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Planning policies for the driverless city using backcasting and the participatory Q-Methodology

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ABSTRACT

Autonomous vehicles (AVs) can potentially bring about major changes in cities. Anticipatory planning approaches may provide valuable opportunities for fostering desirable transitions and pre-empting undesirable impacts. This research employs a combination of two methods to define the key policies to support a transition to the desirable driverless urban futures: the backcasting approach and the participatory Q-method. The combination of these techniques aims to identify different viewpoints about policies with the purpose of determining more effective and more acceptable options. The article analyses viewpoints from 20 citizens and 10 experts. The results point to the existence of two main viewpoints about the most and least desirable policies. The first viewpoint centres around increasing pedestrian mobility and promoting a more compact city. The second viewpoint centres around expanding transit-oriented development (TOD) and new networks of green spaces. Meanwhile, support for regulation-oriented policies to discourage the use of private motorised vehicles was relatively low. This research not only sheds light on the different viewpoints on the policies to achieve more desirable urban visions, it also illustrates the tensions and disagreements that may arise in the process of policy-making.

1. Introduction

Depending on the conditions of introduction, autonomous vehicles (AVs) in cities have the potential to enhance or hinder the transition to more sustainable patterns of mobility (Papa & Ferreira, 2018). AVs potentially represent the most important revolution in the field of mobility since the invention and widespread use of conventional automobiles. Several researchers have highlighted the importance of private motorised vehicles in generating urban sprawl typical of American cities (Glaeser & Kahn, 2004; Nechyba & Walsh, 2004), a phenomenon which is also increasingly common in European cities (Hennig et al., 2016; Ludlow, 2006; Muñoz, 2003). With the advent of AVs, there is a risk that these processes of urban sprawl will be further enhanced due to the convenience and efficiency of journeys. On the other hand, they could potentially help to improve cities by freeing up circulation and parking spaces previously dedicated to cars.

These uncertainties associated with AVs have led researchers to highlight the need to plan ahead for their introduction in order to foster desirable transitions and pre-empt undesirable impacts. This requires a strong focus on desirable city or regional visions to avoid an unplanned gradual adaptation of cities to new modes of transport as happened in the past (González-González et al., 2019; Gruel & Stanford, 2016; Papa & Ferreira, 2018; Vitale Brovarone et al., 2021). One planning technique for this purpose is backcasting which allows the normative definition of one or several desired futures, as well as the identification of the measures that should be implemented to achieve them (Banister & Hickman, 2013; Dreborg, 1996; Geurs & Van Wee, 2000). Research employing this approach can be carried out in collaboration with experts, researchers and/or citizens who provide opinions or assessments on policies to be implemented (Soria-Lara et al., 2021; Soria-Lara & Banister, 2017a, 2017b). Encouraging the engagement of citizens and stakeholders affected by the implementation of AVs is useful, not only to define and rank the policies to be implemented but also to identify points of consensus and dissent (Mladenović et al., 2020).

Due to the complexity of identifying transition paths, very little research has been carried out using this approach to establish policies/policy packages coherent with the desired future, and those that do exist do not consider citizen participation which represents a critical gap in

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the literature, as researchers have recently noted (see e.g. Soria-Lara et al., 2021), since active citizen support and involvement of key stakeholders is crucial for finding and implementing successful policy measures. This paper aims to contribute to address this issue by combining the participatory Q-method with the backcasting approach.

More specifically, this research focuses on the phase of backcasting in which policy packages that contribute towards desirable visions of the future are identified. For this purpose, a backcasting approach was combined with the Q-method, in which a group of people were invited to rank a series of statements to identify diverse points of view of citizens and experts (Curry et al., 2013; Kougias et al., 2020; Watts & Stenner, 2005). Participants were asked to consider a set of 41 policy measures in terms of effectiveness and acceptability of achieving more desirable urban development. This type of approach has not been applied before and therefore represents a novel contribution to research. Combining planning (backcasting) and participatory techniques (Q-method), this article develops an innovative approach that helps to identify a broad set of policies that can contribute to desirable urban development, highlight different points of view that experts and citizens have in relation to these policies and detect consensus and dissent that may arise in the planning process.

The article is divided into four parts. Section 2 reviews the backcasting approach, the participatory processes usually employed in planning urban futures, and the use of Q-method. Section 3 explains the key steps of the participatory methodology proposed, and the details of the consultation carried out. Section 4 presents the main results of the consultation. Finally, Section 5 discusses the results obtained and summarizes the main conclusions of the study.

2. Planning urban futures with autonomous vehicles

2.1. Scenario-based planning methods

Among the set of methods that can be used in the field of urban and transport planning, scenario building is one of the best known, given the need to construct descriptions of a possible and probable future in order to propose different courses of action in the present. There are three main groups of scenario building techniques (Banister & Hickman, 2013; Börjeson et al., 2006): predictive, exploratory and normative. These correspond respectively to three possible questions about the future in a given planning domain: what will happen in the future, what could happen and how to reach a desired goal. Of these planning methods, predictive and exploratory techniques are the scenario typologies most widely used in transport and urban planning (e.g. Chakraborty & McMillan, 2015; Lyons & Davidson, 2016; Melander, 2018).

Predictive techniques seek to select the most likely scenario that will occur in the future, either given the current trend of the system under study (Business-as-Usual scenario), a policy change or the occurrence of a specified event (What-if scenarios) (Börjeson et al., 2006). Such predictions are useful in situations where no substantial changes are expected and are usually carried out within the framework of some kind of formal model that attempts to replicate the fundamental characteristics of the functioning and equilibrium of the system under study.

On the specific topic of driverless urban futures, a substantial part of the studies uses scenarios in order to develop forecasts (see Stead and Vaddadi (2019)). Thus, Gruel and Stanford (2016) investigate how autonomous driving might affect the attractiveness of car travel, how this in turn might affect mode choice, and thus the wider transport system. Fulton et al. (2017) study three revolutions that are underway: vehicle electrification, automation and shared (on-demand) mobility. How each of these changes develops and how they interact will have important implications for transport and for implementing policies that steer these revolutions in optimal directions for cities.

Exploratory techniques, on the other hand, are based on the systematic construction of scenarios that can plausibly occur in the future, even if it is uncertain whether they will actually happen. Scenario building is typically done by constructing a matrix structured around the main factors that are considered to be key to the future evolution of the system (Schwartz, 2012). This type of technique allows planners to consider different factors and situations that could arise while accepting the uncertainty associated with the future.

Most recent studies on the introduction of AVs and their implications for urban form and the structure of cities employ exploratory approaches (see Stead and Vaddadi (2019)). Thus, Milakis et al. (2017) use scenario analysis to identify plausible paths of future development of AVs and estimate the potential implications for traffic, travel behaviour and transport planning over a time horizon up to 2030 and 2050. Key factors for future AVs development were identified and four scenarios were constructed assuming combinations of high or low technological development and restrictive or supportive policies for AVs. In a report, Bouton et al. (2015) analyse four key technological changes, in-vehicle connectivity, electrification, car sharing and autonomous driving, which they consider must work together to achieve a more sustainable mobility.

Finally, the normative method of scenario building is based on the idea of achieving a desired goal or set of goals. Achieving this desired scenario may involve the application of a set of policies that simply adjust the baseline situation (preserving scenarios) or, if the desired scenario is deemed unachievable under current circumstances, another set of policies that contribute to structurally changing the system under study (transforming scenarios) (Börjeson et al., 2006).

Backcasting technique falls into this second category. This approach is based on the idea of establishing a vision of the desired future and identify the goals to be achieved and steps/policies to implement to reach that vision (Dreborg, 1996). It is considered a particularly suitable method when disruptive changes are expected that require a drastic modification of the policies to be implemented. Backcasting is increasingly applied in futures studies in the fields related to urban planning (Bibri & Krogstie, 2017; Carlsson-Kanyama et al., 2003; Phdungsilp, 2011) and transport (Åkerman & Höjer, 2006; Banister et al., 2000; Höjer & Mattson, 2000; Hickman & Banister, 2014; Soria-Lara & Banister, 2017a).

The backcasting process is generally structured in three phases (Soria-Lara & Banister, 2017b): 1) the visioning phase of defining the desired future image; 2) the policy packaging phase of identifying policy measures and organising them temporally into policy packages that can lead to that desired image; and 3) the appraisal phase of evaluating policies to try to foresee their effectiveness, social acceptance and potential implementation problems. Each phase can be carried out by groups of researchers (think-tank backcasting), by experts (expert-led backcasting) or also through more open participatory processes (participatory or collaborative backcasting), either through the involvement of experts, interest groups or the general public (Doyle & Davies, 2013; Robinson et al., 2011). The approach offers opportunities for involving people who are not directly linked to the design process.

Despite interest within the field of planning, the specific use of backcasting for autonomous vehicles, although has increased in recent years, it still relatively limited. Most studies have focused on the visioning phase (Chapin et al., 2016; González-González et al., 2019; Höltl et al., 2018; Marchau & van der Heijden, 2003; Papa & Ferreira, 2018; Staricco et al., 2019; Vaddadi, 2017), while relatively fewer studies have focused on identifying policy packages and pathways (Dragomanovits et al., 2020; González-González et al., 2020; Karlsson & Fredriksson, 2019; Staricco et al., 2020; Vitale Brovarone et al., 2019, 2021) or on the final appraisal phase (Nogués et al., 2020).

With regard to the policy packaging phase, the focus of this paper, only a few studies have considered this in relation to visioning. Examples include Karlsson and Fredriksson (2019) who explored the effect of AVs on urban public transport and defined the conditions for a sustainable future, the gaps between the current reality and the desired future, and the actions and strategies that could help to achieve it. Dragomanovits et al. (2020) developed an online decision-making tool for AVs which included a backcasting subsystem for identifying interventions that could lead to desirable city visions. González-González et al. (2020) focused on identifying four scenarios and 37 relevant planning measures for AVs in urban settings, encouraging sharing mobility strategies and a significant release of public space linked to restricted access to central parts of the city. Meanwhile, Vitale Brovarone et al. (2019, 2021) and Staricco et al. (2020) focused on defining policies to guide the diffusion of AVs grounded on the application of the superblock model.

Most of these policy packaging studies outlined above have applied participatory backcasting based on consultation with experts and decision makers. In other transport backcasting studies, authors such as Soria-Lara and Banister (2017a) have also employed participatory methods, involving practitioners and policy makers, who were asked to group different transport policies into packages and define policy pathways to achieve the desired vision. Moreover, this participation allowed actors to assess the suitability of the diverse packages, as well as their political and financial feasibility. Tuominen et al. (2014) also applied pluralistic backcasting to the definition of policy packages through a participatory process with transport experts, who also had to consider the timing for implementation of the measures in the period 2010–2050.

Obtaining visions of the future, as well as policy proposals and their evaluation, that are ground-breaking and unpredictable in collaborative backcasting processes can be difficult (Soria-Lara et al., 2021). This may be due to the fact that experts and stakeholders may tend to make proposals that are based on linear projections of the current situation. To minimise this problem, some research has applied a participatory backcasting method involving people outside the core group that elaborated the proposal (Robinson et al., 2011; Soria-Lara & Banister, 2017b; Tuominen et al., 2014). Involving a wide group of citizens can be particularly useful as it can provide more varied ideas.

2.2. Participatory processes and Q-Methodology

Urban and transport planning can be strengthened and legitimized through the use of participatory techniques. Such techniques allow for the exchange of information about the perceptions, attitudes and values of those affected by planning and the stakeholders designing the planning (Mikkelsen, 1995). This enables planning to be more informed and more widely accepted by society, thus increasing its chances of being successful.

According to Glenn (2003), participatory methods can be differentiated into four broad groups: (1) conducted in one location to a small group of participants (<100 people); (2) conducted in one location to a large group (hundreds to thousands of people); (3) conducted in multiple locations to a small group; and (4) conducted in multiple locations to a large group. Type 1 includes participatory techniques such as focus groups, future search conferences, VisionQuest and Q-method. Compared to top-down planning methods, participatory methods have both strengths and weaknesses. Strengths include the ability to coordinate different actors, the shorter time needed to obtain feedback relationships between the actors involved, and the strengthening of the planning processes by considering potential conflicts and contrasting values of stakeholders (Ernst et al., 2018). On the other hand, weaknesses can also be cited such as superficial analyses of the problems encountered in the planning process, the lack of plausibility of the results obtained (Ernst et al., 2018), the lack of transparency of the procedure (McGookin et al., 2021) and the excessive influence of actors who can manipulate the process in their own interest or create excessive polarisation (Glenn, 2003).

Among the participatory methods, Q-method can be combined with backcasting in visioning processes (Curry et al., 2013) or in the definition of paths to the future (Kougias et al., 2020), focusing on the identification of different viewpoints of a group of individuals (Watts & Stenner, 2005). These visions are obtained by assessing a series of statements on the topic collected from various sources, such as scientific literature, working documents or social media.

The Q-method was introduced by William Stephenson in 1935 as a mixed method combining qualitative and quantitative approaches (Newman & Ramlo, 2010; Stenner & Stainton-Rogers, 2004). Q-method allows qualitative aspects of human subjectivity such as preferences and opinions to be studied using statistical analysis tools, such as correlation and factor analysis, to establish and describe the different views that exist on a topic. This methodology has proven particularly effective for topics that cannot be easily measured with reliable quantitative indicators or for which large representative samples of the population cannot be obtained (Ellingsen et al., 2010; Wilson et al., 2008).

The Q-method has a relatively long history in some academic fields, including political science, education, human geography, sociology and psychology, as well as the health sciences (Cross, 2005; Eden et al., 2005; Gao & Soranzo, 2020; van Exel et al., 2015). Although the approach has been employed in the area of transport and urban planning (e.g. Brůhová Foltýnová et al., 2020; Stapper et al., 2020), its use has been fairly limited to date. Its application to disruptive innovations, such as AVs, offers new opportunities to determine and understand the variety of views in the population. This is relevant for identifying the most and least efficient and accepted policies to guide the deployment of new technologies such as AVs.

The Q-method has only been used a few times in research concerning AVs. One example is the paper by Milakis et al. (2018), which focused on the potential impacts of AVs on accessibility and location decisions of the population. A second example is the paper by Zhou (2020), which examined the impacts of AVs on economic development, energy consumption, social equity and public health. In a third example, Lee and Ahn (2020) characterise typologies of potential users of AVs. A fourth example is the paper by González-González et al. (2023) in which the Q-method was used to establish desirable future visions of the driverless city, based on dimensions related to urban design, society, economic development, environmental protection and mobility and transport use. These contributions illustrate that the application of Q-method to the study of AVs is still in its infancy.

3. Participatory policy packaging using Q-Methodology

This research employs the Q-method in the context of backcasting with the aim of clarifying the possible existence of different views on the urban and transport policies or sets of policies that may be necessary to achieve a desired future of cities when AVs are implemented. The application of this combined methodology, focusing on the second of the backcasting phases, is developed in the stages detailed in Fig. 1.

3.1. Definition of the concourse and key Q-set

The definition of the concourse consists of the selection of all possible statements that may reflect existing opinions on the topic under investigation. The concourse should contain many more statements than will eventually be presented to the selected persons in order not to bias the possible opinions that may be present among individuals (Brown, 1980). To do so, statements can be collected from sources on public debates on the topic, such as Twitter, or previous participation carried out for other studies, such as the elaboration of the Master Plan of the city and others.

In this case, the concourse focuses on the selection of policy measures from various thematic areas to guide the city planning, both from the urban and transport point of view, towards a desired future considering the existence of autonomous vehicles. The starting point was the consultation on the ideal city of the future carried out by González-González et al. (2023), in which three visions were detected (citizen-centred, disruptive and business as usual). In order to select the policy measures to be assessed, the statements of the three visions that scored highest in positive (most desirable characteristics of the city) and in negative (least desirable) were first extracted (Annex 1), to identify

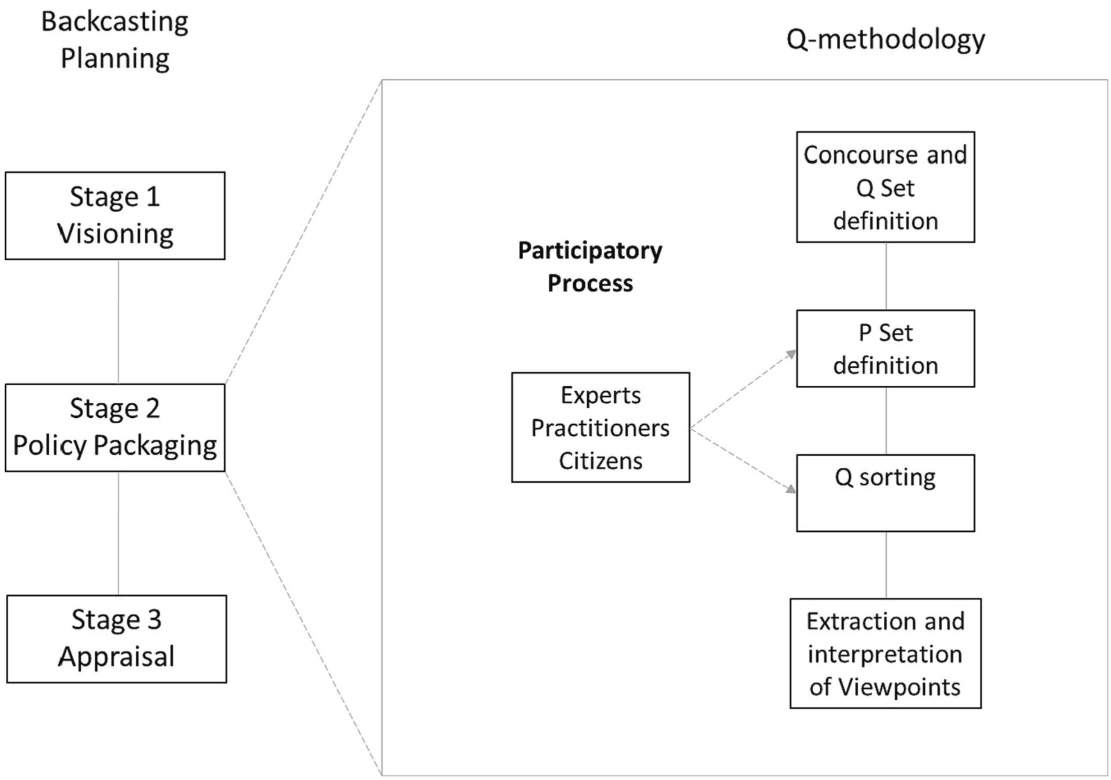

Fig. 1. Proposed methodology.

goals and issues that could lead to greater consensus for all. From this inventory, policy measures were sought that could cover and be directly related to all the visioning statements list. For this purpose, measures were collected from different sources, particularly academic studies on planning policies (e.g. Givoni et al., 2013; Kalkuhl et al., 2018; Pojani & Stead, 2015; Razin, 1998; Szarata et al., 2017; Gruel & Stanford, 2016; Wiseman, 2017; RPA, 2017; González-González et al., 2020; Staricco et al., 2020; Vitale Brovarone et al., 2021).

After an initial review of the scientific literature and planning documents, a provisional list of 60 policy measures was obtained, which was later reduced to 41 statements (Table 1), a more manageable number for inclusion in Q-set, reflecting the full spectrum of desired views/perspectives of the three ideal visions defined by the participants. Among these 41 statements, there are policies of the four most common types: 9 market-oriented (M), 14 regulation-oriented (R), 12 public infrastructure or services (P) and 3 educational and awareness-oriented (E), and another 3 related to regulatory and public infrastructure (R-P). Some of the policies are generic and applicable to many urban contexts, regardless of the presence of AVs, whereas others are more focused on autonomous vehicles and their relation to the city as a whole (statements 22–26, 29–36 and 40–41).

3.2. Selection of the P-set

The P-set refers to the group of people who are part of the participation process and carry out the ordering of the policies presented in the Q-set. Since the Q-method aims to establish whether different views exist among people, and what these views consist of, the number of participants does not necessarily have to be very large, as it is not intended to establish whether these views are representative of the general population (Corr, 2001; Valenta & Wigger, 1997). In general, Q-method based studies have been applied to P-sets smaller than Q-sets, somewhere between 10 and 40 persons (Dryzek, 2005).

In this study, the same 30 participants from the visioning phase were selected to ensure that they had a minimum level of knowledge to provide well-informed opinions (Kougias et al., 2020) and able to express how they believe the desired future defined could be achieved. This involved a group of 20 citizens and 10 experts in urban and transport planning from the Autonomous Community of Cantabria, in North Spain. The main city and capital of this region is Santander, a medium-sized city with of approximately 173,000 inhabitants. Participants were explicitly told that the policies to be applied need not necessarily apply to Santander, but to a similar type of city: a traditionally compact city, with a diversity of uses in its urban centre, which is undergoing a certain process of population dispersion towards neighbouring municipalities and towns.

The survey was conducted on the end of July 2021. The gender distribution of participants was fairly even, with a high representation of young people: 23 % under 20 years-old and another 33 % between 21 and 35 (Table 2). High representation of young people was deliberate since they will be the most affected in the longer term by the introduction of AVs. All participants involved were under 65 years old. As for the experts, 40 % were from academia and 60 % from the public and private sectors. Around half of the experts were from land-use planning related professions while the other half worked in transport planning. Most participants claimed some knowledge of AV technology but not extensive knowledge.

3.3. Q-sorting

In this phase of the Q-method application, the participants were asked to rank the policies presented in the Q-set on a scale from −5 (strongly disagree) to +5 (strongly agree). They were contacted via email to perform the ranking on a digital form. In addition, they were asked to read the 41 Q-set policies in detail before making their assessment. As usual in Q-method studies, a forced quasi-normal distribution was chosen to perform the sorting (Fig. 2). This type of distribution allows for fewer statements to be placed at the extremes of the distribution and more in the neutral area in between, as well as for the distribution of the statements to be symmetrical, facilitating the

Table 1
Q-set statements on urban planning, social and mobility policy measures to achieve desired driverless future cities.

N°	Type	Statements on urban planning, social and mobility policy measures to achieve desired driverless future cities
1	R-P	Give priority to pedestrians over other modes, by means of more pedestrian crossings, longer crossing times at traffic lights, signage, etc.
2	P	Create more infrastructure for pedestrians, by pedestrianizing main streets, shopping streets, street with many services and facilities, etc.
3	P	Improve pedestrian routes by widening pavements to facilitate the movement of people with reduced mobility, children and the maintenance of social distance
4	P	Create safe pedestrian routes, such as the Safe Routes to School programme
5	R	Designate central urban areas with restricted motorised access, except for special or emergency vehicles
6	R	Restrict motorised traffic within some streets in central urban neighbourhoods to convert them into rest, play and recreation areas (superblocks)
7	R	Plan urban developments with a mix of residential, office, service and retail uses
8	R	Promote regulations to facilitate residential areas with ground floor retail, services and neighbourhood shops
9	R	Establish regulations to limit urban developments characterised by the separation of uses in the periphery (exclusively residential, exclusively commercial areas, etc.)
10	M	Higher economic rates (green taxes) for the development and purchase of housing away from the urban core
11	R-P	Encourage housing, workplaces, service facilities to be <15/20 min away on foot, by bike or public transport
12	P	Create a system of green spaces spread in all areas of the city forming green axes, including tree-lined streets, parks, gardens, etc.
13	R	Encourage residential developments with a density of at least 50–60 houses/ha. (medium density), with a predominance of collective housing as opposed to single-family dwellings
14	R	Establish urban quality standards for liberated areas, indicating minimum and/or maximum density, uses, typologies, vegetation, urban furniture, etc.
15	E	Encourage citizen participation in the design and typology of use of new car-free urban spaces
16	M	Economic incentives or fiscal advantages to promote small economic activities in the new car-free spaces
17	P	Locate workplaces in the vicinity of public and shared transport interchanges or provide transport interchanges in areas of high employment activity
18	P	Improve the technology of public transport (computerisation of payment systems, information on waiting times and occupancy, etc.)
19	P	Increase the frequency, stops and lines of public transport services
20	P	Create transport interchanges where diverse transport modes (public, shared and private) can be combined
21	M	Lower the price of public transport, and establish financial aid for access to public transport for people with reduced mobility, people at risk of social exclusion, etc.
22	M	Lower the Price of shared mobility, and establish financial aid for access to shared mobility (purchase or use) for people with reduced mobility, people at risk of social exclusion, etc.
23	E	Establish educational campaigns to promote public transport and shared mobility
24	P	Create apps and tools that promote the use of shared vehicles
25	R	Delimit exclusive lanes for public transport and shared autonomous vehicles in the city centre
26	R	Reduce the number of available parking spaces in the city centre and locate them in the periphery, including charging points
27	M	Establish economic taxes to restrict and discourage the use of single-passenger vehicles
28	M	To create an access fee for privately-owned vehicles to the city centre, higher for single occupant vehicles
29	M	Increase taxes on the purchase of a car for private use only
30	R	Increase the environmental requirements for a vehicle to be allowed to circulate
31	E	Educational campaigns to change the view of private car ownership as a social status symbol
32	M	Establish fees to restrict the circulation of autonomous vehicles without passengers driving around in order to get users
33	M	Establish vehicle road charges per kilometre travelled, to penalise medium/long distance commuting
34	R	Replace old service stations with new pick-up and drop-off points for autonomous vehicles
35	P	Sharing public transport shelters for shared autonomous mobility
36	P	Create pick-up and drop-off zones for autonomous vehicles (private or shared) only in specific zones at the edges of delimited central areas
37	P	Create logistic pick-up/drop-off points for parcels in each neighbourhood that are accessible by walking or cycling
38	R-P	Regulate individualised delivery of goods only by drones and provide drone delivery fleets
39	R	Regulate motorised mobility of people by air only where this option is possible, leaving the street for walking and cycling
40	R	Allow mobile retail stores shops in autonomous vehicles, but set a maximum percentage of total urban commerce
41	R	Limit the use of private autonomous vehicles for inter-urban trips to park-and-ride zones, where they switch to public transport, shared transport or bicycles to reach the city centre

Table 2
Characteristics of the people surveyed (n = 30; Experts n = 10; Citizens n = 20).

Characteristic	Categories	%
Expert	Yes	33.3
	No	66.6
Experts field of work	Urban/spatial planning	50
	Transportation planning	50
Experts professional profile	Academic world	40
	Public and private sector	60
Gender	Male	50
	Female	50
Age	≤20	23.3
	21–35	33.3
	36–50	30
	51–65	13.3
Degree of knowledge about AVs	I have heard on the subject	86.7
	I have worked on it	0
	I know nothing about it	13.3

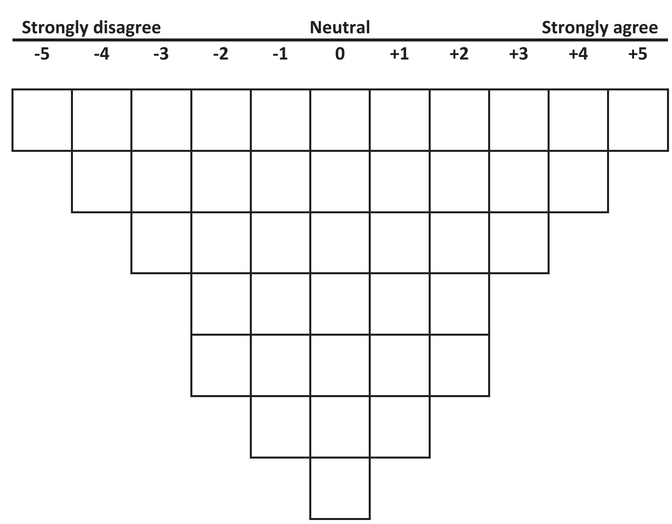

Fig. 2. Forced distribution to partial sorting the 41 statements.

subsequent correlation analysis of the Q-sorts (Brown, 1980).

3.4. Obtaining and interpreting viewpoints

By analysing the Q-sorts (i.e., the complete rankings of the statements provided by the selected experts and citizens), it was possible to obtain different points of view in the P-set. A standard procedure based on Principal Component Analysis (PCA) was then applied to aggregate the Q-sorts. Subsequently, Varimax rotation was employed to maximise the sum of variances of the squared loadings, which facilitated interpretation of the factors. Finally, the participants/Q-sorts that load significantly on each factor were studied to select those that are shared by at least two individuals (Rajé, 2007). This was done to ensure that the factors selected are views that are truly shared by several members of the P-set. These operations were performed using the specialised Q-method software KADE v1.2 (Banasick, 2019). The use of PCA and Varimax was chosen over alternatives, such as centroid factor analysis and judgmental rotation, since they offer a more replicable procedure. The selected factors were interpreted in terms of standardized scores (Z-scores) of the different statements, especially those that showed a higher degree of positive or negative agreement among the respondents (i.e., higher or lower Z-scores).

4. Results

4.1. Statistical results

The PCA applied to the ratings of the different statements yielded eight factors with eigenvalues >1 and a total explained variance of 73 % (Table 3). Considering the factor loadings, in six of the eight factors (1, 2, 3, 4, 5 and 7) at least two individuals/Q-sorts were purely loaded, i.e., they were significantly associated only with that factor. In total, these six factors represent 27 loaded individuals and 16 purely loaded individuals on only one factor (Table 3). In the specific case of the experts, they were loaded on all the factors except factor 6, so it cannot be said that they clearly predominate on any of them with respect to the rest of the individuals surveyed.

4.2. Screening of factors

As the last step of the method, the meaning of each of the views/frames obtained was interpreted through the statements that received the highest agreement and disagreement from the loaded individuals (high or low z-scores). Attention was paid to whether the valuation of a statement was clearly different from that present in the rest of the viewpoints (distinguishing factors). The two factors that presented at least three purely loaded individuals (factor 3 and 5) are considered first, and only secondly and, more briefly, the remaining factors (1, 2, 4 and 7) that presented fewer individuals clearly framed in them. In the following text, the factors are referred to as frames since their meaning are interpreted according to the level of support attached to them by the participants.

4.2.1. Frame 3 – supporting pedestrian mobility and public transport

The policies to be applied according to this frame (Table 4) are based on enhancing sustainable mobility, giving greater priority to pedestrians in the streets (ST1) and improving pedestrian routes and pavements, especially for the most vulnerable groups (ST3). These policies are in line with other studies that consider them to be very effective measures to favour sustainable mobility (Nogués et al., 2020). This policy would also be complemented with the reinforcement of public transport through cheaper prices for the service or through direct aid to groups with access problems (ST21) and by improving the technological capacities of the service (ST18). Likewise, shared mobility was considered important by participants, including through the establishment of

Table 3
Factor loadings matrix.

Respondents/sorts	Factors							
	1	2	3	4	5	6	7	8
1	−0.12	−0.08	0.08	0.00	0.78*	−0.21	0.28	0.17
2	−0.10	−0.02	0.74*	−0.26	0.07	−0.11	0.20	−0.01
3	0.39	−0.22	0.28	−0.03	0.33	−0.22	0.54	−0.11
4	0.19	−0.03	0.29	0.23	0.54*	0.06	0.28	0.18
5	0.15	0.33	0.15	−0.03	0.03	0.07	0.79*	0.05
6	0.37	0.38	0.35	0.33	0.15	−0.30	−0.16	0.20
7	0.08	−0.04	0.12	0.00	0.17	0.05	0.80*	0.22
8	0.82*	0.06	0.25	0.00	0.11	0.13	0.33	−0.03
9	−0.14	−0.10	0.07	−0.10	0.04	0.04	0.18	0.83*
10	−0.01	0.40	−0.31	0.02	0.39	−0.26	0.15	0.50
11	0.16	0.22	0.64*	0.26	0.23	0.05	0.19	0.07
12	−0.62	0.35	0.53	−0.02	0.06	−0.01	0.08	0.17
13	0.56	0.08	0.25	0.14	0.26	−0.12	0.46	0.27
14	0.34	0.36	0.50	−0.08	0.22	−0.18	0.48	0.25
15	0.12	0.46	0.14	0.06	0.14	0.20	0.03	0.45
16	0.51	0.50	0.07	0.19	0.20	−0.38	0.04	0.31
17	0.19	0.66*	0.11	−0.10	0.38	0.23	0.19	−0.04
18	0.49	0.33	0.23	−0.03	0.06	−0.27	0.59	−0.11
19	0.09	0.49	0.09	0.20	0.53	−0.09	−0.15	0.02
20	−0.01	0.00	−0.02	0.77*	0.29	0.09	−0.05	0.08
21	0.07	0.12	0.65*	0.12	0.20	0.38	0.14	−0.35
22	0.18	0.09	−0.01	0.08	0.60*	0.16	0.03	0.48
23	0.75*	0.14	−0.05	−0.16	0.12	−0.12	0.15	−0.04
24	−0.07	0.76*	0.09	−0.03	−0.14	0.08	0.16	−0.09
25	0.12	0.19	0.19	0.05	0.70*	0.00	0.28	−0.08
26	0.36	0.10	0.36	−0.14	0.68*	0.13	−0.17	0.05
27	−0.11	0.14	−0.02	0.04	−0.01	0.87*	−0.04	0.10
28	0.20	0.00	0.04	−0.69*	0.34	0.08	−0.04	0.38
29	0.33	0.31	0.55	−0.13	0.16	−0.08	0.38	0.26
30	0.38	−0.15	0.51	0.23	0.32	−0.15	0.11	0.34
Eigenvalue	9.06	2.61	2.37	2.06	1.95	1.54	1.34	1.16
% exp. variance	30	9	8	7	6	5	4	4
N. individuals loaded	5	4	6	2	6	1	4	2
N. individuals purely loaded	2	2	3	2	5	1	2	1

[*] Significant (p-value < 0.05).

Table 4
Standardized scores of the statements of factor 3 ranked higher and lower compared to other factors.

N	Type	Statement	Factor 3
1	R-P	Give priority to pedestrians over other modes, by means of more pedestrian crossings, longer crossing times at traffic lights, signage, etc.	2.55
3	P	Improve pedestrian routes by widening pavements to facilitate the movement of people with reduced mobility, children and the maintenance of social distance	2.01
21	M	Lower the price of public transport, and establish financial aid for access to public transport for people with reduced mobility, people at risk of social exclusion, etc.	1.46
22	M	Lower the Price of shared mobility, and establish financial aid for access to shared mobility (purchase or use) for people with reduced mobility, people at risk of social exclusion, etc.	1.08
10	M	Higher economic rates (green taxes) for the development and purchase of housing away from the urban core	0.94
23	E	Establish educational campaigns to promote public transport and shared mobility	0.87
18	P	Improve the technology of public transport (computerisation of payment systems, information on waiting times and occupancy, etc.)	0.70
31	E	Educational campaigns to change the view of private car ownership as a social status symbol	0.62
14	R	Establish urban quality standards for liberated areas, indicating minimum and/or maximum density, uses, typologies, vegetation, urban furniture, etc.	−0.01
Negative statements ranked lower than in other factors			
35	P	Sharing public transport shelters for shared autonomous mobility	−0.31
6	R	Restrict motorised traffic within some streets in central urban neighbourhoods to convert them into rest, play and recreation areas (superblocks)	−0.55
34	R	Replace old service stations with new pick-up and drop-off points for autonomous vehicles	−0.61
8	R	Promote regulations to facilitate residential areas with ground floor retail, services and neighbourhood shops	−0.99
5	R	Designate central urban areas with restricted motorised access, except for special or emergency vehicles	−1.10
16	M	Economic incentives or fiscal advantages to promote small economic activities in the new car-free spaces	−1.33
40	R	Allow mobile retail stores shops in autonomous vehicles, but set a maximum percentage of total urban commerce	−1.46
38	R-P	Regulate individualised delivery of goods only by drones and provide drone delivery fleets	−1.85
33	M	Establish vehicle road charges per kilometre travelled, to penalise medium/long distance commuting	−2.01

subsidies for its use (ST22). At the urban planning level, there is support for the idea of introducing higher taxes on housing development further away from the centre (ST10). Finally, a policy of establishing educational campaigns to promote public transport and shared mobility (ST23) and to change the social view of the private car as a symbol of social status (ST31) is seen as positive.

Crucially, those who support these policies do not approve of the introduction of car-kilometre taxes aimed at penalising medium and long-distance commuting (ST33) and the restriction of vehicles in central areas (ST5). In addition, they do not favour more radical applications proposed for technological innovations such as making good deliveries solely by drones (ST38) or allowing mobile shops by AVs (ST40).

From this point of view, the policies to be implemented are largely concerned with mobility issues, especially active pedestrian mobility, public transport and shared mobility. However, participants grouped in this frame are reluctant to implement policies that penalise or restrict car use. These types of restrictive measures, although considered effective by planning experts (Szarata et al., 2017; Wiseman, 2017), are usually less popular, and are contested by citizens as well as businesses. In order to avoid excessive use of motorised mobility, the participants associated with this frame rely on the idea of making real estate developments further away from the urban core more expensive as a disincentive. In general, regulatory measures are more negatively valued, while those with an economic incentive component or the creation and improvement of infrastructures are more highly valued.

4.2.2. *Frame 5 – promoting public transit-oriented and green policies*

The most supported policies in this frame (Table 5) relate to encouraging transit-oriented development (TOD), either by ensuring that jobs are created near public and shared transport interchanges or by locating interchanges in places with a certain concentration of jobs (ST17). This statement was also supported significantly more than others. There is also support for the promotion of public transport by increasing the frequency of services, the number of stops and lines available (ST19) (Cordera et al., 2019), technological improvements in public transport (ST18), the creation of new interchanges for the combination of public, shared and private transport (ST20), the delimitation of exclusive lanes for public transport and shared AVs in the city centre (ST25) and the reduction of the price as well as the provision of financial support for the use of shared mobility (ST22). Not directly related to transport policies, a system of open spaces throughout the city was supported (ST12).

As in the previous frame, there is low support for new taxes per kilometre travelled by car (ST33). There is also little support for developing more housing away from the city centre (ST10), regulating medium-density housing development as opposed to single-family homes (ST13), or reducing parking spaces available for cars in the city centre and relocating them to more peripheral areas by providing them with charging points for electric vehicles (ST26).

This viewpoint can therefore be interpreted as mainly favouring policies focused on improving public transport and TOD (Ibraeva et al., 2020). In this group, there is a clear interest in policies such as the creation or improvement of infrastructures and public services (P), being 60 % of the most highly valued, while regulatory measures are once again the least valued, both regarding anti-sprawl measures and parking and car transit restrictions as pointed out by previous studies (Marsden, 2006; Nogués et al., 2020; Szarata et al., 2017).

4.3. *Other frames*

The four frames grouped in this section presented less than three purely loaded individuals, so they have not been considered as views of the same relevance as the previous ones. Even so, they are appraised in a more summarized way given that in total they have grouped 15 people, 8 of them being purely loaded.

Table 5
Standardized scores of the statements of factor 5 ranked higher and lower compared to other factors.

N	Type	Statement	Factor 5
17	P	Locate workplaces in the vicinity of public and shared transport interchanges or provide transport interchanges in areas of high employment activity	1.96**
19	P	Increase the frequency, stops and lines of public transport services	1.93**
12	P	Create a system of green spaces spread in all areas of the city forming green axes, including tree-lined streets, parks, gardens, etc.	1.91
20	P	Create transport interchanges where diverse transport modes (public, shared and private) can be combined	1.62**
25	R	Delimit exclusive lanes for public transport and shared autonomous vehicles in the city centre	1.52*
22	M	Lower the Price of shared mobility, and establish financial aid for access to shared mobility (purchase or use) for people with reduced mobility, people at risk of social exclusion, etc.	1.25
18	P	Improve the technology of public transport (computerisation of payment systems, information on waiting times and occupancy, etc.)	0.81
41	R	Limit the use of private autonomous vehicles for inter-urban trips to park-and-ride zones, where they switch to public transport, shared transport or bicycles to reach the city centre	0.38
14	R	Establish urban quality standards for liberated areas, indicating minimum and/or maximum density, uses, typologies, vegetation, urban furniture, etc.	−0.10
Negative statements ranked lower than in other factors			
31	E	Educational campaigns to change the view of private car ownership as a social status symbol	−0.85
1	R-P	Give priority to pedestrians over other modes, by means of more pedestrian crossings, longer crossing times at traffic lights, signage, etc.	−0.96
13	R	Encourage residential developments with a density of at least 50–60 houses/ha. (medium density), with a predominance of collective housing as opposed to single-family dwellings	−1.07
26	R	Reduce the number of available parking spaces in the city centre and locate them in the periphery, including charging points	−1.18
10	M	Higher economic rates (green taxes) for the development and purchase of housing away from the urban core	−1.63
33	M	Establish vehicle road charges per kilometre travelled, to penalise medium/long distance commuting	−2.08

* Significant distinguishing factor ($p < 0.05$).
** Significant distinguishing factor ($p < 0.01$).

4.3.1. Frame 1 – encouraging pedestrian mode without penalising cars

This frame is based on encouraging the pedestrian mode (ST1, ST2), the 20-minute city (ST11) and mixed-use development (ST7). It is therefore somewhat related to frame 3, especially in terms of pedestrian emphasis and the importance of urban proximity. However, it differs from the latter in the strong rejection of policies that penalise the most polluting private motorised vehicles (ST30), taxes on vehicle purchases (ST29) or penalising AVs that may be circulating without passengers and trying to attract new users (ST32). So again, there is a clear opposition to policies that have to do with restriction or penalisation.

4.3.2. Frame 2 – AVs and technology supporters

The potential of using AVs as mobile shops is supported (ST40), as well as promoting carpooling through specific applications and tools (ST24) and through the creation of AV drop-off and pick-up zones at the edge of the city centre (ST36). Furthermore, the idea that private AVs should be limited to inter-city trips between the area of origin and a park-and-ride location (ST41) or that it is positive that delivery of goods should be carried out exclusively by drones (ST38) is discarded. There is therefore more support for the idea that AVs should be leveraged and can be used in multiple contexts. This frame was supported by younger individuals, with ages ranging from 17 to 28 years old, which confirms that these individuals tend to support more radical visions and policies with respect to the *status quo*.

4.3.3. Frame 4 – discouraging motorised ground transport

The most supported statements are concerned with establishing fees to restrict non-passenger AVs (ST32) and increasing environmental requirements to allow vehicles to circulate (ST30). There is also support for the idea of boosting motorised aerial mobility (ST39) and the individualised delivery of goods by drones (ST38). On the urban planning side, there is support for planning mixed-use developments (ST7) and promoting regulations that make it easier for residential areas to have nearby shops and services (ST8). Among the least supported policies are limiting AVs to inter-city trips (ST41) and the use of campaigns to promote public transport and shared mobility (ST23), probably because they are considered ineffective. There is therefore support for policies that seek to discourage land-based motorised transport and encourage urban developments that favour commuter mobility.

4.3.4. Frame 7 – chrono-urbanism, active mobility and distrust of technological solutions

The promotion of active mobility with safe pedestrian routes (ST4), the restriction of motorised mobility in the central area (ST5), the creation of superblocks (ST6) and the 20-minute city based on pedestrian mobility, cycling or using public transport for daily life (ST11) are supported. People in this frame are also reluctant to new technological solutions such as the restriction of motorised aerial mobility (ST39), mobile shops in AVs (40) and the creation of pick-up and drop-off points for AVs (ST36). This frame is therefore related to frame 3 and 1, although using a different policy mix in terms of reinforcing urban proximity, active mobility and with a more negative view of some of the technological solutions proposed in different areas.

5. Discussion and conclusions

The potential future penetration of AVs into cities has opened a debate about the need to develop urban plans to anticipate the consequences (Gruel & Stanford, 2016; González-González et al., 2019, 2020; Papa & Ferreira, 2018; Porter et al., 2018). Various authors have called for these plans to put issues of quality of life, sustainability and well-being at the core (González-González et al., 2019; Martin, 2019; Milakis & Müller, 2021). However, few policies to achieve these desired urban futures have been agreed and developed, partly because not all the impacts of AVs are clear, and because there is little consensus among planners and policy-makers about the effectiveness and acceptability of the different policy measures to be adopted.

The aim of the research carried out was to establish whether there are different points of view in relation to the policies that would be applicable to achieve a planned future that is more desirable than the current one, considering that technological innovations such as AVs will be present. To achieve this objective, a backcasting-type planning methodology has been combined with the well-known Q-method technique. To the best of the authors' knowledge, this approach has not been applied before and therefore offers a new method for detecting the existence of different points of view in a group of surveyed individuals.

The application of Q-method points to the existence of two main views on the policies that are favoured. The first with a greater support for policies favouring pedestrian mobility, public transport, and shared transport with a disincentive to develop housing far from urban centres. The second with a greater tendency to favour public transport in conjunction with public transit-oriented urban development and the creation of more green spaces. In both cases, private AVs do not play a major role in the type of city being promoted but are subordinated to the promotion of modes generally considered more sustainable (active modes and public transport) and shared use. Moreover, it is notable that in both views, people do not support measures to penalise car use, such as charging for long journeys, and therefore favour a policy of positive incentives (carrots) rather than negative ones (sticks) (Piatkowski et al., 2019). This happens even when negative incentives are probably more effective and less expensive than positive ones in limiting private car use (Nogués et al., 2020). This confirms, in line with the findings of previous studies (Hasan et al., 2020; Jones, 1991; Stead, 2008), that there is a gap between the actual effectiveness and public acceptability of transport policies. In fact, there may even be an inverse relationship between effective and acceptable policies, given that more effective measures can have less public support because of the personal consequences they may entail (Stead, 2008).

In addition to these two main policy viewpoints (frames 3 and 5), four additional viewpoints were also detected, with a smaller number of individuals loaded on them. Two of them presented some relationship with frame 3, in terms of the priority given to enhancing active mobility (frame 1) and urban proximity (frame 7 chrono-urbanism). The other two showed more support for policies oriented towards AVs (frame 2) or towards discouraging motorised land transport, empty AVs trips and polluting vehicles in general (frame 4). This points to the existence of a variety of views and even disagreements that need to be considered, something also highlighted by previous research such as that of Strömberg et al. (2021), which showed that different types of actors may diverge in terms of their assumptions, hopes and concerns associated with AVs. In this sense, Mladenović et al. (2020) defend the thesis that frameworks for participatory deliberation about AVs should be created with the aim of showing and exploring the existing dissensions between different agents. This would avoid the establishment of artificial consensus on how planning should be approached, especially if this consensus is based on arguments about the technological inevitability of AVs and the necessary adaptation of society to them. The application of Q-method has also allowed the participants to identify the policies which they consider will achieve desirable urban visions, while maintaining the plausibility of the answers, transparency of the process and avoiding the excessive influence of particular actors, problems that are sometimes mentioned as weaknesses of the participatory process (Ernst et al., 2018; Glenn, 2003; McGookin et al., 2021).

Considering the coherence between these policies and the views on the desired city, it is important to highlight the consistency between the idea of a future city based on the priority of the pedestrian mode, with more space for walking, more vegetated and traffic-calmed streets, a compact form and active citizens and the policies that advocate encouraging active pedestrian mobility, the priority of pedestrians over other modes and a city more based on accessibility to goods and services nearby, policies that are present, to a greater or lesser extent, in frames 3, 1 and 7. Public transport, although less mentioned in the desirable city visions, represents a mode that can help to increase accessibility through the introduction of autonomous public transport. Policies related to public transport appear clearly in frames 3 and 5. As regards the most innovative technological solutions, drones were considered to have a role in goods distribution, while AVs were considered to play a role in improving transport safety.

In the different views on the most supported policies, the role of AVs has more to do with shared rather than autonomous mobility per se, with the exception of frame 2, where users were more supportive of the potential of AVs, although this was in the minority in terms of the number of individuals within the frame. This underlines the idea that AVs were not seen as key to desirable urban visions by the participants, but as one more mode whose needs should be subordinated to the overall strategy and whose most important contribution may be to enable the reduction of urban space currently allocated to vehicle traffic and parking. This is entirely in line with what has been highlighted by several authors who have analysed the issue from an urban planning perspective and have advocated integrating these measures into tools such as planning documents (González-González et al., 2020; Staricco et al., 2019, 2020; Vitale Brovarone et al., 2021).

Although the study offers a transferable methodology to support urban policy and decision-making processes, the results may be affected by aspects such as the size and development pattern of cities, so further research is recommended in a wide range of urban areas in different geographical contexts in order to develop sets of policies that are specific to different city types. This article has highlighted the opportunities that AVs open up to promote policies that enhance active mobility, accessibility and compact urban development. While these policies may enjoy the support of citizens, they may not welcome policies that imply a restriction of their choices, especially with regard to the ownership and use of the private car. Increasing the acceptability of these policies poses a key challenge for policy-making and there are no simple solutions. Nevertheless, a number of strategies may help in this regard, including innovative policy mixes or packages (see for example Givoni et al., 2013) rather than individual measures, the use of demonstration schemes (e.g. Börjesson et al., 2012) and marketing and communication techniques (see for example Eliasson & Jonsson, 2011).

CRediT authorship contribution statement

Soledad Nogués: Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original draft preparation, Writing - Reviewing and editing, Funding acquisition. **Esther González-González**: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original draft preparation, Writing - Reviewing and editing, Visualization. **Dominic Stead**: Conceptualization, Writing - Reviewing and editing. **Rubén Cordera**: Methodology, Formal Analysis, Investigation, Writing - Original draft preparation, Writing - Reviewing and editing, Visualization.

Declaration of competing interest

None.

All authors have read and approved the final revised version submitted.

Data availability

Data will be made available on request.

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Annex 1. Statements ranked during the visioning phase

Ranked	N°	Statements on the urban form and design, society, economy, environment, transport, and mobility of my desired future city
Highest ranked	27	In the city, pedestrians have priority over other modes of transport
	41	Aerial mobility by drones for passengers and goods is widespread while streets are used for walking and cycling mobility
	5	It is a compact city with a clear mix of land uses, housing has retail and basic services that can be reached by walking, cycling or public transport in <15 min
Highly positively ranked	2	In every neighbourhood, including those in the city centre, there are many open areas, such as squares, playgrounds, parks, sport and resting/meeting areas for children and the elderly, in spaces that have been freed from vehicle transit
	1	In every street there is enough space to walk safely, with safe social distance to other people, for cafés, cultural mini-spaces (e.g., parklets) due to the elimination of old curbs
	22	The city is equitable and inclusive, all citizens, including disabled, elderly, minorities or young people have the same accessibility opportunities to public services
	7	Most of the streets are green, naturalised, with trees, gardens…
	20	Citizens are in very good health because they do most of their journeys on foot or by bicycle
Medium positively ranked	19	As there is almost no vehicle traffic in the city centre and inside neighbourhoods, and AVs are connected and do not make mistakes, there are no traffic accidents and children can go on their own to school, their extracurricular activities…
	25	The cultural diversity of the neighbourhoods has been enhanced through the regeneration of spaces freed from car parking and transit, and the urban identity has been reinforced, creating a cultural richer city
	30	Autonomous public transport is the priority mode, with a wide range of means (bus light rail, tram, etc.) and services, and is easily accessible in all neighbourhoods
	8	There are specific pick-up and drop-off points for AV travellers, usually in the old bus shelters and in very important buildings/landmarks
	40	AVs are mainly shared, with several users on the same journey
	31	Intermodality between public transport and private modes in user-friendly
	18	Delivery of goods is made to collection points located in each neighbourhood that can reached on foot or by bicycle
Highly negatively ranked	33	Any vehicle can circulate regardless of the pollutant emissions it produces
	26	As there are many private vehicles energy consumption is enormous and there are energy supply problems and cuts
	4	There are not many physical meeting areas and open spaces in the city, most interactions are online so there are virtual spaces and facilities
	34	As there are many private vehicles, there are serious traffic and congestion problems
	6	The population has grown enormously and most live in small dwellings in high-rise buildings (skyscrapers)
	32	Automobiles have priority in their journeys and the streets and roads are adapted to allow motorised traffic to flow as smoothly as possible
	23	Only a few citizens, the wealthiest, can afford private AVs, the rest can only access shared and active mobility (walking, cycling)
	21	There are many opportunities for door-to-door travel which has increased sedentary lifestyles, and consequently health problems
	12	Most of the shopping, leisure, facilities and working areas are located on the outskirts of the city, people do their shopping or pick up their orders on their way to work or home, and have to use a motorised mode of transport to access them
Medium negatively ranked	3	The city has large open areas and green spaces, but they are located in some specific neighbourhoods and/or on the outskirts where there used to be large car parks, to which people can access by public or public transport
	17	Delivery of goods is done on an individual basis to each citizen and house
	14	There are many mobile retail stores, inside AVs which can serve anywhere without the need for a physical store
	39	Private motorised mobility is restricted in some parts of the city (e.g., downtown area)

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