



Empowering local authorities towards successful dynamic curbside management

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AUTHOR:

Mitchell Neels

THESIS SUPERVISORS:

Ivo Cré

Andréia Lopes Azevedo

Nina Nesterova

CONTRIBUTORS:

Ivo Cré

Alessia Giorgiutti

LAYOUT:

Alessia Giorgiutti

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1. Introduction

European cities and regions are facing increasing demands for the mobility of people, goods, and services. Historically, these mobility demands were satisfied by expanding capacity, but now, cities need to operate within specific boundaries due to the lack of space and climate obligations: this results in a need for innovations that allow them to make more optimal use of space to satisfy the increasing mobility demands.

The increasing demand for mobility leads to increasing demand for curbside access. The curb is the place where a function shift happens between the transporting function and the activities of the street, where the people, goods, and services stop moving and generate value for the city. The limited amount of curb space available for one transport system leads to conflicts regarding the allocation of space among different users and uses — this can have various negative impacts on the economic productivity and livability of a city. Moreover, additional innovative functions are presenting themselves in this limited space due to new mobility services models, such as ride-hailing and e-scooters, and the competition for space spreads like wildfire, as it is not unique to high-traffic volume city centres but also occurs in the calmer areas.

The high demand for curbside access and the limited amount of curb space requires a more dynamic use of curb space to satisfy these demands. All models that aim to solve mobility challenges rely on the 'curb kiss' to be successful, shifting away from static vehicle parking offers the opportunity to 'open up' space for quick delivery of people and goods or temporary parking. While the effects of these types of measures and strategies on the curb have been researched (often separately), the process elements for successful implementation have been widely neglected, leaving local authorities in the dark and limiting European implementation of advanced dynamic curbside management solutions.

The paper discusses the importance of a dynamic curbside strategy for local authorities and how it can be successfully implemented. While previous research has focused on the traffic engineering perspective, this paper investigates five overlooked pillars that have been identified together with POLIS (local regulations, institutional arrangements, stakeholder involvement, technology and digital services, and street design) that contribute to the successful implementation of dynamic curbside management.

2. Curbside Management

In 2018, 55% of the world's population lived in urban areas, this is projected to grow to 68% in 2050. Urbanization, densification, and accessibility are major challenges that cities are facing. Between 1990 and 2015 globally city surfaces have increased equal to the size of Ireland. For cities, there is a growing need to optimize the limited amount of space for inclusive and sustainable urbanization. This includes the streets which are the arteries of a city. The street facilitates people, goods, and services the ability to move throughout the city. UN-Habitat (2013) found that for the five European cities participating in their research, between 22.7% and 33% of their land was allocated to street systems. Effectively managing these systems is a determining factor for a city's economic productivity and accessibility.

The movement of people, goods, and services through the street systems of a city is defined as mobility and can be facilitated by different means ranging from walking to motorized transport. The movement stops when the destination is reached, in the street system this happens at the curbside. The curb is the physical border between transport systems and the activities of the street. The value for citizens and cities is created, when people, goods, and services stop moving and arrive at their destination. The transport systems themselves don't necessarily generate value through movement. Therefore, the curb is one of the most valuable pieces of real estate in a city and must be managed effectively. Ineffective management of the curb not only causes implications for the overall accessibility and economic productivity of the city but also causes issues for the mobility flow in the street systems.

Evidence of this has been presented to us multiple times throughout history. As a reference in Figure 1., the evolution of Grosvenor Square in London is shown after the implementation of the first paid parking curbside management strategy in Europe. When given the opportunity a driver will park as close as possible to their destination. Also, if this means obstructing the traffic corridor or the pedestrian walkway. Parking fees are introduced to optimize the use of curb space, influence turnover, and minimize the number of vehicles obstructing traffic flow. The prices can be changed based on the demand. Increased when the demand for parking is high (no sport available), decreased when too many spots are vacant.



Figure 1. 1958, Grosvenor Square, London (TLR)

Traditional methods to manage the curb rely on land-use demand estimates to allocate the access priority to the curb. About seventy years ago, competition for curb access was limited, the main sources of demand were parking and non-parking zones, bus stops, and taxi stands. This led to the curbs mainly functioning as a place to mainly store private vehicles. In the ITDP paper, “Europe’s parking U-turn: From accommodation to regulation.” written by Kodransky and Hermann in 2011 successful parking management strategies are categorized.

| Economic mechanisms: | Regulatory measures: | Physical designs: | Technology: |
|----------------------|---------------------------------|--|-------------------------------------|
| On-street pricing | Parking supply caps | Bollards and height restriction bollards | Electronic parking guidance systems |
| Progressive charges | Parking maximums | Striped lines | Smart meters |
| Residential permits | Regulating the parking location | Repurposing public space | Pay-by-phone |
| Workplace levies | | Street geometry | Scan cars |

Table 1. Curbside management categories

The measures in these categories can be combined in various combinations to achieve different effects. The implementation of these measures differs from city to city in alignment with their goals.

These measures were effective in minimizing conflicts at the curbside and making optimal use of the limited amount of space yet, they still only focus on managing cars at the curbside. Nowadays, traditional methods have been outgrown by the increasing pressure of innovations that demand access to the curb:



With reduced vehicle ownership and mobility becoming a service, the use of the curbside changes. This intense competition for curbside space can lead to conflict, chaos, and even accidents. Part of this issue can be solved by off-street parking strategies. Off-street parking refers to enclosed parking lots or garages and could take pressure off the curbside. However, automobilists prefer on-street parking for lower fees or even park illegally rather than paying the off-street. So, an increase in off-street parking capacity does not mean a decrease in on-street parking demand. Regulations and policies need to be shaped in a certain way to deter on-street parking and open the curbs for the new emerging demands.

2.1. Dynamic curbside management



Despite decades of debate about how to manage the allocation of space and time to different users, the curb remains a highly contested space which the state finds hard to govern effectively

Parallel to this debate, as stated before, the parties that demand curbside access have increased tremendously. Resulting in the methods to manage the curb becoming less effective and an increasing need for an alternative management strategy.

The fundamental goal of curbside management hasn't changed over the years: making efficient use of the limited and high-demand curb space. A more dynamic form of curbside management could be the tool that enables the effective use of the limited amount of space. **Dynamic curbside management** is a strategy where the allocation of curbside functions is tailor-made based on the needs of the users. The demands for the curbside can change during the day, week, month, or season, and the curbside functions will change accordingly to these demands.

For effective management of a resource, it is essential to first understand the resource, analyzation of the high-demand areas, understand the rules, and understand the needs of the users. Local authorities must understand that there is no one shoe fits all strategy when it comes to implementing a dynamic curbside management approach.

One of the approaches that could be taken to prioritize the function of the street to determine strategy and measures is shown in Figure 2. The model creates a hierarchy of functions based on the street type where the curb function needs to be changed. The benefit of using a model like this is that there is a structural method of determining the curb function



Figure 2. Curb's function prioritized by land use in San Francisco (SFMTA, San Francisco)

Imagine now a street with traditional management of the curb and another with dynamic/flexible use of the curbside. Even though the changes made to the street are permanent the flexibility comes from the curb providing more functions than roadside parking. The traditional parking street is the cause of many conflicts this is due to the intense competition for space by different users. A more in-depth analysis of the conflicts that occur around the curbside will be given later in the paper. The flexible-use street has minimized conflicts by satisfying the demands of the users. This makes the street overall more inclusive by making it accessible for all users. The implementation of a dynamic curbside management strategy/solution will often be executed in an incremental and trail-based approach. This is a result of the uncertainty about the systematic impact on parking and changes in parking supply are often controversial for both residents and businesses.

The allocation of the curbside function can also dynamically change throughout the day based on the demands of the curb. Making optimal use of the limited amount of space available. In the mornings and evenings, the priority of the curb is to facilitate large flows of people with the opportunity to travel to work. During the mid-day and after evening rush hour, the curbside can be used by street vendors or restaurants to host outdoor seating increasing the economic activity in the area. At night the curb takes on a more delivery function when shops need to be restocked for the next day.



2.2. Examples

2.2.1. Parklet

Parklets are public seating platforms that convert curbside parking spaces into vibrant community spaces. A parklet can be implemented to satisfy different types of demands such as outdoor dining, seating, kids' playground, etc., and is a seasonal measure that could be implemented in various street types. The parklet is shown in Figure 3. functions as an outdoor dining area for a restaurant.

Benefits

- 20 to 30% increase in revenue after instalment
- Up to 150 unique visitors a day
- Greater economic benefits for the city
- No negative impact on businesses in surrounding blocks
- Predictable success
- Improved livability of the city
- Promotion of active mobility
- Increased road safety
- Relatively cheap intervention

Challenges

- More permanent seasonal measures
- Reduction in parking facilities and potential negative public response coming from this reduction
- If a public parklet: construction and placement costs
- Vandalism
- Local regulation



Figure 3. The Publican's sidewalk and parklet seating on Windsor Road (Quackenbush)

Stakeholders



Preferred location

- Vibrant streets with facilities like a restaurant or ice cream shops

Technology needed

- No specific technology

2.2.2. Dock(less) shared bicycle locations and bicycle corrals

Shifting the curb's function from parking to hosting bicycle facilities can be achieved in two ways. The first and probably simplest option is converting the parking space to a bicycle corral (parking facility). The second option is implementing a bike-sharing system as shown in Figure 4. This bike-sharing system can be an integral part of the public transport system.

Benefits

- Reduced congestion
- Increase urban transport options
- Provision of healthy and active transport
- Estimated increase in spending from \$219.65 a day to \$334.06 a day per converted parking
- More inclusive transport system for different income groups and ethnic backgrounds
- Lower bicycle theft
- Parking opportunities for 12-24 bicycles instead of one car
- Station maps and kiosks located at bicycle-sharing facilities can help tourists and visitors orientate around the city

Challenges

- If dockless shared bicycle: uncontrollable parking resulting that could lead to hindrance in the public space



Figure 4. Roadside bike-sharing docking station Vancouver (Toulgoet)

- Good coverage of the city
- Reduction in parking facilities and potential negative public response coming from this reduction
- Local regulation

Stakeholders



Preferred location

- Near public transport facilities like a train, metro, and bus station
- Go to areas in the city like

Technology needed

- An application that shows docking locations and available bicycles

2.2.3. Greenery

Greenery can be implemented in various forms around the curbside. It can be implemented as a miniature park in a parking spot as shown in Figure 5., as well as into the parklets; it could function as an urban garden for the community, and it can be also implemented as a traffic calming device by narrowing the roads and forming a chicane.

Changing a parking location for greenery might not be the first thing that comes to mind when thinking about a change of curbside function. However, the benefits are plentiful and might be worth considering.

Benefits

- Better quality of public space and higher quality of life
- Increased biodiversity in the city
- Increased city's climate resilience
- Decreased heat stress
- Improved air quality
- Better and cheaper method of water retention, draining, groundwater level restoration, and groundwater quality improvement

Challenges

- High cost of investment
- Could require maintenance and/or landscaping
- Vandalism
- Reduction in parking facilities and potential negative public response coming from this reduction
- Local regulation



Figure 5. Parking spot converted to greenery (Moore)

Stakeholders



Preferred location

- Any street where there is a shortage of greenery and an abundance of asphalt

Technology needed

- No specific technology

2.2.4. Function altering parking location

Figure 6. visualizes how a parking location can alter functions throughout the day. Basically, the spot rotates through the functions of delivery, commercial use, parking, and then delivery again. The functions that can be implemented in such a parking spot are entirely up for debate and should be hand-selected based on curbside demand.

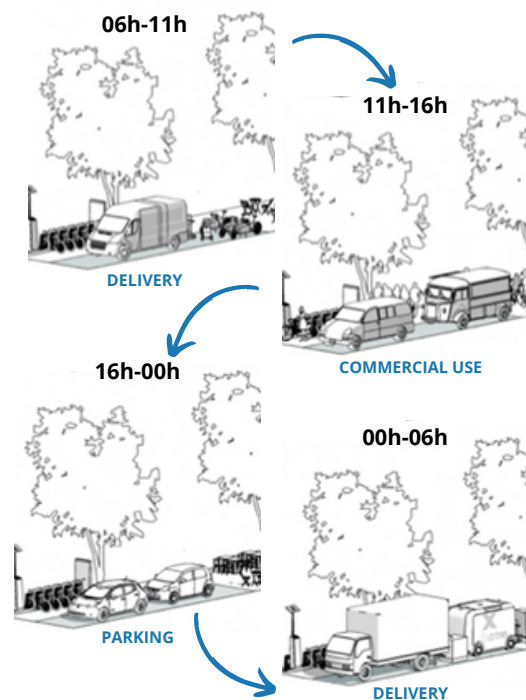


Figure 6. Function altering parking location (ITF, 2018) - adapted from NACTO 2017 (Roe & Toocheck, 2017)

Benefits

- More efficient use of the limited amount of space
- Less curbside conflicts
- More equitable curbside access

Challenges

- Digital inventory of the curbside
- Implementation of technology
- Local regulations
- Enforcement of new curb functions
- Finding the perfect curbside access balance
- Reduction in parking facilities and potential negative public response coming from this reduction

Stakeholders



Preferred location

- Any street where there is a high demand for curbside access
- Locations where a lot of conflicts are occurring around the curbside
- High traffic volume areas but also low traffic volume areas

Technology needed

- Digital street signs communicate the current function and platform communicating curbside's function and availability to potential users
- Sensors or cameras to track spot occupancy and duration time
- Enforcement methods

3. Reasons for a change

3.1. Conflicts at the curbside

While observing the curb, it can be quickly noticed that it is a highly congested piece of public space in many cities worldwide. This high demand for curbside space is causing multiple conflicts around the curbside having various negative effects on the city overall. The following causes have been identified and will briefly be discussed:



Cruising for parking and halting

Phenomenon of driving around in search of (the cheapest) parking possibility.



City logistics

Different logistical aspects of a city range from parcel delivery to garbage collection.



New Mobility Services (NMS)

Combines traditional public transportation with private enterprise options.

These causes are described separately but it is important to understand that these conflicts can have a synergizing effect on each other and that there are more causes for the conflicts at the curbside than listed above.

3.1.1. Cruising for parking and halting

Multiple types of research done in American central business districts found that 30% of the traffic was caused by people searching for a curbside parking location. Shoup (2006) presented broader numbers, estimating that between 8% and 74% of traffic volume is related to cruising for parking. A surplus of cheap parking locations has been linked to worsening traffic congestion, more solo driving, higher rent, and all the other social costs that occur with a car-dominant infrastructure. Authorities in American cities are clinging to minimum parking policies, suggesting that they see it as a side effect and not a key cause for increased driving. It must be stated that these cruising studies were done in the American context and that it is unclear if the studies would present the same results in Europe.

European cities see as much as 50% of congestion being caused by people searching for a cheaper street parking location, no matter how many street parking locations the cities created. Research was done by INRIX (2017) on the pain of parking in 30 cities across the UK, USA, and Germany. The results showed that UK citizens spend on average 44 hours a year searching for parking locations with the city of London being the front runner with an average of 67 hours a year. In Germany citizens spend on average 41 hours a year searching for parking locations, the city of Frankfurt had the highest average of 65 hours.



Curbside users



Behaviour

- Parking close to the destination
- Parking for the lowest possible fee
- Parking for longer periods

Conflicts

- Search for the closest/cheapest available spot causes traffic flow to slow down

3.1.2. City logistics - Parcel delivery

The rapid growth of e-commerce has had an enormous impact on parcel delivery. The limited parking possibilities, parcel sizes and weight, and delivery policies cause the parcel deliverers to double park. Observations in New York found that double parking by parcel delivery trucks reduced the capacity of a street by 6 to 12%. Considering the increasing trend of e-commerce – also on this side of the ocean, it can be assumed that these problems will continue to grow if no changes are made in managing the curbside.

In Madrid, congestion related to urban freight reached 38% in 2020 and is predicted to reach 48% in 2025. The transportation of goods and people in Madrid is one of the most complicated among large European cities. This is due to the historical evolution of its urban structure which resulted in “an irregular and radio-centric map, with narrow streets and closed construction plans combined with large squares and regular avenues created by the successive remodelling undergone by the city.” Like Madrid, many cities in Europe were designed before the car, meaning that the streets are often narrow. In Europe, there is great growth in the e-commerce sector, with a difference of 10% between 2019 (€690 billion) and 2020 (€757 billion) (Ecommerce Europe, 2021). The sector was expected to grow by another 12% in 2021.



Figure 7. Parcel delivery truck double-parked and other vehicles (Kuntzman)

Curbside users



POSTAL COMPANIES



RETAIL SUPPLIERS



HOTEL, CAFÉ, AND CATERING SUPPLIERS

Behaviour

- Double parking
- Parking close to delivery, loading, and/or unloading location
- Efficiency no.1 priority
- Postal companies have short contact with the curbside
- Retail, hotels, café, and catering suppliers have maximum contact with the curbside of 30 minutes
- Competition for space with road users and delivering companies

Conflicts

- The urge to be as efficient as possible leads to double parking when there is no available space
- Double parking leads to temporary narrowing of the transport system resulting in congestion
- If the vehicle is parked half on the sidewalk, it is an obstacle for pedestrians and cyclists

3.1.3. City logistics - Service provision

Parcel delivery vans do not account for all the curbside conflicts in city logistics. Indeed, service providers like plumbers, painters, and more, put pressure on the curbside. A study done by the Amsterdam University of Applied Sciences in 2018 concluded that one in four vans in Dutch cities belonged to a service provider. In 2017, the Netherlands was home to 923,000 vans, which averages out to one van per nine inhabitants. Of these vans, only 2%-3% were used for parcel delivery and 27%-40% were used for service provision. These service vans account for 35% of all the kilometres driven in the Netherlands. The service providers prefer job site parking since they often have equipment and materials in their vans. This can lead to two conflicts: either a van occupies a parking spot for the entire day resulting in more cruising for parking by other vehicles, or drivers park on the curb and obstruct traffic flow for pedestrians, bicycles, and cars. Next to these more obvious service providers, it is also important to broaden the scope to the less obvious service providers such as home caretakers. Their parking and mobility behaviour has barely been researched, but 20% of EU households use professional homecare services, which may apply for a city-wide parking permit. The assumption could be made that they have the same parking preferences as the other service providers which could lead to the same conflicts.



Figure 8. Service provision vans illegally parked on the curbside. (Rossum du Chattel)

Curbside users



Behaviour

- On-location parking
- Parking for longer periods
- Parking on the curb when needed

Conflicts

- Occupation of a parking spot for longer periods leads to cruise for parking by others
- Parking on the curb causes obstructions for other road users

3.1.4. NMS - Ride-hailing

New mobility services (NMS) enable users with the use of technology to easily transfer between transport modes and make their trips more efficient. NMS transport methods have a variety of forms such as shared micro-mobility options but also ride-hailing, like Uber or Lyft. The conflict that occurs at the curbside differs per transport mode. The ride-hailing process is pretty similar to traditional taxi services yet, ride-hailing services have created a surge in curbside demand. In the city of San Francisco trips made by taxis represented 1% of vehicle trips a couple of years ago. Today 15% of vehicle trips are done by ride-hailing services. The first painted bicycle lane street in the city is also the hotspot destination for ride-hailing services. "Every couple minutes, another car with an Uber or Lyft sticker pulls over into the bike lane." These ride-hailing services are creating conflicts in the busy bicycle infrastructure resulting in collisions and injuries with cyclists. The San Francisco Police Department has papered that two-thirds of all congestion-related traffic violations in the downtown area were caused by Uber and Lyft vehicles.



Figure 9. Uber driver blocking off bicycle lane (Twitter:@SFdirtyparking)

Curbside users



TRADITIONAL
TAXIS



RIDE-HAILING
SERVICES

Behaviour

- Short contact with the curbside
- Double parking or parking on the traffic lane for pick-up of passengers
- Efficiency and pick-up points are essential

Conflicts

- Unsafe situations are caused by obstruction of the bicycle or car lane
- Micro congestions are caused by obstruction of the bicycle or car lane

3.1.5. NMS - Micromobility

New mobility services' demands for curbside use, which are often neglected in traditional curbside management methods, are worth mentioning, though considered beyond the scope of this paper.

The origin of conflict on the curbside caused by micromobility options comes from the unregulated method of parking. For example, e-scooters cause conflicts on the curbside by obstructing the walkways if parked incorrectly. This causes multiple problems for less mobile individuals like the elderly and wheelchair users. These users are often unable to get off the curb to move past this obstacle. In the city of Groningen in the Netherlands, GO scooters were banned from the city because the scooters caused too much nuisance and were constantly parked in the middle of the sidewalk.



Figure 10. Go Scooters obstructing the sidewalk (Holsappel)

Curbside users



MICROMOBILITY
OPERATORS

Behaviour

- Bring too many scooters, bikes, etc. to the curbside.
- Users park wherever they want because they are allowed to do so by the service

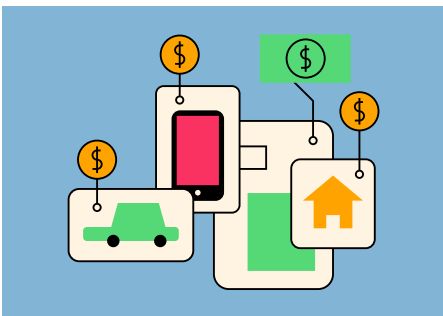


Conflicts

- Obstructing the sidewalk
- Taking up too much space in general
- Decreasing the economic value of the curbside.

3.2. Consequences of the conflicts

The conflicts previously described have various negative consequences for a city. The consequences are described separately but it is important to understand that these consequences can occur at the same time and therefore have a big impact on the city. More consequences result from the conflicts at the curbside. The consequences discussed will help to get the main gist of the issues that could come from the conflicts caused by traditional curbside management. The following negative consequences have been identified and will be briefly discussed:



Economic productivity

The overall economic productivity of a city



Traffic safety

The overall safety within traffic, how dangerous is it to participate?



Quality of life

Quality of life is bound to the livability of the city



Accessibility

How easy is it to get around in the city?

3.2.1. Economic productivity

The first consequence of the conflicts around the curbside is the impact on the economic productivity of a city. The impact on economic productivity can be reasoned from different perspectives. From the perspective of the urban freight sector with a high value of time, efficiency is everything. It is not in the best interest of urban freight operators to circle looking for the best loading/unloading location. This often leads to double parking at the front door which is a major cause of city congestion. This puts other urban freight operators in traffic congestion hurting their way to operate efficiently and therefore could be seen as a negative impact on the economic productivity of the city.

Another perspective that could be taken is one of the commercial facilities in the city. Biswas et al. 2017 described roadside parking to be a major component of the accessibility of an area. It makes roadside shops reachable and enables street vendors to interact with commuters. They argue that the implementation of restrictions can reduce the number of customers and thus lower their profit. But, in areas where motorization rates are high, the curb mainly functions to store vehicles, sometimes for minutes, often for hours.

3.2.2. Traffic safety

The conflicts around the curbside are hurting traffic safety. This subject was already briefly mentioned when discussing the conflicts caused by ride-hailing services. Where ride-hailing services are causing collisions with cyclists by moving abruptly into the bicycle infrastructure to pick up or drop off a client. Next to this, there are more unsafe situations that can occur because of the conflicts. The double parking related to the UFL often results in unsafe situations for other motorized traffic, cyclists, and pedestrians.

One of the most common results is rear-ended collisions from the vehicles that drive in the (partly) blocked lanes. The double parking might also block bicycle infrastructure, resulting in cyclists moving over into the car lanes which causes dangerous situations. The cruise for parking also can result in various dangerous traffic situations. This comes from the fact that drivers searching for parking are distracted by searching for parking locations making them unable to respond in time when necessary often leading to a collision with cars or bicycles.

3.2.3. Quality of life

The quality of life within a city is highly impacted by the conflicts that occur around the curbside. High levels of noise and air pollution decrease the quality of life within a city. It is believed that almost 70% of all noise pollution is caused by traffic noise. Next to this, air pollution plays a more important role in the decrease in quality of life. "Ambient air pollution accounts for an estimated 4.2 million deaths per year due to stroke, heart disease, lung cancer, acute and chronic respiratory diseases."

It must be stated that there are more causes for ambient air pollution which influenced the numbers presented by the WHO however, "Air pollutant emissions from transport are a main contributor to air quality problems in Europe." Next to these emissions have an impact on the air quality they also hurt the sustainability of a city. Delivery journeys are also linked to new pollutants and non-exhaust emissions (breaking, tires).

3.2.4. Accessibility

The accessibility in the city is also affected by the conflicts occurring around the curbside. The impact of micro-mobility services on the less mobile curb users is touched upon in the previous subchapter. The accessibility of the city is also impacted by the other conflicts occurring at the curbside. The micro-congestions caused by double parking, high traffic volume, and cruising for parking locations are negatively impacting the efficiency of buses and other shared mobility services, especially in the absence of priority lanes, resulting in delays and unreliability of busses and other shared mobility options.

The unauthorized use of curbside public transport space (e.g., a bus stop) by parcel delivery trucks or private motorized transport also has an impact on the delays and unreliability of shared mobility options like the bus. Next to the congestion caused by double parking, double parking also hurts accessibility by itself. If double parking takes place on the bicycle lane or bus priority lane the parked car obstructs the transport possibility and causes a lot of irritation for its users.

4. Effective implementation

Eight steps – Five pillars

EIT Urban Mobility (2021) has developed a course that provides the general ins and out of flexible curbside management. When a city is assessing and implementing a dynamic curbside it is recommended to take the following eight steps into account:

- 1** Get to know the streets, what is their purpose?
- 2** Anticipate the impact of shifting the curb.
- 3** Make room for emerging mobility modes.
- 4** Create a team that manages the diverse demand for the curb in flexible ways and in real-time.
- 5** Standardizing encoding information about curb use.
- 6** Rethink the curb as a flexible space and plan accordingly.
- 7** Manage the curb dynamically.
- 8** Monitor overall transport activity.

Alongside these eight steps, five pillars should be considered by local authorities for the successful implementation of a dynamic curbside management strategy.

4.1. The five pillars

The five pillars of dynamic curbside management are local regulations, institutional agreements, stakeholder involvement, implemented technologies and digital services, and physical street design. Visually, they could be represented as follows:



Figure 11. The five pillars of dynamic curbside management implementation (Mitchell Neels) - layout revisited by Alessia Giorgiutti

4.1.1. Local regulations

Enforceability plays a critical role in ensuring the effectiveness of a dynamic curb by ensuring compliance with regulations. For example, if a regulation requires the curb to shift from parking spaces to outdoor seating for a restaurant, non-enforcement could result in cars remaining parked in the designated area without consequence. Also, when designing and implementing dynamic curbside interventions, local authorities must consider the unique parking enforcement challenges and opportunities in their respective cities and countries: some cities have technology-based solutions such as automatic license plate recognition systems to improve parking enforcement, others have increased parking fines and implemented more rigorous enforcement procedures to deter noncompliance, showing that there is no such thing as a one-size-fits-all.

To ensure the successful implementation of any dynamic curbside intervention, enforceability must be a key consideration. During the exploration phase, local authorities should ask themselves the following questions:

- Are we by law allowed to implement this new curbside function?
- Do we need regulation for this new function?
- Does the current regulation allow us to enforce this curbside intervention?
 - Are new regulations necessary for the implementation of this curbside intervention?
 - If you're not able to enforce the curbside regulations: What could be done to make enforcement of the curbside intervention possible?
- Do we have the regulatory power to implement the necessary regulations?
 - How can we regulate/enforce this new function when the regulations are changing?
 - If you don't have the regulative power: what can be done to push for the change needed?
- What lies within our power to regulate the curbside?
 - What kind of outside-of-the-box methods could we use to regulate/enforce the new curb function?
- How do we communicate the new rules to the end users?

4.1.2. Institutional arrangements

Effective integrated dynamic curbside management requires collaboration among departments, such as public transport, maintenance, parking, urban planning, road/mobility planning, police, digital/smart city, legal, and environmental. However, division of responsibilities can make cross-departmental collaboration difficult, resulting in institutional silos. Breaking down these silos and improving collaboration among departments is crucial for effective curbside management.

Research on Urban Freight Transport (UFT) shows that the lack of resources hinders local authorities from implementing UFT policies that balance economic, environmental, and social interests. They tend to prioritize other areas, resulting in the lack of integration of UFT in their policies. Effective dynamic curbside management requires institutional arrangements that promote collaboration, sufficient resources, and evidence-based decision-making. During the exploration phase of any dynamic curbside intervention, local authorities should ask key questions like:

- Who do you invite to a meeting to get the implementation going?
 - Which department would be the most appropriate to start this conversation?
 - Are you aware of all the departments involved in the curbside?
- Do we have sufficient manpower to execute the project?
 - How can we work on capacity building?
- Do we have enough funds to execute the project?
 - How can we raise the funds needed for successful execution?
- Do we have the expertise for evidence-based interventions at the curbside?
 - How can we accumulate this expertise?
 - How can we ensure that the department expertise stays up to date?
- Should we create a dedicated task force for all curbside-related issues?
 - Could this task force grow into a dedicated department?
 - How do we ensure that all the needs of the different departments are represented equally (horizontal decision making)?

4.1.3. Stakeholder involvement

Effective management of stakeholders is crucial for the success of any strategy related to the curbside, which is a busy and complex piece of public space with numerous stakeholders involved. By involving all relevant stakeholders, both internal and external, local authorities can gain a mutual understanding of their objectives, expectations, and concerns, resulting in a conceptual strategy with a higher chance of success and acceptance. This is particularly important for controversial topics such as the removal of roadside parking.

In order to ensure the involvement of all stakeholders, local authorities should segment them into internal and external categories, and have a clear overview of those directly affected by the proposed interventions and those who are not — more specifically, internal stakeholders are individuals or parties who are directly involved in the project: these individuals or parties are often part of the local governmental body and have a significant impact on the process and outcome of the project; external stakeholders are individuals or parties outside of the local government body which is affected by the project like residents and business owners.

By considering all these factors, local authorities can make the city function better overall for all stakeholders. That being said, in the exploration phase, local authorities should also ask themselves the following key questions:

- Which stakeholders are directly involved/affected by this strategy? (Internal and external)
- Which stakeholders are indirectly involved/affected in this strategy? (Internal and external)
- At what point in time in the project do we decide to involve stakeholders?
- Which external stakeholders have decisive power?
- How can we create effective stakeholder involvement?
- How can we effectively educate these stakeholders on the why/how/what?
- How can this strategy be made as inclusive as possible?
- How can we create a high level of stakeholder acceptance?

4.1.4. Implemented technologies and digital services

Technology will play an essential role in enabling a dynamic curbside, but local authorities must make a distinction between technology expectations on the roadside and of end users. Implementing technology around the curbside is referred to as 'digitising the curb', and creating a digital inventory of the curb's function and regulation is essential for future technological developments. Currently, curb policies are changed case-by-case and without a digital record: this presents a challenge to develop a digital infrastructure that can house different providers with different solutions. Once a digital inventory is established, local authorities should ask themselves the following key questions:

- What technology do we currently have implemented on the physical street? (e.g., cameras, sensors, etc.)
- What do we want to achieve with the implementation of technology?
 - How can technology support the city's mobility goals?
 - How can the implemented technology be beneficial for the overall development of the city?
- How can we create a technological infrastructure that makes us flexible to work with different technology providers?
 - How do we prevent dependence on one provider?
- Are there any regulations that could implicate the use of technology? (e.g., privacy regulations)
- How do we educate the end-users on using the new technologies?
- How do we create a social technological balance?
- How can we prevent digital exclusion for the digitally illiterate demographic?
 - Are we taking all the measures to ensure that the technology is inclusive?
 - How do we communicate the new curb regulations to this demographic when no physical signs are communicating this?

4.1.5. Physical street design

The competition for curb space is a significant challenge for cities and local authorities, and the physical street is where the theoretical curbside strategy must be put into action. While local solutions are necessary to address specific needs, there is also a growing demand for standardised and recognisable curbside solutions to deal with the demand of 'professional curbside users', like taxis and postal delivery services.

Developing a successful curbside strategy requires the synergy of the previously mentioned pillars of local regulations, institutional arrangements, stakeholder involvement, and implemented technologies and digital services. Failure to address the challenges posed by any one of these pillars will have consequences for the physical street and the overall effectiveness of the strategy.

It is important to note that each city is unique, with its own urban structure, culture, institutional regulations, local legislations, implemented technologies, and physical street design. As a result, cities must develop their curbside strategies based on their specific needs and limitations, and can only look to other cities for inspiration rather than a one-size-fits-all approach.

Furthermore, any curbside strategy must be adaptable and flexible enough to accommodate changes and respond to the shifting needs of the community. This requires ongoing monitoring and evaluation of the physical curbside environment and the effectiveness of the implemented interventions. It is important to gather data, analyse trends, and make adjustments accordingly to ensure the curbside remains functional and effective in meeting the needs of all stakeholders.

In the exploration phase of any dynamic curbside intervention local authorities should ask themselves the following key questions:

- What is already implemented on the street? (signs, sensors, cameras, etc.)
- How easily can we make alterations on the street?
- What conflict do we want to solve in this street?
- How much street space do we want to allocate for the implementation of a dynamic curbside intervention?
 - What period do we need for the physical implementation of the measure?

5. Takeaways

Where to go from here? Effective curbside management is becoming increasingly important as cities continue to grow and face new challenges. In this report, we have explored the complex nature of curbside management, including the various stakeholders involved, the need for local solutions as well as standardised approaches, and the importance of integrating technology and data analysis. We have also discussed the four key pillars of successful curbside management: local regulations, institutional arrangements, stakeholder involvement, and implemented technologies and digital services.

Based on these insights, we have identified three key takeaways that can help cities develop effective curbside management strategies:

1 Dynamic curbside management matters

Dynamic curbside management is an important tool that needs to be implemented to plan for the mobility challenges of the future.

2 Cities should put their money where their mouth is

Cities should invest in their overall 'readiness' for the implementation of dynamic curbside management. By improving overall readiness, a city enables communication to service providers about the conflicts that need to be solved and the infrastructure that can be utilised to achieve this.

3 Implementation with no evaluation means nothing

Further research is executed on the successful implementation of a dynamic curbside management strategy. If you deploy such strategies yourself: reserve resources for evaluation and impact assessment, taking into account the five pillars for successful strategies.

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For more information on the Parking Working Group, click [here](#).

For more information on POLIS, click [here](#).

For more information on Breda University of Applied Sciences, click [here](#).

AUTHOR:

Mitchell Neels

THESIS SUPERVISORS:

Ivo Cré

Andréia Lopes Azevedo

Nina Nesterova

CONTRIBUTORS:

Ivo Cré

Alessia Giorgiutti

LAYOUT:

Alessia Giorgiutti

Contact

POLIS

Rue du Trône 98, B-1050

Brussels, Belgium

Tel +32 (0)2 500 56 70

polis@polisnetwork.eu

www.polisnetwork.eu

Ivo Cré

icre@polisnetwork.eu