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REPORT

The end (of the end) of traffic congestion

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Traffic jams: When digital makes impossible promises

Fig. 1: Satire III, The Annoyances of Rome, Juvénal (1929)

"The wagons thundering past through those narrow twisting streets, the oaths of draymen caught in a traffic-jam, would rouse a dozing seal—or an emperor. […] however fast we pedestrians may hurry crowds surge ahead, those behind us buffet my rib-cage, poles poke into me; one lout swings a crossbeam down on my skull, another scores with a barrel."[1]

Satire III, "The Annoyances of Rome", Juvenal

"Coaches, horses and deafening noise. Such is Paris; how does it seem to you?"[2]

Paul Scarron, On Paris, 1654

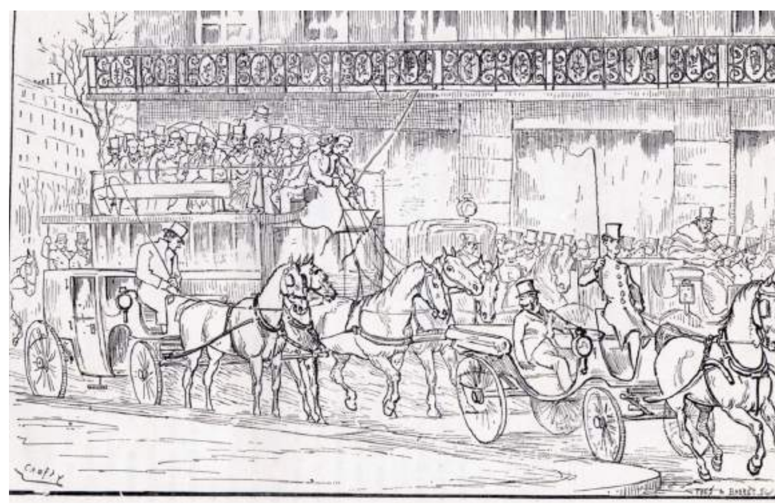

Fig. 2: street of Paris at peak hour (1889)

Fig. 3: Annoyances of Paris (18th century)

"Embarrassed by the same rude embrace. Soon twenty carriages arrive in single file, followed apparently by a thousand others."[3]

Nicolas Boileau,
Annoyances of Paris, 1666

The "congested city": a tautology

Nothing new under the sun: already in the first century of the common era, Juvénal formulated a perfect definition of urban congestion as the product of an imbalance between the availability of space and the flow of traffic.

An intrinsic feature of cities, **traffic congestion can also lead to serious consequences**. Primary among which are its economic consequence: in France, time wasted in traffic costs drivers an average of 3.3 billion euros[4] annually. Moreover, while a significant portion of urban road space is shared between users of various transportation modes, **overuse of public space – a rare commodity in dense areas and seldom designed for more than one traffic type – carries a substantial cost** for cities[5] (CNT, 2005). From an environmental standpoint, **several thousand vehicles burning fossil fuels while deadlocked in traffic generates even more CO_2 emissions**. On top of that, **fine particulates dispersed into the air pose additional health risks**. In the United States, traffic congestion alone accounts for an extra 25 billion kilograms of CO_2 emissions[6]. Traffic congestion also increases stress and anxiety for city-dwellers. In major urban areas, where residents spend an average of one day a year stuck in traffic jams, workers and professionals cite urban congestion as one of the top sources of stress (25%)[7].

Cities have spelled congestion since their inception. And for just as long, urban areas have sought out a miracle solution that would eliminate the problem. In 1662, with the approval of Louis XIV, **Blaise Pascal tested the world's first public transport system in Paris to fight urban congestion**: the *Carrosse à cinq sols*, or five-sol coach. Fifteen years later, heavy restrictions imposed by the Paris Parliament coupled with rising fares put an end to the experiment. A century later, works overseen by Baron Haussmann changed the face of Paris dramatically by cutting broad new avenues through the city to relax the dense distribution of space in the historical urban core[8].

In the 20th century, **the automobile emerged as a mass-market consumer good**, thereby claiming a central role in society. The same century brought about the rise of personal mobility: ever faster and sleeker, cars emerged as the leading transport method for everyday travel[6]. At the same time, cars also became a status symbol conveying an individual's sense of personal achievement and independence. Massive adoption of the automobile triggered new transformations in the city[10]. Originally scaled for travel by horse or foot, **cities soon needed to find ways to open up new spaces in order to solve *"the problem of automobile traffic"***[11]. In this way, the 20th century signaled ***"the shift from the metrics of pedestrians to the metrics of automobiles"***[12]: roads widened, parking spaces multiplied, and the city sprawled out through a centrifugal dynamic powered by the automobile. Despite these transformations, congestion remained, survived and became so dominated by cars that in 1908 the president of the Tourism Council proposed a solution for "*channeling*" traffic flows through the use of stop lights, right of way and the adoption of France's *Code de la route*, or Highway Code, in 1921.

Fig. 4: traffic jam in New York City

This urban space previously opened up for automobiles is now gradually closing. Cities are moderating automobile traffic to favor new modes of transport by cutting back on the amount of space dedicated to cars (street lanes, parking). **This paradigm shift has resulted from an onslaught of new considerations including familiar topics like combatting traffic congestion, as well as antipollution efforts, policies to reduce single-occupancy vehicles and a preference for multimodal transport that notably integrates greener modes** (biking, walking, public transit). In their effort to slow or reverse the growing plague of traffic congestion, cities have taken new measures such as reducing speed limits, instituting urban toll systems, restricting traffic and expanding public transportation options.

Digital to the rescue of congested cities: what promises does it offer?

Is it possible that the digital revolution might deliver the miracle solution cities so desperately need? In 2005, the foundations of what would later become the "smart city" gave form to the utopian vision of a controlled, predictable and regulated city, a city in which human intelligence gives way to the intelligence supposedly obtained by using digital tools. When applied to the city, digital conjured up a host of fantasies about law and order, safety and security long found in the arts (film, painting, literature). From its inception, **the digital city has presented itself as an idealized vision of the city that will not only solve inveterate problems like traffic congestion, but also address issues of sustainable development and quality of life against a backdrop of rampant urban development**. This new form of so-called intelligence relies almost exclusively on communication and information technologies (CIT). From the start, many have expected digital to unleash a new capacity for cities to learn, understand and transform their everyday experience. This spurred the CIT giants of the time to launch an all-out campaign to win over cities. "Connected Urban Development" (CUD) became the first such plan for developing connected cities, initially launched in three cities (San Francisco, Amsterdam, and Seoul), with the specific aim of solving many of the problems facing cities, notably in terms of traffic congestion[13].

Still today, **mobility remains the preferred playing field for digital platforms, with traffic congestion still the worst enemy**. In terms of recurring traffic jams, for example, digital tools like Waze promise to help drivers "*outsmart traffic*", while Citymapper pursues the broad ambition of "*making cities usable*". In this way, the digital transformation of the city encompasses both new technologies and new players – **which provides plenty of fuel for cities' new ambitions in terms of their targets for reducing urban congestion**.

However, beyond their marketing slogans, what actual benefits can digital technologies bring to the table when it comes to cutting back on traffic jams?

For Antoine Picon, recent decades have seen a shift from the "*city of flows and networks*" – a model that has dominated since the 20th century – to the "*city of events*". In his view, the latter is based on each city's ability to attract and host a permanently growing schedule of events. Each of these events, or data sets, offers a new opportunity to represent the city in a new and different way. In this sense, the script replaces the map as the dominant metaphor of the smart city. With an ever-expanding web of data, artificial intelligence and sensors, digital offers a vast palette of technologies and techniques that cities can apply to their organization. **These tools enable private players and municipal authorities to process massive data volumes in real time**. By delivering these new capacities, the hope is that digital will create a more streamlined and livable city. To achieve these promises, digital can help cities activate or facilitate three basic levers: expanding knowledge of mobilities, supplying information to users and rolling out a smart transport system that can adapt in real time.

Knowledge: gaining a detailed understanding of mobility with digital

Since the mid-1970s, France's Household Transit Surveys (*Enquêtes ménages déplacements - EMD*) have helped flesh out a global and coherent vision of domestic mobility. Analyzing the data collected by these surveys has contributed to outlining and evaluating the country's public policy on mobility questions. The surveys employ a series of interviews conducted at subject's homes, using the same methodology across the entire country. **Considering the logistical challenges and costs of conducting the EMD surveys (several thousand euros for large cities), digital offers a critical tool and major opportunity to expand this knowledge of mobility**.

With the emergence of new geolocation techniques (GPS, GSM, WiFi), new data acquisition protocols (mobile apps, web, connected vehicle data) and the expanded data ecosystem, cities now enjoy access to an unprecedented body of knowledge concerning mobility. Today, every connected object and citizen doubles as an additional source of data, simultaneously expanding our understanding of mobility and playing a key role in improving our modes of transport.

Information: taking part in improving the redistribution of flows

Urban congestion is the product of an imbalanced relationship between two variables: space (infrastructure supply) and flow (travel demand). Applications like Waze promise to help passengers bypass traffic jams by acting directly on the space variable: uncongested routes are preferred over main roads. In Belgium, the city of Ghent recently implemented "*the country's most ambitious traffic redirection plan*". The program sought to reduce traffic by nearly 40% in the downtown area by restricting vehicle access to the city's urban core[14]. A partnership between Waze and the city even published a detailed map of the new traffic plan as soon as it came into effect, thereby permitting drivers to avoid traffic jams along the edge of the restricted traffic zone. Data provided by the application has also allowed drivers to find alternate routes to avoid the city's main roads and optimize traffic flow within the city.

Since the initial application of this new traffic plan in the urban core of Belgium's second-biggest city, the municipality has seen a nearly 15% rise in bus and tram ridership and a growing number of cyclists (27%). These rising numbers, as secondary effects of the plan, can be attributed in part to digital. In fact, the capacity of digital services to aggregate and distribute vast swathes of data makes it possible to create applications that compare all mobility solutions available for a given route. **Multimodal route planners of this sort have the potential to influence which transport modes users choose based on their relative competitiveness, expressed in terms of time and/or cost**.

Optimization: rolling out a smart transportation system

Intelligent Transportation Systems (ITS) refer to transportation infrastructure augmented by data. Infrastructure of this type receives and communicates data with every link in the global system: vehicles, smartphones and applications. ITS represent a hybrid form of physical infrastructure (roads, transportation networks) and digital infrastructure. This type of network delivers many benefits: since operators can adjust these systems in real time, they enable operators to boost their overall efficiency by ensuring safer, more streamlined traffic flows. In this way, smart transportation networks can send updated directions to users based on the actual traffic conditions observed across the network.

In Singapore, the government implemented an urban toll system to cope with the scarcity of available space and the saturation of its roads. Upon its initial release in 1975, the system was manually operated and functioned independently of traffic conditions. In 1998, the city reinvented the system to create a digital and dynamic tool. **The system now enables the city-state to exercise greater control over traffic flows through a dynamic and targeted toll system that adapts to traffic conditions in real time**. Introducing the new digital urban toll system helped cut vehicle traffic by 10-15% compared with its manually operated forerunner[15].

Such systems make it possible to optimize physical infrastructure in real time, while also delivering more information to users of the network. Digital is not just a source of information, it is becoming an efficient protocol for governing communication between all connected objects across a network.

An alluring promise

Digital has brought along a host of promises when it comes to simplifying transit and the way we travel. The leading players in this new economy have been the first to champion these promises in wildly enthusiastic terms. To solve the age-old bottleneck problem, digital players suggest using data to avoid them ("*outsmart traffic*", Waze); they also plan to solve the challenges of intermodal transit by simplifying the city (Citymapper); finally, as service quality declines on traditional modes of transport, they promise comfort and efficiency at an affordable price (Uber). Behind these words are the promises of services rolled out by digital players. **Focused on the goal of simplifying mobility by making it more streamlined and less complex, they have set out to reinvent the transit experience**.

In fact, in just a few years, digital has dominated the mobility landscape to such a point that people now view these new services as essentials. In a sector like mobility, which had experienced little change since the mass adoption of automobiles, these new services are seen as vectors of innovation and change to move things in the right direction. In fact, they promise to liberate users from their daily transit constraints and the bane of traffic. In this way, they are reinventing the transit experience. Their service is often perceived as superior to the quality offered by traditional transit operators, and it is getting better every day[16]. For a vast majority of Europeans, **expanding digital services is seen as a crucial step towards getting around with ease**. Among the many services developed through digital, Europeans particularly value the ubiquity of digital payment services (62%), route planners that favor intermodal transit (73%) and finally, passenger information (77%)[17]. Offering predictability, real-time information, the ability to aggregate data from a wide range of operators and more, the innovations brought about by digital have emerged as essential services in the public imagination in a very short time.

This is because these services have capitalized on travel time, either by reducing trip length or by offering additional services. For example, ridehailing services eliminate the need to drive and thus offer more free time to users. A UC Davis study published in October 2017 develops this point by indicating that over a third (37%) of users of these services in major U.S. cities mentioned not having to find a parking spot as a main reason for using these services[18]. In France, a study by the research firm 6t indicated that Uber users valued the ease of use and competitive prices compared with taxis, and the ease of use compared with public transit. In the Paris area, respondents valued the ease of use offered by the service compared with taxis (43%). In several major urban areas in France[19], ridehailing services are preferred for their low cost (40% on average), their ease of use compared with taxies (30% on average) and finally, because they are easier to use than public transit (15% on average)[20].

Route planning apps, for their part, help to reduce driving times. In the United States, more than three fourths (77%) of people with a smartphone regularly use navigation apps[21]. Among these users, 25% prefer digital maps because they feel these services find better routes.

Fig. 5: driver using a navigation app in a traffic jam

More knowledge, information, and intelligence, but the problem remains…

Powered by data and digital tools, **cities can now ascertain the provenance and destination of each person**, as well as their current location and reason for travelling. Digital has made it possible to track several key pieces of information for understanding congestion, such as traffic speed and accident information – though this information has not (yet) helped to reduce the phenomenon. Citing the example of Boston, Marta González, Associate Professor at UC Berkeley, noted that **only 2% of the city's roads reached their peak capacity, adding that targeted efforts on this small percentage of roads could help cut travel times by 18%**. The case of Boston also demonstrates that traffic jams are never exclusively local phenomena[22]. For example, by shifting problems to other areas, navigation applications have only created new traffic jams, effectively making traffic congestion worse despite their promise to end it.

In New York, one of the world's most prominent smart cities, **digital has not managed to reverse the trend of urban congestion. In fact, the problem has only grown worse, as New Yorkers spent an average of 91 hours stuck in traffic jams in 2017**. Since the early 1980s, congestion in large urban areas with populations above 3 million residents has risen by almost 25% in the United States. In the early 2000s, small American cities (between 500,000 and 1 million residents) even reached the same level of congestion seen in the 1990s by large urban areas of over 3 million residents[20]. Since **Uber and its counterparts set out in 2011 to simplify mobility by providing access to "*the simplest mode of transport*" at the press of a smartphone button, more than 50,000 additional vehicles have transformed mobility for everyday New Yorkers**, competing even with public transit – while also creating new traffic jams[24].

Far from contracting, traffic congestion seems to have expanded in many cities[25]. **No strong global movement to reduce traffic congestion is apparent from the INRIX Global Traffic Scorecard**, the world's largest ranking of cities based on traffic jams. Moreover, Los Angeles, Moscow, and New York, cities that have made a strong commitment to the digital revolution, have formed a stable trio for many years – as the most congested cities in the world…

Reinvestigating the connection between digital and mobility has now become a matter of urgent importance.

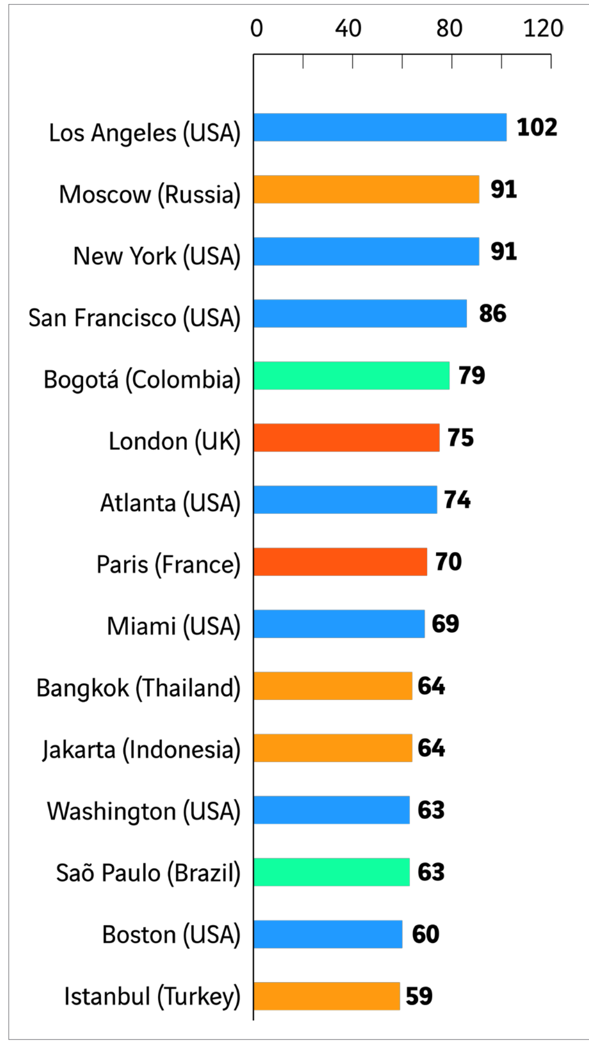

Fig. 6: hours lost in traffic jam per year in the 15 most congested cities in the world
(Source : INRIX, Traffic Scorecard 2017)

Notes

1 Translated by Peter Green, Revised Edition, 1999. (Link: http://blogs.getty.edu/iris/the-seven-plagues-of-the-ancient-roman-city-dweller/) [Accessed on May 14, 2018].

2 Our translation.

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4 Calculated by INRIX based on the following assumptions: "Wasted time per driver is valued at 50% of the hourly wage in a country or city, given that workers are expected to make up for a portion of productivity lost in traffic during the work week. The CEBR estimates that companies pass on 80-90% of direct costs (fuel, employee productivity) to households that travel by car.".

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12 Yann Dubois, op. cit.

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16 Nicolas Colin, Faut-il avoir peur du numérique ? 25 questions pour vous faire votre opinion,Armand Colin, 21 septembre 2016, 160 p.

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W Post Rd
Arville St
Rogers St
W Warm Springs Rd
SPEED LIMIT 45
S Decatur Blvd
W Sunset Rd
Edmond St
S Power Line Rd
Bruce Woodbury Belt
W Teco Ave
1000ft
PORSCHE
OPT
TUNER
MEDIA
NAV
MAP
SOURCE
PHONE
CAR
HOME

When digital makes traffic worse, or the paradoxes of modernity

2

"Jam yesterday, jam today but please no jam tomorrow is the plea of London's motorists."

The Great Hold Up, British Pathé (1953)[1]

Fig. 7: Parliament Street in London (1923)

A paradox of modernity: when digital makes traffic worse

Traffic jams are more common than ever in cities—a far cry from digital's initial promise to ease traffic jams. The gulf between digital's promises and its actual results has left many disappointed. **Optimizing travel time is not enough on its own to counter the upward trend of traffic**. These services have certainly improved and even transformed the user experience on a micro level. They enable people to make informed decisions and avoid constraints when traveling. However, **the global state of traffic has continued to worsen except in a few rare cases**[2]. According to data collected by the TomTom app, traffic congestion in European and American cities has risen by 1.8 and 1.5 points, respectively. Improving the situation on a macro level remains an unsolved dilemma.

Dare we ask **if digital has in fact increased traffic congestion**? Far from having improved the situation, digital may, in some respects, actually contribute to creating more traffic jams. By finding the most direct route to a destination, trip planners actively reduce total Vehicle Miles Traveled, while ridehailing services increase this metric. However, though they have opposite effects on traffic, the pair of digital services has ultimately increased traffic jams.

Ridehailing companies have emerged in just a few years as the new leaders in urban mobility. In New York, **in the space of only three years, Uber and Lyft, the juggernauts of this new economy, have beaten out the iconic "medallion taxis" in terms of total trips**[3]. Their success is widespread. In the United States, 21% of people now use ridehailing services. Applauded for their efficiency, they allow users to get by without their personal cars in downtown areas and thus contribute to reducing car ownership[4]. **Digital companies have gained their reputation for efficiency and their role as mobility leaders directly on the ground, notably by rolling out a vast fleet of vehicles to reduce wait times and ensure the service's reliability**[5]. Taking New York as an example provides a clear illustration of the scale of these new players.

Between 2015 and 2016, and **for the first time since 2009, the city saw a decline in ridership on public transit (bus and subway), while Uber and similar services tripled their passenger** totals over the same period. Observed in all major U.S. cities[6], this trend is especially strong in dense urban areas for trips taken outside of peak travel hours.

In the greater Boston area, a study conducted among users of ridehailing services indicated that 42% of users would have taken public transit in the absence of ridehailing services; 12% would have walked or biked; 5% would not have taken the trip. In other words, **59% of trips made by Uber and company put additional vehicles on the streets**[7]. However, we should add some nuance to this data. Though public transit may have lost some ridership in favor of ridehailing services, we have not – yet – seen a dip in the number of transit passes.

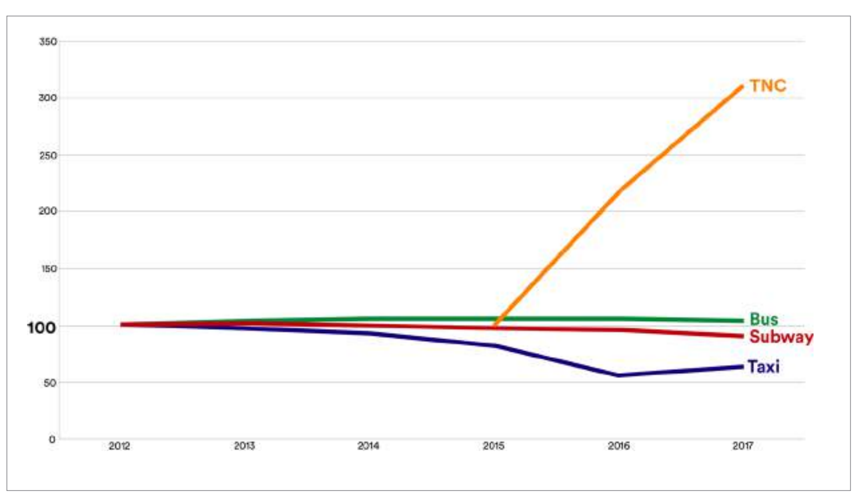

Fig. 8: evolution of transport use in New York City, index base 2012, for cabs, buses, and subways; 2015 for TNCs.
(Source : TLC Commission, MTA).

By competing with traditional modes of transport like public transit, walking and biking, these new digital services have contributed to the rise in urban traffic congestion. This phenomenon represents a major transformation in urban modes of transport: a shift among a portion of mobility demand in favor of these new digital modes. Among these new digital services, ridehailing services have placed additional pressure on traffic congestion. **They have simultaneously sparked new mobility demand**[8] (5% of trips taken with these services) and also **replaced a portion of public and non-motorized transit methods** (54%). This phenomenon has led to an overall rise in the number of kilometers traveled by car and an increase in urban congestion. **Caught unprepared by the intense and fast rise of this phenomenon, public authorities now find themselves in search of answers to this situation.**

Originally supposed to improve the way people get around, digital mobility services have in fact become one of the main causes of gridlock inside American cities. One notable factor at the root of this situation: the subsequent increase in the number of taxis and chauffeured vehicles in downtown New York[9]. For example, **between 2013 and 2017, the number of ridehailing vehicles more than doubled (from 47,000 to 103,000), while the number of taxis remained capped by city hall at 13,600**.

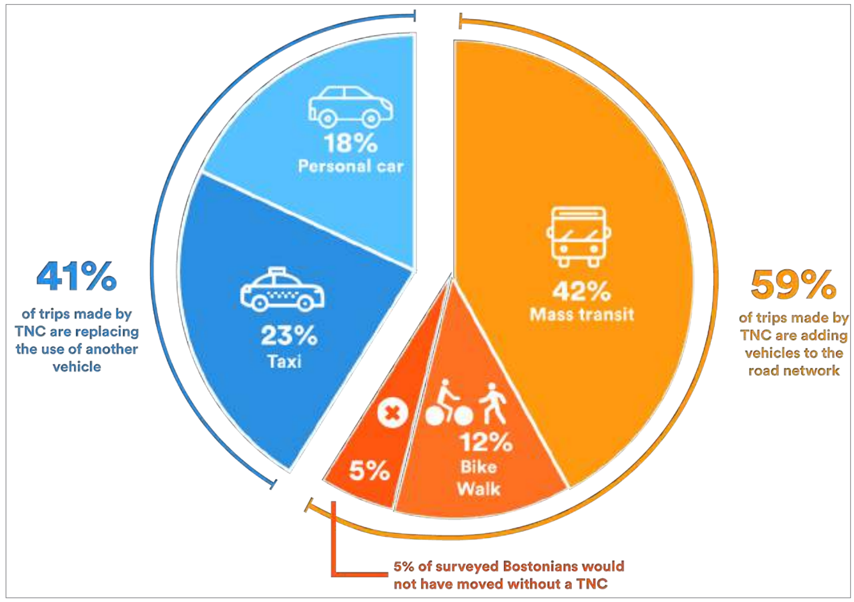

Fig. 9: modes of transport replaced by TNCs in Boston.
(Source : MAPC Research Brief, February 2018).

City planners versus algorithms? [10]

Digital has transformed everything we know about mobility. The data it provides have enabled us to develop more precise transit frameworks, while gaining a comprehensive and real-time vision of mobility solutions. However, this expanded knowledge has not in fact improved the way we regulate and manage traffic flows in urban areas. Behind the information provided to municipal authorities through data sharing partnerships with digital companies, **the actual impact of these services continues to disrupt the frameworks** and policies designed by public authorities. What explains this paradox in which public authorities, despite having access to more mobility data, have failed to adapt their efforts? How can we explain what amounts to a fundamental paradox of modernity?

City planners versus algorithms: this polemical formula describes the latent conflict that has for years pitted municipal authorities against digital companies. For Sam Schwartz, former traffic commissioner for the New York City Department of Transportation, local authorities have been caught off guard[11] by the rapid onslaught of new players and services.

Nicolas Colin explains this situation by pointing to the fact that the scale of operation of these new players far exceeds the administrative boundaries of any municipality[12]. **The efforts of companies in this new economy have weakened the role of public authorities; but dœs that mean it heralds a general decline in the role of public authorities in managing urban traffic**? For now, as they find themselves overwhelmed and contested from many sides, public authorities are facing a fundamental challenge to their role and legitimacy in urban traffic management.

For example, in France, if the urban transit plans ("*Plans de déplacements urbains*" - *PDU*) are indeed the cornerstones of mobility planning and scheduling in urban areas[13], why haven't new digital tools expanded and strengthened these plans?

It is clear that the efforts and expansion of digital companies do not correspond to the same timeframes and regional boundaries as the traditional stakeholders in urban life. Digital players are agile, responsive and have no geographic boundaries. In this sense, digital companies are the negative image of public authorities. Operating on the basis of medium and long-term planning, public authorities are completely disoriented by the paradigm shift in time and space wrought by the digital economy. Municipalities and public agencies continue to regulate and organize mobility according to timeframes that do not adequately integrate the effects of the new and sudden rise of digital services, notably when it comes to traffic.

Contrary to this governmental organization, digital companies have taken a step forward in their approach to mobility. In the first place, they have positioned themselves as intermediaries in the relationship between users and the traditional players in the mobility ecosystem by offering seamless booking and payment, dynamic navigation, real-time information and more. Without needing to fundamentally transform urban mobility, the features made possible by digital technology have facilitated and personalized mobility services, by acting as an intermediary in our daily transit experience. In this way, digital companies have emerged as the new key players in urban mobility. Secondly, digital players have gradually positioned themselves as key players in personal transportation, taking on a role in the distribution of urban transit[14].

Traditionally, transit distribution has typically fallen under the scope of ensuring smooth traffic within cities. Public authorities exercised a monopoly over these roles. On the urban level, apart from specific concessions (tunnels, highways) and private roadways, public authorities have always managed the transportation network. Acting simultaneously to regulate traffic and provide public transit services, public authorities continue to play a central role in coordinating individual trips in order to prevent traffic jams in cities. This effort includes coordinated action to manage traffic flows (offering alternative routes, providing incentives to use alternatives to cars), implement an efficient multimodal offer (both streamlined and reliable), upgrading networks (maintenance) and providing information to users[15]. These actions ultimately aim to ensure streamlined mobility for all citizens, regardless of the mode of transport they choose.

But **the monopoly held by public authorities over the organization and regulation of urban transit flows has recently encountered a challenge from digital players**. Under the impetus of new mobility services, which have convinced citizens of their utility in a remarkably short time span, the legitimacy of public authorities as promoters of transportation services and sources of reliable information on actual traffic conditions is now facing a major challenge. Digital companies owe their success to their ability to identify and capitalize on pressure points in the current network, while closing the real or perceived gaps in public mobility services.

Divergent visions of the city

Growing out of the data sharing partnerships frequently promoted by a range of stakeholders, the relationship between urban digital services and municipal authorities has never been easy. This relationship is manifested through the oppositions, tensions and battles that have marked its history. Cities are complex systems which, by their nature, provide the backdrop to confrontations between a range of different players and points of view. For Antoine Picon, Director of Research at *École des Ponts ParisTech*, "*the city is both a political and technical phenomenon*"[16], intertwining a host of functional and governance issues. **As they attempt to solve urban traffic congestion, each stakeholder in the city will implement its own solution. In this way, on top of the vision conveyed by public authorities, digital players will impose their own divergent vision**.

Determined to conquer cities, these new mobility players have adopted a strategy which, after disrupting the traditional order of business in this sector, now tends to impose its own vision and agenda on public authorities[17]. This fundamental change is a new phenomenon. As such, it is either interpreted as a tension between an innovative and agile culture of entrepreneurship aiming to overcome the sluggish bureaucratic pace of public authorities overwhelmed by these issues; or as a predatory dynamic of global economic players against municipalities that are disoriented and caught off-guard by new challenges. As indicated above, public authorities aim to ease traffic along major routes by offering alternative itineraries and an adequate transportation offer. Their role concerns the macro level on the scale of the entire network. Above all, they hold a spatial vision of transit flows. For their part, digital players focus on a simple value proposition: optimizing travel time for individual travelers. In short, their goal is to enable their customers to get where they are going faster or enjoy an enriched travel experience. This vision is primarily temporal and focused on a micro level: the user. Because **navigation services have a simple aim: to find "*the best itinerary*", the shortest route in both space and time. The key to success for this type of service lies in fact in relying on secondary and tertiary infrastructure networks**[18] **to complement the primary network**[19] **when it becomes too congested**.

By optimizing itineraries, this feature minimizes travel time and reduces the number of kilometers traveled by cars by preparing an itinerary that combines different networks to obtain the most direct route. The main difference between these networks lies in their traffic volumes. While the primary network is designed to carry heavy traffic flows (several lanes, high speed), the other two are scaled to provide local and therefore limited service (single lane, moderate speed).

Navigation services aspire to optimize networks by shifting a portion of traffic (vehicle flows) to less congested routes – even though the latter were never designed to carry high traffic volumes[20]. In this way, the secondary network will also break down and experience traffic jams when demand is too high. This means it is impossible to direct excess traffic from primary routes to secondary and tertiary networks without creating new traffic jams[21].

However, many users opt for the alternative itineraries that navigation systems present as faster routes. And this is when the system falls apart. On a basic level, the more traffic is diverted from the primary network to the secondary network, the more it will create new traffic jams in the secondary network[22], without necessarily absorbing the excess traffic from the primary network. **These new traffic jams arise from an inadequate distribution of traffic, caused directly by the digital services promising to offer a "better" itinerary. Though the alternative route may be better from certain angles, it fails to question the model of a single vision managed by a single entity**.

"Don't believe the app": innovation is not enough

Each equipped with its own vision, these different systems do not cœxist without conflict. **Examples abound of direct opposition between cities and digital players**. Including major cities like London[23] and Austin[24] opposing Uber, as well as small towns like Leonia, New Jersey[25] tacking action against the wave of vehicles redirected through its downtown streets every day, these conflicts do not bode well for the possibility of a harmonious relationship between municipalities and digital players. **In the meantime, traffic congestion is growing worse in cities, and it seems like nothing can reverse this trend**. The problem is complex: as uncertain as the impact of new mobility players on urban congestion may seem, no one can deny that they are revealing the shortcomings of existing mobility services, just as they attempt to respond to these challenges.

For that reason, it is more necessary than ever to move beyond this fruitless opposition that benefits no one, except traffic congestion. If the goal is to ease traffic on roadways, cities and digital players need to join their forces in this effort. Of course, this transformation is underway, as new partnerships between municipalities and digital services emerge every day[26]. Their initial results are encouraging, even though these partnerships have not yet managed to reverse the trend of increasing traffic. In addition to these partnerships, we need to review the fundamentals underlying congestion. **Together with Alexandre Bayen, Director of the Institute for Transportation Studies at UC Berkeley, we need to ask the question: "*how can we solve the problem if we don't understand it?*"**[27].

Fig. 10: demonstration against Uber in London in 2014

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Improving our understanding of traffic to improve our response: “It’s the economy, stupid!”

03

Congested cities or congested society: space, time... and us

Urban congestion, as defined by traffic experts, appears when transit demand[1] exceeds the infrastructure capacity[2]. This means there are two states of traffic: fluid traffic and congested traffic arising at the critical point beyond which transit demand exceeds infrastructure capacity.

Two types of phenomena can lead to transit network congestion. They are known as recurring congestion (or demand congestion) and non-recurring congestion (or offer congestion)[3]:

- In the first case, traffic jams occur when **demand increases beyond the availability offered by the road network**. This phenomenon notably emerges during rush hour or at times of holiday or vacation traffic.
- In the second case, **traffic jams are triggered by a sudden or planned reduction in the road network capacity**. These traffic episodes notably arise during construction, lane closures or traffic accidents.

A traffic jam thus occurs above all due to an imbalance between capacity and demand. In this respect, cities are particularly conducive to creating traffic jams...

For our societies to operate efficiently and effectively, it is important to **synchronize our working hours.** This means that working people and students need to meet in the same places and at the same times in order to interact. This need imposed by our societies means that a majority of people travel during the same periods: 7:00-9:00 AM and 4:00-6:00 PM. In addition, **the spatial concentration of jobs, exacerbated by urbanization, contributes to greater use of road networks around employment hubs**. Although digital technology promised to do away with traditional office spaces and eliminate commutes, the reality is that working people continue to commute, even doing so across longer distances.

Several factors explain this **growing reliance on commuting over long distances**.
First of all, this trend was facilitated by the presence of long-distance transportation networks (suburban trains, buses) and by the **diminishing cost of car ownership**[4]. Faster and more available transportation has expanded the boundaries of cities and enabled people to live farther from downtown. In addition, the increase in travel distances has become a **solution to the tensions between the job market, rising property values and disparities between regional appeal**[5].

Far from the return to rural living enabled by computers and the Internet, society remains decidedly urban. For Edward Glæser, Economics Professor at Harvard University and a specialist in urban growth factors, this situation comes down to the fact that cities are not just places where people work. They are also spaces of consumption where people like to spend their time[6]. **Contrary to the changes predicted by the arrival of computers and digital technology, cities have gradually expanded their sprawl** just as daily commutes have stretched across longer distances and durations. People are becoming increasingly mobile. This trend has gained particular steam in Europe in recent years[7]. **In France, the distances traveled by commuters**[8] **increased by an average of 1.6 km between 1999 and 2013**[9]**; the same trend occurred in the United Kingdom between 2001-2011**. A study led by the Urban Sociology Laboratory (LaSUR) at the Swiss Federal Institute of Technology Lausanne (*EPFL*) indicated that in 2015, between 11-15% of European working people between 25-54 fit the description as "*extremely mobile*"[10]. In France, the share of trips under 10 km decreased, just as trips between 20-50 km increased. As these distances increase and extend farther from downtown, **cars remain the primary – and often the only – mode of transportation, which, when not optimized, contributes to disproportional use of roads and favors the emergence of traffic jams**.

This excessively high demand leads to the emergence of traffic jams when use of the road network exceeds its capacity. This excessive concentration of traffic prevents vehicles from reaching the optimal travel speed[11]. The main cause of this phenomenon pertains to the **suboptimal character of personal cars**. Often singled out for their ill effects, personal cars display a **low occupancy rate** relative to their capacity. In Europe, vehicle occupancy rates fell between 1990 and 2005 from 1.65 to 1.45 passengers per vehicle[12]. At the same time, the number of kilometers traveled per passenger has increased over the same period: by 45% in Germany, 28% in France and 15% in the United Kingdom[13]. As a result, the number of vehicles on roads is growing faster than the number of people being transported.

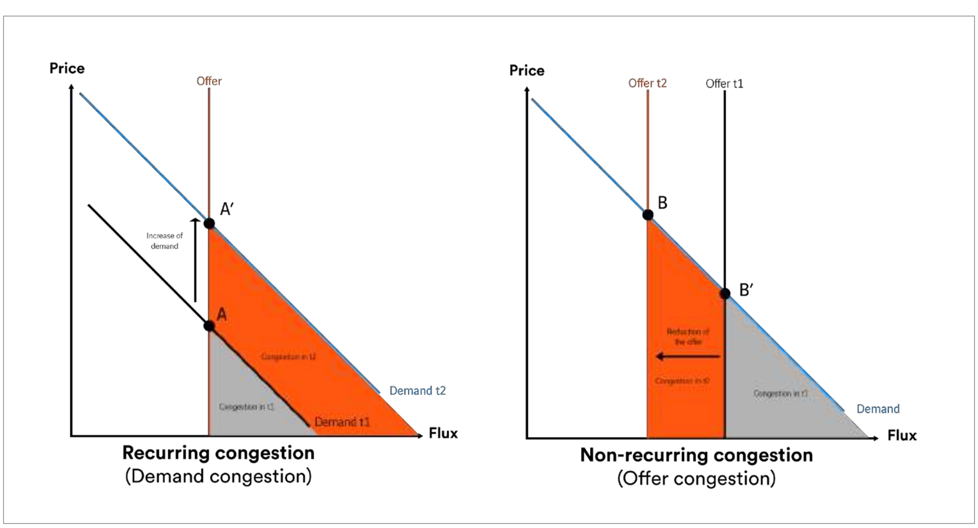

Fig. 11: Formation of recurring and non-recurring congestion

What efforts are possible?

It is plain to everyone that road networks cannot simultaneously carry an increasing number of people who also want to travel over longer distances with more vehicles.

Several types of efforts are available to remedy this problem: increase the road network supply, reduce demand or shift demand to other areas.

Supply-side efforts

Fig. 12: Katy Freeway in Houston.

By defining traffic congestion as the result of car transportation demand that exceeds the road network capacity, it may seem intuitive to **increase the road network capacity or build new roads** to absorb traffic congestion. Although this line of reasoning may seem fool-proof, the reality is more complex on the road and so the actual results are less conclusive.

In Houston, to ease traffic in what the American Highway Users Alliance (AHUA) ranked as the second-worst bottleneck in the nation, which wasted 25 million hours of commuter time every year, the city decided to increase capacity along a stretch of the highway[14]. At the interchange with Houston's beltway, the Katy Freeway (fig. 12) was expanded to become the widest highway in the world with nearly 26 lanes in 2008 (12 main lanes, 8 feeder lanes, 4-6 toll lanes). **The project tripled the original capacity of the highway**, which upon its construction in 1968, could carry 80,000 vehicles per day along 6 lanes[15]. **However, congestion along this route has continued to grow even after opening these additional lanes**: it has since increased by 33%[16].

As this example shows: **increasing a roadway's capacity without changing the cost of use**[17] **attracts greater transportation demand**. Since newly built or widened roads are initially less congested, if their cost dœs not change, they become more competitive. For that reason, traffic along these routes continues to increase until bottlenecks form once again, thus reducing its appeal. The reality of traffic means that by increasing the supply, we simultaneously create new demand[18]. This is known as induced demand generated by increasing the road network supply. As illustrated by the example in Houston, **traffic may actually become worse after building or widening a highway**.

Instead of permanently increasing a roadway's capacity, **providing temporary access to an additional lane in order to prevent bottlenecks is another solution that has been tested**. In 2017, in Rennes, a study undertaken through a *Pacte État-Métropole* agreement aimed to study the possibility of allowing some users (bus and carpool) to use the emergency lane along the Nantes-Rennes highway (RN 137) during traffic jams[19]. Without permanently increasing the roadway's capacity, and thus avoiding the risk of worsening the original situation, **this operation should make it possible to ease traffic while encouraging new behaviors and influencing transportation demand**.

Demand-side efforts

Whether due to fears of worsening the initial situation or a lack of public funding, supply-side efforts are not always possible. In the absence of solutions for increasing road capacity, it may be possible to influence transportation demand. In theory, this type of effort has a direct impact on vehicle flows, traffic concentration and, subsequently, traffic congestion. How? By getting more passengers in cars, first of all. In 1997, it was estimated that the average car in Europe transported 1.1-1.2 passengers during commutes[20]. In suburban areas, where nearly 97% of residents used their car regularly, that rate fell to 1.06 passengers[21]. Considering this situation, the solution seemed simple. "*To cut traffic jams, we simply need to reach 5% self-driving cars*"[22]; "*if we achieved 1.7* [passengers], *we would solve traffic jams in Paris*"[23], read some of the headlines in the French press.

This approach aims primarily to encourage carpooling during commutes. Experiments like the one launched in September 2017 in Toulouse and Reims by BlaBlaCar aspire to develop carpooling, which according to ADEME accounted for just 3% of all commutes in 2015[24]. Efforts like **developing roads to encourage carpooling, creating parking spaces and meeting points** or including carsharing in corporate transportation plans ("*Plan de déplacements d'entreprises*" *-PDE*) provide incentives for carpooling during the daily commute.

Another solution consists in desynchronizing transportation rhythms. Just like similar efforts on electric grids, this involves **eliminating a portion of demand during peak hours**. This can be done either **temporally**, by providing incentives to travel at a different time (earlier or later), or **spatially**, by choosing alternative routes. In any case, any such actions will require the agreement of companies and the creation of reliable alternative routes. Moreover, as with the electric grid, how much will users need to receive in return before changing their habits?

Finally, **what would happen to traffic congestion if we simply commuted less**? This is the question posed by remote work and the gradual emergence of shared workspaces, for example near or even inside train stations. **Though a growing share of the working population is starting to adopt remote work, this solution is still very limited, while a majority of workers (60%) and a substantial portion of jobs (45%) are not eligible for remote work**[25].

Fig. 13: Macleod Trail in Calgary (Canada) at peak hour

What is the right price of traffic congestion?

However, it is clear that solutions like remote work and carpooling, though they are already available and are occasionally put into place, have struggled to take off with a mass audience. At the same time, traffic congestion continues to get worse.

Faced with the long-term inefficiency of efforts focusing either on road network supply or transportation demand, other approaches of economic nature have been envisioned. According to economist Anthony Downs, the previously mentioned efforts cannot solve traffic congestion[26]. Even worse, the nearly automatic reflex of rebalancing transportation demand can also lead some people who previously used public transit to opt instead for personal cars, due to the extra appeal generated by the decongested roadway. This is explained by what Downs calls "*triple convergence*". When it comes to transport networks, **traffic flows adjust automatically. For this reason, the additional space made available by efforts focusing on road network supply (widening, new construction) or on transportation demand (reducing the number of vehicles on the road) will quickly reach capacity**.

Within these conditions, **a single mechanism has the ability to neutralize the triple convergence phenomenon: increasing the cost of using a car by imposing a geographic fee or by increasing taxes on petroleum products like gasoline**.

Moving beyond a physical approach to traffic jams by adding an economic angle: for economists like Anthony Downs, the only way to put the brakes on rising traffic congestion and stabilize it at an optimal level is to attach a cost to the negative externality it generates. However, it is still necessary to find a way to calculate this cost and evaluate the negative externalities generated by cars and their use: congestion, pollution, noise pollution, premature decay of roads, stress, anxiety, etc. Recall that a negative externality corresponds to the moment when the consumption of a good or service – in this case, road use – is affected negatively by the consumption of other individuals. Traffic congestion represents a unique type of externality[27]: the people caught up in a traffic jam are subjected to it just as they also cause it[28].

The total cost of urban congestion is often calculated by totaling the costs of the various negative externalities it generates. By adding up the toll of decay, wasted time, pollution and health consequences, some experts estimated the total cost of traffic jams in France at 17 billion euros per year in 2014[29], or about 0.8% of the nation's gross domestic product (GDP). However, not everyone agrees with this calculation. Rémy Prudhomme casts doubt on these figures, which he deems scarcely credible. **Overestimating the total cost of traffic congestion constitutes a risk for anyone seeking to develop the fairest possible assessment**. These approaches differ based on how we define traffic volumes and the duration and value of time wasted in traffic jams. This type of calculation tends to **overestimate the amount of time wasted in traffic jams by comparing it with an ideal control situation in which roads are completely empty** of any cars and traffic moves without obstruction. This postulate is questionable in that roads are not designed to be unused. Therefore, this control situation is not realistic. In urban areas, roads are almost always congested[30].

For society, reaching an optimal traffic equilibrium requires different types of efforts. According to Downs, **the most effective action consists in increasing the cost of using infrastructure in order to reduce demand**. Enforcing a fee equates to charging the additional driver (who disturbs the balance to the natural state of traffic) for the delays they impose on other drivers.

Aside from the difficulties involved in assessing a fair price, the very concept of charging for urban traffic congestion raises several issues. In the first place, it requires making people pay to drive in specific areas at certain times of day. T**his type of fee is especially unpopular, because using roads was once seen as a right acquired simply by paying taxes**. Enforcing an additional fee on traffic congestion amounts to charging a double tax for the use of a single space.

Next, **these measures can be perceived as antilabor**. In fact, though one portion of the population may be able to avoid driving or pay the fine, another portion may not have this option. Finally, drivers already pay a large portion of the cost of congestion through the time wasted in traffic jams every day. To achieve what it sets out to accomplish, traffic congestion fees will need to overcome all these setbacks.

Unlike an actual public utility, which offers limited resources, the road network is expandable. Nevertheless, **once its**

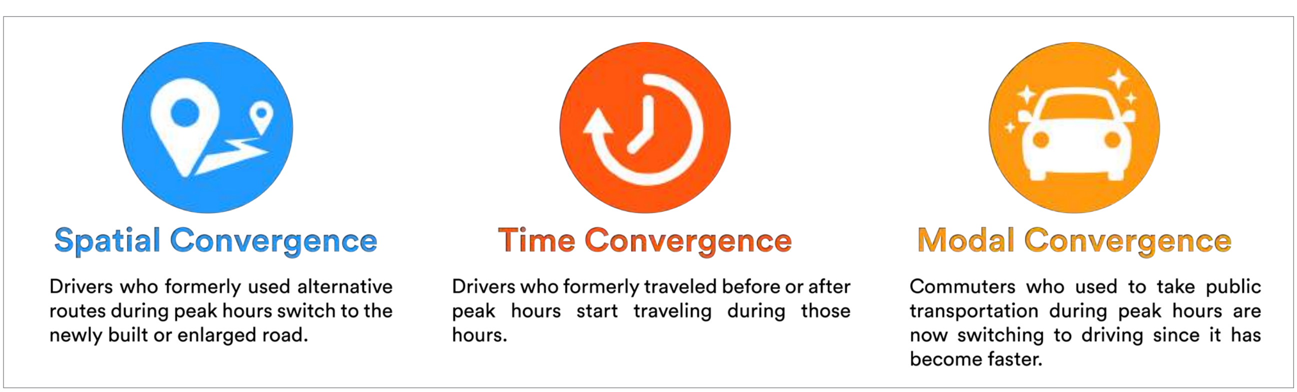

Fig. 14: Triple Convergence according to Anthony Downs

expansion capacity is reached, either because of a lack of space to build new roads, or because of a lack of resources to do so, we can consider the road network as a finite resource and, therefore, a public utility for the portion not under concession (and therefore free of charge). On these roads, traffic jams constitute a perfect example of the "*Tragedy of the Commons*". Theorized by Hardin in 1968, this phenomenon is defined as the **overuse of a shared and limited resource resulting in a no-win situation for all the economic players competing for its use**. In other words, everyone loses in a traffic jam. This theory is useful for thinking about how drivers can influence this situation and adopt the best decisions together[31].

Resolving this situation raises a complex problem: how to simultaneously coordinate the individual decisions of a large mass of people in order to regulate the use of a freely accessible consumer good? For now, each driver will tend to operate in a rational way: their top priority will be to reduce their total cost of traveling. As indicated above, the organization of our society leads all drivers to make these types of individualistic decisions at the same time, thus favoring the emergence of traffic jams and a **situation in which everyone loses by getting caught in traffic jams**[32]. This is an imperfect configuration, in which everyone stuck in traffic jams stands to benefit from improving the situation.

Prudhomme's calculation of the marginal cost of congestion (1999)

In 1999, Rémy Prudhomme presented a model for calculating the cost of traffic congestion, aiming to provide a more credible method than the standard model, which was based on imprecise definitions of congestion and its cost. First of all, he deconstructs the founding myth of this type of calculation. In his view, the cost of traffic congestion should not be calculated in relation to an extremely unrealistic scenario in which there are no cars on the road. Roads are built to be used.

As a result, Prudhomme bases his method for calculating the cost of traffic congestion on a natural traffic equilibrium (point A). This more realistic scenario comes into play when an additional driver pays a private cost (primarily composed of the value of time spent on the road and the cost of the vehicle's operation) that is equal to the benefit the driver receives from using the road. Beyond this balance, the additional driver will see the cost of using the road exceed the value they receive from it, so they will logically decide not to use it. For Prudhomme, although this equilibrium is natural, it is still not optimal for society.

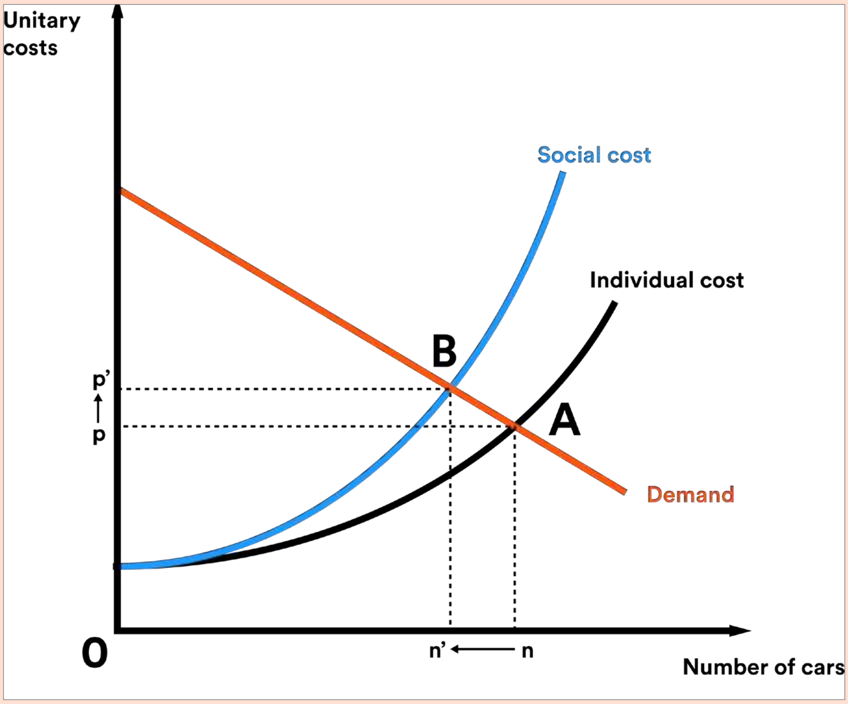

Fig. 14: calculating the marginal cost of traffic congestion according to Prudhomme (1999)

Prudhomme therefore considers a social cost, which corresponds to the private cost paid by the driver, as well as the cost that the driver's vehicle imposes on all other vehicles when it is on the road. This second cost curve compares demand at a second equilibrium point (B), which Prudhomme considers the optimal traffic equilibrium for society. Beyond this equilibrium, it's not just the use value for the driver that decreases, but the use value for all other drivers on the same road. For the author, a cost occurs, and is paid for by society, when the equilibrium is natural instead of optimal. One initial conclusion derives from this demonstration. Natural equilibrium is a scenario that often already includes traffic jams because, according to Prudhomme, the natural use of a road is nearly always greater than its capacity. In this way, the goal of public mobility policies is not to eliminate all congestion, but to stabilize it at an optimal level.

To influence the emergence of traffic jams, it is necessary for each driver **to act in a way that considers the actions of other drivers**. However, choosing a route is not simply a process of opting for route A instead of route B. **Transportation involves a combination of choices connecting a starting point to a destination**. Highway exits, intersections, detours: every crossroads presents a new alternative. **Optimizing a trip is a process that takes place at every instant, since an infinite number of itineraries are available**. It is not farfetched to think that such complexity can put the rationality and good intentions of drivers to the test when it comes to solving urban traffic congestion. For this reason, individualistic behaviors within this scenario actually appear as perfectly logical.

Today, several tools enable drivers to account for the choices of their fellow drivers. For example, when they encounter a slowdown or bottleneck, drivers would previously make a choice favoring their own utility instead of the good of everyone[33]. Now, in the case of a slowdown, digital tools theoretically make it possible to guide choices towards routes that will optimize use of the entire road network. However, as noted above, digital traffic management tools frequently worsen the initial situation. Because, while these tools help to reduce travel time for individual users, they are not yet able to account for the decisions of drivers who follow traffic app suggestions or who use another service. One identifiable solution for reducing traffic congestion may lie in **connecting all traffic regulation services**. This would involve greater collaboration between public and private traffic management services.

Conclusion

Remote working, building additional lanes, taxing traffic: between apparently short-term solutions and medium-term quandaries (building new lanes), complex transformational changes involving all players (changing social rhythms) and technically efficient but politically difficult measures (charging drivers), the strategies for reducing traffic congestion extend far beyond the realm of digital technology. As underlined by Martin Wachs, professor at UC Berkeley, "*we consistently label congestion a major problem to be solved but find it unacceptable to adopt the most effective solutions*"[34].

The real challenge, therefore, is not to do away with traffic congestion but to regulate it successfully – a challenge in which digital has a key role to play.

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Living with urban traffic congestion: when digital makes us love bottlenecks

4

Why we continue to live with traffic jams: congestion, our collective choice

Only one city, Singapore, has put theory into practice by rolling out a broad panel of efforts to influence mobility supply and demand, thus demonstrating that it is indeed possible to solve the problem of traffic congestion.

Faced with the insufficient amount of available public space and the fact that roadways devoted to cars covered 12% of its surface area, **the city-state carried out drastic actions aiming to reduce the number of cars in the city**. These measures include requiring an expensive Certificate of Entitlement to own a personal car[1], implementing a quota on the number of private vehicles and, finally, instituting a citywide toll system in 1974[2]. Each of these efforts aims to stall the rising number of vehicles on the city-state's streets[3] and to improve traffic speed[4].

Singapore's efforts have achieved noteworthy success. Despite its population of 5.5 million people, as well as a density (8,800 residents/km^2) and area (719 km^2) similar to Greater Paris, Singapore has managed to **reduce the annual duration of traffic jams to 10 hours a year**, or nearly seven times less than Paris (69 hours per year)[5]. The determining factor in Singapore's success lies in its ability to take extreme measures to reduce traffic congestion[6].

The main barrier to success facing any strategy for reducing traffic jams is not technology: it's policy. The extremely proactive – some might say authoritarian – measures put in place in Singapore seem difficult to envision in regions whose geography and political culture make such restrictive measures an unlikely sell.

What's more: we have an ambiguous relationship with urban traffic congestion. Even though they place a burden on cities, traffic jams are also seen as the most obvious sign of a city's appeal and strong economic health. Downs affirms as much when he sees traffic jams **not as a failure of our mobility policies, but rather as a sign of a city's good economic health**.

Fig. 15: Singapore urban toll

This is the reason why, even though it is clearly one of the most effective ways to reduce traffic congestion, citywide tolls raise so many objections. Its detractors thus point out its potentially harmful impact on a city's appeal. Such tolls can notably raise costs for travelers (unless their vehicle is exempt from tolls). This added cost also has a negative impact on the appeal of working inside the city's toll zone[7]. In the long run, **it could displace certain businesses outside of toll zones** and, ultimately, reduce the city's appeal. In the current context of stiff competition between urban areas, it is in no city's interest to implement an urban toll system if its neighbors are not doing likewise.

In the context of these discussions on urban appeal, cities have a choice: **either implement efficient solutions that may damage the city's appeal, or maintain the status quo by balancing appeal and congestion. In reality, they have already decided**. Urban congestion is in large part a choice. **By allowing traffic jams to form, cities have employed one of the most efficient ways to reduce demand for car travel: through dissuasion**. For Anthony Downs, congestion is an essential tool in combatting traffic jams. Without traffic jams, a roadway remains competitive. As soon as the network becomes congested, drivers have less incentive to travel on it.

The issue is, therefore, not to eliminate urban congestion, but to control it and use it as a regulation tool. This is the proper angle for understanding the role and potential of digital technology in this area. The challenge now consists in making digital a tool for improving the acceptability and control of traffic congestion. In this respect, recent discoveries in behavioral economics provide many apt lessons.

Digital to make congestion more acceptable

Urban congestion causes a needless and anxiety-inducing waste of time for citizens, who frequently list traffic jams as one of the main sources of stress. A survey conducted by Waze in October 2018 indicated that traffic jams represented the biggest cause of stress for 79% of Isræli drivers[8]. And yet, these episodes, as undesirable as they may be, are part of the everyday reality of mobility – and they are here to stay. So why do we continue to fuel traffic jams in the city? Behind this paradox lies a complex reality. In fact, even though drivers curse traffic jams on the micro level, they often procure a much greater utility from car travel than any other mode of transportation.

A variety of factors determine our choices. We can notably distinguish between the utility a user derives when planning their trip from the utility they perceive in the moment when driving their car. **In traffic jams, stress is caused by the user's feeling of losing control, since they are not moving as quickly as they would like** and, as a result, their movement is constricted. The other determining factor of this stress is the unpredictability of traffic jams and the fact that they can occur at an inopportune moment[9]. In his study of the factors that prevent us from learning from poor choices, Norbert Schwartz indicates that **drivers' perception of traffic jams is often out of proportion to their actual lived experience**[10]. Instead of learning from our actual experience with the torments of traffic, we dwell instead on how the trip should have gone in an optimal scenario, thus erasing the memory of congestion episodes.

Digital services also influence users' perceptions of traffic jams, by enabling them to avoid bottlenecks (navigators) or turn driving time into free time (ridehailing). Moreover, by providing a real-time analysis of a trip before it starts (travel time and events), they help users stay better informed, avoid unwelcome surprises and limit the stress caused by eventualities like traffic congestion. For example, the survey conducted in 2017 by IPSOS and the Boston Consulting Group (BCG) on European Mobility revealed that users believe that digital services can improve their travel experience. And for good reason, because digital technology has brought about services enabling them to stay better informed in real time. Though these features are not enough to solve urban congestion, they can still ease the stress and anxiety caused by trips made without adequate preparation or information, both in terms of duration and itinerary.

For lack of ways to cut down efficiently and sustainably on time wasted in traffic jams, digital players are expanding their approach. **They now aim to make the time wasted in traffic jams more acceptable**. Through a better understanding of uses, digital companies operating as mobility players understand the way users perceive their trips and the time spent in traffic jams. In turn, they use this knowledge to develop their service to make traffic less stressful[11]. In this vein, they offer features informing drivers of real-time traffic conditions. By receiving real-time traffic updates during a trip – taken by car, ridehailing service or public transit – digital services like route planners enable users to anticipate frustrating variables on their route (slowdown, accident, breakdown).

Though many view solving traffic jams as the major challenge facing cities today, it remains true that, **in a majority of cases, drivers have already internalized the existence of traffic jams**[12]. However, though people have internalized traffic as an inherent part of cities, they can only tolerate it up to a certain point[13]. Beyond the threshold of acceptability, traffic causes more stress and anxiety in drivers. **And the reason they can accept it up to a certain point is that traffic is somewhat predictable**. In this way, a necessary addendum to the acceptability of traffic is the importance road users attach to the predictability of traffic episodes and the reliability of traffic information. Already in 1976, the French Ministry of Transportation published a report indicating that users often care more about the unpredictable nature of their trips than their actual duration. In other words, users of mobility services value their ability to identify and prevent any eventual delays rather than simply calculating the trip duration[14].

Predictability was thus cited by the same report as a key factor in service quality alongside speed, comfort and regularity. Currently, traffic analyses provide a real-time vision of a situation, which shows users what they would have encountered were they already en route, instead of enabling them to predict what they will encounter on their actual trip. Traffic prediction takes this a step further. Since 2015, the *Optimod'Lyon* app offers reliable traffic prediction at a specific time by combining real-time and historic traffic data[15]. For the OECD, experiments like this constitute an important avenue for reducing the effects of bottlenecks on road users. In fact, thanks to traffic and bottleneck prediction, it is now possible to determine the likelihood of encountering these phenomena and organize trips accordingly.

This information, even if it offers traffic predictions, will have no impact on a user's route if the user dœs not take it into account. When it comes to routine trips along which the driver is familiar with the traffic points, it remains unlikely that they will seek out this type of information. One of the major challenges facing digital mobility services will be to become more proactive by informing drivers of upcoming traffic conditions before their trips, so they can determine whether or not to travel at a different time or take an alternate route.

By working to make traffic more acceptable[16], digital players are pivoting away from their original promise to solve traffic jams. Now we are seeking to live with them. Is this a sign of resignation or a genuine inability to do otherwise? What power do algorithms and data have to solve this urban challenge? Considering the geographic and financial constraints that prevent them from altering physical infrastructure, is it not in the interest of public authorities to capitalize on these data which, if properly used and shared in the right conditions, can advance a broad strategy to reduce traffic? In other words, how can we start to think of digital not as an end but as a means of easing traffic?

Building comprehensive mobility services at the right scale

The digital revolution has reexamined the role and place of various mobility players in solving urban traffic problems. However, in spite of the massive changes brought on by digital's entry into our transportation habits, it has not solved the issue of traffic. This question has therefore fallen to public authorities, which remain the dominant forces in managing transportation networks. How can public entities leverage digital technology to regain control over mobility?

Far from slogans like "*Outsmarting traffic together*" (Waze) and "*Move the way you want*" (Uber)[17], the new mobility players from the digital realm are now forming partnerships with other stakeholders in urban mobility (operators, municipalities, transit authorities, etc.) to share some of their data in order to solve urban challenges like traffic. Now, digital titans aim to work with cities to build **smarter systems by interfacing public and private mobility data**. Turning to these new data sources is neither unusual nor insignificant: with the right guarantees, this new information can enable municipalities to broaden their understanding of mobility at low cost[18]. In order to achieve the best results, such partnerships must take into account the evolution of mobility. These changes include an increasing number of players, modes of transport and, ultimately, data producers. This new situation fragments and complicates access to information. Similarly, the **sprawling nature of transportation through time and space, regularly crossing administrative boundaries, neutralizes any action that dœs not consider traffic flows at an appropriate scale**[19].

To date, digital titans point to two main types of successes: **the possibility of implementing efficient and targeted efforts and developing a better understanding of the phenomenon**. In Boston, Waze notably helped to improve traffic light synchronization at several intersections, thus reducing traffic congestion by nearly 18%. In London, during the Tower Bridge renovation, Uber's data shed light on the domino effect caused by closures on traffic congestion throughout the network[20]. Though it may not lead to a general improvement in the situation, Marta González, Associate Professor at UC Berkeley, indicates, by drawing a parallel with flows in other networks, that **resolving the main traffic bottlenecks improves the operation of the entire system**.

Conclusion

Provided to a central stakeholder in traffic regulation, personal mobility data may make it possible to develop high-quality, comprehensive mobility services[21] that transcend the silo mentality that has dominated the industry up to now. Integrating data collected by global platforms would provide precise information on automobile mobility. When interfaced with public transit data, this information **would make it possible to offer efficient alternatives to drivers whenever possible**. Cutting down on car use will not happen by decree[22]; on the other hand, it makes sense to prove to drivers that a more efficient solution in terms of time, cost and comfort is available.

These partnerships are both promising and inexpensive. As long as they set a clear framework for data sharing and use, they may represent a win-win exchange for mobility authorities, mobility service operators and users, who receive better service in exchange for their data. It now remains to be seen, on the one hand, if the platforms are ready to follow their own marketing slogans and put their skin in the game, and on the other hand, if we are ready to have the bold discussion we need about the price of mobility. Without it, these partnerships designed to benefit everyone will inevitably end up maintaining the same high level of traffic, if not making it even worse.

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Conclusion

Before praising digital as the miracle solution to traffic jams in cities, we need to be sure about one thing: do cities actually want to do away with traffic?

Nothing is less certain. Though traffic congestion leads to the temporary and recurring gridlock of many vehicles along urban roadways, this phenomenon can be analyzed in two distinct ways. Viewed from the angle of urban transportation, bottlenecks illustrate the failure or inadequacy of mobility policies, as citizens waste several dozen hours – even over a hundred in extreme cases – sitting in traffic jams every year. But as Anthony Downs explains, traffic is also a direct indication of a city's good economic health. For cities, though traffic jams are a source of frustration, they are also a sign of their appeal. This dual interpretation of traffic congestion makes its resolution even more complex: which side is right?

To date, a majority of cities prefer the status quo of their relative control over traffic, notably by using digital tools. Behind the promise of these tools to reduce traffic congestion, the reality persists: nothing seems able to stop the slow progression of traffic jams in the city, not even the smartest technologies. If solutions proven to reduce traffic jams in cities are available, why hasn't the situation improved?

Easing traffic congestion cannot be reduced to digital technology alone. To resolve the current impasse in which cities have found themselves, and in which traffic congestion is the only winner, it behooves cities to move beyond the role of digital players in reducing traffic congestion and, as Anthony Downs invites us, investigate the most effective tool to date in cutting traffic congestion: taxing mobility. This mechanism takes on many different forms and methods. From internationalizing the externalities tied to using personal cars in urban areas to a complete overhaul of automobile taxes and fees, this fundamental avenue responds to a two-fold challenge: aligning taxation with today's environmental and spatial challenges and updating taxation with current technologies (GPS, pay-per-use) for which digital represents a privileged platform.

However, faced with the polemic stirred up by mentioning or implementing such reforms, even when they offer an efficient response to one of the main sources of frustration in the city, **the main lever to activate is not technology: it's education**.

“Before praising digital as the miracle solution to traffic jams in cities, we need to be sure about one thing: do cities actually want to do away with traffic?"

Credits

Fig. 7: Parliament Street in London in 1923 - Leonard Bentley (CC BY-SA 2.0)
Fig. 10: Demonstration against Uber in London in 2014 - David Holt (CC BY 2.0)
Fig. 12: Katy Freeway in Houston - Aliciak3yz (CC BY-SA 4.0)
Fig. 13: Macleod Trail in Calgary (Canada) at rush hour - Sergei ~ 5of7 (CC BY-SA 2.0)
Fig. 15: Urban toll of Singapore - Carlos Felipe Pardo (CC BY-SA 2.0)

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