AUTONOMOUS ELECTRIC VEHICLES FOR MOBILITY AS A SERVICE: WHAT CHARGING INFRASTRUCTURE IS REQUIRED?

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Emerging Trend of Shared Mobility

Mobility as a Service (MaaS)

- Car sharing
- Ride sharing/hailing
- Bike sharing

- Integration with public transit for first mile/last mile transportation

Growth of Car-sharing and Ride-hailing Services

Enabled by information technology, shared-vehicle service companies offer inexpensive, flexible, convenient personal transportation options that are rapidly growing in popularity

- Car-sharing companies had nearly 5 million members worldwide in 2014 (including 1.6 million in the U.S.), up from 350,000 in 2006, and is projected to exceed 23 million globally by 2024[1,2]
- Ride-hailing company Uber took 5 years to deliver its first billion rides, but delivered its second billion in the first half of 2016 alone[3]

1. “Faster toward the future of mobility,” Deloitte Review, issue 20, Jan 23, 2017, http://tinyurl.com/fmobility
2. Shaheen, S., Cohen, A. (2016). Innovative mobility carsharing outlook. University of Berkeley, California.
3. Solomon, B. (2016). Uber just completed its two billionth ride. Forbes. July 18, 2016. http://tinyurl.com/uber2b

Car-sharing Business Models

Car-sharing services provide convenient short-term vehicle rental options with a range of pricing, vehicle sizes, and fuel options

1. Round trip model
   - Customer must return the vehicle to the designated parking spot
2. One-way model
   - Customer can drop off the vehicle at any designated parking lot
3. Free-floating model
   - Customer can drop off vehicle anywhere within designated geographic area

Examples:

zipcar wheels when you want them

MAVEN

blueindy

CAR 2GO

ReachNow

Ride-sharing Business Model

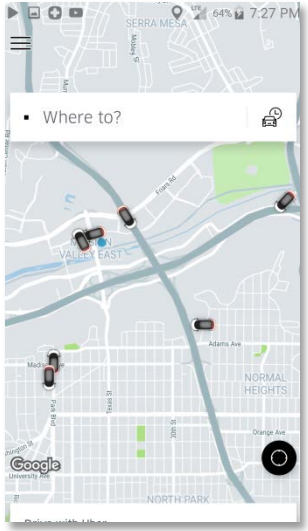
Transportation network companies (TNC) provide platforms to enable peer-to-peer ride sharing

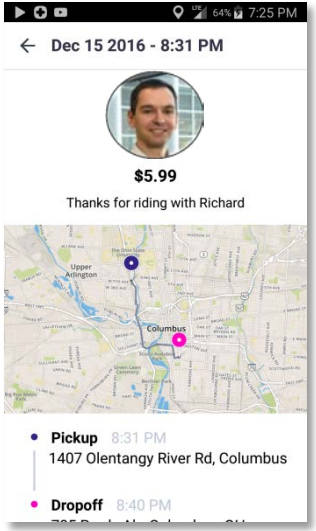
Ex: Uber, Lyft

Also known as ride-hailing, ride-sourcing, or taxi-booking companies

TNCs employ an “asset-light” model

- Provide information technology tools to connect privately-owned vehicle drivers with riders
- Streamlined payment process
- Driver/passenger ratings promote good behavior





Opportunities for Electric Shared Mobility Today

Reduce cost

- Low operating cost of plug-in electric vehicles (PEV) amplified by high utilization

Maintain flexibility

- Trip-specific vehicle selection removes “one size fits all” barrier to PEV adoption for private ownership

Displace petroleum

- Growth in shared mobility market means electrifying only a fraction of car/ride-sharing VMT would displace significant petroleum consumption and tailpipe emissions

Challenges for Electrification of Shared Mobility Today

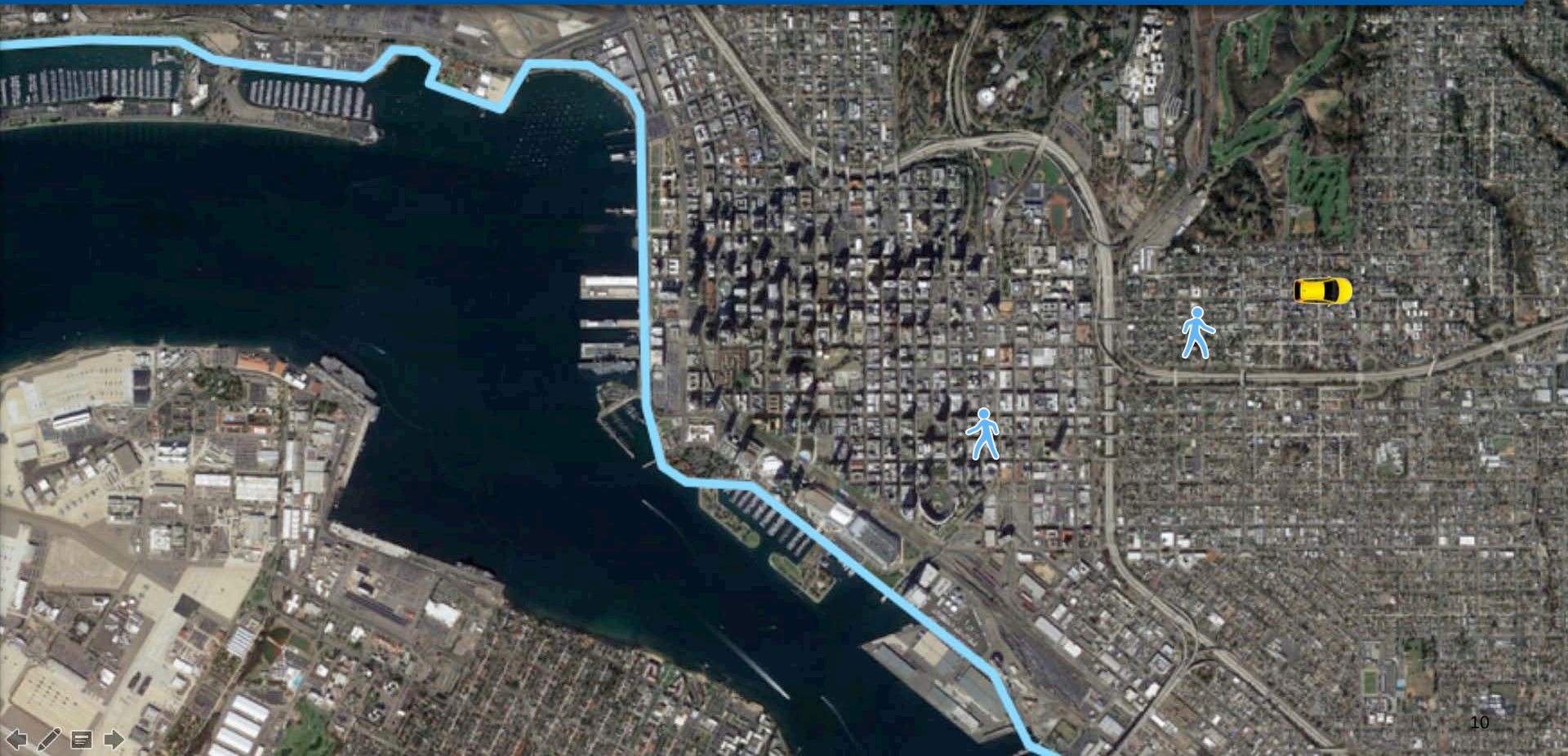
Battery life? (Subject for another day)

Down time for charging has a true financial cost

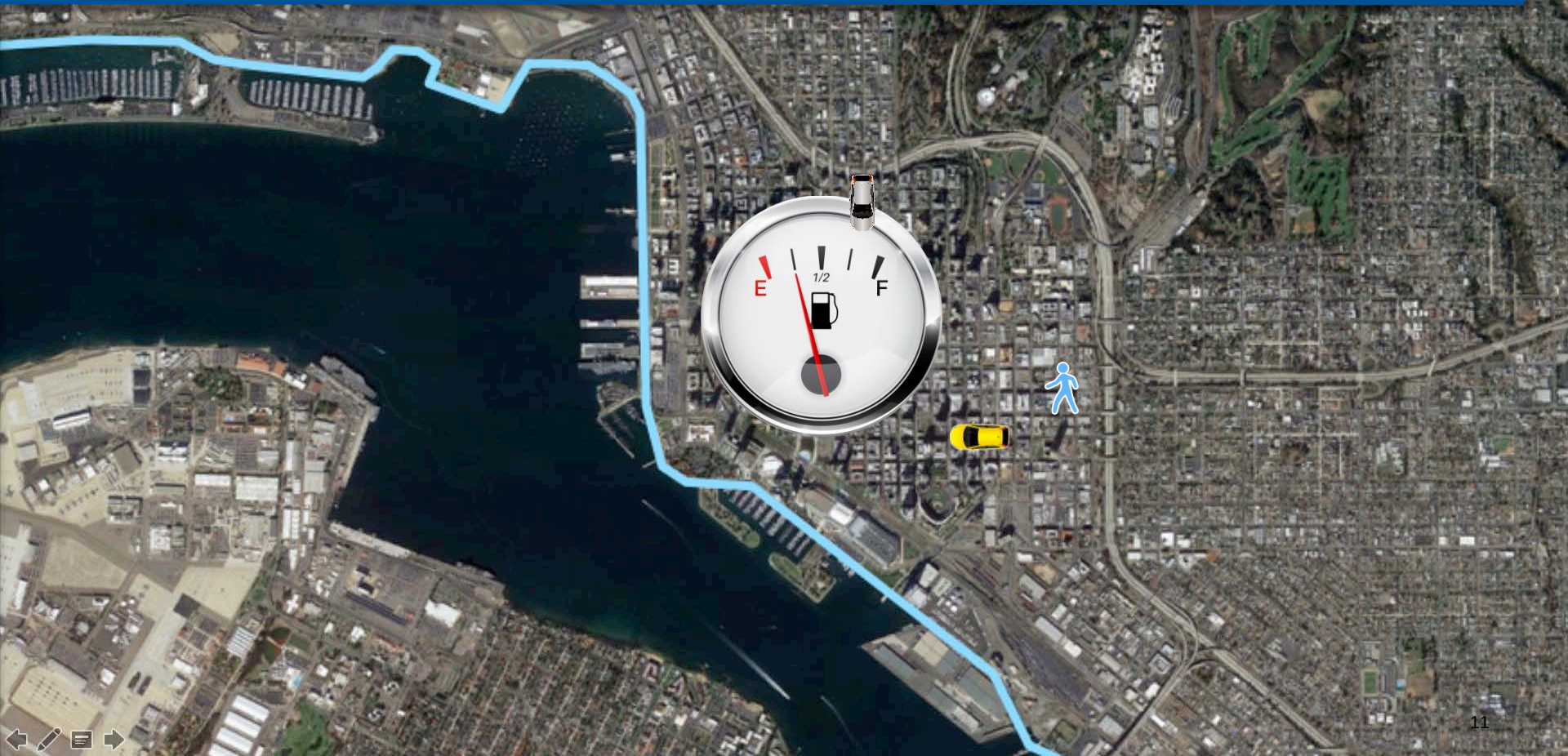
- Without well planned charging infrastructure matched with vehicle range and charge power rating, the opportunity cost of “fueling” PEVs can be prohibitive
- This is illustrated by the following example of a single free-floating car-sharing vehicle

Free-floating car sharing home area

Customer uses car-sharing for a trip downtown



Fleet managers monitor fuel level and refuel vehicle when necessary



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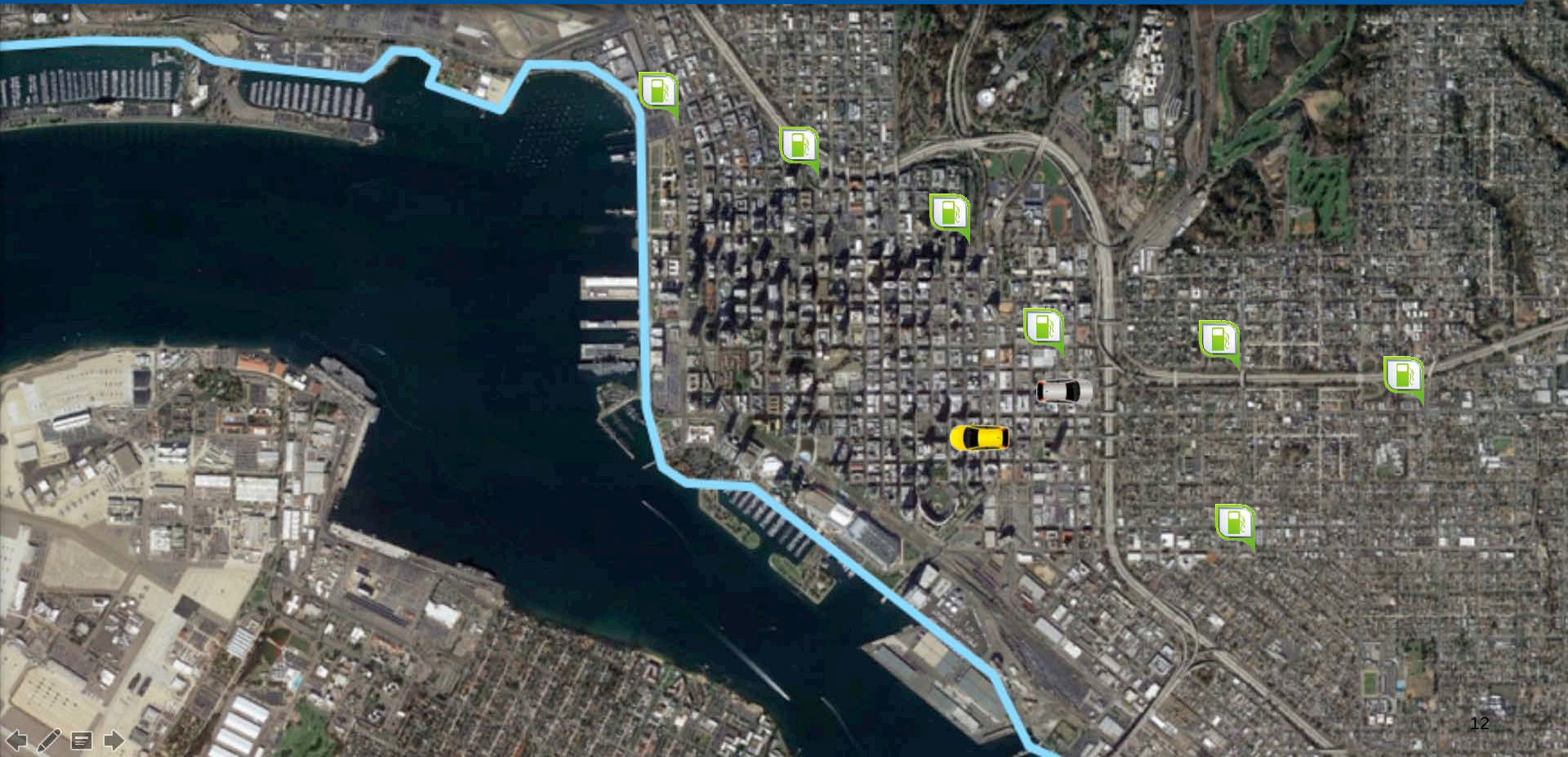
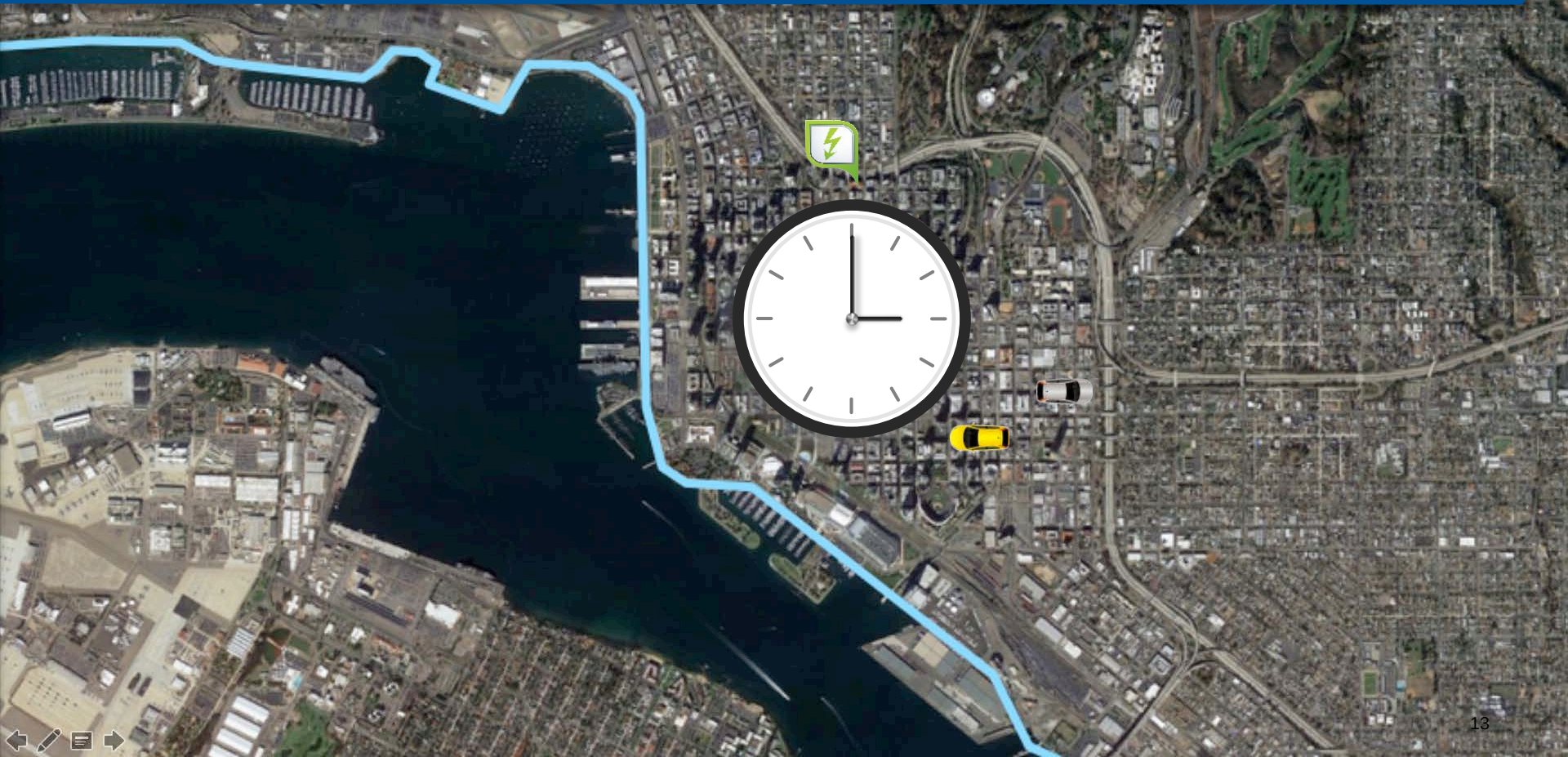


Difficulty with PEV charging



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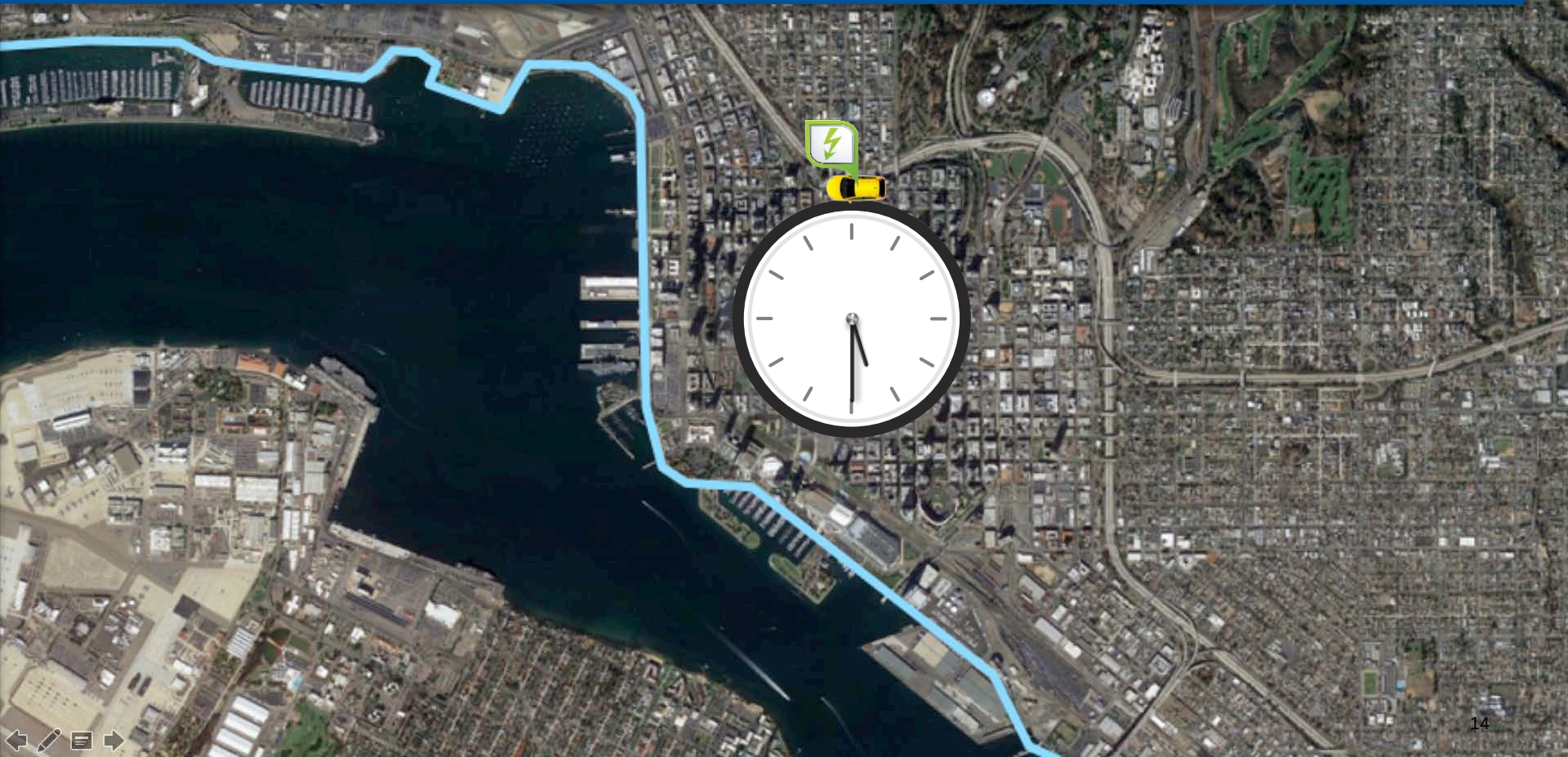


Potential Solutions for Charging Infrastructure of Shared Vehicles

- ~~Ubiquitous AC Level 2 street-side charging so customers can plug in vehicles after use~~
- ~~Numerous dedicated parking lots with AC Level 2 charging~~
- Strategically located fast charging stations

Expensive, if not impossible in most cities

Neither works for ride-sharing

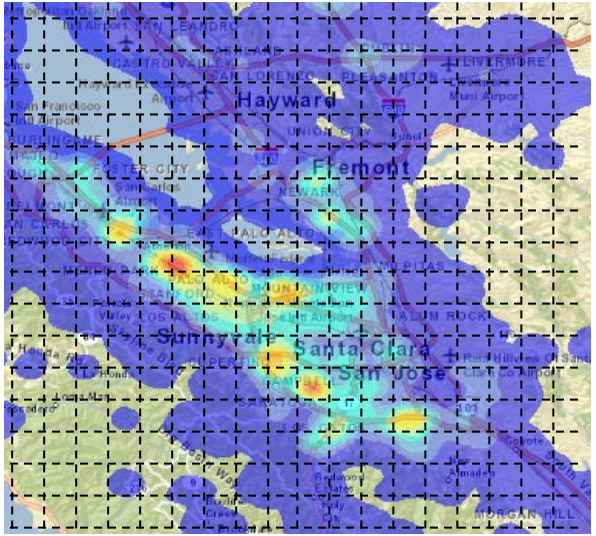
Fine for round-trip and one-way but defeats the purpose of free-floating model

Data-driven DC Fast Charger Siting

- Least-cost / shortest-path optimization using machine learning to determine the fewest number of charging stations and where should they go

- Must consider trade-off with increased battery size / vehicle range
  - Rolling stock analysis

- Project started Oct 1, 2016



What Changes with Fully Automated Vehicles?

Business models merge

Car sharing
Fleet asset ownership and management

Autonomous mobility on demand

Ride hailing
Vehicle dispatching

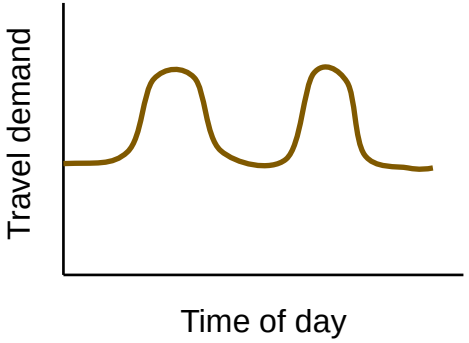
Home area = Automated mobility district

Additional Degrees of Freedom for Fleet Management

With fully automated vehicles, vehicles can be dispatched to:

- Provide rides
- Deliver goods
- Charge at opportune time
- Stay connected to provide grid services

based on real-time and forecasted demand vs. cost



Ultimate solution:
Real-time asset management

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