Urban Robotics: Achieving Autonomy in Design and Regulation of Robots and Cities

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Part I: Introduction

Are cities ready for self-driving, artificially intelligent, vehicles and robotics? The urban marketplace is increasingly filled with products emblematic of "smart" cities, from widely discussed autonomous vehicles to smaller variations on the theme, such as robotics for delivery, security, and entertainment.[1] Altogether, such urban robotics represent a new wave of technology in which digital sensors, networked devices, and their associated data stores are given the algorithmic, physical, and legal means to move in public space.[2] As time goes on, the public is increasingly likely to encounter self-driving vehicles, robots, and drones on city streets, sidewalks, and in urban airspace. How should cities respond to these new and impending technologies?

Firms have technological, market, and financial interest in testing and deploying their products in public space, but the implications for cities span a broad array of intended and unintended consequences. Cities are natural sites of experimentation for firms interested in bringing these products to market, and the perception of economic opportunity associated with tech firms is leading city representatives to reclaim public spaces, transforming them into testbeds for product development.[3] It is worth noting, however, that experimentation involves trial and error, and there are limitations to the ability of artificial intelligence to navigate the wide range of conditions and events that comprise the urban environment.[4] Ultimately, the design of the

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[1] Jeffrey Mervis, *Are we going too fast on driverless cars?*, Science, (Dec. 14, 2017) http://www.sciencemag.org/news/2017/12/are-we-going-too-fast-driverless-cars, "Transportation experts have developed six levels that describe autonomous vehicles. In general, a higher number means a more independent vehicle, with less for the human driver to do, thanks to more sophisticated sensors, cameras, and algorithms. …[a] level-four car … will operate autonomously only under certain conditions, say in good weather during the day, or on a road with controlled access. The technology for that capability already exists"; Olivia Solon, *Robots are invading malls (and sidewalks) near you* MIT Technology Review, (June 8, 2016) https://www.technologyreview.com/s/601635/robots-are-invading-malls-and-sidewalks-near-you/, "a small but growing number of human-scale mobile robots … are finding employment outside the confines of industrial settings like factories. They're invading consumer spaces including retail stores, hotels, and sidewalks in a quest to deliver services"; Paul Miller, *Taking a ride on Segway's Loomo robot*, The Verge (Jan. 11, 2018) (https://www.theverge.com/2018/1/11/16874220/segway-loomo-robot-hands-on-ces-2018).

[2] On the theory of the combinatorial evolution of technology, W. Brian Arthur, *The Nature of Technology,* NY: The Free Press, (2009).

[3] E.g., Regarding a new partnership with Ford, Mayor Carlos A. Giménez of Miami-Dade, Florida said, "We want to learn from Ford what it is we need to do to get ready for these vehicles, so that when AVs become a reality, fully, we'll be one of the first communities to get them,... We want to let the world know that Miami is ready to be a testbed." Laura Bliss, "Self-driving pizza just hit Miami" CityLab, February 27, 2018, https://www.citylab.com/transportation/2018/02/self-driving-pizza-just-hit-miami/554138/.

[4] Futuris, "Urban robots: a new generation of robots" YouTube, www.euronews.net, UPC, May 10, 2012 (https://www.youtube.com/watch?v=t8cstaDhjjI), describing one of the many challenges of designing robots to operate amongst people in an urban environment, "for example, autonomous navigation, that's

environment may be as important to the success of urban robotics as the design of the hardware and software that comprise these products.[5] These are matters that city officials care about; the design, function, and finance of urban built environments is generally the purview of local government. Additionally, artificial intelligence imbues devices with the purpose of replacing as well as augmenting the roles and responsibilities of persons, and this tension exists at the local level.[6] Significant new questions in law, such as legal liability for the performance of artificially intelligent devices, are being addressed as autonomous vehicles and devices enter public rights-of-way.[7] Lastly, these products generate rich data stores about the public, bringing market potential along with the coupled moral hazard of data monetization and loss of privacy, including surveillance.[8] Which parties are positioned to benefit from this experimentation, and

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to say [the robots would] be able to move around and find out where they are, those are things that to us seem very routine and very simple, but for the robots they are very complex".

[5] US Department of Transportation, "FHWA Announces Vehicle to Infrastructure Guidance" Transportation.gov, January 19, 2017 (https://www.transportation.gov/briefing-room/fhwa0317), U.S. Transportation Secretary Anthony Foxx notes that vehicle-to-infrastructure communication is a, "critical component of a connected vehicle environment—a system of hardware, software, firmware and wireless communication that enables the dynamic transfer of data between vehicles as well as between vehicles and elements of the roadway infrastructure"; Futuris, "Urban robots: a new generation of robots" YouTube, www.euronews.net, UPC, May 10, 2012 (https://www.youtube.com/watch?v=t8cstaDhjjI), describing one method to overcome the challenge of designing a robot to navigate the urban environment, "this campus is equipped with wifi internet and twenty cameras to allow the robots to navigate around; the same setup would be needed in any city for [the robots] to be able to work autonomously".

[6] Olivia Solon, "Robots are invading malls (and sidewalks) near you" MIT Technology Review, June 8, 2016 (https://www.technologyreview.com/s/601635/robots-are-invading-malls-and-sidewalks-near-you/), Urban robots and the firms that deploy them are "in a quest to deliver services alongside human staff members for a fraction of the price of employing people to do a variety of typically unexciting tasks."; Jeffrey Mervis, "Are we going to fast on driverless cars?" Science, December 14, 2017 (http://www.sciencemag.org/news/2017/12/are-we-going-too-fast-driverless-cars), "Technologists see AVs as the next step in what's called "mobility as a service." That is what taxi fleets and ride-sharing services such as Uber and Lyft now offer. What is attracting AV investors is the huge payoff from removing the biggest cost of that service, namely, the person behind the wheel."

[7] Sci American interview, cite; others. The death of a pedestrian by an autonomous vehicle test driven by Uber in Arizona highlights the import of these issues. An investigation is underway at the time of writing and fault has not been determined. https://www.npr.org/sections/thetwo-way/2018/03/19/594950197/uber-suspends-self-driving-tests-after-pedestrian-is-killed-in-arizona?sc=tw

[8] E.g., Kayla Matthews, "How anonymous cars will make big data even bigger" *DATAFLOQ*, January 7, 2018 (https://datafloq.com/read/how-autonomous-cars-will-make-big-data-even-bigger/1795), "autonomous vehicles, or "smart" cars of the future, are nothing more than a cog in a much larger data-collection system"; Matt McFarland, "Your car's data may be more valuable than the car itself" *CNN Tech*, February 7, 2017 (http://money.cnn.com/2017/02/07/technology/car-data-value/index.html), "A self-driving car can generate 1 gigabyte of data per second … More data means more potential money. All sorts of creative business opportunities will arise." and "By collecting data from vehicles, you effectively digitize the public space, unlocking potential safety, security, municipal and commercial benefits,"; S. Somesegar and Daniel Li, "Business models will drive the future of autonomous vehicles" *TechCrunch*, August 25, 2017 (https://techcrunch.com/2017/08/25/business-models-will-drive-the-future-of-autonomous-vehicles/), "The issues of who owns data, who can access data and who will process the data will be a critical question for companies and regulators over the next several years. As vehicles generate and consume more and more data, it will be critical to watch who controls the data and how they decide to monetize the data."; McKinsey & Company, *Monetizing Car Data,* September, 2016 (https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/Monetizing%20car%20data/Monetizing-car-data.ashx);

which will absorb the costs? In the face of these potentially widespread and enduring industrial and technological changes, how might cities act in the public interest?

The answers to these questions lie as much in the institutional arrangements designed to govern this new wave of technologies as it does in the intrinsic capabilities of these products. Anyone evaluating the existing policy environment for artificially intelligent devices today would find technological optimism as well as pessimism, conflicting perspectives of the public interest, and preemptive acts at the state and federal levels.[9] In particular, preemption in current policy-making raises issues, because the consequences and cost of product design, including safety and surveillance as well as convenience and expense, play out at the local level.[10] As city officials ask their residents to co-exist with robots and negotiate with firms over the transaction costs that accompany these products, they need the flexibility and funding necessary to adapt to market conditions and the authority to act as market makers.[11] In the best of circumstances, federal agencies provide guidance and domain expertise, while states provide a supportive framework for cities to operate in, with a backstop against the expansive possibility of harm. In the most egregious cases, preemption threatens to revoke the rights of the persons who, at the local level, are asked to bear the risk and cost of residing with robots, and to prevent the resolution of conflicts through local levels of government.[12] Preemption debates in technology law have already arisen around net neutrality,[13] sharing economy platforms,[14] and municipal broadband,[15] with important consequences. Some proposed federal and state laws and existing state statutes already preempt cities on robotics in several important ways.

The purpose of this article is to provide a framework for public decision-makers to engage effectively with the firms that are bringing artificially intelligent robotics to market in public space. With an institutional economic perspective, this article suggests a means for evidence-based policymaking by breaking down design and its evaluation into constituent sequential components, recognizing the private and social costs of experimentation in cities, and recommending a limited scope for state and federal intervention. Part II begins by defining the

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[9] Noah Seigel, *Will the feds handcuff cities on automated vehicles?*, Public Square: A CNU Journal (Nov. 9, 2017) https://www.cnu.org/publicsquare/2017/11/09/will-feds-handcuff-cities-automated-vehicles

[10] Noah Seigel, *Will the feds handcuff cities on automated vehicles?*, Public Square (Nov. 9, 2017) https://www.cnu.org/publicsquare/2017/11/09/will-feds-handcuff-cities-automated-vehicles and Lisa Nisenson & Brad Davis, *Ten steps toward autonomous urbanism*, Public Square (Dec. 11, 2017) https://www.cnu.org/publicsquare/2017/12/11/ten-steps-toward-autonomous-urbanism

[11] On the potential for autonomous vehicles to impact local public finance, see: Benjamin Y. Clark, Nico Larco & Roberta F Mann, The Impacts of Autonomous Vehicles and E-commerce on Local Government Budgeting and Finance, Oregon Next (Aug. 2017) https://cpb-us-east-1-juc1ugur1qwqqqo4.stackpathdns.com/blogs.uoregon.edu/dist/f/13615/files/2017/07/Impacts-of-AV-Ecommerce-on-Local-Govt-Budget-and-Finance-SCI-08-2017-2n8wgfg.pdf

[12] https://www.cnu.org/publicsquare/2017/11/09/will-feds-handcuff-cities-automated-vehicles

[13] Jon Brodkin, FCC will also order states to scrap plans for their own net neutrality laws, Ars Technica (Nov. 21, 2017) https://arstechnica.com/tech-policy/2017/11/fcc-will-also-order-states-to-scrap-plans-for-their-own-net-neutrality-laws/ ; https://www.citylab.com/equity/2018/03/net-neutrality-executive-orders-fcc-mayors-bill-de-blasio/555344/

[14] http://nlc.org/sites/default/files/2017-02/NLC%20Preemption%20Report%202017.pdf

[15] https://arstechnica.com/tech-policy/2016/08/in-blow-to-muni-broadband-fcc-loses-bid-to-overturn-state-laws/

characteristics of the current wave of robotics entering public space, placing public-facing robotics within the theory of the nature of technology, and elaborating on the process of product design with algorithmic feedback for machine learning in complex urban environments. Part III explores the opportunities and hazards that await cities as sites of experimentation, and introduces a comparative approach to policy-making to forestall social externalities while permitting technological change. Part IV explores the policy environment that is already taking shape for governing artificially intelligent robotics in public space. Part V draws on the arguments from the preceding parts of the paper to recommends against broad express preemption or field preemption at the state and federal level of local governments in robotics law. Part VI addresses possible counter arguments. Part VII concludes with a research agenda for urban robotics going forward.

Part II: Urban Robotics and the Quest for Intelligent Design

This part provides an overview of the emerging field of autonomous machines in public space, including a section that situates these products in the evolution of technology, and brings the process of design to the forefront of discussion about the benefits and pitfalls of this new wave of technology for cities and local residents.

A. Robots are Coming to a City Near You

Companies that make robots are sending their products out into the cities of the world. Not to be confused with the spectacular humanoid devices of science fiction, the robots entering our city roadways, sidewalks, parking lots, and airspace include any machine that can sense, process, and act upon the physical world.[16] The robots being deployed, tested, and marketed in urban public rights of way fall into four broad categories: automated vehicles for transporting persons and cargo, delivery robots, security robots, and entertainment or companion robots.

The automation of vehicles currently allows drivers to turn their attention away from the road for periods of time, but the purpose of this technology is to eventually transform human-driven fleets of vehicles into services provided with self-driving fleets of vehicles. Several tech companies and numerous automobile manufacturers are experimenting with these capabilities.[17] Though most are working on automobiles, recent market entrants and hopefuls include automated buses, automated semi-trucks for cargo delivery, and personal drones for air travel.[18] At the time of this writing, 17 cities in the US have active pilot programs for automated

[16] People working in the field are quick to separate artificial general intelligence, such as the development of a sentient being, from today's forms artificial intelligence: "Artificial intelligence is not about building a mind; it's about the improvement of tools to solve problems." Gideon Lewis-Kraus, "The great A.I. awakening" New York Times Magazine, December 14, 2016; Ryan Calo, Robotics and the Lessons of Cyberlaw, 103 Calif. L. Rev. 513 (2015), defines robots.

[17] Danielle Muoio, Ranked: The 18 companies most likely to get self-driving cars on the road first, Bus. Insider (Sep. 27, 2017).

[18] Alex Davies, "Self-driving trucks are now delivering refridgerators" Wired, November 13, 2017, https://www.wired.com/story/embark-self-driving-truck-deliveries/; David Katzmaier, "In the future we'll all fly personal drones like this" CNET, September 28, 2017, https://www.cnet.com/news/in-the-future-fly-personal-drones-like-this/.

vehicles, with several more in the planning stage.[19] In 2016, for example, the city of Pittsburgh established a test center and became an early test site for Uber's self-driving taxis.[20] Google's Waymo website identifies 25 US cities in its map of test locations, most of which are in the San Francisco Bay Area of California, or in proximity to its early test site of Chandler, in Arizona.[21] Other noteworthy cities with automated vehicle pilot programs include Denver, Boston, Detroit, Las Vegas, Reno, San Antonio, Tampa, and Washington, DC.[22] It is important to note that the dedication of an area for testing does not necessarily imply permanence for the technologies or the firms; following the recent death of a pedestrian in Chandler Arizona, Uber has suspended testing and operations of automated vehicles in all of their current locations.[23]

Delivery robots are intended to complete last mile logistics -- the most complex and expensive portion of the shipping system -- where products move to and from distribution centers and homes or offices.[24] The wide variation in the characteristics of these devices has them destined for all manner of public spaces, including sidewalks, roadways, parking spaces, and airspace. For example, Starship Technologies' short, electric, six-wheeled robots operate autonomously to deliver items up to 40 pounds in weight within a 2-mile radius, with the possibility of intervention by remote operators.[25] Starship Technologies has teamed with DoorDash to deliver meals in Redwood City, California, and with Postmates to provide automated delivery of a variety of packages in Washington, DC.[26] Robots from Dispatch, Robby, and Marble strike a similar profile and occupy a similar market niche.[27] Robots like these operate under a patchwork of legal rules, sometimes requiring a permit, but sometimes enabled to operate without, either because of a lack of regulation or permissive state laws. There are also firms competing in this space with larger vehicles, which may be subject to the same regulations as autonomous vehicles for passengers. Nuro's delivery vehicles are about half of the size of an automobile, suggesting larger payloads, travel on roadways, and the need to park while loading, unloading,

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[19] Bloomberg Philanthropies and The Aspen Institute, "Initiative on cities and autonomous vehicles" Accessed March 4, 2018, https://avsincities.bloomberg.org/.
[20] Cecilija Kang, "No driver? Bring it on. How Pittsburgh became Uber's testing ground" The New York Times, September 10, 2016, https://www.nytimes.com/2016/09/11/technology/no-driver-bring-it-on-how-pittsburgh-became-ubers-testing-ground.html.
[21] Waymo, "On the road", Accessed March 4, 2018, https://waymo.com/ontheroad/.
[22] Bloomberg Philanthropies and The Aspen Institute, "Initiative on cities and autonomous vehicles" Accessed March 4, 2018, https://avsincities.bloomberg.org/.
[23] https://www.npr.org/sections/thetwo-way/2018/03/19/594950197/uber-suspends-self-driving-tests-after-pedestrian-is-killed-in-arizona?sc=tw
[24] Lora Kolodny, Postmates and DoorDash are testing delivery by robot with Starship Technologies, TechCrunch (Jan. 18, 2017); Erica E. Phillips, *When Robots Take to City Sidewalks*, Wall Street Journal (Apr. 12, 2017) https://www.wsj.com/articles/when-robots-take-to-city-sidewalks-1491970141.
[25] Lora Kolodny, "Postmates and DoorDash are testing delivery by robot with Starship Technologies" TechCrunch, January 18, 2017, https://techcrunch.com/2017/01/18/postmates-and-doordash-are-testing-delivery-by-robot-with-starship-technologies/.
[26] Lora Kolodny, "Postmates and DoorDash are testing delivery by robot with Starship Technologies" TechCrunch, January 18, 2017, https://techcrunch.com/2017/01/18/postmates-and-doordash-are-testing-delivery-by-robot-with-starship-technologies/.
[27] Marble's delivery robot rolls through SF, TechCrunch, (Apr. 12, 2017) https://www.youtube.com/watch?v=pNpH4G-hoIY

or perhaps charging up.[28] Notably, automakers envision a role for themselves in this market.[29] Ford has announced that it will test its full-sized automated vehicles for package delivery services.[30] In addition, at least two firms offer delivery services via aerial drones: Flirtey and Matternet.[31] Flirtey garnered attention in 2016, with its first delivery sanctioned by the Federal Aviation Administration of a product from a 7-Eleven to a home.[32]

Security robots, which could be said to operate like mobile closed circuit television with the capacity to automatically call authorities, are intended to reduce the need for human security guards, persistent monitoring, and private surveillance.[33] Although such products are privately owned and operated, some scholars have conceptualized them as a form of automated law enforcement.[34] For the most part, security robots have been deployed without ex ante permission from cities.[35] The company most prevalent in searches for security robots is called Knightscope, although there are others.[36] Robots from Knightscope can be programmed to patrol a pre-defined area, and are currently being used or contemplated for use in parking lots, residential neighborhoods, and quasi-public areas such as corporate campuses, shopping malls, museums, and airports.[37] The K5 units for outdoor use weigh over 300 pounds, are over five feet tall, and come with an electrical pad for charging.[38] They are outfitted for 360 degree video recording, storage and streaming, including thermal imaging, reading license plates,

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[28] Alan Ohnsman, "Ex-Google Engineers Raise $92 Million To Roll Out Robot Delivery Vehicles This Year" Forbes, January 30, 2018, https://www.forbes.com/sites/alanohnsman/2018/01/30/ex-google-engineers-raise-92-million-to-deploy-robot-delivery-vehicles-this-year/#3c7c739875d1.

[29] Daimler has invested in both Starship Technologies and Matternet, and Ford's recent agreement suggest the interest of automakers in automated delivery services. CB Insights, "Automating The Last Mile: Startups Chasing Robot Delivery By Land And Air" Research Briefs, March 30, 2017, https://www.cbinsights.com/research/autonomous-drone-delivery-startups/; https://www.citylab.com/transportation/2018/02/self-driving-pizza-just-hit-miami/554138/

[30] https://www.citylab.com/transportation/2018/02/self-driving-pizza-just-hit-miami/554138/

[31] CB Insights, "Automating The Last Mile: Startups Chasing Robot Delivery By Land And Air" Research Briefs, March 30, 2017, https://www.cbinsights.com/research/autonomous-drone-delivery-startups/.

[32] CB Insights, "Automating The Last Mile: Startups Chasing Robot Delivery By Land And Air" Research Briefs, March 30, 2017, https://www.cbinsights.com/research/autonomous-drone-delivery-startups/.

[33] "Knightscope wants to keep humans in the loop with its robots, but it's not hard to imagine a day when someone else gets the bright idea to give other security machines a lot more autonomy" Matt Simon, "The tricky ethics of Knightscope's crime-fighting robots" Wired, December 21, 2017, https://www.wired.com/story/the-tricky-ethics-of-knightscopes-crime-fighting-robots/; "Already, Knightscope robots are edging into the private security industry, patrolling parking lots, a shopping center and corporate campuses in California." Los Angeles Times, http://www.latimes.com/business/la-fi-robots-retail-20160823-snap-story.html; Knightscope, "K5" 2018, https://www.knightscope.com/knightscope-k5/, Accessed March 4, 2018, "If a marked law enforcement vehicle were placed in front of your facility, criminal behavior would dramatically change. ADMs [autonomous data machines] have the same impact."

[34] Hartzog et al., *Inefficiently Automated Law Enforcement*, 2015 Mich. St. L. Rev. 1763 (2015). Elizabeth Joh, https://lawreview.law.ucdavis.edu/issues/51/2/Symposium/51-2_Joh.pdf

[35] http://marketurbanism.com/2017/11/13/cities-should-not-design-for-autonomous-vehicles/. But see SF's ban on Knightscope robot.

[36] Robbie Gonzalez, I Spent the Night With Yelp's Robot Security Guard, Cobalt, Wired (Aug. 4, 2017). https://www.wired.com/story/i-spent-the-night-with-yelps-robot-security-guard-cobalt/

[37] Los Angeles Times, http://www.latimes.com/business/la-fi-robots-retail-20160823-snap-story.html; McClatchy, http://www.mcclatchydc.com/news/nation-world/national/article181343981.html

[38] McClatchy, http://www.mcclatchydc.com/news/nation-world/national/article181343981.html

tracking parked cars, playing pre-recorded messages, and for use as a two-way intercom between a remote operator and people who encounter the device.[39] Also known as "automated data machines," the devices stream data to the company's "security operations center," and the firm advertises the ability to stream the same to recipients' online web portals.[40] A report in October, 2017, noted that the firm had already deployed 47 of these devices for clients in 10 states, including venues in Boston, Atlanta, Dallas, Sacramento, Washington DC, and Tampa.[41]

Entertainment robots represent another wave of autonomous devices entering urban space.[42] Synchronized drones, for example, are in use by Disney, and were featured in the opening and closing ceremonies of the Winter Olympics.[43] The film industry is using drones to replace expensive rigging with aerial cinematography.[44] And, perhaps more importantly for public space, anyone can now purchase an aerial drone that follows and video records any specified person, animal, or moving object, wherever it goes, for an elaborate form of "selfie".[45] Though they appear to be no different from remote controlled commercial drones, these devices may be set to automatically track a signal or follow an individual, and may also be equipped with the software necessary to detect and avoid other objects.[46] The same "follow me" features are also emerging in devices on roadways and sidewalks. At the 2018 Consumer Electronics Show, the Segway company unveiled Loomo, which is marketed as a robot that can follow its user, take pictures, and display simple social computing characteristics (smiley faces).[47] It is a hoverboard that users can ride or load with up to 200 kilograms of packages, capable of traveling up to 11 miles per hour and a range of 22 miles on a single charge, with sensors and software that includes voice command and facial recognition.[48] Segway promises that Loomo will be on the

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[39] Los Angeles Times, http://www.latimes.com/business/la-fi-robots-retail-20160823-snap-story.html
[40] Knightscope, https://www.youtube.com/watch?v=UtuLB2duq2E
[41] Govtech, http://www.govtech.com/public-safety/can-robots-replace-human-security-guards.html; McClatchy, http://www.mcclatchydc.com/news/nation-world/national/article181343981.html
[42] William Grimes "Drones kill, yes, but they also rescue, research and entertain" New York Times, May 11, 2017, https://www.nytimes.com/2017/05/11/arts/design/drones-kill-yes-but-they-also-rescue-research-and-entertain.html
[43] "The Making of Walt Disney World's First Drones Show | Disney Springs" Disney Parks, YouTube, December 1, 2016, https://www.youtube.com/watch?v=dHHMrvaXgyA; Ron Dicker, "The Olympics Opening Ceremony Drone Show Is Just So Damn Impressive" Huffington Post, February 9, 2018, https://www.huffingtonpost.com/entry/opening-ceremony-drone-show-is-just-so-damn-impressive_us_5a7db877e4b08dfc930363ae
[44] Richard Verrier, "Drones are providing film and TV viewers a new perspective on the action" Los Angeles Times, October 8, 2015, http://www.latimes.com/entertainment/envelope/cotown/la-et-ct-drones-hollywood-20151008-story.html
[45] Antonio Villas-Boas and Rachel Sandler, "This $2,500 'self-flying camera' can follow you around and snap photos without anyone controlling it — here's how it works" Business Insider, February 15, 2018; Fintan Corrigan, "12 best follow me drones and follow you technology reviewed" Dronzon, February 16, 2018, https://www.dronezon.com/drone-reviews/best-follow-me-gps-mode-drone-technology-reviewed/
[46] Fintan Corrigan, "12 best follow me drones and follow you technology reviewed" Dronzon, February 16, 2018, https://www.dronezon.com/drone-reviews/best-follow-me-gps-mode-drone-technology-reviewed/, "It is good to remember that the vast majority of Follow Me mode drones do not have object avoidance".
[47] Paul Miller, Taking a ride on Segway's Loomo robot, The Verge (Jan. 11, 2018) https://www.theverge.com/2018/1/11/16874220/segway-loomo-robot-hands-on-ces-2018.
[48] Andrew Tarantola, "Segway's Loomo is the robotic hoverboard nobody asked for" Engadget, March 6, 2018, https://www.engadget.com/2018/03/06/segways-loomo-robotic-hoverboard-hands-on/

streets in 2018.[49] Similarly, the company responsible for Vespa Scooters is working on Gita, a small cargo "droid" designed to free the user's hands as they traverse dense urban environments.[50] Another company recently unveiled a robotic suitcase.[51] While not strictly meant as entertainment (although one writer described Gita as "more like having a pet than an artificial intelligence"), these machines are designed to delight users while contributing to leisure experiences.[52]

B. Urban Robots and the Evolution of Technology

To understand the magnitude and endurance of urban robotics, it may be helpful to place these products within the evolutionary theory of technology.[53]

According to theory, technologies are designed to apply scientific knowledge for a purpose, they are in and of themselves assemblies of technologies, and their evolution occurs through the recombination of newly incorporated phenomena with existing components.[54] Technology is commonly developed to augment the forces of nature and, as it relies on basic science about how the world works, modern technology is understood to advance along with discoveries in basic science.[55] As products, however, technologies are recursive, in that they are made of assemblies of components which are themselves technologies, each harnessing scientific knowledge about physical effects and other natural phenomena.[56] Given that all technologies rely on the understanding and application of natural or physical effects, the combinatorial evolution of technology accelerates when a new family of phenomena are discovered and incorporated into components for further recombination.[57]

Urban robotics combine the newfound capacity for autonomous controls, brought about by machine learning and artificial intelligence, with a multitude of existing sensor, robotic, compute, communication, energy, and transportation technologies.[58] Given that machines can now be programmed to use algorithms that process richly expansive data collected from the

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[49] https://www.indiegogo.com/projects/loomo-mini-transporter-meets-robot-sidekick-mobile?gclid=Cj0KCQjw1q3VBRCFARIsAPHJXrH8cDkDj3X-2WZ08UUh6heo3V5X542nzwuo0N7Cs23ouXreJ6LOauIaArpVEALw_wcB#/

[50] Ian Bogost, https://www.theatlantic.com/technology/archive/2018/02/piaggio-gita-jeffrey-schnapp/554222/

[51] https://venturebeat.com/2018/01/03/travelmate-robotics-robot-suitcase-will-follow-you-to-ces-2018/

[52] https://www.theatlantic.com/technology/archive/2018/02/piaggio-gita-jeffrey-schnapp/554222/. Entertainment robots like Gita or the robotic suitcase could conceivably constitute a separate "personal service robot" category, but until such use cases actually develop we will use the current classification scheme.

[53] W. Brian Arthur, *The Nature of Technology: What it is and How it Evolves*, New York: Free Press, 2009.

[54] W. Brian Arthur

[55] W. Brian Arthur

[56] W. Brian Arthur

[57] W. Brian Arthur

[58] Machine learning algorithms allow computers to recognize patterns and make connections that are not pre-program, but instead "learned" based on associations in large data sets. As such, they require large amounts of data to be effective. Cite.

environment and, flipping the process, modify or develop new algorithms based on feedback from the environment, people can and should expect products to come to market that attempt to navigate the physical environment autonomously.[59] In the language of the evolutionary theory of technology, nascent human scientific understanding of how the brain works is accelerating evolution by providing the opportunity to combine a whole new family of artificially intelligent controls with existing technologies.

With this perspective, today's autonomous urban robotics and vehicles can be understood to represent the beginning of a long arc of technological exploration, development, and proliferation, which may stretch at least as long as one can imagine it will take to learn about intelligence. If markets and institutions permit, people should be able to see the development and emergence of more intelligent designs over time, each competing for survival. At the moment, entrepreneurship is giving rise to a diversity of devices; the presumed standard sizes and uses for vehicles, robotics, and drones, are being blurred as devices appear to fill in gaps in continua of size, shape, and purpose. As technology progresses, new applications should open up and individual robotics platforms should be able to operate in multiple task domains. In other words, the technology will converge, as devices are created to serve multiple or perhaps open-ended purposes across the variety of public and private spaces.[60] This convergence could lead to the creation of open robotics platforms, which could drive further innovation.[61]

The evolution of technology is an endogenous source of economic development, evidenced as new products emerge and flourish in urban markets.[62] In economics, the notion that technology contributes to growth dates back to Adam Smith, with the idea that trade in surplus products may be reinvested in technology and shift the division of labor to result in more surplus for trade, in a virtuous cycle of economic growth.[63] Technology is appealing to city officials because of the promise of economic growth that it may bring. The function of economic development for local government is practically synonymous with attracting businesses with new or established technologies to develop or relocate facilities in the government's jurisdiction. Competitions to attract tech firms demonstrate that cities and states will gamble with significant amounts of tax dollars in the hope that jobs and technological advancement will expand opportunities for local residents.[64]

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[59] Cites from Brockman (ed.), *What to Think about Machines that Think*,

[60] *See* Siddhartha Menon, Policy Initiative Dilemmas Surrounding Media Convergence: A Cross National Perspective, 24 Prometheus: Critical Studies in Innovation 59 (2007). Loomo is an example of a robotics platforms where multiple capabilities converge in a single platform.

[61] Ryan Calo, Open Robotics, Maryland L. Rev. 101 (2011) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1706293.

[62] Joseph Schumpeter; W. Brian Arthur

[63] Adam Smith cite

[64] Cecilia Kang, "No driver? Bring it on. How Pittsburgh became Uber's testing ground" The New York Times, September 10, 2016, https://www.nytimes.com/2016/09/11/technology/no-driver-bring-it-on-how-pittsburgh-became-ubers-testing-ground.html; Cecilia Kang, "Pittsburgh welcomed Uber's driverless car experiment. Not anymore" The New York Times, May 21, 2017, https://www.nytimes.com/2017/05/21/technology/pittsburgh-ubers-driverless-car-experiment.html.

Artificial intelligence assigns, however, a new purpose to technology, because it allows technology to replace as well as augment the forces of nature.[65] While technological change is a source of endogenous economic development, it brings with it the force in economic theory characterized as creative destruction, in which new products disrupt existing markets.[66] When technology attempts to replicate the functions of the brain, as in the autonomous control of an automobile, mobile robot, or drone, this technology can be designed for the purpose of replacing people.[67] Thus the creation of new technology can result in the development of new markets, but also the destruction of existing ones, disrupting current pathways for the creation of wealth in the economy. As the scale of autonomous technology expands, as it is likely to do, such disruptions have the potential to change the structure of the economy for whole industries.

Borrowing from Darwin's theory of evolution by natural selection, technologies may be said to compete for survival, but there are limits to this analogy.[68] What theories of natural and technological evolution share is attention to design over time. Their differences, curiously, are based on whether one can credibly say that evolution is due to intelligent design. Evolution in nature occurs by the process of natural selection, in which design consists of the traits of individuals, passed down to or emergent in offspring, as may happen over time within the resources and constraints of the environment.[69] Though people have advocated for a theory of evolution that attributes the origin and abundance of variety in nature to design by an intelligent being, this concept is not applicable to the natural world.[70] Natural selection is a process which begets design, but has no designer.[71] It has resulted in intelligence, but it is not intelligent. Intelligent design is, however, a useful concept for understanding the theory of the evolution of technology. Technology requires designers, and intelligent design, while in the eye of the beholder, is a description that becomes apt as a product competes in an economic market and survives.

C. The Intelligent Design of Urban Robotics

The following paragraphs provide an overview of the factors that lead firms to seek out testbeds within cities and the basic stages of design. If cities are to be urban testbeds for robots, city officials and their residents should become familiar with the process of design because, whether they realize it or not, they are participating in it.

The design of an autonomous system is a complex process, and one that cannot be optimized in the abstract. Designing an autonomous system requires an understanding of the task for the device and the environment in which it must reside. Design is a process of making trade-offs: between mobility, sensing, intelligence, cost, and much more. A roboticist must first understand

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[65] W. Brian Arthur
[66] Joseph Schumpeter; W. Brian Arthur
[67] Could quote news here on autonomous vehicles and K5 security robots
[68] W. Brian Arthur
[69] Charles Darwin; and for an account of empirical evidence of evolution by natural selection, *The Beak of the Finch*,
[70] Daniel Dennett, *Darwin's Dangerous Idea*,
[71] Darwin; Dennett

the design specifications and parameters in which the system will operate. Further, robots operate within an ecology; a complex system where changes to one part may impact the whole in unintended ways.

Cities are not the easiest of environments for roboticists to contemplate in design. The simplest environments for robots are factory floors, which are typically engineered in ways that reduce the scope of the task the robot must undertake. The most complex environment for an autonomous system to operate in is the natural environment, which is characterized by uncertainty and lack of structure. The urban environment falls somewhere in between, where considerable structure has been put in place already for humans to navigate. Urban roadways in the US are already highly engineered for human use, with design standards for pavement, curb cuts, sidewalks, crosswalks, auto lanes, parking, bike lanes, street signs, and so on, which have either shaped or been shaped by existing cultural conventions of behavior in public space, such as passing on the right or the left, and signaling a turn.[72] To follow in the path already established by existing modes of transport in public rights-of-way is a fairly obvious economical approach to urban robotic design.

The notion of robots operating in an ecology manifests in an inverse relationship between the intelligence of the robot and investments made in the environment to assist the robot in carrying out its intended tasks. As autonomous systems perceive the world quite differently than humans do, forcing robots to rely entirely on cues that are embedded in the environment for people makes the task for the designer more difficult. Cities simplify the design process when they create controlled spaces or stable task environments where autonomous systems can operate freely and safely. Ultimately, though, these products are not operating in their intended markets until they are active in public space. In some domains, such as supermarkets, barcodes, RFID tags and the like have been embedded in the environment to simplify navigation and identification tasks for autonomous agents. Thus, one pressing question autonomous system designers have for city decision-makers is how much information will be embedded in the urban infrastructure, and not simply the autonomous agent.[73]

As a practical matter, this means that efforts to embed signals for use by robots in urban infrastructure or modify the allocation or design of urban space to accommodate autonomous systems will simplify the effort required by the roboticist.[74] Some policy commentators, mainly stakeholders in automated vehicles, have advocated that cities update or change their infrastructure to speed the adoption and testing of robots. The installation of advanced sensors

[72] Cite ITE design standards

[73] Driverless Seattle, UW Tech Policy Lab (2017) http://techpolicylab.org/wp-content/uploads/2017/02/TPL_Driverless-Seattle_2017.pdf

[74] https://ris.utwente.nl/ws/portalfiles/portal/22918386 "Humanoid robots with a similar size and weight to human beings may have the advantage of being able to use structures designed for humans. However, any deviation from the culturally and materially embedded body norms may result in a disabling environment for such machines in much the same way that similar differences would be disabling for humans. Thus, a question arises whether we should build cities for robots or robots for cities. The answer to this question is likely to be found in a mixed approach, where the built environment will be adopted to enable new robotic applications while safeguarding the quality of city life."

to create smart streets or smart intersections, characterized as vehicle-to-infrastructure communication, is one idea.[75] The idea is that city infrastructure can be updated to communicate with automated vehicles to collect and send the data that helps them drive safely.[76] The city of Atlanta has already begun to implement this, touting the sensors on its "smart corridor" for their ability to promote automated vehicles.[77] Similarly, engineering firm Eng proposed a dedicated lane for automated vehicles in New York that would allow a fleet of automated vehicles to move quickly around the city.[78] Graduate students at UC Berkeley have designed a similar system for automated vehicles dubbed a Hyperlane.[79] From the point of view of the roboticist, such investments raise concomitant tradeoffs in mobility and sensing, which have impacts on cost and energy efficiency for the robot.

The inverse relationship between the design of an autonomous system and its environment suggests that simple environments and smart infrastructure for designers will not bring about the safest or most viable outcomes for urban robots or automated vehicles, because the greater the complexity of the task environment and the ability of the robot to navigate unassisted, the greater the likelihood that the same robotic design will perform successfully in the variety of conditions that occur in urban settings. In other words, unaltered, chaotic urban environments can give rise to smarter autonomous systems. Also, any reliance on embedded technology in urban infrastructure will limit the extent of the market for that robot and its associated firm. In truth, firms may seek out cities regardless of embedded technology in infrastructure. Cities provide unique conditions, which firms and their roboticists take up as challenges in the process of design.[80] New York City is considered a particularly attractive automated vehicle testing location because of its narrow streets and dense pedestrian population.[81] This density also means more interactions between robots and humans, and these interactions generate more data with which to train the algorithms that control the robots. The population density in cities also provides a greater marketplace for services like autonomous vehicle taxis or food delivery, and the ability to earn revenue while testing is appealing to firms. New York City was able to use its coveted status to set additional terms to companies wishing to operate within its jurisdiction.[82]

In order to effectively proceed in the design of an urban robot, users, corporate developers and city managers should all be engaged to better understand and characterize the available trade

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[75] Theier, at 29. https://www.mercatus.org/system/files/Thierer-Intelligent-Vehicles.pdf.
[76] http://marketurbanism.com/2017/11/13/cities-should-not-design-for-autonomous-vehicles/.
[77] https://venturebeat.com/2017/10/11/atlanta-is-betting-on-a-smart-corridor-to-reduce-traffic-jams/.
[78] https://www.citylab.com/transportation/2017/07/will-autonomous-vehicles-lead-to-a-resurgence-of-auto-centric-infrastructure/534804/.
[79] https://www.theguardian.com/technology/2017/jun/03/self-driving-cars-high-speed-lane-berkeley-california.
[80] https://www.nytimes.com/2017/06/07/technology/autonomous-car-technology-challenges.html
[81] Andrew J. Hawkins, GM will be the first company to test self-driving cars in New York City, The Verge (Oct. 17, 2017) https://www.theverge.com/2017/10/17/16488330/gm-cruise-nyc-self-driving-car-test-cuomo.
[82] *Id.*

space prior to design.[83] Trade space may be described as "the range of possible implementation options," and early evaluation involves brainstorming to identify the full range of options.[84] The expertise involved includes those with knowledge of the various subsystems and existing concepts relevant to the design of the new autonomous system, plus those with knowledge of the environment and the intended users of the system. Just identifying the trade space in the fast-paced industry of urban robotics poses challenges, because the technology is itself a moving target. Designing for today may mean you are superseded by those designing for tomorrow, so there is inherent risk in the overall enterprise. At this early stage, the purpose of gathering information is to understand the risks that the various options bring in terms of cost, the need for new development of software or hardware, the ability of the system to perform its intended tasks, and the time it may take to move to market. This information becomes valuable to designers, who then must down-select, or reduce the pool of available options and make trade-offs across the subsystems of robotic design, and result in a prototype.

To ease the integration of users and city managers with robotic designers, it may be helpful to borrow vocabulary from the video game industry, which is known for its reliance on participants from outside the firm as designs are given shape, tested, and prepared for commercial release. In video game development, the first meaningful milestone for bringing a product to market is "alpha." Alpha is reached when designers have completed one of each of the objects, features, and environments to be developed in the game with basic functionality (a.k.a. "vertical slice"), and can thus demonstrate the game to others, begin testing the play of the game with a few trusted people outside the firm, and continue making modifications, adding features, and building out the remaining copies or versions of objects and environments. For urban robots, alpha could be the milestone that is reached when a prototype that is designed to carry out pre-determined tasks is ready for testing in one or more closed or controlled environments of the physical world (as opposed to simulated, virtual tests, which may also be productive).[85]

Once a prototype is developed, the next major milestone is reached when all of the features and environmental interactions have been completed and are ready for large scale user feedback, but contain bugs or glitches that have to be discovered and fixed. Testing at this phase, known as "closed beta," is often by invitation to a wider audience of persons interested in playing the game, but progress for these players in the game is reset or discarded prior to commercial release. Until recently, firms did not charge players for closed-beta invitations, but market

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[83] The idea that the design of urban technologies should involve societal actors and innovators working together, is captured in the general idea of "value-sensitive design", Batya Friedman (1996). Value-sensitive design. Interactions, 3(6), 16–23. https://doi.org/10.1145/242485.242493, and incorporated by reference to urban robotics by Michael Nagenborg, "Urban robotics and responsible urban innovation" Ethics and Information Technology, published online 30 January 2018, https://doi.org/10.1007/s10676-018-9446-8.

[84] Contemporary Planetary Robotics: An Approach Toward Autonomous Systemsedited by Yang Gao, NY: Wiley, section 2.5.2.4 SLR Design Evaluation. Explanations of the concept of trade space are perhaps easier to find for areas of robotics supported by public funds, such as robotics for space exploration. Cite https://dspace.mit.edu/handle/1721.1/59552; http://onlinelibrary.wiley.com/doi/10.1002/j.2334-5837.2017.00442.x/full.

[85] Selected individuals for alpha game testing may be asked to sign non-disclosure agreements to protect the interest of the firm, and waivers of liability may also be appropriate for tests in a physical environment.

interest sometimes allows them to do so. During closed beta, milestones are set up as hurdles to meet before the game can proceed to "open beta," a form of commercial release in which anyone can play and all of the features of monetization are activated. For urban robotics, closed beta milestones could involve increasing the complexity of the task environments, and user testing amongst a wide array of groups, in a wide variety of settings. Commercial release, or launch, finishes the process and allows marketing to begin.

Roboticists have an interest in communicating with governmental decision-makers during the testing phase because legislation passed after a system has been designed can invalidate the initial design assumptions. Participation also creates opportunities for public agencies to research the potential effects of rules to govern robots in the public interest. For example, should there be a speed limit for robots walking on the sidewalk? Should robots or autonomous vehicles ever legally be allowed to bump into people? When technology progresses faster than regulatory systems, designers build systems for the unknown, which can have the effect of raising costs and risks for the firm.

Still, many robotic system designers have assumed that they know what people want, and moved through the design process without prior consultation. This historically has led to the bankruptcy (e.g., Denning Mobile Robotics[86], Lily Robotics[87]) or abandonment of product by numerous companies who have created security robots, entertainment (iRobot's My Real Baby[88]), research platforms, and the like. This is also what happens when firms adopt strategies that involve asking forgiveness rather than permission, and purposefully move to market before legal issues are settled. This aggressive stance is risky, because it may result in harm to consumers and local action to ban the product.[89] Yet the prospect of being a first-mover in a new market, or competing for market share in the early years of development has been known to motivate firms to take this risk.[90]

Part III: Cities as Testbeds for Autonomous Vehicles and Robotics

This part of the article explores the enthusiasm that city decision-makers and managers have for autonomous vehicles and robotics, and the hazards that await cities as sites of experimentation. An evidence-based, comparative institutional economic approach to policy-making is recommended, to forestall social externalities while permitting technological change.

A. The Interest of Cities in Firms and their Autonomous Products

City decision-makers that welcome autonomous vehicles and devices perceive their efforts through the lens of economic development, job creation, the need to position for a wave of economically beneficial technological change, and as part and parcel of visionary plans for the future in the transportation sector. Through the formation of partnerships, the adoption of tech-friendly policy, and changes to city information systems and physical environments, city

[86] https://www.frc.ri.cmu.edu/~hpm/project.archive/robot.papers/2000/Denning.Mobile.Robotics.bankruptcy
[87] https://www.wired.com/story/the-drone-company-that-fell-to-earth/
[88] https://www.gizmodo.com.au/2009/08/creepy-irobots-my-real-baby/
[89] https://www.theguardian.com/us-news/2017/dec/10/san-francisco-delivery-robots-laws
[90] Re: Uber;

decision-makers are extending invitations to firms and their products. As the intended markets for these products, cities and their decision-makers will be vital to any effort to shape these products and their uses in the public interest.

As cities have formed partnerships with the firms that want to mobilize autonomous products, their decision-makers have raised the hope or expectation of reciprocal efforts on the part of firms to deliver civic benefits. Public reports of Alphabet's Waymo use in the San Francisco Bay Area highlight the ability of a blind person to achieve mobility by hailing a driverless automobile.[91] Pittsburgh assisted Uber in acquiring a large plot of land and the Mayor and Governor fended off state legislation that would have banned autonomous vehicles with the expectation that the firm would provide jobs, free rides, and further commitments in an application for a high-profile US DOT "smart city challenge" grant.[92] Boston's approach, which currently includes testing by nuTonomy, Optimus Ride, and Aptiv, is framed by the city's action plan for transportation, with goals for equity, economic opportunity, and climate responsiveness.[93] The recipient of the US DOT challenge grant, Columbus, Ohio, set the target of reducing infant mortality by 40 percent by 2020, through the automation of transit in low-income neighborhoods.[94]

While some benefits can be expected from investments in transportation services, the scale of claims associated with autonomous systems is beyond the imaginable. Cities of the US have under-invested in transit and related transportation infrastructure for decades, with noticeable impacts to equity.[95] The fact that the transportation sector is responsible for about one third of US greenhouse gas emissions, provides the US government with the added burden of investing in or overseeing the electrification of the system, with concurrent investments in carbon neutral energy sources.[96] The widely touted notion, however, that artificially intelligent vehicles and devices can eliminate traffic congestion, death, injury, disparity, and emissions, while freeing up the vast acreage of asphalt and concrete currently devoted to parking, is ludicrous. The simple math of public space allocation, single occupancy vehicles, and the basics of machine learning do not add up in favor of these claims.[97]

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[91] cite

[92] https://www.nytimes.com/2016/09/11/technology/no-driver-bring-it-on-how-pittsburgh-became-ubers-testing-ground.html; https://www.nytimes.com/2017/05/21/technology/pittsburgh-ubers-driverless-car-experiment.html; https://www.politico.com/story/2017/05/01/uber-pittsburgh-city-mayors-237772.

[93] https://www.boston.gov/sites/default/files/document-file-03-2017/go_boston_2030_-_plan_highlights_to_download.pdf; https://www.boston.gov/departments/transportation/go-boston-2030; https://www.boston.gov/departments/new-urban-mechanics/autonomous-vehicles-bostons-approach

[94] https://www.citylab.com/transportation/2017/11/when-a-smart-city-doesnt-have-all-the-answers/542976/

[95] http://theconversation.com/people-are-stranded-in-transit-deserts-in-dozens-of-us-cities-92722

[96] "In 2015, greenhouse gas emissions from transportation accounted for about 27 percent of total U.S. greenhouse gas emissions, making it the second largest contributor of U.S. greenhouse gas emissions after the Electricity sector." https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[97] Bloomberg Philanthropies and the Aspen Institute, Taming the Autonomous Vehicle, file:///C:/Users/janwhit/Desktop/TamingtheAutonomousVehicleSpreadsPDFreleaseMay3rev2.pdf; NACTO, Blueprint for Autonomous Urbanism, Module 1, Fall 2017, Designing Cities Edition; The Boston Consulting Group, "Quantifying the impact of autonomous vehicles on city traffic" https://www.youtube.com/watch?v=zMZIEBoR49U; Allison Arieff, "Automated vehicles can't save cities" The New York Times, https://www.nytimes.com/interactive/2018/02/27/opinion/automated-vehicles-cant-save-cities.html

In the face of unrealistic claims of benefits from autonomous vehicles and robotics, cities must be recognized as critical forces in the effort to shape these products and their uses for public good. The public good and current designs, composition, or envisioned uses of these products are not necessarily aligned, and the effects of these products, for better or worse, are going to be experienced locally. For example, the choice of whether to allow and financially support changes to urban physical infrastructure to accommodate autonomous systems are almost entirely local, in that state departments of transportation tend to have responsibility only for state and national highways. Even for drones, the Federal Aviation Administration regulates airspace, but changes to the local urban infrastructure to accommodate delivery or "follow me" drones will be almost entirely up to local governments and the physical environments that they own or regulate. This means that city managers and decision-makers are likely to experience pressure from firms to modify the allocation of public space and environmental design, regardless of state and federal legislation. For example, online magazine Quartz reported that in negotiations with the city of Pittsburgh, Uber wanted the city to grant non-exclusive access to bus lanes and municipal parking lots to use as staging areas.[98] These demands contributed to the breakdown in the working relationship between Uber and the city.[99] Relatedly, other groups have advocated that cities reduce parking space to promote automated vehicles.[100] As enthusiastic as city decision-makers and managers may be for firms with autonomous products, they still need to represent the interest of local residents and taxpayers, and this places them in a position to negotiate with firms on behalf of the general public.

As stewards of the public good, city managers and decision-makers care about efficiency, effectiveness, and equity in the provision of essential goods and services, as well as the effects of the choices they make on jobs and the economy. Publications from the National Association of City Transportation Officials (with membership from 52 cities across the US), and the Regional Plan Association (serving the New York metropolitan area), urge city managers to brace against the potentially disruptive effects of automated vehicles, for example, by engaging in proactive policymaking to ensure that "public benefit guides private action," to "shape how [automated vehicles] interact with transit," and to "prioritize street space for public transit, pedestrians, bikes, and freight."[101] Several of these choices are exhibited today in the attempts of ride-sharing firms to partner with local governments and transit agencies, for example, for subsidized first and last mile passenger delivery to remote transit stations.[102] Guidelines for city

[98] https://qz.com/874548/uber-asked-a-lot-of-pittsburgh-for-its-self-driving-cars-and-offered-back-very-little/.
[99] https://qz.com/874548/uber-asked-a-lot-of-pittsburgh-for-its-self-driving-cars-and-offered-back-very-little/.
[100] "Transportation and land use planning and policies should minimize the street and parking space used per person and maximize the use of each vehicle. We discourage overbuilding and oversized vehicles and infrastructure, as well as the oversupply of parking." https://www.sharedmobilityprinciples.org/
[101] National Association of City Transportation Officials, Blueprint for Autonomous Urbanism, New York, 2017, pages 13-14, lists "public benefit guides private action" as one of six principles for autonomous urbanism; Regional Plan Association, New Mobility: Autonomous Vehicles and the Region, October 2017, page 3.
[102] Cite MOD Sandbox projects

officials break down the components and possible effects of autonomous vehicles into modules and provide schema for the gradual, sequential alteration of the design and allocation of public space.[103] Highlighting the disruptive effects of artificially intelligent transportation, the Regional Plan Association also suggests that plans get underway to determine how to transition the 220,000 or so persons in vulnerable positions in the region to new forms of employment.[104]

For the public good, cities are also interested in the information that firms collect, for direct use in balancing demand and supply of services and built environments in the transportation sector, and due to the general need to govern the flow of information for accountability, transparency, and privacy. Historically, transportation agencies have had to rely on relatively expensive and time-consuming methods to collect data on travel behavior and the use of transport facilities, because of the lack of integration of information technology in vehicles and the fact that autos and trucks are predominantly owned and operated by individuals.[105] The information technology of transport is already undergoing dramatic changes: rideshare, car-share, and bike-share services concentrate travel information into the hands of comparatively small number of firms.[106] With the adoption of autonomous systems, the industrial organization of the entire transport sector is headed for upheaval: autonomous controls are likely to result in the concentration of the ownership of vehicles as well as information about their uses and users.[107] The ability of public agencies to make smart decisions about the allocation and governance of public space will depend on their ability to access and merge this information with data on public services and investments.[108] If disputes between the firms of the sharing economy and cities over access to data are indicators of what is to come, there will have to be neutral third parties to operate trusted data platforms and broker these exchanges.[109] Travel patterns are remarkably unique

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[103] NACTO, 2017, modules on page 9; RPA, 2017, "A Prospective Timeline in Four Phases", pages 16-17.

[104] RPA, page 5.

[105] The World Bank, "The World Bank Launches New Open Transport Partnership to Improve Transportation through Open Data" December 19, 2016, http://www.worldbank.org/en/news/press-release/2016/12/19/the-world-bank-launches-new-open-transport-partnership-to-improve-transportation-through-open-data, "traditional methods for collecting traffic data needed to address congestion are costly and rely either on labor-intensive field work or capital-intensive sensor data networks that far exceed available resources"; In US cities, labor-intensive traffic counts and travel diary surveys as information sources for transportation system decisions have recently been augmented by license plate readers, cell phone tracking data, data feeds from bluetooth and wifi sniffers, as cities have contracted with private vendors and university researchers to serve this need.

[106] Prominent firms in US markets include Uber and Lyft in rideshare, Reachnow and Car2Go in car-share, and Lime, ofo, Spin, and Mobike in dockless bike-share markets, all of which collect information on travellers from a combination of their mobile apps and the GPS and related technologies installed in the cars and bikes.

[107] Cite concentration of auto ownership

[108] NACTO, 2017, page 20, "Billions of detailed street-level data points are collected in real time daily on everything from traffic speeds and volumes to travel patterns and transit use. This data is vital to the operations and management of streets, regardless of the entity generating them."

[109] Cite legal contests between Uber, Lyft, and cities over the public release of data; e.g., University of Washington Transportation Data Collaborative, https://www.uwtdc.org/, "The Transportation Data Collaborative (TDC) is an initiative at the UW to create a protected and linked data repository of sensitive information from public and private transportation providers… The TDC allows partnering agencies to create data-driven policy, support research uses, and provide individuals with authenticated access to

and sensitive for what they reveal about individuals and the actions of the firm, making the data valuable to firms inside and outside of the transport market, and of great concern to officials tasked with protecting the privacy of city residents.[110] At the same time, government agencies need to use the same data sources to hold firms accountable, and the public deserves transparency in the actions of government agencies for the same.[111]

In contrast to Federal and State government, cities are critical to the rollout of autonomous systems because the diversity of approaches taken by city decision-makers in the adoption of new technologies makes them laboratories for policy, governance, and the implementation of enforcement mechanisms. Governments are in the business of institutional change; institutions are "the formal rules, informal norms, and enforcement characteristics" developed and used by the polity and judiciary to govern in the public interest.[112] In the face of rapid change in technology, it is remarkably difficult to determine ex ante the structure and content of policies most beneficial to the public. The public interest is, in and of itself, complex phenomena, and institutional change has historically been led by cities and related local and state governments for their diversity of policies and evaluations of related outcomes in the formation of lasting regulations for the public good. At the local level, pilot programs, sunset clauses with requirements for audit and program evaluation, and geofencing are mainstays of governance when testing new concepts, technologies, and environmental designs in public space, that have the practical purpose of supporting evidence-based changes to policy over time. Irrespective of technology, the authority city decision-makers have to draw boundaries that limit the spatial extent of the market, afix rules to public and private space that limit allowed activities, determine required and allowed uses and flows of information, develop and enforce pricing schemes, issue or revoke operating permits, and to tax, audit, charge fees, levy fines, and ban goods, constitute critical leverage in the negotiations between firms and city governments for the public good.

In sum, as enthusiastic as they may be, city decision-makers should be strategic in their evaluation, adoption, and regulation of autonomous vehicle and robotic technologies.[113] The benefits of utilizing cities as laboratories for policy-making depends on the ability of city

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their own transportation records."; NACTO, 2017, page 21, "In order to protect user data, an independent third-party company can sort and anonymize data collected before it is used for analysis, ensuring individual users are not identified. Once analyzed, this data can be used to direct city policy and prioritize projects."

[110] Yves-Alexandre de Montjoye, César A. Hidalgo, Michel Verleysen & Vincent D. Blondel, "Unique in the Crowd: The privacy bounds of human mobility", *Scientific Reports*, volume 3, Article number: 1376 (2013) doi:10.1038/srep01376, https://www.nature.com/articles/srep01376, "We study fifteen months of human mobility data for one and a half million individuals and find that human mobility traces are highly unique. In fact, in a dataset where the location of an individual is specified hourly, and with a spatial resolution equal to that given by the carrier's antennas, four spatio-temporal points are enough to uniquely identify 95% of the individuals."; NACTO, 2017, page 20 "intricate information on people movement is laden with personally identifiable information that neither government nor private companies should have access to."

[111] Cites on accountability and transparency

[112] Cite Douglass North; Oliver Williamson, "NIE taking stock, looking ahead" Journal of Economic Perspectives

[113] Regional Plan Association, New Mobility: Autonomous Vehicles and the Region, October 9, 2017, http://www.rpa.org/publication/new-mobility-autonomous-vehicles-and-region; University of Washington Tech Policy Lab, Driverless Seattle, n.d. http://techpolicylab.org/wp-content/uploads/2017/02/TPL_Driverless-Seattle_2017.pdf

managers and decision-makers to shape these new markets for the public good and to enter these relationships with eyes wide open, on the lookout for unintended as well as intended consequences.

B. The Hazards in Store for Cities as Testbeds of Autonomous Systems

Cities are appropriate centers of autonomous robotic innovation, but they should proceed carefully to avoid treating the associated risks of these technologies and partnerships as afterthoughts. The problems that accompany autonomous systems in cities could be understood in the same terms as the promises associated with these technologies, for safety, convenience, equity, emissions, and the economy.

Safety is perhaps the one risk that has risen to the forefront for governmental offices as they have witnessed the early adoption of autonomous vehicles and robotics. The bulk of activities at the Federal, State, and local level, from reports and model legislation to the development of testbeds outside as well as within public rights-of-way, highlight the importance of safety in the design and use of these products. Similarly, accounts of accidents in the news have raised public and private concern over the continuing role of the human behind the wheel and the impacts to people and property from collisions with autonomous vehicles, robots and drones.[114] Recent news that a pedestrian was killed by an automated vehicle in Chandler, Arizona, may strike many advocates of the technology as shocking.[115] Such anecdotes may temporarily pierce the popular notion that autonomous systems will eliminate death and injury. The idea that autonomous controls will eliminate injury is unrealistic because, like all complex technological systems, artificially intelligent autonomous controls are never completely understood, even by those that design the system.[116] The complexity and processing power of autonomous controls can be expected to increase over time as the systems are trained to operate within complex environments. But, because of the tendency designers have to add responsibilities to these systems as fast as possible, there are some in the field who caution that it may be impossible to create a truly safe autonomous system.

Public pronouncements that autonomous systems will usher in an unprecedented era of convenience, contrast with early evaluations of autonomous vehicles that show, in the context of the holistic use of urban public space, that they are not as cost-effective as existing alternatives. Most of the firms engaged in trials of autonomous vehicles are using cars that would carry three or fewer occupants. Recent studies of the impact of autonomous vehicles on traffic in downtown Boston, with associated simulations to model preferences for mode choice, show a 15 percent reduction of vehicles on the road, coupled with a 16 percent increase in vehicle miles traveled, resulting in only a 4 percent improvement in travel time in general and a 5 percent increase in

[114] https://www.engadget.com/2017/12/07/san-francisco-restricts-delivery-robots/; https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/; https://arstechnica.com/tech-policy/2018/03/drone-crashes-in-arizona-national-forest-starts-a-wildfire/

[115] https://www.npr.org/sections/thetwo-way/2018/03/19/594950197/uber-suspends-self-driving-tests-after-pedestrian-is-killed-in-arizona?sc=tw

[116] https://www.popularmechanics.com/technology/security/a14537028/i-am-an-ai-researcher-this-is-what-keeps-me-up-at-night/

travel time and associated congestion in the downtown area.[117] As improvements, these impacts fall short of traditional investments in bus and rail transit services, and underscore the importance of transitioning from single occupancy vehicles to pooled ridership and renewed investment in transit.[118] Otherwise, the influx of autonomous services in the form of vehicles and robots would be predicted to increase congestion, and cause more of a nuisance than a convenience.

Autonomous vehicles and robotics can only be expected to make cities more equitable if they are accessible to all. The firms participating in these markets are like any other firms in that they will reach a point in time when the profitability of autonomous services matters.[119] As they strive for profitability, firms can be expected to care about pricing, market share, participation in two-sided markets, their ability to influence the adoption of rules and regulations that stave off competition, and to generally safeguard their financial self-interest. The moves of firms in these areas can also be expected to be regressive, having a disproportionate impact on those who have relatively little ability to pay for transportation services and those who are in vulnerable, low-wage jobs.[120] These economic conditions are not going to change with autonomous systems. Reading the media today, it would be easy to assume that the free or low-priced services that accompany the initial rollout of products to market would continue into the future, because it is tempting to think that firms will pass on the cost savings that come from automated fleet services to customers. To assume so would be naive. The need for free and reduced price services and requirements of service-area coverage enforced today by transit and transportation agencies will not disappear with new technologies. The equitable pricing and access to transportation services will continue to be of critical importance for policy-makers in the era of autonomous systems.

Emissions will only be reduced by autonomous vehicles and robotic systems if the sources of energy used to power them are less carbon intensive than the current fuel mix. Environmental and political pressure to convert from fossil fuel sources to electricity are transforming the auto industry, at the same time that automakers are partnering en masse with information technology firms to adopt autonomous control systems.[121] The conversion to electric energy is also leading automakers to expand into areas of the transportation market in search of opportunities to lock-in new sources of revenue, such as long term concession agreements that would place firms in the position of controlling access to and the price of public parking spaces in exchange for capital investment in electric charging stations.[122] Altogether, the combined forces of automation and electrification may upend the industrial organization of the transportation industry,

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[117] https://www.youtube.com/watch?v=zMZIEBoR49U

[118] Cite from transit/transportation lit

[119] Tech firms benefit in early development and market expansion from venture capital and other types of investment for revenue.

[120] Cite recent study of increasing cost of rideshare v. existing transportation options; cite recent study of impact focused on low-wage jobs

[121] Recent announcements from France, China, and other nations to ban the sale of vehicles that rely on fossil fuels; Recent announcements from automakers converting market offerings to all electric. Recent announcements of GM, Fiat Chrysler, Ford, and so on in partnership with various AV firms.

[122] BMW and others in this area

transforming what has been a highly disaggregated ownership structure based on private personally-held assets, into highly concentrated ownership of fleets, and firms with ownership in search of preferential or exclusive rights to currently public rights-of-way.

Of these concerns, perhaps the most complex is the question of whether or not autonomous vehicles and robots will bring about economic and associated financial improvements in the public interest, for the cities responsible for the infrastructure that these systems rely on. Early reports already suggest that public parking, which is one of the most important sources of revenue for cities in the transportation sector, may be under threat by autonomous systems. Results from last year's simulation of the effect of autonomous vehicles on Boston's parking system show a reduction in demand for parking by 48 percent. At the same time, cities can expect to experience pressure from firms to invest more in public rights-of-way, by either embedding technologies in infrastructure or re-designing and constructing built environments to favor their products, and to provide preferential or exclusive allocations of public space for their private use.[123] In general, such efforts should be recognized as attempts to pass on the private cost of adopting these technologies to the public taxpayer, and with that to society.

D. How cities can prepare to be sites of experimentation

This paper argues that cities should be given the authority and flexibility to experiment with autonomous vehicles and robotics, and that city managers and decision-makers should prepare to participate in the testing process with the designers of artificially intelligent systems. This section provides an overview of the task ahead for cities, highlighting perspectives and methods useful for evaluating the effects of policy choices in the public interest.

From an institutional economic perspective, cities as sites of experimentation need to recognize and harness their ability to act as market makers. Governments create the rules of the game for private firms. In times of institutional change, governments can act in the public interest by orienting policy-making toward the purposes of minimizing social harm, internalizing externalities, and preventing the transfer of private costs to society. When considering the many facets of change accompanying autonomous vehicles and technologies, focus should build on the collection of metrics such as those emerging from Boston, and move to evidence-based policy and evaluations that compare the costs to firms and the public of existing and new technologies as they occur under various institutional arrangements.

City managers and decision-makers will need support for sophisticated negotiations in the domain of automated vehicles and robotics. Policies, procedures, regulations, and enforcement implicated in governing these technologies span the boundaries of the transportation and information technology sectors as we understand them today. It is perhaps for these reasons that several cities have formed interdisciplinary working groups on the topic of testbeds for autonomous vehicles, including partnerships with outside organizations, some of which appear to be unique in the history of the sector. One of these is Boston's multi-year partnership with Boston Consulting Group and the World Economic Forum which, in the first of several reports

[123] Cite examples, such as Uber in Pittsburgh

affirms that cities should work cooperatively with state and federal agencies, but that cities should really be in "the lead in establishing a governance structure and testing policy and parameters to foster innovative solutions to their most pressing transportation challenges."[124]

Advice and support can be especially helpful if it can be interdisciplinary, providing a clear picture of the implications of the various policy options ahead. At times like this -- when the adoption of policy can actually reshape the entire industrial organization of a sector of critical infrastructure -- it pays to place policy debates in economic and social terms. When political arguments have economic motivations, it is particularly important to know the economic implications of their adoption in law and policy. Arguments for the freedom to innovate may have ideological merit, but the practical implications for policy change are usually about the reallocation of property rights across the public and private sector for economic or financial gain. These reallocations have the effect of determining, inter alia, the factors and associated costs that will be internal to markets and therefore borne by firms and established in the pricing of goods and services on the market, and the factors and associated costs that will be externalized, and thus borne by public agencies, the taxpayers that fund them, and society in general.

Furthermore, the methodologies used to reveal these relationships matter. Simple cost-benefit analyses, commonly recommended in the analysis of public expenditures, are not appropriate when the alternatives to be evaluated serve differing policy goals. More promising analyses are possible if, borrowing somewhat from research methodologies in institutional and transaction cost economics, the economic effects of policy options are examined holistically for the trade-offs experienced by the various public and private parties involved in delivering and receiving services, with current and potential future industrial organizations of the sector in mind.[125] In all cases, it is important to understand the comparative effects of current and proposed policy options with respect to the distribution of production and transaction costs across the parties involved in delivering, governing, and consuming the products and services. The methodologies for examining comparative institutional arrangements from transaction cost economics, which break down the delivery of services by task, noting which party bears costs and which receives benefits, and in what amounts, may be adapted to this purpose.[126]

It is also important that research consider the effects that policies may have on competition, and the impacts that would occur if competition in the transport sector were to be replaced by concentrated ownership of assets. Competition is still the most important force in delivering

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[124] https://globenewswire.com/news-release/2017/10/17/1148405/0/en/Boston-Test-of-Self-Driving-Cars-Reveals-Five-Key-Lessons-for-Cities-Worldwide.html; https://www.bcg.com/publications/2017/automotive-making-autonomous-vehicles-a-reality.aspx.

[125] Cite Whittington, Journal of the American Planning Association, on a transaction cost methodology for comparing costs and trade-offs, shown as the amount of funding allocated to and from the parties involved in the various tasks involved in delivering infrastructure projects, according to alternative policies. Cite Whittington and Hoofnagle, UNC Law Review, on the consequences of small numbers of competitors for consumers in information-intensive industries, such as social network services, with demand and supply side economies of scale.

[126] E.g., Whittington, Journal of American Planning Association, 2012

economic benefits from markets, but the extent to which society reaps these benefits and maintains competition depends also on the institutions that govern the sector. Historically the private ownership of mobile assets and public investment in network -- operated as a non-excludable asset -- has assisted this sector in avoiding several market failures that are more visibly acute in, for example, the communication sector's struggle over net neutrality or rent-seeking behavior on the part of organizations that own the transmission systems needed to wheel water from one community to another. Policies that preserve equal access to essential infrastructure such as the underlying network of roads, parking, conduit, utility poles, curb, and gutter, and resist the urge to privatize public space on transportation and related communication networks, have the economic effect of keeping this space in play for all parties, and keeping barriers low for competitors seeking entry to the market with mobile assets. Privatization of public space and policies that offer preferred or exclusive access have the opposite effect, locking public entities into monopoly or oligopoly relations in the provision of services and thus the potential for multiple downstream hazards, such as disputes over pricing, quality of service, and a host of opportunity costs that accompany the privatization of public assets.[127]

Guidance from National Association of City Transportation Officials and the Regional Plan Association of New York suggests that cities create public-facing, proactive strategies for exploring, testing, permitting, and supporting autonomous vehicles, and the same guidance should be extended to include urban robotics and drones. City strategies should be designed to assist decision-makers in understanding the strengths and limitations of artificially intelligent products, and the prevailing business models that firms are relying on as they enter the market. It would be important to know, for example, the interests of firms as they seek access to the public rights-of-way, the models for pricing of goods and services, plans for market and service-area expansion, and the disposition of the data the firm collects about the public. These factors are central to the operation of firms and happen to coincide with the interests that cities have in crafting policies in the public interest. Each city should be prepared to evaluate these products and their providers on the merits and the costs to city government and city residents. Existing guidance attempts to summarize the values that city decision-makers and managers consider important and, as noted above, these considerations are not necessarily aligned with the interests of the firms. Firms may seek to externalize costs and use data about local residents on secondary markets, and cities should avoid this trap. The capacity to evaluate policy will matter, as noted in this section, and so will the capacity to evaluate the various forms of agreements and contracts that will be instrumental in preserving public values while adopting these new technologies.

In their efforts, city managers should perhaps make a point of explaining to the various parties in these new industries that environmental design is local, expensive, and extremely consequential. Guidance from National Association of City Transportation Officials and the Regional Plan Association makes this point in subtle ways, by emphasizing efficient options for intersection design, for example, and laying out a timeline for the gradual redesign of urban arterials that surely appears to be slow in comparison to the business plans of firms and their

[127] Cite Elliot Sclar, You Don't Always Get What You Paid For, ; Ellen law article on hidden costs of privatization; and Siemiatycki?

investors. From the point of view of city management, this slow pace of environmental design is what may be realistic, under the most ambitious of timeframes, given how changes to the built environment actually proceed. Earthwork, concrete, utility posts, the relocation of utilities -- these are the types of modifications that people take for granted, but are highly significant for their expense and opportunity cost in the budget cycle of public agencies. One new sensor or communication device on a utility pole will not cost very much, but when contemplated at the scale of the transportation system the cost quickly becomes prohibitive for all but the most wealthy of jurisdictions. The consequences of alterations to the built environment are of course physical, but they are also financial, they are dependent in their financial impact on the contractual arrangements that made them possible, and they matter for the extent to which they give rise to new flows of information, impacts to privacy, and monetization of data about local residents. Lastly, many legal requirements extend from local environmental design, from local speed limits, to liabilities for safety, nuisance, security, and privacy.

Part IV: Preemption, Cities, and the Governance of Autonomous Systems

This Part is an account of the law of urban robotics. It begins with an overview of federal and state preemption and city police powers, noting that federal and state governments can greatly restrict local authority, although there are some spheres where cities typically exercise their authority. Next, it surveys existing or proposed federal and state robotics laws, with particular attention to preemption issues. We then provide an account of how cities are regulating urban robots and serving as test beds for innovation.

[The individual sections of this part need to be expanded with more detail and nuance. There was simply not enough time for a full account of every state's Home rule status and AV laws, for example. Suggestions for improvement are welcome]

A. Federal Preemption and Home Rule

Two types of preemption are important for this account of urban robotics: federal preemption of states and localities, and state preemption of localities. Federal preemption is where federal law supersedes and invalidates a state or local government law. It is is based on the Supremacy Clause of the US Constitution, which provides that federal law and Constitution are "the supreme Law of the Land; and the Judges in every State shall be bound thereby, any Thing in the Constitution or Laws of any State to the Contrary notwithstanding."[128] The dispositive question for a court in finding federal preemption is whether Congress intended to preempt the states on the matter.[129] If Congress expresses its preemptive intent in the text of the law, it has created express preemption.[130] If a court finds express preemption, it must then determine "the substance and scope of Congress' displacement of state law..."[131] The Supreme Court has said that when statutory preemption language has more than one plausible reading, courts should "accept the reading that disfavors pre-emption."[132]

[128] U.S. Const. art. VI, cl. 2.; see also McCulloch v. Maryland, 17 U.S. (4 Wheat.) 316 (1819).
[129] Altria Group v. Good, 555 U.S. 70 (2008).
[130] *Id.*
[131] *Id.* at 76
[132] Bates v. Dow Agrosciences LLC, 544 U. S. 431 (2005)

If a court finds no language that expressly preempts state law, it may still find implied preemption in the legislation's structure and purpose.[133] Implied preemption takes two forms: conflict preemption and field preemption. With conflict preemption, state or local laws either conflict with federal law or present an obstacle to the Congressional purpose.[134] With field preemption, the Congress has expressed an intent to "occupy the field" on that issue, leaving no room for states to supplement the law or otherwise regulate.[135] For example the Supreme Court has held Illinois licensing and training requirements for hazardous waste handling to be invalided by the Occupational Safety and Health Administration's regulations.[136]

While federal law may be supreme, the constitutional system of federalism provides only certain enumerated powers to the federal government, while reserving all others to the states.[137] The 10th Amendment prevents the federal government from "commandeering" state governments by imposing affirmative duties to do things that they would not otherwise do.[138] For example, Congress may not force states to assume liability for radioactive waste, or use state police resources to conduct federal background checks for firearm purchases.[139] Congress may condition federal grant money on certain state actions, such as raising the drinking age to 21.[140] However the conditions of the grant may not be so onerous that they coerce the states into action.[141]

State preemption of local governments does not operate under the same constitutional framework as federal preemption. While the U.S. Constitution reserves broad power for states in the 10th Amendment,[142] cities are not even mentioned in the document. Broadly speaking there are two views of local power in relation to states: Dillon's rule and Home rule. Under the traditional view described in Dillon's Rule, cities are simply administratively convenient organizations that derive their power from states, so they only have the limited powers granted by the state.[143] They are not themselves sovereign. Discontent with Dillon's rule eventually led states to grant more powers to cities, first on matters of "local concern," and later broader "police powers."[144] Police powers encompass the public's health, safety, welfare, and morals.[145]

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[133] Altria Group
[134] Altria Group
[135] Gade v. National Solid Wastes Mgmt. Ass'n, 505 U.S. 88, 98 (1992).
[136] *Id.*
[137] U.S. Const. 10th Am.
[138] New York v. United States, 505 U.S. 144 (1992); Printz v. United States, 521 U.S. 898 (1997).
[139] *Id.*
[140] South Dakota v. Dole, 483 U.S. 203 (1987)
[141] National Federation of Independent Business v. Sebelius, 567 U.S. 519 (2012)
[142] U.S. Const. 10th Am. https://www.law.cornell.edu/constitution/tenth_amendment
[143] "Municipal corporations are political subdivisions of the state, created as convenient agencies for exercising such of the governmental powers of the state as may be entrusted to them....The number, nature, and duration of the powers conferred upon these corporations and the territory over which they shall be exercised rests in the absolute discretion of the state." Hunter v. Pittsburgh, 207 U.S. 161, 178 (1907)
[144] Paul Diller, Intrastate Preemption, 87 B.U.L. REV. 1113, 1122-25 (2007)
[145] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf

However, they are still "subject to denial of power in a particular substantive field by specific act of the state legislature."[146] That is, local governments typically do not have unfettered police powers even under home rule. States enact home rule either in their constitutions or legislatively.[147] Home rule powers come in two forms: empowerment/initiative, the ability to enact substantive policy; and immunity, the ability to "resist encroachment from another governmental entity or from a private party."[148]

A group of legal experts convened by the American Constitution Society identifies five categories of municipal power. *Structural* authority is the power to choose or modify the form of city government.[149] *Personnel* authority is the power to set employment policies, compensation, and collective bargaining.[150] *Fiscal* authority is the power to "raise revenue, borrow money, and spend."[151] *Proprietary* authority is the power to set policy through the procurement and contracting process, what we call market making.[152] *Regulatory* or functional authority encompasses the "police power" to set substantive policy and regulate health, safety, welfare, and morals.[153] Cities often rely on regulatory power when setting rules for firms, so it is often at issue in state preemption fights.[154]

Home rule schemes vary a great deal from state to state. In states where the home rule grant is purely legislative, the state can preempt any city action and cities have no immunity.[155] However some state constitutions expressly protect local authority.[156]

Cities and states legislatures have engaged in high profile preemption conflicts on a variety of issues. These issues run the gamut from anti-discrimination rules for transgender individuals, to sanctuary city and minimum wage laws, to municipal broadband and ride-sharing apps.[157] Cities feel that they have an interest in the impact of technological change on the health or safety of their residents, or the provision of city services. Where firms operate new technological platforms in cities, namely ride and room sharing, several states have preempted city

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[146] *Id.* at 1125.
[147] The Troubling Turn in State Preemption: The Assault on Progressive Cities and How Cities Can Respond, American Constitutional Society (Sep. 2017) https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[148] Nestor M. Davidson, Cooperative Localism: Federal-Local Collaboration in an Era of State Sovereignty, 93 Va. L. Rev. 959, 967 (2007)
[149] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[150] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[151] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[152] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[153] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[154] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[155] https://acslaw.org/sites/default/files/ACS_Issue_Brief_-_Preemption_0.pdf
[156] E.g., COLO. CONST . art. XX, § 6 (declaring that local charters and ordinances involving "local and municipal matters...shall supersede . . . any law of the state in conflict therewith"). [Need other examples]
[157] National League of Cities, http://www.nlc.org/sites/default/files/2017-03/NLC-SML%20Preemption%20Report%202017-pages.pdf

regulation.[158] Cities have also sought to impose regulation or alter street design to keep traffic algorithms like Waze from redirecting freeway traffic onto urban and suburban side streets.[159] These recurring debates highlight the fact that cities occupy a legally difficult space when it comes to the source and scope of their power to regulate.

Even with the variety that exists among states, cities tend to have a great deal of authority in certain areas related to environmental design. Cities tend to have broad powers in zoning to determine the nature and character of city neighborhoods.[160] Cities usually control the maintenance of public streets within their territory, although the lines of which government body is responsible for which street can blur.[161] They also regulate the design of public and private spaces by placing restrictions on building height or space between the building and the street (called the "setback").[162] Cities exercise broad taxing authority to raise funds for improvements to public space, manage those improvements, and maintain the condition of the space, either in house or in contract with the private sector. Many utility services, such as parking, electricity, water, communications, wastewater, stormwater, and solid waste, occupy the same rights-of-way and may be publicly owned. [Expand this in the future].

The preemption debate is already beginning to play out with urban robots. Proposed federal autonomous vehicle legislation has quite broad preemption language. One libertarian think tank has raised the alarm that ride sharing firms will lobby cities to ban individual ownership of autonomous vehicles and urged states to preempt cities on that issue.[163] Five state laws currently preempt city regulation of autonomous vehicles. On the other hand, the five states with delivery robot laws on the books explicitly allow cities to regulate such machines.

B. Federal and State Robotics Laws

The following section reviews federal and state law pertaining to autonomously controlled vehicles for passengers and cargo delivery, and robotics for security and entertainment, including drones.

Federal and state laws pertaining to robots in the urban environment are complex and evolving rapidly. Some types of robots may be legal already, without requiring any changes to existing law. Professor Bryant Walker Smith has argued that this is generally true of autonomous

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[158] National League of Cities, http://www.nlc.org/sites/default/files/2017-03/NLC-SML%20Preemption%20Report%202017-pages.pdf

[159] https://www.bostonglobe.com/business/2017/12/24/apps-like-waze-reroute-commuter-traffic-towns-fight-back/WqzeqfiikCc9yPtBFkgvbO/story.html

[160] Richard Briffault, Our Localism: Part I--The Structure of Local Government Law 90 Colum. L. Rev. 1 (1990).

[161] See e.g. http://www.goshennews.com/news/who-is-responsible-for-sidewalks-the-city-the-state-or/article_3a89622d-f811-56ea-853e-734fa7b317a8.html; https://www.cityofsacramento.org/Public-Works/Questions/Maintenance; http://www.richmondgov.com/PublicWorks/StreetMaintenance.aspx.

[162] E.g. http://qcode.us/codes/davis/?view=desktop&topic=40-40_26-40_26_010. Cite to bellevue, portland.

[163] https://cei.org/blog/uber-wants-make-it-illegal-operate-your-own-self-driving-car-cities

vehicles.[164] Smith argued in 2012, before the passage of any specific AV legislation, that AVs are legal under international and federal law and most state laws.[165] He noted that some laws might inadvertently present an obstacle, such as a New York law that requires the drivers to keep their hands on the steering wheel, but as a general principle AVs should be allowed on roads without new laws.[166] Some states like Arizona have adopted this approach to permissionless innovation,[167] although many others have enacted legislation to allow AVs on the road. In fact, a disagreement between Uber and the California Department of Motor Vehicles over whether Uber needed a permit to test its autonomous vehicles in San Francisco (Uber thought it didn't, California thought it did), reportedly led the company to move its operation to Arizona.[168] Since Smith's 2012 publication, autonomous vehicle regulation has become more complex, with a growing number of state and federal regulators setting rules in this space. At the time of writing, 21 states have enacted some form of autonomous vehicle legislation, and six more have relevant executive orders.[169] A large majority of states (41) have considered legislation since 2012.[170] Five of these states, Illinois, Nevada, North Carolina, Tennessee, and Texas, have preempted municipal regulation of autonomous vehicles in their legislation.[171]

Recent federal action on autonomous vehicles has historically centered on administrative agencies, although legislation has passed in the House and is pending in the Senate.[172] The US Department of Transportation has convened a series of meetings aimed at reducing regulatory barriers and promoting autonomous vehicle technology.[173] The National Highway Traffic Safety Administration (NHTSA) has solicited comments from the public "to identify any regulatory barriers in the existing Federal Motor Vehicle Safety Standards (FMVSS) to the testing, compliance certification and compliance verification" of autonomous vehicles.[174] The agency

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[164] *See* Bryant Walker Smith, Autonomous Vehicles Are Probably Legal.
[165] *Id.*
[166] *Id.* [find pincite]
[167] Arizona's governor recently signed a new executive order creating some registration and notice requirements for AVs, but the state has long decided against amending its driving laws with AVs in mind. The governor has cited this hands-off approach to AV regulation for making the state a leader in AV development, although the state's weather is also a factor. http://www.phoenixnewtimes.com/news/arizona-governor-doug-ducey-creates-rules-for-self-driving-cars-10191122.
[168] https://www.curbed.com/2016/12/22/14057046/uber-driverless-car-san-francisco-fail
[169] http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx
[170] http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx
[171] Cite to state laws. Idaho's preemption is less severe than the others.
[172] It was a federal agency that kickstarted the development of AVs. The Defense Advanced Research Projects Agency (DARPA) Grand Challenge is considered to have set off the current boom in AV research and development. https://www.wired.com/story/darpa-grand-urban-challenge-self-driving-car/.
[173] US Department of Transportation, Automated Vehicle Activities, https://www.transportation.gov/AV (last visited Feb. 26, 2018).
[174] Removing Regulatory Barriers for Vehicles With Automatd Driving Systems https://www.federalregister.gov/documents/2018/01/18/2018-00671/removing-regulatory-barriers-for-vehicles-with-automated-driving-systems (last visited Feb. 26, 2018).

has also issued voluntary safety guidelines that includes model state policies and other technical guidance for state legislatures and transportation officials.[175]

NHTSA guidance contemplates a dominant role for federal regulators as compared to states. In *Autonomous Driving Systems 2.0: A Vision for Safety*, the agency "strongly recommends States to allow [the US Department of Transportation] alone to regulate the safety design and performance aspects of [autonomous driving system] technology. If a State does pursue [autonomous driving system] performance-related regulations, that State should consult with NHTSA."[176] It lists state responsibilities as 1) "Licensing human drivers and registering motor vehicles in their jurisdictions," 2) "Enacting and enforcing traffic laws and regulations," 3) "Conducting safety inspections, where States choose to do so," and 4) "Regulating motor vehicle insurance and liability."[177]

Federal legislation that has passed in the House contains broad preemption language that would prevent states and cities from regulating autonomous vehicles. It contains the following preemption language: "No State or political subdivision of a State may maintain, enforce, prescribe, or continue in effect any law or regulation regarding the design, construction, or performance of highly automated vehicles, automated driving systems, or components of automated driving systems unless such law or regulation is *identical* to a standard prescribed under this chapter" (emphasis added).[178] A "political subdivision of a State" refers to cities and local governments, as cities typically derive their police power from the state.[179] The bills allow cities and states to maintain laws related to "registration, licensing, driving education and training, insurance, law enforcement, crash investigations, safety and emissions inspections, congestion management on [State or city streets], or traffic unless the law or regulation is an unreasonable restriction on the design, construction, or performance" of autonomous vehicles.[180] Companies say that this preemption language is necessary to avoid a patchwork of regulation that will hinder innovation, but it has drawn criticism from safety and consumer advocacy groups and state governments.[181]

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[175] U.S. Department of Transportation, Automated Driving Systems 2.0: A Vision for Safety https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf (hereinafter DOT AV 2.0); Federal Automated Vehicle Policies https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf

[176] DOT AV 2.0, at 20. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf

[177] DOT AV 2.0, at 20. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf (The relevant section in the 2016 guidance under Obama was functionally the same).

[178] SELF DRIVE Act https://www.congress.gov/bill/115th-congress/house-bill/3388/text

[179] See infra.

[180] https://www.commerce.senate.gov/public/_cache/files/1fb8fa36-331b-4f0b-907a-6dededda4d31/37F56742A509A877F54FDF7389DFDAA7.s.-1885-av-start-act.pdf

[181] https://www.theverge.com/2017/7/19/15998356/self-driving-car-congress-legislation-lobbying-safety; https://www.reuters.com/article/us-autos-selfdriving-analysis/u-s-push-for-self-driving-law-exposes-regulatory-divide-idUSKCN1BQ24J; https://ggwash.org/view/65027/have-senators-let-cities-and-states-shape-autonomous-vehicles-avs-affect-us-preemption-congress.

The Senate AV START Act which is still pending, originally had the same language as the House version. However, it has been amended to read: "No State or political subdivision of a State may adopt, maintain, or enforce any law, rule, or standard regulating the design, construction, or performance of a highly automated vehicle or automated driving system with respect to any of the safety evaluation report subject areas described in section 30107(b)."[182] This language is less broad than the House bill. The Senate bill also preserves some powers specifically for state and local governments: "Nothing in this paragraph may be construed to prohibit a State or political subdivision of a State from maintaining, enforcing, prescribing, or continuing in effect any law or regulation regarding the sale, distribution, repair, or service of highly automated vehicles, automated driving systems, or components of automated driving systems by a dealer, manufacturer, or distributor."[183]

It is unclear how state privacy rules might fare under this preemption language. The House bill currently requires companies to formulate a privacy policy for automated vehicles.[184] Having a policy will open companies to enforcement action by the FTC if they break the promises contained therein. State AGs may bring similar actions under state law. However, some states have substantively stricter privacy rules that may create an "unreasonable restriction" on automated vehicles. For example, Texas or Illinois' law against collection of biometric data could interfere with facial recognition capabilities in automated vehicles.[185]

Autonomous *flying* cars present a separate set of challenges. Although the flying taxi company Kitty Hawk recently announced an agreement with the government of New Zealand to test its autonomous flying personal vehicles, the Federal Aviation Administration has been less active on the topic of flying cars.[186] The agency has issued an exemption to some of its regulations for general aviation aircraft, but the process is reported to be quite complicated and time consuming.[187] This process could, for example, complicate Uber's promise to deliver flying car service by 2020.[188]

State and federal Regulation of delivery vehicles is more nascent than autonomous vehicles. Since 2017 five states have enacted laws to specifically allow and regulate delivery robots (called PDDs for "personal delivery devices"): Florida, Idaho, Ohio, Virginia, and Wisconsin.[189] Each law allows cities to pass their own PDD regulations or safety requirements.[190] At the time of writing we have not found any federal regulatory action on PDDs.

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[182] https://www.congress.gov/bill/115th-congress/senate-bill/1885/text
[183] https://www.congress.gov/bill/115th-congress/senate-bill/1885/text
[184] [Cite to SELF DRIVE Act.]
[185] These laws have already prevented a google facial recognition app from running in both states.
[186] Andrew Ross Sorkin, Larry Page's Flying Taxis, Now Exiting Stealth Mode, NY Times (Mar. 12, 2018) https://www.nytimes.com/2018/03/12/business/dealbook/flying-taxis-larry-page.html.
[187] https://aerospaceamerica.aiaa.org/faa-excite-nascent-flying-car-industry/; https://www.washingtonpost.com/news/the-switch/wp/2016/06/20/flying-cars-just-took-a-big-step-closer-to-being-legal/?utm_term=.a42f4cdc9a84
[188] https://www.aopa.org/news-and-media/all-news/2017/april/27/uber-promises-flying-cars-by-2020
[189] Cite to state laws.
[190] *Id*.

Other federal regulatory activity may not be specifically directed at robotics but is likely to have an impact. The Department of Commerce work on Internet of Things patchability and security will effect robots that are connected to the Internet and therefore part of the Internet of Things.[191] A recent, though now defunct, proposal to nationalize the 5G telecommunications infrastructure highlights the interplay between federal telecommunications policy, physical infrastructure, and technological development.[192] The proposal cited Chinese dominance in artificial intelligence and other emerging technologies as well as China's infrastructure spending as motivating factors.[193] Federal privacy and cybersecurity rules, either from the Federal Trade Commission or some future legislation, could also be relevant.

It is also not clear how either the House or Senate AV laws would apply to PDDs. Both laws refer to section 30102 of chapter 49 of the US code, which defines a motor vehicle as "a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways, but does not include a vehicle operated only on a rail line."[194] While this definition arguably does not apply to PDDs that operate primarily on sidewalks, it does appear to apply to larger delivery robots that operate on city streets.

Security robots have thus far escaped the attention of state and federal regulators. This is probably due to the fact that they mostly operate on private property, by private actors. Or perhaps they are simply less widespread, or seen as disrupting a less vital industry than transportation or last-mile delivery. Should they evolve into government controlled police robots, they will warrant greater regulation by state and federal actors. Professor Elizabeth Joh has predicted such a development and called for "uniform national policies" for police robots, such as the use of conditions or strings attached to federal procurement grants to require police departments enact policies governing the use of robotic force.[195]

As with security robots, entertainment robots are currently unregulated at the state and federal levels. This may be just as well, as most have not even been deployed in commerce yet. In some cases the regulations for PDDs may apply, such as with Gita, the droid designed to "fit a case of wine."[196] Segway is also marketing package delivery as a possible use case for Loomo.[197] It is possible that as these types of urban robots proliferate new laws may be proposed, but it is a little premature to speculate now.

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[191] https://www.ntia.doc.gov/category/internet-things

[192] Jonathan Swan, David McCabe, Ina Fried & Kim Hart, Scoop: Trump team considers nationalizing 5G network, Axios (Jan. 28, 2018) https://www.axios.com/trump-team-debates-nationalizing-5g-network-f1e92a49-60f2-4e3e-acd4-f3eb03d910ff.html. Like other IoT applications that require a great deal of bandwidth to communicate with each other and the cloud, robots that communicate via the internet may need advanced telecommunications infrastructure technologies like 5G.

[193] *Id.* https://www.axios.com/trump-team-debates-nationalizing-5g-network-f1e92a49-60f2-4e3e-acd4-f3eb03d910ff.html

[194] 49 USC Section 30102 (a)(7). https://www.law.cornell.edu/uscode/text/49/30102.

[195] https://www.uclalawreview.org/policing-police-robots/.

[196] Cite to atlantic article

[197] Cite to Loomo website.

Drones are a unique case for this paper because they fly and are thus regulated by the Federal Aviation Administration, and because they have applications that cut across the categories of urban robots we have explored thus far. Autonomous drones that are large enough to fit a person could serve as a type of flying robo taxi, while last-mile drone delivery has been a goal of companies (especially Amazon) for some time.[198] Startup companies are working on security drones to monitor property, an aerial version of Knightscope,[199] and the recreational drone was the "hot holiday gift" of the past few years.[200] Drone use cases extend to several other fields such as construction and surveying, agriculture, and the military, but the four categories of urban robotics are what interest us here.

The Federal Aviation Administration (FAA) is the federal body charged by Congress to write rules to "safely accelerate the integration of civil unmanned aircraft systems into the national airspace system."[201] The result is the "small unmanned aircraft systems [UAS] rule" codified in 14 CFR 107.[202] Section 107 applies to drones under 55 pounds and requires that recreational and commercial drone (also called UAS) operators obtain a drone pilot certificate and register their drone with the FAA.[203] The rules for safe operation also prohibit flying over 400 feet, flying over people, and flying outside visual line of sight of the operator.[204] However, these safe operation rules can be waived with a "107 waiver" from the FAA.[205] Legislation introduced in the Senate in 2017 directs the FAA to create an "air carrier certificate" for companies to conduct package delivery via drone.[206]

Statements by the FAA and a recent federal district court case indicate that federal drone rules operate under conflict preemption, leaving room for states and cities to regulate so long as they do not conflict with federal law. In 2015 the FAA's Office of Chief Counsel issued a document that warned states and localities against creating a patchwork of rules that would hinder nationwide UAS safety, but listed examples of where states and localities would have authority to act.[207] Examples include warrant requirements for police use of drones, or peeping tom

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[198] https://s3.amazonaws.com/s3.documentcloud.org/documents/2182311/amazon-revising-the-airspace-model-for-the-safe.pdf.
[199] Cite
[200] https://dailygazette.com/article/2017/11/24/drones-expected-to-be-popular-gift-again-in-2017
[201] FAA Modernization and Reform Act, Section 332, https://www.govtrack.us/congress/bills/112/hr658/text.
[202] 14 CFR 107 https://www.law.cornell.edu/cfr/text/14/part-107.
[203] 14 CFR 107. The registration requirement was struck down by a federal court in 2017 (Taylor v. Huerta (No. 15–1495; decided on May 19, 2017)), but later reinstituted by Congress National Defense Authorization Act of 2018 H.R. 2810, Section 1092 (d).
[204] 14 CFR 107.51 https://www.law.cornell.edu/cfr/text/14/107.51
[205] 14 CFR 107.205
[206] S. 1405, Section 2136 "Small UAS Air Carrier Certificate" https://www.congress.gov/bill/115th-congress/senate-bill/1405/text#toc-id488e863d365a47cbbc1db9205799f44c.
[207] https://www.faa.gov/uas/resources/uas_regulations_policy/media/uas_fact_sheet_final.pdf; see also https://www.faa.gov/uas/resources/event_archive/2017_uas_symposium/media/Workshop_7_Local_and_State_UAS_Enforcement_Authorities.pdf.

laws.[208] The agency also recently instituted a program for states, cities, and tribal authorities to partner with companies to bypass existing regulations more easily and experiment with advanced UAS applications at the local level.[209]

A recent court case also concluded that the FAA rules operated under conflict preemption, not field preemption. *Singer v. Newton* related to a city ordinance that sought to impose certain regulations on drone flight within the city.[210] The city of Newton, Massachusetts passed a drone ordinance that applied to drone flights within the city limits. Michael Singer, an FAA-certified drone pilot who resides in Newton, challenged provisions that required drone operators register with the city, banned flights over private property without the property owner's permission, banned flights over Newton city property without permission, and required visual line of sight flight.[211] The ordinance also banned drone surveillance and interference with manned aircraft, but Singer only challenged the previous four provisions. He argued that air safety is normally solely regulated by the FAA, so field preemption should apply. However, Judge Young noted the FAA's statements about preserving some authority for state and local governments to regulate.[212] At the same time, he concluded that the FAA had not created "an express carve-out for states and localities to regulate," but rather hinted that "whether parallel regulations are enforceable depends on the principles of conflict preemption."[213]

The judge invalided each of the challenged provisions under conflict preemption. The FAA expressed its intent to be the "exclusive regulatory authority" for drones in the navigable airspace, and therefore the city's registration provision was invalid.[214] The judge concluded that Newton's requirement that drone flights over private and public property first obtain permission was effectively a ban on drone flights over the city, which frustrated the FAA and Congress' intent to integrate drones into the airspace.[215] Finally, the judge ruled that the line of sight rule impermissibly intervened "in the FAA's careful regulation of aircraft safety," because the FAA allows visual observers to augment line of sight flight or outright waivers of that requirement.[216] The Court's ruling makes sense given the FAA's policy statements about letting states and localities act in the drone space. However, it should stand as a warning against regulation that even seems like a ban on drones in the airspace. State or municipal attempts to regulate drone safety are especially suspect.[217]

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[208] *Id.*
[209] https://www.faa.gov/uas/programs_partnerships/uas_integration_pilot_program/; https://www.geekwire.com/2017/faa-lays-process-advanced-drone-operations-giving-lift-amazons-plans/.
[210] https://www.documentcloud.org/documents/4058344-Singer-v-Newton-Decision.html
[211] https://www.documentcloud.org/documents/4058344-Singer-v-Newton-Decision.html
[212] *Id.*
[213] *Id.*
[214] *Id.*
[215] *Id.*
[216] *Id.*
[217] *Id.* "The Ordinance seeks to regulate the method of operating of drones, necessarily implicating the safe operation of aircraft. Courts have recognized that aviation safety is an area of exclusive federal regulation."

Proposed additional federal legislation seeks to clarify and preserve the authority of state and local governments to regulate drones. The Drone Federalism Act of 2017 directs the FAA to "ensure that the authority of a State, local, or tribal government to issue reasonable restrictions on the time, manner, and place of operation of a civil unmanned aircraft system that is operated below 200 feet above ground level or within 200 feet of a structure is not preempted."[218] It also requires the FAA to receive permission from property owners before authorizing "the operation of a civil unmanned aircraft in the immediate reaches of the airspace above property."[219]

Clarification of the relative authorities of city, state, and federal authorities would be timely given the proliferation of states with drone laws. According to the National Conference of State Legislatures, 41 states have enacted laws relating to drones and three more have adopted resolutions.[220] State drone laws range from anti-peeping Tom or voyeurism laws (California), to designations of "critical infrastructure that define the permissible airspace for drones (Nevada), to prohibitions on weaponizing drones (Oregon), to criminal sanctions on harming people or livestock (Utah).[221] Eight states have some kind of preemption for local drone regulation, although to varying degrees.[222]

The picture that emerges from this overview of state and federal robotics regulation is complex, with overlapping jurisdictions and atomistic rules that govern constituent technologies of robotics (e.g. telecommunications) or certain applications of robotics (e.g. AVs). Technological change may prompt federal authorities to become involved with issues that were traditionally the purview of state or local governments. Fatal and non-fatal accidents involving AVs have spurred investigations by the NTSB.[223]

This complexity accompanies a discussion in the legal literature about the appropriate level of governance for information technologies. Professor Ryan Calo has called for the creation of a Federal Robotics Commission not to regulate robotics, but to create a resource of technical expertise to better inform the federal government.[224] Attorney Matthew Scherer has proposed an artificial intelligence regulatory agency that would certify AI systems for safety to provide a safe harbor from tort liability.[225] Public figures such as Elon Musk and Stephen Hawking have also

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[218] Drone Federalism Act of 2017 https://www.congress.gov/bill/115th-congress/senate-bill/1272/text
[219] *Id.*
[220] http://www.ncsl.org/research/transportation/current-unmanned-aircraft-state-law-landscape.aspx
[221] http://www.ncsl.org/research/transportation/current-unmanned-aircraft-state-law-landscape.aspx [need to cite individual laws later]. See also http://dronecenter.bard.edu/files/2017/03/CSD-Local-and-State-Drone-Laws-1.pdf.
[222] http://www.ncsl.org/research/transportation/current-unmanned-aircraft-state-law-landscape.aspx. [need to cite individual laws later.]
[223] https://www.bloomberg.com/news/articles/2018-01-23/u-s-safety-board-opens-probe-of-second-tesla-autopilot-crash; https://techcrunch.com/2018/03/19/ubers-fatal-self-driving-car-crash-prompts-ntsb-investigation/.
[224] Ryan Calo, The case for a federal robotics committee, Brookings (2014) https://www.brookings.edu/research/the-case-for-a-federal-robotics-commission/.
[225] Matthew Scherer, *Regulating Artificial Intelligence Systems: Risks, Challenges, Competencies, and Strategies*, 29 Harvard J.L. & Tech. 354 (2016) available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2609777.

called for regulation of artificial intelligence.[226] Professor Margot Kaminski has argued for "drone federalism," where the federal government regulates the safe operation of drones and states regulate for privacy concerns.[227] Privacy is of a particular concern because robots, both airborne and grounded, will rely on advance sensing and processing, so widespread deployment of robots means widespread use of powerful surveillance technologies.

Some legal scholars and technologists have pushed back against regulation of artificial intelligence or robotics, cautioning that it would stifle innovation or lead to regulatory capture or stagnation.[228] Professor Adam Theier argues for a "permissionless innovation" model, of a kind with the hands-off regulation that allowed the internet to flourish.[229] With permissionless innovation, "innovators should be 'innocent until proven guilty' (unless, that is, a thorough benefit-cost analysis has been conducted that documents the clear need for immediate preemptive restraints)."[230] Preemptive regulation should be a last resort.[231] This stance comports with Professor Smith's argument that the default stance for autonomous vehicle regulation should be that a thing is permissible unless explicitly prohibited. While some jurisdictions, notably Arizona, have taken this approach, the sheer number state and federal autonomous vehicle, PDD, and drone laws promulgated with consultation from firms suggests that robotics companies may feel more comfortable innovating in partnership with governments.

C. Cities and Local Government Robot Regulation

Cities have taken a variety of approaches to regulating urban robots, as might be expected in a system of federalism where cities are sites of experimentation. Many cities have pilot programs to implement automated vehicles into their own transportation systems, for example with autonomous buses.[232] These pilot programs appear to be implemented through public-private

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[226] James Vincent, Elon Musk says we need to regulate AI before it becomes a danger to humanity, The Verge (Jul. 17, 2017) https://www.theverge.com/2017/7/17/15980954/elon-musk-ai-regulation-existential-threat; John Koetsier, Stephen Hawking Issues Stern Warnings on AI: Could be 'Worst Thing' For Humanity, Forbes (Nov. 6, 2017) https://www.forbes.com/sites/johnkoetsier/2017/11/06/stephen-hawking-issues-stern-warning-on-ai-could-be-worst-thing-for-humanity/#49989c0d53a7. It should be noted that Musk and Hawkings are expressing concerns about runaway AI and artificial superintelligence, which is a different problem than AV safety or other, more prosaic robotics issues under discussion here.

[227] Margot Kaminski, Drone Federalism: Civilian Drones and the Things They Carry, 4 Cal. L. Rev. Cir. 57 (2013) https://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1007&context=clrcircuit.

[228] Adam Theier, Problems with Precautionary Principle-Minded Tech Regulation & a Federal Robotics Commission, Medium (Sep. 22, 2014) https://medium.com/tech-liberation/problems-with-precautionary-principle-minded-tech-regulation-a-federal-robotics-commission-c71f6f20d8bd; Andrew O'Sullivan, Don't Let Regulators Ruin AI, MIT Technology Review (Oct. 24, 2017) https://www.technologyreview.com/s/609132/dont-let-regulators-ruin-ai/; Andrew Burt, Leave AI Alone, NYTimes (Jan. 4, 2018) https://www.nytimes.com/2018/01/04/opinion/leave-artificial-intelligence.html.

[229] Theier.

[230] *Id.*

[231] *Id.*

[232] SF: https://www.sfmta.com/sites/default/files/projects/2017/ATCMTD%20Grant%20Application.pdf. Cite to Atlanta.

partnerships between cities and firms.[233] With the exception of Boston, we have not been able to find publicly available copies of these agreements however.[234] Cities have also created dedicated physical spaces for automated vehicle testing.[235] They have already begun planning the necessary infrastructure upgrades to accommodate and prepare for widespread automated vehicle deployment.[236] In sum, in regulating automated vehicles most cities have relied on their proprietary authority to form public-private partnerships with firms, or their regulatory authority to shape the physical space in which the technologies operate. A notable exception is the ordinance proposed in the City of Chicago, which would limit automated vehicles to permitted firms for test purposes.[237] The law's sponsors cited cybersecurity concerns and potential job losses to automation as motivations.[238] They had considered an outright ban but lacked the support for that law.[239]

Cities have also begun pilot programs for PDDs. Cities including Washington DC, Austin, Texas, and a few cities in the Bay Area of San Francisco, have created pilot programs either through partnerships with firms or by passing an ordinance to allow delivery robots.[240] Ordinances passed in Austin and DC are naturally public, and Redwood City has published its partnership agreement along with reports on the pilot.[241] These laws and agreements tend to follow the same pattern. They define where the robots may operate (on sidewalks, not on highways), and create a permitting system for firms to gain permission to test the robots.[242] They also define certain parameters for the robot such as the maximum weight and speed, and impose certain safety requirements, such as not to interfere with pedestrians or bicycles.[243] Not every city is so welcoming however. San Francisco passed an ordinance that heavily regulates PDDs.[244] The law requires a permit for each robot being tested and limits the total number of permits to nine at any given time.[245] It also requires a human operator be present at all times and limits testing to industrially zoned areas away from high traffic.[246] The law was said to be motivated by safety concerns.[247] Similar to Chicago, the legislator who introduced the ordinance considered an

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[233] Cite to article about Pittsburgh
[234] https://www.boston.gov/departments/new-urban-mechanics/autonomous-vehicles-bostons-approach
[235] Ann Arbor; San Jose https://www.arcgis.com/home/item.html?id=68b10f2c69ff42ba97cc2c0efe93edc6;
[236] https://www.sfmta.com/sites/default/files/projects/2017/ATCMTD%20Grant%20Application.pdf
[237] http://www.chicagotribune.com/news/local/politics/ct-chicago-driverless-cars-regulations-met-20170821-story.html.
[238] *Id.*
[239] *Id.*
[240] Cite to DC, Redwood City, Austin.
[241] Cite.
[242] Redwood City "Conditions of Approval"; Austin ordinance, DC ordinance.
[243] *Id.*
[244] http://www.chicagotribune.com/news/local/politics/ct-chicago-driverless-cars-regulations-met-20170821-story.html; Cite to SF Ordinace.
[245] https://sfgov.legistar.com/View.ashx?M=F&ID=5675962&GUID=C23EBA7F-DF09-472B-A644-6E97400676B9.
[246] https://sfgov.legistar.com/View.ashx?M=F&ID=5675962&GUID=C23EBA7F-DF09-472B-A644-6E97400676B9.
[247] Cite.

outright ban but lacked the votes.[248] We are not aware of any active PDD pilot programs in cities where the state has passed a PDD enabling law. But the laws in each state explicitly allow cities to regulate PDDs either for safety, or to ban them outright.

As with federal and state law, security robots have largely escaped regulatory attention at the city level. San Francisco is again a notable exception. In a widely publicized incident, residents complained about a Knightscope robot being used to chase off homeless people in the frontage space and parking area of a local SPCA animal shelter in the Tenderloin district.[249] The city's department of public works demanded the SPCA cease using the robot because it was traversing public sidewalks.[250] The source of the department's authority is unclear.

There has also been local action that would impact police use of robots. A member of the board of supervisors of San Mateo County drafted a resolution calling on Congress and the United Nations to ban killer robots, although he later withdrew it and the board agreed to study the issue further.[251] More substantively, San Mateo County and the Cities of Oakland, Berkeley, and Seattle have passed surveillance ordinances requiring citizen approval before police departments acquire new surveillance equipment.[252] Cities tend to have a great deal of control over local police departments through their power to regulate health and safety.[253] They could easily use their proprietary power to regulate vendor agreements with the makers of any future police robots, even in the absence of a surveillance ordinance.[254]

Entertainment robots are also largely unregulated, although that could change to the extent that they cross over into other, more regulated use cases. Recall the discussion of Loomo's use for package delivery and the possibility of a "follow me" suitcase.

Of all of these technologies, drones have seen the most local legislative action. This may be because domestic drones hit the market earlier than other forms of robotics, or because drones incited a more visceral reaction in the public (serving as a "privacy catalyst").[255] The National League of Cities cites Chicago's drone ordinance, passed in November 2015, as the first comprehensive drone law in a major city.[256] The ordinance places a number of prohibitions on drone flights, such as: flying directly over a person or private property without consent; flying over a school, hospital, place of worship, prison, or police station; flying outside visual line of sight, flying between dusk and dawn, and flying for the purpose of surveillance.[257] Some of the

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[248] Cite.
[249] https://techcrunch.com/2017/12/13/security-robots-are-being-used-to-ward-off-san-franciscos-homeless-population/
[250] https://www.bizjournals.com/sanfrancisco/news/2017/12/08/security-robot-homeless-spca-mission-san-francisco.html.
[251] Dec. 12, 2017 San Mateo County Board of Supervisor Meeting Minutes.
[252] Cite.
[253] Cite.
[254] C.F. Elizabeth Joh, Power of Surveillance Technology Companies on Policing Policy.
[255] Calo, drone as privacy catalyst.
[256] http://uavs.insct.org/wp-content/uploads/2016/09/NLC-Drone-Report.pdf
[257] https://chicagorealtor.com/wp-content/uploads/2016/09/SO2015-5419-Drone-Substitute-Ordinance.pdf

provisions are similar to those overturned in *Newton*, namely the ban on flights over private property. However, the ordinance contains an exception for any flights authorized by federal or state law.[258] It is important to note that this ordinance passed in 2015, before the FAA promulgated its current regulations. The FAA currently allows waivers for flights outsight visual line of sight, at night, or over populated areas,[259] so without an exception allowing for such flights, the Chicago ordinance would almost certainly be preempted.

A 2017 study by the Center for the Study of the Drone found 133 local drone ordinances in 33 different states.[260] The author found the most common rules to be restrictions against flying over public property or private property without the owner's consent.[261] He concluded that the many of these rules could conflict with federal or state laws.[262] The *Newton* case may inspire others to challenge local drone ordinances, although the FAA was not involved in that case and has not yet challenged any such laws itself. However, many cities also regulate privacy or trespass, which the FAA has deemed within the scope of local authority to act.[263]

Cities likely have regulations on the books that can already be applied to drones. Simple criminal matters involving a drone are within the scope of city power to regulate. An assault committed with a drone is still an assault. The City of Seattle successfully prosecuted a reckless endangerment case against a man who lost control of his drone and crashed it into a woman during the 2015 Pride Parade.[264] Seattle has no law specific to drone endangerment, it simply prosecuted the man under Washington's reckless endangerment statute.[265]

Part V: Conclusions and Recommendations

This Part argues that federal and state legal rules dealing with robotics should avoid broad preemption and allow cities authority to act as test beds for urban robotics. It includes recommendations for federal, state, and local governments in designing rules that empower cities to serve as testbeds of innovation, and the recommendation that cities be supported in their efforts to serve as laboratories for the development of evidence-based policies in the public interest, noting that preemption can have a chilling effect on research to determine the impacts that are ultimately meaningful if the public benefits of these technologies are to be realized.

A. Impact of preemption on robotic and environmental design

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[258] https://chicagorealtor.com/wp-content/uploads/2016/09/SO2015-5419-Drone-Substitute-Ordinance.pdf
[259] Section 107.
[260] http://dronecenter.bard.edu/files/2017/03/CSD-Local-and-State-Drone-Laws-1.pdf
[261] *Id.*
[262] *Id.*
[263] *Id.* There may be a tension between cities permissibly regulating trespass by drones and impermissibly banning flights over private property.
[264] http://dailysignal.com/2017/03/09/seattle-case-shows-why-drone-regulation-should-be-local-not-federal/
[265] *Id.* Seattle does have a proscription against flying drones in public parks, but it was not at issues in that case. https://library.municode.com/wa/seattle/codes/municipal_code?nodeId=TIT18PARE_CH18.12PACO_SUBCHAPTER_VIIUSRE_18.12.265MOMO.

The legal rules that govern urban robots will have consequences for autonomous systems and the urban built environment, and vice versa. For example, speed limits for automated vehicles or delivery robots will determine the machine's top speed. Or zoning laws will influence a neighborhood's use and character, including the design of public spaces and restrictions on the co-mingling of people with robotics. Laws that set a particular weight limit for machines enable some designs while foreclosing others. This very problem has occurred with some state delivery robot laws. Virginia's law defines a delivery robot as weighing under 50 pounds, but Marble, one of the main delivery robot startups, uses a machine that weighs almost 80 pounds.[266] Some have accused Marble's competitor of writing the law to close off competition.[267] A law that requires a robot to yield to pedestrians,[268] effectively requires the design of sensing and processing capabilities to achieve this end. On the other hand, laws that require people yield to robots could dramatically reshape environmental design. Such was the case with the advent of the automobile and jaywalking laws.[269]

Urban robotics, environmental design, and legal rules will likely interact in more indirect or diffuse ways that are nonetheless impactful on the local level. The placement of any future restricted automated vehicle "hyperlanes," could have significant opportunity costs by influencing the distribution of travel modes onto other transportation infrastructure. One study has shown that ride sharing apps increase traffic and reduce public transit ridership.[270] This effect will likely get worse if the cost of automated vehicle ride sharing plummets, and further introduces the prospect, so evident today in cities with dockless car and bike share systems, of automated vehicles occupying streets and utilizing energy without passengers at all.[271] In terms of long-term planning, it is important to consider that the provision of transportation infrastructure and services influences where people live in cities.[272] Transportation economists have long advocated for congestion pricing on roads to offset increases in miles traveled, and while this may be applied to automated vehicles, the need for increased density, specifically in public rights-of-way, highlights the need for other pricing structures, such as occupancy-based pricing for automated vehicles to promote shared vehicle and transit-scale systems.[273] In all there will likely be many unforeseen consequences to the proliferation of cheap, diffuse networks of last-mile logistics and public safety machines in the form of delivery and security robots, as well as automated vehicles for passenger and cargo.

Changes brought about by new technology often have consequences for environmental design, and therefore need regulation that is sensitive to local context. Consider the impact of room sharing (Airbnb) on urban housing markets. While the anticipated death of the hotel business

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[266] Cite to news article criticizing starship for writing laws.
[267] Cite
[268] Virginia PDD law.
[269] Cite.
[270] Cite to Davis study in https://www.bloomberg.com/news/articles/2018-02-13/self-driving-cars-will-kill-things-you-love-and-a-few-you-hate
[271] *Id.*
[272] Cite
[273] Sarah J. Fox, Planning for Density in a Driverless World, 9 Northeastern University L. Rev. 151, 194 (2017).

never came to pass, some research suggests that Airbnb contributes to housing shortages and drives up rents.[274] This effect has been attributed to property owners permanently shifting their homes from the rental market to "private accommodation," and Airbnb has worked with local governments to combat this practice.[275] This is just one example of technology's impact on local environmental design and legal rules, and more is in store as the industrial organization of the transport sector shifts from the concentrated ownership of information technologies in today's sharing economy, to more concentrated ownership of the mobile assets on the street.

State and federal laws that preempt cities on robotics may disrupt the natural interplay between the design of autonomous systems, urban environments, and local law, and so state and federal lawmakers should consider the local impacts of robotics laws and be wary of broad preemption. The controversy over the weight definition PDDs locking out some models of PDDs is one example.[276] Right now the regulation in this space is still developing, but the chances of future conflict arise as more laws relating to automated vehicles are enacted. Proposals for exclusive automated vehicle highway lanes have already been floated to some state legislators.[277] A proposed law in Illinois would require infrastructure updates for networked sensors that would collect vehicle and pedestrian traffic data and send it to automated vehicles.[278] These laws are likely just the beginning. Further, there is a recent history of cities attempting to regulate only to have states preempt them and reverse those rules.[279] Advocates have also expressed concern over proposed federal automated vehicle laws that preempt "unreasonable restrictions" on these products.[280] Not only could the law upset the regulatory balance between the federal government and states (and localities by extension), but the term "unreasonable restrictions" is seen as overly vague.[281]

In addition, legislating to specific verticals of robotics may prevent cities from planning holistically as technologies converge in robotics platforms. Consider the state laws enabling PDDs. Five state laws allow PDDs and define them as "*an electrically powered device that (i) is operated on sidewalks, shared-use paths, and crosswalks and intended primarily to transport*

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[274] https://www.theatlantic.com/business/archive/2018/02/airbnb-hotels-disruption/553556/

[275] https://www.theatlantic.com/business/archive/2018/02/airbnb-hotels-disruption/553556/. Need to cite to actual ordinances.

[276]

[277] http://nwnewsnetwork.org/post/dedicated-lanes-i-5-self-driving-cars-get-ear-washington-state-officials; https://www.jsonline.com/story/money/business/2017/11/13/driverless-vehicle-lanes-94-being-studied-foxconn/860515001/

[278] https://custom.statenet.com/public/resources.cgi?id=ID:bill:IL2017000H2997&ciq=AsteigenHAV&client_md=ff84cafdb9162f7303cc19e4a57a9a17&mode=current_text. V2I communication will require a network protocol to communicate; so prematurely regulating V2I statewide could lock in certain network protocols over others.

[279] National League of Cities

[280] https://www.reuters.com/article/us-autos-selfdriving-analysis/u-s-push-for-self-driving-law-exposes-regulatory-divide-idUSKCN1BQ24J.

[281] https://www.reuters.com/article/us-autos-selfdriving-analysis/u-s-push-for-self-driving-law-exposes-regulatory-divide-idUSKCN1BQ24J.

property."[282] This definition serves its purpose of providing explicit permission for delivery robots to operate within the state. It is written narrowly to cover delivery robots as they currently exist.[283] However, new robots are already being marketed that can serve more than one function; they can be delivery robots, or security robots, or personal mobility devices.[284] What had previously been distinct categories of robot are beginning to converge into a multifunctional platform. If a machine can be both a delivery robot and a security device, which law applies? Does the applicable law change depending on how the robot is being used? Delivery robots are also defined as machines that operate on the sidewalk, but it is at least conceivable that engineers could build a robot that is equally capable of operating on both the sidewalk and the street. In fact Bloomberg categorizes delivery robots as a type of automated vehicle.[285] The convergence of delivery robots and automated vehicles could accelerate if cities redesign their streets for mixed robotic traffic, as some have suggested.[286] So far the states with PDD laws have left room for cities to act, although some are more permissive than others. For instance Idaho allows cities to regulate PDDs for "safe operation,"[287] but it is not clear how the Idaho law would handle the technological convergence described. This is another reason to allow cities the freedom to experiment and regulate accordingly.

There are of course some situations where regulatory certainty and uniform guidelines are warranted, and preemption may be the appropriate tool to achieve that policy end. We simply caution that when it comes to urban robots, preemption is a design issue in addition to a legal question.

B. Preemption recommendations

This section lays out specific recommendations for federal, state, and local authorities to craft their rules governing robots to avoid preemption interfering with local design.

Courts should recognize that local government design choices over their public rights-of-way are legitimate exercises of police power, not obstacles or conflicts with federal rules meant to encourage the adoption of robots. Choices about whether to offer robot fast lanes, whether to create designated robot zones, how to structure parking for shared robo-taxi fleets, and even how to price congestion to reduce traffic, all have a local character. Courts should only find preemption if it is clear that federal or state legislatures intended to preempt those design choices. This also means courts should avoid field preemption because broad readings of legislative intent will displace city prerogatives in local design.

For their part, legislatures should expressly recognize and carve out authority for cities where the law impacts environmental design, including the deployment of related sensors and other

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[282] https://lis.virginia.gov/cgi-bin/legp604.exe?171+ful+CHAP0251. Cite to others. https://legislature.idaho.gov/wp-content/uploads/sessioninfo/2017/legislation/H0204.pdf

[283] Except for Marble's robots.

[284] https://newatlas.com/segway-loomo-transporter-robot/53677/

[285] Bloomberg

[286] NACTO and others, Lyft maybe.

[287] https://legislature.idaho.gov/wp-content/uploads/sessioninfo/2017/legislation/H0204.pdf. 23 Idaho Code 40-2305.

information communication systems. States should recognize city home rule authority over environmental design, and over system design to the extent it impacts environmental design. The state PDD laws that do this, especially Illinois', are a good model to follow. The Drone Federalism Act of 2017 and the FAA's own policy statements on preserving state and local authority are also good approaches. Broad preemption of the kind found in the House SELF DRIVE Act should be avoided. Legislatures should consider the relative costs for firms and cities that preemption can create by forcing certain design parameters or precluding market competition. Robotics laws should work in the public interest and not force cities to bear socialized costs of system design.

It is somewhat counterintuitive that federal drone regulation is so circumspect with preemption of local governments while the House autonomous vehicle bill embraces it, because autonomous vehicles are likely to have greater local impacts than drones. Regulating and redesigning the airways does not involve the types of expensive or time-consuming changes to the built environment that an exclusive automated system hyperlane would. While drone delivery might result in changes to the transportation infrastructure,[288] it likely will not require a reimagining of city streets.[289] Drones would also seem a natural technology to apply broad preemption because of the FAA's traditional role as the sole regulator of air traffic safety. That the preemption priorities for drones and automated vehicles are flipped in this way suggests that House legislators may be more attuned to the creepiness of drones than the design implications of automated vehicles. Never mind the fact that three quarters of Americans (74%) believe automated vehicles will not be safe,[290] and over half (56%) say they would not want to ride in one.[291] We believe the Senate bill's explicit carve-out of authority for states and localities is a better approach. We would add control over environmental design to the list of enumerated powers reserved for states and localities, however.

Cities should not tempt fate by regulating so heavily that they draw a preemption challenge in court or inspire legislatures to act.[292] Robotics ordinances should work with state and federal laws, not against them. Chicago was wise to create exceptions to its ordinance to avoid a preemption conflict.

Lawmakers at every level of government should remember that development of both robotics systems and the built environment can evolve over time, sometimes in unexpected ways. They should be platform agnostic to avoid design "lock-in" too early. Robotics technologies will undoubtedly converge, which may render some rules out of date.

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[288] https://www.wired.com/story/would-delivery-drones-be-all-that-efficient/
[289] NACTO white paper.
[290] https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/deloitte-study-future-of-autonomous-vehicles-in-minds-of-consumers.html?nc=1.
[291] http://www.pewinternet.org/2017/10/04/americans-attitudes-toward-driverless-vehicles/.
[292] The ACS notes that instances of punitive preemption, where state legislatures target cities to overturn specific laws, is on the rise.

Altogether, we advocate for a true federalism in the system of robotics law. Cities should serve as the sites of experimentation for robotic system, environmental, and legal design. States can provide backstop rules that ensures cities act in the public interest, for example by setting rules against privacy harms or discrimination that could be exacerbated by robotics.[293] They can also handle intrastate regional issues as they arise. The federal government can provide technical and regulatory guidance; issue grants; and, after the technology has had a chance to evolve through experimentation in cities, create rules for robots in interstate commerce. In this way, each level of government plays to its relative institutional strengths,[294] while preserving local autonomy.

Part VI. Counter arguments in favor of preemption of local governments

This part concerns counter arguments, such as the need for regulatory clarity and consistency, the idea that state and national regulators are in a better position to negotiate with firms than cities, and the notion that cities do not necessarily act in the best interest of the region.

A. Need for regulatory clarity/consistent rules

Proponents of preemption might cite the need for regulatory clarity or consistent rules to ease the way for firms. Automated vehicle manufacturers have made such arguments in favor of the federal SELF DRIVE Act.[295] Having to plan for and comply with 50 state automated vehicle laws is more complicated, and therefore more costly, than just dealing with one federal law. In addition, being cars, automated vehicles are highly mobile and will eventually cross state lines. For the legal requirements to differ between states such that an automated vehicle from California cannot cross the border into Nevada without violating the law would be troublesome, to say the least. Overcoming such obstacles to interstate commerce is one of the reasons the federal government exists in the first place.[296] Put another way, scale matters with technology.

We are sympathetic to these arguments and even grant that regulatory uncertainty can be a burden on firms, but the burden to firms is only part of the overall story. First, uncertainty creates a cost, and costs can either be internalized by firms or socialized to the public. Avoiding preemption allows for cities to be sites of experimentation and true partners in the autonomous system and environmental design for urban robots. Preemption may cut off that process too early. There will be a time when nationwide standards make sense, but it should be after cities have had a chance to experiment. In the meantime, the principle of permissionless innovation, which likely applies to automated vehicles and many other robots,[297] should insulate firms from the worst regulatory excesses. Second, innovation proceeds unevenly, so regulatory standardization should as well. Certain safety standards may make sense to implement on a statewide or national level now.[298] But there will be other areas where cities require room to experiment, especially as it impacts environmental design. There are situations with technology

[293] https://www.theatlantic.com/technology/archive/2017/12/self-driving-cars-free-future/548945/
[294] Margot Kaminski, Drone Federalism.
[295] Cite reuters article on federal AV preemption
[296] Cite to interstate commerce clause
[297] Smith, supra.
[298] Prohibitions on PDDs carrying hazardous material may be one.

where scale can have undesirable consequences. For example one of the concerns with creating a national health database is fear of a massive data breach that compromises the personal health data of every American, and as the integration of surveillance technology expends in service to the transportation industry, these issues will be compounded.[299] Scaling a system of unsafe or inefficient AVs by acting too early is not a desirable outcome.

It is also possible to achieve some harmony and an environment that favors innovation without imposing a nationwide standard with broad preemption of local governments. The system of federalism for which we advocate recognizes roles for state and federal regulators. It merely preserves the design space for cities.

B. State/National agencies are in better bargaining position vis a vis firms

Another critique that is somewhat related to the first one is that scale matters in regulation. State legislatures and attorneys general may have more bargaining power as negotiators of the public interest. National regulators have even more bargaining power. Cities may become caught in a race to the bottom by attempting to lure firms, or they may get captured by special interests.

Concerns that cities will race to the bottom by giving away public goods to robotics firms are warranted; we raised them ourselves above. For that reason we think state rules that guard against socialized costs may be a good idea. Still, any preemption provision for urban robots should weigh the potential regulatory economies of scale against the benefits of innovation with cities as distributed sites of experimentation. Further, cities have their own power as market makers when they are able to deal directly with firms.[300]

C. Cities do not act in the best interest of the region (NIMBY)

One might argue that cities will not plan in the best interest of the region or state as a whole, but instead regulate for narrow interests defined by NIMBY-ism (Not In My Back Yard). NIMBY-ism has been a problem in other intractable urban and regional planning issues like housing,[301] as well as transportation.[302] The Competitive Enterprise Institute, a libertarian think tank, worries that ridesharing companies will pressure cities to outlaw private ownership of automated vehicles by touting the environmental benefits of shared fleets.[303] The group praised states that preempt cities in their laws to avoid just this outcome.[304]

We are sensitive to this concern as well. Cities are not and should not be the only stakeholders in regional planning. For cities to succeed in our model they must operate within a patchwork of federal and state regulation and cooperate with private companies and regional stakeholders. We agree with Sarah Fox that regional tools like environmental impact reports or statements

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[299] Cite

[300] Cite to Jan.

[301] https://www.buzzfeed.com/carolineodonovan/the-rent-is-too-damn-high-the-truth-about-airbnbs-impact-on?utm_term=.ebNpR84Z4#.ypxOApdnd

[302] Cite to Cobb county refusing MARTA extension because they don't want black people.

[303] https://cei.org/blog/uber-wants-make-it-illegal-operate-your-own-self-driving-car-cities

[304] https://cei.org/blog/uber-wants-make-it-illegal-operate-your-own-self-driving-car-cities

can support density or other positive regional planning goals.[305] However, giving cities the tools to regulate robots means that some cities may abuse those tools. Further, the notion of experimentation implies that some failure will occur. But if cities are the site of experimentation, at least those failures won't proliferate across the entire state or country by fiat. Cities are not the only actors who can err in urban planning. For instance, suburban sprawl and low density housing was driven by federal housing policy as much as cities.[306]

To the specific concern that cities will ban individual car ownership, it is also possible that states could use preemption and enact policies that favor individual ownership to benefit entrenched interests like car manufacturers.[307] Without taking a specific position on individual ownership of automated vehicles, we note that almost any policy choice will favor some interests over others. The question is which level of policymakers will make those choices. We argue in favor of local political bodies, as they must deal most directly with the consequences of those choices and are the most politically accountable for those choices.

Part VII: Research Agenda for Urban Robotics

[This is an initial brainstorm of issues to formulate an agenda for urban robotics. We have no pretensions of it being a complete list. Comments and suggestions are welcome.]

A. The social impact of urban robots

1. How will the proliferation of urban robots impact vulnerable populations? Will security robots push out homeless people? Will smart infrastructure also lead to more hostile architecture?
2. Communities of color may have different perceptions of urban robots, especially security robots. Is a robot seen as less biased than a human police officer?
3. AV's potential use in social control[308]
4. How will autonomous transportation systems serve the poor? Will they destroy public transit?
5. What are the impacts of urban working class jobs being automated quickly?

B. Labor and employment law implications

1. Of jobs in public and private sector: Does hiring a robot create a change in circumstances to trigger new negotiations? Can it constitute constructive dismissal?
2. Does "human" become a protected class in employment discrimination?

C. Data practices for urban robots

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[305] Sarah J. Fox, Planning for Density in a Driverless World, 9 Northeastern University L. Rev. 151, (2017).
[306] Cite
[307] Cite to state fights over direct to consumer car sales.
[308] https://www.economist.com/news/leaders/21737501-policymakers-must-apply-lessons-horseless-carriage-driverless-car-self-driving.

1. Privacy: Urban robots, especially AVs, will collect large amounts of sensitive data on users and potentially on bystanders. We should be particularly aware of privacy issues because of the tendency to externalize privacy costs, the heightened risk of robots to privacy, and the local character of privacy regulation (e.g. privacy localism)]
2. Use of public sector data and open data. The AI that powers robots will require data to work. How should cities handle it?
3. Should there be sector-specific privacy regulation for robots; a HIPAA or GLBA for AVs?
4. What happens when AVs can direct people to particular store fronts (sponsored rides) based on data collected about the use?[309]

D. Finance and Economic development

1. What happens when AVs shift the urban tax base? Can cities tax robots?
2. How to implement granular congestion or occupancy-based pricing and preserve equality of access to local road networks. [310]

E. Psychological or social issues in urban robotics

1. For example, over half of Americans do not trust driverless cars.
2. How do urban robots, especially AVs, serve as the public facing avatars for AI and robotics? What do they represent to the public?
3. What are the issues with affective computing for urban robots?
4. What social aspects can help urban robots integrate more easily into public spaces?

F. Algorithmic Bias

1. New York City recently established a first-of-its kind AI transparency task force.[311] While we have focused on robots as the physical embodiments of AI, issues of algorithmic bias and transparency are also timely for cities. The AI Now Institute has promoted an algorithmic impact assessment for public agencies.[312] What other models can help cities cope with this technology.

[309] https://www.theatlantic.com/technology/archive/2017/12/self-driving-cars-free-future/548945/.
[310] https://www.economist.com/news/finance-and-economics/21735019-they-will-spare-world-neither-traffic-congestion-nor-infrastructure-expense-why
[311] http://www.govtech.com/Could-New-York-Citys-AI-Transparency-Bill-Be-a-Model-for-the-Country.html?flipboard=yes
[312] https://medium.com/@AINowInstitute/algorithmic-impact-assessments-toward-accountable-automation-in-public-agencies-bd9856e6fdde