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Cargo Cycles for Local and Last Mile Delivery: Lessons from New York City

Alison Conway
City College of New York

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Alison Conway, Assistant Professor of Civil Engineering

The City College of New York

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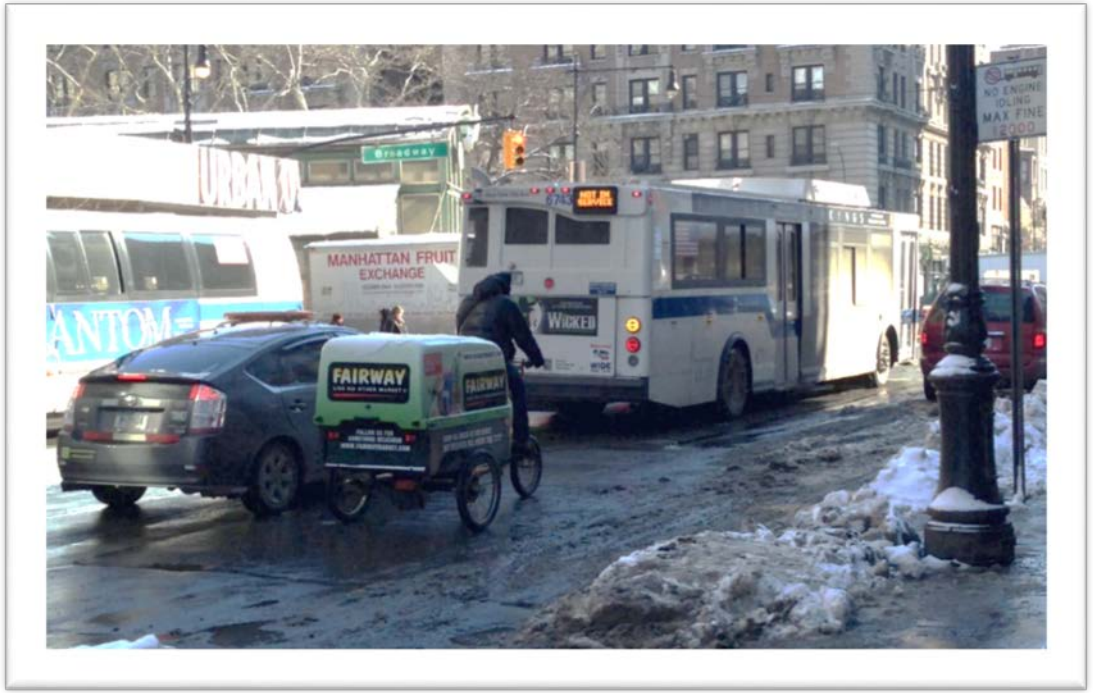
Project Motivation and Approach

Changing Conditions for Urban Freight

- Nearly all freight moves by truck/van
- Parking is inadequate and expensive
- Demand is growing and becoming increasingly complex
  - Just-in time commercial deliveries
  - Omni-channel retailing
  - e-Commerce
- Urban streets are becoming increasingly multimodal
  - 400 mi bike lanes since 2007
  - 60+ Complete Streets projects
  - 8 SelectBus corridors since 2008
  - Citibike implementation
- New interactions/incompatibilities
  - Reduced road and parking capacities
  - Narrow lanes/small turning radii
  - Increased bike/ped volumes

What is a cargo cycle?

- Primarily human-powered bicycle or tricycle with cargo carrying capacity



Project Approach

- What are the potential applications of cargo cycles in NYC?
- What are the benefits, challenges, and barriers to operation?
- How do freight tricycles perform in NYC conditions?

State of the Practice Review	
Literature Review	Original Survey

NYC Case Study Analysis			
Data Collection	Data Processing	Performance Measure Estimation	Externality Analysis

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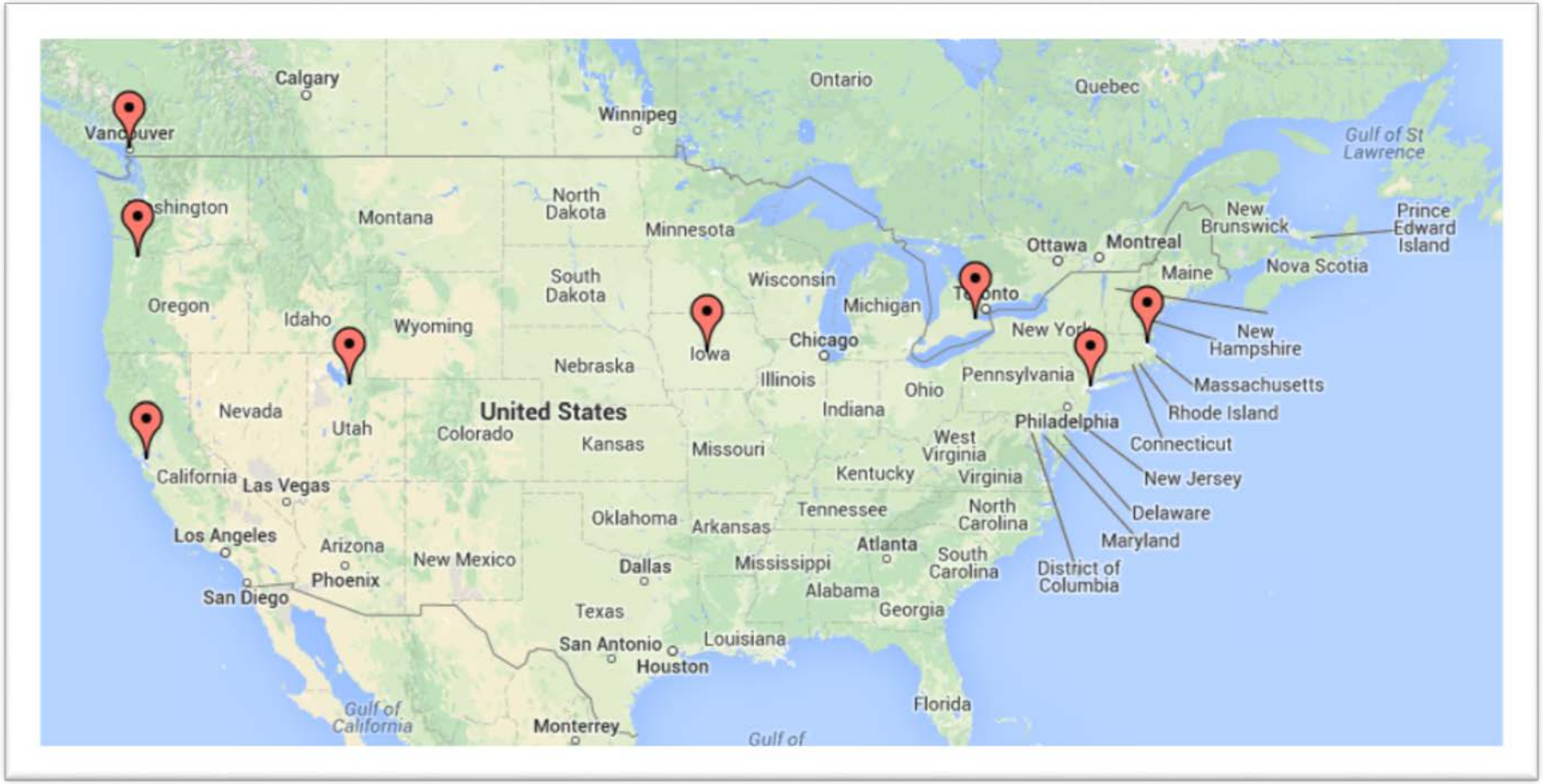
State of the Practice

Literature Review

Study	Focus
Transport for London (2009)	Outlined existing and potential future applications for cargo cycles in London
Dablanc (2011)	Monitored the operations of La Petite Reine, a cargo cycle company performing deliveries from a consolidation platform in central Paris
Browne, Allen, and Leonardi (2011)	Conducted a before and after analysis of an office supply company replacing van deliveries with cargo cycle operations from a micro-consolidation center
Verlinde et al. (2014)	Conducted a before and after analysis of a major parcel company implementing a mobile depot utilizing cargo cycles to replace motor vehicles for last-mile delivery
Gruber, Kihm, and Lenz (2014)	As part of ongoing "Ich ersetze ein Auto" project, studied the market potential for replacing motorized (car and van) courier operations with cargo cycle operations
Tipagornwong & Figliozzi (2013)	Modeled the cost competitiveness of cargo cycle vs. motor vehicle delivery operations in Portland
Koning and Conway (2015)	Quantified the externality savings from growing cargo cycle operations in Paris between 2001 and 2014

North American Survey



Commodities/Sectors Served

- Last mile parcel / courier
- B2B food deliveries
- B2C retail/restaurant deliveries
- Office supplies
- Pharmaceuticals
- Waste/recycling

Dominant sector in Europe ;
Large international operators

Dominant sector in North America;
Small, green-oriented businesses

Benefits of Cargo Cycles

For Operators

- Lower vehicle maintenance and fuel costs
- Driver health benefits
- Demonstrated commitment to sustainability
- Infrastructure flexibility
- Parking flexibility (and reduced fines)

For Urban Areas

- Not inherently incompatible with pedestrian/bicycle-friendly infrastructure
- Reduced exposure to heavy vehicles (especially for non-motorized travelers)
- Reduced GHG and air pollutant emissions
- Reduced noise impacts

Challenges

Operational

- Requires dense market within limited radius; usually located in expensive CBD
- High cost for transloading
- Lower economies of scale vs. fully utilized larger vehicles
- High driver costs (#, worker's compensation insurance)
- Customer perception/fear of the unknown

Regulatory

- Ambiguous vehicle classifications

Public Sector Involvement

Europe

- Funded pilot studies (EU and Local)
- Recognition schemes
- A few examples of direct operating subsidy
- Policies limiting motor vehicle access (e.g. bans, congestion charges, low emissions zones)
- Policies permitting flexible use of dedicated infrastructure

North America

- Limited research to date
- Ambiguous operating regulations
- Expensive insurance regulations (NYC)
- Limited regulation of freight access
- Limited financial investment
  - 2 cities: "capital" grants
  - 1 city: contract for recycling pickup
- Limited formal recognition of "green" best practices

Lower risk
Higher credibility
Reduced costs differential between modes

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NYC Case Studies

Participating Partners

City Bakery

- Local green bakery chain
- 7 locations - Midtown/ Downtown Manhattan
- 2 trikes / 5 total drivers
- Typical day: 7 AM – 7 PM
- Morning tour + on-demand deliveries

City Harvest

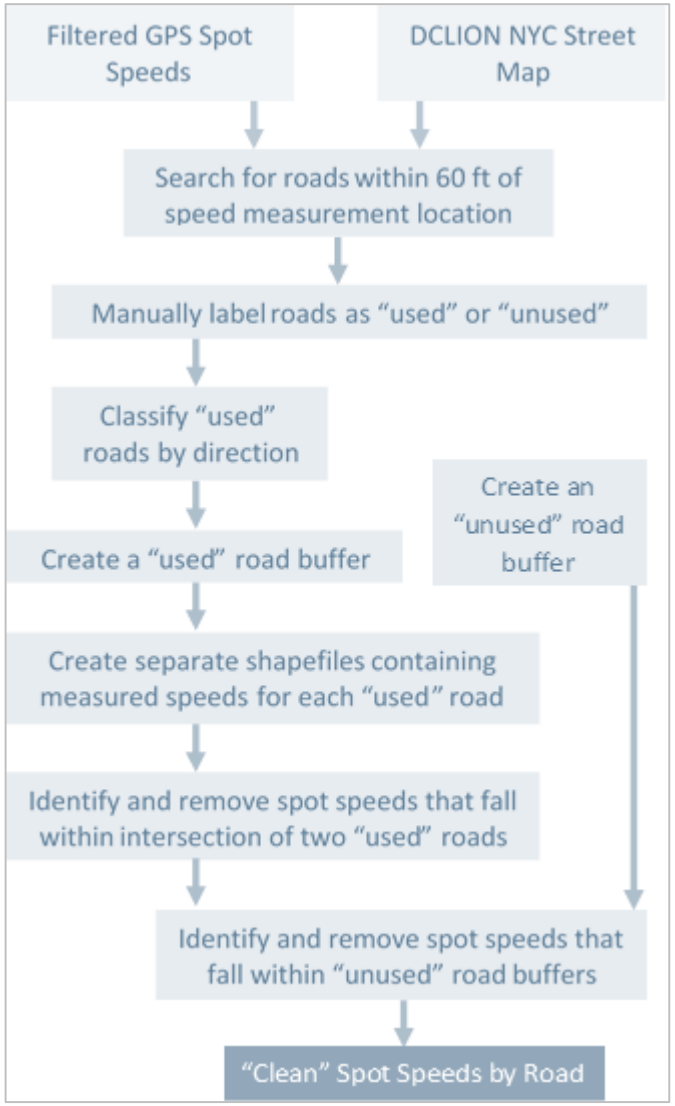
- Local food rescue non-profit
- 120+ potential Manhattan locations (by all vehicle types)
- 19 trucks - Long Island City
- 3 trikes - Midtown and Upper East Side / 1 driver per trike
- Typical Day: 12 PM – 12 AM
- Donation pickups < 50 lbs

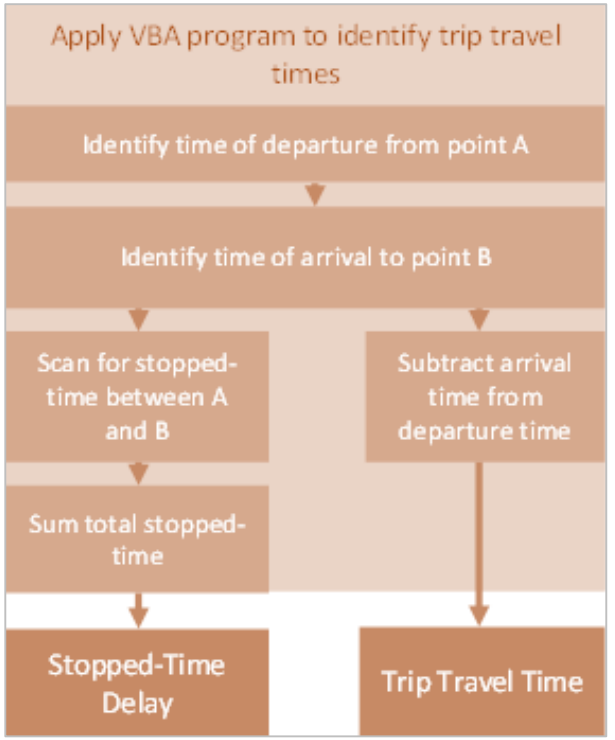
Data Collection

- QSTARZ BT-Q1000XT travel recorder
  - Stored in OtterBox
  - Attached to trike undercarriage/under truck seat using high strength Velcro
  - Chosen for passive operation
- Data Collected
  - 53 unique days of data for CB Trikes
  - 40 unique days of data for CH Trikes
  - 29 unique days of data for CH Trucks
- Challenges
  - Urban canyons
  - Drift points
  - Limited battery life and storage capacity
  - Vehicles not in operation

Variables
Local Date and Time
Latitude
Longitude
Spot Speed
~~Distance~~
Heading

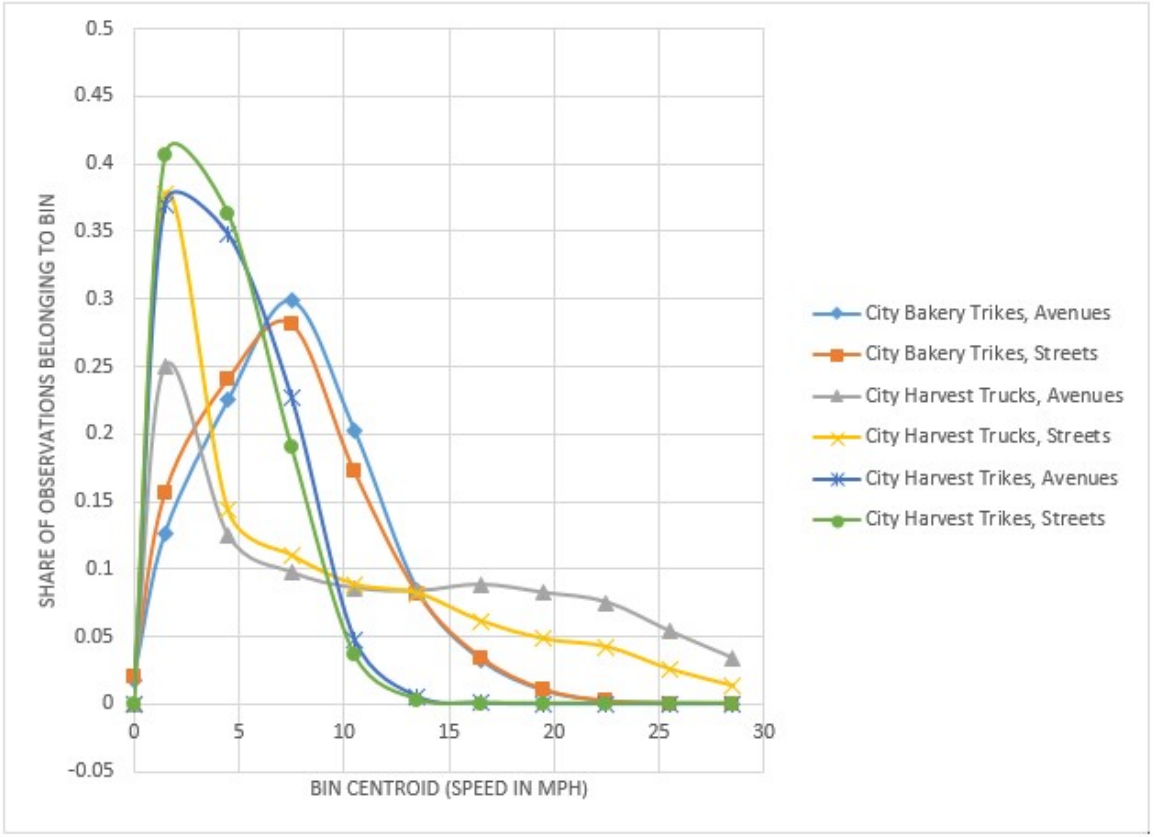
Performance Measure Estimation





Performance Measure 1: Corridor Moving Speed

- 60 ft road buffer
- Remove points within stop buffers and intersections
- Median is better estimator of central tendency than harmonic mean (Quiroga and Bullock, 1998)



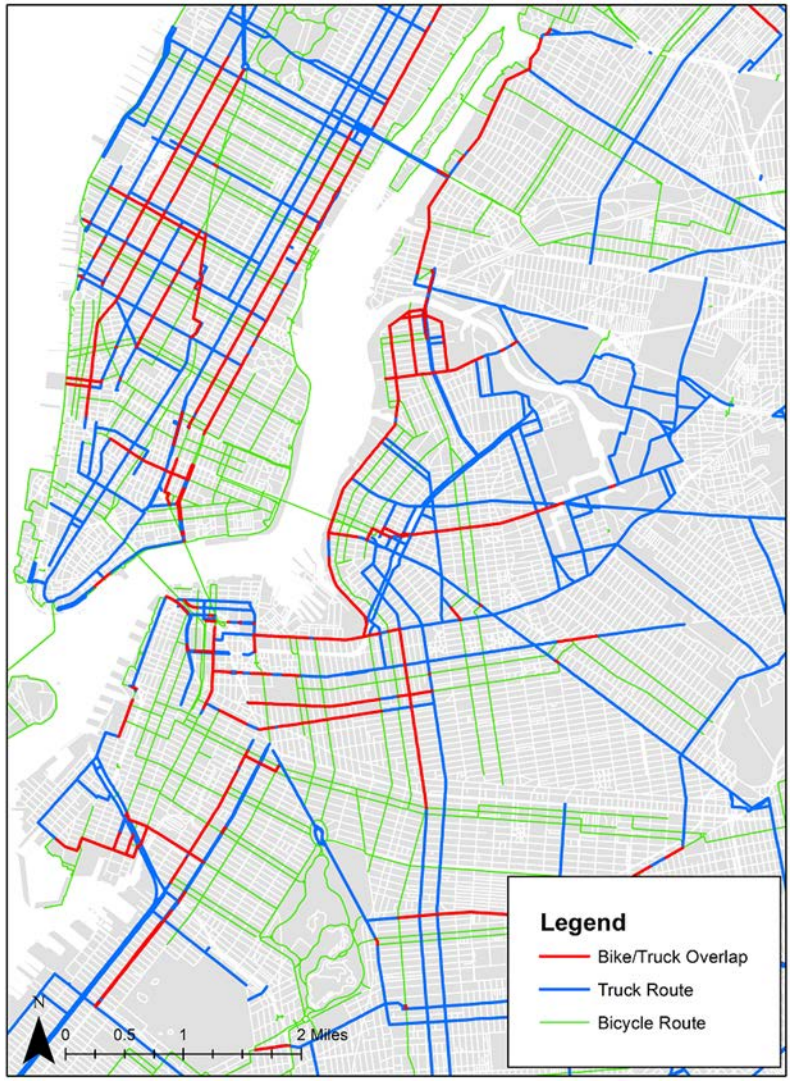
Dedicated Infrastructure

Operator Road Type	Mean Speed (mi/h)			t Statistic	Maximum Difference/Mean
	Truck Route	Non-Truck Route	Difference		
CB Tricycle, Avenue	7.7	7.5	0.2	7.2*	0.034
CB Tricycle, Street	8.0	7.1	0.9	12.0*	0.117#
CH Tricycle, Avenue	5.2	3.9	1.2	30.7*	0.315#
CH Tricycle, Street	4.5	4.0	0.5	9.2*	0.125#
CH Truck, Avenue	12.2	11.0	1.1	7.2*	0.104#
CH Truck, Street	9.1	7.4	1.7	8.2*	0.230#

Operator Road Type	Mean Speed (mi/h)			t Statistic	Maximum Difference/Mean
	Bicycle Lane	Non-Bicycle	Difference		
CB Tricycle, Avenue	7.7	7.5	0.2	5.0*	0.03
CB Tricycle, Street	7.0	7.7	-0.7	-10.9*	.09#
CH Tricycle, Avenue	5.1	4.2	0.9	19.0*	.21#
CH Tricycle, Street	4.1	4.0	0.1	3.5*	0.03
CH Truck, Avenue	10.2	12.0	-1.8	-10.1*	.17#
CH Truck, Street	7.5	8.2	-0.7	-1.6	.09#

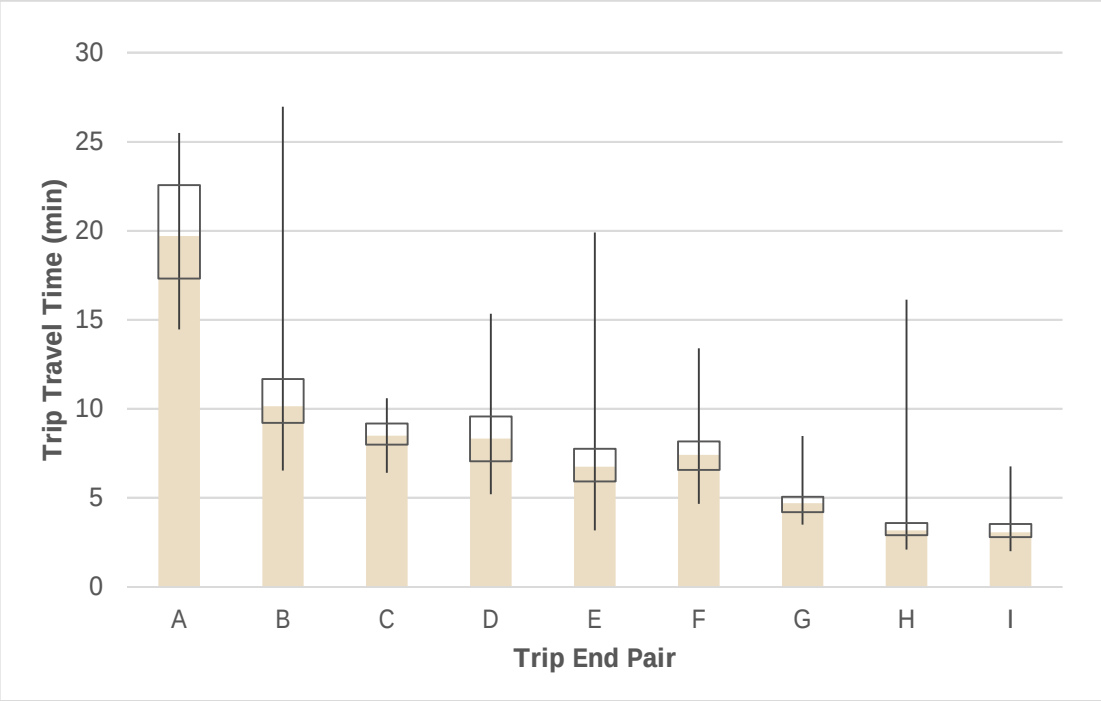
* Difference significant at confidence level of 95%

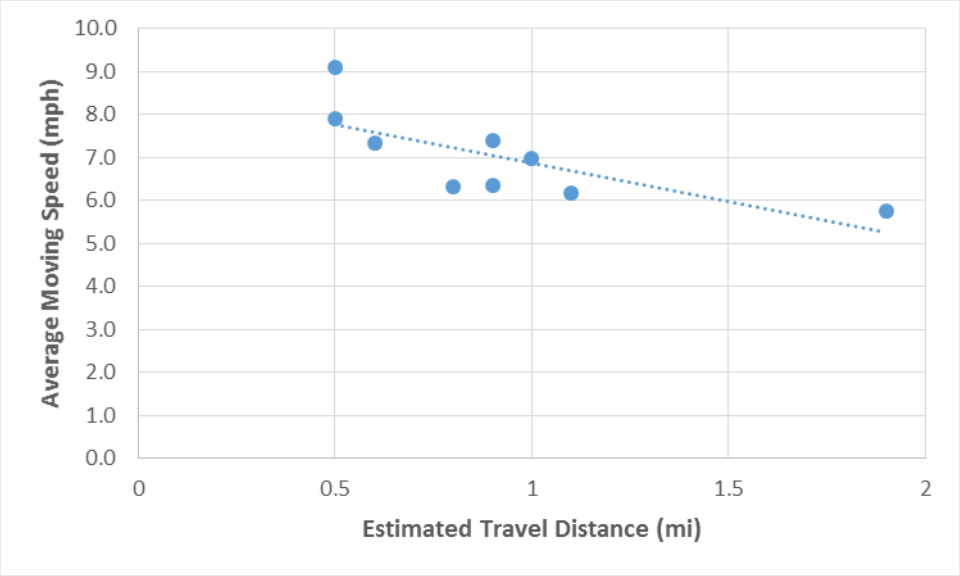
\# Difference more than 5 percent of median observed value



Performance Measure 2a: Travel Time

- Direct evaluation of repeated trips for City Bakery

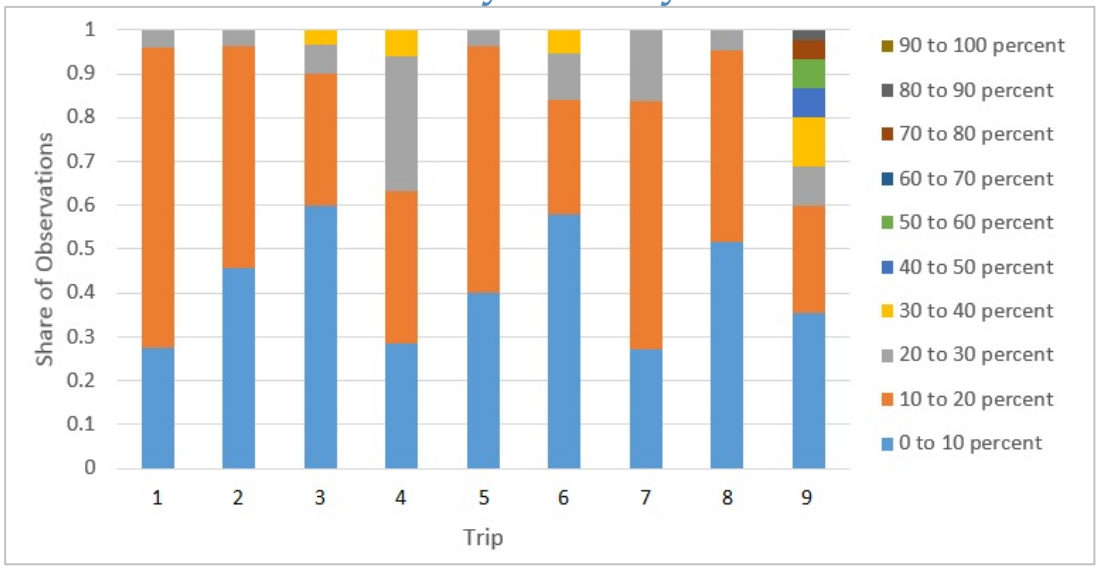




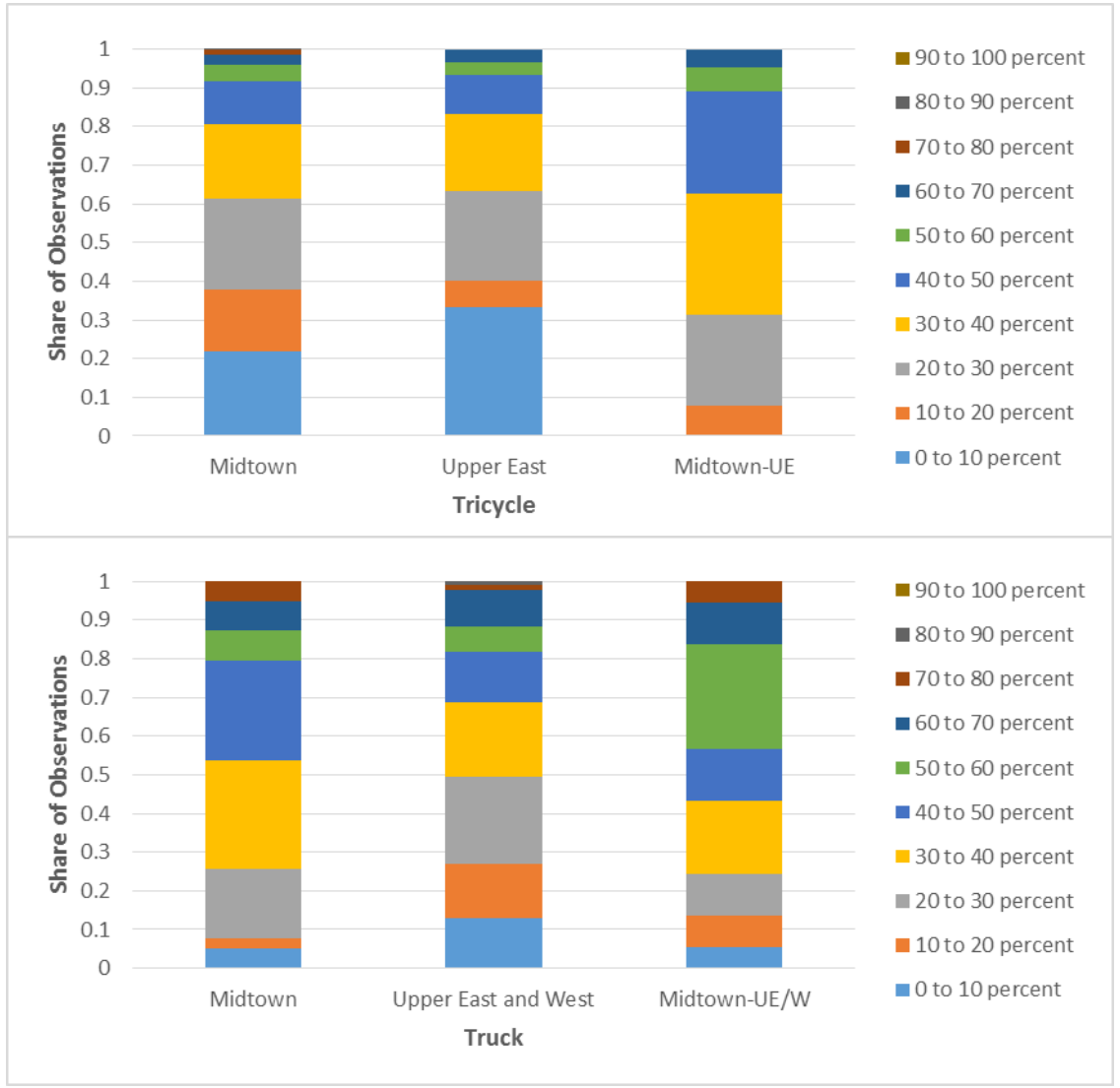
Performance Measure 2b: Stopped-Time Delay

- Direct evaluation of repeated trips for City Bakery
- Neighborhood to neighborhood trips for City Harvest

City Bakery

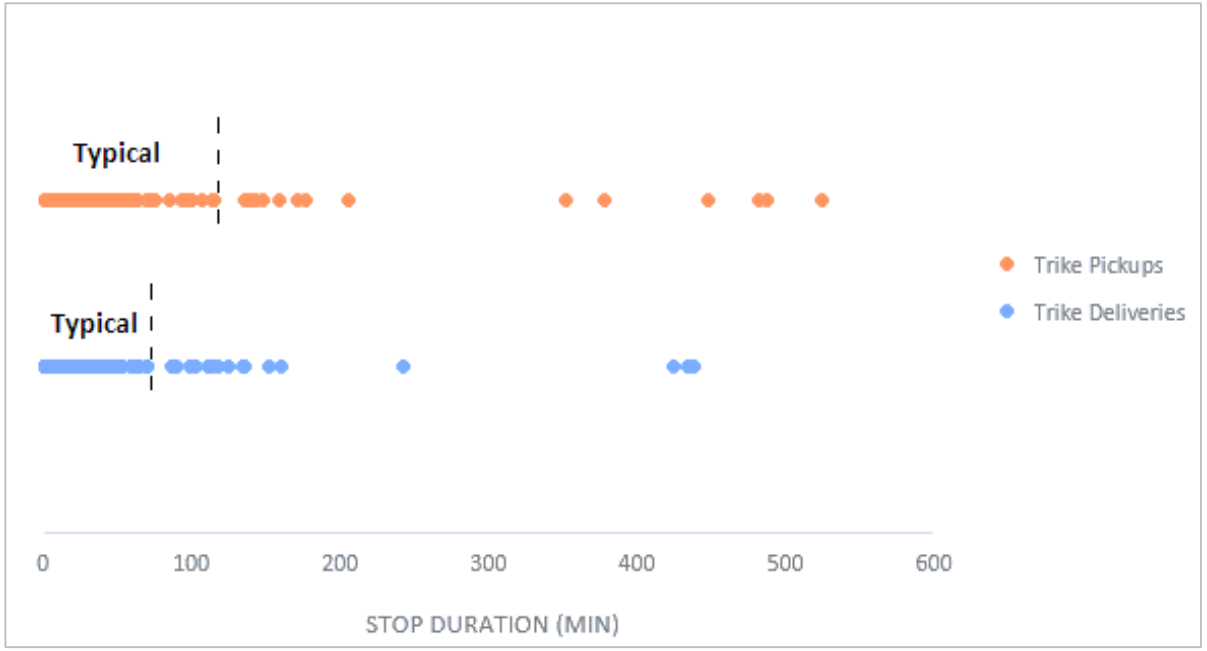


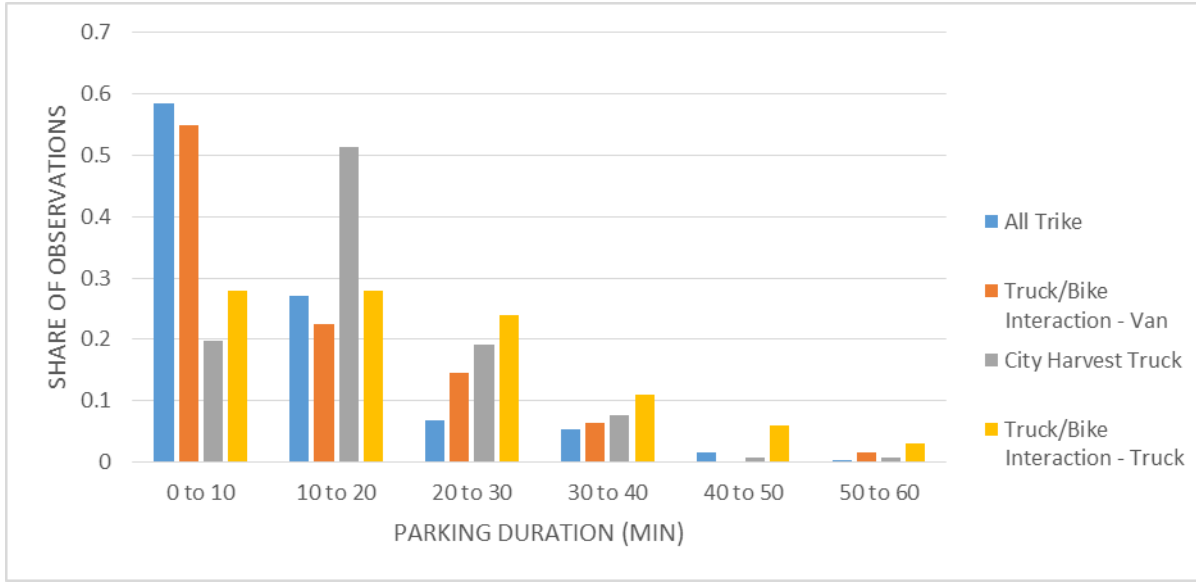
City Harvest



Performance Measure 3: Stop Durations

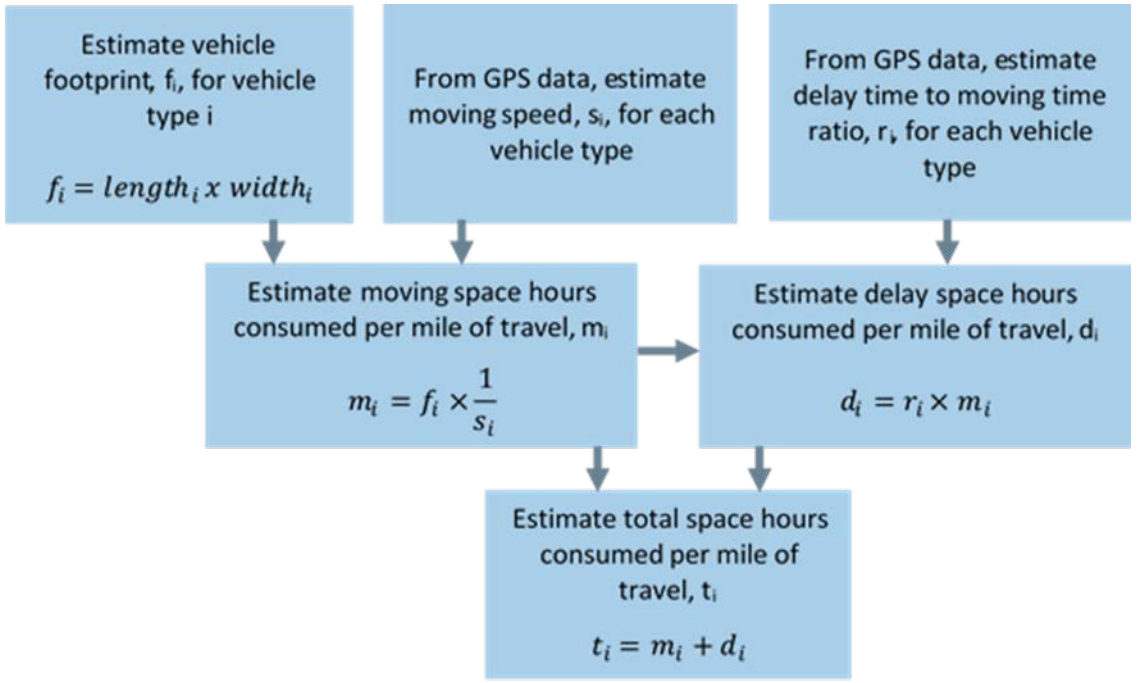
- City Bakery
  - Producer Locations
  - Receiver Locations
- City Harvest Trikes
  - Pickup Locations
  - Delivery Location
- City Harvest Trucks
  - Deliveries only in study area





Space Consumption

Moving



Parked

$$s_l = f_x * D_x$$

where

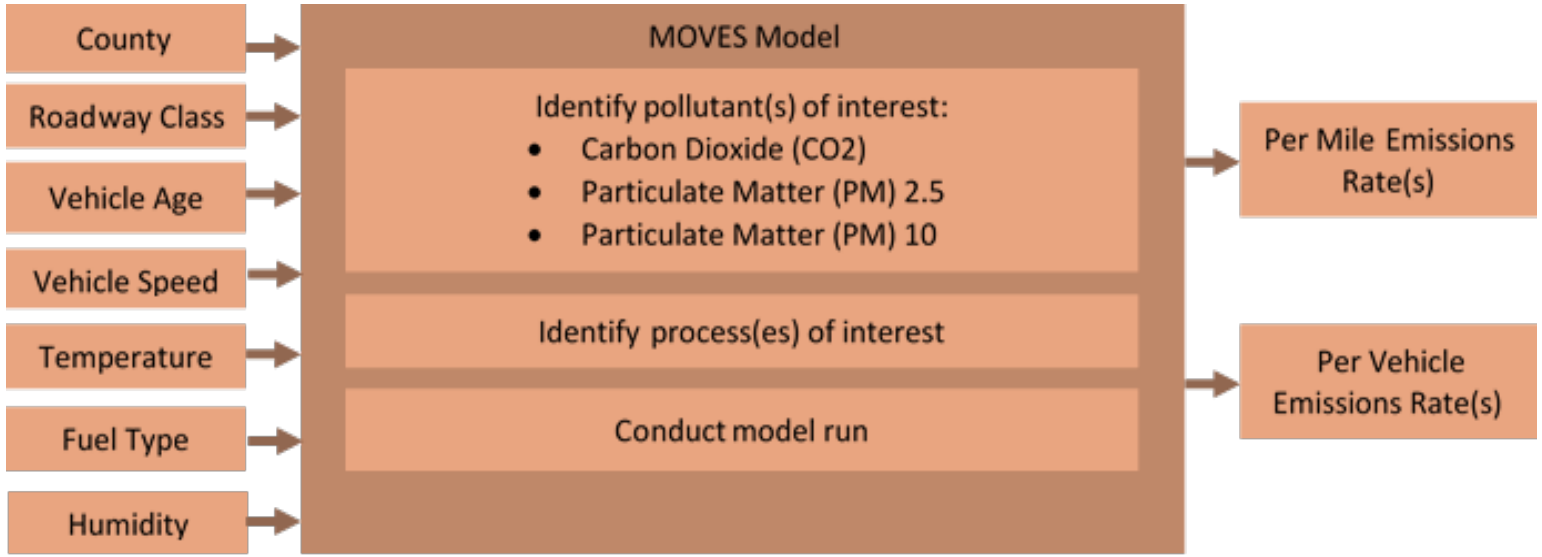
s_l = space consumed at location l

f_x = footprint of vehicle x

D_l = duration vehicle x parked at location l

Emissions Estimation

- Model emissions of vehicle replaced using EPA's MOVES model



NYC Externality Results: City Bakery Cycle vs. Van

	Cargo Cycle	Direct Replacement	Combined Tour
Total Road Space Consumed (ft^2*hrs)	109	475	422
Total Parking Space Consumed (ft^2*hrs)	164	599	541
Total Space Consumed (ft^2*hrs)	272	1074	964

	$PM_{2.5}$	CO_2
Rate (lbs/mi)	$1.3*10^{-4}$	2.95
Estimated Annual Savings	(lbs)	(tons)
Scenario A	1.1	12.8
Scenario B	1.0	11.4

Sensitivity Analysis

- Relative space consumed by van → 2.8 to 8 times cargo cycle
- Savings .7 to 2.3 x benchmark → most sensitive to vehicle age

Lessons Learned

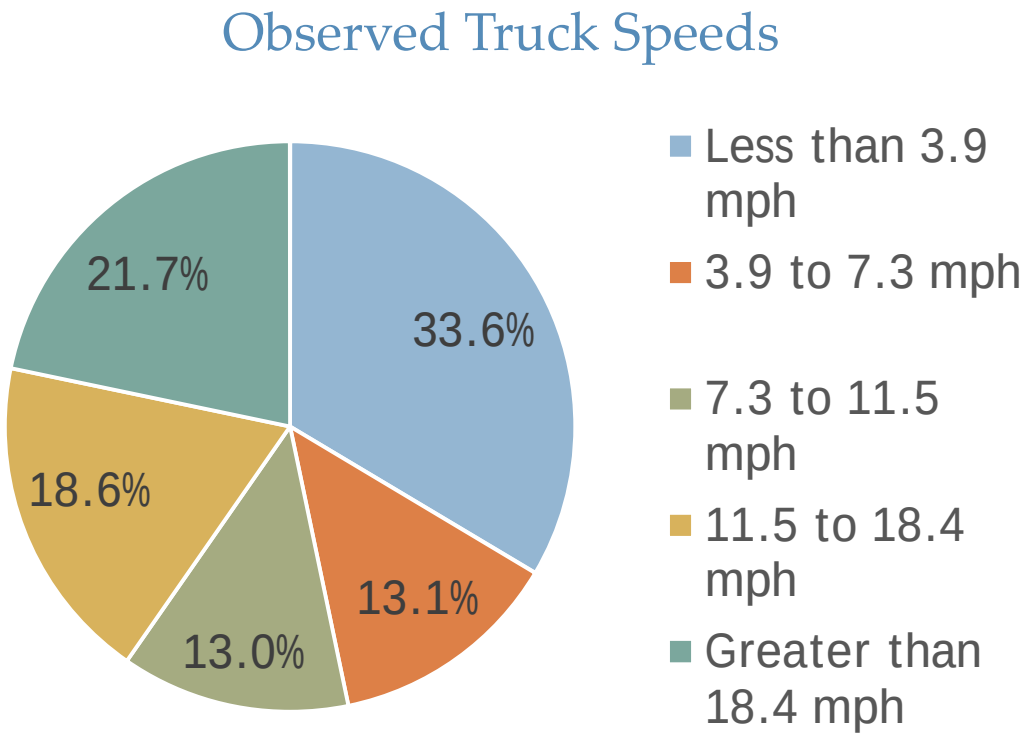
Performance Summary

- Speeds competitive with MV speeds in dense areas
- Speeds influenced by payload, trip distance, trip urgency
- High travel time reliability/low stopped-time delay
- Mostly short stops/some very long stops little influenced by regulations

- Emissions and space savings highly variable based on vehicle replaced, reorganization of logistics
- Emissions and space savings greatest in most severe conditions

- Trike trip distance often < motor vehicle trip distance

Estimated 1-Mile Travel Time (min)		
CB Trike	CH Trike	CH Trucks
9.4	20.9	9.7



Benefits of Cargo Cycles

For Operators

- Lower vehicle maintenance and fuel costs
- Driver health benefits
- Demonstrated commitment to sustainability
- **Infrastructure flexibility**
- **Parking flexibility (and reduced fines)**
- **Reliable travel times in congested traffic (within limited radius)**
- **Shorter trip distances on constrained network**

For Urban Areas

- Not inherently incompatible with pedestrian/bicycle-friendly infrastructure
- Reduced exposure to heavy vehicles (especially for non-motorized travelers)
- **Reduced GHG and air pollutant emissions**
- Reduced noise impacts
- **Reduced road and parking space consumption**

Challenges

Operational

- Requires dense market within limited radius; usually located in expensive CBD
- High cost for transloading
- Lower economies of scale vs. fully utilized larger vehicles
- High driver costs (#, worker's compensation insurance)
- Customer perception/fear of the unknown
- **Lower speeds in uncongested conditions/constrained by human limitations**

Regulatory

- Ambiguous vehicle classifications
- **Inhospitable infrastructure (e.g. bridge security ballards)**
- **(Il)legality of electric assists**

Acknowledgements

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  - Bikes at Work Inc., Ames, Iowa
  - B-Line Urban Delivery, Portland, OR
  - Metro Pedal Power, Somerville, MA
  - Pedal Express, Berkeley, CA
  - Shift Urban Cargo Delivery, Vancouver, BC
  - Stick Dog Pedicabs, Salt Lake City, UT
  - The Hammer Active Alternative Transportation, Hamilton, ON

Questions?

aconway@ccny.cuny.edu

Project Report

http://www.utrc2.org/sites/default/files/pubs/Final-Freight-Tricycles-NYC.pdf