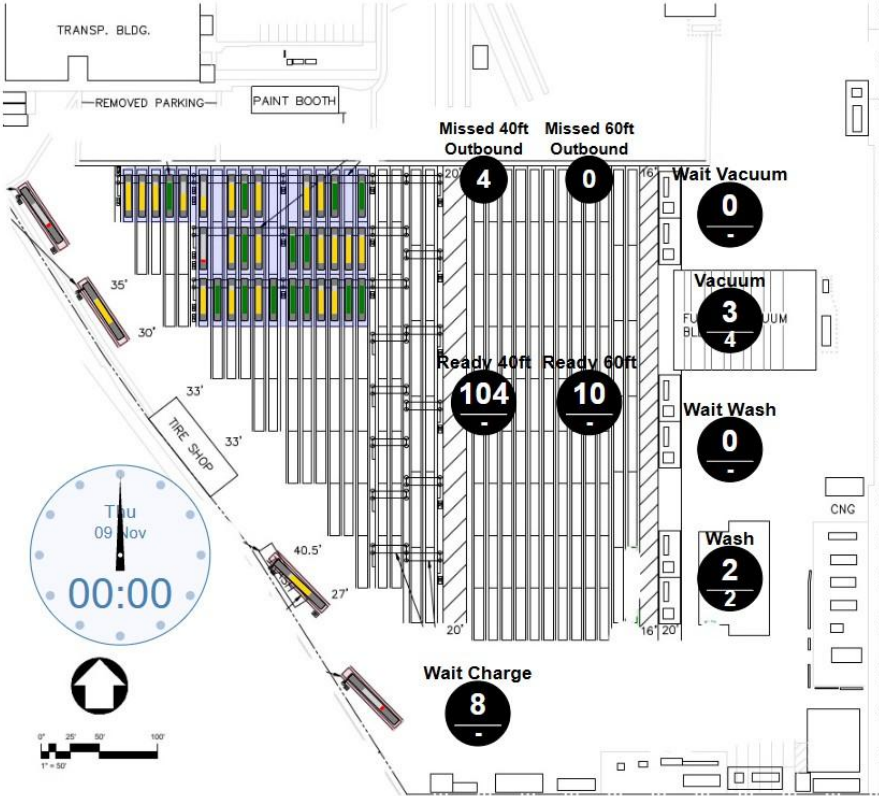
Model Results

LA Metro DIV 18 Depot Charge Regular

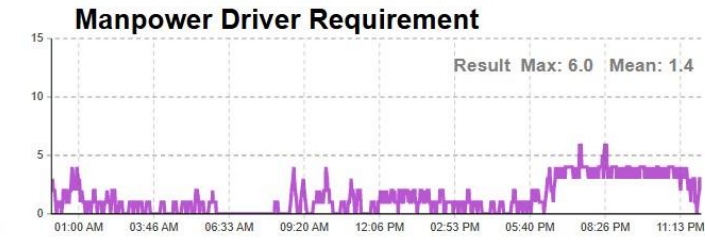
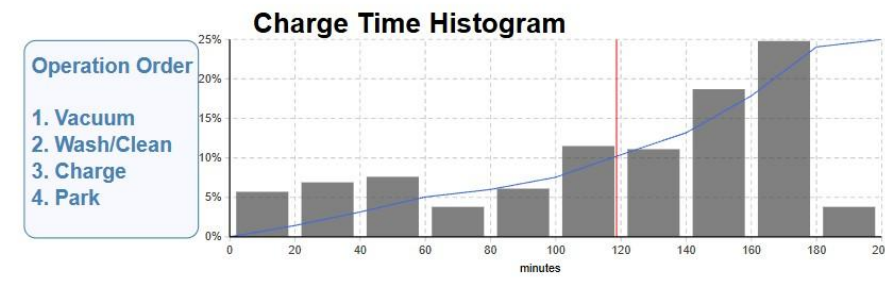
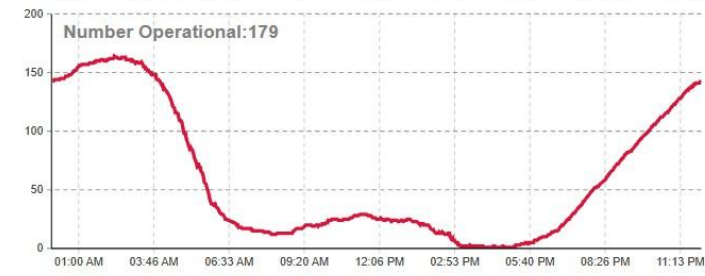
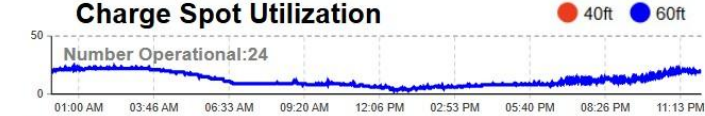
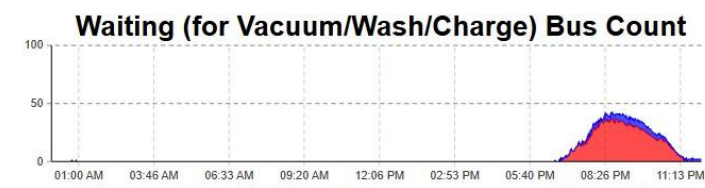
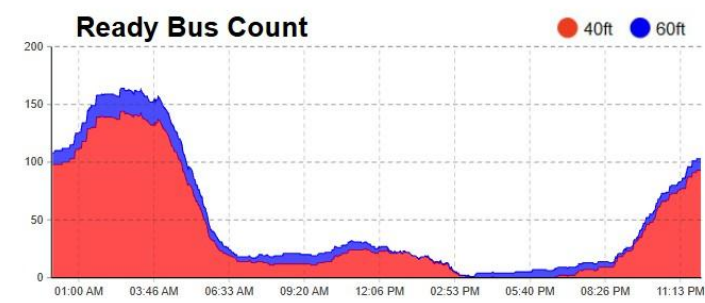
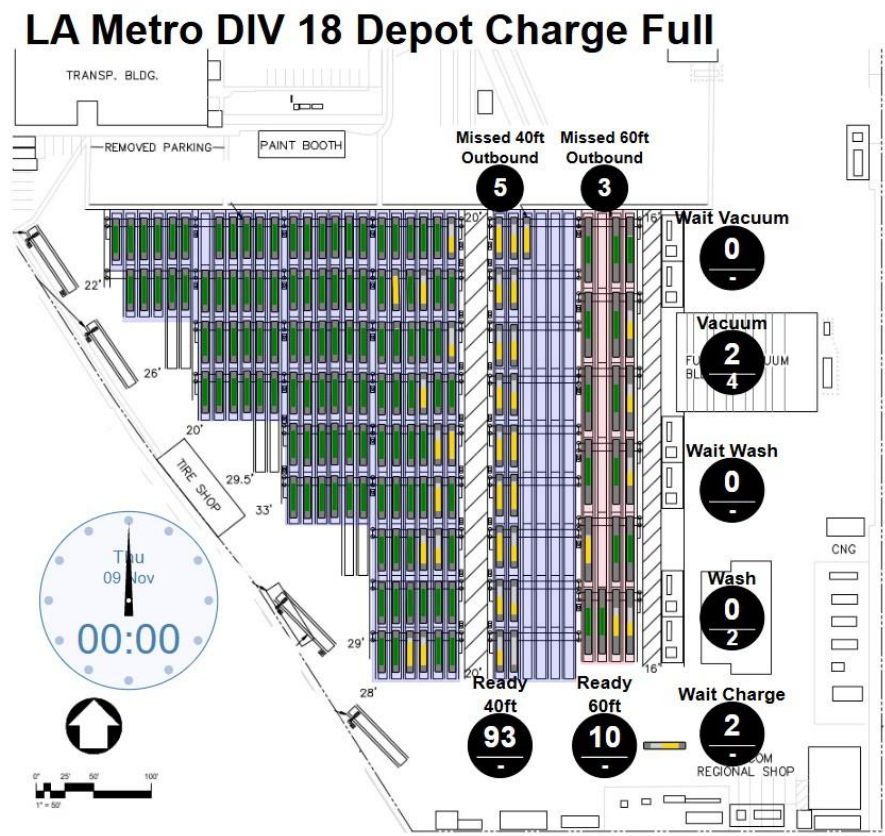


Model Results

LA Metro DIV 18 Fast Charge

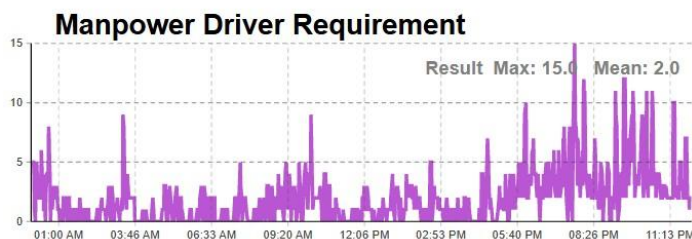
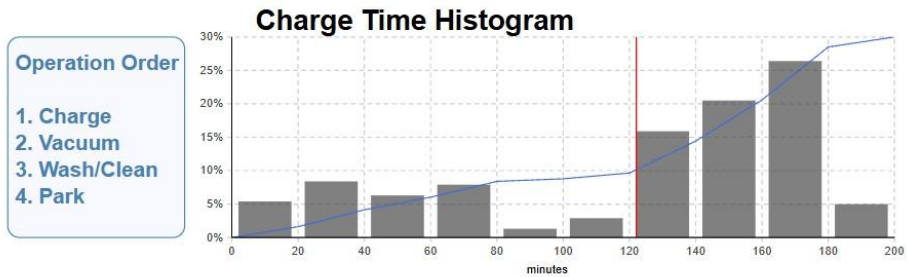
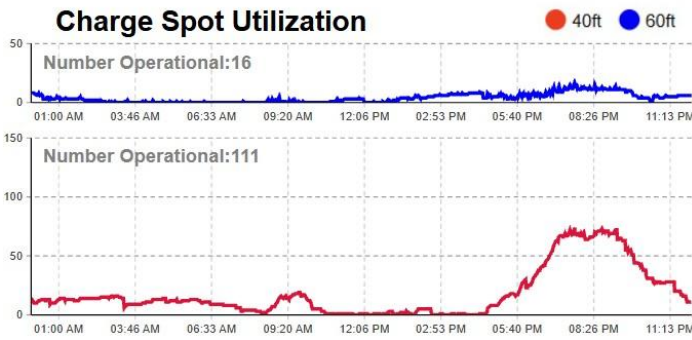
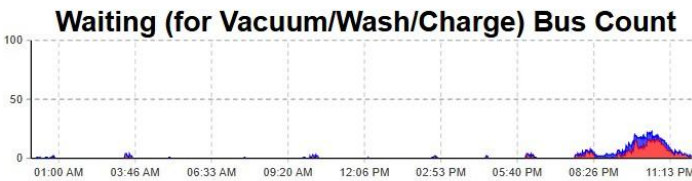
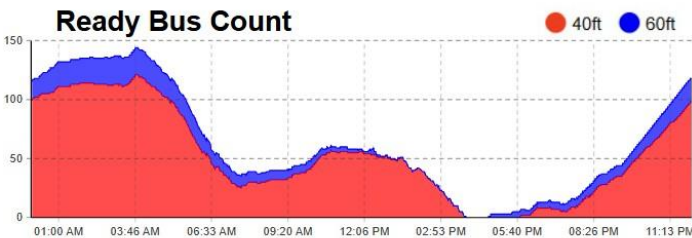
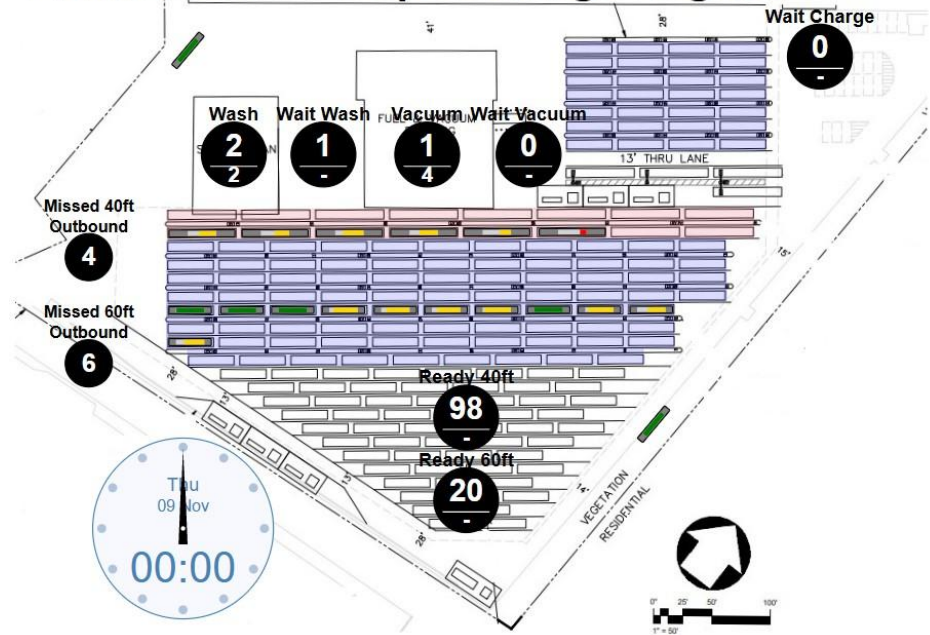


Model Results



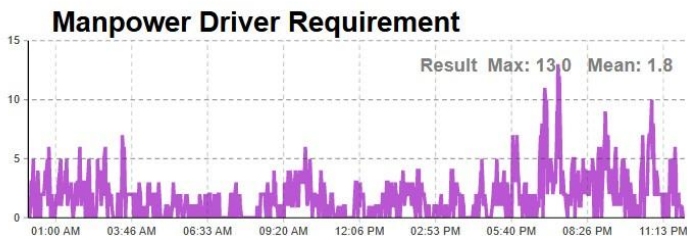
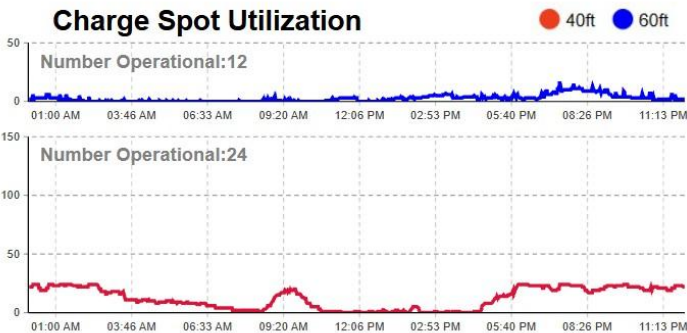
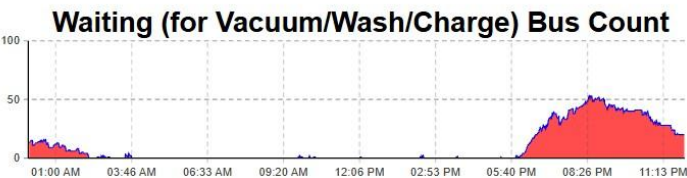
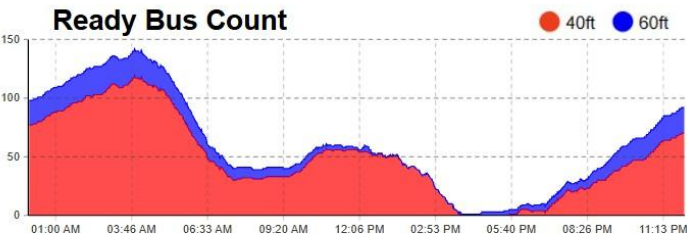
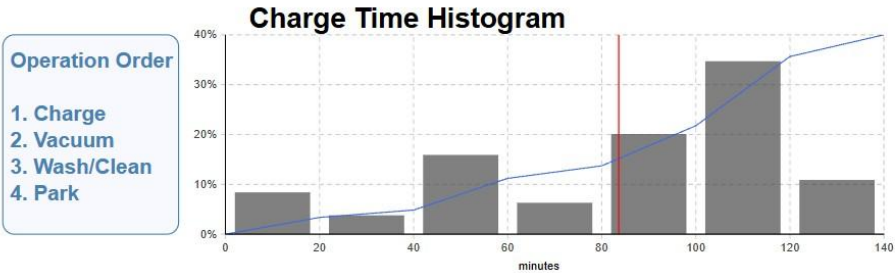
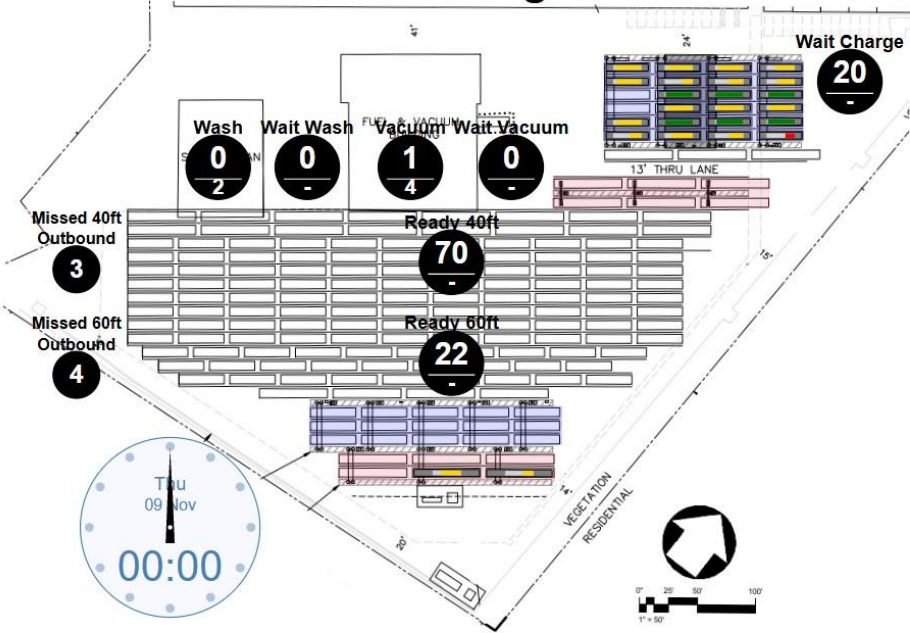
Model Results

LA Metro DIV 7 Depot Charge Regular



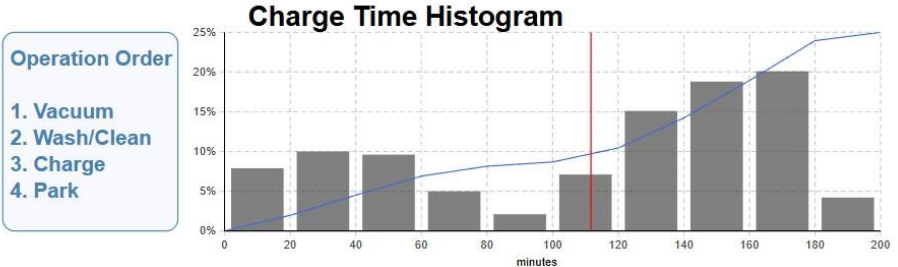
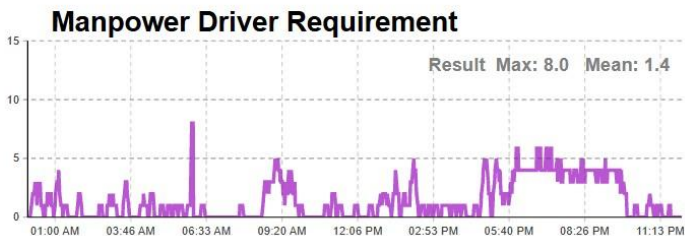
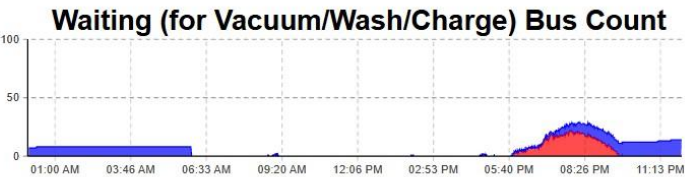
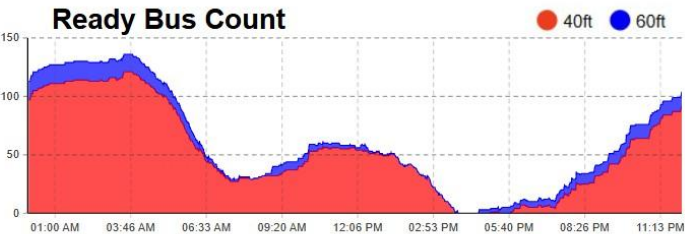
Model Results

LA Metro DIV 7 Fast Charge



Model Results

LA Metro DIV 7 Depot Charge Full



Insights

- Depth of Charging lane
 - The deeper (having more spots) the charging lane, the more likely:
 - Empty spot being blocked from access by incoming buses
 - Charged bus being trapped behind still charging buses
- Vacuum step can become a constraining bottleneck
 - Different account of how long the process takes
 - Limited spots available
 - May render capacity improvements at other steps useless

Insights

- Impact of process step order
 - May improve efficiency for certain scenarios
 - Location of queues
- Impact of Manpower as a constraint
 - If sufficient manpower can not be guaranteed, it may introduce additional delay
 - Average and Max doesn't tell the story
- Relationship between (number of bus in operation) and (number of blocks per day)
 - How many blocks a bus must take on each day
 - Time on the road vs Time in the yard, limitations
- Interdependency of inbound schedule and outbound schedule/availability

Q & A