CPS EAGER: Autonomy-enabled Shared Vehicles for Mobility on Demand and Urban Logistics

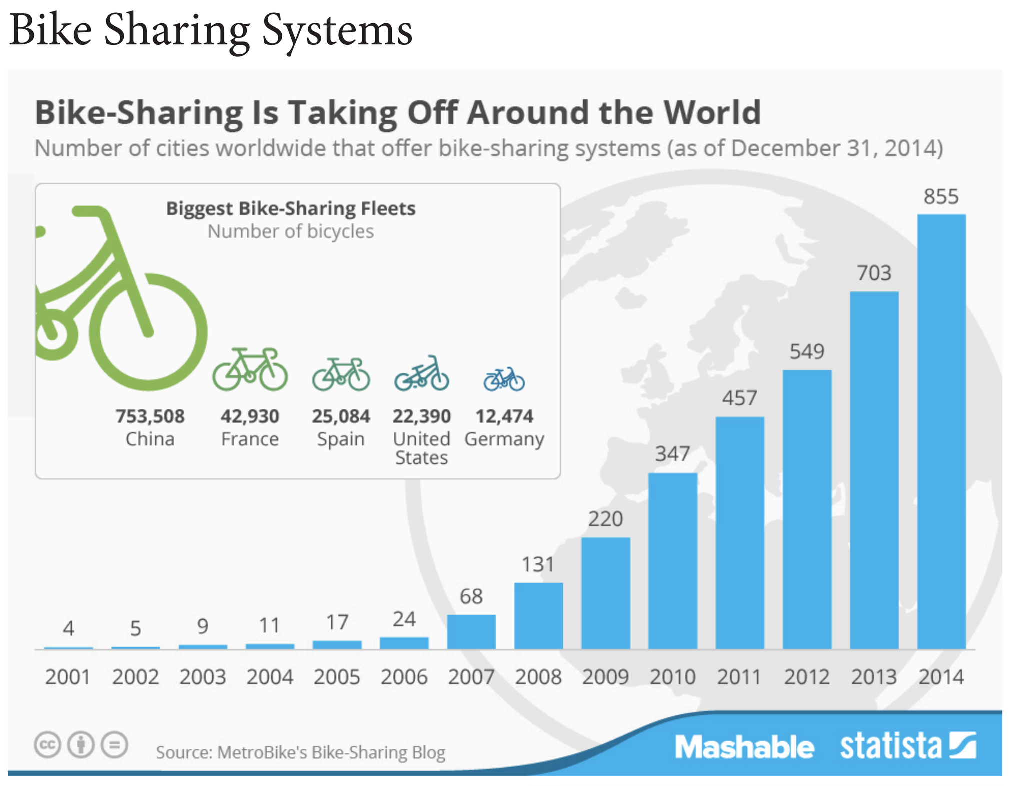
PIs: Sertac Karaman & Kent Larson, Massachusetts Institute of Technology

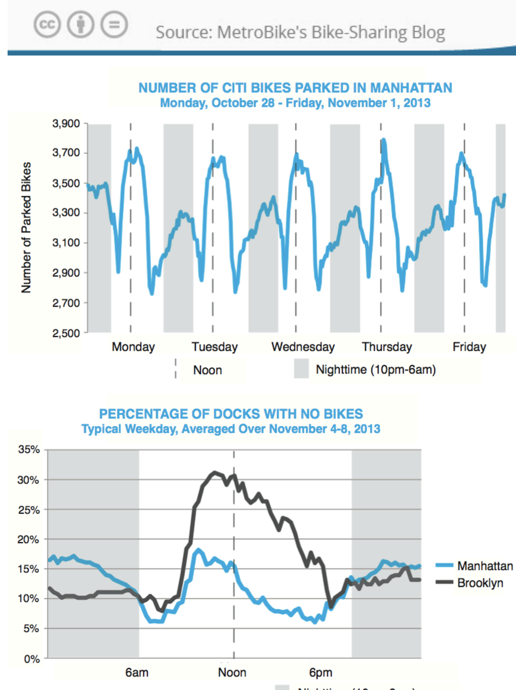
Abstract: The cities in the U.S. and elsewhere in the developed world are experiencing a transformation: Many people demand denser neighborhood with mixed use, while they choose to utilize public transportation, rather than private cars, for their commute and other daily transportation needs. To support this trend, cities are in need of novel transportation and logistics services that can help address the needs of their citizens, boost their productivity, and increase the wellness of their lives. There are a number of emerging technologies that can address this challenge. Among these are Internet-of-Things-enabled vehicle sharing services, electric vehicles, and autonomous vehicle technologies. Bringing these technologies close together can help enable joint mobility-on-demand and urban-logistics services. The proposed work aims to develop and demonstrate the Persuasive Electric Vehicle (PEV), an autonomous tricycle that can shuttle passengers as well as packets ordered through online vendors, in an urban environment utilizing the bike lanes.

The **intellectual merit** of the proposed work is found in the co-development of design and algorithms for vehicle-level and system-scale autonomous vehicles to operate in urban environments delivering both mobility-on-demand and urban-logistics services. On the algorithmic front, provably-safe algorithms for autonomous navigation in bike lanes as well as algorithms for high-performance routing and rebalancing will be developed. On the design front, the designs that can best embrace CPS technologies will be investigated. The proposed work will also investigate the best neighborhood and city planning practices that help enable the proposed concept.

The **broader impacts** will be materialized through education activities and participation in the Global City Teams Challenge organized by the National Institute of Standards and Technology (NIST). The proposed project will fuel various relevant Cyber-Physical Systems (CPS) classes at MIT. Furthermore, the PIs will partner with the New Urban Mechanics Group at the City of Boston Government to participate in the Global City Teams Challenge, where they will demonstrate their prototype PEV as well as their simulation results on a 3D model of a relevant neighborhood of the City of Boston. With the help of this participation, the proposing team will engage with city governments and researchers throughout the world.

Bike Sharing Systems

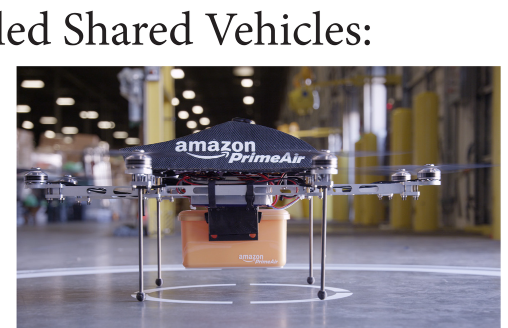




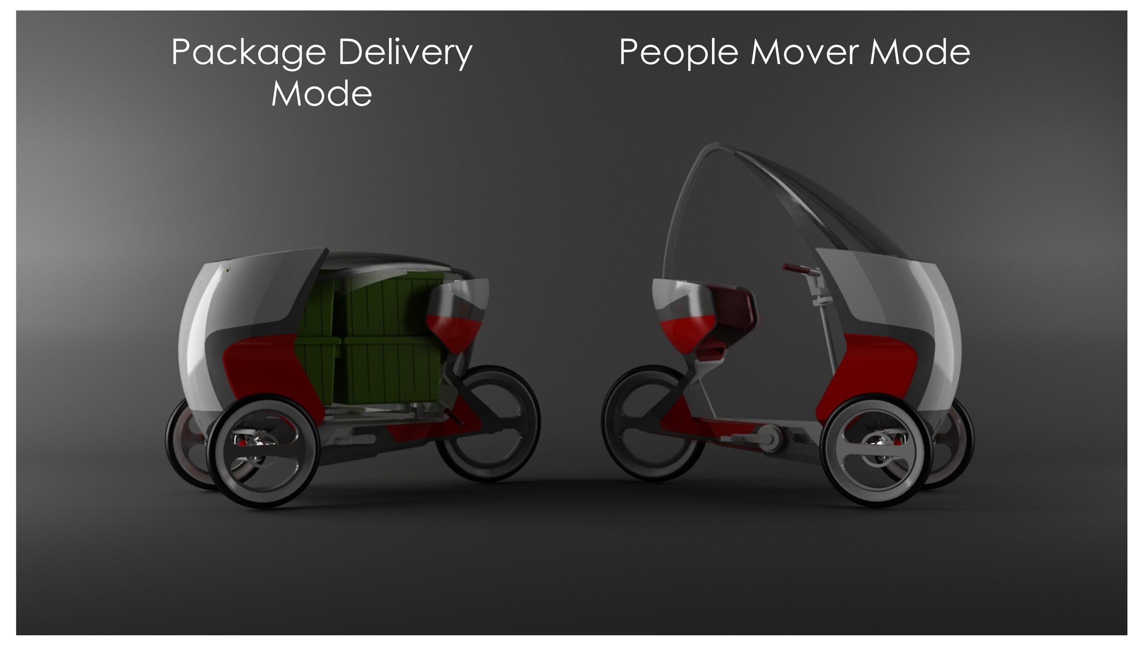
Urban Delivery with Tricycles

Ideas for Autonomy-enabled Shared Vehicles:


Google's self-driving car


Amazon's delivery drone

The Persuasive Electric Vehicle



Our Team

Kent Larson & Ryan Chin
The Media Lab
Massachusetts Institute of Technology

Sertac Karaman
Laboratory for Information and Decision Systems
Massachusetts Institute of Technology

Edgar Blanco & Mathias Winkenback
Center for Transporation and Logistics
Massachusetts Institute of Technology

Chris Osgood & Nigel Jacob
New Urban Mechanics Group
City of Boston

Progress

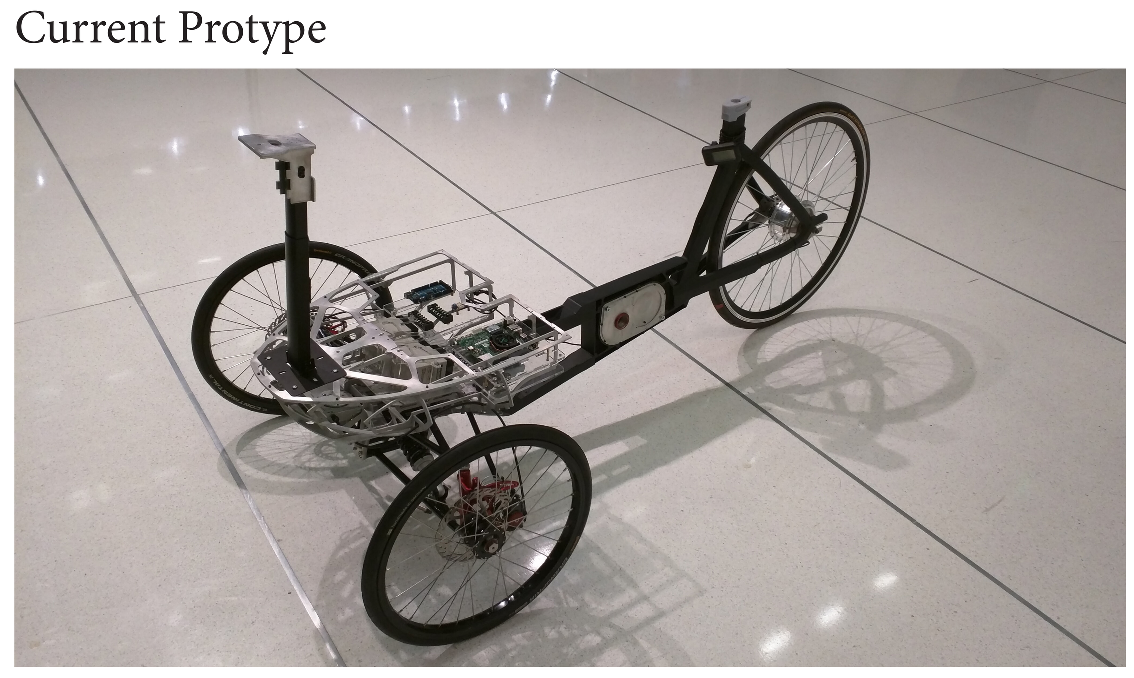
- Second prototype completed: Aluminum construction vehicle, built by professional bike manufacturers; Utilizes state of the art embedded supercomputers and sensors.
- Simulations show tremendous improvement in emissions, and transportation delays.
- We are investigating novel algorithms allow detailed perception with stereo cameras and one short range laser range finder.

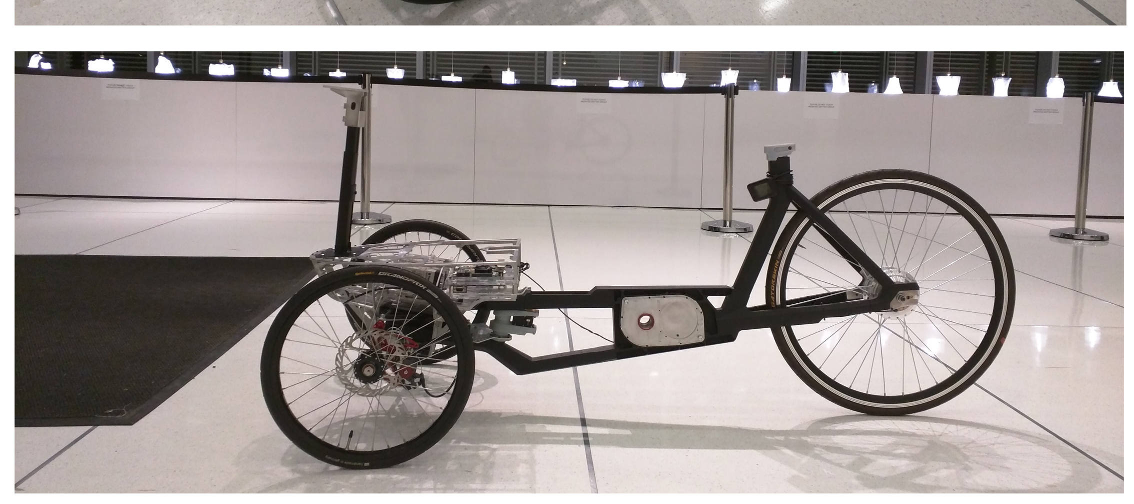
Participation in Major Events

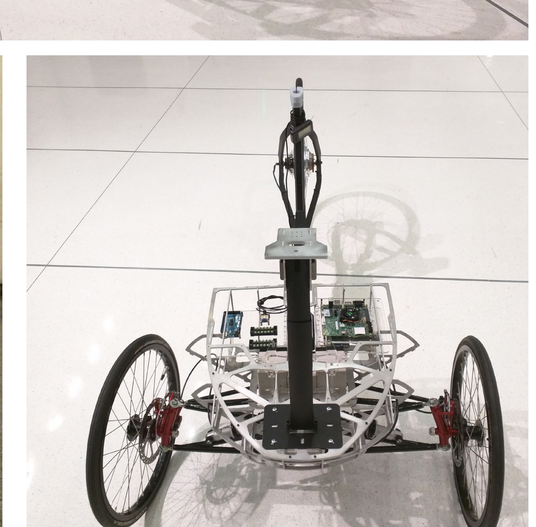
- Participated in the Global City Teams Challenge in 2015.
- We will particpate in the Global City Teams Challenge in 2016.

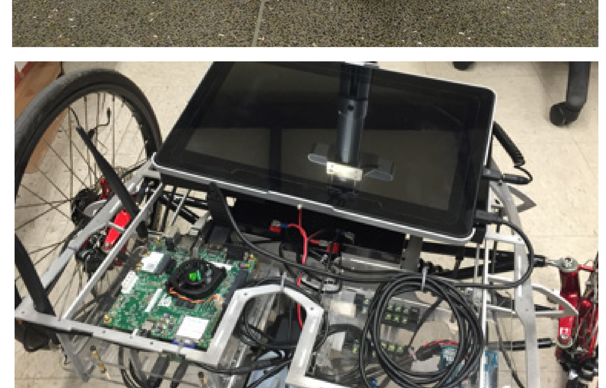
GLOBAL CITY TEAMS CHALLENGE

Current Protype





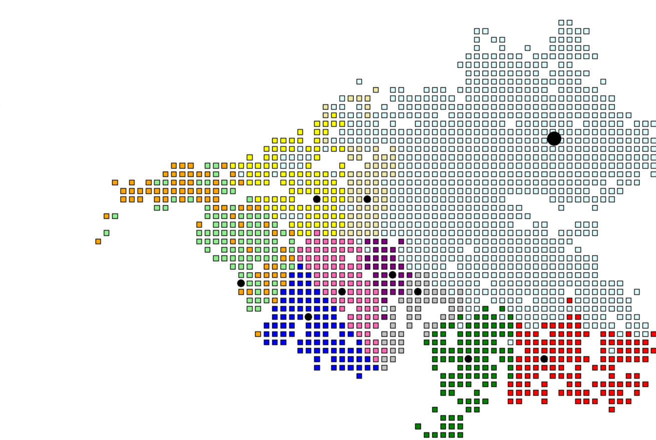




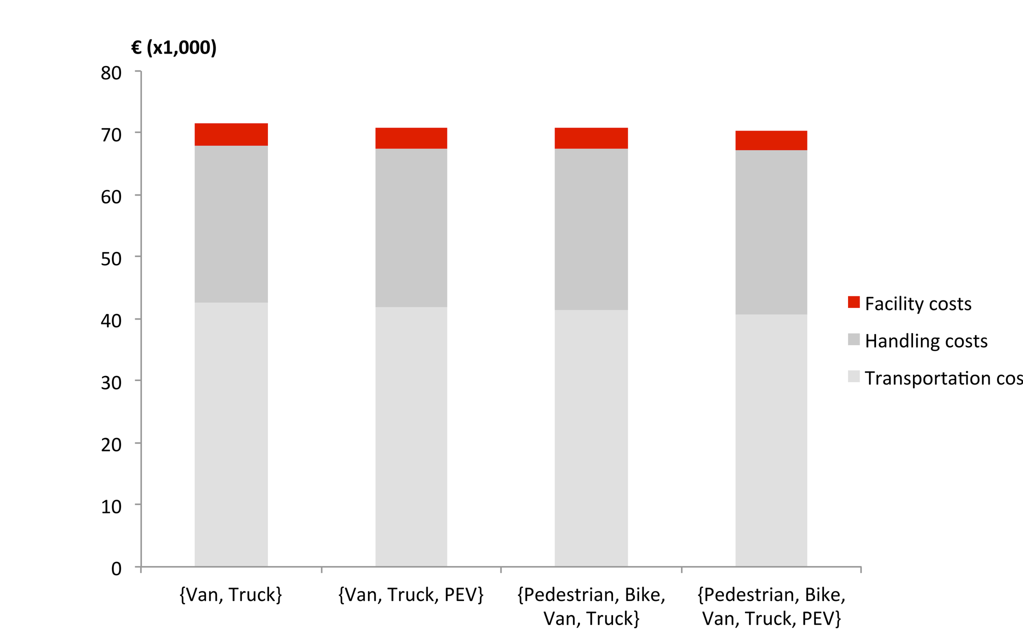

Nvidia Jetson TK1

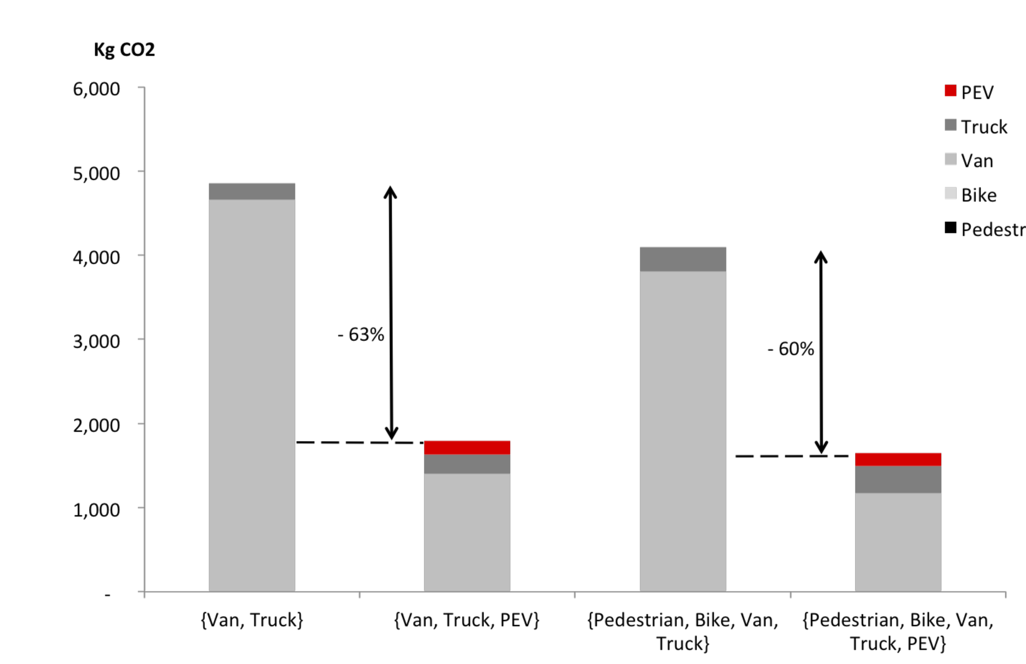
Simulation Studies

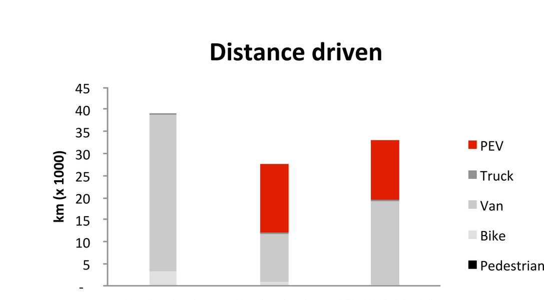
Some of the facts:
- 600,000 people in 400 km2 'de
- 30,000 packets per day
- Carriers: Pedestrian, Bicycle, Van, Truck



		Pedestrian	Bike	Van	Truck	PEV
Capacity	liter	320	900	2,500	20,000	216
Speed within tour	km/h	3.6	9.0	20.0	25.0	10.0
Speed line haul	km/h	3.6	9.0	25.0	25.0	15.0
Fixed costs	€/day	0.50	2.30	10.00	45.00	17.81
Operating costs	€/hour	-	-	5.00	21.50	3.12
Wage (during route)	€/hour	26.40	26.40	26.40	26.40	-
Wage (PEV Hub)	€/hour	-	-	-	-	26.40
Relative distance factor		-2.64%	8.13%	18.89%	22.47%	8.13%
Time per stop	min	2.33	3.33	4.33	5	4
Service time per item	min	0.67	0.67	0.67	0.67	1







Similation studies indicate a significant improvement in emissions, when the cost is kept constant.

Acknowledgements

- This project was funded by the NSF Cyber-Physical Systems (CPS) program