Massachusetts Institute of Technology

SMART
Singapore-MIT Alliance for Research and Technology

Innovations in Freight Data Workshop

Integrated Freight Survey, Shipment Tracking, and Vehicle Tracking

Presenters:

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Integrated Commodity Flow Survey

Freight data collection methodology

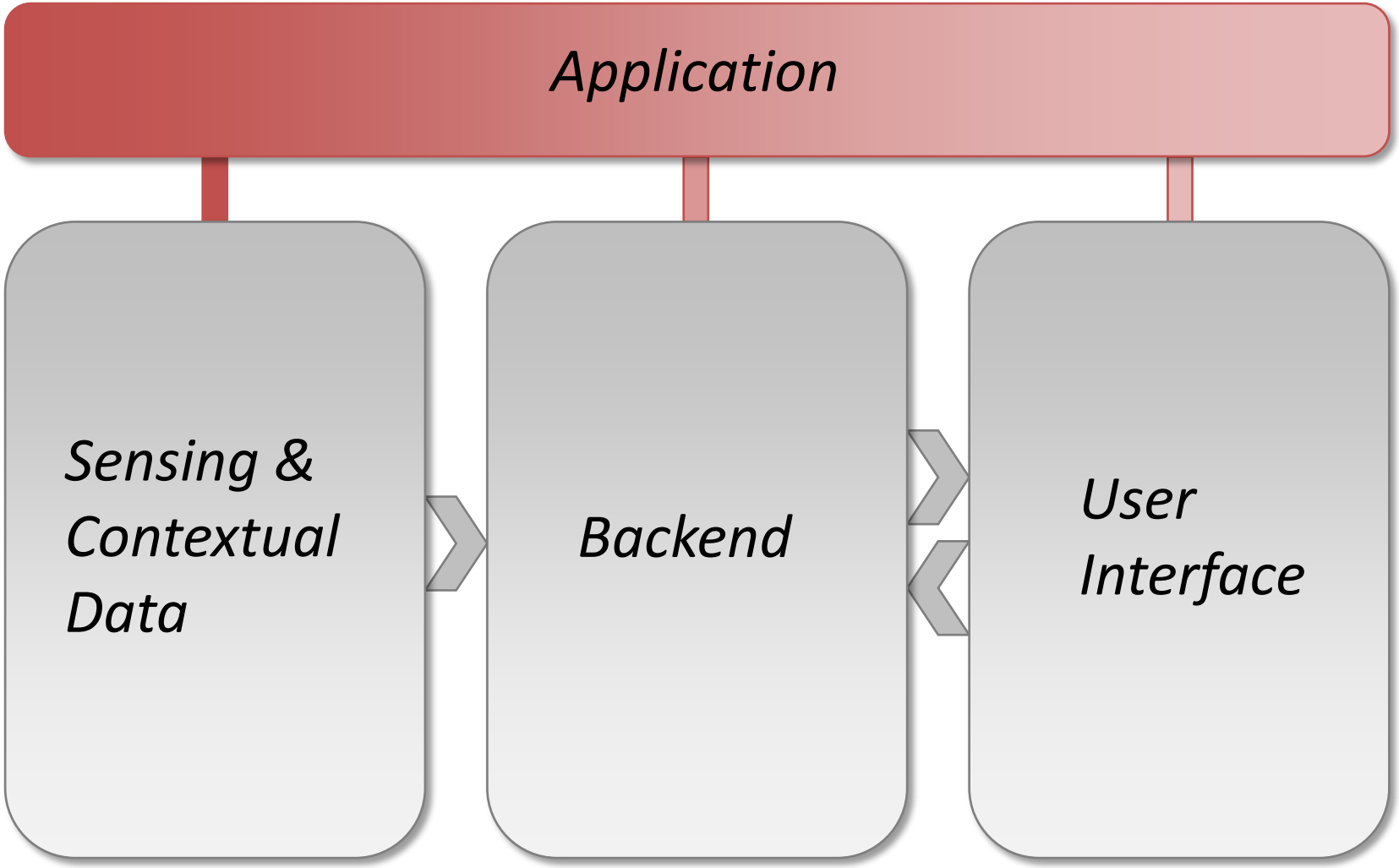
- leverages next generation sensing technologies
- utilizes machine learning in backend
- integrates survey stream using unified, coherent questionnaires

Conduct surveys

- data for policy analysis
- support freight modeling needs

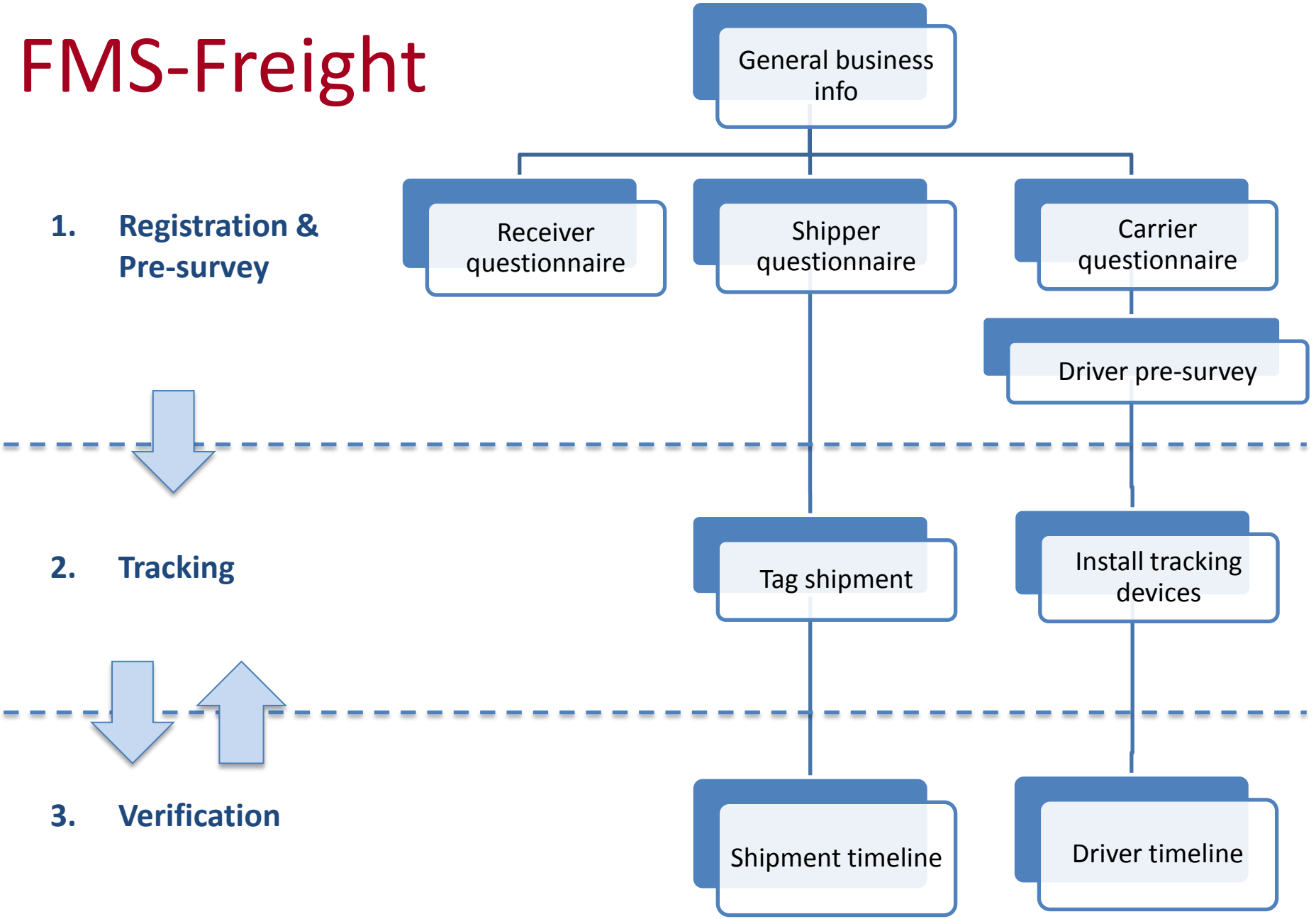
FMS-Freight

Future Mobility Sensing (FMS)

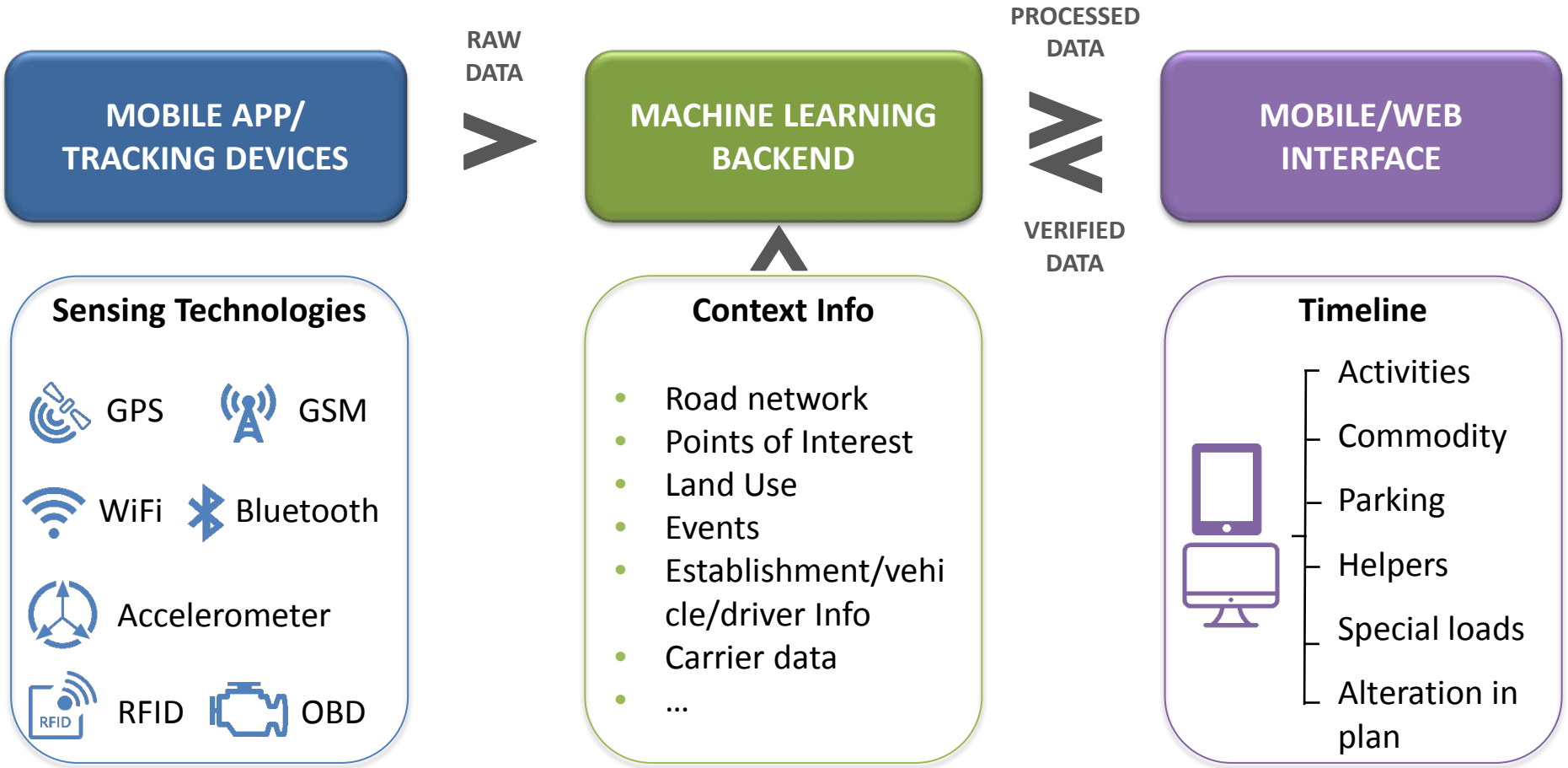


FMS-Freight

1. **Registration & Pre-survey**
2. **Tracking**
3. **Verification**



System Architecture



Main Contributions

All electronic, full integration of data between related entities

Machine learning with user verification

Multi-platform, multi-devices

Machine Learning

Main objectives

- Stop detection
- Activity inference

Flexible algorithm to utilize available information

- GPS/OBD/WiFi/accelerometer/barometer etc.
- Contextual information such as frequent places, user history, as well as Points of Interest etc.

Stop detection

- Rule based heuristics
- Random forest
- Change point detection

FMS-Freight Interfaces

FMS-Freight

1. **Registration & Pre-survey**
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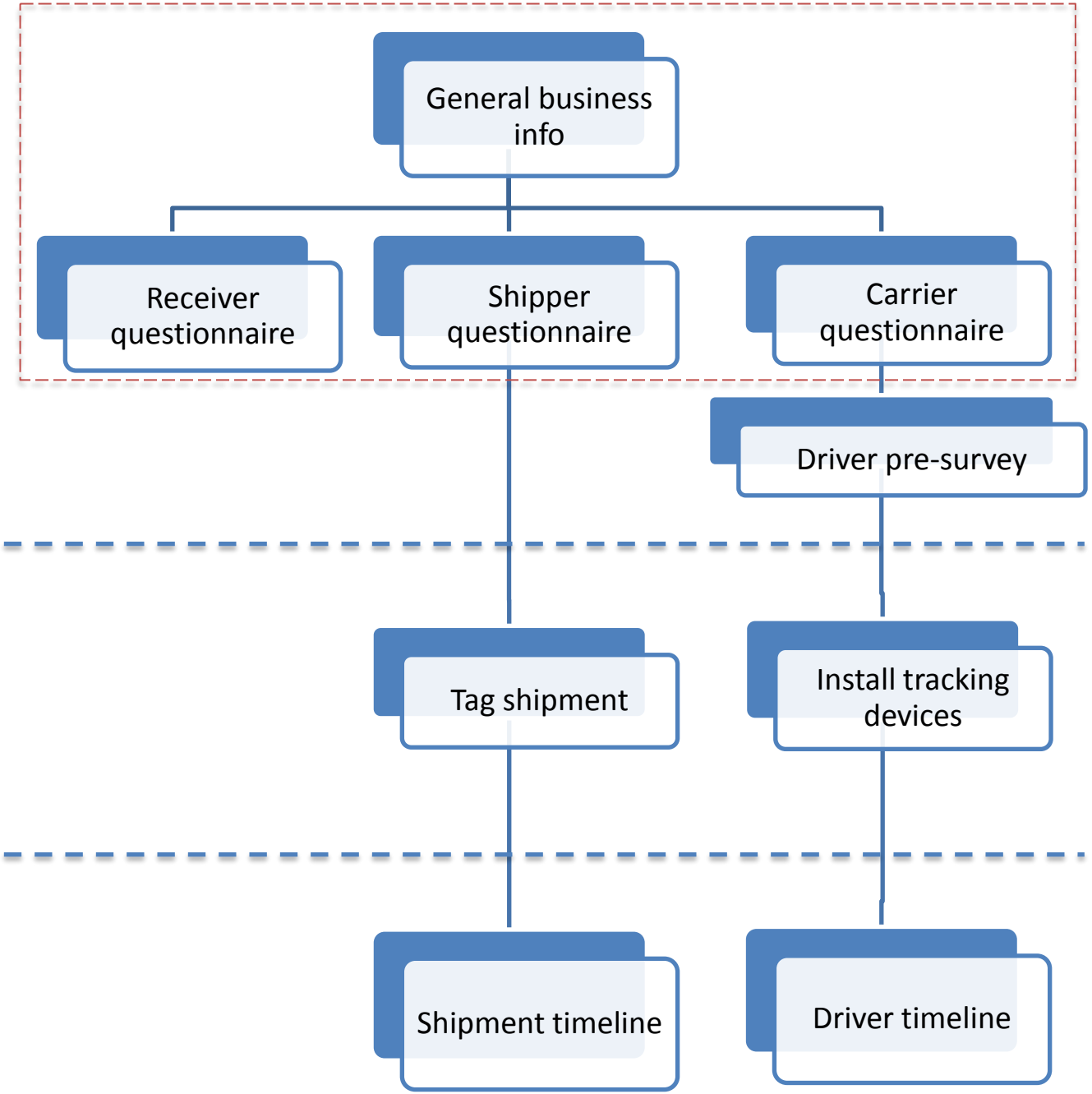
3. **Verification**



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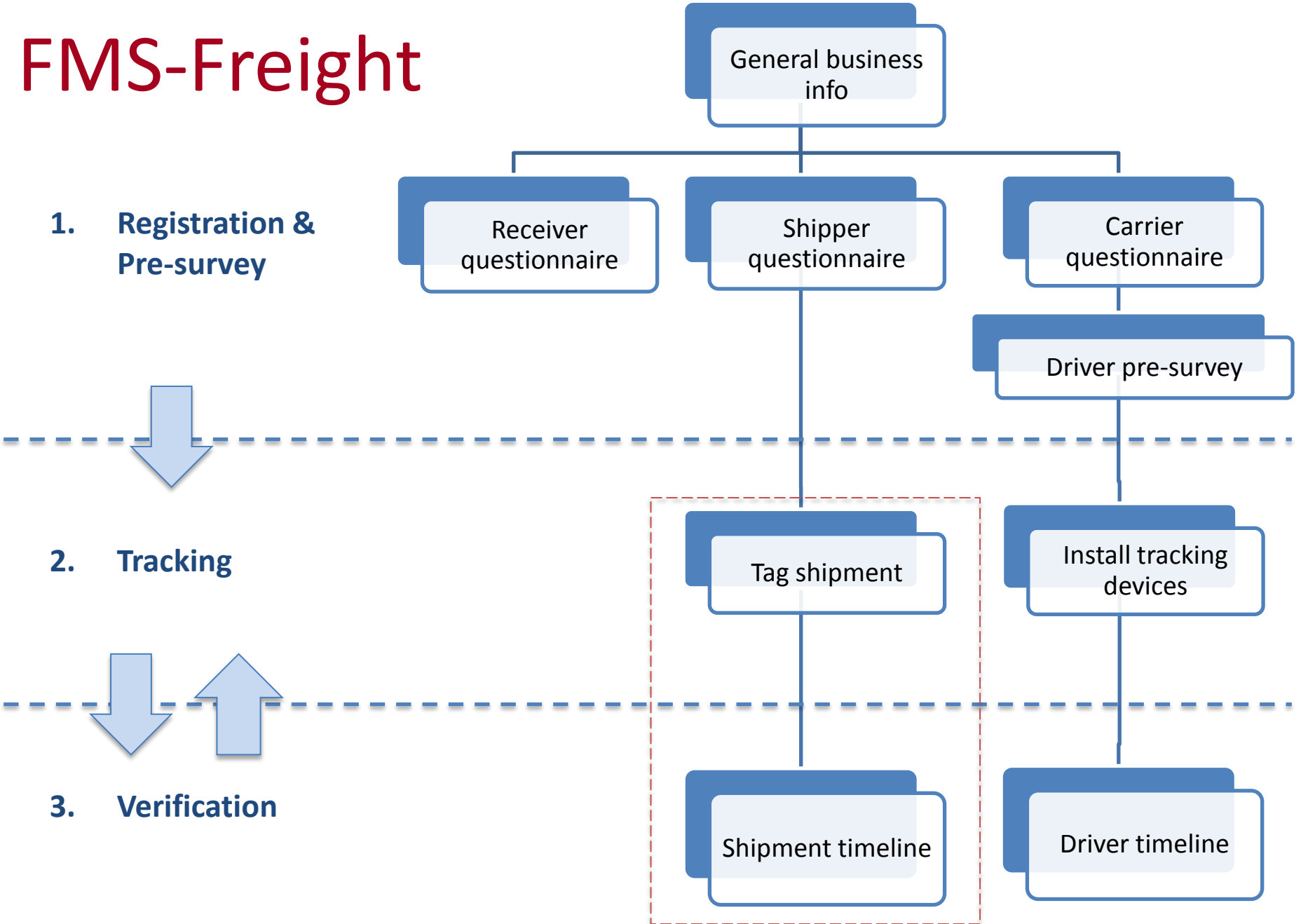

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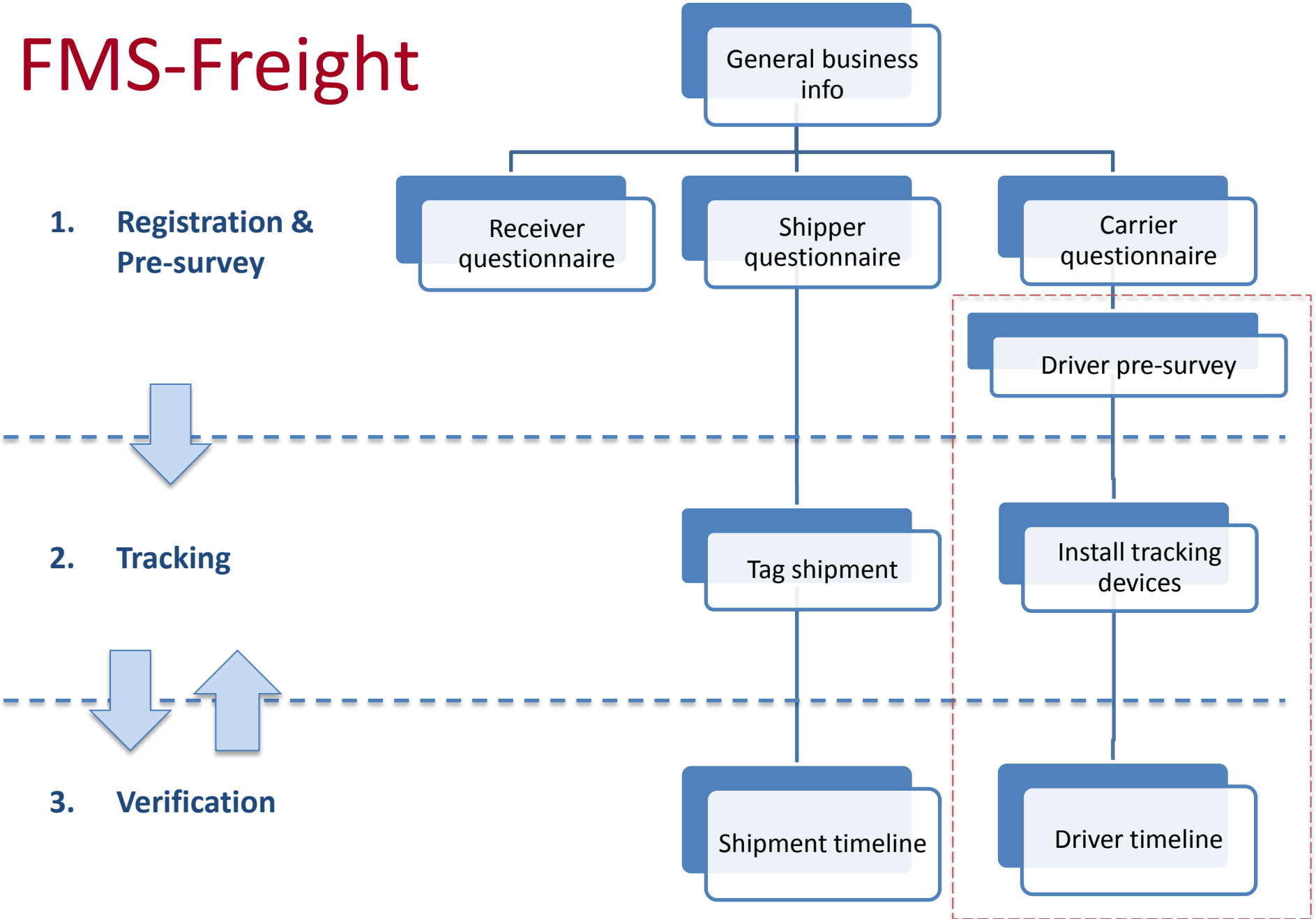


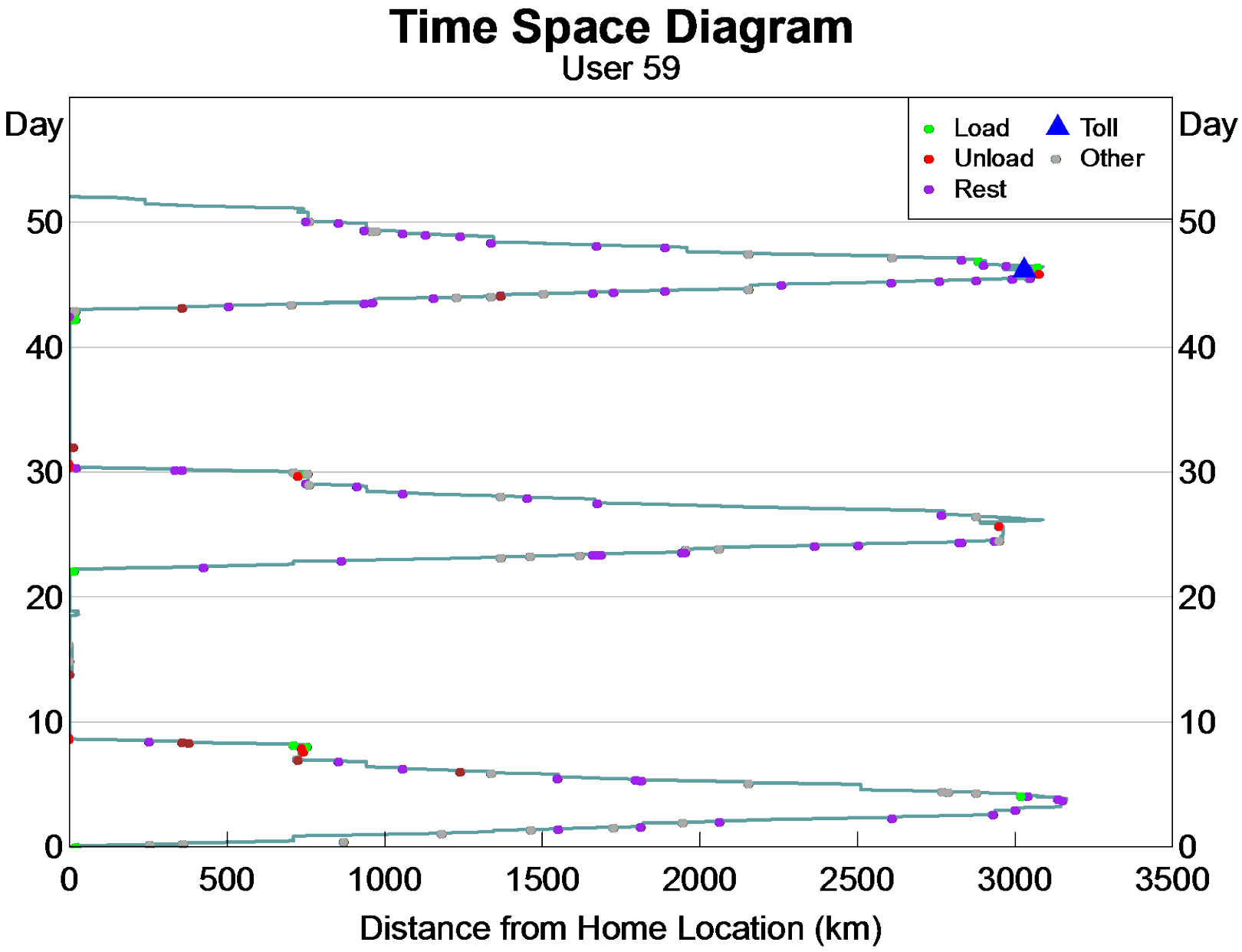
Truck Driver Survey Pilots

Time	Sponsor	Recruitment Location	Type	Vehicle Types	Scale
Jan 2014	Ferrovial	US (Texas, Indiana, Ontario, Northeast)	Intercity	Mostly heavy, some single unit	Large (Survey Firm)
Oct 2016 – Dec 2016	FHWA	US (Boston Metropolitan)	Urban + Intercity	Various, e.g van, single unit, heavy	Small (MIT research team)
Feb 2017 – Present	URA	Singapore	Urban	Heavy	Large (Survey Firm)

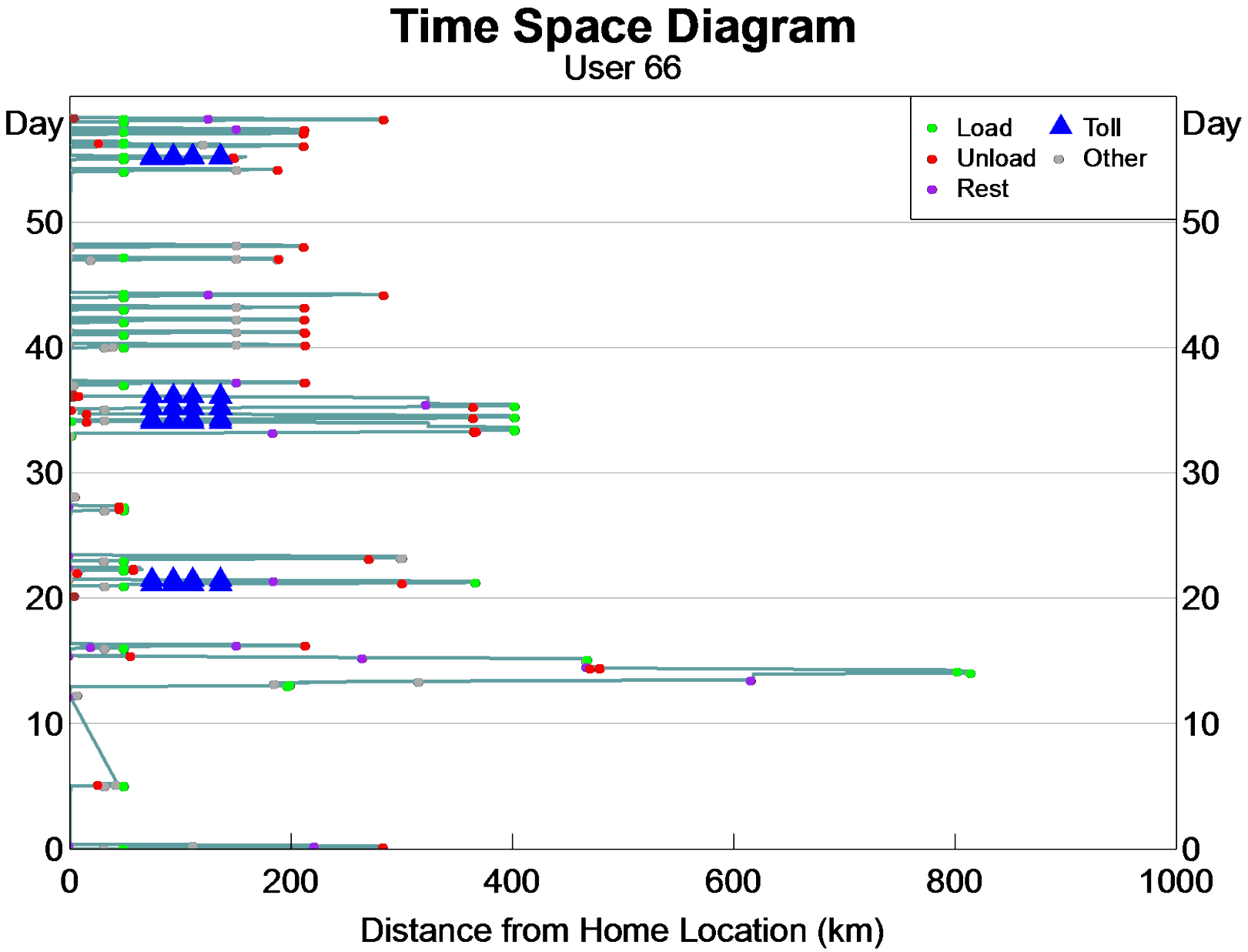
Assisted machine learning enhancing GPS

- Tour patterns
  1. Intercity
     i. Long tour
     ii. Short tour
     iii. Gypsy
  2. Urban
     i. Chained tours
     ii. Centralized tours
     iii. Decentralized tours
  3. Mixed
- Stop sequence (and route) in one tour
  1. Distance based stop sequence
  2. Cargo based stop sequence
  3. Location/timing based stop sequence
- Activity patterns for one day

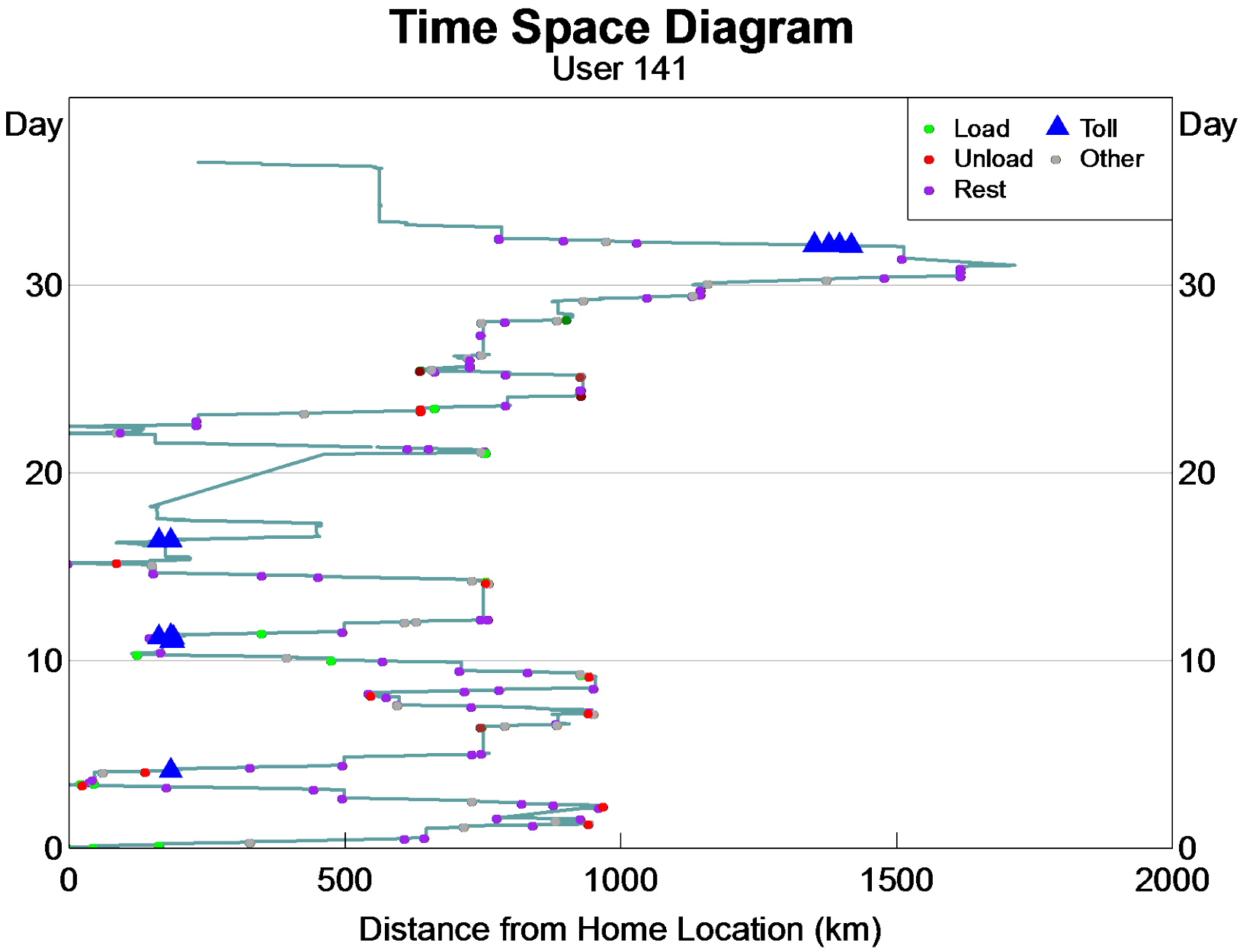
1. Intercity: Long tour



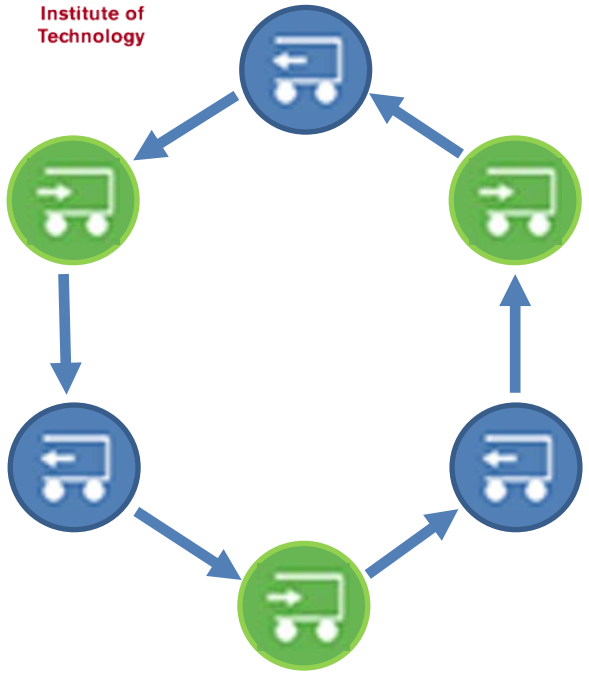
1. Intercity: Short tour

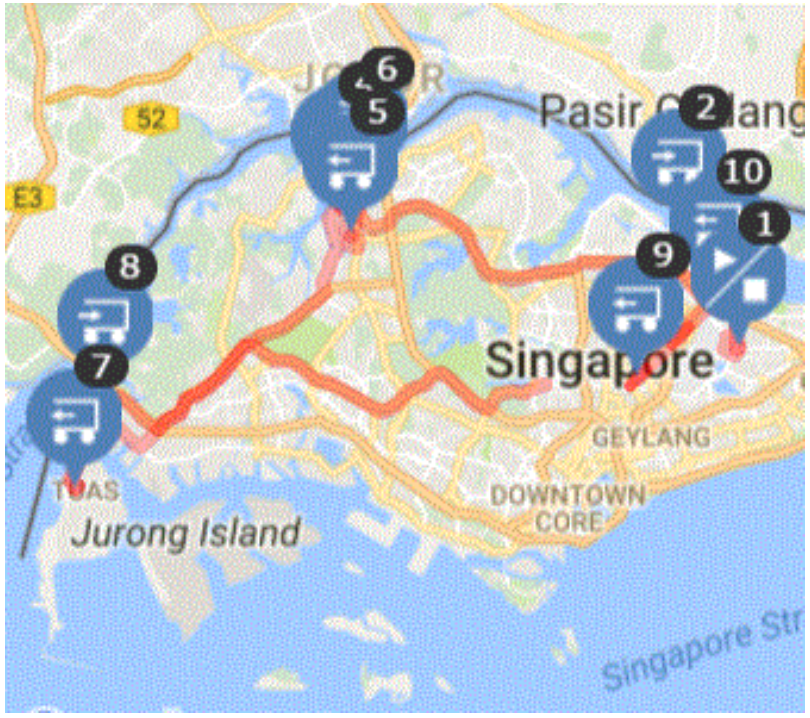


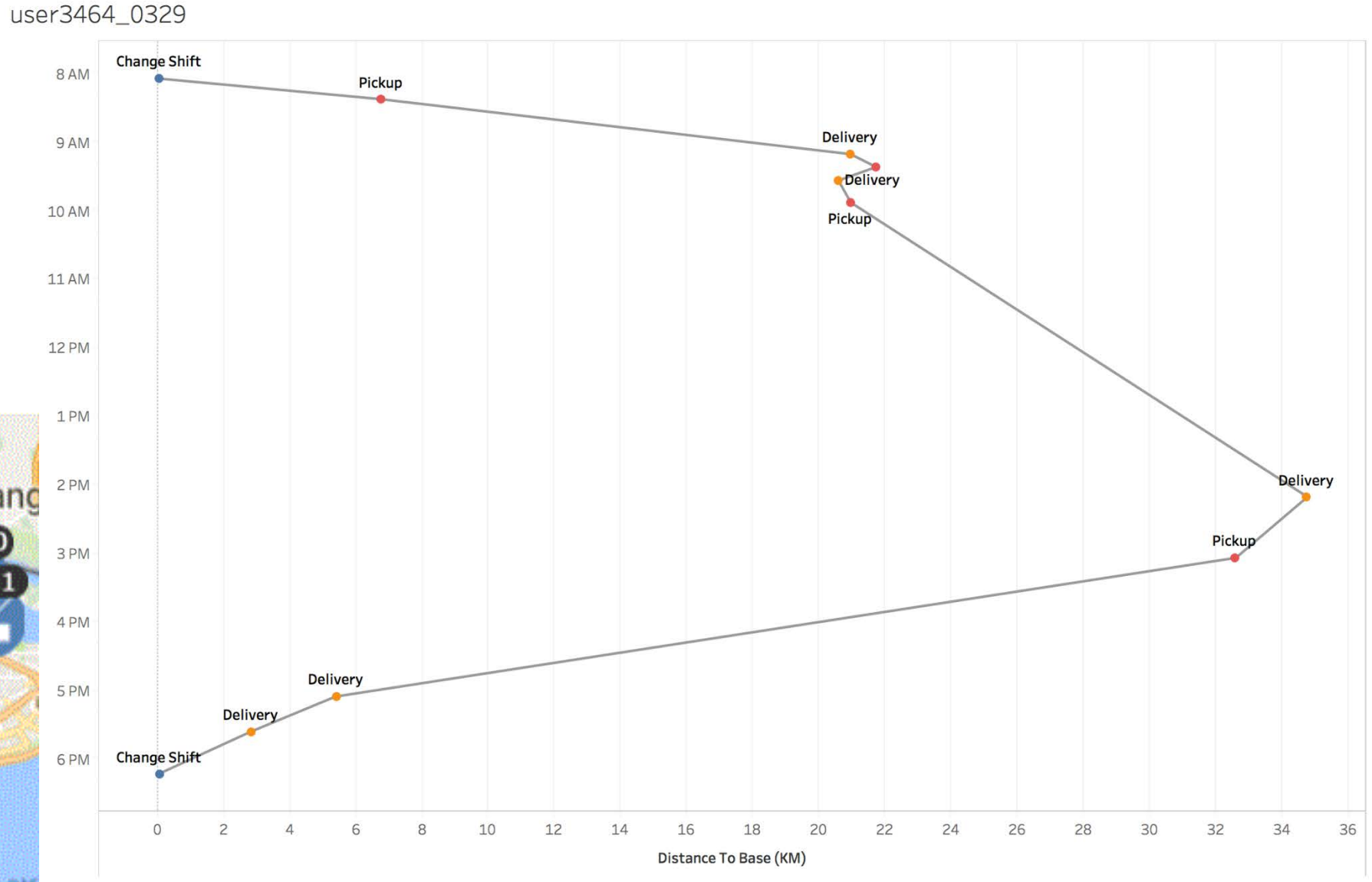
1. Intercity: ‘Gypsy’



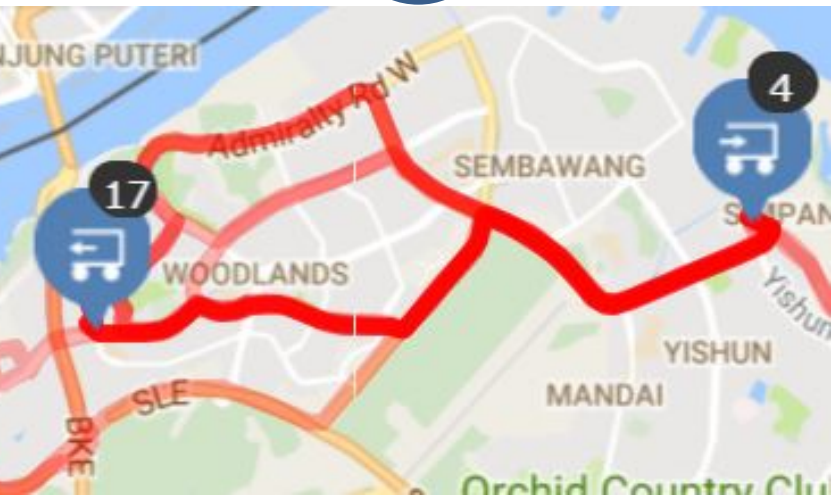
2. Urban: chained tours

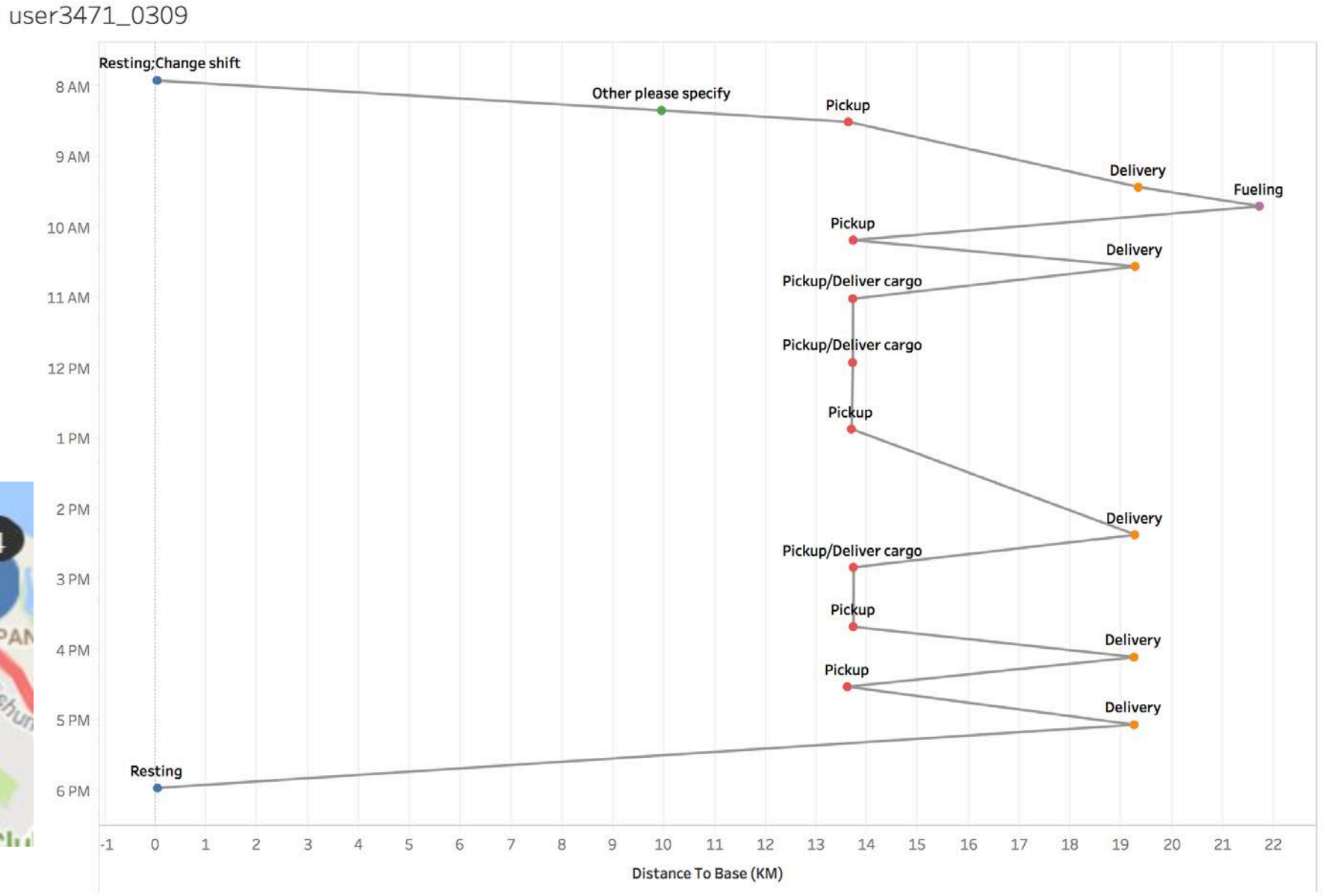




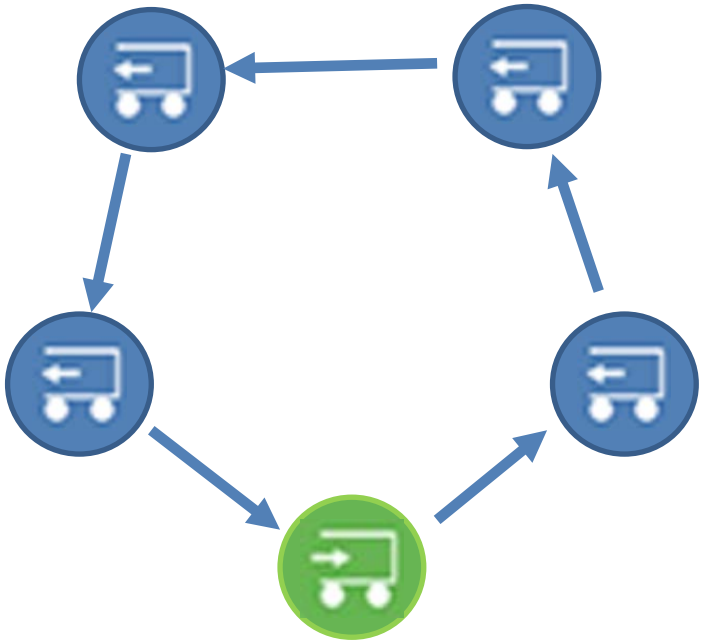


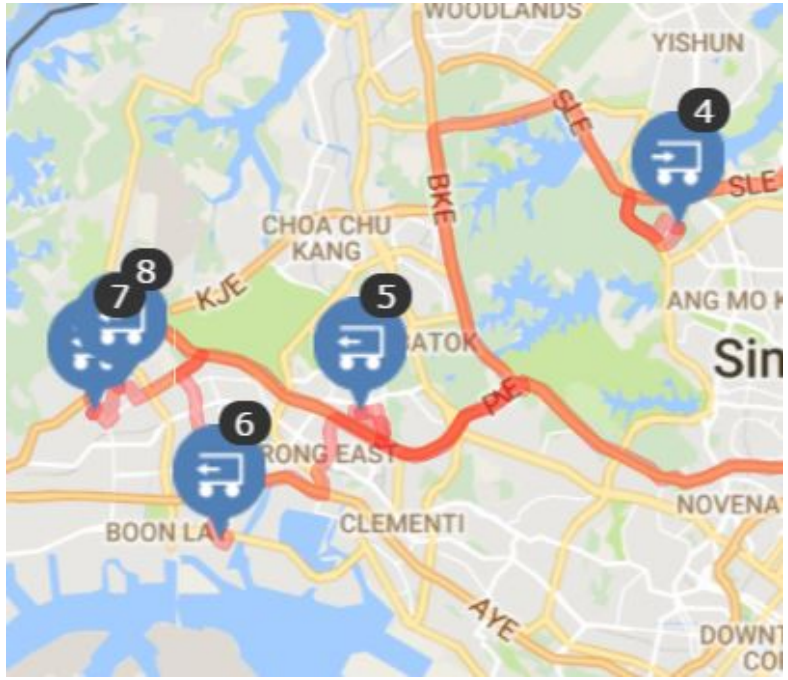
2. Urban: centralized tours, time of day route choice

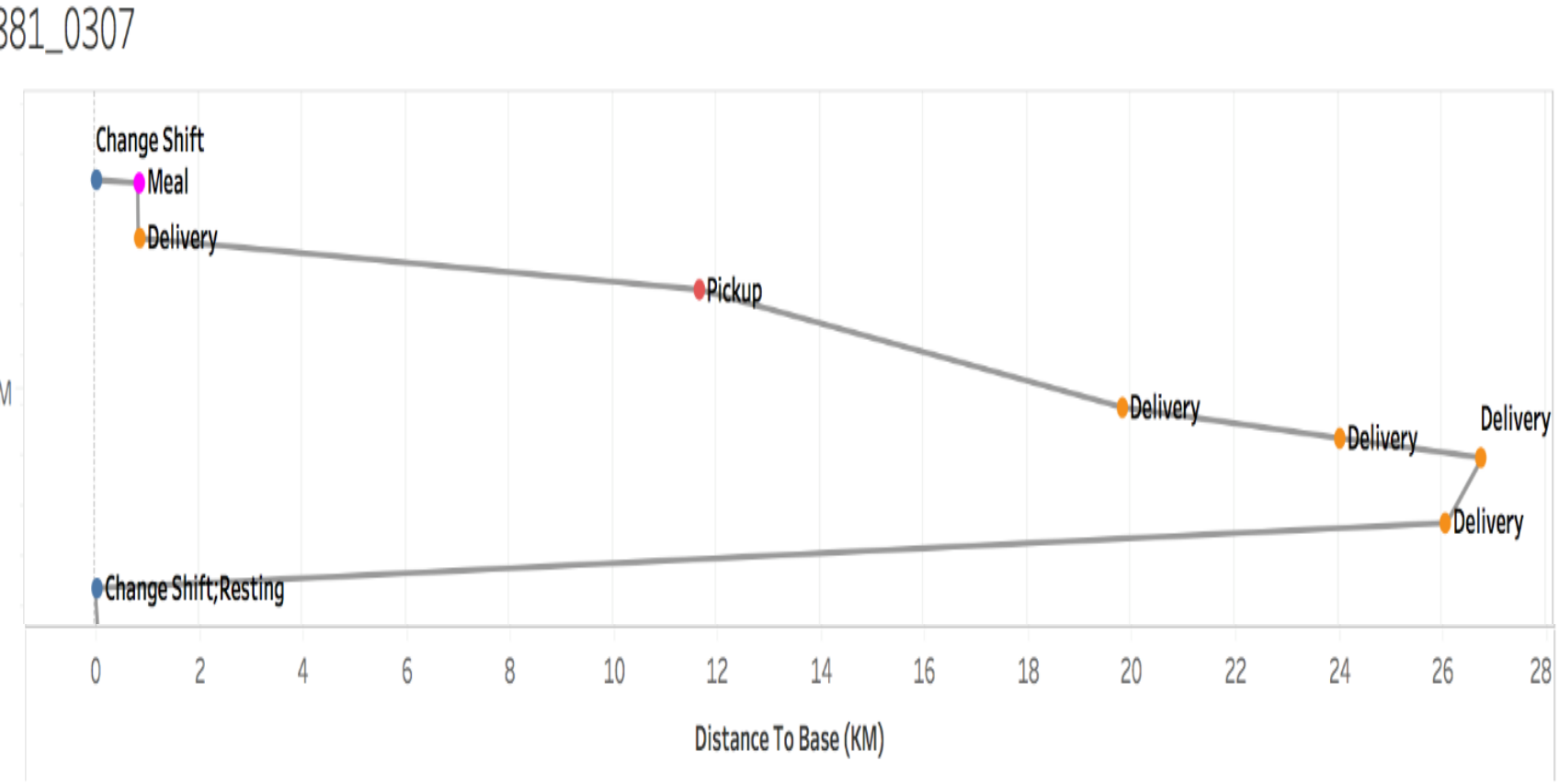




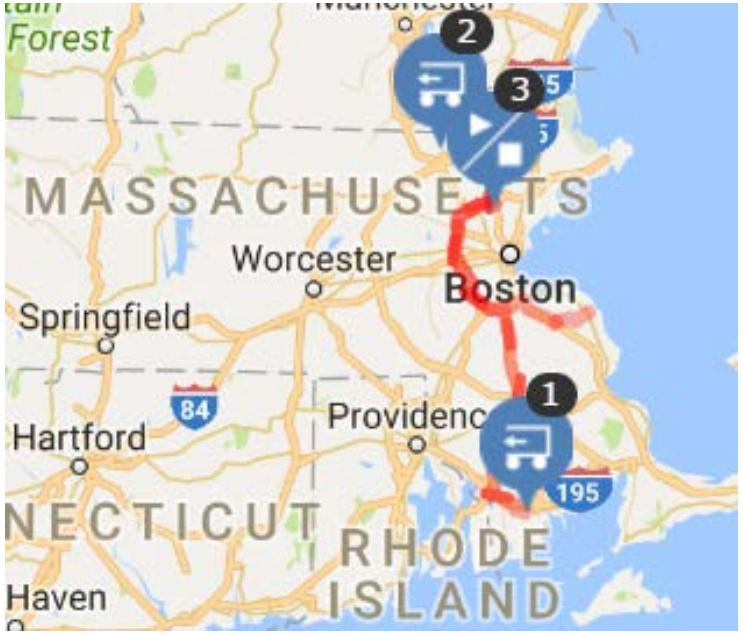
2. Urban: decentralized tours
distance based stop sequence choice

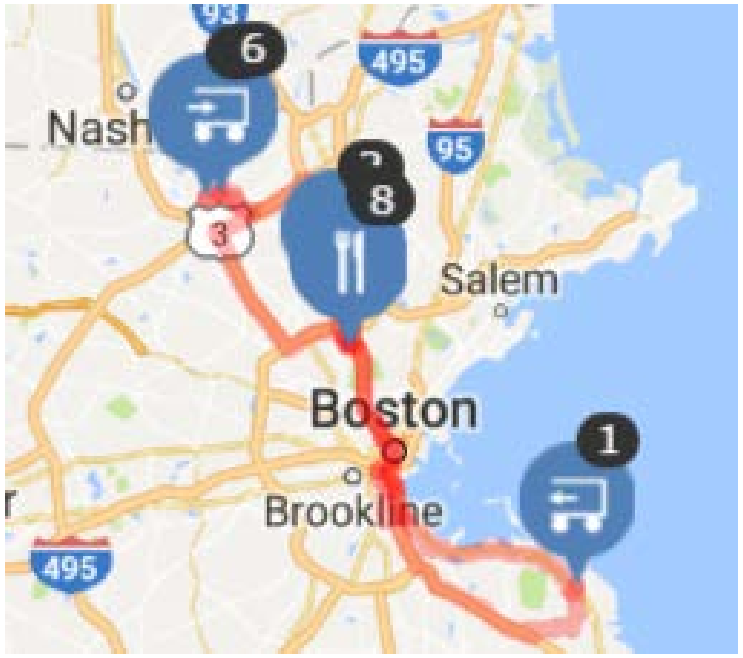


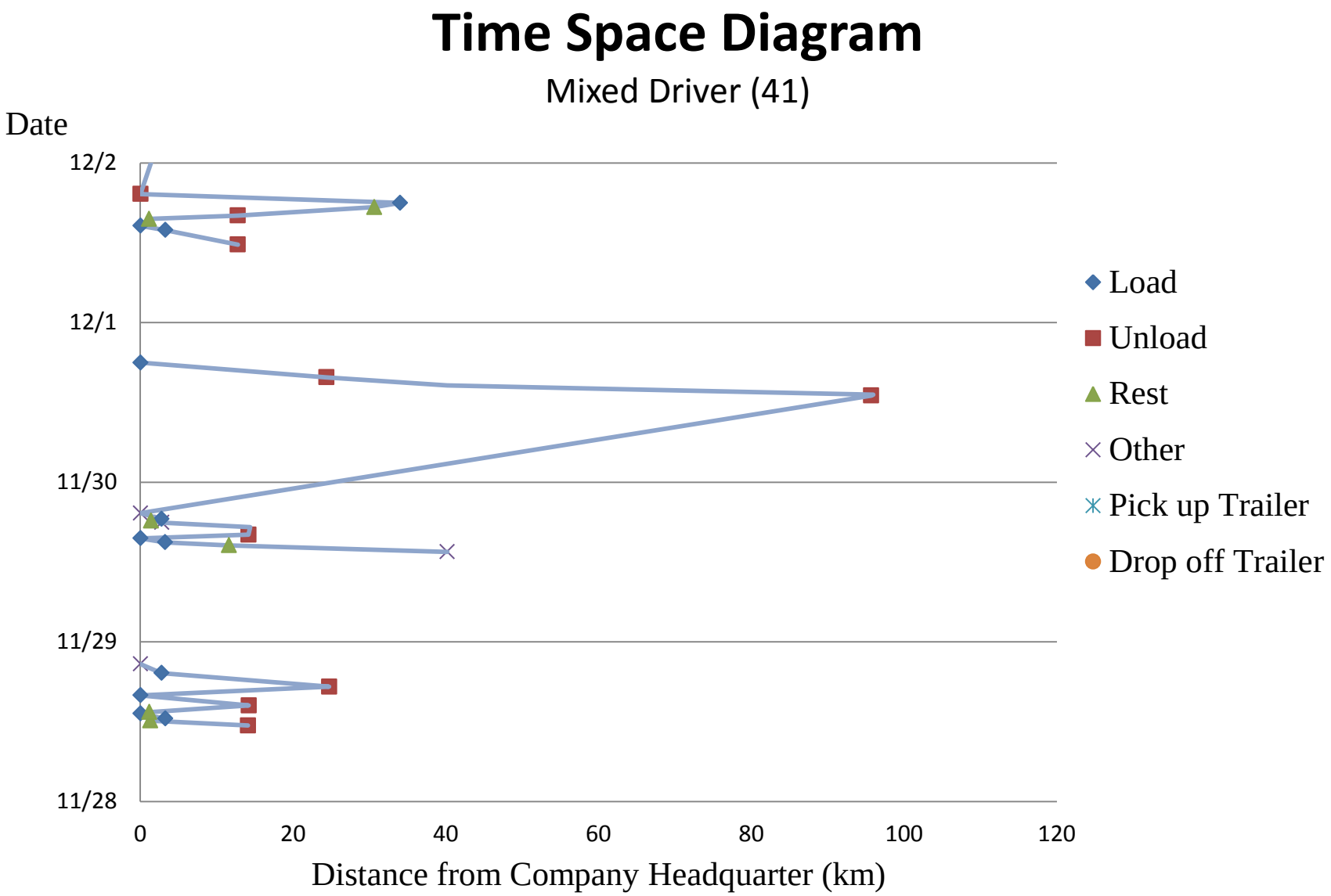




3. Mixed: Intercity and Urban

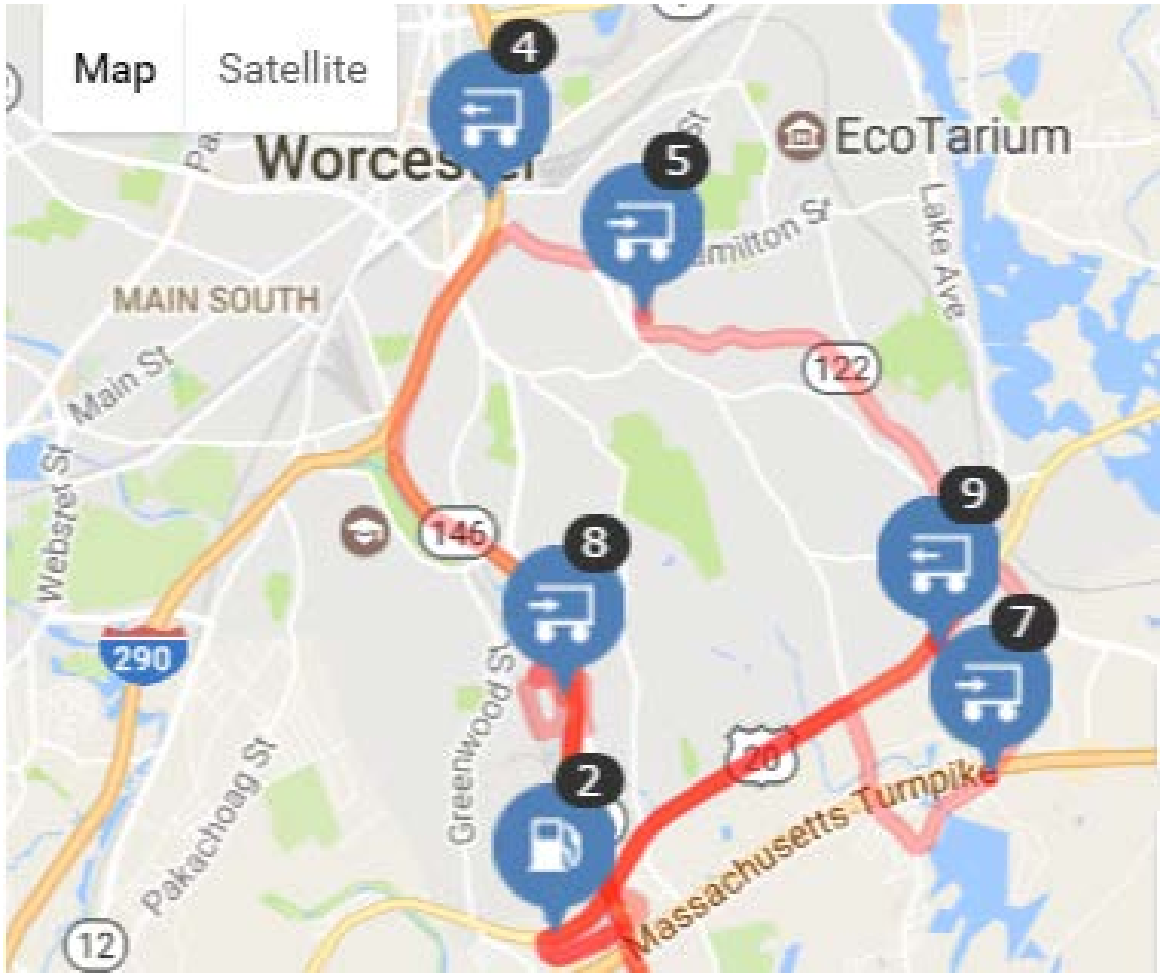




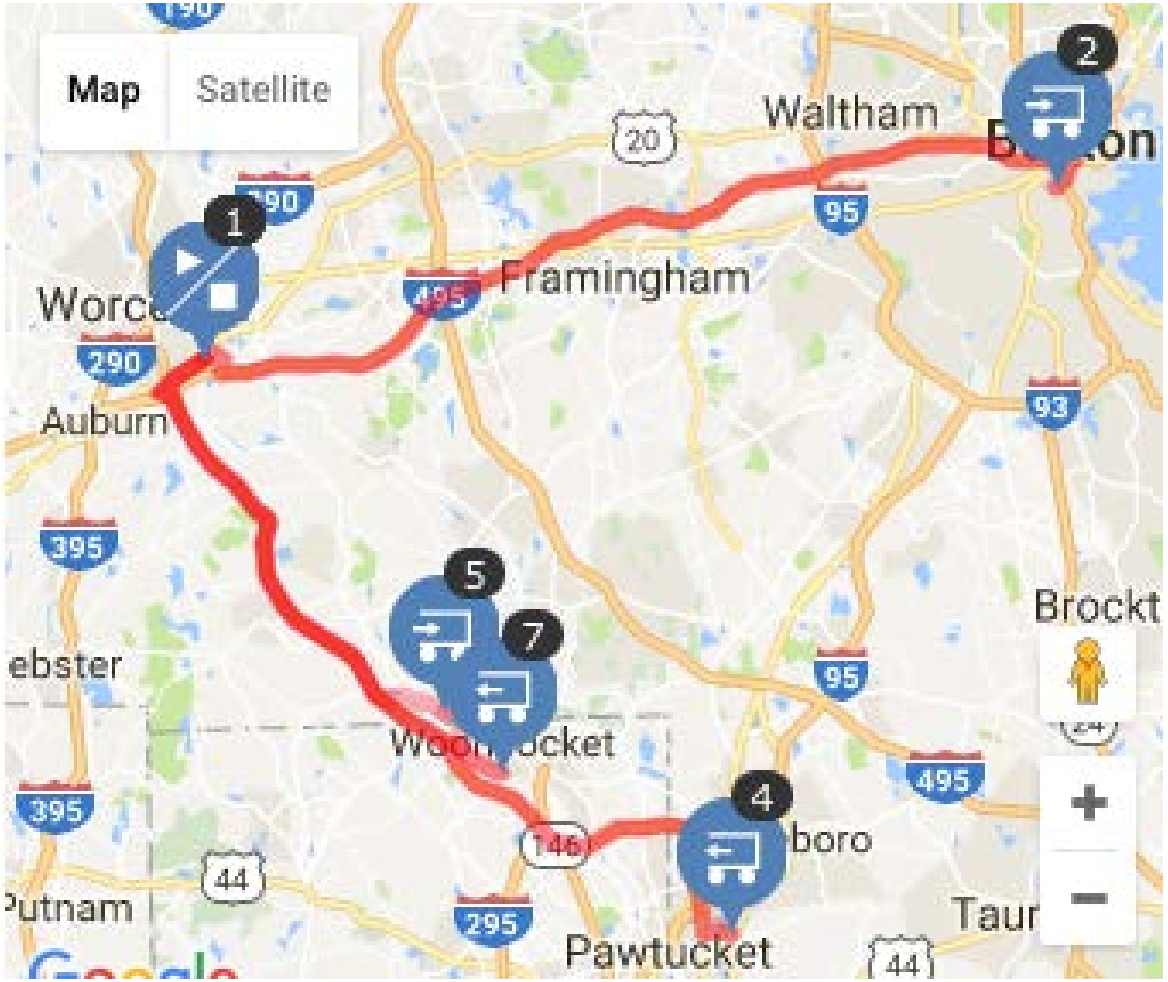


3. Mixed: Intercity and Urban Variability for One Driver

- Snow day: deliver snow plows on snow days
- Typical non-snow day: deliver machine parts with a different tour pattern



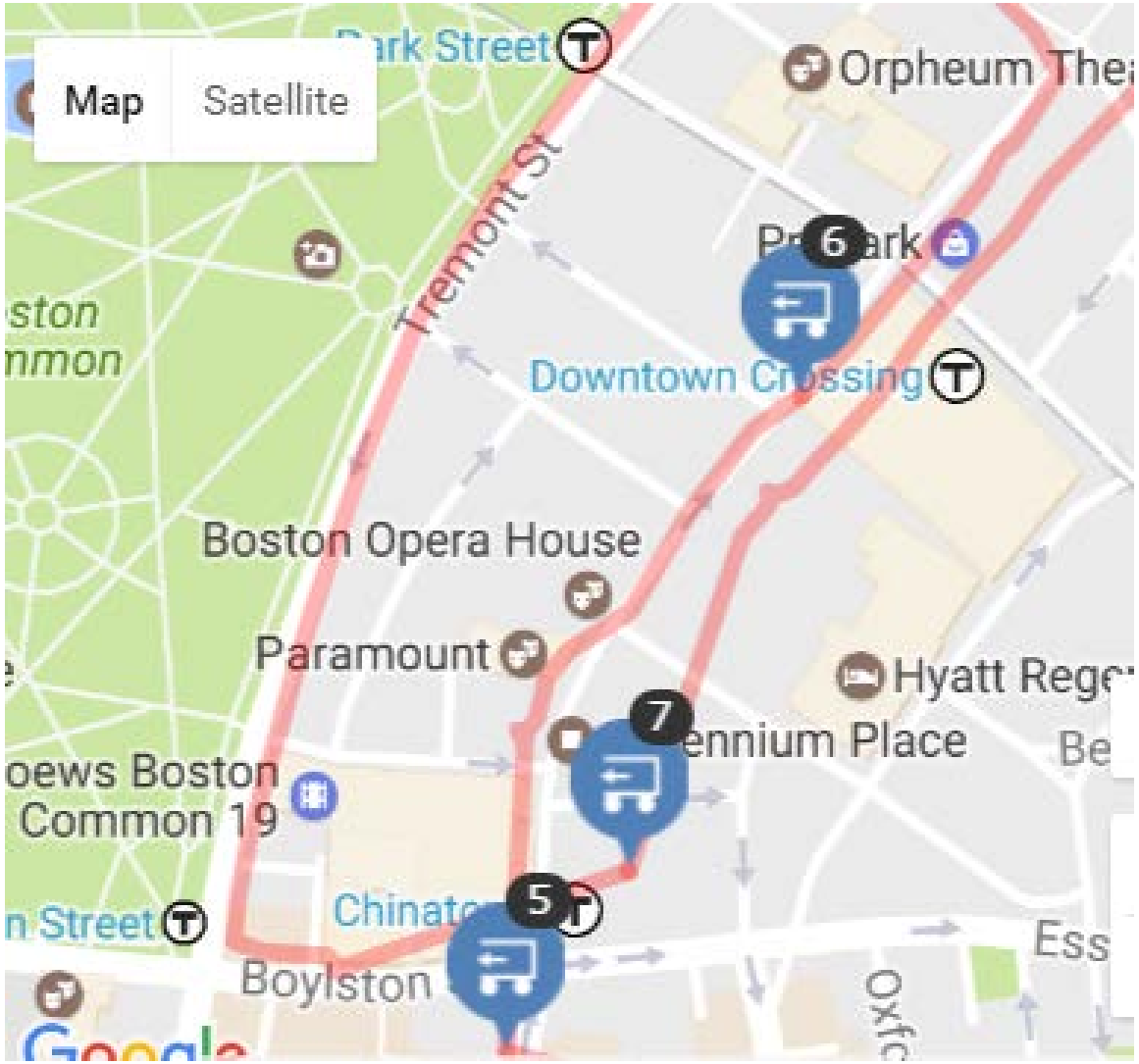
Typical Snow Day Trip



Typical Non-Snow Day Trip

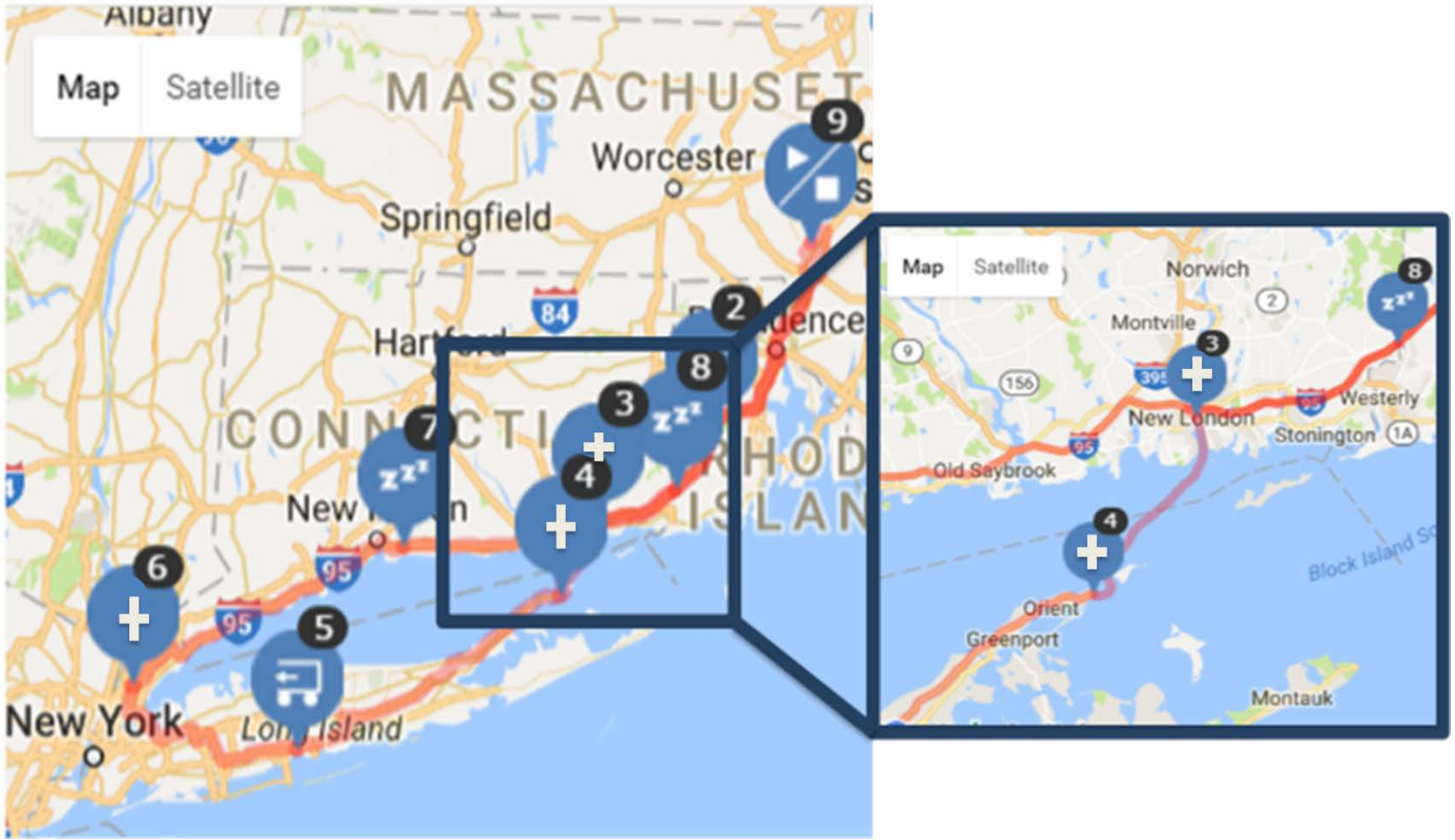
Stop Sequence Patterns: cargo based stop sequence choice

- Shipping carrier, express cargo at stop 6
- User 61 took detour to deliver 6 first then go back to deliver 7

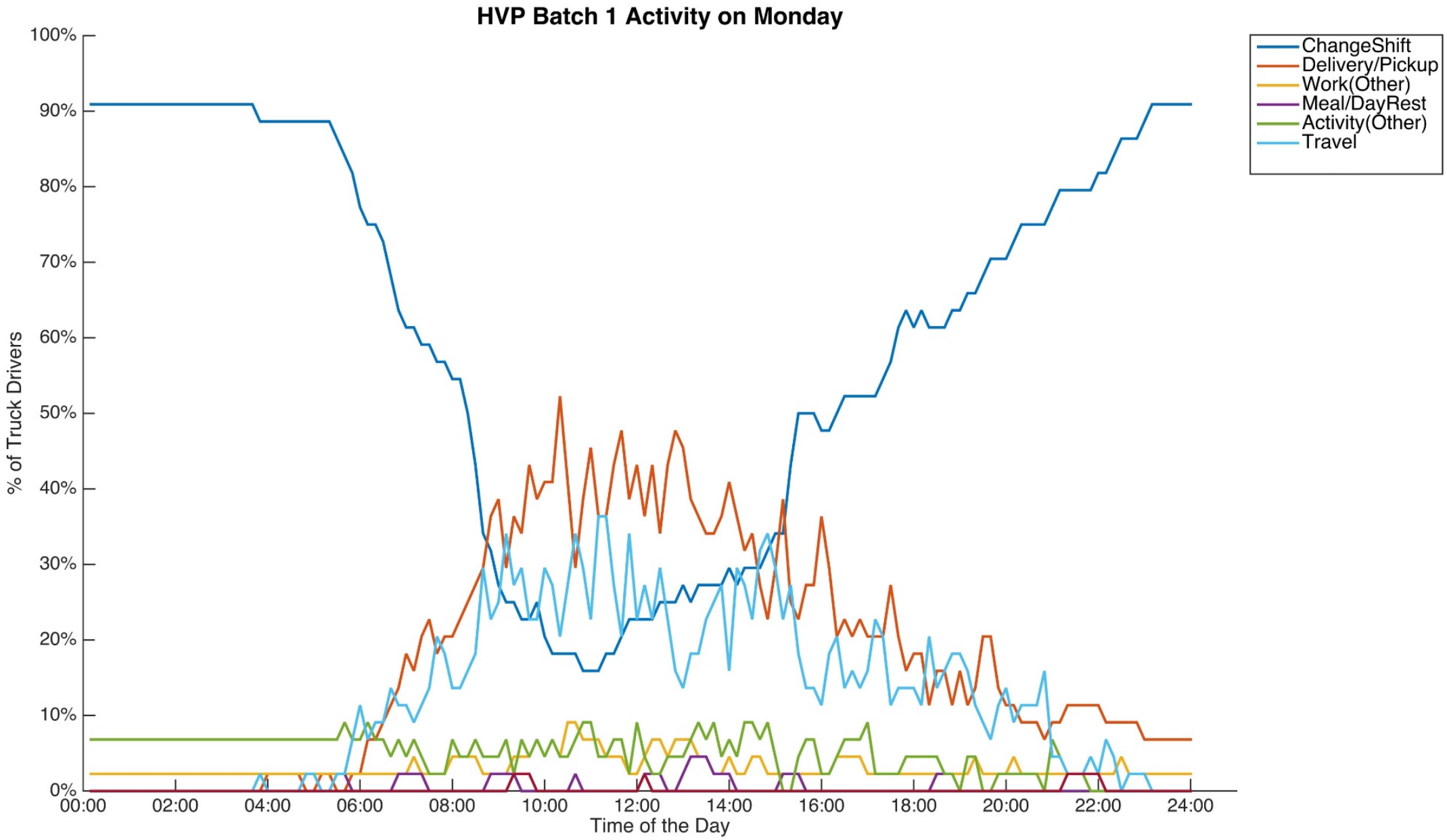


Stop Sequence Patterns:
location/timing based stop sequence choice

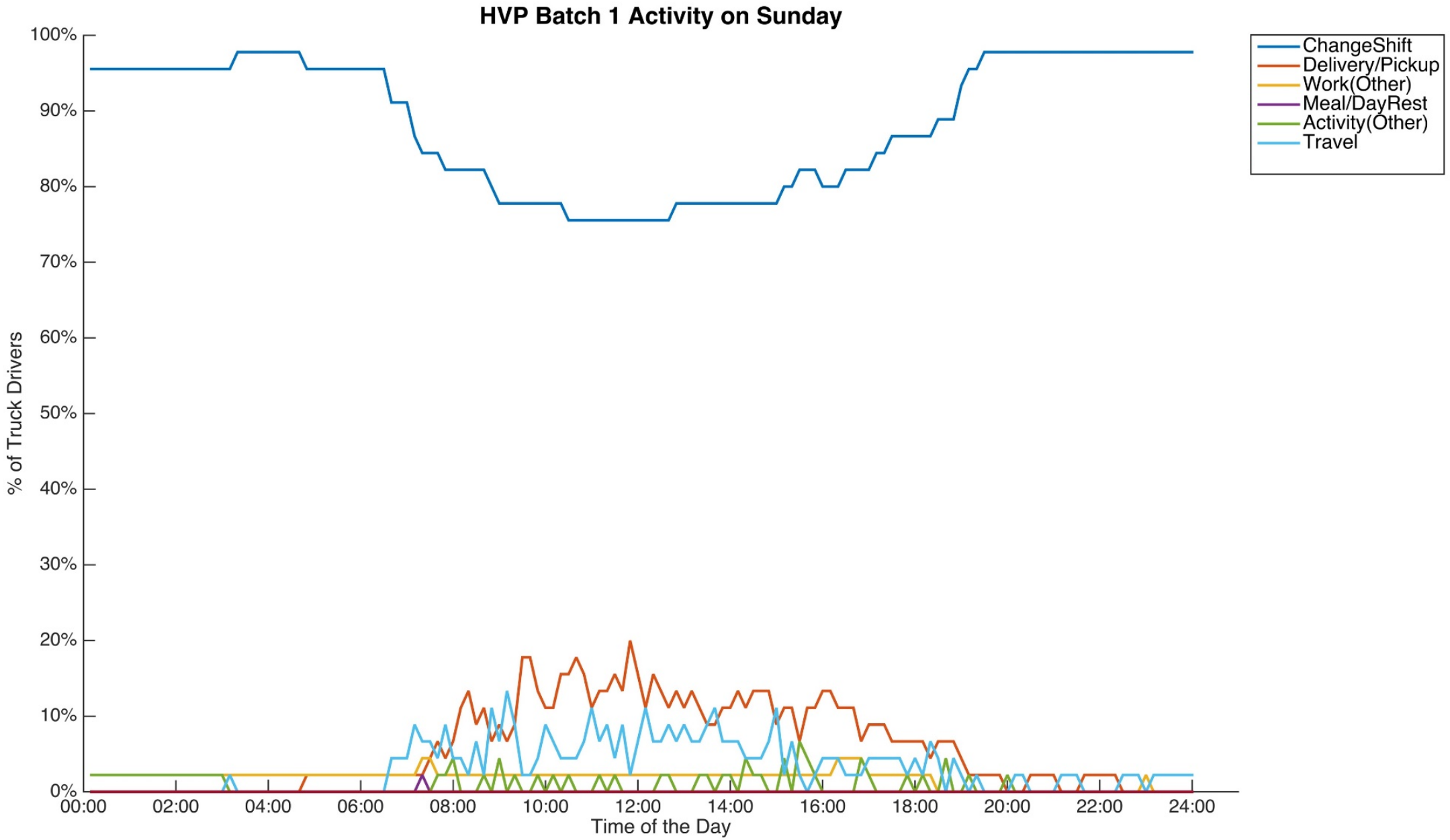
- Pickup in Boston, deliver to Long Island and New York City
- Deliver in Long Island first by taking the ferry to avoid morning peak in New York City
- Cost of ferry v.s. value of time



Urban Activity Patterns: Monday



Urban Activity Patterns: Sunday



Conclusions and Next Steps

Conclusion

- Integrated freight survey platform
- GPS combined with assisted machine learning to enable rich and high resolution data
- Previously unavailable insights into freight movement
- Behavior modeling innovations, e.g. stop sequence choice, route choice, activity pattern clusters

Next Steps

- Singapore Pilots
  - Integrated freight survey in Changi (started Nov 2016)
  - Island-wide Integrated freight survey (2018)
- US Pilots
  - Shipment survey (2017)
  - Larger integrated vehicle and shipment survey (2018)

Thank you!
Questions and comments?

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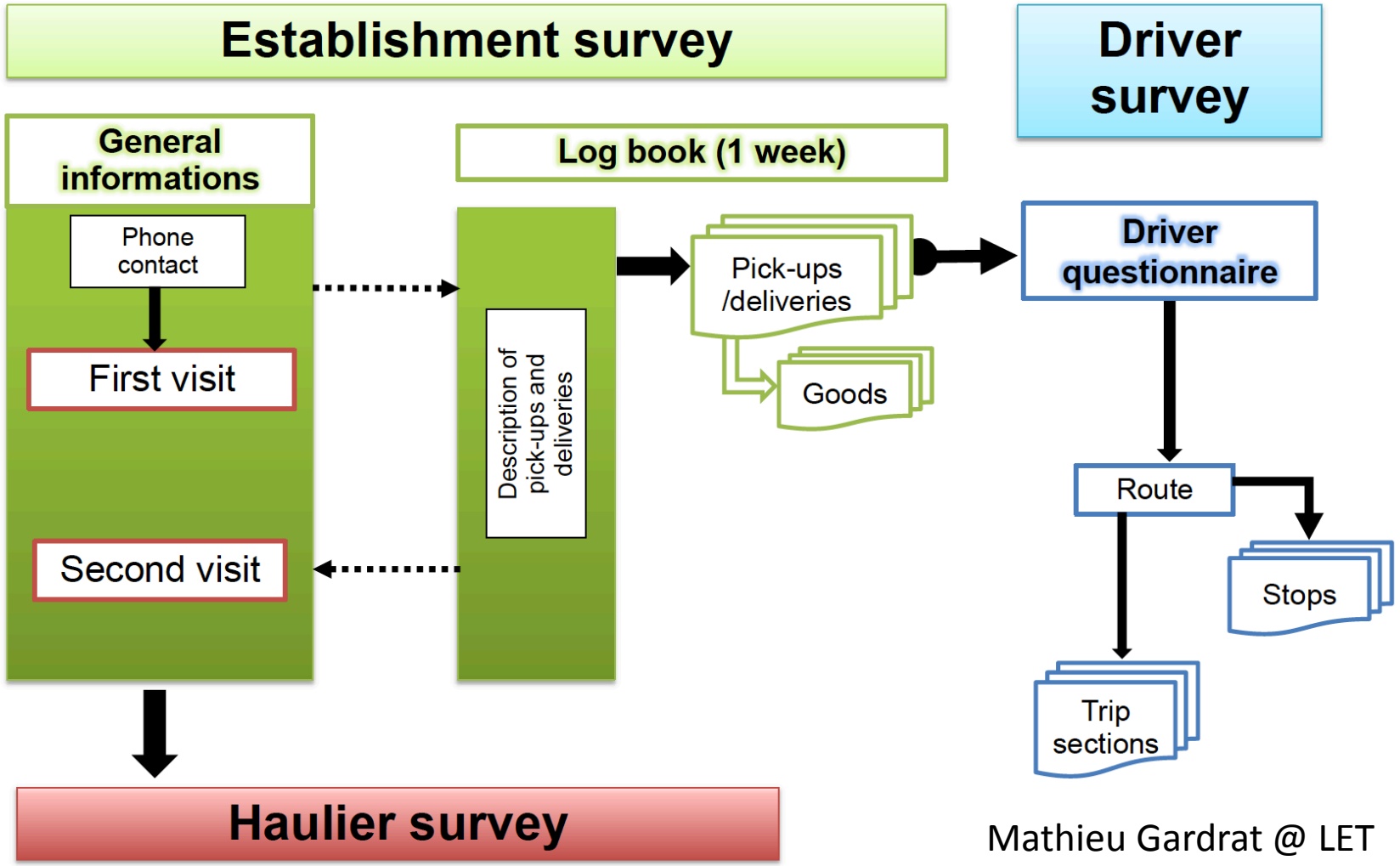
Pilot Survey Websites:
https://truckers.mit.edu
freight-sg.fmsensing.com

Appendix

Paris Urban Freight Survey

Three combined surveys for complementary results



Mathieu Gardrat @ LET

Truck Driver Survey in US 2014

- Intercity, mostly heavy with some single unit, recruited in Texas, Indiana, Ontario (Canada), Northeast US
- Survey firm recruitment and verification
- Compensate $100, logger tracking, daily verification online (by driver) or via phone (by surveyor)
- Recruited 107 drivers, 2255 days pilot

Truck Driver Survey in US 2016

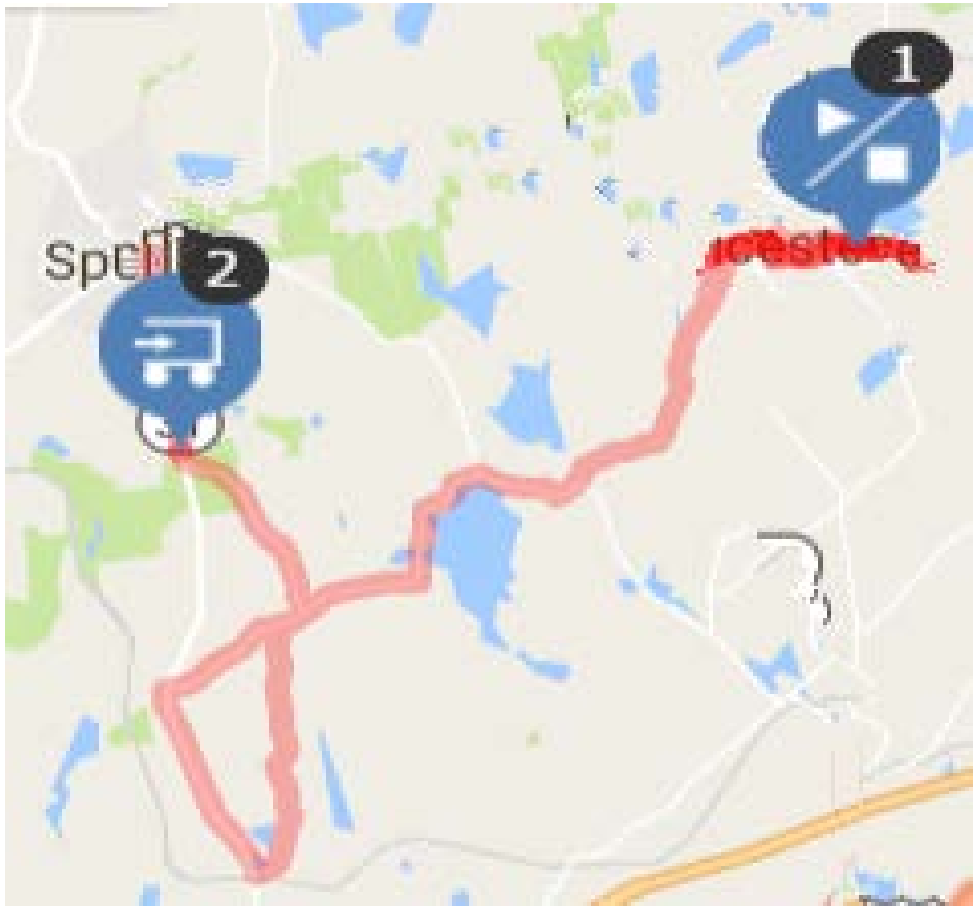
- Intercity and urban, a variety of freight vehicle types, recruited in Boston Metropolitan
- MIT research team recruitment and verification
- Compensate $100, logger tracking, daily verification for 15 days online (by driver) or via phone (by surveyor)
- 28 recruited drivers (8 urban, 15 intercity, 5 mixed), 18 completed, 53 days pilot, 650 days tracking, 442 days verified
  - Intercity: carries freight beyond a local or metropolitan area
  - Urban: collects and delivers freight within the limits of a local or metropolitan area
  - Mixed: some days urban, some days intercity; deliver in multiple urban areas daily

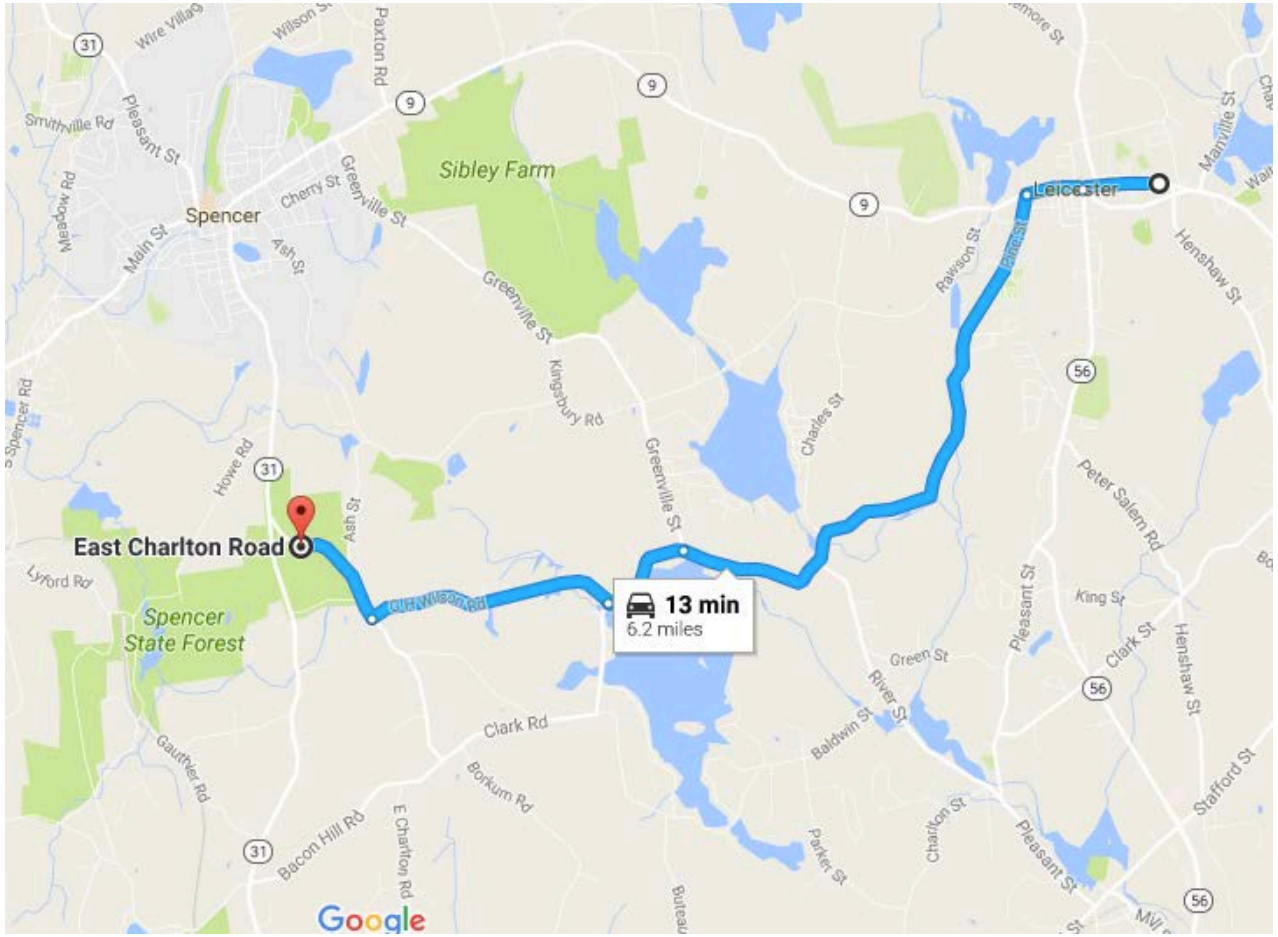
Truck Driver Survey in Singapore 2017

- Urban freight, heavy vehicles, recruited in Tampines heavy vehicle parks (east island)
- Logger installation by Quantum Inventions in batches (mandatory), recruitment for survey by Agility (optional)
- Vouchers as reward, daily verification for a week, online (by driver) or via phone (by surveyor)
- 629 drivers tracked, 282 recruited for survey, 206 verified 5 week days and some weekends

Route Patterns: cargo/vehicle based choice

- Circuitous route (red line) from stop 1 to stop 2
- Auto carrier, oversize cargo, GPS as navigation source
- Cannot make tight turns or enter narrow roads suggested by GPS (blue line)





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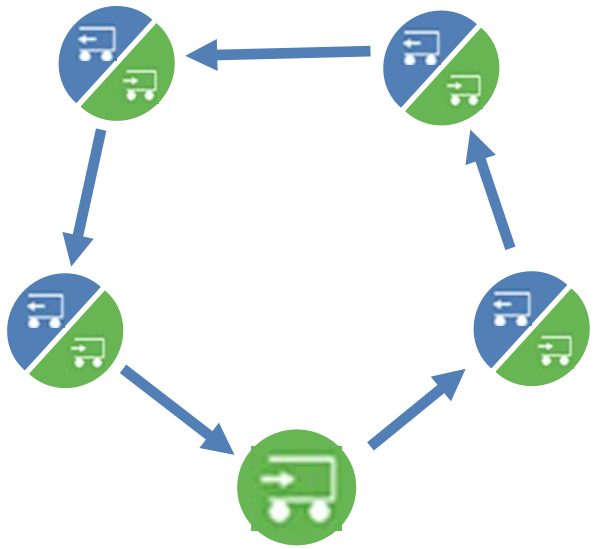

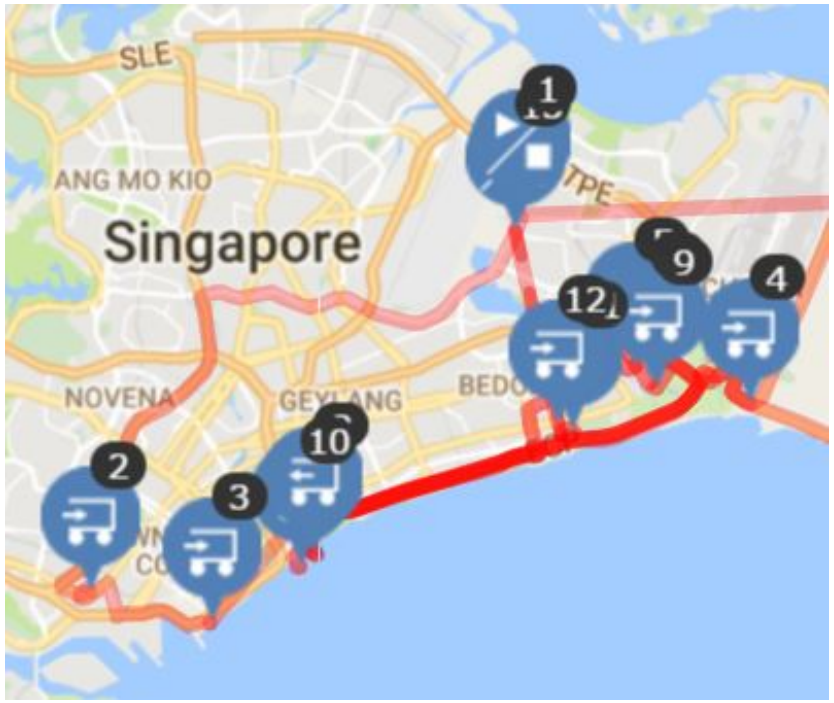

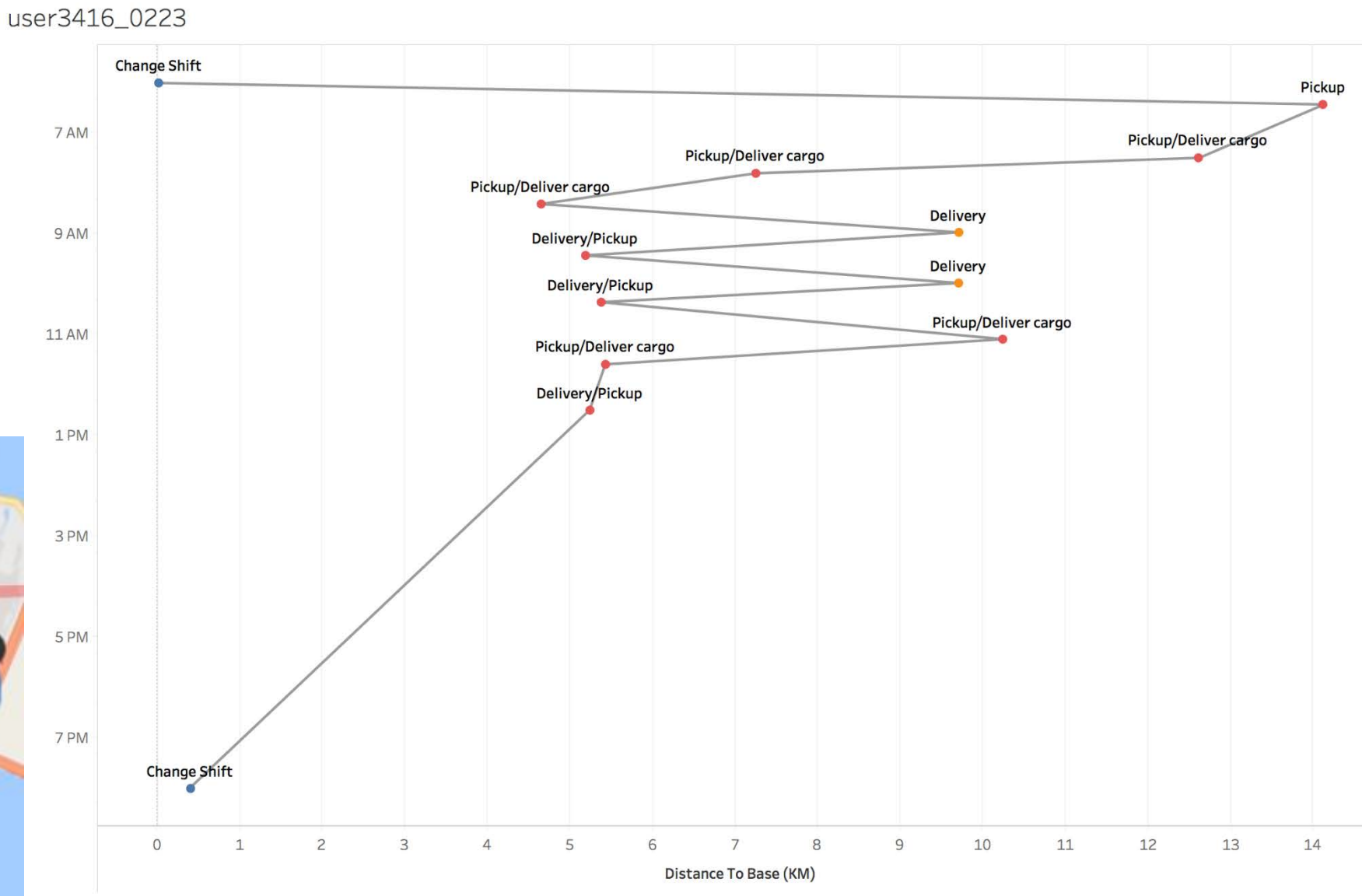

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