Mobility Impacts of the second phase of Covid-19: General considerations and regulation from Tuscany (Italy) and Kentucky (USA)

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Abstract. The second phase of the virus Covid-19 is about to start a new configuration of accessibility to activities and cities. This phase, which will be able to see different restriction levels both between different countries and between successive periods, is the great challenge that the whole world is facing and which, if not managed in a planned and strategic way, risks turning into a further catastrophe. The social distancing rules imposed will necessarily lead to an escape from public transport in the cities, which could turn into total congestion of city traffic, leading the cities themselves to paralysis. We need a series of countermeasures that define new mobility capable of mitigating the effects of the mobility offer imbalance by intervening quickly, economically, and, in the short term, emergency on the whole transport chain. This article presents some possible actions to be put in place, and some mobility measures actually applied in Tuscany coastal area.

Keywords: Sustainable Mobility, Vehicle Routing, Covid-19, Mobility Management.

1 Introduction

The second phase of the virus Covid-19 will introduce new mobility concepts and behaviors with increased importance to individually based-transport mode. The European Commission's response to the virus prioritizes keeping citizens healthy. This includes keeping essential transport moving, for example, to transport medical supplies and other essential goods and, in the second phase, to maintain precautions through Personal Protective Equipment-PPE and individual distancing [2]. The effect of the social distancing rules, with all difference between their narrowness among the different European and Extra-European Countries will be a general decrease of Public Transport passengers both from the rail and road system (see figure 1 for the Wuhan region). These will due to citizen behaviors and from social distancing rules itself; if for the same number of passengers, when the social distancing within public transport is introduced, the capacity needs to increase. Therefore, the number of operating buses, trains, and trams will increase. [3].

This measure will be difficult to implement, especially in cities with a significant portion of transit trips, both because increasing trams and buses take time to change the operating program and, above all, because it would lead to an unsustainable economic balance, with an increase in the supply that would have a decrease in demand. The problem is less pronounced in cities with a high proportion of private automobile trips, as is the case in most American cities. Still, transit is important to many lower income populations, and in larger cities. Impacts on transit have a more profound effect on disadvantaged populations who may already be underserved, and who must go to work outside their home.

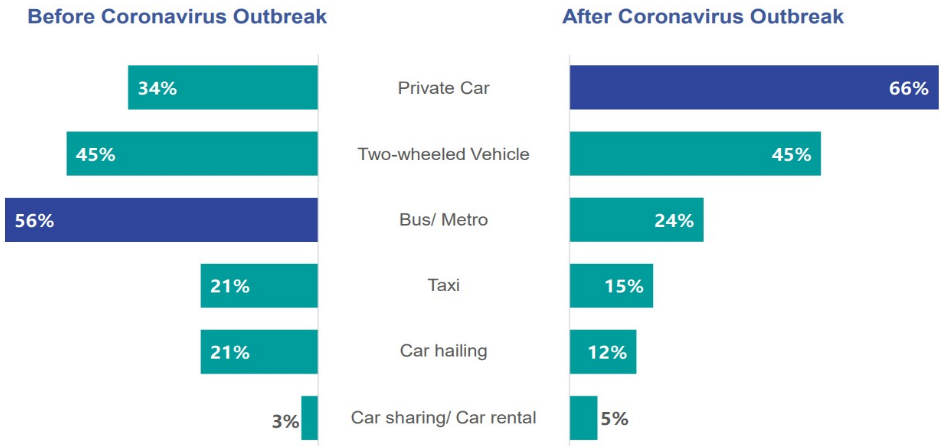

Fig. 1. Modal share in Wuhan Region before and after Coronavirus emergency (Source: [1])

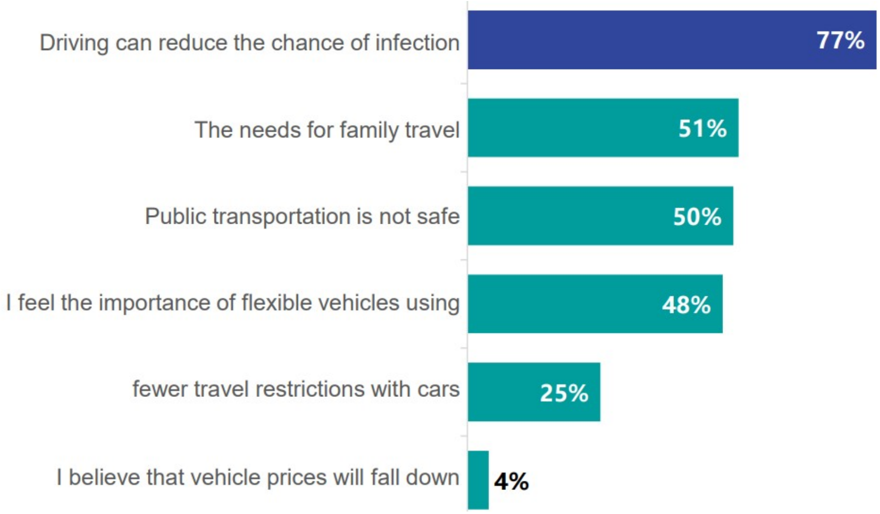

Fig. 2. Reason for new car purchase (Source: [1])

The motorization level (the number of vehicles per 100 inhabitants) will increase with the purchase of cars by even those who did not have this means of travel (figure 2 shows the percentage of non-car owners who have indicated that they want to buy a car in a sample survey within the Wuhan region of China). Another effect of Coronavirus second phase will be the practically reset of sharing mobility that needs to find other solutions to remain in the mobility market. Finally, the increase of individual mobility will foster growth in bike use and culture joined together with other sustainable mobility solutions (electric scooter and bike, mini-scooter, etc.).

The rest of this paper is structured as follows. In Section 2 we introduce some general considerations and possible measures (including non-actions) to lighten the future private vehicle traffic impact as much as possible while in Section 3, we present solutions adopted in Tuscany coastal area and considerations for American cities, exemplified by information from the State of Kentucky.

2 Possible sustainable mobility actions

The analysis of possible actions starts in introducing which of these it is good to avoid and not to implement. Administrations, instinctively in reaction to the shock due to the mobility blockage and to the pressure of business owners who want to resume activities quickly, could activate a change in the city's accessibility system, suspending the restrictions on access to controlled traffic areas, to pedestrian areas until the elimination or reduction of parking rates (case applied from 04/05/2020 in a famous Tuscany Municipality). Reducing the restrictions on car traffic would, however, only lead to a congestion acceleration with amplification of the problems indicated in the previous paragraph. It is, therefore, essential to maintain the regulatory regimes for parking and urban access before the onset of CoVID-19.

Fig. 3. An example of a pedestrian area extension (source [4])

Moreover, it is key in this phase, to develop an emergency mobility network and to study changes in urban roads to give light-mobility (including pedestrians, cyclists), and micro-mobility users more spaces, especially for pedestrians (see figure 3) near commercial activities, and reserved lanes to avoid congestion and encourage sustainable mobility. Such measures on mobility supply, taking into account the reference regulations are often feasible only in large cities like Milan, Berlin, Barcelona, Paris [4], where there are oversized lanes and many connections alternatives for city central nodes that could accommodate the mobility demand changes.

In this operation, the safety of weak mobility must not be left behind by only focusing on the current emergency needs. For example, a solution presented in a post-Covid manual as shown in Figure 4, the reductions of lanes width and admixtures of dangerous modes of transport is not safe for cyclists.

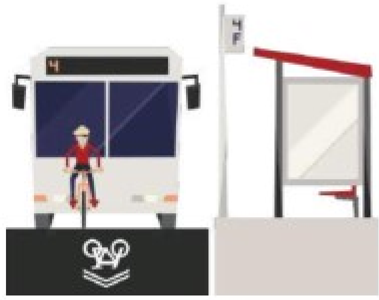

Fig. 4. An example of unsafe solutions for urban cyclists [3]

It is likely that many of the daily home-to-work or home-to-schools trips, initially made by train or bus, will now take place by car. A possible remediation would be to provide) parking areas at the urban cordon. From these parking areas sustainable mobility networks would then be used, such as bike lines, public transport "'organized' rides, ' or micro-mobility options (e.g., scooters).

It will be important to introduce incentives or restrictions to encourage use of the cordon parking lots andtake the sustainable mobility modes beyond and into the city center. Example incentives include Good_Go and SaveMyBike open-source rewarding platform [5, 6, 7, 8] that will be applied soon in some Tuscany Municipalities to incentive bike and foot trips inside the city (see figure 5). The reward system requires mobility management tools to achieve specific goals; in detail, it will be possible to:

- stimulate the use of all sustainable mobility (like the second and third competitions of figure 5);
- stimulate to the Park&Ride or Park&Bus at particular intermodal nodes (like the first competition in figure 5);
- stimulate the use of smart working hours and trips to avoid the rush hour overlaps and so to use train and bus network capacity at an optimal level;
- stimulate the use of a particular transport mode (like the fourth competition in figure 5).

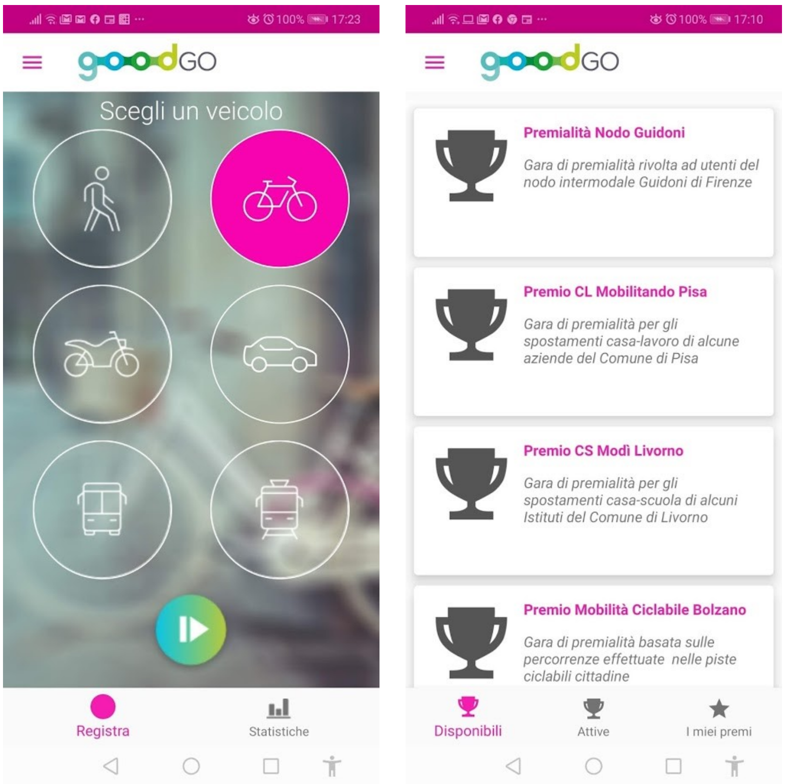

Fig. 5. The sustainable mobility competitions organized inside Good_Go platform and the system to register mobility modes used

The sharing-mobility, involving Car-Sharing, Bike-Sharing, and Car-Pooling must be rethought at this stage, for example in the following way:

- Car-sharing and Bike-sharing need to become long-period (6-12 months) of rental services, ensuring cleanliness during delivery and providing the vehicle on loan for use to the customer on an individual level;
- Car-Pooling at an peri-urban level (e.g., facilitated by BlaBlaCar) should be re-thought as daily commutes with different people could exacerbate the transmission of disease.

3 Measures applied in Tuscany center coastal area

In this section, we describe the ongoing methodology and analysis regarding some companies located inside the Province of Livorno. In this case, each company had its employees fill out a questionnaire to understand the actual travel behaviors including timetables,work locations, intermediate constraints on home-work trips, and future preferences travel arrangements. Figure 6 shows the start page of the survey/questionnaire.

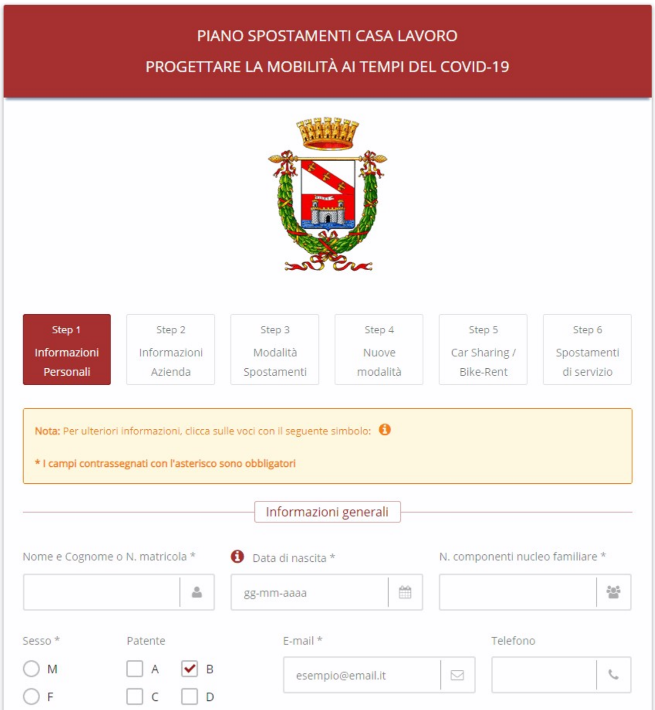

Fig. 6. The questionnaire for employees

The questionnaire was completed by about 300 employees from the 16 companies involved. A first analysis of the main features of the sample shows (see figure 7) that the use of private car goes from 46% in the summer to the 63% in the winter while the mean age of the sample is rather high.

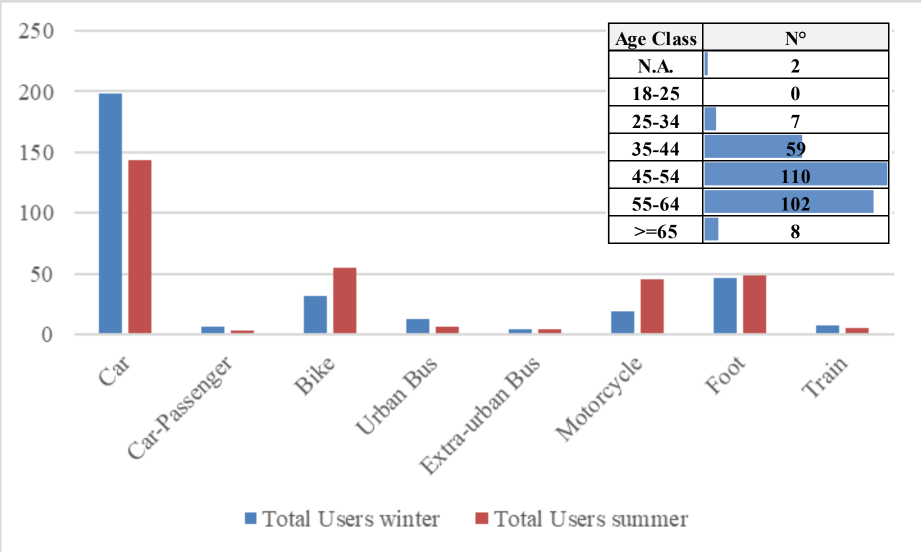

Fig. 7. The main features of the sample of respondents (the actual modal split and the age class)

Other important information collected with the questionnaire includes residence and work addresses, work times, and shifts differentiated by day of the week. Based on these data, home-to-work/HW desire lines have been reconstructed. For each employee, a desire line connects the residence with the workplace. Among these, two types of lines are developed, namely:

- the desire lines which concerned access routes to urban areas from neighboring suburban territories;
- the desire lines contained within urban areas.

The analysis was developed separately from the two desire lines clusters. The first group of lines consists of elements often isolated and coming from very distant territories. Groups of users having part of the overlapping home-work journey have been identified. Groups of employees who make up **fixed-composition car-pooling**, with compatible work start and end times have been designed (see the 'employees' pool in figure 8). Traditional self-organized car-pooling (like BlaBlaCar or others) cannot be widely used in the second phase of Covid-19, due to the random nature of the ride share match. Composition of fixed users groups facilitates safe travel management.

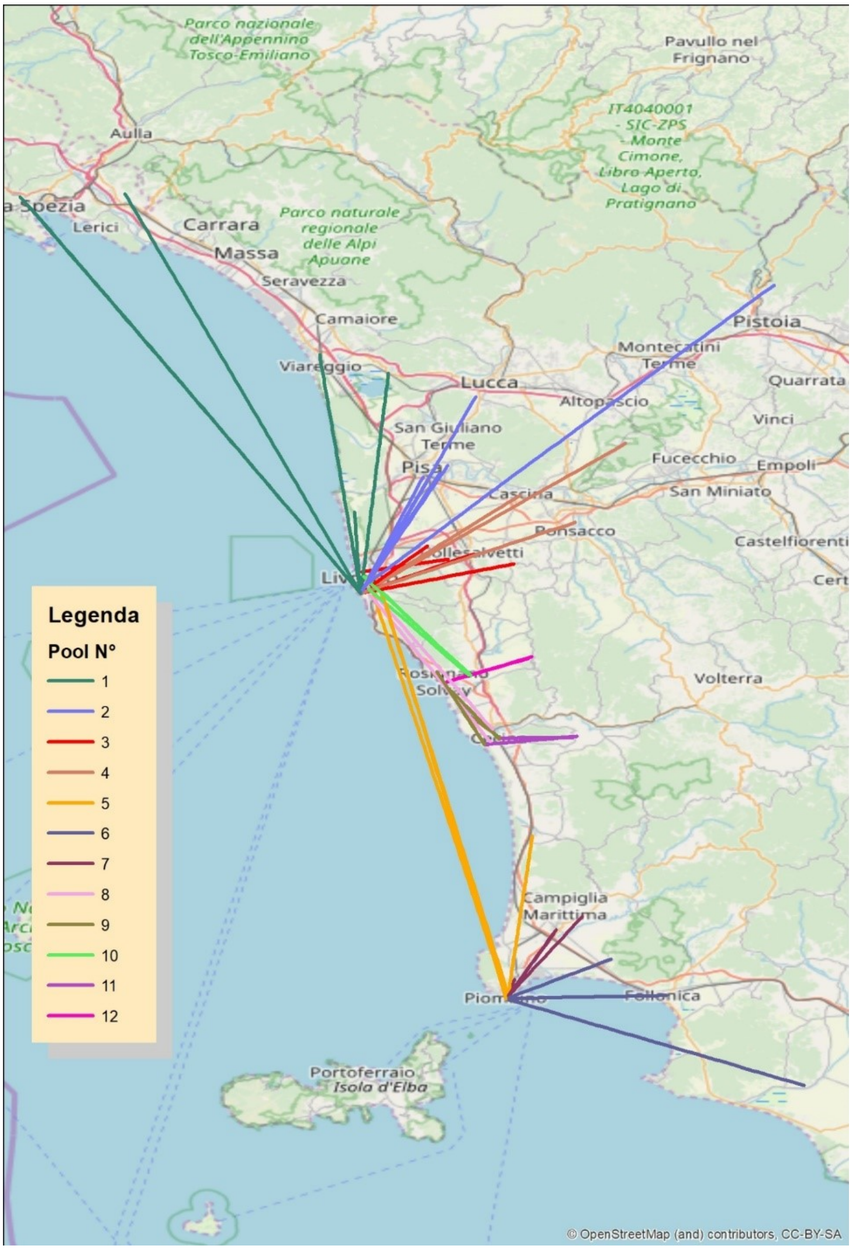

Fig. 8. The set of 'marginal' pools extracted

The second cluster of desire lines (figure 8) uses a vehicle routing algorithm to identify groups of employees who can go to work using public transport. The algorithm was also used to identify **public transport journeys with a fixed composition** (maximizing vehicle capacity) and provide the passenger with the security of always finding the same people on the bus. These fixed compositions, both in car-pooling and in urban public transport, also facilitate the identification of individuals to be quarantined in the event of contagion from Covid-19 by one of the passengers.

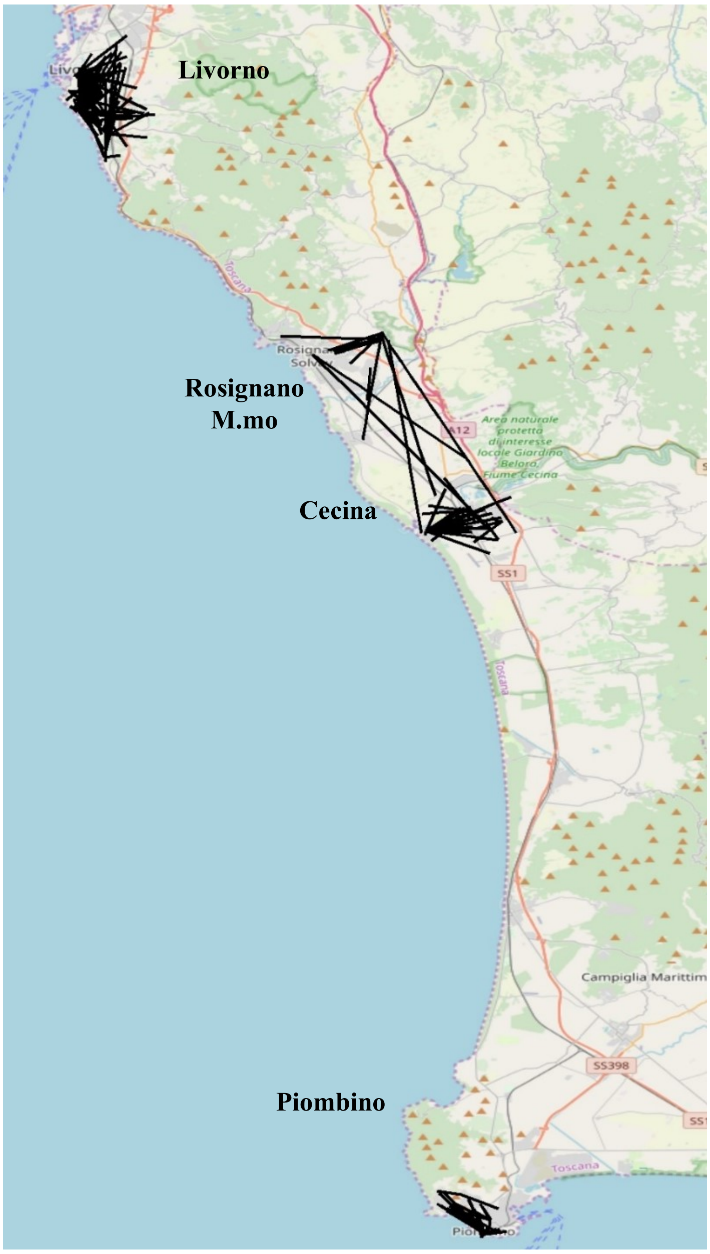

Fig. 9. The three clusters of 'local' travel lines

The second desire lines group was divided into three urban areas, that is to say the Piombino, Livorno center, and the continuous residential area between Cecina and Rosignano M.mo.

Between the many complex methodologies applied to study and model territorial dynamics [9, 10], we have chosen vehicle routing algorithms. In the following section, we describe the vehicle routing problem used and its features. Lastly, the results are presented.

3.1 The Vehicle Routing Model

The vehicle routing problem (VRP) is a superset of the traveling salesman problem where one set of stops is sequenced in an optimal fashion. In a VRP, a set of orders needs to be assigned to a set of routes or vehicles such that the overall path cost is minimized. It also needs to honor real-world constraints, including vehicle capacities, delivery time windows, and driver specialties. The VRP produces a solution that honors those constraints while minimizing an objective function composed of operating costs and user preferences, such as the importance of meeting time windows.

The VRP solver starts by generating an origin-destination matrix of shortest-path costs between all order and depot locations along with the network. Using this cost matrix, it constructs an initial solution by inserting the orders one at a time onto the most appropriate route. The initial solution is then improved upon by resequencing the orders on each route, as well as moving orders from one route to another, and exchanging orders between routes. The heuristics used in this process are based on a tabu search metaheuristic.

The basic form of Tabu Search (TS) is founded on ideas proposed by Fred Glover [11] based on procedures designed to cross boundaries of feasibility or local optimality, instead of treating them as barriers [12, 13].

The analysis shows that the 16 companies that responded are divided into 40 different total working locations located within the areas of the local clusters themselves.

The analysis saw the search for solutions, through local public transport, linked to a series of elements necessary to make the solution itself acceptable by users:

- Route with time on board of less than 30 minutes;
- Route starts from the bus depot, loads the employees at their residence and takes them to each different workplace;
- Arrival at the workplace from 30 to 5 minutes before work entry (home-work trip);
- Departure from the workplace from 5 to 20 minutes after the exit time (work-home trip);
- Constraint of vehicle capacity (taking into account its decrease due to social distancing of about 65/70%);
- Route constraints due to the one-way streets present in the road graph;
- Assumptions of an average commercial speed of 27 km/h, average between the commercial speeds of the current presented urban lines.

The Piombino Municipality example of led to the identification of three different bus journeys, for the three working shifts of the municipality employees, to be carried out with a 30-seater vehicle with a maximum capacity of 9 passengers per single race (all passengers work in Piombino Municipality).

Starting from a total of 31 possible users, it was possible to build a public transport service with a fixed composition that includes 27 (87% of the total). Figure 10 illustrates the three strokes linking home to work with the various intermediate connections.

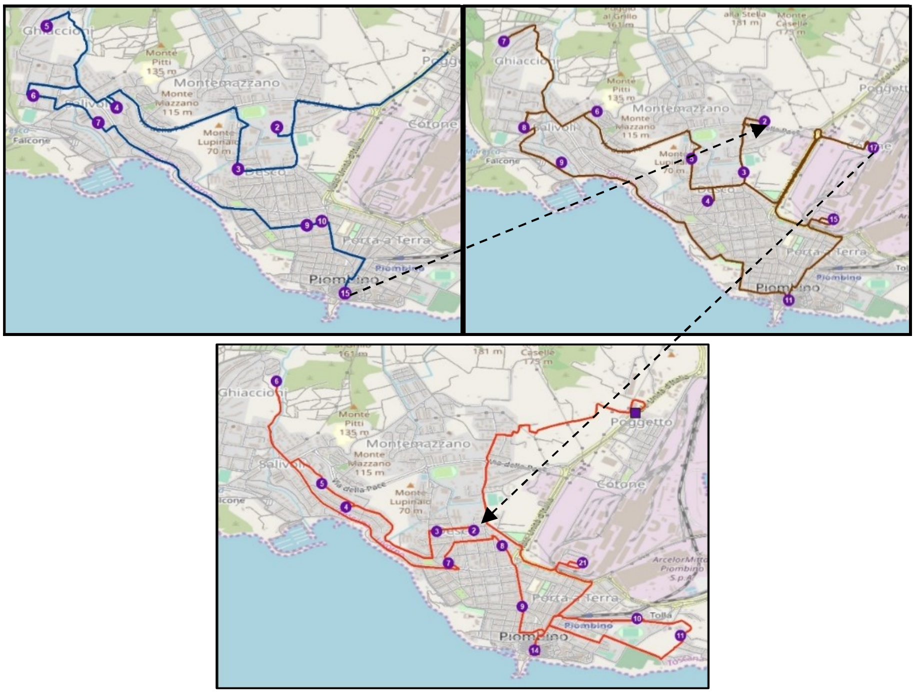

Fig. 10. The three fixed-composition public transport bus strokes with the link between them (dashed lines)

In the Cecina Municipality, we analyzed 21 employees of the Collodi Primary School. In this case, the analysis was simpler than before (Piombino case) because the work entry and exit time are the same for all employees. The results individuated a fixed 18 passenger bus ride with a length of about 19 kilometers covered in about 36 minutes, starting from the busses depot (see figure 11).

Fig. 11. The three fixed-composition

3.2 Conclusions and future developments

The twelve pools/clusters using fixed-composition car-pooling took about 54 users, who would have gone to work independently by driving cars. With only 12 car-pooling groups, a 77% decrease in traffic show both environmental gas emission and congestion reduction benefits in the destination urban areas. This case study showed a practice-ready solution for the short term.

With the second solution based on fixed-component public transport rides, an efficiency of 81% was achieved in the Piombino Municipality. In the Cecina-Rosignano area, a 94% decrease in the equivalent circulating vehicle fleet was achieved. (solution to be implemented in the medium term as it involves a modification of the public transport service scheduling) A summary of all case studies is presented in Table 1, below.

Table 1. Results coming from the Case Studies analyzed

Case Study	Type	Decrease in circulating cars
Whole Livorno Province	*Fixed car-pooling fleet*	77%
Piombino Municipality	*Fixed Public transport fleet*	81%
Cecina-Rosignano area	*Fixed Public transport fleet*	94%
Livorno Municipality	*Fixed Public transport fleet*	in progress

The bicycle use incentive is just getting underway in the Municipality of Livorno and in Rosignano Marittimo, providing rewarding actions differentiated between users type (i.e., long-term participation programs for residents/commuters, with prizes of higher value such as discounts on the purchase of electric bicycles or scooter and more immediately rewarding solutions for tourists, such as discounts on products sold by local businesses).

3.3 Considerations for American cities

The solutions offered in this paper would seem to be applicable and perhaps more helpful to many larger American cities. Still, the sustainability aspects are helpful even to smaller areas independent of immediate public health concerns.

Kentucky is a relatively lower population state, with between 4 and 5 million residents. Its largest city, Louisville, has one of the lowest transit usage rates in the country at 2.7 percent [14]. Clearly, even a significant reduction in this low of a percentage would do little to cause the auto-centric problems likely to be experienced by more transit dependent regions.

Indeed, the planned response to the crisis in the Kentucky region is focused more on safe usage of public transit as well as lowering demand. However, in most American cities, the problem has been too little demand to support more robust transit services. So, like many other aspects of dealing with the pandemic, there are winners and losers.

The types of specific responses include:

- Transportation Cabinet (DOT) Secretary Jim Gray has issued Emergency Declarations suspending certain regulatory restrictions to support the supply chain [15].
- Transit authorities have implemented various onboard social distancing procedures including limitations on what types of trips can be made, hours of service, stop changes, and hygiene directives [16] [17].
- The University of Kentucky has recommended walking and alternative ways to accomplish the "last mile" to reduce transit demand [18].

3.4 Closure

This paper presented the context and need for a new mobility, at least during and probably after the global pandemic. For this period, several feasible approaches are suggested. Recognizing that each region will need, and be able to implement, these strategies, they were designed to both address the ongoing emergency as well as provide sustainable solutions for years to come. The application of the indicated transport measures will open, in a future monitoring phase, the possibility to evaluate the effective decrease in carbon emissions [19].

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