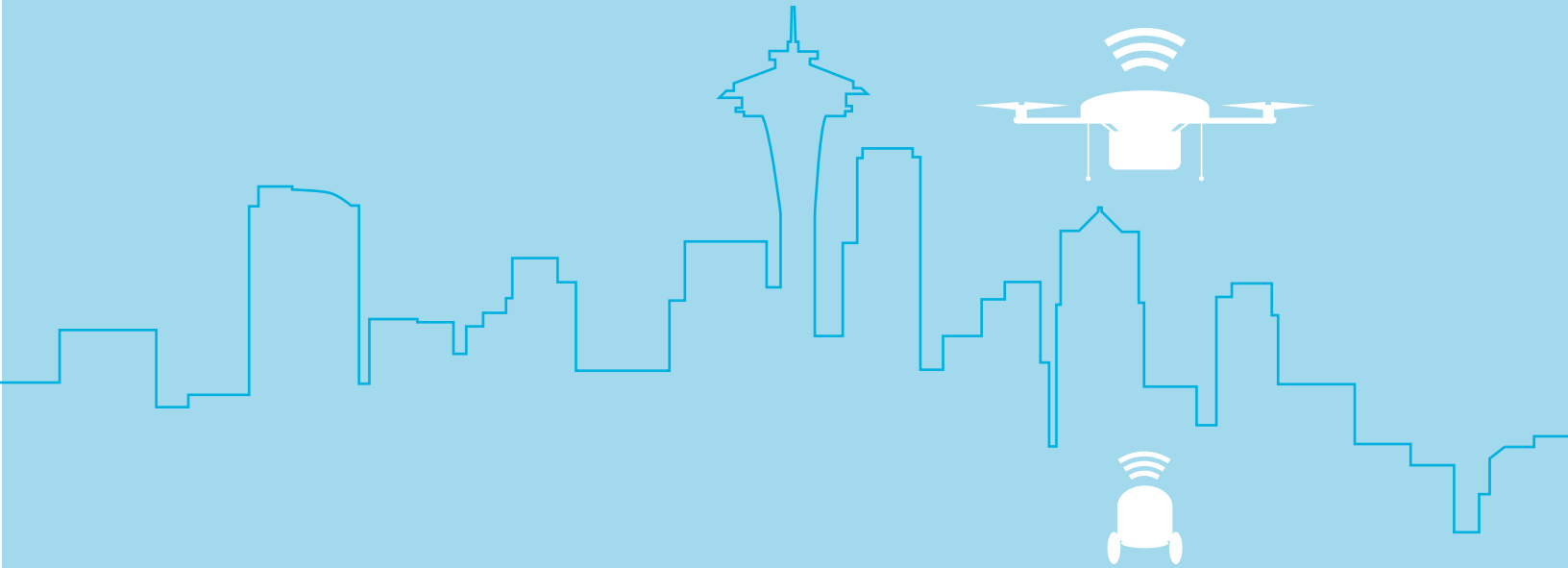
PERKINS+WILL

2017 INNOVATION INCUBATOR /

Delivery by Design



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DELIVERY BY DESIGN
ENVISIONING THE INTERFACE OF AUTONOMOUS DELIVERY

This study is an initial design exercise that seeks to understand the changing landscape of freight delivery, and evaluates two emerging delivery technologies: drones (air) and robots (autonomous ground vehicles (AGVs), or droids) on the built environment.

Given that this is a high-level exercise, the sole purpose of this document is to highlight emerging trends and provide guidance for future policy development around autonomous delivery systems to ensure that these technologies are implemented with the safest, most-equitable considerations in mind.

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PICTURE-IN-TIME /

PICTURE-IN-TIME, THE CHANGING LANDSCAPE OF DELIVERY

RETAIL IS CHANGING

The way people purchase goods and services is constantly evolving, especially in the retail sector. Historically, companies have utilized the brick and mortar operating style, featuring fixed physical locations where items are typically stocked on-site. This has and continues to shift into new models, including the following models on the far top right corner.

Retail model alternatives to brick and mortar, including guideshops and conversational commerce models, are considered *disruptive*, as they offer a unique form of commerce that impacts the traditional brick and mortar experience. Large retailers that offer a combination of retail models operate in what is referred to as an omni-channel system, and currently includes companies like Nordstrom and Amazon. This model also allows retailers to utilize less space for on-site merchandise storage, as they offer the alternative of expedited or same-day delivery. Retailers that haven't adapted to this model, including Walmart and Macys, are making adjustments to either consolidate locations or diversify from the traditional brick and mortar experience.

FREIGHT VOLUME IS INCREASING

According to a study by McKinsey, freight deliveries in mature markets (including United States, Germany, China) have the potential to grow by 7-10% percent per year, almost doubling between 2016 and 2026 to over 25 billion parcel deliveries per year in the United States alone. Of these deliveries, the number of B2C, or *business to consumer,* deliveries are on the rise. B2C deliveries in countries, including Germany, now account for 50% or more of total deliveries, as opposed to the established B2B, or *business to business* model. While B2B shipments have the benefit of allowing for bulk deliveries to centralized locations, B2C deliveries create the potential for a higher volume of smaller deliveries to the same location.

DELIVERY TYPES

B2B BUSINESS TO BUSINESS
B2C BUSINESS TO CONSUMER
X2C ANYTHING TO CONSUMER

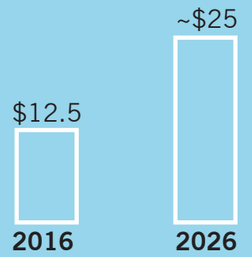
Source: McKinsey

RETAIL MODELS, 2017

	Current market sales % in 2017	Projected retail sales % by 2020	Examples of brick and mortar "guideshops" (pop-up-shops)	Examples of Pick-up services	Examples of "Conversational Commerce" option	Example expedited/same-day delivery services	Example In-House Delivery
BRICK AND MORTAR	**91.%**	**88.6%**	**Nordstrom Local**	**Fred Meyer**	**Walmart/Google Home**	**Nordstrom**	**n/a**
ONLINE "E-COMMERCE"	**8.1%**	**11.4%**	**Warby Parker**	**Amazon Pickup**	**Amazon Echo**	**Amazon Prime**	**Amazon Key**
MOBILE SHOP (IN DEVELOPMENT)	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**Moby Mart concept store**	**LULU Dans Ma Rue**

Sources: Nordstrom, Amazon, LULU Dans Ma Rue, CNN, BBC

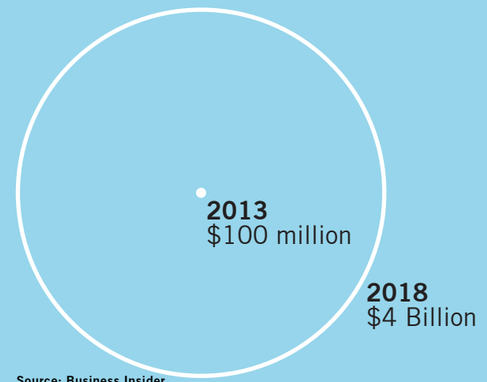
FREIGHT DELIVERY GROWTH, MATURE MARKETS



Figures represented in billions

Source: McKinsey

PROJECTED INCREASE IN SAME-DAY DELIVERIES



Source: Business Insider

DELIVERIES ARE FASTER

Not only are the number of deliveries increasing, but demand for expedited delivery services is also on the rise. An early study by Business Insider projected that same-day deliveries would increase from $100 million in sales in 2013 to $4.03 billion in 2018, as shown on Page 5. Although this projection is speculative, it points to a significant upward trend in frequent deliveries.

The chart to the far right identifies different anticipated methods for delivery to accommodate expedited deliveries, with special attention to the emerging X2C model. Details on the different delivery types are addressed in the following section.

PARCELS ARE SMALLER

As a result of these models, coupled with a rise in expedited or same-day deliveries, freight deliveries are anticipated to be compressed with smaller parcel sizes meeting the expedited delivery option, as noted in Seattle's 2016 Freight Master Plan (FMP).

These combined factors have the potential to place additional burdens on existing transit infrastructure and negatively-impact the quality of life of the public realm. Additionally, it should be noted that this decrease in quality of life will be amplified in communities residing along primary freight corridors the most.

ANTICIPATED DELIVERY MODELS

Overarching Product Categories		1. Rural areas with low to average density	2. Urban areas with average density	3. Urban areas with high density
X2C (ANYTHING TO CONSUMER)	**Regular Price**			
	High reliability, e.g. time window	**Drones (same-day, if fulfillment times feasible)**	**AGV's (Autonomous Ground Vehicles) with lockers (e-grocery with today's delivery model)**	
	Same day			
	Instant	**Fulfillment (likely) not possible at economical cost levels**		**Bike couriers (or droids)**
B2B (BUSINESS TO CONSUMER)		**Today's delivery model**		

1. Below 50,000 inhabitants
2. 50,000 - 1 million inhabitants
3. Above 1 million inhabitants

Source: McKinsey

In Summary

- Retail models are changing
- Freight volume is increasing
- Deliveries are faster
- Parcels are smaller

PICTURE-IN-TIME /

EMERGING TECHNOLOGIES

CHANGING TECHNOLOGY

According to McKinsey, the following autonomous delivery methods, referred to as X2C, or *anything to consumer,* have the potential to handle 80% of deliveries in addition to the standardized parcel delivery model:

A. Drones: air-based delivery systems

B. Crowdsourced Deliveries: freight version to the Uber or Lyft model

C. Autonomous Ground Vehicles (AGVs) with lockers: amazon locker on-the-go

D. Bike Couriers: Possible alternative to small AGVs

E. Semiautonomous Ground Vehicles: offers additional flexibility for delivery person

F. Small AGVs: or robots/small autonomous vehicles/droids, currently occupy the sidewalk

A B C D E F

Two emerging forms of delivery, in particular, drones and robots have the potential to radically inform the future design of our public spaces and internal circulation of our built environment. Given that much of these technologies are under development, understanding the full potential of these technologies is limited, and may not fully reflect the entire impact on existing delivery systems.

The preliminary landing pad design shown does not include many of the design considerations, and may not provide a safe and accessible method for parcel delivery for apartment users

DRONE DELIVERY SYSTEM

According to Engadget, drones, or more-appropriately named *unmanned aerial vehicles (UAVs)* are "aircraft without a pilot aboard…broken into two categories: rotary [commercial] and fixed wing [military]. Rotary drones are currently used/under development by JD.com and Amazon.

The following features should be considered when accommodating space for a drone-based parcel delivery:

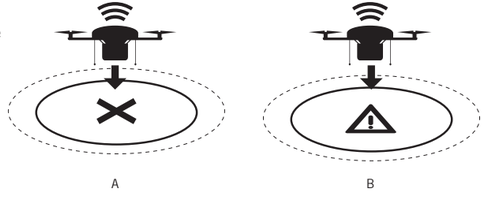
A. Landing pad(s), with safety buffer

B. Emergency landing zone, in addition to the current landing pad

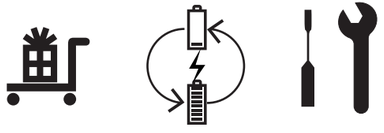
C. Package loading zone

D. Battery swap/charging zone

E. Maintenance bay



A B



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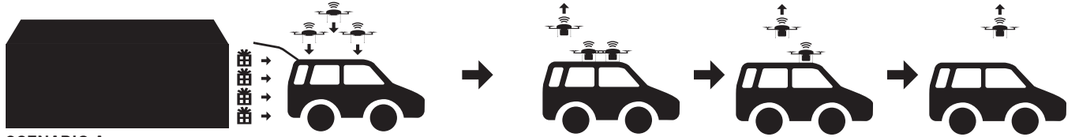
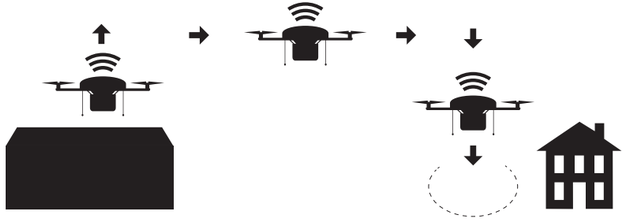


SCENARIO A



SCENARIO B

HOW DRONE DELIVERIES COULD OPERATE

The diagrams above illustrate two scenarios of how drone services could support deliveries.

Scenario A

1. Packages are loaded into standard, semi-autonomous, or fully autonomous delivery vehicle.
2. Delivery drones launch from delivery vehicle at specified locations close to delivery zone.
3. Delivery vehicle could potentially double as charging/maintenance station

Scenario B

1. Package is loaded from a distribution center
2. Drone makes non-stop delivery direct from distribution center

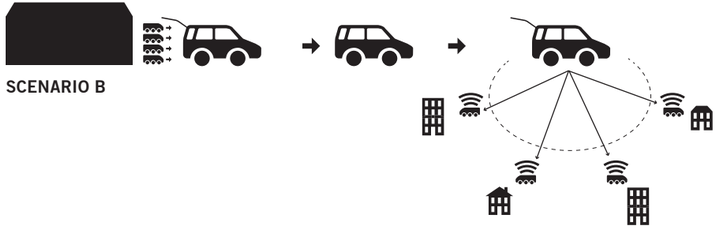
HOW ROBOT DELIVERIES COULD OPERATE

It should be noted that there are multiple terms for a delivery robot, including more-appropriately named *unmanned ground vehicle (UGV)* or *droid*. According to roboticist, Anna Dragan from UC Berkeley, a robot is defined as, "a physically embodied artificially-intelligent agent that can take actions that have effects on the physical world."

Examples under development can be found from Starship Technologies, Marble, and Piaggio Fast Forward (Piaggio, in particular, serves as a personal robot designed for the transport of belongings.)

SCENARIO A

SCENARIO C



SCENARIO B

Like most new technologies, it will be imperative to understand how these components change, and with it, how they influence the development of land use codes.

HOW ROBOT DELIVERIES COULD OPERATE

The diagrams above illustrate three scenarios of how robot services could support deliveries.

Scenario A

1. Item for shipment is loaded into robot
2. Robot makes non-stop delivery direct from origin point
3. Individual is notified via smart device of robot arrival, and given code to unlock storage unit

Scenario B

1. Multiple orders are loaded into standard, semi-autonomous, or fully autonomous delivery vehicle
2. Vehicle travels to centralized location where multiple robots are launched to make direct deliveries
3. Individual is notified via smart device of robot arrival, and given code to unlock storage unit

Scenario C

1. Multiple orders are loaded into semi-autonomous to fully-autonomous vehicle and driven to centralized location
2. Individual is notified via smart device of vehicle arrival, and given code to unlock storage unit

POTENTIAL IMPACTS /

LAND USE IMPACTS

LAND USE IMPACTS

The following potential impacts are identified from research conducted through the University of Oregon Sustainability Cities Initiative. Additional impacts are identified through findings identified previously in this document and surveys completed by participants from Perkins+Will, Nelson\Nygaard, and members/staff from both the Seattle Planning Commission and Seattle Design Commission.

A. CHANGING GROUND-LEVEL/BRICK AND MORTAR FUNCTIONS

Traditional brick and mortar outlets are not going away. There may, however, be fluctuations on where outlets will be maintained, added, or closed. These changes could potentially include the loss of neighborhood brick and mortar services, negatively-impacting the walkability and overall quality of life of a neighborhood.

B. GUIDESHOPS

Guideshops are temporary spaces that support online retailers, and may seek temporary spaces in high pedestrian-traffic locations for a few months.

C. MOBILE SHOPS

This experimental concept involves an autonomous store, on-demand-ordered via a smart phone. In theory, the store parks in a space where a user ordered it.

D. INCREASED UTILIZATION OF TRANSIT INFRASTRUCTURE

As identified in the FMP, we are likely to see a higher number of smaller delivery vehicles on the road, and will continue to see this increase. Freight routes not only utilize major corridors with residential uses, but also neighborhood streets.

E. LARGER DISTRIBUTION (FULFILLMENT) CENTERS

According to research conducted by the University of Oregon Sustainable Cities Initiative, the size and locations of distribution centers (DCs) are changing. Not only are they increasing in size, but also in location—moving away from city centers and traditional freight centers to suburban locations on the outskirts of a community. These larger, more suburban distribution centers handle a greater volume of goods and services to support JIT deliveries, and indecently, generate a high volume of deliveries, placing an additional burden for drivers.

F. PICKUP STORES

Pickup stores, including BingoBox, Amazon Pickup, Amazon Go, and Amazon Locker continue to gain popularity, as they provide a reasonably-accessible and safe means of picking up deliveries for users.

G. INCREASED USE OF DELIVERY SPACES WITHIN A BUILDING

Residential buildings of all sizes are experiencing higher volumes of deliveries in a building. These deliveries overwhelm mail and storage rooms, and create accessibility and safety concerns for buildings without package storage.

OTHER SYSTEMS, LIKE BIKESHARE, ARE ALSO IMPACTING THE ENVIRONMENT

Private bikeshare systems have launched in Seattle, and offer a preliminary example of how new unregulated systems impact the public realm. While these services promote healthier alternatives to single-occupancy vehicle use, the lack of designated parking has the potential to create accessibility conflicts for pedestrians, especially those with mobility challenges. It is possible to assume that a higher volume of bikes occupying the sidewalk could potentially create a negative impact on the pedestrian experience, both for safety and access.

Image above: recent bikeshare additions to Seattle's streetscape

POTENTIAL IMPACTS /

PUBLIC REALM IMPACTS

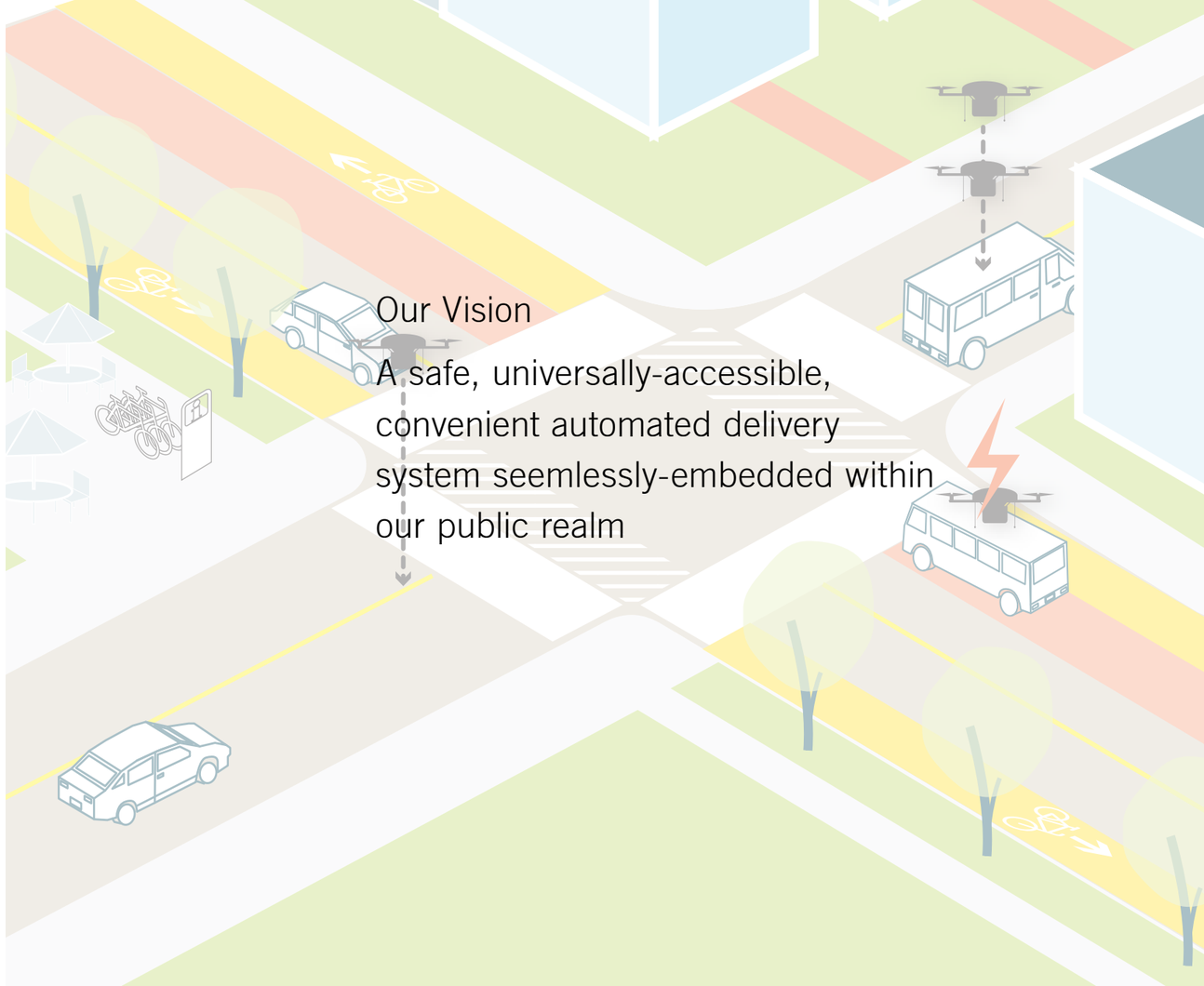
The following section identifies design considerations that reflect the pros and cons for how drone and robot technologies could be integrated with our architecture (existing and new) and the public realm.

To achieve this, a series of surveys were distributed to participants from Perkins+Will, Nelson\Nygaard, and commissioners and staff from the Seattle Planning Commission and Seattle Design Commission. All participants were asked to provide input on the following:

- Streetscapes: Pros and cons of drone and robot operations above street features (including features like sidewalks, landscape buffers, bike lanes, and streets)
- Intersections: A focused study for controlled and shared intersections that asks, “what is the safest way a drone can cross an intersection?”
- Drone-building integration: Potential loading areas for a mid/high-rise building at different locations (roof, amenity level, podium, alley, and front entrance).
- Robot-building integration: Potential loading areas for a mid/high-rise building at different locations (alley, front entrance, Amazon Locker, unit entrance).

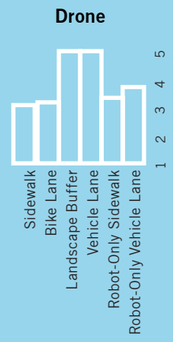
WORKING ASSUMPTION: FAA REGULATIONS FOR DRONES

Drones are currently subject to stringent FAA regulations that limit the ability to operate freight deliveries. For the purpose of this study, it will be assumed that these regulations will eventually change to allow for deliveries.

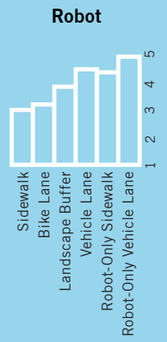


STREETSCAPE FEATURES

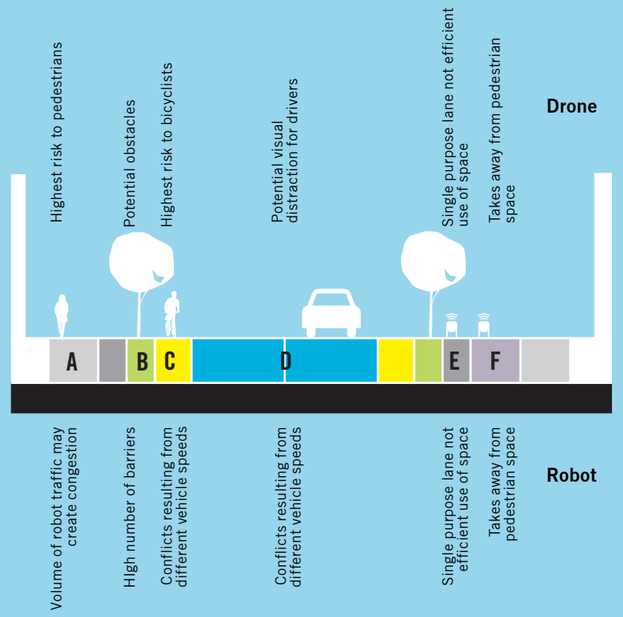
The following comments summarize survey results for how a drone or robot could be incorporated into a traditional streetscape. Overall, the survey results indicate low support for both technologies on-or-above a sidewalk, while use on-or-above a vehicle lane is generally more favorable.



On a scale of 1-5 (1 being the most problematic, and 5 being the least problematic) What location(s) of this street do you feel should accommodate drone (air) transportation



On a scale of 1-5 (1 being the most problematic, and 5 being the least problematic) What location(s) of this street do you feel should accommodate robot (ground) transportation

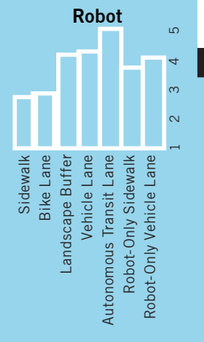


A. Sidewalks
B. Landscape buffer
C. Bike lane
D. Vehicle lane
E. Robot-only sidewalk
F. Robot-only vehicle lane

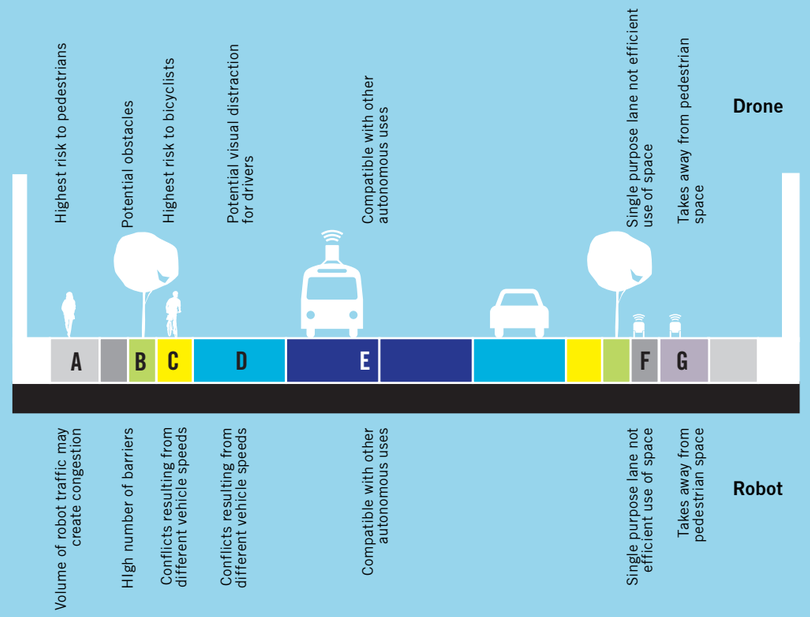
STREETSCAPE FEATURES: WITH AUTONOMOUS-ONLY LANES INCLUDED

The following comments summarize survey results for how a drone or robot could be incorporated into a traditional streetscape. Overall, the survey results indicate low support for both technologies on-or-above a sidewalk, while use on-or-above an autonomous transit lane is generally more favorable.

On a scale of 1-5 (1 being the most problematic, and 5 being the least problematic) What location(s) of this street do you feel should accommodate drone (air) transportation with the inclusion of an autonomous transportation lane



On a scale of 1-5 (1 being the most problematic, and 5 being the least problematic) What location(s) of this street do you feel should accommodate robot (ground) transportation with the inclusion of an autonomous transportation lane



A. Sidewalks
B. Landscape buffer
C. Bike lane
D. Vehicle lane
E. Autonomous transit lane
F. Robot-only sidewalk
G. Robot-only vehicle lane

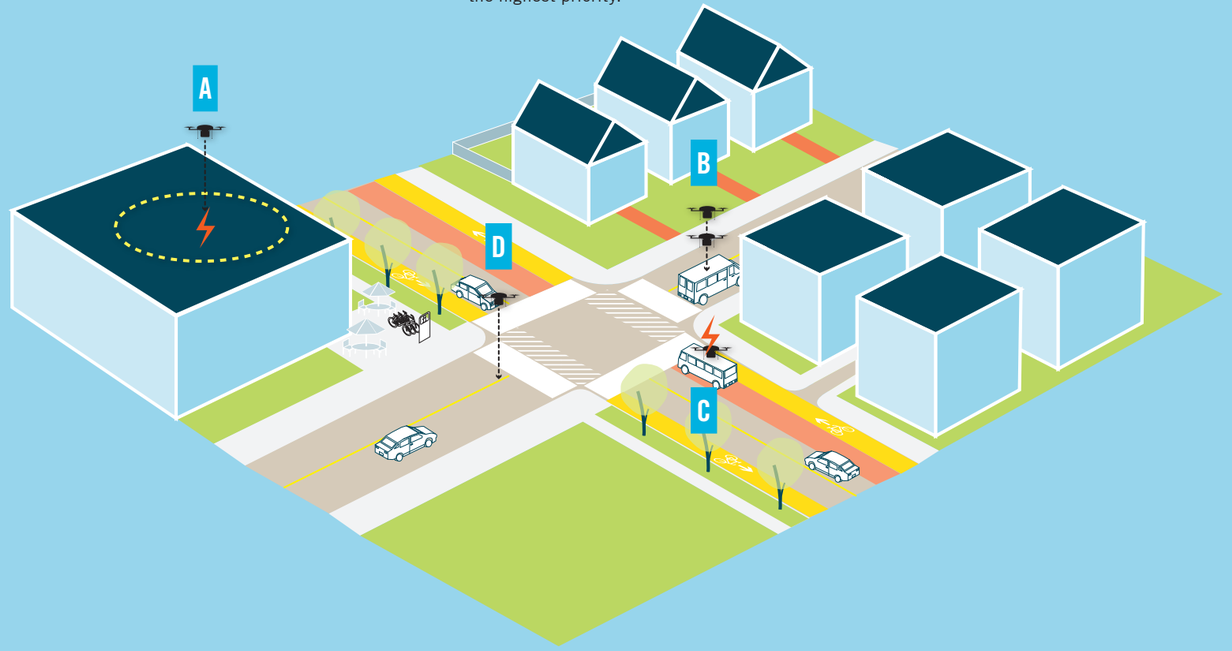
INTERSECTION STRATEGIES

The resulting recommendations are in response to the question, “what is the safest method a delivery drone can cross an intersection”, both controlled and shared.

HOW COULD A DELIVERY DRONE CROSS A CONTROLLED INTERSECTION

The following strategies are identified as optimal methods for the safest crossing of delivery drones for a controlled intersection--placing pedestrian safety as the highest priority.

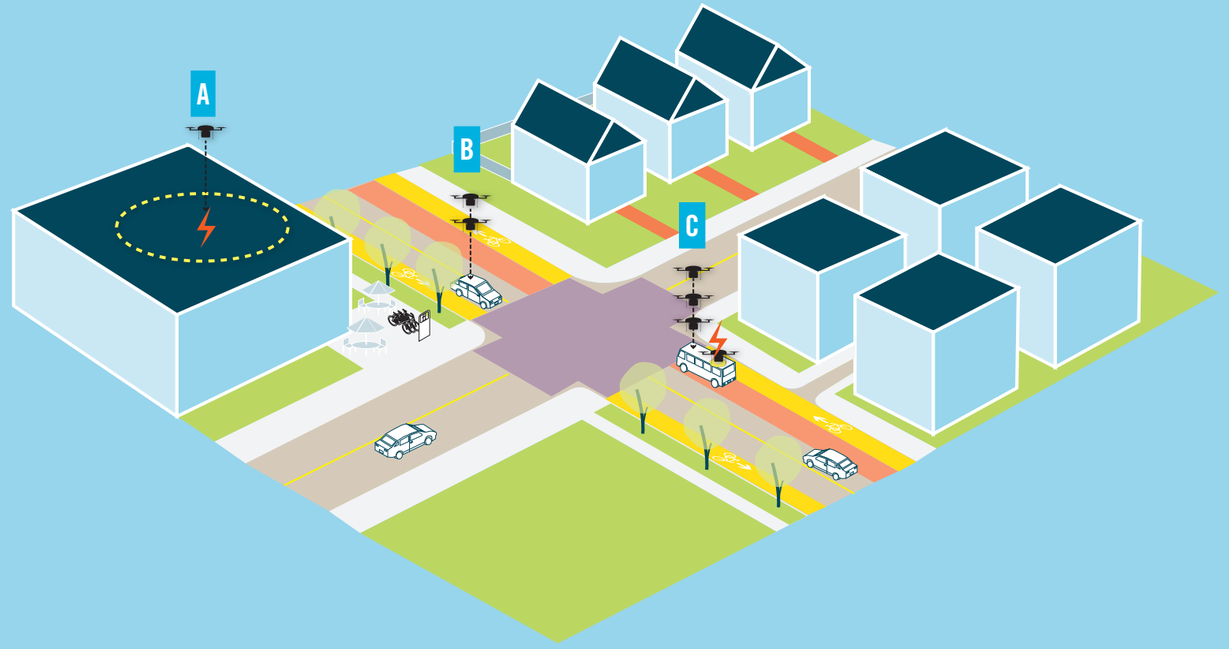
A. Concentrate deliveries in one corner
B. Utilize vehicle rooftops
C. Support public transit as option for roofs/shipping/charging
D. Utilize driving lane in between vehicles

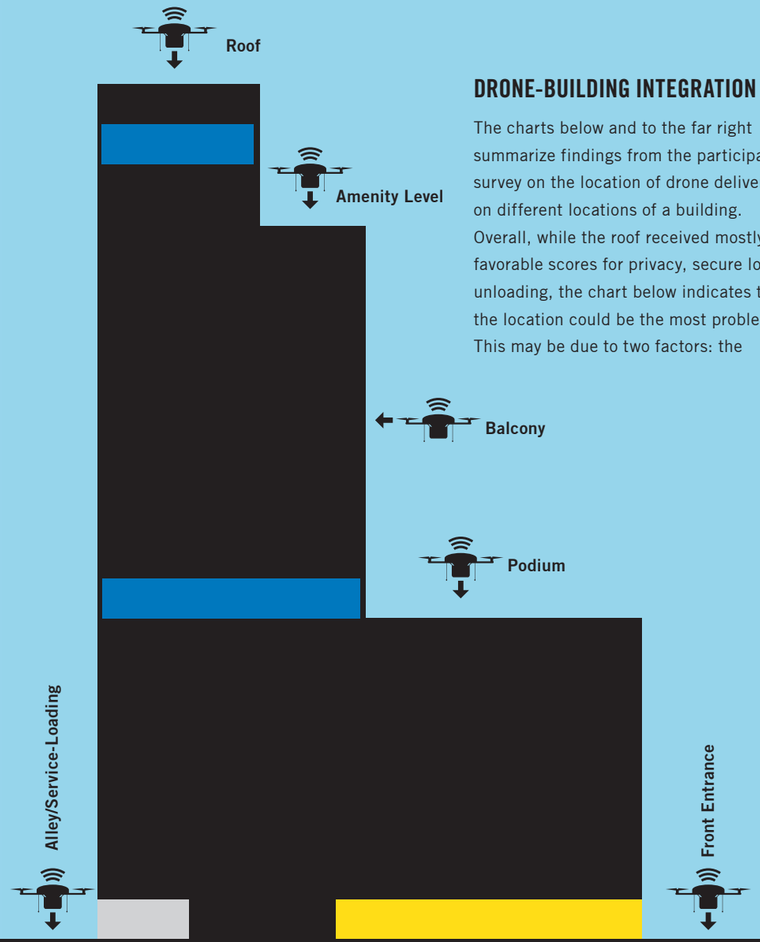


HOW COULD A DELIVERY DRONE CROSS A SHARED INTERSECTION

The following strategies are identified as optimal methods for the safest crossing of delivery drones for a shared intersection--placing pedestrian safety as the highest priority.

A. Concentrate deliveries in one corner
B. Utilize vehicle rooftops
C. Support public transit as option for roofs/shipping/charging

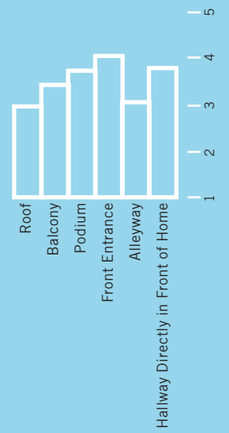




DRONE-BUILDING INTEGRATION

The charts below and to the far right summarize findings from the participant survey on the location of drone deliveries on different locations of a building. Overall, while the roof received mostly favorable scores for privacy, secure loading/unloading, the chart below indicates that the location could be the most problematic. This may be due to two factors: the potential for major changes to development codes to accommodate additional rooftop uses, and potential hazards of drones landing on top of mechanical equipment. Additionally, although the front entrance recieved a favorable rating in the chart below, the scores shown on the far bottom right indicate a high number of risks, including the potential for obstructions into the sidewalk.

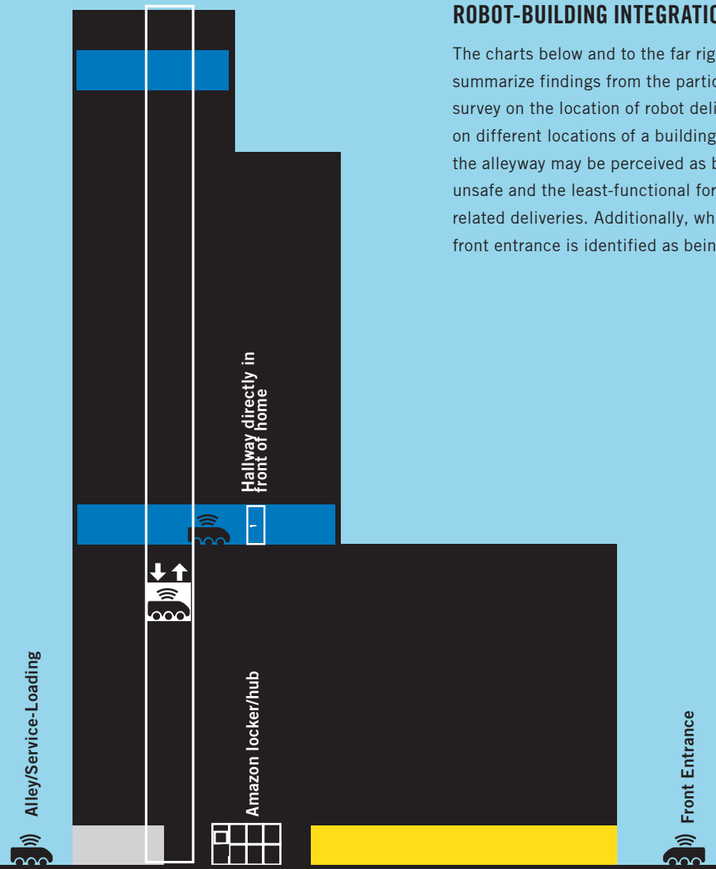
Please rate,on a scale of 1-5 (1 being the most problematic, and 5 being the least problematic), your opinion on the ability for drone deliveries to take place in the following locations of a building



Rating Categories

- *Low risk*
- *Moderate risk*
- *High risk*

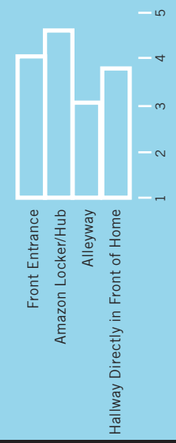
Location potentially supports/does not support:	Universal accessibility	Personal safety	Maintained privacy	Low visual impact to public	Low visual impact to building occupant	Secure loading/unloading	Code adaptability	Weather protection	Accommodates drone support (e.g. battery swap)	Safety buffer	Primary Pro	Primary Con(s)
Roof											**Avoids using amenity spaces**	**May require change in development code. Potential hazard landing on top of mechanical equipment**
Roof Amenity Level											**Can be co-located with other amenity spaces**	**If option, takes up valuable real estate**
Balcony											**Direct delivery to unit**	**Not all units have balconies**
Podium											**Can be co-located with other amenity spaces**	**If option, takes up valuable real estate/reduced sense of privacy**
Alleyway											**Co-location with existing loading**	**May be unsafe. Potential for code violation**
Front Entrance (Outside)											**Close proximity to user**	**Physical/visual obstruction**



ROBOT-BUILDING INTEGRATION

The charts below and to the far right summarize findings from the participant survey on the location of robot deliveries on different locations of a building. Overall, the alleyway may be perceived as both unsafe and the least-functional for robot-related deliveries. Additionally, while the front entrance is identified as being less problematic, results indicate that the front entrance may result in conflicts including sidewalk obstructions. It should also be noted that deliveries to a front entrance may pose a personal safety risk for users, especially for unsecured entrances.

Please rate,on a scale of 1-5 (1 being the most problematic, and 5 being the least problematic), your opinion on the ability for robot deliveries to take place in the following locations of a building



Rating Categories

- *Low risk*
- *Moderate risk*
- *High risk*

Location potentially supports/does not support:	Universal accessibility	Personal safety	Maintained privacy	Low visual impact to public	Low visual impact to building occupant	Secure loading/unloading	Code adaptability	Weather protection	Primary Pro	Primary Con(s)
Alleyway									**Co-location with existing loading**	**May be unsafe. Potential for code violation**
Front Entrance (Outside)									**Close proximity to user**	**Potential for personal safety risk**
Amazon Locker/Hub (Inside)									**Close proximity to user**	**Not available in all buildings**
Hallway Directly Outside Unit/House									**Most accessible**	**Hallway may not be fully secure**

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