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Making space for new mobility services? The curb as a critical boundary object

Abstract

The curb is the critical site of interaction between people and vehicles, and between movement and place. 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. New pressures on the curb are already apparent: recent changes to the mobility system have resulted in an intensification of use with growth in home delivery and servicing traffic and greater use by ridehailing services. Simultaneously there is a diversification of demands with requirements for bespoke access for new mobility services and innovations such as car and bike share and electric charge points. Looking ahead, a range of actors are developing visions of a shift from individual ownership of cars to shared but intensively used highly automated fleets. The balance of parking, pick up and drop off and movement could be radically different in future.

Drawing on literature on the literature on boundary objects, this paper explores the way in which different user groups seek to ensure their own interests are represented at the curb. Through examination of the changing nature of streets in-use, the paper reveals the on-going processes of reallocating and appropriation of curb space. The formal and informal codification of curb use stimulated by interests operating at national and international scales marginalises some user groups and works against place-based planning approaches. The paper makes the case for public policy to reassert itself in the curb debate to avoid a significant decline in conditions and to seek to balance commercial and social interests.

1. Introduction

The street has always been a place where different uses and users come together. Physical separation of the footway or sidewalk from the road began around 200 years ago as horse manure and open sewers rendered roads unsanitary.. The idea of the curb in modern parlance therefore emerged as a kind of threshold or boundary between the filthy chaos of the carriageway (literally) and the frontages of properties (Johnson, 2015). The acts of alighting and boarding vehicles represent the physical interface between these two different realms, and are hardwired into our conception of the curb.

Whilst the physical nature of the curb has remained largely unchanged, the use of it has not. The advent of the private car and the growth in goods vehicle movements through the 20th century led to a very different set of demands on the curb. In some cities, where the use of the curbside is not pro-actively managed, there is chaos – unfettered parking of cars, acute safety problems and poor local environments in terms of pollution and a lack of effective public space. In others, the car has been given priority and we see highly formalised streets with different uses allocated to different places, at different times of day. This can involve segregation between uses at the curb and those on the road with, for example, pedestrians in particular required to only use formal crossing points. Moreover, the function of the curbside as a place for parking has come to dominate many areas given motorists' desire to maximise the door-to-door journey potential of driving. This comprises a complex mix of residential parking, workplace parking and parking to access shops and leisure facilities (Shoup, 2011; Ison and Mulley, 2014).

The curbside is not just an interface between spaces of vehicular interaction and pedestrian movement, however. It is also an important frontage to all sorts of different land-uses and activities. For residents, it can form part of the amenity of their neighbourhood, for children part of their play area, for businesses their point of access and 'shop window', and for cafes and restaurants sometimes part of their operating floor space. It is home to road signs, street lighting, rubbish bins, advertising, bus stops, benches and public toilets. The debate about the extent to which streets of different sorts

are about facilitating movement, parking or creating good quality environmental spaces has been a critical tension since the 1960s (Jacobs, 1961; MoT, 1963; Appleyard, 1981; Goodwin, 1995; Jones et al., 2007; Karndacharuk, 2014).

Such longer term processes of change in the purpose, meaning and operation of the curb continues as a result of new pressures and new actors. Fragmentation in servicing, deliveries and retail is changing the intensity of freight access and the rise of ridehailing services places significant new pick up and drop-off demands on the curb, more pronounced in busy areas. In parallel there are growing demands for public electric charge points, space for bike share schemes and better bike infrastructure. Whilst still in the early part of the smart mobility transition, new mobility options and policy needs are already altering the character of pedestrian-vehicle interactions and, in turn, the infrastructural requirements of the curb in complex ways. Looking further ahead, companies and governmental bodies are exploring how to make our streets ready for the advent of autonomous vehicles. Visions of fully automated and highly shared vehicles have been suggested to 'solve' the urban transport space management challenge by removing the need for individual vehicle ownership and thereby freeing up vast tracts of land currently given over to parking (ITF, 2018, NACTO, 2018). Advocates of this type of transition acknowledge that the challenges of getting from 'here' to 'there' are significant:

> "*Moving to a more flexible use of curb space is not a trivial thing. It will imply design changes, engineering and construction costs (including knock-on congestion costs), revisiting the regulatory treatment of different transport modes and their access to public space (including anti-competition oversight), modifying or designing new revenue-collecting mechanisms, accounting for changes in peoples' travel behaviours and integrating a wide range of sometimes conflicting stakeholder concerns. One thing that seems clear is that the impacts of curb space reallocation on the location and availability of parking will likely be contentious and this must be carefully considered.*" (ITF, 2018: 49)

In this paper we are concerned with the management of the future curb and the transition towards it. In Section 2, we use the literature on boundary objects (Star and Griesemer, 1989) to ask how any transition in practice will work. In particular, we see curb use as a negotiated process whereby vested interests seek to establish their right to reconfigure the curb through the formal and informal codification of curb regulation. This highlights the need to foreground the different social meanings that the curb has, in order to understand why transition is so contentious. We explore how different actors and interests are producing an intensification and diversification of curb use which must be managed. In Section 3 we explore, through on-street research in Australia and the UK, the already evident practice of recodifying the use of the curb either through new regulations or the exploitation of old regulation to new ends. Whilst elements such as fully autonomous vehicles may yet be some time off, the street of today is already being reconfigured in ways which exacerbate long-standing tensions. In Section 4, we examine the governance of the curb in light of the issues identified focussing on three key issues of formalising the informal, demands for codification and curbs, places and prices. In Section 5, we conclude by reflecting on the key policy issues for the curbside of the future. Crucially, curb space is not well managed today and those pressures are growing. Technology could help resolve some of these issues but it could equally exacerbate them by marginalising less powerful or visible interests through the diversification of actors competing for curb access. The extent to which socially beneficial outcomes will result depend on governments being proactive in resolving curb management before the interpretations and demands of the new commercial interests take root, much as they did with the advent of the private car.

2. The Curb as a Boundary Object

A practical definition of the curb is the physical interface between the public highway and the footway or sidewalk. It is a point where vehicles stop so that people can transition between vehicular movement and pedestrian activity and vice versa. Whilst it is easy to point at the physical

manifestation of the curb, what it means to different users is quite distinct. The curbside services the land-uses beyond the curb and is, therefore, a part of these interests as much as it is of relevance as a point of interchange between the movement on the roadway and the curb itself. Pedestrians cross curbs to access activities elsewhere in the urban area, cyclists ride alongside it in either open or specially demarcated lanes (sometimes now in the footway). It is a scheduled meeting point for business transactions (e.g. bus stops and taxi ranks) and a place for random encounters. It is represented by a line in a local authority budget spreadsheet and a plan in a utility companies' server. It is a facilitator of essential urban services like food delivery or garbage collection, and is home to various poles, wires and antennas to deliver electricity and communications from streets to homes. Table 1 provides a more systematic outline of these diverse uses and the interests that shape them, dividing interests in the curb in terms of travellers, transport providers, adjacent land uses and street services. Though not fully representative of either the totality of the users of the curbside nor indeed the diversity within those groups, Table 1 does indicate the potentially conflicting interests that shape the curb. For example, local businesses and residents value the convenience of curbside parking, hotels value exclusive access, whereas taxi operators place higher value on access unfettered by parking. So, whilst there might be agreement on where the curbside is, we suggest that there is much less agreement about what it is for and, therefore, how access to it should be prioritised.

<<Table 1 about here>>

In addition to viewing and accessing the curb in a different way, each of these user groups have different formal and informal relations to the regulation and governance of the curb. Lobbying and other forms of influence on policy are common across a range of transport providers, while pedestrians are comparatively weakly organised as a group and have had relatively limited success on regulation given their sheer numbers. Some use classes have specific regulations dedicated to them (e.g. loading or unloading restrictions, parking or pick up and drop off arrangements, pedestrian crossing rules). Some use classes are new (e.g. dockless bikes and car sharing clubs) and may interpret

or reinterpret the rules for access (Dowling and Kent, 2015). Others may see the rules as open to interpretation (e.g. waiting where it is prohibited, overstaying parking permissions or blocking footways and cycle lanes). The key insight from this reflection is that the curb as we understand it today is seen in different ways by different user groups and thus, whilst there is a shared understanding of it as a physical concept it acts as a 'boundary object' around which different user interests coalesce.

Interpreting the curb as a boundary object is useful because it suggests adopting a relational and ecological view to be adopted of what infrastructure is (Star, 1999). The regulations we have in place today have emerged both in response to changing circumstances (e.g. new technologies such as the car) or changing in-use practice of existing technologies (e.g. the shift to on-line shopping and associated rise in deliveries). The way in which curbs are regulated is the outcome of decisions about the trade-offs between the priorities of different user groups for access to a finite resource across time and space. Bowker and Star (1999) identify that the influence which different groups have can be traced through the technical and institutional work which is done in order to try and standardise institutionalised practices, norms and modes of operation. Summerton goes on to suggest that the narratives of the different interest groups will likely be "inscribed in the configuration of infrastructures" and that it is possible to "critically explore the ways in which such standardized practices work to marginalize, exclude, or silence certain individuals and groups" (Summerton, 2015: 460). We see the current codification of the curb and the arguments which accompany new technology and business models around changing this codification as a critical area of inquiry (see Dudley et al., 2017 on the role of Uber in influencing regulatory change). Through this, it becomes possible to understand the motivations of different actors with interests in the curb and the synergies and conflicts between them.

Whilst the curb of today is a contested space, it is the changing nature of the demands on the curb which make now a particularly important time to rethink how the curb is used. The first change is in

the *intensification* of demand for curb use with a "dramatic increase" in delivery and passenger vehicles servicing the curb (Chen et al., 2017). In the UK for example, e-commerce is growing at a rate of 6% per annum (Braithwaite, 2017) and light goods vehicles for retail, servicing and B2B is forecast to almost double in urban areas by 2040 to around 22% of traffic (DfT, 2018a). There has been no concomitant reallocation of curb space to cater for this demand.

A second key driver of intensification is the uptake of services such as Uber and Lyft. This has been rapid in some cities, with 15% of trips in the city of San Francisco now made by ridehailing services (Clewlow and Mishra, 2017). At small levels, the growth in taxi style services will have limited impact on the curb. However, regulations on pick up and drop off date as far back as the 1800s in the UK and are very permissive in terms of where this can happen (Marsden et al., 2019). Demand may be highly spatially concentrated and therefore problematic already for some places (PHTM, 2017). There is much uncertainty about how far these systems will disrupt our future mobility patterns but some suggest that the changes will be so significant that "we are moving from a "parking" city world to a "pick-up/drop-off world" (see discussion in Clewlow and Mishra, 2017 and Schaller, 2017). The critical distinction we make here is that this intensification is happening now, with these systems acting as complements to existing vehicle ownership (Circella et al., 2019). We might not yet be moving away from a parking city, but we are already moving towards a pick up/drop-off one.

There are other socio-demographic shifts which will also intensify curb access requirements over time. In developed economies in particular it is the aging population which is driving future projected traffic growth. In the UK, for example 82% of the growth in population to 2041 will be in the over 65 category (ONS, 2017) and this age class is the only group which is driving more intensively than previous cohorts (Headicar, 2018). It is also the age group with the highest recorded levels of disability with more than one in three over 65s reporting a disability of some sort (DWP, 2018). The demand for reserved and accessible disabled parking is set to rise.

The second important dimension of change is the *diversification* in the demands for curb space. Motorisation of some active travel modes (such as electric bikes and scooters), for example, introduces new users and new businesses that seek to define access to the curb (Birtchnell et.al. 2018; Dowling 2018). Car sharing companies require access to curbside parking to provide certainty for those seeking to access to car share vehicles (Dowling and Kent, 2015). Electrification of the vehicle fleet is also bringing with it requirements for increased on-street charging points, be those for residents, e-taxis or as public charge points to reduce range anxiety and accelerate adoption. It is estimated that, in the UK, by 2020 "an additional 83,500 charging points will be required to meet the demand from electric vehicles (EVs). To date there are 16,500 charging points" (EMU, 2018, p8). The UK strategy to 2040 states that "we want all new street lighting columns to include charging points, where appropriately located, in residential areas with current on-street parking" (DfT, 2018b, p16).

At the same time as moves towards accommodating more motorised mobility are underway there is increasing discussion, though thus far limited implementation, of the curb as a place to stop rather than move through. Complete streets, shared streets and road diets, for example, reimagine mobility in which the car is secondary and redesigns transport infrastructure accordingly (Karndacharuk et.al. 2014). This may include the removal of parking lanes, an increase in the space allocated to more active forms of travel such as walking and cycling, and a reduction in the number of lanes available for traffic movement (Sadik-Khan and Solomonow, 2016). This also re-sites and occasionally removes curbs. In some cases, curbs become parks or public spaces of congregation.

We summarise some of the key intensification and diversification trends in Table 2. Critically, these all matter today and so, whilst it is important to look ahead to the next level of digital disruption through vehicle automation (Guerra and Morris 2018), the potential to manage a more automated curbside of the future (should this become technically feasible) will be shaped by the approach taken to managing space in the transition. In the next section, we therefore turn our attention to understanding some critical conflicts.

<<Table 2 about here>>

3. Issues of the contemporary curb

3.1. Methods

The previous section highlighted the intensification and diversification of curbside uses that are both present currently and likely to continue. Following the boundary object literature's suggestion that the success of the different interest groups will emerge through the extent to which they are already codifying their interests on-street, in this section we conduct an empirical examination of issues of the contemporary curb. We do so through fieldwork observations conducted in both Australia and the United Kingdom, in cities with which the authors are familiar and, more importantly, in which pressures and transformations of the curb are already widely apparent. Fieldwork was conducted at four sites in Australia and four in England. The sample of sites is small, but the purpose of the investigation is to establish how recodification is already *happening now* rather than to provide any definitive quantitative estimate or generalizable formula about the future. The method deployed was to walk along busy streets where there are significant existing efforts to manage curb conflicts and to identify what may be changing through observation, supported with photographic evidence.

The sites selected In Australia were all in and around the Central Business District of Sydney: around the central train station, King St Newtown which is both a busy thoroughfare and destination for restaurants, cafes and bars; the Haymarket corridor, and the main roads of Glebe, surrounding the University. The sites selected in the UK were two corridors in Leeds, a major bus corridor with new cycle infrastructure in Manchester, a busy town centre (Eltham) and a range of neighbourhood streets in suburban communities in London where residential on-street parking is widespread. We take a critical case approach, focussing on findings which demonstrate the importance of paying attention to recodification processes.

3.2. Findings

Those who seek to automate the management of the curb are imagining a world in which there are no violations of the 'rulebook' on how it should be used. This has to be the case, because as for any computational system combining 'hardware' – in this case the roads, streets and curbside infrastructure – with 'software' – the real time operational protocols that enable connected and autonomous vehicles to function – there needs to be a clear set of codified rules that all mobility technologies operate to otherwise the system will 'crash' figuratively, and perhaps literally. For transportation engineers this might be seen as a positive shift as it simultaneously formalises and enforces the rules of the street as currently expressed by a myriad of lines and signs. However, this would be a very deterministic approach which relies on the assumption that the rules are defined *correctly*. Our site visits showed that the practice of using the street is often quite different from the formalised rules, with the intensification of use exacerbating these issues (see Figure 1). There will be a number of reasons why rules are not observed. These include ignorance or deliberate decisions to ignore rules as a calculated risk. Our observations suggest that it also reflects a mismatch between the frontage land-uses and the curb space that has been made available to access and service them. Public agencies currently know very little about what goods vehicles will be in their areas at what times and for how long, so the mismatch between supply and demand exists and is managed through tolerance and limited enforcement. Similarly, we see practices which have clearly been accepted for years, with parking on footways and shop frontages where access is not legal. Formalising the use of the curb space would certainly have the potential to benefit pedestrians and cyclists who suffer substantially from illegal parking behaviour (see Figure 1). However, the informal arrangements are allowed to persist, we suggest, because they reflect the realities of the mismatch between the requirements of the adjacent land-uses and the curb, and the constantly evolving social construction of what is regarded as acceptable use of the curb. One (unintended) consequence of this state of affairs is that it allows public authorities to avoid difficult decisions about providing more curb space or enforcing

the rules about use of existing space. Such decisions cannot be avoided in a shift to a more automated future.

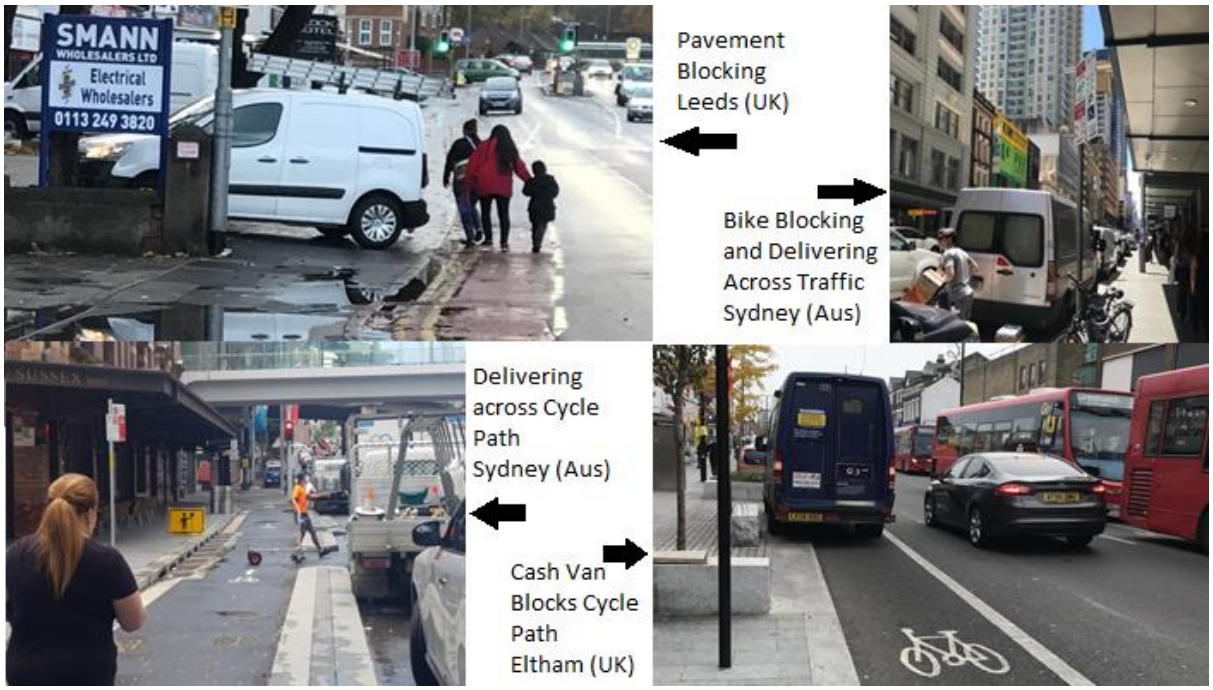

Figure 1: Disorder and the use of streets in practice

It is also important to note that, in many of the busiest locations, curbside parking has already been removed. There is no 'space bonus' that will emerge from a shift from ownership to access to mobility in these places. Indeed, under the current rules for use of the street, these areas stand to be more intensively utilised, as it is currently permitted for taxis and private hire vehicles to stop anywhere it is safe with a few small exceptions (bus stops, immediately outside schools or by formal pedestrian crossings, in no stopping zones in Australia) and there will be more of this activity. The taxi and private hire industry has been quite resistant to changes in definitions and operational distinctions and rules (Law Commission, 2014). The current definitions are partly about separating and managing two industries. Private Hire Vehicles are, for example, not allowed to wait at ranks. It may though be advantageous for specific spaces to be set aside for ridehailing matches to happen away from the curb (ITF, 2018) and it may not be desirable to have vehicles circulating in pursuit of the next job. The

interests of the different industries using the curb in this instance are not focussed on optimising curb design and operation and we see this as a much greater issue looking ahead (see Section 4).

One way of managing the growing demand for curb use has been to allocate space to different user groups at different times of the day, although this has some limitations. In Australia, quite complex signage has been developed to try to manage use across the day but in fairly crude use classes (See Figure 2). In the UK, it is possible to designate different uses for a piece of curb at different times of day but it is not possible to have managed curb space for more than one use type at any one point in time. Technology offers possibilities to make users better aware of regulations and of the availability of usable space (e.g. Digitial Totems and real-time signage). A much more transparent and dynamically managed curb space could be foreseen (Arup, 2019). However, the transition from physical signage to digital management remains a challenge given the need for one clear set of operating rules and the very diverse set of digital literacy skills which exists in the population. The demands for or response to codification will not be uniform.

Figure 2: Complex physical signage to deliver basic time of day management

The diversification in use classes shows how recodification work is being practiced today. Looking at nascent shifts to electrification in the UK, shown in Figure 3 below, we see a number of unwritten but important shifts in curb use. EV charge points have been installed in areas which were previously marked with double yellow lines (and therefore deemed unsuitable for parking). The design of the charge points differs, with some taking footway space and others being placed in the carriageway, but both requiring the establishment of an accompanying connector box in the footway. This reallocation of space *from pedestrian amenity to fuelling of vehicles* happened without debate and is a necessity for those promoting electric vehicle adoption on *sustainability grounds*. Finally, there is also the allocation of particular spaces to specific user categories. E-taxis in particular will require rapid

charging and so are being given a dedicated network of charge points to stimulate uptake. E-car club vehicles will also require more rapid, and potentially exclusive, charging infrastructure.

Figure 3: Recodification of the curb for Electric Vehicles

Shared transport systems are sometimes part of formal codification and sometimes not. Docked bike sharing schemes and car sharing clubs each require interaction with local government for either the allocation of space and sometimes the provision of supporting funding. Dockless systems such as bikes or e-scooters (where legal) are out for public use without any requirement for consultation (see Figure 4). In general the management of dockless schemes is currently done through voluntary codes of conduct agreed between the operators and the local authorities. Other uses also emerge which have no formal process of engagement such as last-mile delivery bikes and food delivery services. Some of these developments may be socially desirable and environmentally beneficial, others less so. Our

point is that many of these services change the use of the curb in ways which have not been envisaged and planned for. Without formally recodifying the curb they change the use in practice which, we contend, is what really needs to be thought about if curbs are to be a fully integrated part of the streets of the future.

Space for Docked Bikes - Formal

Space for Dockless Bikes - Informal

Figure 4: Docked and Dockless Bikes and what gets coded

4. Governance of the curb

Drawing on the preceding sections we identify three principle governance challenges in making space for new mobility services at the curb. In doing so, we emphasise the importance of considering the governance challenges as part of a socio-technical transition which will unfold over several decades. Fully automated, connected and shared mobility systems may or may not be achievable or desirable.

What we can say for certain is that no end-state is pre-ordained and agreed on. How these challenges are mediated will, just as with the advent of the automobile, determine the sorts of streets, places and outcomes that result.

4.1 Formalising the Informal

Governance of the curb is achieved in practice by the creation of a system of regulation that seeks to balance the competing demand of different user groups. The instruments through which the curbside is governed in everyday use can therefore be interpreted as a spectrum from the (criminal) law at the 'formal' or 'hard' end to 'informal' or 'soft' behavioural nudges and the desire to conform at the 'soft' end. Our empirical work in Section 3 shows just how much flexibility and negotiation around the formal rules occurs in practice and is, by inference, tolerated by the state. We suggest that this reflects the challenge of trying to marry up the sheer diversity of street uses with space available. Technology could offer some opportunities to change this, with greater sensing of space and communication between vehicles and infrastructure and in turn with users of space. However, this would not of itself resolve the question of how to manage the mismatches between supply and demand at different times of day or between user groups with different preferences.

A completely different perspective is implied by autonomous transport, as the future would require absolute clarity on rules and no violations. It would require the supply and demand issue to be resolved by the system, rather than mediated by the users and the state. This is one of the reasons why a mixed model of manual and automated vehicles is so challenging. Whilst full automation is argued to be desirable from some perspectives (e.g. traffic efficiency and safety) it means taking an agreed position on street space allocation which has not been within reach to date (Jones, 2018). In addition, there are on-going and significant concerns about privacy and data management and substantial societal resistance to the use of technology in enforcement, evidenced by the continued controversies over the use of video cameras for bus lane and parking enforcement. These issues are matters of public interest and cannot be resolved by handing over the management of street space to

a smart management system. These are instead, we suggest, issues which must be agreed through democratic discussion of the costs and benefits of different approaches. Achieving public acceptance of the requirement for (near) universal observance of agreed rules and regulations will be at least as big a challenge as defining such a regulatory framework in the first place.

4.2 Demands for Codification

As the insights into the contemporary curb developed above using the boundary objects literature revealed, there is significant technical and institutional work being done in order to try and create new standardised and institutionalised practices, norms and modes of operation for new technologies and systems. It seems clear that this is largely being driven by technological and business interests, sometimes separate to and sometimes in concert with the state.

Technologies have particular needs and have specific requirements of infrastructure (in this case curbs) to enable users to engage with them. The examples of electric vehicle charge points in Section 3 showed how the necessity of public on-street charge points is changing what the curb is for. It also showed that there are choices as to how to manage that transition by using parking space or footway space for locating charging infrastructure. Our limited observations suggested much more of the latter than the former. Where road space was taken up this was as likely to involve handing over previously restricted space as it was to reducing existing space. This could have been, but has not yet, been sufficiently debated. How charging infrastructure is hard coded into design manuals will matter.

EV charging can be accommodated within existing planning processes. By contrast autonomous vehicles cannot. The codification of the practice of moving round in a vehicle was built, in almost all countries, on the presumption of there being a driver responsible for the vehicle. There is thus considerable discussion from legal perspectives about the potentially wicked problem of future pedestrian / vehicle interaction and its regulatory requirements. As well as trying to set out the possible approaches to litigation in the event of crashes (which are argued to be much less

commonplace in the future, but more problematic legally given there would be no human driver with responsibility for the vehicle), there are the beginnings of a debate about how the presence of autonomous vehicles in the physical environment will impact on much wider aspects of regulation.

Perhaps most interesting of these is the Law Commission of England and Wales's notion that it might be necessary to codify how CAVs can 'nudge' pedestrians out of the way if they are to operate in busy urban environments (Law Commission, 2018). The implicit assumption being put forward here - that we should overturn the historic assumption (in Australasia and Europe at least) that pedestrians and their safety have ultimate priority in public spaces - illustrates the event to which new mobility technologies might change the ways we live our lives in a most profound way. This suggests that it will be necessary to undertake a much broader discussion than at present about how we should create a legal framework in order for CAVs to operate, including the extent to which the curb should be given over to them.

Some advocates for CAV technologies even go so far as to adopt the bold stance that it will be possible to create "Dedicated Driverless Spaces (that) avoid challenging philosophical and legal debates. As a result, they will accelerate CAV deployment and most importantly provide confidence to the public about how CAVs will act and interact with them" (CityScience, 2018: p10). But this would appear strongly at odds with our viewpoint about the socially-constructed nature of the curb, and the need to act quickly to ensure that governance processes and regulatory frameworks balance competing demands rather than be captured by the loudest or best resourced. Indeed, we would argue that creating a durable governance framework for the future curb necessitates that we think through, from first principles, key choices such as how much of the public realm we in fact want to redesign, reprioritise and reregulate in order to facilitate the introduction of future mobility technologies. Whilst we should not dismiss the potential to create niches of experimentation, we have demonstrated that there is not enough space today and the use of the space is intensifying. Any

handing over of space to dedicated provision of any kind requires taking away space from another use or set of uses. The difficulties of that cannot be wished away.

4.3 Curbs, Places and Prices

The codification of the curb and any shift to a 'no violations' operating norm opens up the potential to manage access to the kerbside much more appropriately given its status as a scarce and highly prized public resource with significant potential to generate public value (Bryson et al., 2014). Perhaps the most obvious policy tool to regulate access to the curbside and prioritise the access and movement of people rather than individual vehicles other than regulatory prohibition is by pricing. The idea of pricing to access the curb has been established for many decades given that charging for on street parking is commonplace. However, this is not established as a norm for loading and unloading or for picking up and dropping off (at least in cities, although it is at airports).

The International Transport Forum notes that "the curb materialises the interface between the transport function of the street and its other uses. As such, curbs are the points where streets generate value for citizens and cities. This is because transport systems don't necessarily generate value through movement per se, but rather, do so when people or goods stop moving when they arrive at their destination" (ITF, 2018: 11). Such an approach is consistent with the boundary objects literature, and also consistent with the conceptualisation of the curb as capable of crystallising value through the imposition of user fees to promote a more efficient allocation of resources. As we identify in Section 3, given that autonomous transport services need to appropriate this value to deliver on their seamless door-to-door vision, the horns of the dilemma for the state are:

(a) to ensure that there is a negotiated balance struck between the different legitimate uses of the curb; and

(b) to generate revenue from the use of the curb that reflects its true value and avoids the potential for rent seeking on a huge scale that would be open to private autonomous mobility providers without effective regulation in place.

A key governance question for the codified curb of the future will therefore be 'how are prices set and by whom?' Where demand for the curbside is high, it is a prime rentable economic asset, and so the extent to which it is perceived to have the character of either 'public' or 'private' is both contestable (see Paget-Seekins and Tironi, 2016 for discussion on the publicness of transport) yet also profoundly important in setting the terms for who has the right to achieve rents from its use, and for what purpose. How different actors approach this framing, we argue, will be a critical part of which pathways of curbside management are seen to be legitimate. For example, on-street parking allocations and prices are currently clearly set by government and there is accountability for the collection and disbursement of resources. Decisions about whether to make areas parking or traffic free have an important direct impact only on government income from parking, not on commercial operators. If, as some visions suggest, the future mobility system is run by private operators through fleets which the public subscribe to access, then the implications of changes to street use, allocation and pricing could potentially affect the profitability of a small number of private interests. Is the potential resistance of such actors to space allocation or pricing changes really something to be anxious about? We note the success of the taxi industry in defending its interests and rights through lobbying and demonstrations despite only accounting for around 1% of all trips. This suggests to us that the risk of substantial shifts in power relations is real.

Governance arrangements will need not only to bring some kind of transparency to what is likely to be highly dynamic pricing, but also to determine which, if any, user classes, such as mobility impaired people, retain privileged access to the curb irrespective of their ability to pay. Then there is the issue of 'non-users'; what level of disruption to other uses of the curb and it associated public spaces are we ready to accept in order to raise revenue? As we show in Sections 2 and 3, the conflicting interests

of different users today have not always been resolved or even sufficiently acknowledged, such as in attempts to rebalance the street and the curbside away from the dominance of motorised vehicular traffic (Jones et al., 2008; Aldred, 2014 and Martens, 2016). It is not simply a case of integrating conflicting stakeholder concerns, since these can sometimes be diametrically opposed, such as the competing desires of both car share organisations and residents for exclusive access to the same curb space. Also important is acknowledging stakeholder tensions in the policy process, and how power hierarchies between users influence policy outcomes and therefore who 'wins' and who 'loses' in such processes (Salas Gironés and Vrščaj, 2018). Indeed, the extent to which different uses and users are imagined (or ignored) in future planning processes and the degree to which these users are homogenised and stylised to exclude the diversity of society is a developing critique within the literature (Imrie, 2000; Jensen, 2011 and Bergman et al., 2017).

In order, therefore, to be able to take advantage of the potential for a more dynamically priced curb we suggest that governments should pay more attention to streets as places. An approach which is more explicitly 'multi-use and multi-stakeholder' and which ensures that the residents and stakeholders from land-uses around the street have a key role in allocating space, or even in benefiting from any trade-offs which are made in those allocation decisions, could provide a framework within which the technological innovations unfold and are tailored.

5. Conclusions

Through discussion of the on-going transition in-use of the streets today, this paper has demonstrated that there is already a significant intensification and diversification of uses of the curb, in advance of any of the benefits promised by advocates of shared autonomous mobility. By applying the insights from literature on boundary objects we have identified the on-going processes of both formal and informal recodification and appropriation of curb use and the importance of understanding what interests lie behind claims to recodification. The array of increasingly automated future technologies and other use classes which might be brought to bear on the curb of the future are already beginning

to seek to assert their rights to this precious and highly contested asset either by design or default. This requires a pro-active response by government, as there are real risks that the role of streets as places for people as well as sites of curbside transactions, will be lost in the competition for access.

Whilst there are wider arguments in the literature about the continued decline in the state's ability and capacity to influence transport, we suggest that it will always be the provider of the public highway, footway and curb space and therefore the arbiter of how that space is allocated, regulated and paid for. It is therefore in a position of considerable power to determine how best to manage these transitions and the risks and opportunities that they bring.

However, it is less clear whether the state understands or is capable of acting to deliver change for the full set of public interests. We have already seen that commercial interests – which stand to gain billions of dollars globally from capturing rents from the future curb – are becoming actively mobilised in order to frame the debate and establish their claims to what might be considered a 'normal' distribution of private- and public rights in future governance and regulatory structures. By contrast, the state has allowed deterioration in curb conditions to develop as an informal but pragmatic governance response to supply-demand imbalances rather than rigidly seeking to allocate and manage this scarce resource. Users have responded accordingly, creating an environment where there are clear opportunities to make things better. However, the kinds of decisions that need to be taken to allow more fully autonomous systems to work require a completely different highly formalised rules-led approach which has not be accepted or acceptable to date. As a bypass to this tricky, but necessary, debate we already see companies laying claims to dedicated space. Unless the state acts urgently we may find, before too long, that the curb has been 'curated' such that some users find the new technologically advanced future very enticing indeed, whilst others' experience of the urban public realm is much diminished. We suggest that governments need to develop a clear multi-use and multi-user framework for thinking about streets which ensures that regulatory recodification is properly thought through and allocates rights to maximise wider public goals.

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References

Aldred, R. (2014) What's wrong with place and movement hierarchies, Blog, August, http://rachelaldred.org/writing/whats-wrong-with-place-and-movement-hierarchies/

Appleyard, D. (1981) Livable streets. Berkeley and Los Angeles, California: University of California Press.

Arup (2019) FlexKerbs: Evolving Streets for a Driverless Future, Arup, https://www.arup.com/-/media/arup/files/publications/f/flexkerbs_roads-for-the-future_arup.pdf?la=en&hash=6D592CD247A85A00D200BF7D21BAEF3401BB04CE, Last Accessed 08/03/2019

Bergman, N., Schwanen, T. and Sovacool, B. K. (2017) Imagined people, behaviour and future mobility: Insights from visions of electric vehicles and car clubs in the United Kingdom. *Transport Policy*, **59**, 165-173

Birtchnell, T., Harada, T., & Waitt, G. (2018). On the verge of change: Maverick innovation with mobility scooters. *Environmental innovation and societal transitions*, **27**, 118-128

Bryson, J., Crosby, B., Bloomberg, L. (2014) Public value governance: Moving beyond traditional public administration and the new public management. *Public Admin.Rev.* **74** (4), 445–456

Bowker, G. and Star, S.L. (1999) Sorting things out: Classification and its consequences, Cambridge, MA: MIT Press

Braithwaite, A. (2017) The Implications of Internet Shopping Growth on the Van Fleet and Traffic Activity, Report for RAC Foundation by Professor Alan Braithwaite, London.

Chen, Q., Conway, A., & Cheng, J. (2017). Parking for residential delivery in New York City: Regulations and behavior. Transport Policy, 54, 53-60.

Circella, G., Matson, G., Alemi, F. and Handy, S. (2019) Panel Study of Emerging Transportation Technologies and Trends in California: Phase 2 Data Collection, A Research Report from the National Center for Sustainable Transportation, UC Davis.

CityScience (2018) Roads for the Future: Dedicated Driverless Spaces, City Science, https://www.cityscience.com/download/Dedicated-Driverless-Spaces.pdf, Last Accessed 08/03/2019

Clewlow, R.R. and Mishra, G.S. (2017) Disruptive transportation: The adoption, utilization, and impacts of ride-hailing in the United States. Davis, CA: Institute of Transportation Studies, UC Davis, 2017.

DfT (2018a) Road Traffic Forecasts 2018, Department for Transport, London, September

DfT (2018b) The Road to Zero: Next steps towards cleaner road transport and delivering our Industrial Strategy, Department for Transport, London, July.

Dudley, G., Banister, D. and Schwanen, T. (2017) The rise of Uber and regulating the disruptive innovator. *The Political Quarterly*, **88**(3), pp.492-499.

Dowling, R. (2018) Smart Mobility: Disrupting Transport Governance?. in Eds. Marsden. G. and Reardon, L., Governance of the Smart Mobility Transition, Emerald, 51-64

Dowling, R. and Kent, J.L. (2015) Practice and public–private partnerships in sustainable transport governance: The case of car sharing in Sydney, Australia. *Transport Policy*, **40**, 58-64.

DWP (2018) Family Resources Survey 2016/17, Department for Work and Pensions, London.

EMU (2018) A Sustainable Future: Preparing for Electric Vehicles, EMU Analytics, May.

Goodwin, P.B. (1995) The end of hierarchy?: a new perspective on managing the road network. Oxford: Council for the Protection of Rural England (CPRE), ESRC Transport Studies Unit, University of Oxford.

Guerra, E., & Morris, E. A. (2018) Cities, Automation, and the Self-parking Elephant in the Room. *Planning Theory & Practice*, **19**(2), 291-297.

Headicar, P. (2018) Analyses from the National Travel Survey, Department for Transport Statistical Release, London, January.

Imrie, R. (2000) Disability and discourses of mobility and movement, *Environment and Planning A*, **32**, 1641-1656

ITF (2018) "The Shared-Use City: Managing the Curb", OECD-ITF Corporate Partnership Board, Paris.

Ison, S. and Mulley, C. (2014) Volume 5 - Parking Issues and Policies, Emerald, ISBN: 978-1-78350-919-5

Jacobs, J., 1961. The death and life of great American cities. New York, NY: Random

Jensen, A. (2011) Mobility, space and power: On the multiplicities of seeing mobility", *Mobilities*, **6**(2) 255-271

Johnson, B. (2015) The Great Horse Manure Crisis of 1894, Historic UK, http://www.historic-uk.com/HistoryUK/HistoryofBritain/Great-Horse-Manure-Crisis-of-1894/

Jones, P., Marshall, S. and Boujenko, N. (2008) Creating more people-friendly urban streets through 'link and place' street planning and design, *IATSS Research*, **32**(1) 14-25

Jones, I. (2018) SmartRoads: tracing the limits of managing road space at the metropolitan road network scale, *Urban Policy and Research*, **36(**2), 242-256

Karndacharuk, A., Wilson, D.J., and Dunn, R. (2014) A review of the evolution of shared (street) space concepts in urban environments. *Transport Reviews*, **34**(2), 190–220.

Law Commission (2014) Taxi and Private hire Services, Law Com No 347, Cm8864, London, May.

Law Commission (2018) Automated Vehicles: A joint preliminary consultation paper, Law Commission and Scottish Law Commission, Law Commission Consultation Paper 240, Scottish Law Commission Discussion Paper 166, https://www.lawcom.gov.uk/project/automated-vehicles/, Last Accessed 08/03/2019

Marsden, G., Birtwistle, J., Dales, J., Docherty, I., Liu, R., Martin, C. and Tang, T. (2019) Future Streets: Project Summary Report, Department for Transport, London.

Martens, K. (2016) Transport Justice: Designing fair transportation systems, Routledge.

MoT (1963) Traffic in Towns, Ministry of Transport, HMSO, London.

NACTO (2017) Blueprint for autonomous urbanism, National Association of City Transportation Officials, New York.

ONS (2017) National Population Projections: 2016-based statistical bulletin, Office for National Statistics, London.

Paget-Seekins, L. and Tironi, M. (2016) The publicness of public transport: The changing nature of public transport in Latin American cities, *Transport Policy*, **49**, 176-183

Sadik-Khan and Solomonow, S. (2016) Street Fight: Handbook for an Urban revolution, Viking, New York.

Salas Gironés, E. and Vrščaj, D. (2018) Who benefits from smart mobility policies? The social construction of winners and losers in the connected bikes projects in the Netherlands, in Eds. Marsden. G. and Reardon, L., Governance of the Smart Mobility Transition, Emerald, 85-104

PHTM (2017) Taxi protest to cause Monday traffic disruption in Leeds, 10th Decemeber, https://www.phtm.co.uk/news/860/phtm-news/taxi-protest-to-cause-monday-traffic-disruption-in-leeds, Last Accessed 08/09/2018

Schaller, B. (2017) Empty streets, full streets: Fixing Manhatten's traffic problem" Brooklyn, NY: Schaller Consulting, 21 December 2017

Shoup, D. (2011) The High Cost of Free Parking, Routledge

Star, S. L. and Griesemer, J.R. (1989) Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39, *Social Studies of Science*, **19**(3), 387-420

Star, L.S. (1999) The ethnography of infrastructure, *American Behavioural Scientist*, **43**, 377-391

Summerton, J. (2015) Those who are not served? Exploring exclusions and silences in transport infrastructures, in Eds. Bowker, G,, Timmermans, S., Clarke, A. E. and Balka, E. Boundary Objects and Beyond: Working with Leigh Star, MIT Press, 459-472.

Table 1: Curbside Stakeholders: Existing Situation

	Uses of the Curb	Motivations	Means of Influence
Travellers			
Drivers	Parking Pick-up and drop-off	Convenient access	Political-economic dominance of automobility; Motoring lobby groups
Cyclists	Travel largely adjacent to the curb and sometimes on facilities adjacent to or part of the sidewalk. Use also for parking bikes at formal or informal points	Safe and well maintained cycle paths or sides of road with adequate space. Secure and convenient parking spaces with low risks of theft.	Often well organised lobby groups although limited in size relative to other interests.
Pedestrians	Browsing, socialising, moving between destinations, health (e.g. jogging, dog walking), crossing roads	Varied but requires consideration of diversity with safety (e.g. lighting) and disabled access important	Weakly organised interests Primarily pursued through lobbying
Public Transport Users	Pick up and drop off at fixed points	Convenience Accessibility	Weakly organised and/or not politically powerful interest Pursued through making public transport formal election issues
Transport Providers			
Emergency Services	Access to adjacent land uses	Convenience Accessibility	Legislated access
Taxi Companies	Principal point of transaction with passengers both at formal stands and in hail and ride situations.	Ability to stop and drop off or collect passengers wherever required and minimal delays to journeys resulting from other curb use. Formal stands in commercially sensible locations.	Highly unionised in some places Embedded in statutory consultation processes Specific legislation is in place to govern how the taxi and private hire industry is regulated.
Bus Companies	Principal point of transaction with passengers through a series of formal bus stops	Ability to stop without being delayed when rejoining traffic stream. High quality waiting facilities at curbside to encourage bus use and step free boarding facilities.	Varies by country with some public transport operators being managed by local authorities. Elsewhere there are private operators required to work with local authorities with statutory consultee status

Bike Share Companies	Bikes are made available on the curb adjacent to popular land-uses and public transport interchanges. Can be dynamic	Maximising use of asset, sometimes advertising	Lobbying and direct provision with no formal status in planning process
Car Share Companies	Exclusive access for pick up and drop off	Cheap parking	Lobbying and some formal status in planning regulations
Adjacent Land Uses			
Residents	Main point of access to property is from the curb and this may also be a place where own vehicles are parked depending on development type	Protecting amenity of property and ensuring easy access to vehicles where owned, particularly for those with disability	Lobbying of local politicians, participation in planning process (e.g. appeals) and neighbourhood groups in some places.
Shops	Main point of access to property is from the curb. Shop may spill on to curb or be a kiosk on the curb. Require access for deliveries.	Maximising footfall and expenditure to the shop, often considered to be supported by available parking for shoppers	Important source of income through local business rates and often a well organised lobby group.
Bars/Restaurants/ Theatres/Cinemas	Main point of access is from the curb. Seating and patrons may spill on to curb. Require access for deliveries.	Maximising footfall and expenditure to the shop, often considered to be supported by available parking .	Important source of income through local business rates and often a well organised lobby group.
Hotels	Main point of access is from the curb. Larger hotels often have private forecourt for pick up and drop off as premium feature	Convenient access to facilitate easy luggage transfer and sometimes for privacy or comfort of guests.	Privately manage forecourt to exert control over these interests
Street Services			
Refuse operators	Temporary stopping at curbside to allow collection of refuse	Minimising distances which refuse needs to be carried from bin to vehicle	Largely organised from within the municipality but increasingly run by private companies on their behalf
Delivery companies	Parking at curbside to allow primary distribution/collection function	Most convenient access to end delivery sites and minimised time of search for space	Disparate interests with freight user groups rarely exerting strong influence on local planning processes.

N.B. traffic engineers and land use planners are important in defining the curb, but are not a use as such.

Table 2: Potential Changing Dynamics of Curb Use Demand

User Group	Predicted Changes in Curb Use
Drivers	Parking – reduction in availability and legitimacy of on-street parking if move to pick up and drop off
Cyclists	Access – growth in cycle paths
Pedestrians	Unlikely to change but may be more concentrated in some locations
Public Transport Users	Pick up and drop off – more likely to be flexible rather than fixed with growth in Mobility as a Service
Emergency Services	Unchanged with exception of implications of curbside congestion
Taxi Companies	Reduction in formal fixed stands as result of rideshare
Bus Companies	Pick up and drop off spaces – required to be more flexibly located with rise of on-demand services and automation
Bike Share Companies	Bikes are made available on the curb adjacent to popular land-uses and public transport interchanges. Can be dynamic
Car Share Companies	Require dedicated parking 'pods' as car sharers pick up/drop off cars
Ride Share Companies	Increase in pick up and drop off activity; increasing regulatory and political influence
Electric charging operators	Dedicated access for electric vehicle charging and requiring dynamic management
Residents	Dedicated driveway as main point of access to property likely to decline; give way to pick up/drop off access
Shops/Bars/Restaurants	Main point of access to property is from the curb. Shop may spill on to curb or be a kiosk on the curb. Require access for deliveries.
Hotels	May strongly assert privacy of road space
Refuse operators	Temporary stopping at curbside to allow collection of refuse
Delivery companies	Increase in quantity of delivery; likely increase in economic importance and political influence