ACCELERATING SUSTAINABLE MOBILITY
with autonomous vehicles

Mathieu Saujot, Oliver Sartor, Laura Brimont
(IDDRI)

Laura Brimont studies new wealth indicators at the European and international levels. She also works on links between digital and ecological transition, particularly through mobility and crowdfunding. Laura worked for five years on deforestation in tropical countries. She is a graduate in international relations from Sciences Po Paris.

Mathieu Saujot currently coordinates the Linking Digital and Ecological Transitions initiative. He also coordinates the Audacities project which looks into governance of the real digital city, and New Mobility, Clean Mobility, a foresight project on autonomous and shared mobility. Mathieu is a graduate of ENSTA ParisTech and holds a doctorate in economics.

Oliver Sartor is a research fellow at IDDRI who specializes in policy, trade and industrial competitiveness. Oliver worked for CDC Climat, and for the Center for Energy and Environment Markets at the University of New South Wales. He is currently a PhD student in economics at the Sorbonne University in Paris.

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- MAPPING

Autonomous mobility has great potential for transforming mobility, especially towards greater sustainability. But contrary to what advocates of autonomous mobility are saying, its future is far from certain: several different scenarios could play out, both in terms of how they develop and their impacts on the transport system.
Public authorities will have a key role to play in steering this technology towards the desirable scenarios and setting the conditions for the integration of autonomous mobility (planning road systems, regulating local mobility, supporting experiments and pricing services).
Early on, authorities need to determine under which conditions AVs can help them to achieve their sustainable mobility goals.
The private sector also needs to examine how the technological and industrial solutions it develops will be integrated into a sustainable future mobility system.
This shared vision of autonomous mobility should be developed with local and national public authorities.

INTRODUCTION

Over the last few years, autonomous mobility has received extensive media coverage. According to the projections of its advocates, connected and fully autonomous vehicles will be commercially available in about 10 years' time and will help to reduce traffic congestion and road deaths.

This optimism nevertheless tends to mask the uncertainties surrounding the future of these vehicles, especially technological uncertainties: we are still a long way from achieving full automation. Moreover, different scenarios and models for the development of this innovation may play out (shared taxi fleets versus individual vehicles), each with its own risks and opportunities. Faced with the need to ensure more sustainable, accessible and efficient mobility, public policymakers need to examine the way in which automation can help to transform mobility: to what extent will autonomous vehicles (AVs) contribute to reducing local pollution and decarbonising the transport sector? How will they limit the number of cars on the road and the amount of space they use? And will they improve accessibility for all and help to cut mobility costs?

The answers to these questions depend on the development pathway for autonomous mobility. Assuming that this pathway remains to be determined and that the local and national public authorities have a key role to play in shaping it, especially by defining the conditions for market entry, this Issue Brief presents the key structural components of autonomous mobility upon which public policymakers will need to act to ensure VAs become the drivers of sustainable mobility. The second part of this Brief illustrates the risks and opportunities of AVs for the transition to more sustainable mobility systems.

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1. WHAT KIND OF AUTONOMOUS MOBILITY?

We consider that the development of autonomous mobility will be structured by the convergence of different technological and service-based possibilities with individual and group demands (reducing congestion and pollution, guaranteeing the right to mobility for all, etc.).

1.1. HOW MATURE ARE AUTONOMOUS TECHNOLOGIES? *TECHNOLOGICAL POSSIBILITIES*

There are five levels of automation[1], defined by the growing capacity of a vehicle to carry out a range of manoeuvres without intervention from a driver, in a variety of different driving situations. Level 5 refers to a theoretical time horizon with autonomous vehicles in all situations.

The key obstacle to developing high levels of automation is the complexity of interaction between AVs and traditional vehicles during the coexistence phase, as well as with other road users. This constraint implies reaching a certain level of driving data acquisition, developing high computing power and producing test protocols that compare AV algorithms with a wide range of situations.

Faced with these technological challenges, autonomous mobility actors are developing different strategies according to the skills and resources of their trade. These include: progressive learning through automation seen as additional automotive equipment (car manufacturers, Tesla); learning through shuttles used in dedicated lanes (urban transport operators); or more direct deployment, for example through fleets with safety drivers (Google Car, Uber).

Finally, digital mapping with a view to enabling autonomous mobility raises important questions of competition regulation and public safety, in that it is set to become a new digital infrastructure for mobility. In this context, the issue of which actor will impose its cartography is of real political importance.

Automation thus faces numerous technical constraints, which require substantial investments, such as the need to create dedicated AV zones or lanes, or to ensure accurate territorial mapping. Whether or not and under what conditions public action can remove these constraints will be decisive in shaping the development of autonomous mobility and thereby facilitating disruptive services.

1.2. WHO WILL BE ABLE TO AFFORD AUTOMATION? *ALIGNING POTENTIAL SERVICES WITH INDIVIDUAL DEMANDS*

One of the promises of autonomous mobility is that it will save the cost of drivers for public transport and taxis/private hire cars, making it possible to develop new mobility services that are not economically viable in the current context. This promise of economic gains raises the question of the cost of autonomous technologies, which is a key factor in determining the nature of services provided and their potential users: will it be an expensive niche market, or can services be developed with user costs on a par with those of public transport?

The existing literature anticipates that, eventually, the digital material required could represent a few thousand euros per vehicle and the cost per kilometre for an AV fleet could prove competitive in relation to other modes of urban transport. This projection depends on technological advances, on the capacity of actors to take advantage of returns to scale and on choices made regarding AV use: high speed, for example, implies greater computing power requirements and thus potentially heavier digital infrastructure, whereas vehicle sharing would reduce the cost per kilometre/user. Although there is considerable uncertainty about these factors, the huge investments made in this sector by numerous private actors seem to indicate that autonomous mobility services could be economically viable in the medium term.

The cost of autonomous mobility will also be determined by the regulatory framework imposed (subsidies, taxes, pricing schemes).

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1 Level 1 and level 2 include respectively one and several simultaneous automated functions (e.g. steering and acceleration), while leaving supervision of driving to the driver. Level 3, conditional automation, means the driver is no longer required to monitor driving in some situations, but remains behind the wheel in case of need. Level 4, which is more obviously disruptive, refers to vehicles that no longer require a human driver in a significant number of driving modes.

1.3. WHICH AUTONOMOUS MOBILITY OFFERINGS WILL BE THE FIRST TO BE ROLLED OUT? *ALIGNING POTENTIAL TECHNOLOGIES AND SERVICES WITH GROUP DEMANDS*

There are several possible ownership and usage configurations for AVs (understood here at automation levels 4 or 5) that could theoretically coexist: traditional individual cars, individual cars that could be returned to a fleet when not being used by their owners (Tesla model), a private fleet of AVs, either shared (like UberPool) or not, or a minibus network run by a public transport operator, etc.

Management of the coexistence between AVs and other modes of transport will be crucial to the viability of these services: road system planning will be more favourable to some services than others; the first experiments will determine the general public's perception of this technology; network effects will give the first actors a head start, etc.

The public authorities will therefore have a critical role to play in ensuring an acceptable coexistence between AVs and the other modes of transport and, more broadly speaking, coordination with the rest of the mobility system.

1.4. WHAT DEMANDS, WHAT USES? *INDIVIDUAL AND COLLECTIVE DEMANDS*

The success of autonomous mobility will depend on tradeoffs between its costs and its benefits for users, especially in terms of comfort and time saved[2].

The ways in which AVs are used will also depend on the level of acceptance of a shared, collective mode of transport. Will the popularity of journey sharing gradually extend to society as a whole through AVs? Or will this be an obstacle?

Other challenges linked to uses will also structure the deployment of autonomous mobility: concerns about dependence on a technology perceived as unreliable, reluctance to give up driving, and opposition from other road users.

More fundamentally, will autonomous mobility be an extension of the individual mobility model, synonymous with comfort and in the future with connectivity (cars as a place of services and entertainment)? Or will it follow the "mobility as a service" model, synonymous with flexibility, in which it is the mobility service provided that matters, whatever the type of vehicle? Although the public authorities cannot control all of the tools that shape this social and technical change, they nevertheless have a key role to play in influencing it.

2. WHAT ARE THE RISKS AND OPPORTUNITIES FOR SUSTAINABLE MOBILITY?

Figure 1 presents a set of risks and opportunities linked to autonomous mobility and organises them according to different dimensions. The five blue circles represent the determinants of energy consumption and greenhouse gas emissions[3] from mobility, while the purple circle shows social impacts. This section describes two visions in order to illustrate these risks and opportunities.

2.1. VISION 1: FULLY AUTONOMOUS AV FLEET (ITF 2015)

This vision, based on a modelling exercise like the one conducted by ITF (2015), reflects a radical public choice: "traditional" vehicles are prohibited in a town centre where an AV fleet is deployed[4]. Users have a strong incentive (or are even obliged) to share vehicles.

The impacts are very positive. Nine out of ten vehicles are removed from the road, freeing up space in urban areas. With a single regulator allocating travellers to available vehicles, it is also possible to significantly increase the vehicle occupancy rate and thereby reduce energy consumption per passenger. Intensive vehicle use could also be conducive to electric vehicle uptake: in comparison with internal combustion vehicles, electric vehicles cost more to buy but less to run.

2 One of the promises of AVs is that they will enable passengers to use travel time for tasks other than driving. But AVs could also reduce journey times, for example if they help to reduce congestion.

3 Calculating total CO_2 emissions in a mobility system implies informing each circle (how many pass.km per mode, energy efficiency of each mode, etc.) and multiplying them.

4 International Transport Forum, 2015, Urban mobility system upgrade. The ITF scenario is tested according to three hypotheses: 100% of individual cars and buses are replaced either by a fleet of shared taxis (A), or by a fleet of traditional taxis (B); and a transition scenario in which traditional vehicles (50%) and AVs coexist (C). There are three taxi sizes (1-2; 3-5; 5-8) and an algorithm that allocates users to these services, ensuring that they meet acceptable time constraints.

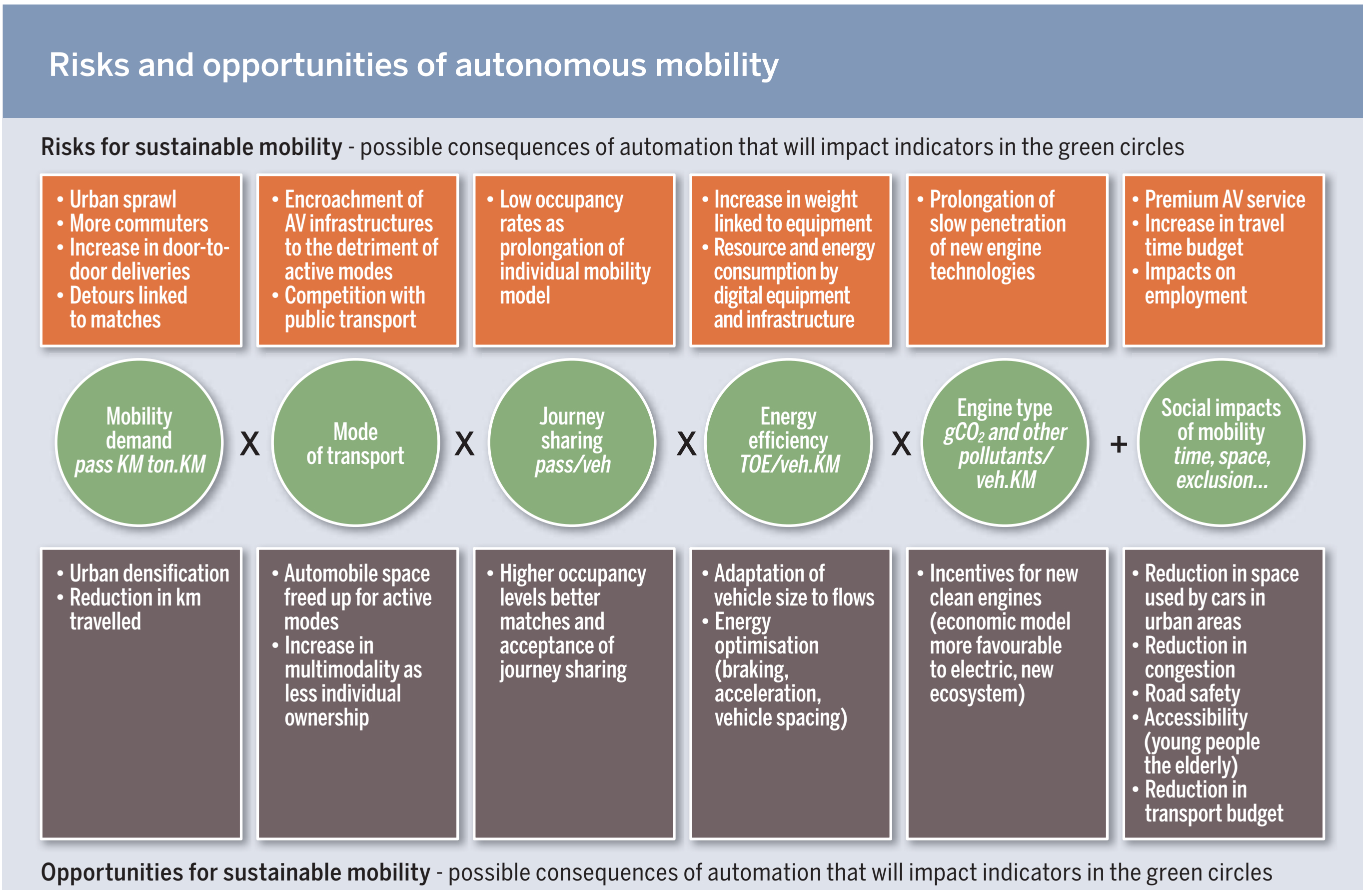

Figure 1

However, to meet mobility requirements, these vehicles operate intensively and it is difficult to reduce traffic volumes (number of vehicles kilometres travelled or 'veh.km') and road use levels[5]. Ensuring a high level of sharing appears to be essential to preventing rebound effects in terms of increased veh.km. Finally, this vision illustrates the risks associated with the transition period: assuming that AVs coexist with "traditional" vehicles, the reduction in the number of vehicles is smaller than in the first scenario, and traffic volumes increase[6].

2.2. VISION 2: WIDESPREAD REBOUND EFFECTS

In this vision[7], autonomous technology is used to improve individual mobility in terms of comfort and time saved. We also assume that congestion decreases through improved traffic flows. The indirect result of this improvement in individual mobility is that people move further away from their workplace, through a process of urban sprawl. AVs could also become a real living space (office, place to meet friends) and no longer just a means of transport. Consequently, the number of kilometres travelled could rise sharply, without any significant change to occupancy levels, which would result in higher energy consumption. In urban centres where the cost of parking is high, owners could send their vehicles to park in peripheral areas, thereby generating additional "empty" kilometres. Changes in online purchasing behaviour could be combined with automation to produce an increase in travel linked to deliveries; travelling shop services could develop, providing the cost of autonomous mobility is lower than that of a commercial lease. AVs could also compete with public transport and weaken their economic models.

These radical images of the future are not necessarily the most likely, but help to illustrate the risks and opportunities of AVs for sustainable mobility. The local and national public authorities have a key role to play in steering the development of this technology, whether in terms of regulation or in terms of industrial and infrastructure investment choices. But this requires foresight exercises that are open to the radical changes that could occur with autonomous mobility and that help to identify the conditions for their implementation and their implications for sustainable mobility. **This is the challenge of the "New mobility, clean mobility?" project currently underway at IDDRI.**

5 Results in terms of traffic (+6% veh.km for A, as transfer of bus users + detours + parking; +50% during peak hours for B with underground trains) and congestion (road use level relatively similar to the reference for A, but +80% for B without underground trains).

6 If we retain 50% "traditional" cars, only 2 out of 10 vehicles are withdrawn and the number of veh km in peak hours increases [A +35%; B +55%].

7 See, for example, the vision of Robin Chase, President of Zipcar: https://www.youtube.com/watch?v=DeUE4kHRpEk