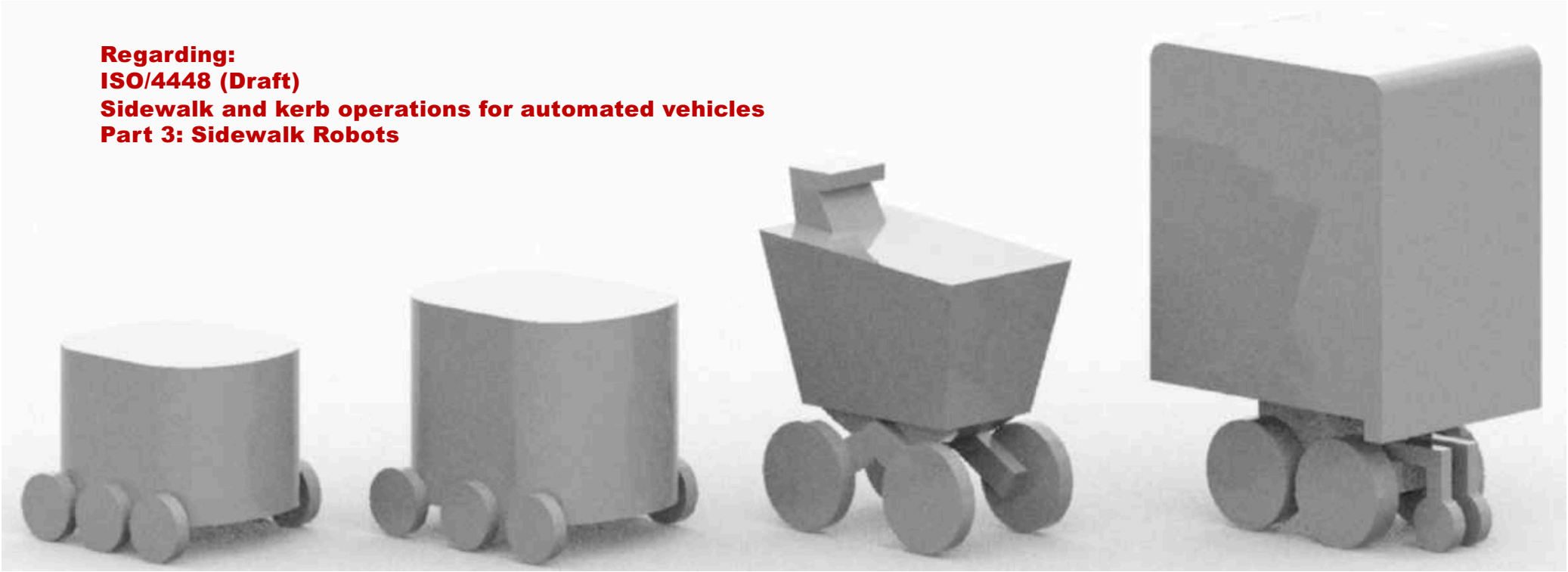
Getting Ready for Sidewalk Robots

What's a Smart City to do? (2021-2025)

Regarding:
ISO/4448 (Draft)
Sidewalk and kerb operations for automated vehicles
Part 3: Sidewalk Robots



Bern Grush
Harmonize Mobility Inc.

This document justifies the ISO technical project to create a standard for managing vehicles that load and unload goods and passengers at kerbs in our cities and towns.

The same standard, ISO/4448, also targets the management of the coming variety of tele-operated devices and vehicles that will deliver goods and provide services along our sidewalks and crosswalks.

It is expected that these vehicles and devices will become increasingly automated in the foreseeable future, possibly approaching near-autonomy.

Regardless of our progress in integrating machine automation into human-occupied spaces, our cities, our planners, and our legislators face many years of interim operating conditions contending with changing mixtures of non-automated, partially automated, and highly automated systems.

This is an early introduction to this long venture. It focuses predominantly on the sidewalk delivery robot.

Getting Ready for Sidewalk Robots

Harmonize Mobility is a thought leader focused on automation and its impact on the future of transportation. We develop platforms and provide services dedicated to improving the movement of people and goods.

As leaders for the **ISO/4448** project, we focus on preparing for the deployment of sidewalk robotics for delivery, maintenance, security, and other services.

We seek ways that cities can ensure pedestrian safety, comfort, and acceptance and that robotic mobility devices do not diminish urban livability.

We devise procedures and systems intended to minimize the environmental footprint of goods movement and street maintenance.

We describe measures and processes to maximize fairness and access to the space occupied and services provided for all of us — of all abilities — who share the city with these devices.

What will Smart Cities do?

Harmonize MOBILITY

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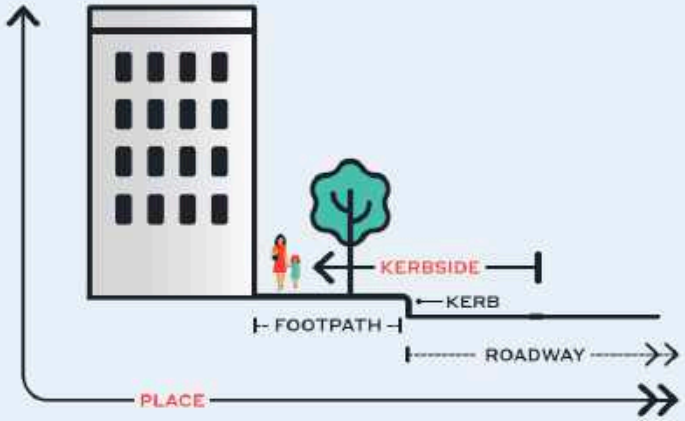
Now what's next?

Cities have been tasked to rethink many things over the past years. In transportation alone, parking payment systems, bikeshares and bike lanes, scooters and e-bikes, ride-hailing and same-day delivery, and more recently, COVID-19 have variously impacted infrastructure, revenue, congestion, and transit use. Imposed changes arrives faster and are more capricious than governed changes. And the gap widens as digitalization outpaces regulatory time scales.

Anticipating a new round of unintended consequences such as those introduced by ride-hailing, many cities watch and worry about the automated vehicle. Whether privately owned or used as robotaxis, what will cities need to prepare? How will appropriate AV use be enforced? If they are electric, always follow rules, and seldom park, how will the expected loss of revenue to City, State or Province be replaced? Never before has a city had to regulate the presence and activity of unmanned, always-mobile machines in the midst of human drivers and human pedestrians. Realization is only slowly sinking in.

But even more immediate, growth in e-commerce, COVID, and same-day delivery have combined to challenge our last-mile logistics and regional warehousing systems. Because goods delivery within cities generates congestion and pollution, this direction contradicts our challenge to address global warming.

One response to this challenge is to use small, electric, autonomous robots to delivery packages and food for short-haul deliveries. These machines are much closer to realization at scale than are robotaxis, leading to cities being caught by surprise once again, even as they may believe they are preparing themselves for AVs.



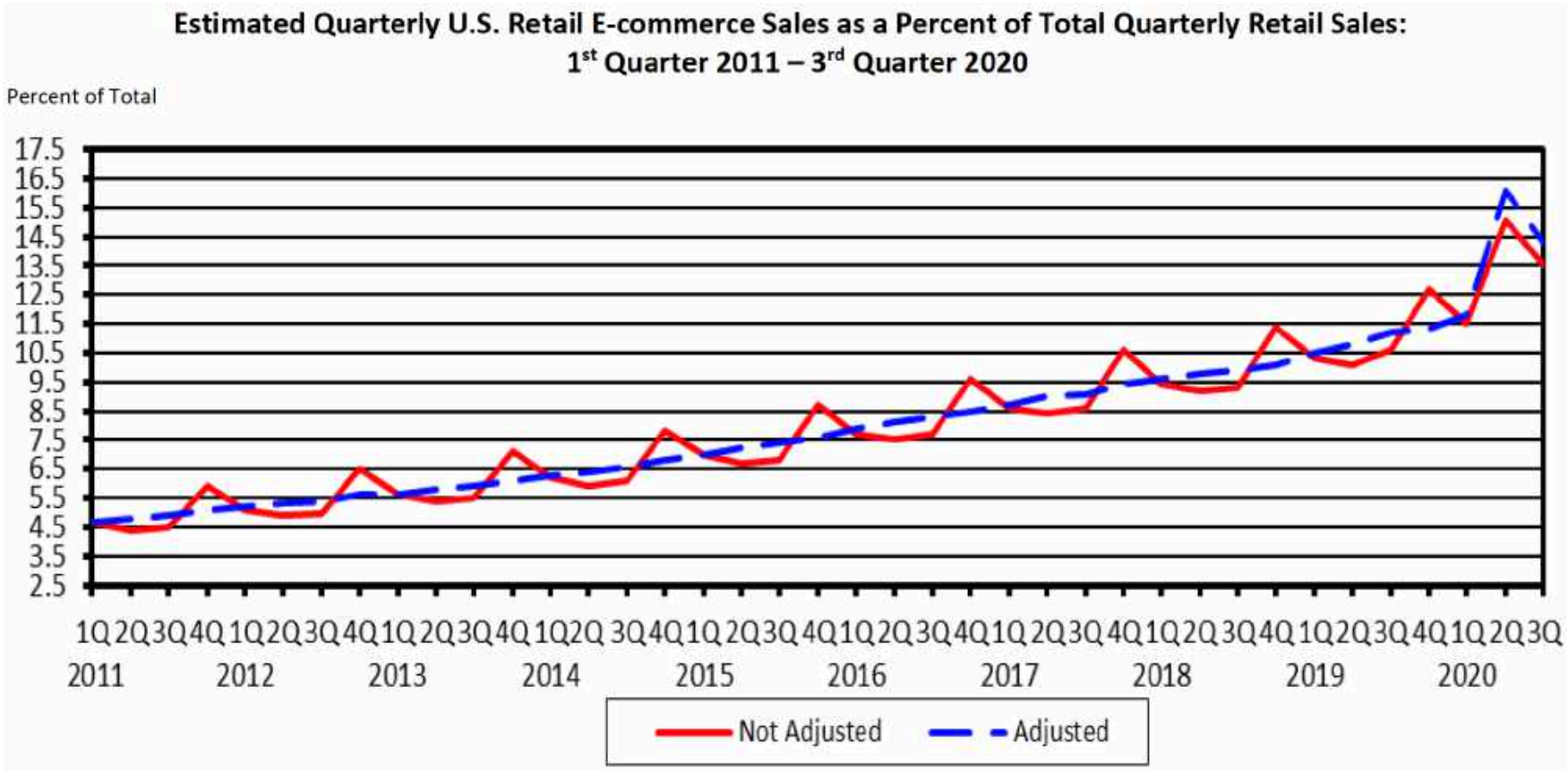
In practical terms, the kerbside is the road lane and area of the footpath either side of the kerb.

> …ground-based drones are starting to be used for last-mile small parcel deliveries in some locations around the world. Consolidation centres in urban areas are serviced by automated vans and ground-based drones. …

Cormack, A., Pointer, G., (2020) *Place and Mobility: **Future Ready Kerbside***. Joint report, Uber and WSP Australia.

These can bring issues … in terms of compatibility with achieving desired place-based outcomes.

U.S. e-commerce grew 313% in the decade before coronavirus

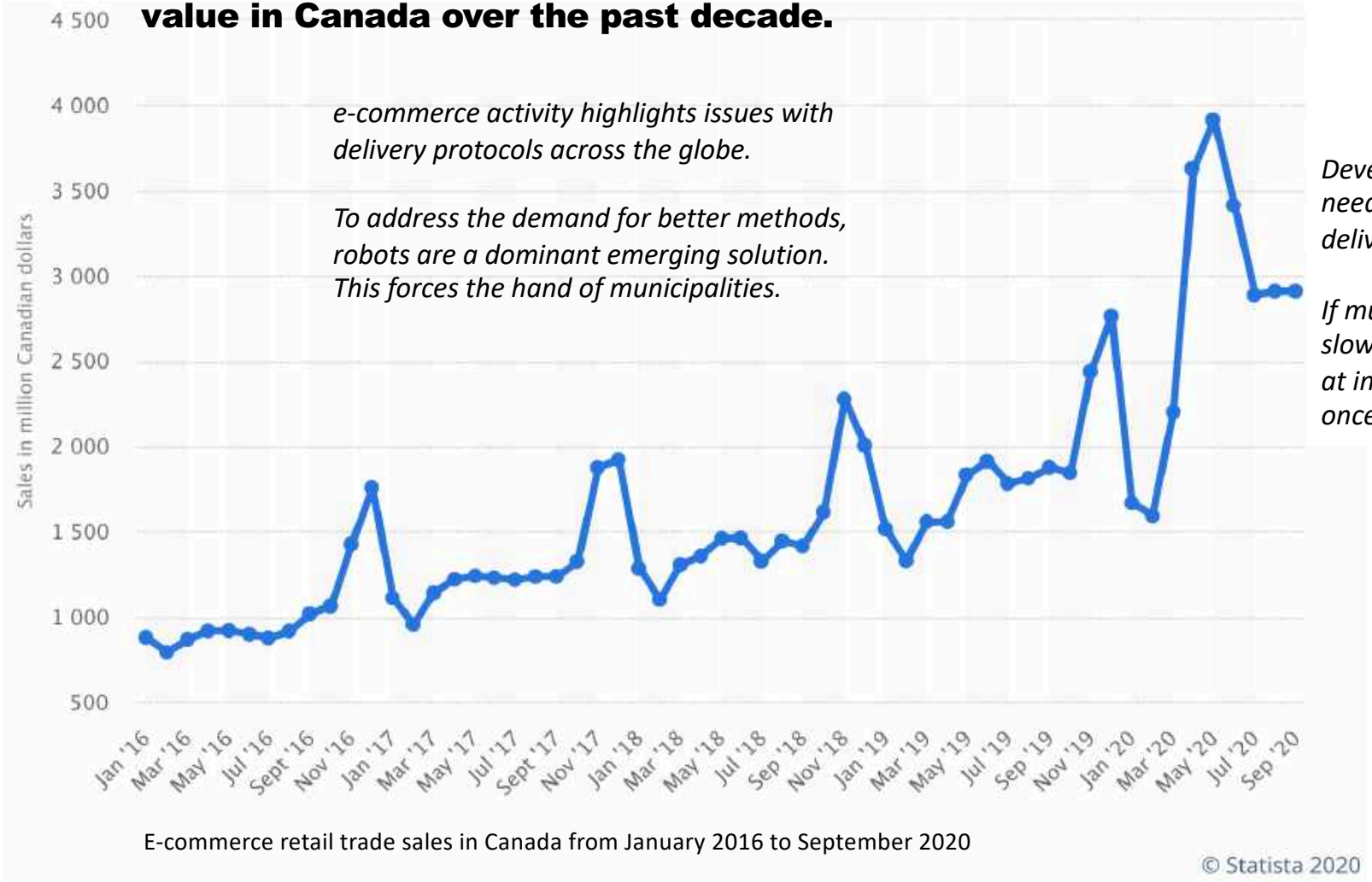


https://www.census.gov/retail/mrts/www/data/pdf/ec_current.pdf?

E-commerce has grown three-fold in dollar value in Canada over the past decade.

e-commerce activity highlights issues with delivery protocols across the globe.

To address the demand for better methods, robots are a dominant emerging solution. This forces the hand of municipalities.



E-commerce retail trade sales in Canada from January 2016 to September 2020

Development of ISO standards needs to start <u>now</u>, in step with delivery system R&D.

If municipalities prepare too slowly, they will be ineffective at integrating service robots once they are deployed.

Humans walk in a nearly infinite variety of urban spaces. To meet, get somewhere, work, deliver, walk a pet, shop, sit and watch … to exercise.

Many of these spaces are what remain of the space between rows of buildings that has not been given over to motor vehicles. Such spaces have, until now, been a relatively safe haven for pedestrians.

The social rules that dictate how we share such space are complex, nuanced, and embedded. Glances and gestures, movements and body language signal intentions that offer or take right of way.* And we often have formal regulations — not always closely followed — to ensure access for people of varying abilities.

How will spatial priority be decided between humans and machines?

The recent invasion of this space by micro-mobility devices has been mixed. Any reduction in the use of an automobile is generally seen as a positive for urban livability, but withdrawals from the space reserved for pedestrians demands closer consideration.

Service robots operating on sidewalks represent a new level of competition for this space. Scooters and bikes may be fair-weather conveyances, but service robots will not be so constrained. They have many more applications, will be useful in every climate, and represent a far greater commercial and monetization value for all participants.

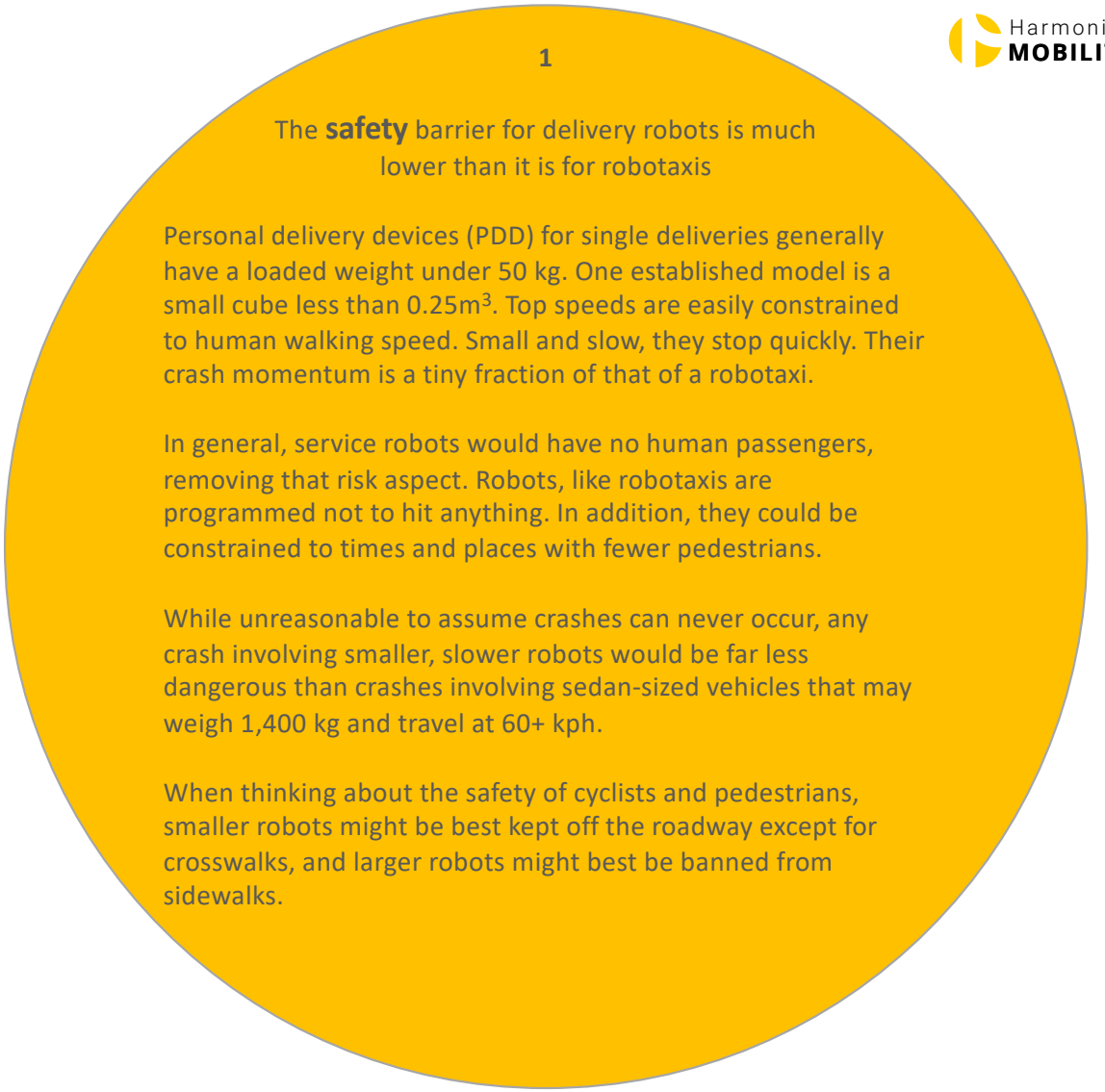
* Wolfinger, Nicholas H. (1995) "Passing moments: Some social dynamics of pedestrian interaction." *Journal of Contemporary Ethnography* 24.3 (1995): 323-340.

12 reasons sidewalk delivery robots are likely to become pervasive long before robotaxis do.

There are many reasons delivery robots will make the leap to pervasive deployment sooner than robotaxis.

The barriers to large scale delivery robot deployment are far lower than are the equivalent barriers for the robotaxi.

The accelerators to deploying delivery robots are more accessible to innovators, investors, and participants.



12 reasons continued…

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2
The **fear** barrier for delivery robots is lower.

Many people express fear of riding in, sharing the road with or walking in front of an automated vehicle.

Such fears are less often expressed about sidewalk robots.

3
The concern for **job** loss, and the political voice to fight it, is lower for delivery robots than it is for robotaxis or autonomous trucks.

4
The **cost** barrier for developing and deploying delivery robots is much lower than it is for robotaxis.

5
Infrastructure is a more complex barrier; depending on location this may disadvantage sidewalk robots.

6
The **regulatory** barrier for the deployment of delivery robots is very much lower than for robotaxis.

This may change, but regulations passed so far bear this out.

The barriers and accelerators for deployment of robotaxis and sidewalk robots strongly favour the sidewalk robot.

Supply-chain factors such as ecommerce, social-distancing, congestion, and efficiency can be addressed sooner and with less difficulty, indicating that sidewalk robots will see sooner and more effective deployment than will robotaxis.

7
That **Full Autonomy** is out of reach hurts the robotaxi far more than it hurts the sidewalk robot.

The efficacy of the robotaxi is reduced by the requirement for safety drivers or for small operating domains. This is not the case for the teleoperated sidewalk robot.

8
The delivery robot will have more **friends** and fewer **enemies** than will robotaxis.

9
The **privacy** barrier for the deployment of delivery robots is lower than for robotaxis.

10
The **versatility** of the sidewalk robot provides more opportunities to exploit.

11
The **security** barrier for the deployment of delivery robots is lower than for robotaxis.

This may soon change as we look closer at potential security scenarios, and the technologies that can defend both technologies.

Grush, B., (2021) The Last Block: Towards an international standard to regulate & manage sidewalk robots

The 12th reason…

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12

Overall, the sidewalk robot is a **lower-risk** deployment.

The total risk equation for robotaxis is likely higher than that for delivery robots by an order of magnitude or more.

Cost. Acceptance. Liability. Investment. ROI. Privacy. Security. Regulatory weight. These all favour the sidewalk robot.

The payoff for dominating the world of people movement is variously projected to scale between seven and ten trillion $US annually, so there is far more media attention, investment, and municipal focus on robotaxis than there is on delivery robots. But the first phase of automating mobility – light, short-haul goods movement — is a clear winner from the perspective of risk.

The degree that cities overlook *last-block* goods delivery technology, in comparison to robotaxis, is a measure of the risk of another unanticipated disruption for which cities would be unprepared!

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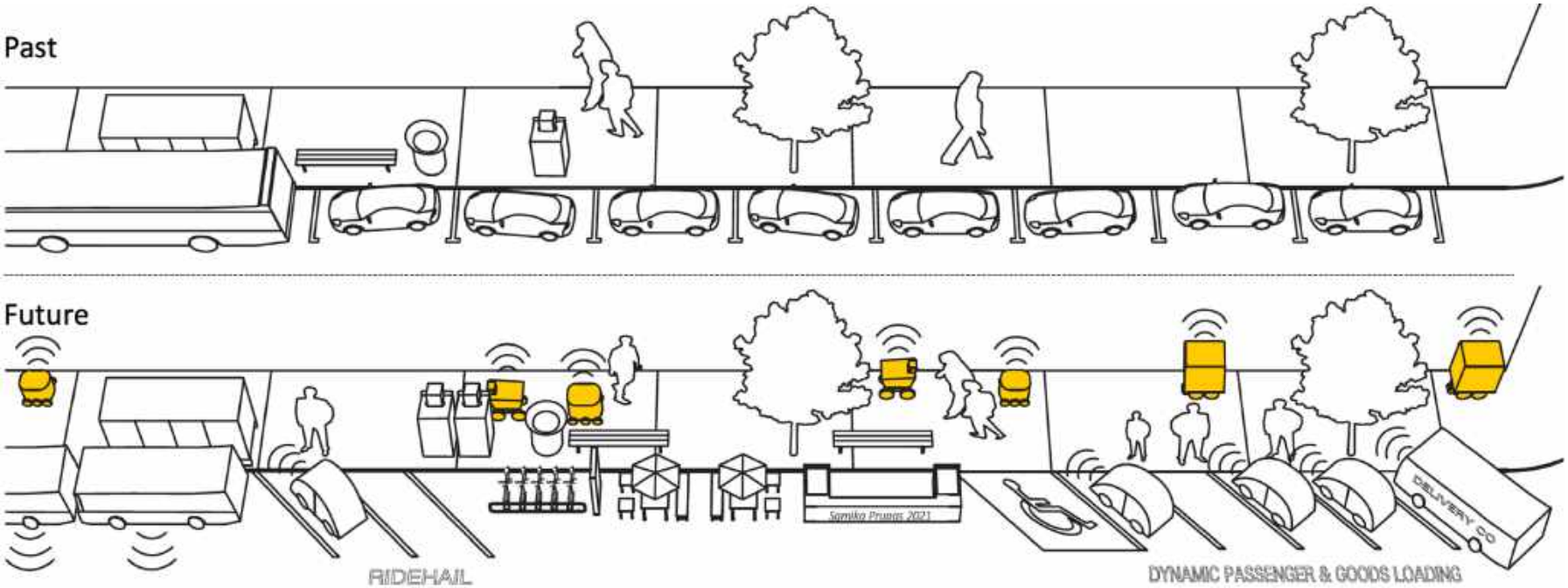
1. Sidewalk robots will precede autonomous vehicles
2. How will sidewalk robots interact with pedestrian spaces?
3. ISO/4448 — an international standard to guide governance and deployment
4. How ready are cities for deployment of sidewalk robots?

We analyse the past. We imagine the future.

But we are challenged by everything in between.



The difficulty with automation at the sidewalk and kerb is how to get from zero automated vehicles to nearly 100% automated vehicles. The beginning and end are easy to describe. The mixed-mode realities in the interim are difficult.

Liability issues will be worked out along the way. Accessibility will be complicated by the trajectories this takes. Planning and infrastructure will morph several times. There will be rapid and clever technical remedies.

But the greatest burden will fall on people and cities.

How will sidewalk robots get along with us?

Safe, clean, quiet, gracious robots

…may be a great step forward — if they reduce delivery van traffic and fit into our existing sidewalk domains to perform other tasks such as snow ploughing, sweeping and monitoring, in addition to delivery.

But how will these devices be accommodated? Pedestrian spaces are highly variable, frequently abused, and often over constrained.

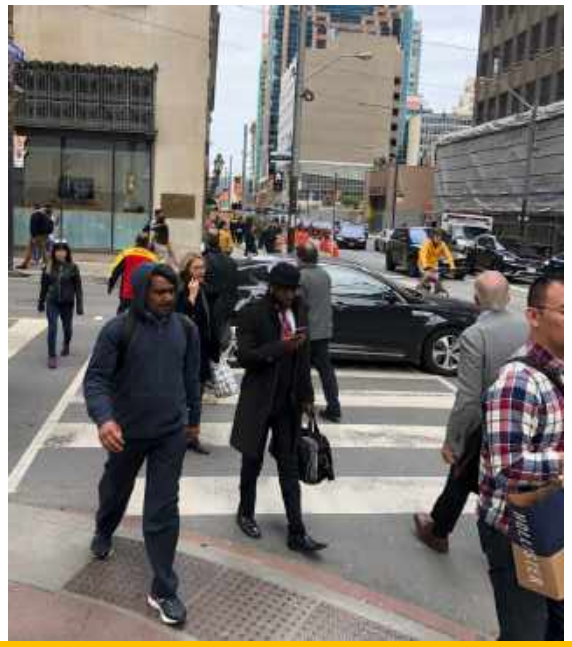
Let's look at some issues around what it will mean to govern the use of these devices…

Pedestrian safety

Distracted pedestrians should not to be endangered or penalized. What rules of speed and alarm sounds will apply to avoid tripping or alarming pedestrians? A constant clamour of sounds and lights would be distressing, if not unworkable.

The matter of watching out for pedestrians is one set of issues when the devices are teleoperated, but a very different matter when they are fully automated.

Far more care must be taken for pedestrians who need extra means, warnings, or precautions. While robots are teleoperated, it may be up to a human operator to be especially diligent and to provide wider berth. Rules need to be explicit whether operations are automated or human-monitored.



Intersections

One of the more contentious locations for robotic service devices will be at intersections. Here pedestrians of every capability and level of patience cluster and clamour to cross. Some have dogs or bikes. Maybe assistive scooters. Others may be using a wheelchair or be sight challenged.

This could be easy. Robots could be programmed to wait until last and cross with the last person. In fact the signals, sounds, and flags of a robot bringing up the rear could even make intersection crossing safer for older or disabled pedestrians.

But this could also upset signal timing…

Transit Stops

Well-used transit stops are another matter. Not only are many transit stops at these same confounding intersections, but if the bus comes only once in 20 minutes, a robot's way could be blocked for several minutes before a path opens up.

Passing within a clearway

Many pedestrian clearways are too narrow for two people to pass without invading normal *shy distance*. In this case, a sidewalk robot might wait at the entrance to this narrow passage, or once committed might have to reverse out or pull to the extreme right and stop. Reversing could lead to other concerns if another pedestrian or robot has followed behind. This may be manageable during teleoperation, but would require an astounding amount of AI for “full automation,” because of edge cases.

In some cases a wheelchair user requires the entire width of the clearway. In this case, the sidewalk robot needs to wait for a time in which it will have a sufficient opening for traversal. This becomes more difficult to judge as the length of the narrow passage increases. It is likely, in this example, that this block-face cannot permit sidewalk robots until this construction is cleared away. Note that the bike stands exacerbate the issue on this blockface.

What of our aspirations?

We aspire to busy streets. Pedestrianized streets. Complete Streets.

Surely, we can imagine wider pedestrian clearways, while setting regulations and systems for robot behaviours and schedules. We can imagine improving pedestrians spaces in ways that make them more accessible at the same time we arrange for robotic service vehicles.

It is also easy to understand that this will take time and be very expensive. It will be a tall order to both continue our evolution toward Complete Streets and admit robots. It is likely some cities will consider both.

Hazards on the pedestrian clearway

This is a temporary, unmapped feature. It was cut away a few days after this picture was taken.

Hazards such as these and more typical ones such as potholes, litter, dog faeces, and loose cobble stones may require a robot to change course. Doing so suddenly, may startle pedestrians.

Should a robot signal such disruptions in an otherwise smooth trajectory? Using sound constantly would be annoying. Pedestrians would acclimatize and no longer notice.

Should a robot slow down and change very cautiously if anyone or anything is even close to shy distance?

If a robot slows down, that might annoy a pedestrian following close behind. When a second robot is following closely, should the first robot signal the one following?

Careless micro-mobility dropoff has been a problem in several cities in the recent past.

Sidewalk abuse

Sidewalks are frequently blocked. Pedestrians are expected to simply walk around or squeeze past any obstacles

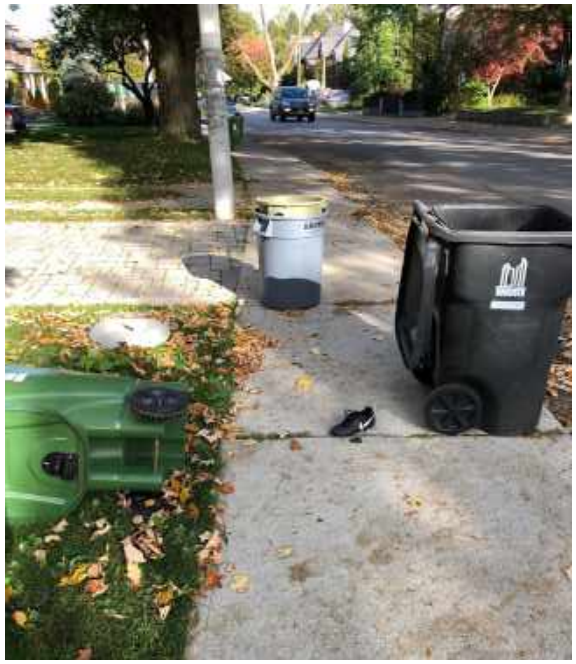
Some cannot.

A lack of reasonably uniform treatment of the sidewalk means that robots may often have to take evasive action, find another way, or be trapped.

Typical human behaviour will add considerably to challenges of sidewalk configuration and congestion.

A wheelchair could not have passed this carelessly parked car. Will this behaviour be addressed for robots once they are monetized? How?

Garbage collection days



Access permissions for sidewalk robots will need to be coordinated with garbage collection schedules.

The clutter of bins and containers cannot be business-as-usual; their placement may need to be regulated accordingly.

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Will robots be an improvement over trucks?

This step van made it awkward for me to step out of the streetcar on the left.

The step van was stopped in a “No Standing” zone; engine running.

The adjacent sidewalk was busy with pedestrians and those waiting for transit.

We can find many circumstances without facilities for unloading express deliveries. Many of these same places have busy sidewalks. In some cases, changing deliveries from step vans to sidewalk robots just moves the problem from street to sidewalk, thereby imposing a solution at a cost to pedestrians, rather than solving it.

Sidewalk robots need rules of engagement for using these sidewalks, but sidewalks need to be ready for these robots. Many are not. Consider that wheelchair users would be better off if sidewalks were widened and organized to be easier for small wheeled vehicles. This factor may be one route to acceptance by all parties — but putting robots onto sidewalks without consideration is a sure route to failure.

Right-sizing will remain a challenge

It is hard to see how very large numbers of package deliveries in some dense urban environments will be handled by fleets of small sidewalk robots.

Rules regarding how many robots could ply a block-face at one time, how fast they can move, how they yield or take rights-of way, how they wait and queue at intersections, etc need to be worked out before such high volumes of packages could be distributed.

Accessibility, advertising, competition, delivery, display, foot traffic, greenery

Before robots, some merchants reach into the pedestrian clearway with advertising and displays to entice foot traffic. When robots become reliable, some merchants may lobby for regulations that facilitate robot delivery while others may fight their incursion. This will be influenced by shifting and non-uniform preferences regarding e-commerce, social distancing, and perceived foot-traffic comfort. Average preferences will change, but variation in preferences will grow more quickly, making such regulations a challenge.

Many cities have guidelines for planters that beautify and attract. Will such programs be altered or reduced? If planters are made narrower and longer to accommodate a wider clearway, will this interact with garbage collection? Will this interfere with loading and unloading of passengers and goods? With docking stations? Make jay-walking yet more hazardous?

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Special case environments

Micro-navigation in leaves, snow. Sidewalks can be complex surface to navigate for small vehicles. What additional risks are imposed by leaves, branches, snow, puddles and other shifting and temporary obstacles. If pedestrians are blocked, delayed, or injured who will be accountable? If robots get trapped or stranded, how will they be rescued? Will that depend on the operator or maker? Or city maintenance? Or peace officers? Or a certification process?

One answer might be maintenance robots to keep pedestrian clearways navigable by clearing leaves and snow. That would benefit all participants, especially those with access challenges. This point is neither pro- nor anti-robot; rather it is to point out that a large number of related considerations must be taken into account for each local decision and their certification processes.

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Will delivery robots form long, dense processions like foraging ants?

Starship PDDs in Milton Keynes. (Photo: @Chris_A_W)

"We want delivery robots to be a common site on sidewalks around the world as quickly as possible."

— Henry Harris-Burland, Starship Technologies marketing VP

May 2018

https://www.foxnews.com/tech/arizona-law-gives-delivery-robots-same-rights-as-pedestrians-but-they-must-abide-by-same-rules

"It is a extremely likely that sidewalk robots will make public urban space more difficult to regulate, more complex to manage, and more costly to maintain.

It is also possible for these systems to improve livability, reduce urban street congestion, and motivate improvements to pedestrian infrastructure." – Bern Grush

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International Technical Standard ISO 4448

Commencing in 2020, the ISO Technical Committee TC204 (Intelligent Transportation Systems) initiated a project called: *Sidewalk and kerb operations for automated vehicles.*

This technical standard (TS4448), will develop data, procedures and protocol for the regulation, governance, and operation of vehicles at all levels of automation for loading and unloading passengers and goods at the kerbside and for delivery and other service robots on sidewalks.

ISO 4448 will be published in four Parts:

- 4448:1 – Data definition
- 4448:2 – Kerb operations
- 4448:3 – Sidewalk operations
- 4448:4 – Integrated kerb and sidewalk operations

Stakeholders in automated movement of passengers and goods

Municipalities	• Governance; Regulations • Re-monetization • Enforcement, including digital enforcement
Planners	• Reformulation of Complete Streets; reorganize planning guidelines • Reorganize kerbs and sidewalks • Continuous rationalization 2020-2050 (long period of change)
BIDs/BIAs Business Improvement Districts/Areas	• Lobbying for and against various levels of automation to un/load passengers & goods • Achieving desired balance between community and business operations • Language to understand possibilities and to express expectations
Logistics	• Shipping, receiving; leverage automation including sidewalk automation • Access to un/loading schedules, queues, priorities, rights-of-way • Optimization of routes
Ridehail	• Passenger un/loading bays and schedules • Queue in motion; no waiting, no circling • Operate mixed automated and non-automated fleets
Transit	• Collaborative scheduling and routing • Subsidize demand more; subsidize supply less • Focus on coverage; leave reach to PPP (both time and geography)

For each of these stakeholders, **accessibility** is a key concern and must be incorporated.

New and implied systems and governance will only work if they work for everyone.

This true whether a jurisdiction follows the guidance of the European Accessibility Act, the Americans with Disabilities Act, the Accessible Canada Act, the Accessibility for Ontarians with Disabilities Act, or any other national or regional accessibility act.

Purpose & Justification for ISO 4448

Five categories of concern are identified as critical needs to be addressed in a standard for automated un/loading at the kerb and for sidewalk service and delivery robots. Each category implies many aspects. While the standard is intended to form the structure for systems of management, local guidance must be layered on top by planners and municipal decision makers.

Safety and Conflict avoidance	• Multiple fleets; vehicle types; purposes; and priorities • Mixed automated and non-automated; segregate or integrate? • Spatial, speed, and access conflicts; vulnerable users *More, next page*
Planning	• Projects to design, format, reorganize streets and street use • Current planning guidelines do not admit automation • Developers, zoning; what is permitted/constrained?
Commercial	• Levels of commercial use, levels of automation, un/load passengers, un/load goods • Reserving, queueing, bumping, reassigning • Business Improvement District — express expectations; lobby for or against operations
Operations	• Residents, shoppers, merchants, shipping, receiving; mixed automated and non-automated • Schedules, queues, priorities, rights-of-way • Dynamic; realtime resets; just-in-time
Legal, Liability, and Insurance	• Certification for operations: e.g., non-automated only, automated-only, mixed? • Residents, customers, businesses, visitors • Per-block guidance may be used to judge risk or liability *More, next page*

Safety and Conflict-avoidance*

“

…navigational conflicts … can be expected to grow with the number and variety of such machines…

…without on-board human operators [these vehicles and devices] … must interact with each other and with human-operated vehicles and devices.

Legal, Liability, and Insurance*

“

Any kerb or sidewalk that is a public space will be shared by many classes of users … whether able-bodied or not.

Any conflict that causes … harm or perceived harm may be subject to legal action.

Hence a common understanding and description for these spaces is necessary to determine correct use and assign liability for legal and insurance purposes.

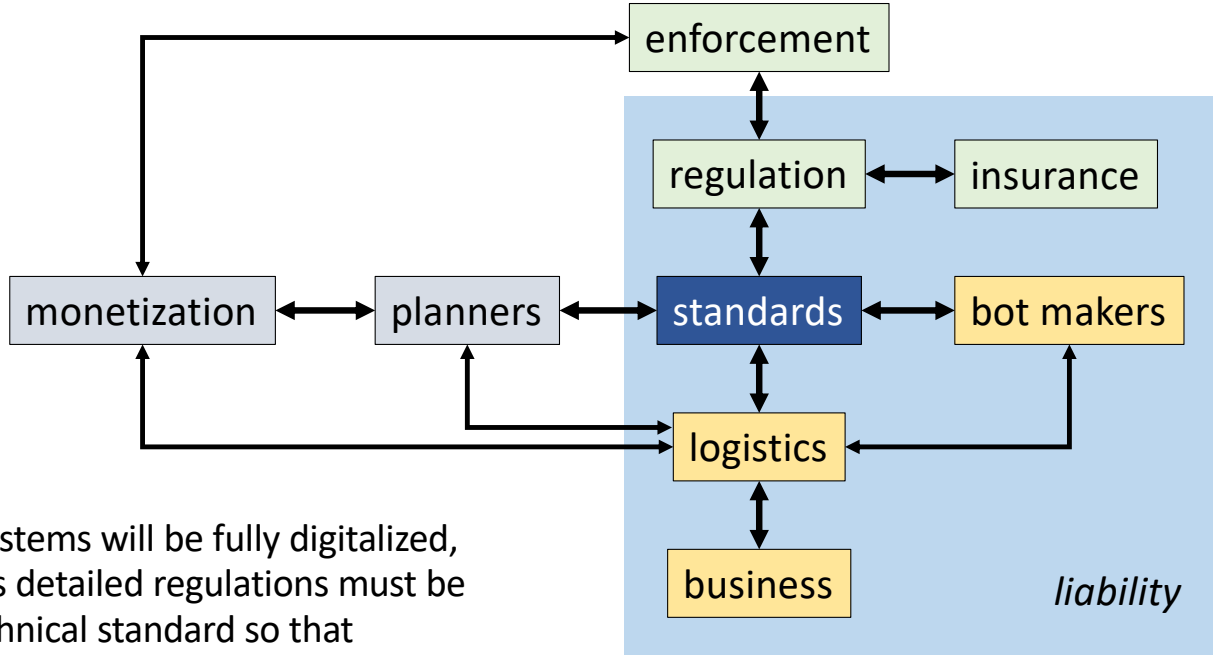
* From the text of the draft 4448 standard “Purpose and Justification”

Liability management is distributed and shared

Standards and regulations should be designed cooperatively to help reduce total system liability.

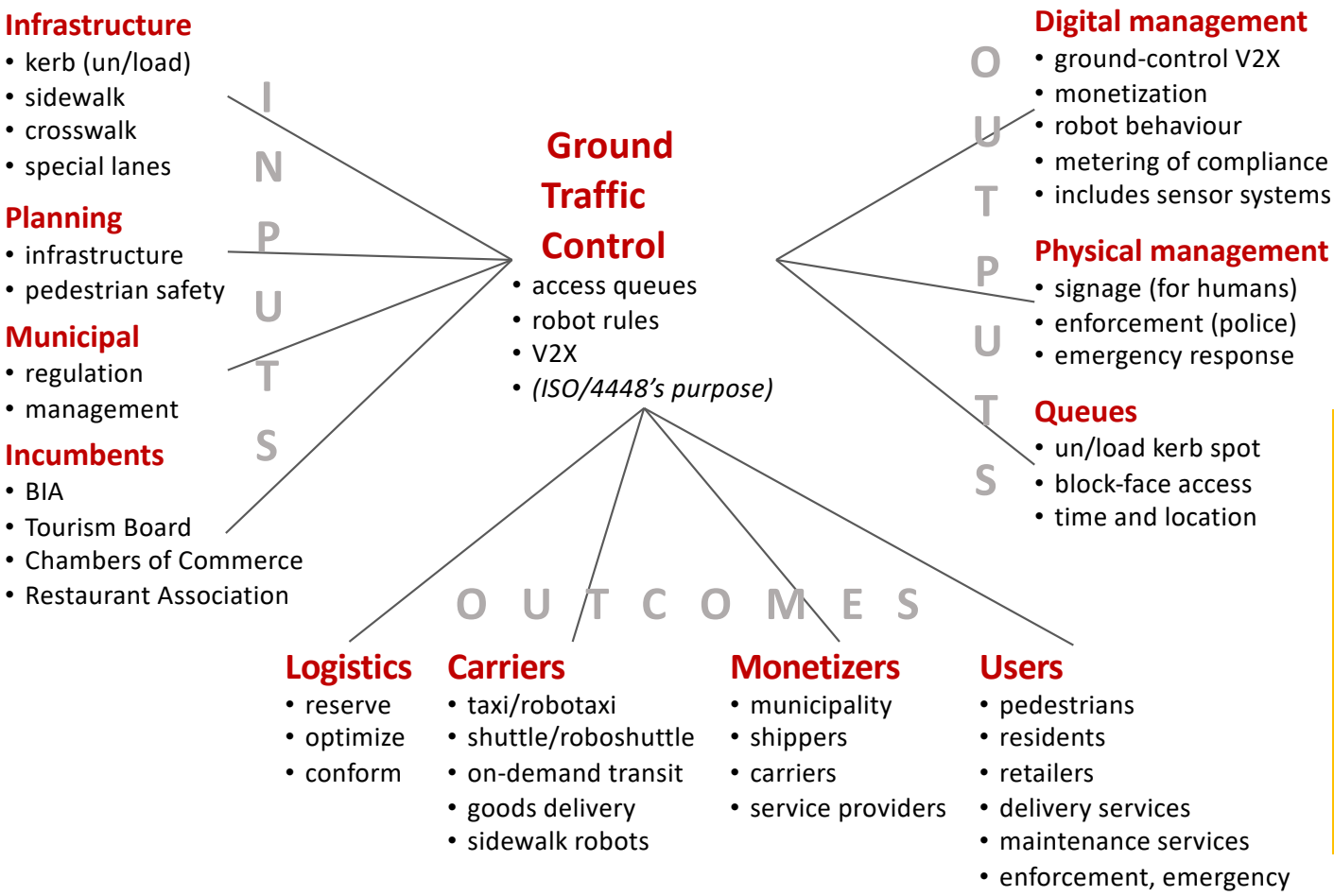
Standards set metrics, language, procedures and protocol for how a system ***can*** work.

Regulations set the rules for how the system ***will*** work.



Automated delivery and service systems will be fully digitalized, realtime, and dynamic. This means detailed regulations must be expressed in the language of a technical standard so that manufacturers, planners, regulators, and logistics operators can (co-)operate with maximum optimality and minimum liability.

Ground-traffic control must be standards-enabled

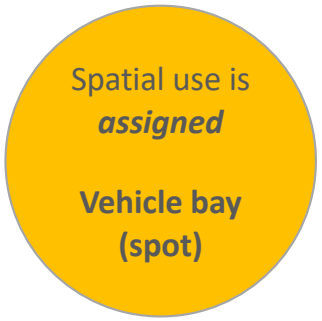


"It would be no more feasible to have automated ground systems for passengers and goods without ground traffic control than it would be to have commercial airflight without air traffic control."

Kerb and sidewalk differ in critical ways

(hence a multi-part standard)

The kerb has a history of motor vehicles parking, loading and unloading. It is a place unwelcoming — even unsafe — for pedestrians. It edges onto fast-moving motor vehicles or stands adjacent to cycle lanes. The kerb is a place where many things are stored and stationary.



Assignment by:

- Vehicle <> spot characteristics
- Request duration
- Special needs
- Hazardous goods

Enables:

- Multiple fleet operators
- Mixed passenger & goods
- Dynamic assignment
- Monetization
- Data from TS5206 (APDS)

The sidewalk, mostly for pedestrian activity, has a far gentler history regarding mechanization and speed. The sidewalk is usually active, a place of going somewhere or socialising. A place of human activity. Human movement.

Adding driverless cars and trucks at the kerb is a much smaller step than adding driverless vehicles on the sidewalk, even if such vehicles are small.

Permission by:

- Size-speed-weight
- Occupancy
- Duration
- Hazardous goods

Enables:

- Multiple fleet operators
- Mixed goods and services
- Dynamic permission
- Monetization
- Describes ground control & sidewalk traffic regulation

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Sidewalk robots are telemonitored and teleoperated

From a promotional Postmates video

This video shows a robot deftly moving around static objects. This scenario would not be a challenge for AI or a teleoperator.

But what about a scooter moving with a passenger? How about a wheelchair on a narrower street? Or with other pedestrians?

Payloads range from 10kg; Speeds from 5k/h

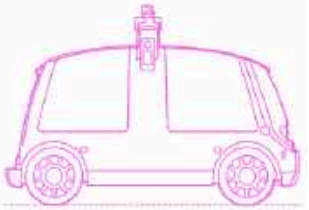
Amazon Scout
23 kg 24 kph

DeliRo
50 kg 6 kph

FedEx Roxo
45 kg 16 kph

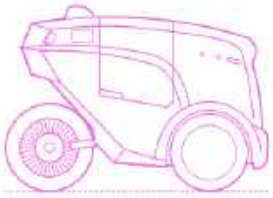
KiwiBot
18 kg 2.4 kph

Nuro R2
190 kg 40 kph



Postmates Serve
23 kg 4.8 kph

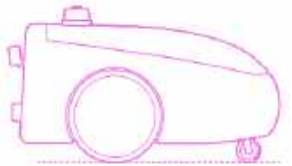
Refraction REV-1
127 kg 24 kph



Robomart
40 kph

Starship Robot
10 kg 6 kph

TeleRetail Delivery Robot
35 kg 56 kph



Under 6kph are intended for personal sidewalk deliveries. Over 40 kph are for larger deliveries or even a mobile retailer. (Mid-sized and larger robots may be relegated to bike lanes or roadways.) What is the ideal speed and weight for each environment? Look at what Amazon and FedEx chose. There are likely to be three major classes when this settles out. Starship and Postmates' lunch size; Amazon & FedEx's goods delivery size; and Nuro & Robomart's multi-stop Retailer size. Of course, all of these dimensions are subject to change.

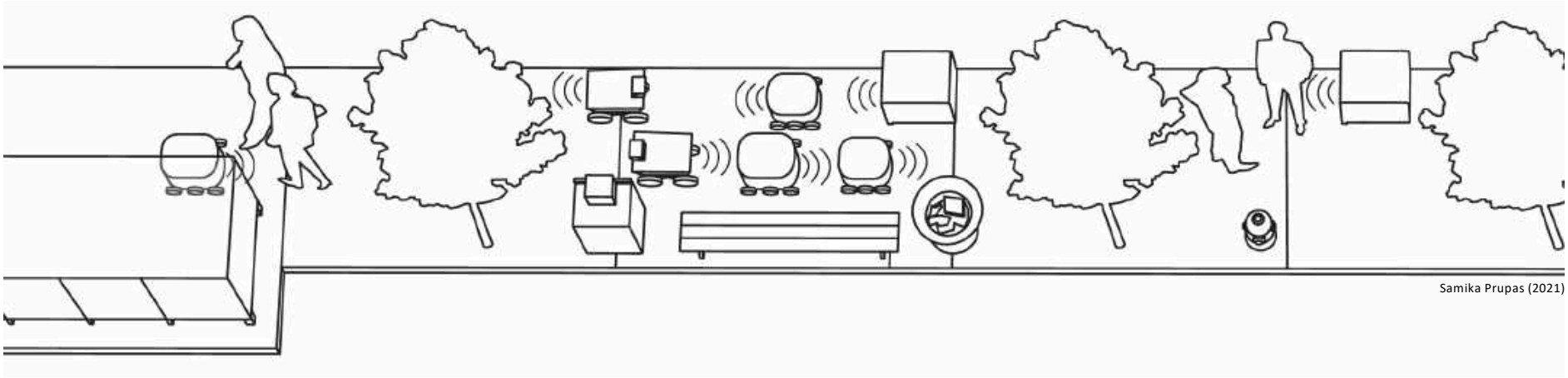
https://www.dimensions.com/collection/autonomous-delivery-vehicles

Managing Rights-of-way, Flow, and Behaviours

How should a sidewalk robot give way to pedestrians?

How many concurrent sidewalk robots should be permitted on a pavement?

What strategies will be permitted to avoid trapping sidewalk robots?



Samika Prupas (2021)

It would not be difficult to set up several dozen rules regarding how robots should behave or will be managed on sidewalks and in crosswalks.

A more difficult aspect would be to find common agreement about how to deploy those rules. For example if there were to be a rule about how many robots would be permitted on a block-face at any one time, the difficulty would be in setting that number in a way that satisfies everyone.

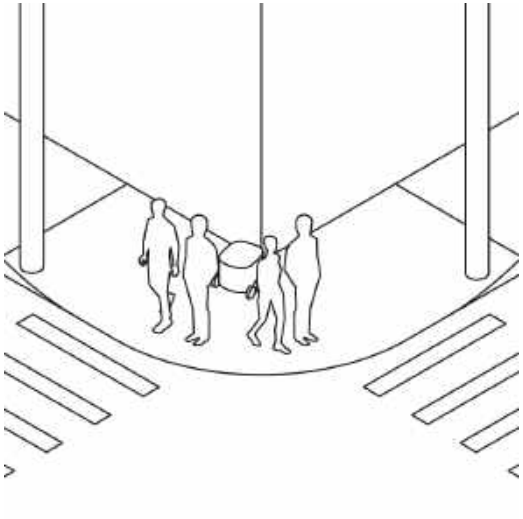
A bit harder would be to manage dynamic rules such that different block-faces at different times would permit variable numbers of robots.

What is hardest is the fact that there will be many edge cases. These will lead to headaches for city managers, until the robots and the systems that manage them mature.

That maturation process will likely take a couple of decades and must be carried out in real environments.

Harmonize MOBILITY

How should a robot behave at a crowded intersection?



vs.

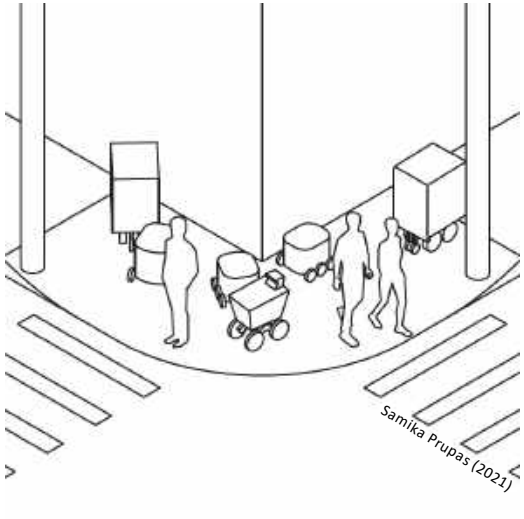
Think about crossing an intersection in a large city at a busy time.

Then think about complex nature of the social navigation problem you are solving — probably unconsciously.

Maybe you are checking your smart phone.

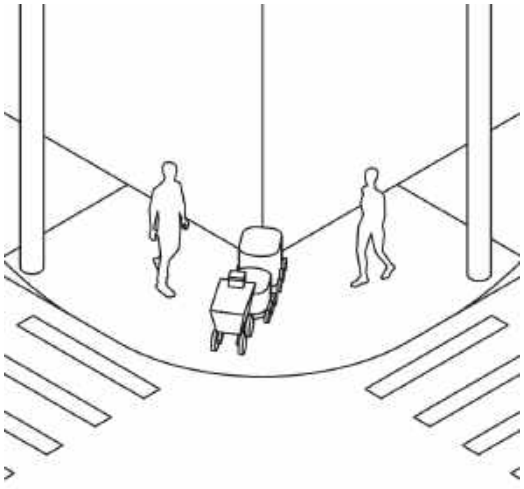
Now add delivery robots.

How should a crowd of robots behave at an intersection?

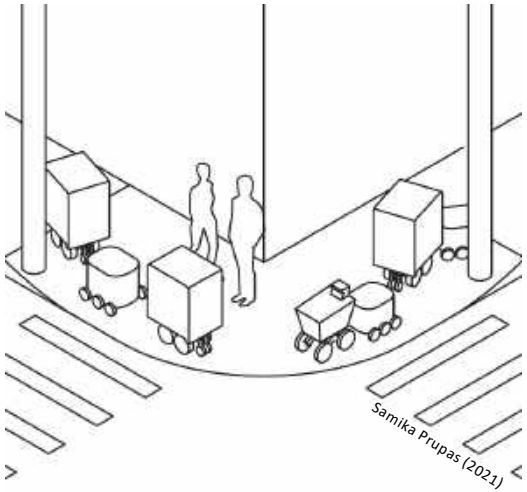


Places of highest potential demand for personal deliveries will tend to be places of highest demand for vehicular and pedestrian traffic.

How should robots line up at intersections?



Even standing aside may raise issues…



What mechanisms will we need to ensure that pedestrians will have unencumbered passage?

Will we limit how many, where, and when?

Harmonize MOBILITY

1. Sidewalk robots will precede autonomous vehicles
2. How will sidewalk robots interact with pedestrian spaces?
3. ISO/4448 — an international standard to guide governance and deployment
4. How ready are cities for deployment of sidewalk robots?

Cities will need a process to gauge readiness

Proactive: What preparations are necessary to configure a specific kerb or a given area of the city for automated pickup and dropoff of passengers? Of goods?

Reactive: What degree or type of automated pickup and dropoff might be permitted along a specific kerb or within a specific district as it is currently configured?

Part 2 of ISO/4448 is focussed on managing vehicles that are using the kerb for loading and unloading passengers and goods. Efficient operation involves matching and reserving — all the procedures necessary for queueing and reassigning, for preparing and maintaining, and for monetizing and enforcing.

In order to prepare or assess a kerb or a district for the deployment of automated vehicles involving all these activities, Part 2 includes a readiness map of preparation activities suitable to each level of permitted automation at specified kerbs.

Between these domains are large goods-robots that may navigate roadways and bike lanes, then need kerb locations to stop/unload (4448:2). If such vehicles are to mount the kerb and traverse any part of a sidewalk then 4448:3 is involved.

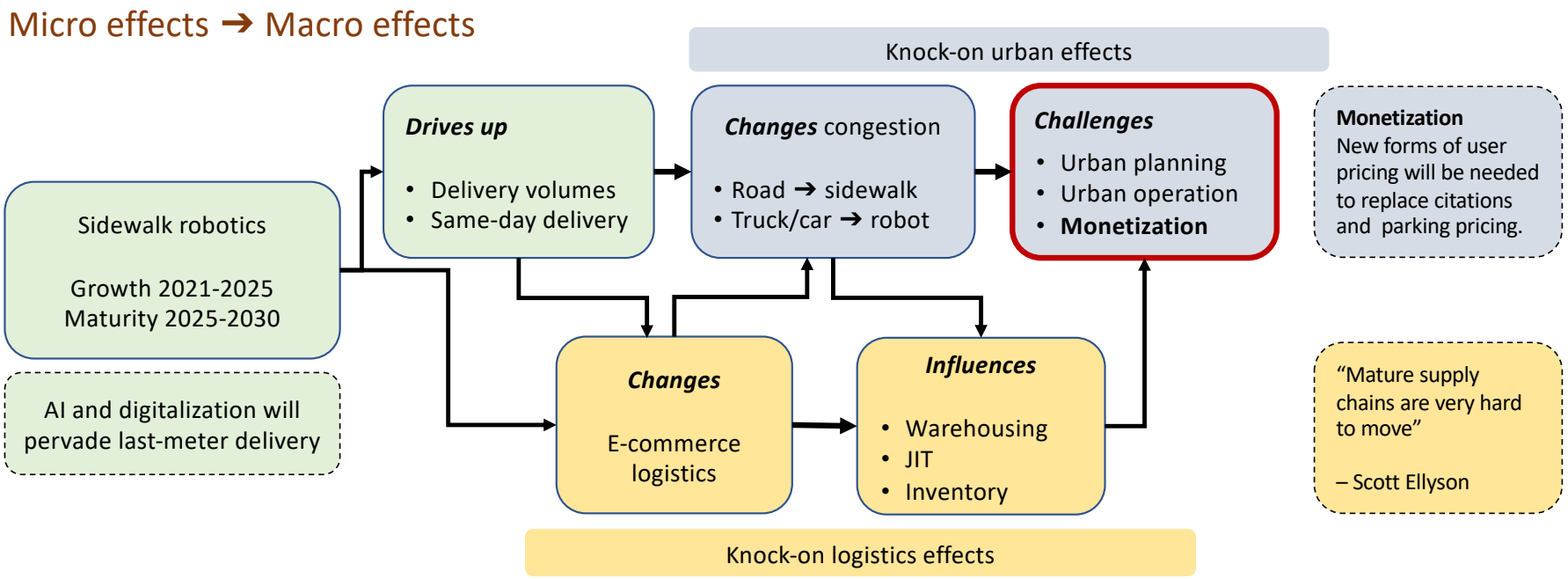
Proactive: What preparations are needed to configure specific sidewalks or group of sidewalks or crosswalks for access by delivery robots? Snowploughs? Pavement sweepers?

Reactive: What degree of automation or class of robot for delivery or service can might be permitted on a specific sidewalk or within a specific district as it is currently configured?

Part 3 is focussed on managing robots that are using sidewalks and crosswalks for performing services and making deliveries. Efficient operation involves permissions and reservations — all the procedures necessary for queueing and reassigning, for preparing and maintaining, and for monetizing and enforcing.

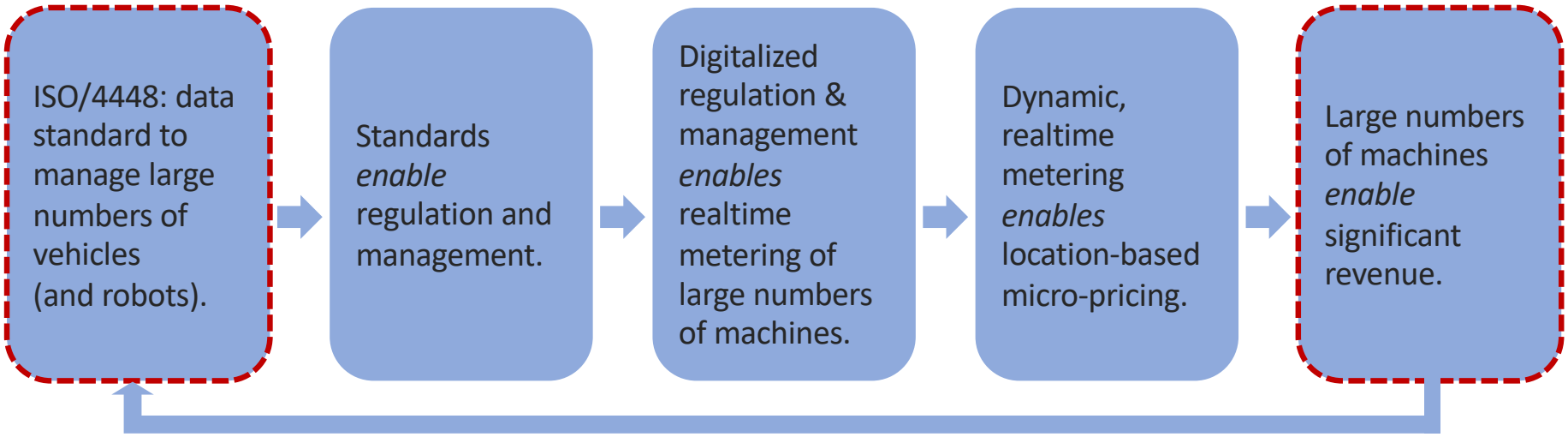
In order to prepare or assess a sidewalk, crosswalk, or a district for the deployment of robots involving all these activities, Part 3 includes a readiness map of the preparation activities suitable to each level of permitted automation at the identified sidewalks and crosswalks.

Cities will need to take a broader view



If sidewalk delivery robots become pervasive — as the factors on pages 9-11 suggest — outcomes would include growth in goods consumption, demand for faster and more deliveries, an increase in sidewalk congestion, new forms of conflicts in pedestrian spaces, long periods of lobbying by multiple interests, changes in planning constraints, demands for improvements in sidewalk infrastructure, specialized loading zones, innovations in warehousing, and an uptick in buy-local, ghost-retail, and ghost-restaurants.

Cities will need budgets to manage sidewalk robots



Virtuous circle:

Standardization is an enabler of monetization.

It is a extremely likely that sidewalk robots will make public urban space more difficult to regulate, more complex to manage, and more costly to maintain.

It is also possible for these systems to improve livability, reduce urban street congestion, and instigate improvements to pedestrian infrastructure.

How will cities and BIAs collaborate to regulate sidewalk robots?

BIAs

Lobby city for:
- local limits
- Speed, size
- schedules
- hazmat - etc

Issues
- local enforcement
- pedestrian grievances
- accessibility justice
- monetization

City

proposed

By-laws
- enforcement
- pedestrian rights
- accessibility rights
- emergency access

Guidelines
- safety enforcement
- monetization
- maintenance minimums
- (sweep, plow, pull-overs, etc)

State
Nation
Province

Legislation
- licensing
- identification
- vehicle safety
- insurance

Regulations
- enforcement
- accessibility

ISO/4448

Standards
- communication
- V2X
- reservations
- robot descriptors

Guidelines
- readiness
- robot <> human interaction

Photo from the site: The Ontario Digital Main Street Initiative

The progress of sidewalk robot legislation (U.S.)

Harmonize MOBILITY

A sidewalk delivery robot is formally known as a *Personal Delivery Device (PDD)* to a U.S. state legislator. Nearly 20 states have prepared bills regulating PDDs. At least two states have already amended these — indicating early volatility and steep learning curves.

Accordingly: "Current hard-lawmaking instruments do not appear to take advantage of knowledge produced by standard-based regulations, virtually wasting their potential benefits." (Villaronga & Golia, *Robots, Standards and the Law*, 2019). ***A review of this early legislation uncovers several areas of inadequacy and concern***:

Weight. Maximum weight ranges from 80-750 pounds; a few of the newer bills are silent about weight — understandable, as the companies lobbying for these regulations represent different machine sizes: Smaller devices, typically under 80 lbs, are suitable for two bags of groceries or a few lunches. Midsize machines, usually between 120 and 200 pounds are designed to carry packaged goods that range more widely in size and weight. Larger vehicles carry goods for multiple personal deliveries or are used as a roving retail store to arrive on demand and allow customers to select goods from its shelves. This latter machine can be quite a bit heavier and could be expected to move along an urban or suburban roadway rather than a sidewalk. Size matters, but legislators cannot possibly anticipate the coming variety and complexity. Rather they consider the weights, speeds, and dimensions indicated by a lobbyist.

Speed. Some maximum speeds (for roadways) are set at 20 or 25 mph, while maximum sidewalk (and usually crosswalk) speeds are set between 3.5 to 12 mph, with a majority between 10 and 12. Two are set at six mph. Ten or 12 mph may be reasonable if there are no proximate humans, but 3.5 mph is more sensible around children, pets, and older pedestrians. The legislation implies that PDD operators will use speed appropriately. A few suggested (inadequate) penalties.

Operator. Most, but not all statutes, describe a registered operator. But assuming that all registered operators are always diligent in order to minimize their business liability is not necessarily a viable assumption. Hired humans are still at the helm, even if "only" monitoring or teleoperating. Machines are machines, and machines fail. Humans will decide how heavily these machines are loaded and other humans and eventually human-written code will determine actual speeds — generally in realtime.

It is the combination of weight and speed, or *momentum*, that causes harm. This is never explicitly recognized in these early statues. The presence of vulnerable and distracted humans makes this speed-weight matter critical for sidewalk safety. Rather than expect the users of these statutes to be versed in physics, this can be partially addressed by including a speed-weight table.

Insurance. These early statutes require a minimum of $100,000 in liability — some on a per-device or per-incident basis and others on a combined fleet basis. One statute reads: "$100,000 for damages arising from the combined operations of personal delivery devices under the entity's or agent's control," while another reads: "…general liability coverage of not less than $100,000 per person per accident for personal injury coverage and property damage coverage…" This would be very confusing for an operator and its insurer operating in multiple states. Large players such as Amazon, FedEx, and Uber, may self-insure, but these statutes need to express insurance requirements more consistently so that local or specialty operators and their insurance companies can understand how to proceed.

Registration and unique ID. All statutes require a marker, plate, or decal to identify the owner/operator of a PDD or PDD fleet. Many of those require a "unique ID" per device. Very few of those require a registration process for devices. And only one of those that do require registration specifies the process. This leaves homework for cities and confusion for operators.

Enforcement. Enforcement guidance is provided in only a few of these early statutes. Coupled with a clause common to a majority of these statutes — "a local authority may not regulate the operation of a [PDD] in a manner that is inconsistent with this article" — means that not only will enforcement vary from state to state, but also from one city or county to the next. Because the behaviour of the vehicles will be increasingly automated, a high variety of enforcement regimes will complicate matters for businesses, courts, and peace officers. The nature of state and local jurisdiction means that this problem is always difficult to address, but the current statutes may make it worse.

Monetization. The impact of PDDs is to shift the delivery of goods from motor vehicles that arrive at the kerb to smaller vehicles that use city sidewalks and pedestrian crosswalks instead. This cannot be done at zero cost to local governments, which will need to fund and perhaps monetize this activity. These statutes are silent about monetization (not a state matter), and it is not clear whether they would permit it.

Pedestrian or Vehicle? These statutes struggle to describe whether a PDD is an exceptional pedestrian or an exceptional vehicle. Saying that a PDD *"has all the rights and duties applicable to a pedestrian under the same circumstances, except that the* [PDD] *must not unreasonably interfere with pedestrians or traffic and must yield the right-of-way to pedestrians on the sidewalk or crosswalk"* seems understandable. But saying that the meaning of "Pedestrian" includes "Personal Delivery Device", as one statute reads, is not. A PDD is a new sort of vehicle or machine that the statutes are calling a "device". Bicycles (excluding children's toys) are considered vehicles largely because they are constrained to the roadway and to the flow of automotive traffic. Some legislators appear to be associating PDDs with the meaning of "Pedestrian" because PDDs started on the sidewalk. But larger PDDs are designed and intended for the roadway.

There are critical differences between vehicles and pedestrians in regards to safety, enforcement, insurance, momentum, and monetization. PDDs need an unambiguously different classification. They will share some rules with pedestrians, some with other vehicles.

Reliable Guidance. It is an error not to demand the registration of unique IDs per device. It is an error to constrain local municipalities in regard to rulemaking. It is an error to begin the process of mechanizing pedestrian spaces without taking more care in regards to momentum. It is an error to regulate PDDs without an ability to monetize, which for some of these states may be blocked. The majority of these statutes do not provide reliable guidance for any enforcement or liability matter. None are ready for operation at scale in urban-human environments.

FOR MORE INFORMATION:

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