Backcasting as a tool for governing transitions beyond technosolutionism: the Torino2050 and ToMove projects

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Abstract
The paper addresses the complex and multifaceted issue of how planners, public administrations and scholars can approach high-tech transitions, and more generally the governance of transition to desired futures beyond techno-solutionism. The paper first presents the results of the Torino2050 project, which addressed the issue of governing the transition to autonomous driving. It then discusses how a collaborative backcasting approach will be applied in the recently launched ToMove project, which will test an autonomous public transport shuttle and a robot for last-mile delivery in a quasi-superblock testbed area. The project is promoted by the Municipality of Turin and the authors are involved in setting up a participatory scenario planning process. The project is a useful opportunity to actively involve the public administration in the scenario planning process, taking stock of the lessons learnt in the previous Torino2050 project.

Keywords:
scenario-planning, backcasting, autonomous vehicles, public administrations

1. Introduction

The salvific power of urban smartification should not be taken for granted, nor should its sustainability (Cugurullo et al., 2023). Whereas techno-solutionism which dominates the smart city discourse highlights the potential of new technologies (including AI) for urban efficiency and performance, a passive laissez-faire approach from public administrations can lead to undesired, unexpected and ungovernable outcomes. The deployment of Autonomous Vehicles (AVs), being a dominant manifestation of the emergence of AI in the management and development of cities, fully encapsulates these dilemmas.

The advent of AVs is likely to produce significant changes in how we move and live. Yet, when, how and to what extent these changes will take place is unclear, due to several dimensions of uncertainty. Not only is there high uncertainty about when full automation will reach significant market penetration, but also the direction and intensity of the potential impacts of AVs are

related to how public administrations will intervene in their diffusion. Public administrations need to deal with this challenge, in the short and medium term, but they are often reluctant to take up the challenge (Curtis et al., 2019). This is due to various factors, such as the high levels of uncertainty, the long horizon – much longer than the timeframe of administrative and political offices, for instance – and the lack of sufficient "actionable" information to direct investments or planning priorities. Scenario planning methods (Ariza-Álvarez et al., 2022; Tori et al., 2023) can be very helpful to support public authorities in dealing with these issues, but they rarely enter planning routines.

Aiming to stimulate discussion on these issues, this paper refers to two projects. Firstly, it summarises the results of the Torino2050 project, aimed to address the issue of governing the transition to autonomous driving, defining, through a collaborative backcasting, a policy pathway toward urban liveability and sustainability in Turin (Vitale Brovarone & Staricco, 2023). The process involved public and private actors, and shed light on three very important issues. The first is the power of anticipatory visions and the importance of defining concrete propositions to govern the technological transitions, beyond techno-determinism and towards desired urban futures. The second is the opportunity to ride the wave of the seductive power of technological innovation to promote goals of liveability and reduction of vehicle traffic within urban neighbourhoods. The third is the challenge of actively involving public administrations in the scenario planning processes (Vitale Brovarone et al., 2021).

Secondly, it discusses how backcasting is going to be applied in the recently launched ToMove project, that will test an autonomous public transport shuttle and a robot for last-mile delivery in a quasi-superblock testbed area. The project is promoted by the Municipality of Turin, and the authors, as part of the FULL-Future Urban Legacy Lab of Politecnico di Torino, are involved to set up a participatory scenario-planning process. In this case, the public administration is leading the process, and has accepted the researchers' proposal to use backcasting as a tool to envision a desired future and govern the transition to it, seeing AVs as just a small part of a desired future. The project is therefore a useful opportunity to actively involve the public administration in the scenario-planning process, taking stock of the lessons learnt in the Torino2050 project.

2. Scenario planning

In recent years, scenarios have been increasingly used to support decision makers to engage with uncertainty. For example, in the transport sector scenario planning is a well-known method to help solve future mobility challenges of cities (Tori et al., 2023). Nevertheless, as Cordova-Pozo and Rouwette (2023: 1) point out, three main challenges "limit the spread and the usefulness of scenario planning: conceptual confusion, methodological chaos, and scarcity of evidence on its effectiveness". Moreover, visions and scenarios are often acontextual as they do not refer to real case studies. This can be seen in the literature on AVs, where scenario planning frequently does not refer to the real spaces in which these vehicles will be circulating and parking (Staricco et al., 2019).

The process of scenario building foresees the delineation of a number of scenarios (generally three), including the reference scenario (usually referred to as the 'Business as Usual' or 'BAU scenario'), that is used to compare desirable futures. An important part of scenario building process is also the identification of key factors, which "may determine qualitatively different paths for the socio-economic environment" (Stead & Vaddadi, 2019: 127). The timeframes of scenarios can vary: they can be developed for both the medium term (e.g. 5-10 years) and the long term (10 years or more).

According to Stead and Vadaddi (2019), scenarios can be quantitative or qualitative. However, both quantitative and qualitative scenario methods seem to carry a certain number of disadvantages. For example, Weimer-Jehle (2006) argues that the complexity of quantitative methods often makes it difficult to involve stakeholders in a scenario building process. To counter these disadvantages, mixed-methods approaches, such as the cross-impact balance (CIB) development of socio-technical scenarios could be used (Tori et al., 2023).

Stead & Vaddadi (2019) identify three main approaches to scenario construction: (i) the forecasting approach; (ii) the exploratory approach; and (iii) the backcasting approach. The forecasting approach is often quantitative, where substantial change is not expected and current trends continue in the future. The exploratory approach is usually interactive and involves the identification of key independent and dependent variables. The backcasting approach is a widely known normative scenario method, which formulates future visions and goes backwards to define the actions needed to achieve them. It is often used to look at long-term futures, examining the way in which the desirable future can be reached. To do this, expert stakeholder participation is expected throughout the various phases of the analysis. It then delineates a set of criteria and policy pathways to support decision makers.

In the following sections, this paper presents, examines and discusses how a backcasting scenario planning approach is being applied to a real context in the City of Turin.

3. The case study of Turin

The case study focuses on the City of Turin, located in the north-west of Italy. Known as the 'city of the car', the city has deep roots in its economic specialization in the automotive sector. Although its economy is no longer centred on the automotive industry, today the local population is largely car dependent and presents high ownership rates, among the highest in Europe. The public transportation system is underused, as well as the bicycle and car sharing networks and services. Nevertheless, the presence of a technologically advanced public infrastructure for the management of the local mobility has led to the designation of Turin among the first cities in Italy for the national experimentation of the 'Torino Smart Road' project.

In 2018, it was the first Italian city to have launched a pilot project, the 'Torino Smart Road', to experiment with the circulation of AVs on public roads. One of the most significant results of the initiative was the definition of a 35 km urban circuit on which innovative autonomous and sustainable mobility solutions could be tested on a real road network (Figure 1). This real-world experiment has helped to place Turin at the forefront as regards the transition to AVs.

Figure 1. A road in Turin equipped with technologies needed to test autonomous vehicles (Source: Scudellari et al., 2020).

In 2021, the City adopted its Sustainable Urban Mobility Plan, which will regulate actions and interventions with a time horizon of ten years (up to 2030), developing a vision of the mobility and transport system that could improve the quality of life of citizens. Moreover, the City of Turin is one of the 100 European 'Mission Cities' that is committed to reducing emissions by 2030, i.e. it is a hub of experimentation and innovation in the climate sector.

4. The Torino2050 project

This section summarises the results of the Torino2050 project[1], which addressed the issue of governing the transition to autonomous driving in the City of Turin. In particular, the research project focused on the possible impacts of the diffusion of AVs, as well as the policy strategies and instruments (e.g. transport and land use policies) that should be adopted to govern them. In fact, one of the aims of the project was to provide policy guidelines that the public administration could implement in the short, medium and long term, to guide the transition of autonomous driving towards a future scenario based on the sustainability and liveability of the urban environment. To do this, the research adopted a collaborative backcasting approach, involving both public and private stakeholders, in order to define a future vision and the actions needed to achieve it. In particular, the project involved the participation of the various stakeholders (e.g. public administration, private companies, non-profit associations) throughout all of the phases of the project. This strong collaboration allowed the research group to deepen the technical knowledge of autonomous driving systems, as well as the understanding of the potentials and risks of these new means of travel (Scudellari et al., 2020). Finally, the project defined a policy pathway toward urban liveability and sustainability (Vitale Brovarone & Staricco, 2023), where the diffusion of AVs could be managed in an integrated and sustainable way.

[1] The project "Governare l'impatto spaziale e territoriale della diffusione di Veicoli a Guida Autonoma" was carried out by the Interuniversity Department of Regional and Urban Studies and Planning (DIST) of the Politecnico di Torino.

As mentioned above, the study adopted a backcasting approach, formulating future visions and going backwards to define the actions needed to achieve them. The visioning exercise was carried out in three different phases (Staricco et al., 2019): (i) the development of three visions by the research group; (ii) the validation of the three visions through a focus group with expert stakeholders, and (iii) the selection of the most advisable vision through a set of more than 50 interviews with expert stakeholders. The first two steps were based on a think-tank model, whereas the third was grounded on a participatory model.

In the first phase, three long-term visions (2050) for the city of Turin were delineated:

(i) a 'business as usual' scenario (Vision 1), in which the diffusion of AVs would not be explicitly governed, not their positive or negative impacts;

(ii) an optimistic and technology centred scenario (Vision 2, strong deregulation), which assumed that the impacts of AVs on the city would be largely positive;

(iii) a pessimistic scenario (Vision 3, strong regulation), which presumed that the negative impacts of AVs on the city would prevail if not properly managed.

The three visions were defined with reference to fourteen items: i) road hierarchy, based on the articulation into main roads and local roads; ii) limitation to vehicle circulation; iii) parking areas, with a specific focus on roadside parking and areas to pick-up/drop-off the passengers, multilevel parking, and intermodal parking; iv) local public transport, with specific focuses on the main lines, feeder capillary network and reserved lanes; v) shared mobility, differentiated between motorised and non-motorised services (e.g. bike-sharing); vi) pedestrian areas; vii) bicycle facilities; and viii) modal split.

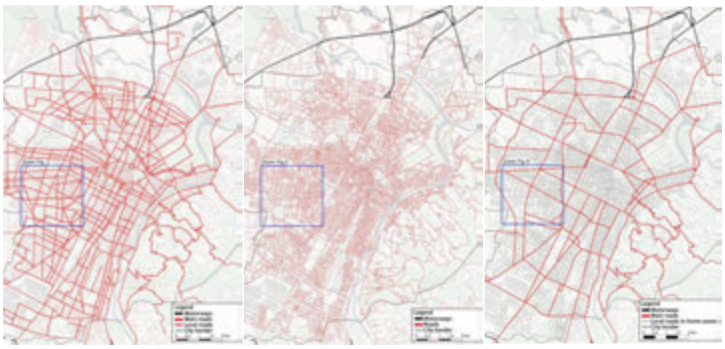

Figure 2. Road hierarchy in the three visions (Source: Staricco et al., 2019: 9, 11 and 13).

In the second phase, a focus group was organised and seven local experts in the transport sector (e.g. from the municipal and metropolitan administration, public transport authority, and third-sector associations) were invited to discuss and validate the three visions and assess their advisability and sustainability.

In the third phase, the seven experts who participated in the focus group and 44 other local stakeholders were interviewed to identify the most advisable of the three validated visions. The stakeholders were chosen in order to cover a wide range of actors interested in the possible future impacts of AVs in the City, such as: automotive companies, research centres, public administration, and environmentalist or professional associations. Finally, Vision 3 (strong regulation) was considered to be the most advisable, Vision 1 (business as usual) ranked second and Vision 2 (strong regulation) was deemed the least advisable.

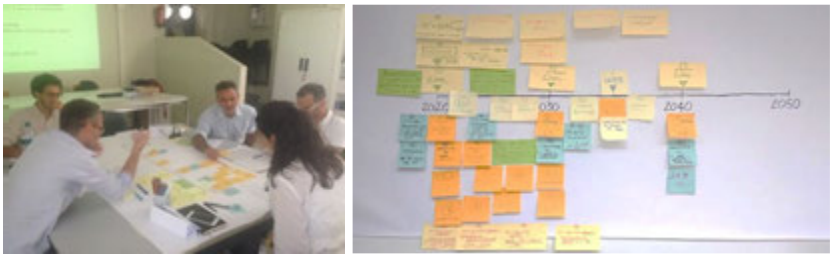

Figure 3. Policy pathway outcome of the Torino2050 collaborative backcasting (Source: Staricco et al., 2020).

The project has shed useful light on three very important issues. The first is the power of anticipatory visions and the importance of defining concrete propositions to govern the technological transitions, beyond techno-determinism and towards desired urban futures. The second is the opportunity to ride the wave of the seductive power of technological innovation to promote goals of liveability and reduction of vehicle traffic within urban neighbourhoods. The third is the challenge of actively involving public administrations in the scenario planning processes (Vitale Brovarone et al., 2021).

5. The ToMove project

Building on the lessons learnt in the Torino2050 project, this section looks at how backcasting is going to be applied in the recently launched ToMove project. The project is led by the City of Turin, and funded with 7 million euros by the National Recovery and Resilience Plan. The overarching aim of the ToMove project is to test an autonomous public transport shuttle and a robot for last-mile delivery in a quasi-superblock testbed area of the City of Turin. To do this, the project foresees a Living Lab, which focuses on the co-design of innovative and sustainable autonomous mobility solutions. As mentioned above, the project is promoted by the Municipality of Turin, and the authors, as part of the F*UL*L (Future *Urban Legacy* Lab) of the Politecnico di Torino, are involved in setting up a participatory scenario-planning process. The public administration has accepted the researchers' proposal to use backcasting as a tool to envision a long-term desired future and govern the transition to it, thus seeing AVs as just one part of a desired future. The project is therefore a useful opportunity to actively involve the public administration in the scenario-planning process. The aim is to actively involve the public administration from the beginning and throughout the various phases of the scenario planning process, thus facing one of the challenges which emerged from the previous Torino 2050 project.

Starting from the test area of the autonomous public shuttle of the ToMove project, envisaged near the Einaudi Campus of the Università di Torino, the scenario planning activity intends to look at a larger urban area, which can experiment with various different integrated forms of mobility. Referring to the approaches of organizing the urban fabric into superblocks (as in the well-known case of Barcelona, which many other cities are taking inspiration from), the area subject to experimentation includes the Vanchiglietta district and its immediate surroundings (Figure 4). The objective is to stimulate a broader reflection on the future of this part of the city, where important urban transformation projects are currently being implemented (e.g. projects involving green and blue infrastructures, redesigning public spaces, addressing climate neutrality, etc.). The study also takes into consideration current and future urban transformations in the test area and its surroundings, such as the former Italgas gasometer area

and the transformations along the riverside areas and the related parks, like the Meisino Park and the Fausto Coppi Motovelodromo.

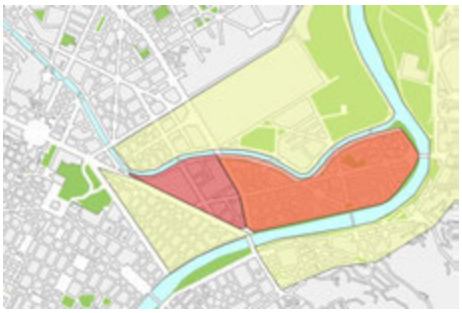

Figure 4. The testing area (in red), the Vanchiglietta area (in orange) and the interface areas (in yellow). Source: own elaboration.

There are various considerations underlying this choice, partly morphological and partly concerning the transformative urban potential. First, the area is contiguous with the autonomous mobility experimentation area around the block within which the Einaudi Campus is located. The extension of the area will provide access to a greater urban area in which to outline strategic transformation scenarios. Second, the spatial conformation of the area along its main road (Corso Belgio), an ogive shape surrounded by the rivers Dora and Po, which is relatively isolated with less than a dozen accesses via bridges lends itself to a reflection on the overall transformation. Third, there are various transformation processes already underway, in particular around the Einaudi Campus of the University of Turin and a former gasometer site. Fourth, the interface area extends north to the city's important monumental cemetery, partly because it is an attractor at an urban scale and partly because the area between the cemetery and the Dora is also relatively isolated. Fifth, the area offers possible solutions to support a redesign of mobility strategies on a larger scale, also through MaaS (Mobility as a Service) solutions. Moreover, this urban area is ideal for supporting a greater valorisation of the area along the rivers, as well as for integrating soft mobility routes.

The scenario planning activity goes beyond the experimental dimension carried out through autonomous driving tests, seeing AVs just as a part of a desired future. In fact, it aims to accompany a reflection on the future of this part of the city from various aspects, such as: innovative mobility (e.g. public transport, sharing mobility, bike lanes), urban regeneration (e.g. urban transformation projects, the redesigning of public spaces) and environmental sustainability (e.g. energy transition, circular economy, urban greening). The ToMove Living Lab also pursues the objectives of energy and environmental sustainability in line with the commitments undertaken within the European programme "100 Climate-Neutral Cities by 2030 - by and for Citizens", in which the City of Turin participates (see Section 3 above). It could be interesting, moreover, to exploit the momentum of Climate-Neutral Cities, where the concept of new mobility with MaaS services would be more visible on both a larger and smaller scale.

In order to co-design a new innovative mobility, the project involves the introduction of the concept of superblock, and the rethinking of public spaces, according to a principle of integration and diversification. In particular, these are the interventions that could be discussed with the various stakeholders and citizens: (i) the rethinking of vehicular traffic by concentrating it on some key sections; (ii) the possibility of using limited transit or pedestrianised areas; (iii) the connection with the areas along the river; (iv) the rethinking/connection with public transport lines; (v) the connection with MaaS systems,

creating exchange hubs; (vi) the taking into consideration of some of the major urban attractors (Einaudi Campus, former Italgas hub, monumental cemetery, etc.) and the customization of travel plans and integrated modes; (vii) indications for the redesigning of public spaces gained through the rethinking of vehicular transit spaces.

The project also looks at the overall normative framework, such as urban planning regulations: the comprehensive plan (Piano Regolatore Generale, PRG) and the various sectoral plans, such as the Sustainable Urban Mobility Plan (SUMP, Piano Urbano della Mobilità Sostenibile) of the Metropolitan City of Turin. Moreover, the test area, due to its particular location, offers the possibility of thinking about possible partnerships with carpooling systems, for innovative mobility services. Finally, the scenario planning will also consider how to integrate the topic of last mile logistics within the area. The scenario planning activity will be carried out within a CityLab[2], adopting the collaborative backcasting method, indicated in the literature as particularly suitable for supporting local authorities in the definition of transition pathways and policy packages towards desired visions for the medium and long term in contexts characterised by multiple elements of uncertainty.

As explained in Section 4 above, the collaborative backcasting method has already been tested by the research group as part of the "Torino2050 – Governing the impacts of the transition towards autonomous driving" project (Scudellari et al., 2019; Vitale Brovarone et al. 2021). The involvement of stakeholders will be based on the experience of the research group and the most recent indications from the scientific literature on scenario planning (Ariza-Álvarez et al., 2022; Tori et al., 2023). The backcasting approach is divided into different temporal and spatial levels (test area / extended area; ten-year scans) and is organised in five work phases:

i) a preliminary phase of identifying stakeholders;

ii) a visioning phase, with a pre-configuration of the different scenarios (there are usually three alternative visions of desirable futures, including the business as usual scenario) and of the transformation drivers;

iii) an interaction phase with experts and stakeholders (focus groups, interviews) to validate the scenarios, evaluate their strengths/weaknesses and select the desired scenario, to which the subsequent backcasting phase refers;

iv) a backcasting phase, for the definition of a policy pathway and the identification of different policy packages, i.e. sets of integrated policies to support the transition towards the desired future. These policy packages will then be evaluated against a series of criteria (e.g. environmental, social and economic). The backcasting operation will be conducted collaboratively, with the direct involvement of the stakeholders, followed by the re-elaboration and systematisation of the results by the research group.

v) a collective public restitution event. The results will be collected in a report that can inform and support the strategic plans and the definition of general (e.g. urban development policies) and sectoral (e.g. SUMP) guidelines of the City of Turin.

As regards the stakeholder involvement, four macro-categories of stakeholders will be involved in the process: (i) public administration; (ii) mobility and ICT services; (iii) research and consultancy; (iv) citizens' associations.

[2] Method already tested in Turin for the project financed by the Compagnia di San Paolo "Mover La Movida", proposed by the Municipality of Turin, and reported in the research report "Vivere, convivere, far vivere la notte a Torino" (Mangione et al., 2023).

6. Conclusions and future directions

As pointed out in the Introduction, today smart cities are dominated by techno-solutionism, pressing for more urban efficiency and enhanced performance. At the same time, the current advent of AVs is bringing a high level of uncertainty to urban areas. Public administrations and decision makers need to face this rising challenge but are often reluctant to do so (Curtis et al., 2019), which may lead to undesired, unexpected and ungovernable outcomes. Nevertheless, scenario planning seems to effectively support public authorities to deal with uncertainty, as well as to plan in such a long-term timeframe.

Both the Torino2050 and the ToMove (even if the latter is currently at an early stage) projects have shed light on a number of relevant issues as regards the application of scenario planning in the City of Turin. First, the governance structure of the urban environment is of fundamental importance to guide the future transition of cities. The urban normative framework, such as planning regulations and sectoral plans (e.g. the urban mobility plan), has a key role in shaping the desired future development of cities. As seen in the Torino2050 project, the "regulation of AV circulation and parking is likely to play an important role in governing the impacts of this innovation on the city" (Staricco et al., 2019: 17). Second, scenario planning seems to be a very useful instrument for decision makers in order to plan uncertainty. Moreover, as González-González et al. point out "in contrast with more commonly used forecasting approaches, backcasting provides a way of imagining a desirable future and identifying a set of core goals on which key decisions can be made" (2019: 153). It also seems that an active involvement of the public administration (as well as expert actors) during the different phases of the scenario planning processes helps the delineation and the evaluation of future scenarios. Finally, the literature on scenario planning seems to be mostly acontextual and a high number of studies seem to focus more on mobility issues rather than general planning issues. The case study of the City of Turin aims to help fill this gap and it is hoped that the ongoing implementation of the collaborative backcasting approach in the scenario planning will provide further fruitful results and considerations that can then be usefully applied in other contexts.

References

Ariza-Álvarez, A., Soria-Lara, J.A. and Aguilera-Benavente, F. (2022) 'Planning Adaptive Strategies for Urban Transport and Land Use using Scenario-Building', *Transportation Research Procedia*, 60, pp.274–281. https://doi.org/10.1016/j.trpro.2021.12.036.

Cordova-Pozo, K. and Rouwette, E.A.J.A. (2023) 'Types of scenario planning and their effectiveness: A review of reviews', *Futures*, 149. https://doi.org/10.1016/j.futures.2023.103153.

Cugurullo, F., Caprotti, F., Cook, M., Karvonen A., McGuirk, P. and Marvin, S. (2023) 'The rise of AI urbanism in post-smart cities: A critical commentary on urban artificial intelligence', *Urban Studies*. https://doi.org/10.1177/00420980231203386.

Curtis, C., Stone, J., Legacy, C. and Ashmore, D. (2019) 'Governance of Future Urban Mobility: A Research Agenda', *Urban Policy and Research*, 37(3), pp. 393–404. https://doi.org/10.1080/08111146.2019.1626711.

González-González, E., Nogués, S. and Stead, D. (2019) 'Automated vehicles and the city of tomorrow: A backcasting approach', *Cities*, 94, 153-160. https://doi.org/10.1016/j.cities.2019.05.034.

Mangione, E., Montanini, M., Postiglione, M. and Servillo, L. (2023) *Vivere, convivere, far vivere la notte a Torino. Analisi, scenari strategici, e proposte per una governance partecipata*

delle aggregazioni notturne. Politecnico di Torino - Future Urban Legacy Lab. Torino. ISBN. 978-88-85745-96-4. https://full.polito.it/reader/vivere-convivere-far-vivere-la-notte-a-torino/

Scudellari, J., Staricco, L. and Vitale Brovarone, E. (2020) *Governare gli impatti territoriali della diffusione dei veicoli a guida autonoma*. Politecnico di Torino, Torino.

Staricco, L., Rappazzo, V., Scudellari, J. and Vitale Brovarone, E. (2019) 'Toward Policies to Manage the Impacts of Autonomous Vehicles on the City: A Visioning Exercise', *Sustainability*, 11(19), 5222. https://doi.org/10.3390/su11195222.

Staricco, L., Vitale Brovarone, E. and Scudellari, J. (2020) 'Back from the future. A backcasting on autonomous vehicles in the real city', *TeMA, Journal of Land Use, Mobility and Environment*, 13 (2), 209-228. https://doi.org/10.6092/1970-9870/6974.

Stead, D. and Vaddadi, B. (2019) 'Automated vehicles and how they may affect urban form: A review of recent scenario studies', *Cities, 92*, 125–133. https://doi.org/10.1016/j.cities.2019.03.020.

Tori, S., Te Boveldt, G. and Keseru, I. (2023) 'Building scenarios for urban mobility in 2030: The combination of cross-impact balance analysis with participatory stakeholder workshops', *Futures*, 150. https://doi.org/10.1016/j.futures.2023.103160.

Vitale Brovarone, E., Scudellari, J. and Staricco, L. (2021) 'Planning the transition to autonomous driving: A policy pathway towards urban liveability', *Cities*, 108, p. 102996. https://doi.org/10.1016/j.cities.2020.102996.

Vitale Brovarone, E. and Staricco, L. (2023) 'A roadmap for the sustainable deployment of autonomous vehicles: Superblocks driving cars out of neighbourhoods', in F. Cugurullo et al. (eds) *Artificial Intelligence and the City*. Routledge, pp. 1–16. https://doi.org/9781003365877-7.

Weimer-Jehle, W. (2006) 'Cross-impact balances: A system-theoretical approach to cross-impact analysis', *Technological Forecasting & Social Change*, 73, 334–361. https://doi.org/10.1016/j.techfore.2005.06.005