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FEEDBACK 

**Urban Transport Policies in the Time of Pandemic, and After: an ARDUOUS Research Agenda**

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Journal Pre-proof

## Urban Transport Policies in the Time of Pandemic, and After: an ARDUOUS Research Agenda

### Highlights

- Individual mobility was severely impacted by the pandemic
- Safe transport systems are crucial in mitigating the spread risks
- A new policy approach is needed to provide safe mobility for all
- Domesticity, Unsharing, Unsustainability are the risks to face in the new normal
- Adjustment, Redesign, Organization and Standardization are needed to create preparedness

### Abstract

While the virus keeps spreading worldwide and mass vaccinations are yet to come, transport policy makers face a dilemma: how is mobility changing? The situation is not unprecedented. But, unlike in past times when medical science was at early stages and little technology was available, counteractions currently undertaken by national and supranational governments integrate highest medical knowledge and technological skills with new, fast-adaptive lifestyles and transport patterns. The paper moves from this to present some key issues, synthesized by the ARDUOUS acronym (*Adjustment, Redesign, Domesticity, Unsharing, Organization, Unsustainability, Standardization*), to cope with the present situation and give rise to a new approach in the future urban transport policies.

The paper, after analyzing the contemporary situation and its implications, addresses each issue in terms of both current limitations and potential to improve the future transport policies. Some directions are proposed and commented, to advance and create a reference for further transport policies, within the general research goal to contribute to advance scientific knowledge in this new transportation study topic.

*Keywords:* pandemic, mobility, transit, emergency, lockdown, new normal

## Introduction

While the new virus spreads worldwide and mass vaccinations are yet to come, transport planners and policy makers face a dilemma: how is mobility changing? The situation is not unprecedented: pandemics are a constant throughout the history of mankind, with traces of their passing in many cultures and built environments.

European cities, during the Renaissance and after, developed specific places to accommodate individuals with infectious diseases, the *lazarets*, which were as remote as possible from the urban core. The word itself “lazaret” comes from the S. Mary of Nazareth island in Venice, Italy, where lepers were isolated. In the following centuries, and especially from the 1850s on, in the aftermath of periodic pandemics (measles, malaria, smallpox, etc.), urban strategies gave rise to two types of interventions: “raze and rebuild” or “modernize and beautify”, both aimed at improving public health and livability of the citizens. The former implied large-scale demolitions of the building stock due to its unsanitary conditions. An example for all: the 1885 Recovery Plan for the City of Naples. After several cholera outbreaks, the demolition of the slums was enforced by a massive, state-funded expropriation in the belief that healthier housing conditions would prevent further outbreaks and “reform residents morally and economically”. The latter was more complex but based on the same vision: esthetics and efficiency. This produced the end-of-1800s Hausmann’s Paris, to erase the image of an unsafe, insecure, insalubrious capital city (Carmona 2002); the worldwide replication of Garden Cities, several of which developed contemporarily to the Spanish Flu rampage, circa 1918; eventually, the more modern districts in colonial cities, pioneered by the modification of the cantonment environments to fight problems of excessive morbidity among the troops), where the installation of light, water, waste disposal systems was a form of colonizers’ administrative organization, to recreate the lifestyles and salubrity of the homeland cities (King 2007). Transport was never an issue in all of the above, with no specific interventions to improve travel conditions. The only exception is, maybe, the forty-days period ships were enforced to stay off-shore by the Venetians, lest to “import” the Black Death from the sea during the Renaissance, from which the term “quarantine” is originated.

Although not novel, the current situation is altogether different because of this pandemic’s unexpected amplitude and initial speed. Since the beginning of the 2000s at least five main pandemic events can be recorded: the SARS in 2002, the H1N1 flu in 2009, the MERS and Ebola in 2014, and the Chikungunya and Zika viruses in 2016. None of them, however, had the worldwide amplitude of the current one, nor its consequences, but in both previous and current cases the common factor was the contemporary travel styles which accelerated the spread. Contemporary hypermobility made the difference (Musselwhite et al. 2020). Before the XX century, diseases’ spreading pace was slow, according to the transport modes’ performance at the time, and the epidemics protracted travels via maritime traffics in the XVIII century Mediterranean, with “infectious” vessels in search of ports of call, are cases in point (Speziale 2006). Once pandemics traveled steam-powered or non-motorized, whereas now by cars and planes. The origin of this pandemic and its initial expansion within China was largely described (Du et al. 2020, Zhao et al. 2020a; Zhao et al. 2020b) and the happenstances (excellent accessibility by train and abundance of flights associated with the New Year festivities) facilitating the process highlighted (Musselwhite et al. 2020). Consistently, a snapshot of the spread in northern Italy, at its onset (first half of March 2020, in Figure 1), evidences how it traveled along the highways in the urban areas where it hit most severely (in red) (Sebastiani 2020).



Fig. 1 – Relationship between spread and road infrastructure in northern Italy

The recurrence of pandemics in the first 20 years of this century suggests that the phenomenon is not isolated, but if the previous pandemics mostly affected long-distance travels, with minor (or thus far underestimated) consequences in urban transport, now this has become central in understanding the spread patterns and mitigating the risk.

As behaviors are driven by contexts (Wright 2020), the current pandemic calls for the development of special policies, focusing on the newly-arising mobility patterns to create sustainable but effective transport options. And the novelty is in the new type of approach needed: unlike in past centuries when medical science was at early stages and little technology was available, counteractions currently undertaken by national and supranational governments reflect the requirement of integrating highest medical knowledge and technological skills with new, fast-adaptive lifestyles and transport patterns. Thus cooperation and multidiscipline are keywords (Goniewicz et al. 2020).

Consequently, in a scenario where urban transport plays a new dominating role in the fight against the pandemic, the research questions are many: what policies can be developed and what measures enforced to cope with new travel behaviors dictated by social distancing? Can these policies partly turn from emergency to long-term, if benefits for the communities lead to permanent healthier lifestyles? How will the citizens' awareness towards sustainable mobility change?

The paper moves from these questions to present some key issues, synthesized by the ARDUOUS acronym (*Adjustment, Redesign, Domesticity, Unsharing, Organization, Unsustainability, Standardization*), to cope with the current situation and give rise to a new approach in the future urban transport policies. From the Italian perspective, and more specifically from Rome's, each issue is analyzed in terms of both current limitations and, since restriction has its goal, potential to improve the future transport policies. The research goal is to contribute to advance scientific knowledge in this novel transportation study area.

## 1. Materials: Where do we move from here?

In Europe, the spread, thus far, went through three phases: the onset and first consolidation, or "first wave", roughly from end of February until May - June 2020, a relatively calmer period coinciding with the summer holidays (July and August), and a "second wave", from September 2020 and currently in progress, with an increased magnitude of infected. So, to date, while the crisis is still rampaging worldwide, directions to cope

with that, at supranational level, seem two-pronged. As emergency situations are often characterized by economic instability, the priority has become to develop conditions to face the arising financial needs to support medical research, on the one hand, and relieve economic losses, on the other. In spite of the implemented financial support, lockdown effects on economies seem as dreaded as the pandemic itself; two examples, at very different scales: in Rome, one in three business (corner shops, small family-owned enterprises) might not reopen again, accounting for a total of 25,000 units (Verucci 2020); like many other car manufacturers, Volkswagen stopped productions in the first half of March (Siegel 2020) facing a 67% reduction in the sale volume, just in Germany (Anon. 2020a). For the 2020, the brand is expecting sales revenue to be considerably lower than the previous year (Anon. 2020b).

But, if an economic crisis is a certainty, and new directions on how to plan healthcare services to manage the aftereffects of this pandemic are being developed, little knowledge is still available on how to cope with future urban mobility. General guidelines on how to manage public transport under pandemics highlight typical problems (absenteeism, limitations to medical services, interruption of supply chains, with severe consequences for the livability of the most secluded communities) and lead to preparedness as the key counteraction to operate transit service safely (NASEM 2014, UITP 2020), but managing the current situation, in the long run, calls for more.

During the first wave, containment first and then lockdown virtually halted personal mobility in many European cities. In Italy, according to the Enel X data (2020), the time-lapse in Figure 2 shows the progressive reduction of systematic and non-systematic trips from the first local outbreaks in early March until mid May 2020, according to the severity of the enforced counteractions and the progression of the pandemic (the peak of which was on March 21<sup>st</sup> with 4,821 individuals contracting the virus). If compared to the baseline (January 13 – February 15), and considering as reference two days after the enforcement of each counteraction as consolidated status, it is possible to observe that the severest reduction was achieved under the total lockdown started on March 23 (-55%), up to the exceptional situation coinciding with the Eastern holidays (-87%), a period traditionally dedicated to leisure trips. After 10 days of partial re-opening of some activities, the situation resumed to that of the onset of the outbreaks (-24%). This analysis is complemented by the results of a national survey (AUDIMOB 2020) to assess mobility changes during the first 30 days of lockdown. Around 60% of the trips were by passenger cars and PTWs - Powered Two-Wheelers, with travelled distances reduced in average by one third. Consistently, longer trips were converted each into more daily shorter ones on foot, thus fostering walking (which increases by 5% in the overall modal share). Usage of transit was generally halved. Most affected categories were students, unemployed, housewives and the elderly whose mobility was strongly reduced (up to 80%). Such reduction, however, is not surprising since compliant with the lockdown forbiddance to travel if not strictly necessary.



Fig. 2 – Reduction of systematic and non-systematic trips, March – May 2020

At urban level, results did not change. In Rome, after March 23, the average reduction was higher than 60% on working days. Even higher reductions were recorded in Milan (more than 70 % in average over the same period), but if compared to Rome, Milan was markedly affected by its proximity to the areas where the outbreak started (soon converted into no-entry zones). Similar situations occurred in other urban areas in Europe, where equivalent lockdown countermeasures were enforced. For example, Santander, Spain also showcased the same situation: within an overall traffic reduction, transit demand dropped (up to 93%), with decreased traffic accidents and emissions rates (Aloi et al. 2020). Exceptional air quality improvements were actually recorded worldwide, from India (Mahato et al 2020) to Brazil (Dantas et al. 2020, Kreel et al. 2020), up to the paradox to acknowledge this pandemic as “a blessing in disguise” (Muhammad et al. 2020).

One more element to consider is the citizens’ perception of such forced lifestyle. A German survey (ADAC 2020a), involving 2145 interviewees during March 2020, revealed that just 26% were not using or less using their own passenger car and 46% did keep on using it, whereas the same preferences for the usage of public transport were 43% and 13 % respectively. To the question about what travel options would be adopted when back to normality, 68% of the interviewees stated that they would resume driving and 50% that they would go back riding by transit. The same survey was launched again in November 2020, right after one of the first vaccine manufacturers announced its product efficacy. Respondents confirmed their favor towards cars and showed the intention to walk more, however they once again did “dare” to use public transport. In March, about one in four respondents said they were no longer travelling by bus, tram and metro (ADAC 2020b).

The only examples of return to normality available, however, is those of Wuhan and other Chinese urban areas. Most commuters resorted to passenger cars when going back to work (Figure 3). This was forecast by a local survey submitted in February 2020 (IPSOS 2020), where the responses from 1,620 interviewees revealed the following mobility trends: private cars and PTWs were likely to prevail over transit; due to lack of trust in public transportation; respondents who had no car were willing to purchase one; 72% stated that “driving can reduce the chance of infection.



Fig. 3 – Congestion levels in the city of Wuhan, second week of May 2020 vs 2019 (re-edited from TomTom 2020)

In line with the Chinese cases, in Rome, where the motorization rate is one of the highest in Italy, solely in the day of the first partial reopening, an increment of 230,000 passenger cars compared to the day before was recorded (De Cicco 2020). Traffic flows recorded after reflect both the return to car and willingness to restart life as before. After a modest decrease in June and July (by 17% and 14% if compared with the same months in 2019), at the beginning and end of August there was a +12% increase vs August 2019 (coinciding with the holiday traffic from/to the city). When the second wave started and until mid-October, again a very minor traffic decrease (1-digit percentage) was observed, as the spread was still relatively moderate, if compared to the situation elsewhere in Italy. Until this period, the attempt was to resume old lifestyles, with schools regularly started, business and retail operating, cultural and social life revamping with very few (much debated) restrictions. But events came to a head: repeated outbreaks at schools, poor sensibility among the youngsters, the

spread rampaging again in Northern Italy led in Rome to a milder form of lockdown (no schools, theaters, museums; teleworking strongly encouraged; curfew from 10pm to 5 am; restaurants and all sorts of eateries closed at 6pm), enforced from November 3 until December 4. Traffic flows in November 2 were already -25% if compared with the same day in 2019 (Romamobilità 2020), and bus occupancy visibly reduced.

If the facts above are considered, the lack of a transport policy to steer the transition from the emergency to the new status is clear. The reasons are many: lockdown restrictions, by drastically reducing travel opportunities, cast a shadow on the need to restore public transport in cities; in fact, transit services were markedly reduced due to the decreased demand. This replicated the vicious circle which prevent sustainable mobility: poor transit demand goes with inappropriate public services (in this case, due to the restrictions enforced), which in turn generates the massive use of passenger cars. The difference is that, now, this is worsened by the perception of unsafety when riding by bus if compared by driving. In light of this poor confidence, the supposed personal convenience of the household car becomes a myth even harder to debunk. This means that restoring the *status quo ante* is not simple: services need to be redesigned according to the new safety requirements and this calls for economic efforts (which at the moment have been sensibly directed to fund medical research and relieve economy).

## 2. The ARDUOUS methodological approach

The development of a policy usually requires gathering of information, but while this pandemic is still in progress the only facts available are mostly related to the medical requirements to meet, to avoid the spread. But the problem seems easy to identify: the aerial transport of the droplets which causes the spread implies that risk is potentially associated with any transport situation and environment where gatherings, close contacts occur and/or where air is only recirculated. This in turns, generate adaptive behaviors and perceptions. Identifying and targeting all these situations and devising interventions accordingly could develop an appropriate policy to manage the contemporary situation and develop the "pandemic-free" transport of the future.

The approach is complex as it relies on contrasting factors, further elaborated, each presenting potential and limitations at the same time. The ARDUOUS acronym seems to be appropriate for this approach as it synthesizes the following key issues to address:

- *Adjustment* of operations due to lower occupancy mandate
- *Redesign* to develop new concepts to design travel environments to reduce spread risks
- *Domesticity* generated by the lockdown and generating in turn specific mobility choices
- *Unsharing* due to the fear of use transport modes where spread is perceived more likely
- *Organization* of resources in general to deal with the pandemic's consequences on mobility
- *Unsustainability* of travel choices generated by the fear of spread
- *Standardization* of procedures and components to create resilient mobility services after the pandemic

Each issue moves from specific limitations affecting the urban mobility, elaborated as follows, and paves the way to explore avenues to create a spread-free transport.

### 2.1 The problems calling for the ARDUOUS approach

#### 2.1.1 Adjustment

The ARDUOUS approach moves from the social distancing which implies the *Adjustment* to the emergency. For transit, reduced densities to fight spread have been already recommended (Muller at al. 2020), although not quantified. The 1.8m/6ft-distance requirement (far beyond the LOS - Level of Service A, *free*, in Figure 3) even if reduced, intuitively results in extremely lower on-board occupancy and increased supply (up five time higher), being demand equal. The natural countermeasure would be to increase supply to accommodate the demand.



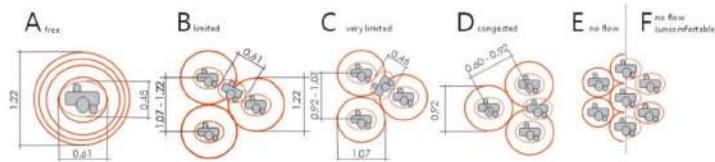


Fig. 4 – Types of Level of Service for transit occupancy (in meters)

Although theoretically possible, constraints are the poor flexibility of some transit modes, the reduced capacity of some infrastructure, especially in urban consolidated areas, the time required to increase the supply.

As to flexibility of the transit modes, to cope with restricted occupancy, a first response could be to increase options with higher capacity, typically underground. But unlike the other surface modes (trams, bus, trolleybuses) where a moderate increase of vehicles might be possible (although limitations further elaborated may apply), metro operations cannot be easily upscaled. Current systems for signaling and power supply for traction are not designed to enable highly-increased performance (for the latter with risks of frequent voltage drops), nor is the management of an increased number of trains at terminuses. The rubber-tired supply, being more flexible, is called to compensate such limitations, although more operational problems might arise: road capacity might not be compatible with more operational vehicles, especially on corridors or reserved lanes; at stops serving more routes, in case of multiple arrivals, lines can be formed while waiting to stop, thus generating vehicles pairing phenomena, even with dwell times being unvaried. Considering urban 10min-headway routes as an example, just trebling the supply would result in a departure roughly every 3min; by extending this to three lines along a single corridor or a reserved lane, arrivals at stops would be every minute, and to keep all perfectly sequenced no dwell times variations should occur. The scenario becomes not feasible for corridors with higher operations. Increasing operations, *per se*, is one more problem: more vehicles and staff cannot be organized at short notice, and this is not just a matter of purchasing/leasing more vehicles or quickly training more personnel. Increasing supply also incurs in higher costs (fuel, staff, maintenance) which cannot be compensated by equally increased revenues, being the demand unvaried or much possibly decreased.

The Rome experience during the Spring 2020 lockdown was to reduce transit services, due to a demand drop. Restoring the service did not correspond to an equally returning demand, which partly facilitated the social distancing meeting. This is corroborated by a survey on the occupancy of three lines in Rome (38, 80, 88) during May 18-24 (reopening of commercial facilities' first week and schools still closed) which highlighted that half of the seats were occupied off-peak, and two-third in peak times, with virtually no passengers standing. So in the end, the service adjusted to the new circumstances, but far from providing the performance levels passengers were used to. Still in Rome, at the beginning of the Fall 2020 wave, bus supply was increased just by few units and occupancy let rise from 50% (as enforced during the first wave) to 80%. None of these two actions proved to be particularly efficient (the unsuitability of transit service is still an unsolved problem for the city), and the easiest solution to ensure safe occupancy levels on board seems still that of decreasing demand via restricting mobility (teleworking and reduced school attendance).

Therefore, *Adjustment* only partly can rely on the adaptation of the transit operations, and longer-term solutions must be sought elsewhere, as reported in 3.

### 2.1.2 Redesign

Low on-board occupancy might implicitly mean more comfortable travel conditions thanks to higher LoS. However, the *Redesign* of buses and metro cars' layouts to accommodate passengers to reduce spread risk is not sufficient. The problem is not just rearranging on-board seats and standing places in a safer way. With reduced occupancy this simply means adopting LoS compatible with the social distancing requirement. Figure 5

simulates the LoSB on-board occupancy of a trolleybus (which could synthesize the layouts of buses and metro cars): the LoSB buffer zone (the red circle) turns some seats and standing places unavailable, and other areas not accessible. As 15 minutes proximity (at 1 mt interdistance) facilitates spread, configurations with facing seats requires even less occupancy.

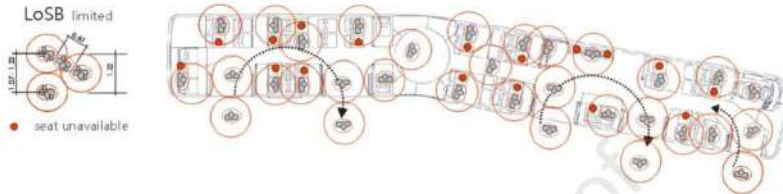


Fig. 5 – Level of Service B (in meters) on a trolleybus

However, this is not sufficient to redesign sensitive areas and equipment to avoid the virus spread due to closer contacts: the doors and the stops, which are natural gathering zones and “bottlenecks” in the passengers’ flows. The former (Figure 6) are contact areas where no strict distancing requirement can be met, even organizing designated doors for boarding and alighting (Figure 5). In this case, dismantling seats close to doors would create more room for standing, while waiting to alight.

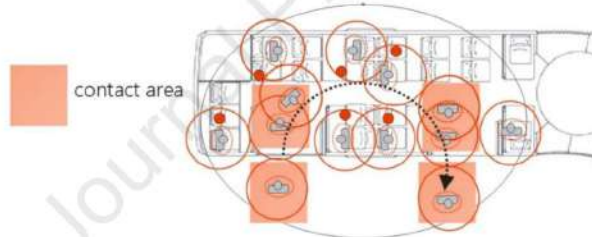


Fig. 6 – Level of Service B (in meters) on a trolleybus: boarding and alighting areas at doors

At ground, bus stops generate areas (red in Figure 7, adapted from Corazza and Favaretto 2019) where strict contacts cannot be avoided, especially in peak times where platoons are likely to occur.

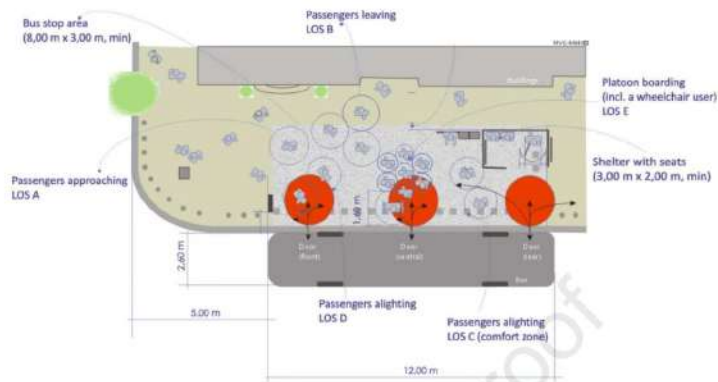


Fig. 7 Bus stop with different Levels of Service and potential risk areas

Also in this case, creating distanced/designated places for standing while waiting could facilitate safe boarding operations, but in consolidated urban areas where sidewalks are narrow this could be not always feasible. Moreover, the alternative to organize passenger flows for boarding and alighting accordingly will certainly result in longer dwell times at stops, lower commercial speed, increased energy consumption. In any case, bus shelters can be hardly used due to their confined environment.

Avoid contacts which could be generated by very diverse situations is important, too: from touch-screen operations (e.g. ticket vendors) due the virus' long-lasting active life on surfaces (Kampf et al 2020), to passengers' gatherings and queues (at escalators, elevators, etc). Wearing masks can help to cope, but certainly this raises the question about who cannot afford multiple changes of PPE - Personal Protective Equipment daily, when daily commuting.

Eventually, a specific care shall be paid to HVAC systems (especially in terms of air recirculation and free airflow intakes). Thus far, emphasis has been placed in analyzing risks in built environments (Azimi and Stephens 2013, Zhijian et al. 2018), and associating these with the level of social interactions (Dietz et al. 2020); similar analyses on transport environments are available correlating travel to risk exposure for typical contagious diseases (Nasir et al. 2016, Mohr et al. 2017, Musselwhite et al 2020). Viruses, in general, can potentially penetrate filters, thus the importance of proper filter installation and maintenance when air conditioning is important, but filtering, per se, does not eliminate airborne transmission risk; window ventilation, on the contrary, increases total air change (Dietz et al. 2020). But in last years, design research in Europe has been steered towards the creation of on-board "sealed" environments for buses, in the attempt to save energy while operating the auxiliaries (Musso and Corazza 2015), up to conceive a unique indoor environment between vehicle and bus stop to avoid heat loss when opening doors at dwell times (Corazza et al 2016), replicating aircraft and trains' closed environment. Consequently, the current generation of transit vehicles is designed to have air-handling (HVAC systems, generally) with poor outside-air ratios and deliver increased amount of recirculated indoor air, thus facilitating the human exposure to airborne spread. Evidence that the combination of closed ventilation system with a heating system, blowing hot air toward the possibly-infectious passenger and into the rest of the bus is reported in literature (Nasir et al. 2016).

### 2.1.3 Domesticity

Forced *Domesticity* and the resulting web-dependence affect transport. Basically, teleworking reduces commuting, and limitations in the everyday errands increase home-deliveries. A study relying on location data

between March, 10 and April 1, 2020, based on a sample of around 20,000 Italian app users shows that the daily average distance travelled decreased by around 50% (Finazzi and Fassò 2020). At the same time, delivery services for basic needs so increased that they were affected by long wait times (Gray 2020), with occasional labor shortage to cope with the demand-side shocks (Hobbs 2020). Additional problems related to mobility generated by protracted domesticity are evidenced in literature: increased vulnerability of the most vulnerable, who have less access to support and care (Nicola et al. 2020, Usher et al. 2020, Armitage and Nellums 2020); sedentary lifestyles which reduce active walking and contribute to major diseases (Jimenez-Pavon et al. 2020, Musselwhite et al. 2020).

However, teleworking mostly concerns medium-to-high classes of the society (Beck and Hensher 2020), whereas leaves aside all the strata with poor web-literacy, thus introducing the issue of equity. Likewise, the new job opportunities promoted due to increased home-deliveries (e.g., a multinational e-commerce company announced to hire 100,000 staff units to meet the increased delivery demand in Italy) are expected to last until the demand stays high, but how this opportunity is planned to last, once the emergency is over, is still an open question. Doubts can be raised even whether to consider this an opportunity for logistics, being this based mostly on gig-economy workers. And again, the fact that this demand rise relies, on the one side, on short-term employment and, on the other, on high-income customers (as highlighted by Barghava et al. 2020) stresses the negative effects of *Domesticity* in terms of equity.

#### 2.1.4 *Unsharing*

Failing to provide safe travel conditions is going to result into solo driving. This was already evidenced by the situations in Wuhan and Rome, both described in section 1. This also goes hand in hand with the observed decrease in transit ridership (Park 2020, de Voos 2020). And low ridership is expected to last (Chandra 2020), as also observed in Rome where, according to a survey, 4 citizens out of 5 state that they are not going to ride in the near future (Arzilli 2020).

*Per se*, this is understandable: the fear of travelling with potential spreaders, also fueled by the “solo” dimension associated with domesticity, along with the potential risk associated with transit restricted travel environments (Musselwhite et al 2020) might trigger these behaviors. Moreover, it is expected telecommuting as a new norm for many workers (Chandra 2020). But if not supported, the “share” myth, a pillar in many transport policies, will be soon debunked in favor of the *Unsharing* attitude. Carpooling, car sharing might be less favored, if the fear is to share the driving environment with unknown individuals, at a spread distance. Proposals to equip cars with hand washes do not seem much viable, if only because time needed to clean the dashboard or the steering wheels reduces the lease time available. Provision of PPEs or vehicles’ frequent sanitization would also result in additional operational costs for operators. The decreasing trend has been already highlighted (Hensher 2020, Molina et al. 2020). Likewise, the already observed demand drop in this field is the harbinger of economic losses for operators and occupational risks for driving staff (Ibold et al. 2020).

#### 2.1.5 *Organization*

The management of all of the above requires a strong *Organization* to coordinate passengers, transit managers and planners, and decision-makers. According to the Italian experience, aside from providing general recommendations based on supranational guidelines (UITP 2020, NASEM 2014) and coherent with the national scientific committee directions for safe travels, in general transit authorities enforced social distancing requirements by simply banning the use of close seats on board and, at ground, by creating corridors spaced enough to accommodate queues at major railway facilities. No specific instructions were imparted to passengers who behaved intuitively; poor communications occurred to inform that vehicles and equipment were regularly sanitized. Operators’ paucity of efforts was facilitated by the reduced supply and demand during the lockdown, thus triggering a kind of vicious circle: few passengers, decreased operations, naturally-met social distancing due to reduced demand, no further restricting measures as long as the demand is low. After the Spring 2020 lockdown, the social distancing measures have been simply reiterated, the demand being still far from usual. But when business-as-usual functions will be resumed and (if) even remote spread risks remain, activities and business have to be re-planned to avoid peak phenomena and packed situations, not compatible with social

distancing (Figures 6,7). Studies on relationship between spread and standing in queues are being developed (Mathews 2020). The same is to apply within transport facilities and vehicles where the adaptation to safe performance might require longer times to solve problems stressed in section 2.12.

“Social distancing just cannot work in any transportation system” (Sidel 2020), and this is even truer under two circumstances: i) where high commuting demand is met by low quality urban transit systems, and ii) where the built environment is shaped by very compact urban forms, developed much ahead of motorization. Both generated problems already in the “old normal” and create limitations now. The general conclusion to draw is that no real risk-free measures can be enforced and that a kind of relative optimum shall be reached, as in any complex issue. But in the lockdown experience some elements typical of complex situations lagged behind: decision, management, communication.

In terms of management, no specific role was assigned to transit managers to deal with the situation nor to steer the transition towards a “new normal”, yet to come. As stated, the extremely reduced demand facilitated that in the beginning, but in the long run “less is more” challenging, as the return to usual functions must include spread-free measures. But poor management stems from poor decision-making: administrators first simply complied with restrictions and then started announcing the launch of temporary measures, some of them unsustainable (as described in the next section), some others mostly relying on paratransit rather than conventional transit. Interpretations can be many: the decreased demand to manage, the *Domesticity* consequences, the awareness that innovating is always more popular than restoring, the awareness that in a near horizon not much can be done to reorganize conventional transit, the inexperience, a strong political commitment to fund plans and activities to adapt. The fact is that no bodies as Transit Risk Managers, Transport Planners Crisis Boards, Transport Emergency Task Forces and the likes were appointed, nor specific Safe Transit Policies developed or enforced to go back to regularity, and no dedicated funding allotted. This is rather unprecedented, as these are typical resources to manage emergencies and are fully contemplated in many planning tools (for example, Italian Urban Traffic Plans enforce mandatory measures to manage emergency situations and divert the demand accordingly). This shortcoming is also evidenced by the lack of appropriate communications. Citizens need to be educated and constantly informed to minimize spread risks when travelling, but they must be also cognizant that transit can be relatively safe and for all. This involves not only media communication, but also specific measures with staff deployment in hot spots on the transit network to help passengers adopt the right behaviors, to support the most vulnerable. From the passengers’ point of view, lack of communication, and more in general of the poor organization has a well-known effect: resorting to household cars for those who can afford that; social exclusion and economic damage for those less affluent, which again raises the issue of equity (Sidel 2020, Schmidt-Sane et al. 2020).

#### 2.1.6 Unsustainability

With poor organization and the unsharing attitude rising, risks of *Unsustainability* are inevitable: transit is neglected in favor of private cars, and the well-known problems associated with massive car-dependence have to be managed. At the same time, environmental benefits (cleaner air and waters, less noise) due to reduced traffic have been constantly publicized by the newspapers, but the way to achieve them cannot be considered a sustainable option (Zambrano-Monserrate et al. 2020). Estimations stressed a 36% of the emissions from surface transport by the beginning of April 2020, within a general reduction of 17% if all the emitting sources are considered (Le Querè et al. 2020). But, if are compared to the Paris COP21 mandate, these percentages might appear modest and the efforts to generate them disproportionate.

During the Spring 2020 lockdown, in many Italian cities, drivers were granted free on-street parking and access to limited traffic zones. The latter, still enforced after the lockdown in Rome, was first originated by the local administrators’ idea to favor retail activities in central areas and further strengthened by permitting eateries to freely occupy public areas (sidewalks and parking lanes) to accommodate customers if the indoor areas were not fit to meet the social distancing requirements. This is resulting in a mismanagement of public areas and a further incentive to drive, which trigger a new vicious circle: transit demand challenged by the possibility to drive

instead of ride, reduced transit supply to meet reduced demand, thus no need to increase transit. Free occupancy was still granted until January 1<sup>st</sup> 2021, but during the Fall 2020 lockdown eateries were again forced to restrict opening times and many closed completely. This resulted in abandoned outdoor areas (Figure 8), and a consequent economic loss for the municipality, due to the missing revenues from parking fees.



Fig. 7 Public areas mismanagement in Rome, Italy

*Domesticity* escalated home-deliveries, and the last-mile delivery business is one of the few to which the pandemic was not detrimental, thanks to its fast, adaptive response to the events. In scientific literature, although this pandemic is considered just one of the many risks affecting worldwide supply chain (Ivanov 2020), investigations on how home-deliveries will develop after the pandemic are lagging behind, probably because data are still few. However, questions should address the sustainability of the home-deliveries, should the trend started with the Spring 2020 lockdown continue. This business during the lockdown relied often on *impromptu* operations and staff with, on the one hand, using household cars or PTWs adapted to the circumstances; on the other, the employment of gig-economy workers (mostly bikers). The result is based on contrasts: motorized deliveries replacing conventional walking for shopping, even for basic needs vs non-motorized deliveries performed by vulnerable workers. Should this trend be reiterated, unskilled employment is expected to increase, and so pollution. If the latter is linked to medical evidence, it is also to consider that studies observed that residents of areas with higher air pollution are far more likely to die in case of pandemics (Karnad 2020) and that pollution could have played a possible retroactive effect on the lethality rate of this virus in Northern Italy in Spring 2020, one of the most polluted areas in Europe (Rugani and Caro 2020).

#### 2.1.7 Standardization

This leads to consider the *Standardization* issue in the ARDUOUS approach. Generally speaking, standardization is a process to achieve quality criteria or reference (i.e. a standard) to design a component, or plan a service thanks to the most efficient use of research, development, and production resources and common or compatible operational, regulatory, and technical procedures.

Emergency situations can be solved when responding procedures are ready and fast implemented. The observation that in the last two decades five worldwide emergency events took place affecting transport, suggests to consider them as recurring, but their magnitude and effects still denote their uniqueness. Probably, in the years to come, these phenomena will repeat, and standards to manage transit under these circumstances need to be developed. Thus far, the set of tools available is still poor and mostly dictated by the necessary medical directions, and each decision-making process was determined accordingly, but the implemented measures were local. Every Italian city strictly reduced the public transport supply during the Spring 2020 lockdown, but in its aftermath each is adopting similar recovery measures, yet in different ways (as synthesized in 3.2).

On the contrary, providing standardized supranational guidelines on how to decide actions and manage transit accordingly in the emergency and after, adopt correct behaviors, timely communicate, set appropriate funding, might help create an “emergency” transportation culture, available to solve prospective emergency situations.

### 3. Directions for the ARDUOS approach to manage transit and emergency for the new normal

Until vaccinations will be fully available, the lesson to learn is that of coexistence with the risk and the use of social distancing, PPEs and other prevention requirements might be long needed. This is in line with many supranational policy documents where it is recommended to identify safe mobility options instead of general prohibitive measures for transport services and ensure safe travel conditions for passengers and staff (European Commission 2020, ECDC 2020). At the same time, the awareness that restrictions or emergency measures still need to be enforced is clear, typically: reduced occupancy rates (ECDC 2020), flows optimization (European Commission 2020), recurring sanitization of vehicles and equipment (European Commission 2020, ECDC 2020), temperature check, waste disposal special management, avoidance of paper tickets (UIC 2020).

The research question is then how to manage coexistence and develop novel safety policy options accordingly for urban transit. The ARDUOUS response is both in the near and far horizons, as some effective measures can be short-term, whereas others implies extended development and implementation. Similarly, novel policy actions can be generated within the transport management sphere or outside. The conceptual map resumming the ARDUOUS approach is presented in Figure 9 and further elaborated.

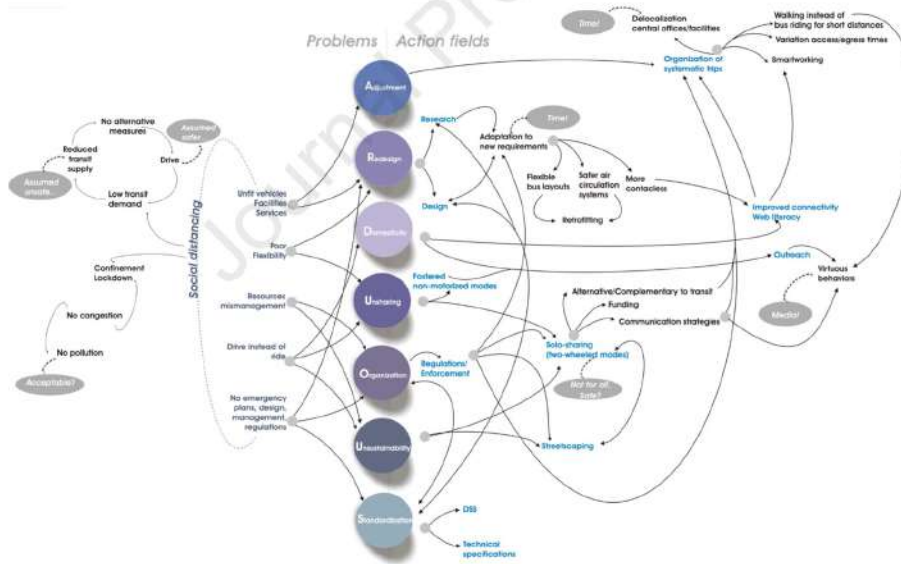


Fig. 9 The ARDUOUS conceptual map for the new normal

#### 3.1 Policy options outside the transport management domain

From the supply side, *Adjustment* as adaptation of the transit operations calls for the temporary measures already implemented (on-board seats availability reduction, designated places for queues to provide the highest LoS and meet social distancing, etc.), due to the physical constraints analyzed in 2.1.1, according to which only a modest increase of service is possible. In turn, from the demand side, *Adjustment* implies to keep transit passengers within moderate volumes, i.e. to adopt measures involving the general organization of systematic trips, i.e.:

- Create permanent teleworking conditions for people usually working in non-domestic professional environment for one day a week, at least
- Anticipate or postpone access/egress times to schools and working premises (thus staggering shifts), to avoid peak times
- Promote web meetings to reduce local missions
- Delocalize centralized services for which physical presence is required (e.g. main libraries, tax central agencies, cadastres, etc.) at district level, at walking distance. The 15-minute city concept could drive this change balancing access with mobility
- Promote healthier lifestyles (walk instead of riding by bus for very short stretches)

All this requires the involvement of corporate and administrative management and employers, educational administrators, trade unions, etc. to develop new working conditions and reduce the usual “nine-to-fivers” peak demand, or more in general the pre-pandemic commuting flows.

The measures above-listed partly bank on *Domesticity*, and per se working from home certainly might help reducing congestion and demand peak phenomena. But *Domesticity* is not for all, as stressed in 2.13. Ownership of computer hardware and web literacy are required. For example, in Italy, the narrative of the educational activities during the lockdown highlighted difficulties for the households with many children who had all to connect at the same time with the classes they had to attend, with only one computer available, or none at all.

*Domesticity* works not for every occasion, either. It is very difficult to forecast whether the rates of home deliveries will remain high, once the pandemic will wear off. Since ever, the assumed personal convenience is one of the drivers of the success of e-commerce and confinement may have fostered this practice and turned it in habitual. However, it is expected that this favor towards e-commerce will be long-lasting (Kim 2020). Consequences may affect mobility choices and more in general lifestyles, with less frequent trips to the corner shops: after one month from the first wave lockdown, in Rome central areas small retailers were still lamenting poor business due to the competition with e-commerce, and despite the free access to the limited traffic zones enforced until August 2020. Not much seems to have changed during the second wave, and seasonal sale events like Black Fridays and Cyber Mondays promoted by the e-commerce majors have only further debilitated conventional shops. Traffic flows in Rome recorded at the beginning of the 2020 Black Friday week (which, on the web, was largely anticipated virtually since mid-November, and extended) were 24% less than usual (Google 2020). Moreover, opportunities like the “Bring-Service-Near-Your-Home” (a private music school renting a long truck as a mobile classroom to impart piano lessons to children forced at home, during the lockdown in Hong Kong, as described by Choi 2020), although reasonable on educational grounds in an emergency situation, cannot be certainly reiterated or upscaled.

*Domesticity* requires then management. If the goal is to contribute to avoid systematic peak flows in line with the solutions proposed for *Adjustment*, conditions to have efficient working options at home must be ensured to all. This entails:

- Funding for the necessary hardware and software equipment at home, for those who cannot afford it
- Appropriate training to develop the necessary skills to work from home

On the contrary, to avoid post-pandemic *Domesticity* becoming conducive to reduced quality of life, by giving up usual proximity walking habits (thus increasing sedentarism), outreach activities are needed. For example, virtuous behaviors (walking errands, local-shopping, fully sanitized commercial environments) can be advertised and acknowledged, so to convey the idea among the public that it is safe to resume healthy pre-pandemic habits. Virtuous citizens could be awarded with complimentary free admission to local cultural facilities, and restart life in common. The role of media and the commitment of local administration is essential in creating this culture.



### 3.2 Policy options within the transport management domain

Rethinking working conditions as just elaborated cannot be solely managed within transport policies, as it implies new approaches for corporate jobs, different management of educational activities, adaptive urban lifestyles, with constant and appropriate funding, political commitment, and media support. But the other components of the ARDUOUS approach are targeted to highlight specific policy options emerging from the changes in mobility and travel behaviors during and after this pandemic. The lesson is to discover the best from this dystopian experience and create a new vision.

*Redesign* could be interpreted as the acronym of *Research* and *Design* which are both essential for the adaption to the new requirements of all the ground and on-board operations. Adaptation will include many measures, among these: new layouts for buses with on-board flexible arrangements (as social distancing will still dictate occupancy rates for a long time), safer air circulation systems, and advanced contactless operations are top priorities. Research and prototypes to improve comfort on-board are already in progress since a decade. Foldable seats and translucent bellows to create more standing room on-board were successfully tested in projects funded by the European Commission (Corazza et al. 2016), to adapt buses and trolleybuses' standing areas to packed situations; now, such additional room can be used for standing passengers who otherwise could not be accommodated due to social distancing. Likewise, an innovative central driving cabin tested on trams (Corazza et al. 2016) could be reconceived to create safer environments for drivers (as a footnote: transport workers proved to be most vulnerable category, with around 30 bus drivers dead in London during the Spring 2020 wave, according to Edwards 2020, and 120 employees of the Metropolitan transit authority dead and around 4,000 infected in New York, according to a Lancet editorial, 2020).

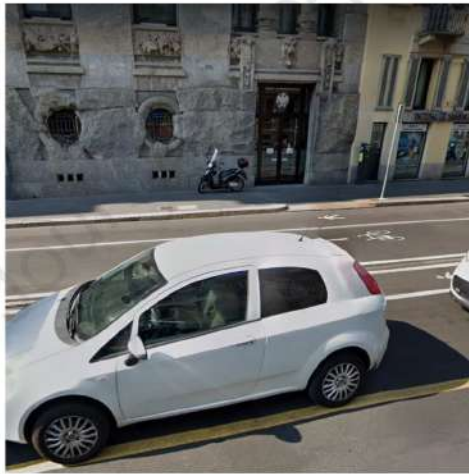
The development of safer air circulation systems is more challenging as the basic function of air recirculation is to avoid (Settimo et al. 2020). As anticipated in 2.1.2, thus far environmental concerns drove research towards the development of "sealed" on-board environments to save energy, especially when operating HVAC systems. But "sealing" might no longer be feasible if the need is to increase the intake of fresh air to mitigate spread risks among the passengers. On the contrary, to protect drivers, sealed cabins would be desirable. This will steer research and design to solve such different requirements by developing more eco-healthy-safe HVAC systems in a near future, and matching energetic problems with health concerns for both passengers and driving staff. However, the challenge is, at present, on the possibility to retrofit current fleets virtually "in real time", focusing on board HVAC units' components (air filters, grills, ducts, etc.) and parts of the bus bodies (fixed widows, namely) if adaptable. In the same vein is the focus on increasing contactless operations with a two-pronged goal: on the one hand, to enable senior passengers not familiar with technologies to "go electronic"; on the other, to use contactless technology to reduce spread risks. The former is just one among many aspects related with the poor web literacy already highlighted, and its solution would represent a step forward more inclusive transport systems. The latter could rely on apps to perform usual functions requiring physical contacts, for instance: to request stops while instead of physically push the button, and avoid to touch surfaces; be alerted at stops, if there is room enough to comply with social distancing requirements, on the incoming buses and decide whether to board or not; connect with the driver, if need be, without using speech-holes, etc.

As for any industrial process forced by circumstances, retrofitting and development of new components will require huge efforts from the manufactures' side, but this would give new momentum to innovation for research and development in a number of fields: ergonomics, component design, energy management, computer programming. Likewise, for the transport behavioral studies, which are called to investigate the passengers' acceptance or usability of the adaptations and whether these will be perceived as an incentive to use transit.

Therefore, transport policies can use *Redesign* as a leverage to re-attract passengers to transit, by conveying the idea that retrofitting can create safer travelling conditions, whereas innovations linked to advanced contactless operations and on-board layouts could turn bus riding in a smarter and more comfortable experience.

*Unsharing* and *Unsustainability* are associated with the "solo" dimension, with passenger cars ever the dominating mode. But as long as the current situation progresses, the preference towards other solo vehicles is

getting stronger, namely bikes and e-scooters (or kick-scooters). Still focusing on Rome, and although no consolidated figures are available, both are favored by the public, judging by the increasing number of shared e-bikes, e-scooters and even 125cc motorbike companies which started operating soon after the Spring 2020 lockdown. The favor towards these modes can be explained in many ways: the users' perception of "unsharing", although on lease, given by the facts that both modes have no "physical" driving environment and that no pillion passengers are permitted, thus contact-less; the feeling of freedom when riding, opposed to lockdown's confinement; affordable costs; the improving weather conditions at the end of the first wave; the companies' efforts to advertise specific sanitization for spread-sensitive parts like helmets, handles, mirrors; the easy compliance with social distancing when riding a two-wheeler mode. Administrations are recognizing such new "solo-sharing": an oxymoron, yet an actual alternative to public transport (much valued as long as transit operations are affected by social distancing). In London a 250 million GBP investment in cycle lanes was announced (Swinford 2020), and in Rome and Milan (Figure 10) temporary cycle lanes were implemented in the first post-lockdown days. This prompted local administrations to revise land use, by enlarging footways, enforcing Zone 30s and newly-pedestrianized areas with examples from many cities, among these: Berlin, Budapest (Laker 2020), Milan (Venni 2020; Borgomeo 2020), and London (Topham 2020). However, pop-up bike lanes on some London arterials could be again removed after that motorists claimed the reduction in road space to be a congestion's worsening factor. This seems to be an emerging problem as a petition to the government ("Remove guidance and funding for temporary traffic measures that cause congestion") with more than 25,000 signatures is currently in progress (Lyddall 2020).



*Fig. 10 – Temporary lanes for bikes and pedestrians in Milan, Italy*

"Solo-sharing" and the increasing use of non-motorized modes create a unique chance to prioritize low-carbon travel options and clean individual mobility, as naturally-generated by the citizens, with no real demand management. National and local administrators should not miss this opportunity and turn what used to be niche or ancillary modes into actual policy options, alternative to transit also when the pandemic will fade. Environmental benefits are clear, but more advantages can follow: increase of active walking and biking, a general beautification process thanks to newly-streetscaped infrastructure to accommodate such flows; a triggering process to reuse other shared options (car-sharing first, probably) once the trust will overcome the

spread fear. A recent survey involving 12.688 Italian car sharers stressed that once the *status quo ante* will be back, the favor towards car-sharing will be resumed (Anon. 2020c).

This “solo-sharing” phenomenon is spontaneous and as such has its limitations. The Italian Ministry of Transport is subsidizing the purchase of electric two-wheelers (including kick-scooters, segways and hoverboards) via a 500 Euros bonus, and the demand soon skyrocketed. But as these vehicles are rather expensive, there is no certainty that the public favor will continue, once funding will no longer be available in the urban areas where no sharing services are operated. Wintertime adverse weather conditions should be also contemplated among the reasons for decreased demand, as well as its poor safety: in the first two weeks of June, seven accidents involving e-scooterists occurred in central Rome (Lupia 2020). More operational limitations are evidenced by the recent problems with the e-kickscooters service providers. This mode’s initial popularity boosted the rental market up to have six different service providers in the city of Rome, in agreement with the municipality. Each operates a free-floating service with fleets up to 1,000 vehicles in the central areas, and variable rates. During the Fall 2020 wave, the overall supply proved to be overestimated: more accidents involving kick-scooterists regularly reported by the local press, government’s renewed directions to stay home and telework, novelty wearing off, problems with parking which called for a specific “geofencing” technology to avoid parking close to landmarks, all made the service less appealing than expected. It is not surprising, then, to observe more vehicles parked than circulating. The result is a drop in the operations efficiency which led the municipality to enforce a penalty of 15-days service suspension for some providers (Rome Municipality 2020).

As for any transport policy option, along with constant and adequate funding, fostering “solo-sharing” requires effective communication strategies to convey the idea that these are both clean alternative to private cars and complementary to transit. Complementarity to transit can be promoted by the convenience for youngsters to use “solo-sharing” and enable less active users to use transit and cope with the restricted capacity dictated by social distancing. But complementarity calls also for specific management to avoid the kick-scooters problems just mentioned.

Many cities are moving in the same direction by promoting the same type of solutions just mentioned, which means that a common process of organizing safer mobility options in an efficient way is under accomplishment, at local level. The next step is the *Organization* of all these efforts within regulatory and enforcement tools to have the benefits lasting beyond this crisis. As above mentioned, the task is complex as in the new normal the possible scenario is to operate transit with the pre-pandemic demand by meeting the anti-pandemic requirements. This means that all the issues highlighted before, i.e. the organization of systematic trips, the adaptation to the new requirements, new sharing habits, and modifications of surface use at street level need to be framed within the usual urban regulatory tools, namely Urban Traffic Plans - UTPs and Sustainable Urban Mobility Plans – SUMPs, according to different enforcement scenarios, from emergency to business-as-usual, with specific management roles.

From the medical point of view, the development of post-pandemic plans for smart and sustainable mobility networks has been already highlighted in literature (Capolongo et al. 2020), and consistently with the recent requirements, in Italy, to have local public health departments assess SUMPs in terms of public health benefits. Moreover, many concepts above-mentioned are already embedded in the UTPs and SUMPs culture and practice. On-board comfort and safety are central in the provision of quality transit service, even if in this case derived from social distancing; demand management to avoid congestion in favor of collective modes (public or collective) is paramount if the goal is to achieve sustainable mobility in SUMPs, although now this could be affected by “solo-sharing”; likewise for the creation of Zone 30s or pedestrianized areas within UTPs; without web literacy the public side of the ITS-based mobility would be thwarted, so the more reasons to improve it to be most beneficial to the vulnerable users in case of emergencies, etc.

Therefore, the post-pandemic provides in terms of *Organization* a novel policy option: contemplate these emergency-originated requirements and measures within the usual regulatory urban mobility tools as additional resources to achieve local sustainability or livability goals, with dedicated funding, management and

communication efforts. Benefits will be two-pronged: in new normal scenarios, these requirements and measures will “add grist to the sustainability mills”; in case of emergency they will constitute a set of fast responses to the events.

Providing fast responding procedures can be even more efficient if these result from test, consolidated practice, and assessment. As anticipated in 2.1.7, a system of global management of the pandemic experiences can pave the way to standardized directions according to a new “emergency” transportation culture. *Standardization*, in this way, can be scalar: from tools providing effective decision-making and management of the urban mobility in case of events like this pandemic (typically Decision Support Systems driven by data, knowledge, models, etc. achieved during this and other pandemics), with scalable and transferable results according to urban context, severity or extent of the emergency, etc.; up to retrofit specifications for vehicles, design criteria for transit facilities (for example, to organize queues by meeting social distancing), magnitude of expenditures, and communication standards. The relevance of *Standardization* in this context relies on its general significance: the provision of technical specifications to achieve quality performance, which in this case can be interpreted as a mean to provide safe, healthy travel options to all, thus overcoming discrimination and exclusion. It has been observed that this pandemic requires to “keep apart and stay together”: *Standardization* can be an efficient tool in pursuing both, by settings common rules for operations, funding, communication.

### 3.2.1 The role of the scientific literature

Usually, the literature review is one of the inception sections in a scientific paper, since relevant peer-reviewed sources contribute to ground, elaborate and corroborate facts and concepts presented further. Needless to say, in a paper on transport policies, this section is virtually unavoidable as it introduces references for comparison, feasibility, transferability, assessment of the operational, technical, cultural, regulatory, societal advances reported.

In this, the present pandemic introduced one more element of novelty: no specific consolidated scientific literature in the field of transportation studies was available, because the previous pandemics in this century had a relatively modest extent and mobility was only partially affected, in terms of modes, duration, areas. So the scientific community had to build a literature in real time, while experiencing the pandemic crisis.

This steered the research towards specific fields. The immediacy and the urgency of the situation paved the way for the descriptions of case studies. Along with the sources already reported, analyses of city-based case studies were extremely useful to understand the resiliency of the different urban areas across the world, at the different scales, from urban to metropolitan (Arimura et al. 2020, Fatmi 2020, Buesky 2020, Orro et al. 2020); and the adaptation to the events of the public transport systems (Arellana et al. 2020, Petrov and Petrova 2020, Wielechowski et al. 2020, Bonful et al. 2020).

The adaptation to the events also triggered a series of behavioral studies, to assess the impact of the lockdown in the everyday mobility in terms of users’ perception (De Haas et al. 2020, Nguyen et al. 2020, Vatavali et al. 2020); modal choices (Abdullah et al. 2020, Tan and Ma 2020, Armstrong et al. 2020). Data mining and mapping in analyzing the demand changes turned to be essential (an example in Huang et al 2020) and many assumptions and considerations in this and in many other articles would have not been possible without.

All of the above studies evidenced the supply-demand vicious circles highlighted in sections 1 and 2.

The unprecedented traffic drop gave rise to studies on the consequences and impacts on the environment. Also in this instance, case studies placing emphasis on pollutants reductions and improved air quality abound, and along site-specific results, continental analyses in Asia (Ghahremanloo et al. 2021, Bao and Zhang 2020) and North America (Venter et al 2020) stress that drastic reduction of human activities might be conducive to better air quality but it is neither feasible nor sustainable. Therefore, the balance between economic losses and environmental gains achieved (Lenzen et al. 2020) is questionable. Unexpectedly, minor emphasis is placed on the impacts on noise (Rumpler et al. 2020, Asensio et al 2020). Many other topics have been and are currently developed, for example the *Unsharing* potential in promoting salutogenic transport opportunities (Capolongo et al. 2020, Teixeira and Lopes 2020, Budd and Ison 2020), and last but not least, studies to build the new normal scenarios (Cenecorta 2020, Domínguez 2020, Ceder 2020).

Virtually all the cited sources rely on the first wave experience which leaves still many avenues to explore especially in terms of comparison with the outcomes from current second wave and consistency of predicted behaviors and scenarios. More consolidated data and facts will help clarify a still less-debated but essential matter: the level of risks while travelling. Much has been studied and explained under the medical point of view, but recent statistics released in Italy and France at the beginning of October 2020 stress that the transport workers' exposure to risk is much lower than other non-medical categories', for example educational staff (Inail 2020, Santé Publique France 2020); moreover, for what concerns travelers, studies focus on single trips where on-board spread is accurately reconstructed and elaborated, but mass analyses are still missing. Still unexplored is also the role of communication to re-orient demand toward transit: one more research area could investigate the quality of social and general media in providing citizens with the right information, at the right time.

These knowledge gaps are essential to fill, within the ARDUOUS approach, in order to convey that riding by bus or metro is safe and thus restore passengers' trust. Still, within the ARDUOUS approach, the role of the scientific literature is much needed. At the very beginning, the task was to turn chronicles into scientific references for the whole community to understand and cope with the novelty. Now, the scientific literature is consolidating knowledge and along with *Standardization* can help creating preparedness.

#### 4. Results: Developing the ARDUOUS policy options

As in any policy, three main variables are to consider (King 2005):

- *the institutional domain* (the totality of legal, regulatory and standardization tools which authorize the enforcement of a given policy)
- *the resources availability* (the amount of funding, time, personnel and technical know-how required to plan and develop a given policy)
- *the society* (the cultural status which makes a community aware of the need to adopt a given policy and willing to accept it).

If the action fields in Figure 10 are considered, the three variables can assume different weights and significance in the development of the ARDUOUS policy options, as summarized in Table 1.

The institutional domain in many policies represents a time-consuming involvement but, in case of emergency, red tape and other formalities which usually slacken the process' pace can be partly abated. Emergency, in this case, can facilitate the development of the reorganization of systematic trips for what concerns access/egress times to work, which is per se a no-cost measure, whereas creating conditions to delocalize and work from home inevitably calls for complex talks with trade unions, corporate establishments, public administrations and workers, as well as specific funding to enable the new working conditions. The public acceptance of all of the above depends on the urgency and necessity conveyed by the media and the institutional communication channels. For example, walking instead of bus riding for short distances so to accommodate on board priority senior passengers and cope with the reduced occupancy dictated by social distancing can be easily accepted and, in the long run, lead to consolidate active walking.

Supporting research and design to carry out the adaptation to new requirements calls for robust investments, and the transition of research and development from more conventional innovation areas like energy may create problems from the manufacturers' side, due to the urgency of the process. However, manufacturers and developers in the field of transport have solid background and assets to quickly react and the overall profitability of spread-safe or spread-mitigating products is undisputed. Likewise, for the further development of contactless technologies, whose attractiveness has limits only in the acceptance from users with poor familiarity. Institutions' task is to select best solutions according to the target users, to accomplish equity and inclusions: multilingual apps, senior-friendly software, free training are the basic requirements to steer research and design towards the contactless technology penetration among the technologically-unfriendly users. Attract this public requires an in-depth analysis of specific users' need, by an active involvement of those who had not access thus

far to such technologies. But the users' active involvement leads also to more awareness on appropriate travel choices, with the possibility to foster non-motorized modes, not only as they are spread-free but because of their health benefits. Fostering "solo-sharing" can be a part of this process and subsidies to have an adequate supply to compensate reduced on-board capacity could be a starting point, with the aim to reconsolidate the share of traditional paratransit in the near horizon. Also in this case, communication is essential to have the passengers aware that using collective and non-motorized modes is still the main step towards sustainable mobility patterns.

Permanent streetscaping to create more appropriate walking conditions and accommodate solo-sharing, after temporary arrangements, can be expensive. Investments are needed but sponsorship programs can be launched among specific categories: from local retailers to multinational brands, whose economic returns are guaranteed by more livable conditions.

Last but not least, actions regarding *Organization* and *Standardization* are pure institutional and multilevel, from supranational to local, but to be effective the political commitment to have plans, specifications and any other decisional tool including emergency management is mandatory.

<i>Approach</i>	<i>Options</i>	<i>Fields of actions</i>	<i>Institution</i>	<i>Resources</i>	<i>Society</i>
<i>Adjustment</i>	<i>Organization of systematic trips</i>	<i>Delocalization</i>	Time, talks, funding	No/low cost	Communication, information
		<i>Teleworking</i>			
		<i>Work access/egress time variations</i>			
<i>Redesign</i>	<i>Research</i>	<i>Walking instead of bus riding for short distances</i>	Communication, information	Investments	
		<i>Adaptation to new requirements</i>			
		<i>Retrofitting</i>			
<i>Domesticity</i>	<i>Design</i>	<i>Improved web literacy</i>	Selection of best solutions	Surveys, analyses, user needs knowledge development	Active involvement
		<i>Contactless technologies</i>			
	<i>Outreach</i>	Communication	Training		
<i>Unsharing</i>	<i>Fostered non-motorized modes</i>	<i>Virtuous behaviors</i>			
		<i>Solo-sharing</i>	Initial subsidies		
<i>Organization</i>	<i>Regulations and enforcement</i>		Mandatory emergency plans		
<i>Unsustainability</i>	<i>Streetscaping</i>			Investments, sponsorship	
<i>Standardization</i>	<i>DSS</i>		Mandatory emergency management		
	<i>Technical specification</i>				

Table 1 – Key policy actions within the ARDUOUS approach

## Conclusions

As stated, the present situation is not unprecedented which makes the resulting lesson necessary to learn, if only because in the last 20 years five main pandemic events occurred. In this case, urban communities are paying a very high toll, highlighting the vulnerability of the local transit systems, perceived by the citizens as unsafe, and its dependence on economic and societal changes, even if dictated by uncommon circumstances.

Although scientific evidence associates the spread with the transit's closed environments, social distancing and PPEs can mitigate the risks. And although some modes or facilities are poorly flexible in accommodating passengers accordingly, other mobility options can compensate. Moreover, an increase in the "solo" travel is being recorded as a reaction to the fear to travel with unknown individuals. On the one hand, this can foster traditional motorized lifestyles with serious problems of sustainability and livability, but on the other is giving

rise to a general favor towards electric scooters and bike sharing systems. Such preference is generally complemented by an increase of walking, no longer ancillary to other modes, up to the point that local administrations planned and enforced temporary measures to accommodate the new demand, and consider to turn them into permanent. This opportunity is exceptional, as never before such a general preference towards walking and biking was observed, and needs to be further exploited in post-pandemic transport policies. One more element to consider is that social distancing, although imposing a restricted on-board occupancy, in the post-pandemic recovery process can be used to improve on-board LoS, thus providing higher travel comfort. The same applies to on-board HVAC systems, where the mandate to avoid recirculated air can be used in the future to mitigate the spread of general and less dangerous respiratory diseases, reducing health externalities.

These are just some prospective options for improvement, but more are available for consideration in the post-pandemic transport policies, and the ARDUOUS approach highlighted some of the most relevant, although far from covering all the possible implications. The contextual complexity, including the fact that for some issues solutions are to be sought outside the mobility management sphere with very different actors, enables to reach only a relative optimum, with some problems left unsolved, typically: the magnitude of the losses incurred to local administrations and transit companies due to the lack of revenues, although compensated by minor expenditures, still to estimate; the consequences in terms of equity of some measures like teleworking, if becoming even partly structural on the poorer strata of the population.

The post-pandemic offers further potential for learning and innovation: the present experience evidences that current governance tools were not resilient enough to this emergency. Mobility governance shall address the “culture of the emergency” and revise the current planning and management practice, accordingly. Eventually, the need to redesign and/or retrofit vehicles, components and facilities will bring a new momentum in the research and development areas, as well as in the manufacturers’ fields.

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