Téoros

Revue de recherche en tourisme

40-2 | 2021 :
Tourisme numérique
Tourisme numérique

The Potential of Public Autonomous Vehicles in Alpine Tourism Destinations[1]

Le potentiel des véhicules publics autonomes dans les régions touristiques alpines.

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Abstracts

English Français
This paper deals with the potential of autonomous public vehicles with an electric power system for alpine tourism destinations. The dilemma of those regions is that they have a high demand for mobility, which is at the same time a risk for their most important assets, such as pure air and tranquillity. This study investigates the opportunities and challenges of public electric autonomous vehicles and focuses on the elements that could hinder a tourism destination from adopting this technology, based on expert interviews. Moreover, it evaluates opinions and concerns of future users of those vehicles. The findings show that public electric autonomous vehicles seem to be a valid solution for alpine tourism destinations that aim to be more sustainable and better aligned with the needs of their tourists. However, those vehicles must be managed in a smart way to avoid an increase in traffic. Technologically, they still need to be improved and be adapted to a challenging alpine environment.

Cette étude porte sur le potentiel des véhicules publics autonomes électriques pour les destinations touristiques alpines. Le dilemme entre tourisme et mobilité dans ces régions repose sur la coexistence d'une forte demande de mobilité et d'une sensibilité à la protection de l'air pur et de la beauté naturelle qui représentent d'importants atouts. Cette étude se concentre sur les opportunités, les défis et les éléments susceptibles d'entraver l'adoption de ces technologies en se basant sur des interviews d'experts. En outre, dans le cadre de cette étude, les opinions et les craintes de futurs utilisateurs de ces véhicules sont évaluées. Les résultats montrent que ces véhicules autonomes publics et électriques paraissent présenter une solution valide pour les destinations touristiques alpines qui souhaitent devenir plus durables et être mieux alignées avec les besoins de leurs touristes. Néanmoins, ces véhicules doivent être gérés d'une manière intelligente pour éviter une augmentation de la circulation. En matière de technologique, ces véhicules ont toutefois besoin d'améliorations pour mieux s'adapter aux conditions particulières d'un environnement alpin.

Index terms

Mots-clés : mobilité durable, véhicules autonomes publics, destinations touristiques alpines
Keywords : sustainable mobility, public autonomous vehicles, alpine tourism destinations

Full text

1 Mobility is a fundamental aspect of our way of living concerning both daily working life and, to a great extent, leisure and tourism activities. In Switzerland, for example, 40% of the reasons to be mobile are related to leisure activities (Bundesamt für Statistik BFS, 2012). Many tourists who spend their holidays in alpine regions travel in their own cars, as it is often difficult or expensive to reach those regions by public transport. This engenders challenges, such as a lack of parking infrastructure, congestion, noise, and environmental pollution, especially during peak seasons (Dickinson *et al.*, 2009). Therefore, it would be a huge advantage for those destinations to integrate a sustainable mobility concept, generating benefits at the economic, environmental, and social scales.

2 In the last decade, an increasing amount of scientific literature has dealt with tourism, transport, and sustainability issues at the global and the destination levels (Guiver *et al.*, 2008; Dickinson *et al.*, 2009; Scuttari, Della Lucia, and Martini, 2013; Orsi, 2015; Scuttari, Orsi, and Bassani, 2018).

3 However, there is a lack of scientific studies dealing with the potential of public electric autonomous vehicles (peAVs) to make a tourism destination more sustainable, smarter, and attractive for tourists from a mobility point of view. We assume that peAVs have the potential to improve a tourism destination's environmental sustainability by reducing greenhouse gas emissions and noise, and thanks to a better and cost-effective traffic management that is connected to intelligent systems engendering real-time data. The latter corresponds to a vision of smart mobility that affects the quality of life of tourists and residents in an equal way. Other benefits at the social level are the reduction in accidents following the automation of the vehicles and higher flexibility as regards customers' needs (Olaverri-Monreal, 2016).

4 This study focuses firstly on peAVs, such as the so-called smart shuttles (up to 15 passengers) that are currently produced by the French specialist in the AV market Navya (2019). The city of Sion, Switzerland, is the first city where this type of vehicle has been tested as a public offer on public roads. The shuttle in Sion can reach a maximum speed of 20 kilometres per hour and carry a total of 11 passengers. During the pilot test, an attendant—who is called "groom"—is in charge of the system and safety monitoring (Ramseyer *et al.*, 2018). This kind of AV is built to be a Society of Automotive Engineers' (SAE) level 4 (high automation) automated driving system (ADS) vehicle (Smith, 2013). These vehicles have been designed especially for the urban context and tested in cities, university camps, or private sites of enterprises. They have generated a great deal of interest in different parts of the world, such as Sweden, Germany, Japan, Singapore, where they are currently tested (Eden *et al.*, 2017). The aim of this exploratory study is to investigate the chances and opportunities of those peAVs for alpine tourism destinations. Secondly, the study focuses on the elements that could prevent a tourism destination to adopt peAVs. Furthermore, it is interested in the opinions and concerns of future potential users of peAVs.

5 Our research questions are as follows: How can the introduction of peAVs respond to the mobility challenges of alpine tourism regions and what are the impacts at the three levels of sustainability (economic, environmental, and social)? What are the technological, environmental, and organizational characteristics that could prevent a

tourism destination from adopting the innovation of peAVs? How do future users evaluate potential scenarios of a touristic use of AVs? To answer the first question, we conducted 14 interviews with experts from the tourism and mobility sectors from the private, public, and academic fields. As regards the second question, we employed a conceptual framework from the organization and management literature and adapted it to the particularities of our research topic. For the third question, we formulated two hypotheses based on potential scenarios some of the interviewees imagined in the field of tourism and asked 64 students from our University's tourism management sector to evaluate both hypotheses. It is important to underline that this is an exploratory study that focuses on a recent phenomenon that is still being tested and is based on a limited amount of data. The global research and advisory firm Gartner (2019) assumes that it will take more than 10 years for autonomous driving level 4 vehicles to reach mainstream adoption.

Mobility and Sustainability in Peripheral Tourism Regions

6 As Anna Scuttari, Francesco Orsi, and Ruben Bassani (2018) outline, tourism and mobility are a symbiotic, but highly controversial couple. The paradox consists, on the one hand, in tourism regions being highly dependent on mobility and transport so that tourists can travel to and within a destination. Transport can even be part of the touristic experience (Lumsdon and Page, 2004). On the other hand, alpine tourism destinations are ecologically very sensitive areas and the beauty of their landscape, fresh air, and calm are among the main incentives that attract tourists to those regions. Transport and mobility, however, threaten exactly those characteristics of alpine regions because of atmospheric pollution, noise, land-use conversions, and other direct impacts on the environment and recreational experience (Orsi, 2015). In the last decade, an increasing amount of scientific literature has dealt with tourism, transport, and sustainability issues not only at the global, but also at the destination level (Scuttari, Orsi, and Bassani, 2018).

7 Janet E. Dickinson, Derek Robbins, and John Fletcher (2009) employed the social representation theory to investigate the reasons of tourist behaviour regarding the use of means of transport in the rural area of Purbeck, Dorset County, in the UK. Their findings reveal that visitors travelling to that region consider the car as an essential means of transport as there is a lack of alternatives and a high need for improvement in public transport. Jo Guiver, Les Lumsdon, and Richard Weston (2008) asked tourist managers in the area of Hadrian's Wall, in Northern England, to what extent they can influence visitor behaviour as regards their chosen means of transport. Managers guessed that most visitors had first chosen their means of transport, then the destination. Additionally, they identified institutional barriers that prevent the implementation of more sustainable travel policies (*ibid.*).

8 Following their exploratory desk analysis, Anna Scuttari, Maria Della Lucia, and Umberto Martini (2013) found that neither "push[2]" nor "pull[3]" mobility measures lead to a reduction in tourism flows in South Tyrol. Likewise, those measures were successful in increasing the use of more sustainable means of transport. To learn more about tourists' preferences regarding several management measures and experiential conditions, Scuttari, Orsi, and Bassani (2018) conducted a survey with visitors of the highly touristic Sella Pass in South Tyrol focusing on traffic management measures that minimize a loss in tourist flows; they found that a combination of incentives ("carrots") and constraints ("sticks") leads to better results than the exclusive use of either measure.

An example of a "sticks" measure is to restrict the access to specific places for private vehicles. Through this measure, pollution in the car-free area can be

decreased and places that have been foreseen for private vehicles, such as parking lots or roads, can be re-designed (Scuttari, Orsi, and Bassani, 2018). In Switzerland, for instance, there has been an association of car-free tourism destinations since 1988. Thanks to their geographical location at the end of a valley or high up in the mountains where they are only reachable by funicular, cable car, or cog railway, they are predestined to be car-free destinations (Lehner, n.d.). As the access restriction only concerns the core of the destinations, many tourists still travel to the destination by private car, producing negative environmental impacts (Holding, 2001). Moreover, such a measure might cause a reduction in inflows in areas where tourists are accustomed to getting around by private car and should therefore be accompanied by the introduction of an excellent alternative transport system (ATS) (Scuttari, Orsi, and Bassani, 2018).

10 The introduction of a more efficient public transport system is an indispensable condition for a modal shift (*e.g.* from private car to public bus) and has favourable environmental outcomes. When planning an ATS, it is crucial to include the entire network of transport, thus employing a comprehensive view (*ibid.*). Scuttari, Orsi and Bassini (2018) found that ATSs based on public transport must be highly performing to prevent tourists from choosing another destination. Orsi (2015 : 16) added that sustainable transport systems, which can be one type of ATS, "are expected to bring positive impacts on a wide range of elements pertaining to the environmental (e.g. air pollution, noise, habitat loss), social (e.g. equity, human health, community cohesion) and economic (e.g. infrastructure, costs, price for the user, accidents) components." According to him, a sustainable transport system minimizes atmospheric pollution, noise, land use conversions, the direct impacts of visitation on the environment, and the impacts of visitation on the recreational experience. Moreover, it safeguards the visual perception of naturalness, enables all visitor groups to move freely, ensures the protection of local communities' quality of life, and is financially sustainable.

11 The introduction of a sustainable transport system is an example of a "carrots" measure. Another example is free public transport for tourists. However, Werner Gronau (2017) found that in Germany, local politicians and several small accommodation providers surprisingly opposed this concept and interpreted it as a cost factor.

12 Different modes of transport have different environmental impacts and experiential values. Scuttari, Orsi, and Bassini (2018 : 14) conclude in their study that it is essential to have "technically effective and emotionally rich alternatives to private transport." When comparing the environmental impact and experiential value of different means of transport, buses and trains, for example, have a low environmental impact, but also a low experiential value. Kayak, balloon, and cycling, for instance, are highly experiential and have a low environmental impact (Peeters, van Egmond, and Visser, 2004; Peeters, Szimba, and Duijnisveld, 2007; Page, 2008; Scuttari, Orsi, and Bassani, 2018).

13 To sum up, tourism destinations should develop an ATS that encourages visitors to travel with eco-friendly vehicles to be sustainable. This ATS should be technically effective and have a certain experiential value. Another important point is to assure the match between the mobility needs of tourists and their activity needs on site. Public transport for example must guarantee tourists a high degree of flexibility and freedom, like a private car. It is also crucial to make the public transport system as easy as possible for foreign visitors. There is however a lack of studies dealing with peAVs, which could be part of a sustainable transport system, for example by reducing atmospheric pollution or noise, improving the quality of life of tourists and the population, and the management of public transport.

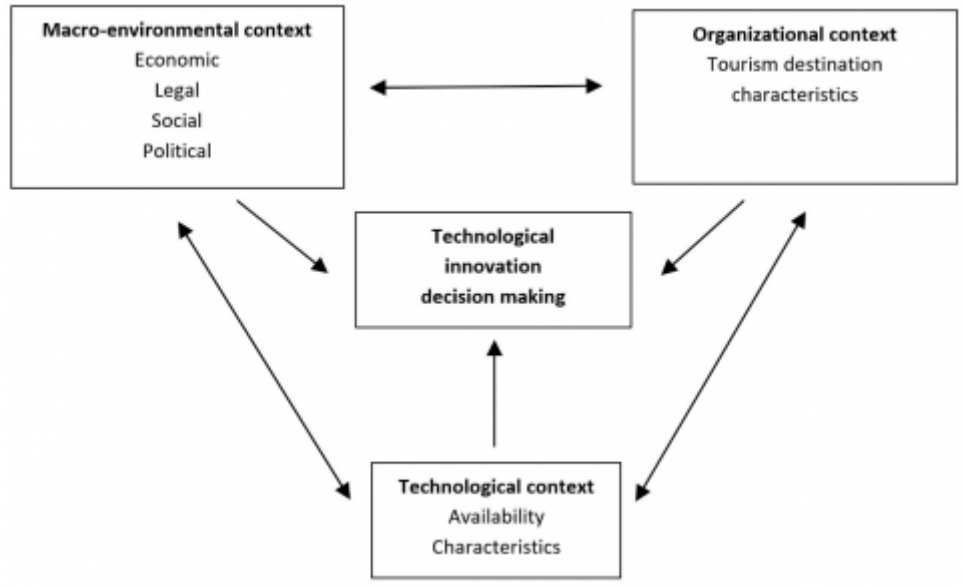
Conceptual Framework for Adoption Process

14 To answer the second research question focusing on elements that could prevent a tourism destination from adopting the innovation of peAVs, we employed the so-called Technology-Organization-Environment (TOE) conceptual framework (Tornatzky and Fleischer, 1990) to better structure the interview questions dealing with the adoption process.

15 We adapted this framework to the research interest of the present study by replacing the organization by the tourism destination (see figure 1). We are interested in the technological context of peAVs, and therefore only technologies that are external to the tourism destination, the characteristics of alpine tourism destinations (organizational context), and the economic, legal, social, and political environments that promote or hinder the adoption of an innovation (in this case peAVs).

Figure 1

Factors Influencing Technological Adoption in Tourism Destinations



Source: Adapted to tourism destinations, based on Tornatzky and Fleischer (1990).

Methods

16 As this study is exploratory in nature and peAVs are rather a recent phenomenon, qualitative methods in terms of semi-structured interviews, which give interviewees the possibility to elaborate on their answers, are especially suitable to identify opportunities and challenges from the point of view of different experts (Patton, 2015). We conducted interviews with key persons from tourism destinations and experts from the private, public, and academic fields to learn more about the potential of peAVs for tourism destinations, but also about technological and environmental challenges (altogether 14 interviews). As regards the key persons from tourism destinations, we limited our study perimeter to destinations from the alpine tourism region of Valais (CH), where we selected persons from five destinations (two nature parks and three destinations specialized in ski sports) to obtain a differentiated picture. We chose experts from Switzerland who had already gained experience in testing the introduction of peAVs or disposed of important knowledge in this field, such as a provider of management solutions for AV fleets (private enterprise), a scientific expert from a university of applied sciences, and a

representative of the association for public transport. We identified them both via a desktop research and the snowball principle.

17 For the data analysis process, we transcribed the registered interviews. With a combination of deductive and inductive coding (Schreier, 2014), we identified important topics regarding the research questions and codified them using NVivo software. We used power quotes to underline claims from the respondents' perspective (McKeever *et al.*, 2015). All the quotes were translated either from French or German into English.

18 In a second step, we asked students to evaluate the pros and cons of two possible scenarios of the touristic use of peAVs that were mentioned during the expert interviews. The aim of this exercise was to have the perspective of potential users of peAVs in a touristic context and to complement the expert views. This prospective approach can be defined as rational and holistic for preparing the future (Godet, 2004). Its aim is not to predict the future, but to elaborate possible and impossible scenarios based on the analysis of available data. The sample consists of 64 German- and French-speaking undergraduate students in the tourism management program at the University of Applied Sciences of Western Switzerland, in Sierre. The students applied the think-pair-share principle: they first think individually about the pros and cons of the different scenarios, then they discuss them in pairs to finally write down the most relevant pros and cons.

Results

Opportunities and Challenges Regarding the Accessibility by Public Transport

According to the experts, one of the challenges alpine tourism destinations face is a lack of accessibility by public transport, which, in most peripheral regions, is not cost-effective. Interviewees emphasized that the introduction of peAVs for the so-called first mile/last mile as a complement or even replacement of the current public transport offer would be suitable, as they are more flexible than public transport and do not require a driver, an important cost factor in a Swiss context. Table 1 shows different possible connections, while table 2 shows the opportunities and challenges related to the introduction of peAVs to improve access to alpine tourism destinations.

Table 1

Possibilities to Introduce Public AVs for First Mile/Last Mile

(based on interviews – IV stands for interviewee followed by a randomly allocated number)

Shuttle service between <u>two</u> points of public transport with a fix trajectory	**Better connections between <u>several</u> points within or between (a) tourism destination(s) with a fix trajectory**
• Airport/station/bus stop/village centre to cable car station (IVs 1, 3, 5, 12) • Station/bus stop to village centre/mountain villages (IVs 5, 6, 13)	• Ski buses, hiking buses (IVs 9, 10) • Connection between different tourism destinations (IV 5) • Connection between hotels (IV 13)

• Station/bus stop/village centre to natural and cultural sights/tourism hotspots (castles, museums, barrier lakes, lakes, nature parks, rare flowers, etc.) (IVs 1, 2, 5, 6, 8, 10, 12, 13, 14) • Station/bus stop/village centre to starting/end point of sports activities (hiking trails, bike trails, etc.) (IVs 2, 6, 10) • Station/bus stop/village centre to event locations (exhibition centres, festivals, events) (IVs 1, 2, 13, 14) • Airport/station/bus stop/village centre to hotels/apartments/chalets (IVs 1, 3, 5) • Transport service to the hotel/apartment (luggage) or transport of other material (*e.g.* to event locations) (IVs 1, 6, 9, 14)	

Table 2

Opportunities and Challenges Regarding Accessibility (based on interviews)

Opportunities	Power Quotes	Challenges	Power Quotes
Further development of public transport in alpine tourism regions **Better distribution between two or several points (first and last miles)** **Replacement of low-frequency bus lines with peAVs**	"The first-mile/last-mile concept via novel traffic systems with autonomous vehicles and the sharing model makes the accessibility of certain peripheral regions possible again, also from an economical point of view, which is somewhat impossible today." (IV 8) "Today's autonomous buses are for 8-12 persons and this is perfect to access peripheral regions and quarters." (IV 8)	Still lack of critical mass on average Huge fluctuations in demand	"Well, in the alpine space, nothing is cost-effective. Even if it's not that nice to say, but there's always a subsidization . . . there may be a bus with too many people, then one that's empty." (IV 12)
Cost savings	"If the driver is removed, it will be much less expensive to make [those regions] accessible." (IV 11) "There are possibilities, which could be economical in the medium term . . . if I can eliminate the driver costs, because that's the main cost factor." (IV 9)	Cost increases (in human resources, infrastructures, introduction)	"What's expensive is not the vehicle but the 'groom' inside." (IV 3) "With autonomous vehicles you can save costs for the driver, but you need other personnel." (IV 8) "In any case it will be more expensive, because today there's no connection for the last mile/first mile." (IV 13)

More flexibility in public transport offer	"[I]f you have an application that informs you that there are 5 persons in a perimeter of 1 km or 500 m who ask for a vehicle, *e.g.*, we can send them a notification [that says] you have a vehicle that will arrive in 5 minutes." (IV 3)	Storing of vehicles	"But anyway, there's a storing problem when you don't use them [the vehicles]." (IV 14)
Reduction of private transport	"Yes, it would indeed be great if we could eliminate a majority of the motorized individual traffic [thanks to the introduction of AVs]." (IV 2)	User behaviour	"For the person who came by car, it's more difficult to tell him, now you take the bus, if he came with his own vehicle." (IV 14)

19 From an economic perspective, the introduction of peAVs for better accessibility seems to have the potential to generate benefits for the destination. For example, the offer of public transport can be improved and peAVs can replace low-frequency bus lines and thus allow savings on the driver's salary. This not only meets tourists' needs but means new sources of revenue for the tourism destination. The introduction of peAVs can improve the image of a destination and strengthen its attractiveness, especially near target groups that are more environmentally conscious. Some of the interviewees however emphasize that even if drivers' salary can be saved, new costs arise, such as salaries of the new personnel that will be needed, notably for technical, logistical, or security/surveillance purposes or to accompany the peAVs in the role of a so-called "groom," as prescribed by law in Switzerland. This is especially the case when new trajectories are made accessible. Moreover, peAVs could be competitors for long-established taxi services.

20 At the social level, jobs (drivers) are lost, but others can be created (surveillance notably). These new jobs are potentially more sophisticated, and these new technologies could serve as a starting point for a holistically planned sustainable transport system. This could moreover be an opportunity for improved collaboration among different actors of the tourism destination.

21 From the ecological standpoint, the introduction of peAVs can, on the one hand, increase the demand and lead to more traffic and congestion, but on the other hand, the increased use of peAVs can be an incentive to reduce the use of private cars and regroup several persons in public buses, which would be favourable for the environment. However, the public transport offer needs to be very attractive for guests to persuade them to change their habits (see Scuttari, Orsi, and Bassani, 2018). Hence, the development of peAVs could be a starting point to reorganize the whole transport system through introducing a holistic sustainable transport plan (*ibid.*) focusing on public transport, promoting the use of new energy sources, and supporting noise reduction. PeAVs fulfil all those criteria. At the same time, soft mobility means of transport (by foot, bicycle, etc.) could be introduced to complete the offer. At the logistical level, the storing of the vehicles must also be organized.

Opportunities and Challenges Regarding Fluctuations in Demand

22 PeAVs might offer solutions for the typical challenge of dealing with fluctuations in demand for mobility in alpine destinations during peak and off-peak seasons, as mentioned by several interviewees. They suggested the following solutions (see also

table 3):

1. The introduction of peAVs in a “park-and-ride” system for the first or last mile and as a complement for private cars. That means that tourists can park their car outside the centre of a tourism destination and subsequently use the peAV to get to the village centre, hotel, cable car, or ski slopes. This “sticks” solution is especially interesting during peak seasons to better organize the traffic situation and to protect the centre from too many private cars having negative environmental and noise impacts and leading to traffic congestion. A challenge here could be the availability of parking facilities.
2. The introduction of peAVs in terms of an on-demand service for short, customized distances. This ensures the use of vehicles when they are really needed and prevents empty trips or trips with a few passengers only, which is sometimes the case with traditional public transport. This solution is interesting for example for tourists who arrive or leave early in the morning or late in the evening. In this case, autonomous cabs with an electric power system produced by the French enterprise Navya could be an interesting solution. Compared to traditional taxi services, there is no need for drivers waiting for clients who have not booked in advance. Moreover, autonomous cabs can also drive short distances, which is normally not profitable for taxi drivers. However, the current peAVs still have a limited autonomy and only follow fixed trajectories. Another example would be to provide peAVs at specific times, based on an intelligent logistic system, for example when ski lifts close, and demand is very high.
3. PeAVs used in different tourism destinations according to their usability, for example in a skiing area during winter, and at the lakeside during summer. This allows for a flexible management of those peAVs according to the demand, bearing in mind that the different tourism destinations can share the costs. The challenge here is to find such destinations in a close perimeter.

Table 3

Opportunities and Challenges Regarding Fluctuations in Demand

23 (based on interviews)

Opportunities	Power Quotes	Challenges	Power Quotes
Park-and-ride: **Less traffic in the village centre** **Zones formerly reserved for cars can be used for other purposes, such as green areas**	“I thought of a tourism destination where there would be a parking in the periphery where this type of vehicle would be really interesting . . . to limit the presence of private cars in the centre of the village.” (IV 6) “The aim is that they park down in the villages and then take the bus to come to the centre of the tourism destination.” (IV 10)	Enough space available for parking lots for private vehicles Tourists still driving to tourism destinations in their private cars	

On-demand service: **Flexibility, no empty runs, no crowded runs** **Adaptability to current demand** **Better management of fluctuations regarding peaks and slumps in demand** **Suitable for big and small groups** **No need for a driver at off-peak hours**	"There's a city in France—if I'm not mistaken—that has already tested vehicles that string together depending on the necessity for more or less space in the vehicle. This could be very useful, especially as regards the need to know if, at certain times, we will put two or three vehicles . . . this flexibility can contribute to an increase in comfort." (IV 4) "Instead of having 5 big vehicles that are not very flexible, maybe we could have 8 or 10 vehicles that are a little bit smaller, and this makes the system much more flexible." (IV 13)	Possibility of an increase in traffic Limited autonomy/flexibility Fixed trajectories/closed systems	"And what you should not underestimate . . . finally there's more traffic at the end." (IV 9) "What concerns programming of the vehicle for those trajectories, it's true that it always follows a predefined trajectory." (IV 6)
Sharing of vehicles between two tourism destinations	"[I]f you have seasonality effects, maybe those vehicles can be used by several tourism destinations during the same year. Maybe during wintertime, they can be in Verbier [a ski sports destination] and during summer, when there's less demand, a part of those vehicles can be used in Montreux at the lakeside." (IV 13)	Utility for peAVs in two relatively close tourism destinations, ideally not too far from each other	

At the economic level, due to reduced traffic in the destination centre and a more specific offer for public transport, the attractiveness of the tourism destination could increase, leading to higher demand. Moreover, through the more efficient use of public transport, savings on the operating costs are possible. At the social level, more places of encounter can be created, as less cars will be present in the centre of the destination or village. At the ecological level, spaces formerly reserved for traffic can be converted into recreation areas and public parks. Moreover, the adaptation of the offer to the exact demand can help save energy and resources. Nevertheless, if tourists still drive their cars to their holiday destination, they contribute to environmental pollution (see Holding, 2001).

Challenges Regarding the Creation of New Offers and Experiences

According to the interviewees, peAVs have the potential to be combined with a touristic experience (see Lumsdon and Page, 2004). This is especially interesting for alpine tourism destinations, as they aim to strengthen their summer and low season offers. In this context, the interviewees cited several possibilities (table 4).

Table 4

Potential Offers to Turn the AV into an Experience

(based on interviews)

Offer	Advantage/Experience
Tours through the vineyards (IVs 1, 5, 10, 13)	No problem with drunk driving; good for transport of wine bottles (IV 10)
Bird observation tours, *e.g.* in a nature park (IV 5)	Birds react less strongly to vehicles than to walkers (IV 5)
Fully customized tours (IV 5)	The guests can determine their own itineraries to include the sights they would like to visit (IV 5)
Tours through the village centre, old town, cities… (IVs 6, 11, 14)	Enhance the experience by providing audioguides, hop-on/hop-off tours (IVs 5, 6)
Fully automated surprise tours (IV 11)	Enhanced experience, as the itinerary is a surprise
Guided tours through the region (IVs 6, 14)	Special offers during the drive, such as a meal, virtual reality experience (IV 5)

25 The opportunities and challenges the interviewees mentioned in this context are summarized in table 5.

Table 5

26 Opportunities and Challenges Regarding Experience Creating
(based on interviews)

Opportunities	Power Quotes	Challenges	Power Quotes
Offer complementary services or packages **Touristic experience during the drive (such as particular meal, virtual reality experience, etc.)**	"You could also eat in this vehicle [*e.g.* a meal like a fondue]." (IV 5) "[W]e can imagine a 'discovery walk' through the vineyards in an autonomous vehicle. This enables people to drink more than the law allows [when driving a car]." (IV 6) "What is interesting with this autonomous aspect is that it transforms the trajectory between two points into a touristic experience." (IV 14)	Current limited speed (feeling of boredom among tourists [IV 9]) Lack of comfort in buses the way they are currently configured (lateral seats, not enough space) (IV 9) No personal contact with a driver (IV 2) Decreased interest after some time (IVs 2, 3, 7, 8, 9, 11, 12, 13, 14) The presence of AVs is not decisive in the choice of holiday destinations (IVs 14, 13)	"They want . . . to be in contact with the indigenous people and the only contact for the hikers is often the bus driver." (IV 2) "It was the attraction of the two first months but now it has become a routine." (IV 3)
Car-free tourism destinations (no individual motorized cars)	"[B]ut there's a real touristic potential, on confined sites, that means they are not accessible for individual motorized cars, such as Zermatt or Saas-Fee." (IV 6)	It is not possible for all types of tourism destinations to become car-free. Especially confined sites are predestined for this (Lehner, n.d.) Car-free tourism	

		destinations already exist. It is nothing new	

27 From an economic standpoint, new offers that are related to AVs can be created through the validation of this new means of transport. However, for specific offers, AVs might be privately owned and no longer be public. Moreover, the attractiveness and the image of the region in terms of sustainability can be improved (IVs 4, 6, 14). The risk is however that tourists are enthusiastic about the new offers and new means of transport in the beginning but lose interest over time. It is therefore crucial to combine AVs and emotionally rich experiences that are expanded over time (see Scuttari, Orsi, and Bassani, 2018). Besides, the comfort and technology of the current AVs still require to be perfected and adapted to the guests' needs.

28 At the social level, joint experiences are promoted, but interactions with indigenous people might be reduced due to fully automated offers, that is, without a driver who would be an interesting contact person for guests.

29 At the ecological level, the use of eAVs can lead to a more sustainable tourism and leisure traffic. Yet, increasing demand leads to more traffic. Consequently, it is a big challenge to find the right equilibrium between economic and ecological needs. One interviewee mentioned that AVs could be suitable for birdwatching, as they are less disturbed by vehicles than by walkers.

Factors Influencing the Adoption Process of AVs in Tourism Destinations

30 When considering the factors that influence the adoption process of this new technology, interviewees brought up different aspects that can be attributed to the technological, macro-environmental, and organizational contexts of the TOE framework. As to the technological context (table 6), many interviewees mentioned that although technology develops extremely fast, there are currently many aspects about those peAVs that should be improved.

Table 6

Important Factors for Innovation Adoption – Technological Context (based on interviews)

Factors of the Technological Context	Power Quotes
Degree of autonomy and flexibility (currently many of those public AVs follow a predetermined trajectory)	"It's true that you are bound by predefined itineraries . . . It's true that this is a little bit a limit of the system, which means that we stay in a system that is very rigid and not very flexible." (IV 6) "[The introduction of such AVs] depends on the autonomy in terms of distance." (IV 14) "[W]ill those vehicles be completely independent? What happens if there's an accident, and there's no driver anymore? . . . what happens if the door doesn't open?" (IV 8)
Level of intelligence of the vehicle (intellectual capacity of AVs regarding the communication between different systems and reaction to obstacles)	"Especially the migration path of these vehicles regarding the existing traffic, that's not yet solved." (IV 7) "In the context of the shuttle there's a project that aims to better communicate to the other road users the intentions of the shuttle." (IV 6)

	"The level of intelligence of the vehicle. Those vehicles have to be really really autonomous, today in Sion it's not the case yet." (IV 13) "Today, the vehicles do not drive around obstacles . . . each time when there's a vehicle that's not parked correctly, or a terrace, or a chair, instead of driving around, it stays blocked." (IV 13) "[A] puddle, for example, can be complicated, because the vehicle can maybe detect the puddle, but how does it know if it's a small one or a big hole?" (IV 13)
Adaptation to the morphology, meteorology, road condition (as alpine regions experience conditions as regards meteorology, climate, infrastructure, and morphology that are extremer than most urban regions)	Several interviewees mentioned the gradient in mountain regions as a particular difficulty for AVs: (IVs 1, 4, 6, 8, 10) "What I perceive as a risk is purely psychological. Between Ernen and Binn, it's very steep." (IV 2) "[A]nd then there's again a landslide, which is a bit critical. Safety is surely a challenge." (IV 9) "You have a narrow road, then one is coming from above and another from below, and I am 'normal' and the other one is 'automatized.' We will not solve this problem within seconds." (IV 9) "Everything that concerns the rural space has a higher complexity associated to natural hazards, with roads that do not comply with norms—in one location a little bit narrower, and that makes it difficult for such vehicles." (IV 12)
Detection system (particularly the ability of the system to detect obstacles)	"[What about] a [tree] branch hanging down? Will the vehicle stop?" (IV 12) "If the vehicle is blocked every time there's a small obstacle or a rubbish bin and someone has to come to put it on the way again, this doesn't work." (IV 13)
Speed	"Those are not vehicles that are made—in any case not today—to cover a distance of 10, 20, 50 kilometres, but rather for distances of some metres or kilometres. Hence for urban centres or villages." (IV 13)
Brake system	"[A]nd they brake quite abruptly." (IV 8)
Technical and mechanical reliability	"The two principal things are the mechanical and technical reliability of the vehicle." (IV 13)
Battery	"There's either a problem of autonomy, let's say in terms of energy, in terms of battery *e.g.*, either an infrastructural problem associated with recharging the batteries at relatively high costs." (IV 4)

Passenger capacity (IVs 6, 14)	"[B]ut it's true that this challenge of capacity depends on the type of AV used. That's quickly a limiting factor in terms of possibilities." (IV 6)
Personal safety (accidents) and security (crime)	"[I] would say that people have to accept to climb into a robot and then people need to think that they are safe." (IV 13) "[A]nd if there's no one in the bus, nobody sees when a person suffers a heart attack . . . that's why cameras are needed." (IV 1)

31 Among those aspects are the degree of autonomy and flexibility of those vehicles, which is limited by predefined itineraries and the autonomy of the battery. The level of intelligence of the vehicle is another important aspect, especially regarding the communication between different systems, such as non-autonomous cars, cyclists, or pedestrians. Moreover, those vehicles are not yet adapted to the geographical, meteorological, and road conditions of alpine regions. Examples are slopes, but also the occurrence of natural hazards (rock fall, landslides), narrow or one-way roads. This is also related to the detection system of peAVs, which is not yet sophisticated enough to recognize for example a hanging tree branch. Furthermore, the speed of those vehicles currently tested in Switzerland is still very low. Nevertheless, they brake very abruptly, which may come as a surprise for many passengers (Eden *et al.*, 2017). The current passenger capacity (maximum of 15 persons) is another limiting element. Then, personal safety and security, which are closely linked to technical and mechanical reliability of the vehicle, are crucial aspects. People must feel safe and secure when they get on these vehicles. Hence, safety and security systems must be developed for instance in cases of a door that would not open when a passenger is being attacked or is suffering from a heart attack.

32 As to the macro-environmental context (table 7), the legal system is still lagging, as so far, at least in Switzerland, the operation of such vehicles is based on legal exemptions.

Table 7

Important Factors for Innovation Adaption – Macro-environmental Context (based on interviews)

Factors of the Macro-environmental Context	Explanation/Examples
Legal conditions	"[T]oday, nothing goes without exemptions." (IV 8) "I think my wish would be that our politicians deal in a more pragmatic way with this topic." (IV 8) "Then there's the question of guilt. At the moment, we are responsible for those vehicles." (IV 1) "The biggest difficulty today is associated with legal conditions. There is always an accompanying person in the vehicle." (IV 12)
User acceptance (tourists)	"The ETHZ [Swiss Federal Institute of Technology in Zurich] is doing an accompanying study. The first results are rather positive. Of course, there are certain fears. Yet, the point is to recognize those fears and react to them in the right way." (IV 8) "The acceptance study shows that—if people sit more than half an hour in such a vehicle, that's enough, then they've seen it." (IV 9) "And what is especially important is the acceptance of people . . . If there's a huge accident, the acceptance degree can decrease quickly." (IV 12)

	"But today the acceptance of those vehicles is relatively good." (IV 13) "The car works well, but in terms of social acceptance it's not yet developed enough." (IV 3) "I can imagine that it's easier to do a tour of the castles in Sion in a zone where there's only little circulation. It's different from being in a small shuttle without a driver along a corniche with an overhanging cliff on your right." (IV 4)
Political support of key actors at different administrative levels	"The most important thing was that we do it together, that it's a promotion of the economy, we did it like that: transport companies, plus the technology part, if the municipality wants that, if the canton wants that . . ." (IV 8) "Well, the most important thing is of course to have the support of politics." (IV 1) "[T]he political will to change things [is very important]." (IV 4)

33 Users' acceptance of AVs is indispensable, and most of them seem to have a high degree of acceptance. Yet, the situation is a bit more difficult in alpine regions, where the roads can be surrounded by steep slopes or where a peAV can be confronted with a non-autonomous car coming from the other direction on a narrow street. The political support of key actors at different administrative levels seems to be of the utmost importance.

34 As to the organizational context (table 8), that is, at the level of the destination, here again the political support of key actors is needed. It is particularly important to discuss the project of the introduction of peAVs with all key stakeholders to garner broad support. In addition, the support from the tourism actors and the population is crucial. Interviewees also mentioned that it is essential to have a centre that manages and coordinates everything. As tourists are often price sensitive (Scuttari, Orsi, and Bassani, 2018), it is crucial to integrate the peAV offer into a financing system that is subsidized, for example through visitors' taxes, or even one that is free (see Gronau, 2017).

Table 8

Important Factors for Innovation Adaption – Organizational Context

(based on interviews)

Factors of the Organizational Context	**Explanations/Examples**
Political support of key actors within the destination	"The next step is of course to organize a roundtable where industry, commerce, and tourism actors sit at one table and where experiences are shared." (IV 1) "[It is very important that] there's a demand from the municipalities. They have to say we can imagine that . . . that would be the most important thing." (IV 5)
User acceptance (indigenous people) and acceptance by actors from the tourism sector	"There are many groups of people who say that it costs a lot of jobs. Yet, this is not true at all, I have to say. On the contrary . . . we have employed 12 people. That's really a lot. We need engineers of course. We need technicians. We need accompanying persons." (IV 1) "[T]hen there's the reaction, when there are accidents or this kind of things, you can never really predict how people will react. Yet, today the acceptation of the vehicles is relatively good." (IV 13) "The acceptance of the project by the partners from tourism [influences positively the introduction of those vehicles]." (IV 4)

Availability of a managing centre	"But there's something very decisive you need. You need somewhere a centre that coordinates the whole thing." (IV 1)
Integration into a financing system	"People who stay overnight, who pay the visitor's tax; they could use these autonomous vehicles for free. That would be financed with the visitor's tax." (IV 10)

Evaluation of Potential Scenarios through Future Users of AV

35 Based on the above interviewees' answers, we have retained two hypotheses proposing two potential future scenarios in tourism regions. By asking a group of 64 German-speaking and French-speaking students at the University of Applied Sciences in Sierre, Switzerland, we wanted to find out if they had similar concerns and expectations as the experts we had interviewed.

36 The first hypothesis was: *"There are no more cars in city centres, which makes cities greener, thanks to a better management of traffic flows."*

37 The students underlined the environmental benefits of this scenario (less traffic jams, less pollution, less noise, and more green areas). They also recognized benefits due to improved traffic management, which is coupled with a reduction of accidents, less parking lots and more space for other types of smooth mobility like bicycles and pedestrians. Moreover, this scenario was recognized as being capable to take into consideration the needs of all age groups. Better management would also help to save time and money and make a city or a village more attractive.

38 However, students also mentioned cons related to hypothesis 1. They showed some concerns at the socioeconomic level. Like the experts they mentioned the potential loss of certain jobs for drivers, taxi operators, but also the automobile industry in general. They raised the security and safety issues related to the technological and reliability aspects of the vehicles and the associated issues of a loss of human control, as well as the potential loss of liberty, autonomy, and experience. As a disadvantage, they mentioned growing dependence on timetables and public transport. This highlights young people's flexibility need. They had some concerns about costs and energy issues and asked which energy would be the most suitable to manage traffic. Students believed that technology is not ready yet and that it is difficult to manage everybody's needs. Especially as concerns tourists, they feared that such a system could be too complex to understand, which could hinder them from travelling to these regions.

39 The students evaluated the pros and cons of a second hypothesis that includes the experience aspects of these new means of transport. With the objective of showing a futuristic scenario, we also integrated taxi drones and augmented reality into the hypothesis: *"Thanks to autonomous vehicles, taxi drones, and augmented reality, travellers can live touristic experiences during their trip."*

40 Some of the students reflected in a very rational way and mentioned the possibility to see a lot in a short time as a benefit for travellers. They also raised security aspects: when tourists live experiences in autonomous public vehicles, rather than in their own cars, there are less accidents and a possible reduction of traffic jams. Students also underlined the experience aspect, especially regarding the many possibilities offered by augmented reality. At the social level, they appreciated the touristic possibilities notably for people with handicaps.

41 As to the cons, students referred again to security issues. More specifically, they brought up the risk of piracy and a loss of control. At the social level, they mentioned again the loss of jobs and of human contact, which however seems to be a crucial point for touristic experiences, as one of the experts also pointed out.

Discussion

42 The aim of this exploratory study was to find out more about the potential of the introduction of peAVs in alpine tourism destinations, taking into consideration the paradox between mobility and tourism in alpine tourism regions (Scuttari, Orsi, and Bassani, 2018). The results show that the introduction of peAVs could be a very good starting point to introduce a sustainable transport system as a "carrots" measure (*ibid.*; Orsi, 2015) with beneficial impacts at the economic, environmental, and social scales. For example, peAVs could be an environmental-friendly way to guarantee better accessibility to alpine tourism regions for the first mile/last mile and encourage tourists to travel by public transport from their residence to the destination. In addition, the flexible utilization of peAVs could contribute to a higher number of vehicles on the road and more congestions. Therefore, intelligent logistic systems are needed to organize the use of peAVs in a cost-saving and efficient manner. Likewise, peAVs could be integrated into the existing transport system in a flexible way by providing an on-demand service which would help to avoid having empty bus rides in non-peaks and to reduce crowded bus rides in peak times. Therefore, with an on-demand service, alpine tourism destinations could react more efficiently to the peaks and troughs, which are so typical for those regions. Another instrument to manage the peaks would be the "park-and-ride" solution, where guests leave their cars in a parking lot outside the centre of the tourism destination; and only peAVs would be allowed within the destination, which would be a "sticks" measure (see Scuttari, Orsi, and Bassani, 2018). This would turn the tourism destination into a car-free site in terms of "cars without combustion engine." However, tourists would probably still travel to the destination by private cars. Another solution to deal with the peaks and troughs would be to use the peAVs in one place in wintertime and another in summertime, depending on peaks, which would entail sharing the vehicles between two or more tourism destinations. When there are geographically close, this solution not only engenders benefits at the economic, but also at the environmental scale. Additionally, AVs can also attract tourists—at least at the beginning—by strengthening the visibility of a destination. By creating new offers, the tourists' experience during transport can be enhanced (see Scuttari, Orsi, and Bassani, 2018).

43 As to the elements that could hinder the tourism destinations from adopting this innovation, at the technological level, peAVs still show some weaknesses associated with safety and security issues, speed, capacity, detection system, intelligent communication, and adaptability to specific roads, as well as natural and meteorological issues of alpine regions. As to the factors of influence outside the tourism destination, the legal framework is still inadequate. Moreover, the acceptance by users is a crucial point (for example, some fear the loss of control), as well as the political support for this kind of vehicle. Within the destination, it is important to garner the support of key actors. Many interviewees emphasized that when AVs are introduced, the costs for drivers can be saved. It is important to bear in mind that drivers' salaries are an important cost factor in Switzerland, but this might be less significant in other countries. Some interviewees pointed out that costs might even increase due to the implementation expenses or the need for more "sophisticated" employees. However, coupled with an integral traffic planning, the introduction of peAVs could help motivate guests to change their behaviour and reduce their use of private cars.

44 To sum up, the introduction of AVs seems to be a valid solution for alpine tourism destinations that aim to be more sustainable and that do not have a lot of financial and human resources available, such as nature parks, as the main advantages of peAVs compared to traditional public transport systems are the flexibility regarding their use and passenger capacity, as well as the absence of a driver. As they are rather

small (maximum of 15 persons), a single peAV can be used in off-peak season and a fleet of them during peaks. However, an in-depth financial assessment is necessary to evaluate which system works best for which destination. For a village like Zermatt that already has a system of electric vehicles (with drivers), for example, the introduction of AVs seems to make less sense. Moreover, those epAVs still require technological improvements to be adapted to the challenging conditions of alpine regions.

Managerial Implications and Conclusion

45 It is important for managers of tourism destinations to think about a holistic traffic management that takes into consideration the needs of tourists, such as flexibility and independence, and respects the principles of economic, social, and environmental sustainability. The introduction of peAVs could be a starting point to reconsider their current transport system and to collaborate with different stakeholders within and outside the destination. Managers should therefore think further than just in terms of their destination and collaborate with other public transport systems that bring tourists to their destination. To redesign their traffic situation, managers should consider the needs of the local actors and different stakeholders. Moreover, they should try to create innovative offers and experiences that not only integrate eAVs, but that stay attractive even after a first hype related to the autonomy aspect of the vehicle. Offers including eAVs could be interesting for tourism destinations that do not always have the same demand, to ensure the provision of the offer that otherwise would not be possible because it is too expensive. Moreover, future users and experts often mentioned the aspects of security and safety. Hence, it seems very important to test the vehicles, to collect user opinions, and to continuously improve the offer. As regards expenditures, the introduction costs could be high. However, when the system is running, it is important to integrate these costs into an intelligent financial system, for example via tourist taxes.

46 This study has some limitations. As the topic is very recent, there is little scientific literature on this theme. Hence, it is exploratory and future research is needed to investigate this topic in more depth and especially in the context of other countries that do not necessarily share the same opportunities and challenges as tourism destinations in Swiss alpine regions. Even within these regions, there are big differences and there is no "one-size-fits-all" solution. It would be very interesting to draft different scenarios for alpine tourism regions for the introduction of an ATS that takes into consideration the potential use of peAVs. As to the TOE framework, more theoretical development and empirical assessment are still needed to adapt it to the particularities of the tourism system. Nevertheless, it can serve as a starting point to formulate hypotheses. In the context of sustainable mobility in alpine regions, aspects of the "sharing economy" should as well be investigated deeper.

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Notes

1 The authors presented the first version of this paper at the 2018 Smart Tourism Congress Barcelona (November 21-23). The current version is augmented with complementary results and conclusions.

2 Mobility measures that encourage sustainable activities.

3 Mobility measures that discourage unsustainable activities.

List of illustrations

Credits	Source: Adapted to tourism destinations, based on Tornatzky and Fleischer (1990).
URL	http://journals.openedition.org/teoros/docannexe/image/10498/img-1.jpg
File	image/jpeg, 98k

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Electronic reference
Sandra Grèzes-Bürcher, Vincent Grèzes, Michael Fux, Randolf Ramseyer and Rolf Wilk, « The Potential of Public Autonomous Vehicles in Alpine Tourism Destinations », *Téoros* [Online], 40-2 | 2021, Online since 09 September 2021, connection on 23 November 2021. URL : http://journals.openedition.org/teoros/10498

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