

Autonomous Urban Delivery

New Systems for Moving People, Goods, and Services

A City Science Design Workshop (MAS 552 / 4.557)

Instructors – Kent Larson, Ryan Chin

Guest Instructors – Sertac Karaman, Matthias Winkenbach, and Edgar Blanco

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Prerequisites – Permission of Instructor, Units (3-0-9), Fall 2015

Class Days – Wednesday, 2:00 – 5:00pm, Room E15-341 (First Class September 9th)

Class Description – This course will focus on the design of new systems for achieving low-cost, low-speed autonomous delivery of people, goods, and services in dense urban environments. Today’s rapidly urbanizing cities face many challenges in mobility networks including excessive congestion, carbon emissions, energy inefficiency, poor land-use, noise pollution, and a low quality of life for many citizens. Autonomous technology holds much promise to address these problems, however, the focus of much of the driverless technology has been targeted at moving passengers in private vehicles at high speed, long-distances, and at high cost (e.g., use of LIDAR systems). However, in cities where speeds are lower, distances are shorter, and the movement of goods and services significantly impacts congestion and the environment, the opportunity is to develop new-shared concepts for disrupting current transportation paradigms.

Students this term will have the opportunity to imagine a new vision for the robotic delivery of people, goods, and services through ethnographic studies, the creation of new user scenarios, fabrication of prototypes, integration of new sensing and autonomous control technology, building of logistics models and simulations, design of new urban infrastructure, and the development of new business models. The class will build upon research conducted by three different labs at MIT including:

- 1) Autonomous Systems – by the Foundations of Autonomous Systems Technology group led by Professor Sertac Karaman in the Aero/Astro Department
- 2) Urban Logistics – by the MegaCity Logistics Group led by Edgar Blanco (Founder) and Matthias Winkenbach (Director) at the MIT Center for Transportation & Logistics
- 3) Mobility-on-Demand Systems – by the City Science initiative led by Kent Larson (Co-Director) and Ryan Chin (Managing Director) at the MIT Media Lab.

The class will also build upon the Persuasive Electric Vehicle (PEV) – a three-wheeled, autonomous, on-demand, electric-assist vehicle designed to be driven bike lanes (legally). The PEV can transform from moving people to goods (see figure 1), thus taking advantage of underutilized capacity in vehicle share networks. For example, the PEV can move goods during evening or non-peak hours if it is part of a bike-share program. Users of a fleet of PEVs can

request a vehicle to be delivered autonomously to a pick-up point along a bike lane, drive the PEV to their destination, and safely get out at their drop-off point. The PEV will then redistribute itself to the location of the next user or park to be recharged or serviced. During non-peak hours, the PEV converts to a robotic delivery machine with point-to-point package moving capability (see figure 2):



Figure 1: PEV converts from people to package delivery



Figure 2: PEV during loading and offloading scenarios

Working in small teams, students will select from the following research topics for their area of focus:

- Design of new lightweight electric vehicles for autonomous delivery
- Low-cost sensing technologies and autonomous control
- System modeling and simulations of people/package movement
- Design of new user interfaces and apps
- Development of new markets (e.g., on-demand robotic coffee)
- Desktop research on existing case studies in urban delivery
- Design of urban infrastructure (e.g., pathways, charging stations, loading docks, handling systems, autonomous intersections)

Student teams are expected to conceptualize a new product or service and develop prototypes for demonstration (by the end of the term) as well as create a roadmap for eventual deployment. Class participants will be divided into small teams to focus on one or more research areas for the duration of the semester based on their interest, experience and skill sets. Each area will be lead by a mentor from the City Science Initiative and our collaborators. Student teams are expected to work together as a unit to conceptualize, design, fabricate, and assemble a series of mock-ups and prototypes throughout the term.

Key Events and Milestones – To accelerate design development the course will participate in the Media Lab’s Members Week event, which includes demonstrations of prototypes during open house sessions. Over 80 multi-national companies will be in attendance during the week of October 27-30th. Representatives from industry can provide valuable feedback on class projects. Secondly, the class will participate in a Hackathon hosted by the Disrupting Mobility Summit on November 6-8th. The theme of the Hackathon is the design of autonomous urban delivery systems. The Hackathon is open to more than 150 participants with criteria for judging winners that are eligible for awards at the end of the Summit. For more on the Summit go here (<http://www.disrupting-mobility.org>). Thirdly, an outside-of-class-time tour will be organized of several logistics centers to familiarize the class on the mechanics and systems behind

distribution centers. Tours will be of facilities like that of UPS, Walgreens, Legal Sea Foods (for cold-food handling), and others (dates TBC).

Enrollment – This class seeks highly motivated students with the necessary skills to prototype new urban systems. Students interested in joining the class will be required to submit a short essay of interest, CV and/or portfolio, and sign up for a short 15-minute interview to be held on either Sep 10th or 11th. Students with a background in mechanical engineering, computer science, robotics, architecture, urban planning, transportation, logistics, engineering systems, management, product design, and human machine interface are preferred.

Website – <http://cp.media.mit.edu/workshops/>

Mentors – Michael Lin, Waleed Gowharji, Mario Siller, Agnis Stibe, Daniel Merchan, Franziskus Wiedemann, Yan Zhang

Schedule – A typical class session will have a presentation by guest speakers, followed by student group discussions. Additional class time requirements include individual and team meetings with instructor(s) and team working meetings outside of class hours.

Week	Date	Session Overview	Lectures/Events
1	9.9.15	<p>FIRST CLASS MEETING, 2pm Introductions and presentations by City Science.</p> <p>Students will identify their top 3 research areas</p> <p><i>Course Interviews on September 10+11 (Essay and CV due at interview)</i></p> <p><i>Course admission announced on (September 12)</i></p> <p><i>Reading Assignment No. 1</i></p>	<p>Course Introduction (30 min.) Course overview (1 hour) Course logistics (30 min.)</p>
2	9.16.15	<p>Team assignments and introductions</p> <p>In-class brainstorming and review of results.</p>	<p>Autonomous Technology (Sertac Karaman)</p> <p>MegaCity Logistics (Matthias)</p>

		Hand out design assignment # 1	Winkenbach)
3	9.23.15	<i>Review of design assignment # 1</i> <i>Start design Assignment #2</i>	Speaker from City of Boston (TBA) Tours scheduled outside of class time (Walgreens, UPS, Legal Seafoods, etc.) – TBC
4	9.30.15	<i>Review of Design Assignment #2</i> Start Design Assignment #3	Deverl Maserang (Starbucks)
5	10.7.15	Review Design Assignment #3	Jinhua Zhao (DUSP)
6	10.14.15	Interim review	Chris Zegras (DUSP)
7	10.21.15	Preparation for Members week	Hossein Rahnama (Ryerson University)
8	10.28.15	Media Lab Members Week (Demos to be shown at open house(s))	
9	11.4.15	Preparation for weekend Hackathon	Hackathon: Autonomous Urban Delivery (Nov 6-8)
10	11.11.15	No Classes (Veterans day)	Disrupting Mobility Summit (Nov 11-13)
11	11.18.15	Set goals and deliverables for rest of term	
12	11.25.15	No Classes – Thanksgiving Holiday	
13	12.2.15	Student Work Session	
14	12.9.15	Last Day of Class	
15	12.16.15	Final REVIEW Invited Critics (TBC): Joi Ito, Hiroshi Ishii, Dennis Frenchman, Ralph Gakenheimer, Nigel Jacob, Chris Osgood, Chris	

		Zegras	

Reference Websites

Changing Places Research Group, MIT Media Lab: <http://cp.media.mit.edu/>

City Science Initiative, MIT Media Lab: <http://cities.media.mit.edu/>

Foundations of Autonomous Systems Group: <http://peris.mit.edu>

MegaCity Logisitics Lab: <http://megacitylab.mit.edu>

Required Readings

Below is a list of general readings for the entire class. Each module will have additional specific readings provided by the Module Mentor.

- *Reinventing the Automobile*, William J. Mitchell, Christopher Borroni-Bird, Lawrence Burns.
Available at: MIT Press (limited availability) or Amazon.com
- *Triumph of the City*, Edward Glaeser
Available at: Harvard COOP or Amazon.com
- *Social Physics: How Good Ideas Spread—The Lessons from a New Science*, Alex Pentland
Available at: MIT Press or Amazon.com