

INVENTING MOBILITY
FOR ALL

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INVENTING MOBILITY FOR ALL

**Mastering Mobility-as-a-Service with
Self-Driving Vehicles**

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Emerald Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2022

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British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-1-80043-179-9 (Print)

ISBN: 978-1-80043-176-8 (E-ISBN)

ISBN: 978-1-80043-178-2 (Epub)



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INVESTOR IN PEOPLE

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FOREWORD

What drove us to write a book about Mobility-as-a-Service? First and foremost, we care about human-centric mobility solutions, which will determine this century. Sure, it's also about technology and more precisely about electric, connected, and above all autonomous vehicles that you can summon with an app. It is about self-driving cars and buses controlled via a mobility platform. But it's also about connecting all those cars, buses, trains, and the various forms of micro-mobility to create seamless transportation. Imagine driving with no steering wheel ... how fascinating is that?! Mobility in its new guise can lend a whole new shape to our lives, our daily routines, and of course our transportation choices. We can reinvent the very notion of travel.

Some of the finer points of the Mobility-as-a-Service concept still must be firmed up. Some aspects are still vague. We nevertheless felt it was important to embark on this tour d'horizon as few other accomplishments will likely transform our lives and the way we go places to the same extent as electric, connected, autonomous driving in conjunction with other modes of transportation. So, the time has come to address the concept of 'mobility at the push of a button', to foster public debate on the subject and to play our part in helping it change our lives for the better.

For us as the authors, engaging with this topic has been a moving experience in more ways than one, above all because discussions of vehicles, sensors, algorithms, and mobility platforms only scratch the surface of what this is really about. More fascinating still are the stories behind the new opportunities that Mobility-as-a-Service opens up for people. Especially in the megacities of this world, we can see for ourselves every day that mobility is one of the most important prerequisites for personal freedom and indeed personal development. If, through mobility on demand, we can succeed in transporting people faster, farther, and more easily, these people will

gain access to better jobs and higher pay and have greater control over their lives. And think of people with impairments or disabilities, the elderly and the young who, in many countries and cities, are dependent on outside help to have any chance at all of a social life and participating in society. Consider the rural areas where the younger generation moves away, leaving the elderly behind, stores close, and even such essential services as a local general practitioner are no longer available. Providing inclusive Mobility-as-a-Service with autonomous vehicles for people, goods, and services could form at least part of the solution to these problems.

But there is even more at stake. At the UN Climate Change Conference in Paris in December 2015, 197 countries signed a new, global climate protection agreement that aims to limit global warming to 1.5 degrees Celsius compared to the pre-industrial era. To reach this goal means attaining carbon neutrality worldwide in the second half of this century; that is to say, not generating more emissions than can be sequestered by forests and other carbon reservoirs. It is imperative for the transportation sector to play its part in achieving carbon neutrality.

Just how important this is can be illustrated by any number of memorable and moving stories – experiences, for example, of the people in many Asian and African cities who are at risk of suffocating in the exhaust fumes emitted by the soaring numbers of vehicles on the roads. Then there are the gigantic projects being undertaken in many metropolises to expand the transportation infrastructure in response to the spiralling mobility needs of their inhabitants. And when we factor in the millions of pedestrians, cyclists, drivers, and passengers killed or injured in road traffic accidents, there is no avoiding the truly decisive questions: Don't we finally need to organise our mobility better? Aren't the social costs way too high? Can we still afford this kind of mobility, knowing full well that it could be done better? Therefore let's go. Let's embark on this journey. Let's get on the trail of Mobility-as-a-Service and see what this innovative concept has to offer.

Many faculty members, colleagues, experts, and leading figures from the fields of politics, business, and society have provided us with ideas and inspiration. We would like to thank them all for their readiness to share their knowledge and experience. Our discussions

with Chris Urmson on autonomous and connected driving; with Anat Bonshtien on the new mobility industry in Israel; with Seung Won Kim on Daegu Smart City in South Korea; and with Cem Özdemir on the challenges for government and society were particularly valuable. And a special vote of thanks goes to Niall Kennedy from Emerald Publishing for his support. He's been a keen advocate of this project since the outset.

The outcome, we hope, is a book that sheds light on this subject from a variety of angles and that contributes to an open, honest, multilayered, and nuanced discussion of the opportunities of Mobility-as-a-Service. We, the authors are, we admit, euphoric and optimistic. We want change! We are convinced that electric, connected, and above all autonomous driving will change our lives, our environment, and our society for the better, in a world where mobility is no longer necessarily owned but used as a service. But of course, there are also doubts and concerns, and these too you will find reflected on the following pages.

Andreas Herrmann
Johann Jungwirth (JJ)

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PREFACE I

Mobility is a topic that concerns all of us and is part and parcel of our everyday lives. We travel to work; visit family and friends; go to a doctor's appointment; or take a trip to the local library, museum, or sports facility.

Mobility is a triumph of civilisation and at the very roots of urbanisation. The nature of our urban lives is shaped by the forms of mobility at our disposal. The identity of a city is inseparable from its iconic transportation system: London's black cabs, the Tokyo Metro, the tuk-tuks in Bangkok and the three-wheelers in Mumbai, the freeways of Los Angeles and Dallas. According to Mark Twain, travel broadens the mind. Mobility also enables people to leverage their economic potential and empowers them to dream. But is the price of mobility not too high?

Andreas Herrmann and Johann Jungwirth take us along on a highly topical post-pandemic tour d'horizon through the diverse aspects of mobility – personal, societal, technological, and economic – complete with numerous deep dives into scenarios from across the globe where new mobility concepts are taking shape.

Given the evident growth of our cities and the associated social costs of mobility, such as traffic jams, space used for parking vehicles, air pollution, road accidents, and the like, simply continuing with 'business as usual' is not an option. Systemic change is inevitable. Interweaving autonomous, connected, and electric mobility within a system where vehicles are shared and the different modes of transportation are digitally linked and coordinated promises to deliver the technical basis for the development of a comprehensive solution. But by choosing to call their book 'Inventing Mobility for All', the authors serve notice that they are casting their net even wider.

What are the economic and behavioural forces of inertia that we encounter on the road to this new mobility? The automotive

industry is a significant economic factor and employer. On the one hand, the shift to electric mobility is creating new jobs. On the other hand, it is rendering many jobs obsolete, particularly at small- and medium-sized companies in the supplier sector. And aren't cars also status symbols, sources of pleasure, and safe havens that we have no desire to share? Are people really ready to make the leap from the individualistic 'city of play' to the utilitarian 'city of speed'? The '15-minute city' with its rhythms that coincide with the natural pace of human life provides a vision, but getting there will ask a great deal of each individual. In many places, this will mean scaling back the physical infrastructure and bidding farewell to our everyday routines.

Does Mobility-as-a-Service (MaaS) make economic sense and will it create prosperity? To date, no entirely convincing business model has been identified, and the automotive industry is backtracking. Clearly, MaaS can only succeed where many people embrace it, which is mainly the case among the millennials and digital natives in our megacities, who have grown up with the sharing economy. But what about people who live in rural areas and feel left behind? What does new mobility look like there and how economical can it be? What about those who live in the slums of our major cities, with no local mass transit system available to them and only limited access to jobs and public utilities?

What could a carrot-and-stick system look like that involves and motivates people, while also taking them by the hand and leading them through the systemic shift with appropriate policies and infrastructure changes?

Rich in examples of potential approaches and the innovations that lie ahead, this book adopts a global perspective and targets an international audience. It represents a truly felicitous balance of optimism and reflection.

Christoph Wolff
Executive Committee
World Economic Forum
(Summer 2021)

PREFACE II

Across the globe, people complain about traffic jams and delays. When we look around, it seems as if the mobility we've all come to love has reached its limits in many places. In Africa, as well as in parts of Asia and Latin America, the number of traffic fatalities and injuries continues to rise. And here in Europe as well, too many people still die in road accidents. 'Vision Zero', the goal of eliminating road fatalities entirely, is still a long way off. In addition, exhaust fumes mean that people have to wear smog masks in some parts of the world. At the same time, more and more valuable land is sealed every year to accommodate rising levels of traffic. And as if that wasn't enough, our current mode of mobility is also a major driver of the climate crisis. Around 25% of all carbon dioxide emissions are generated by the transportation sector.

There's no doubt about it: If we intend to overcome the challenges set out above, we're going to have to rethink our approach to mobility. We need a mobility revolution. And our main challenge here will be successfully reconciling two apparently conflicting goals. On the one hand, mobility is doubtless a key requirement for enabling people to find work and earn a living. Without mobility, there is no participating in social life and in the dialog between people, cultures, countries, and continents. So there can be no question of fundamentally restricting mobility or making it more expensive across the board.

On the other hand, if we do not change course, it will be at great cost to humanity, the climate, and the environment. If we are to achieve the goals set out in the Paris Agreement and not to leave a broken planet to our children and grandchildren, we need to take urgent action. We need to stop building our cities around traffic and instead shape traffic to meet people's needs going forward. Consider this: At present around one third of a city's land area is given over to transportation. That's no way to achieve quality of life, liveable urban spaces, economy, and efficiency!

So how can we reconcile these two goals? Along with a strong local public transportation offering, the massive expansion of the rail network and of bike traffic, the keywords here are ‘electric’, ‘connected’, ‘autonomous’, and ‘shared’.

When it comes to drivetrain systems, in the passenger car sector the die is already cast: On the road to climate neutrality, virtually all the leading automobile manufacturers have opted for electric mobility. Compared with cars powered by hydrogen fuel cells and internal combustion engines which one day will run on synthetic fuels, the electric car has the advantage of being able to harness green power almost directly. A car running on synthetic fuel requires five to six times as much electricity as a battery-powered model on account of the fuel conversion process. The crucial factor in the electrification of our traffic is that we succeed in generating sufficient electricity from renewables. The mobility revolution is also an energy revolution. And without the energy revolution, it cannot work.

At the same time, we need to rapidly ensure that vehicles are connected with one another and with the infrastructure. Talking traffic lights, for example, can inform approaching vehicles that they are about to change from green to red. The cars will then automatically slow down and reach the lights as they turn green, at which point they accelerate again. This has the potential to save a lot of energy. Autonomous driving would take things a step further. Vehicles would drive along in traffic like pearls on a string. Manoeuvres would be smooth, making jerky stop-and-go traffic a thing of the past – with an enormous impact on energy consumption and emissions.

That’s all well and good. But in terms of climate action, autonomous driving will only truly come into its own if we can persuade more and more people to share rides. Think about it: As a stand-alone module, autonomous driving harbours the often-cited risk that it will actually increase the number of vehicles on the road. For us and our climate, it makes a world of difference whether the autonomous vehicle is a sport utility vehicle (SUV), powering several miles to a downtown parking garage, or a shuttle that bundles multiple personal itineraries in the city centre or provides a link

to the suburbs and outlying areas, where bus and rail connections are few and far between. If we make more efficient use of vehicles through ride-sharing and ride-pooling, we can achieve a marked reduction in the number of trips required and vehicles on the road. Not only would this lead to a drop in energy consumption; we'd also have more space in our towns and cities.

All of this is not going to happen of its own accord. It's going to take the right framework and intelligent catalysts to drive the mobility revolution forward. Before us is the opportunity to create a modern, clean, safe, and affordable version of mobility. Let's make the most of it, in the interests of humanity, the environment, and our climate.

Cem Özdemir
Chairman of the Committee for
Transport and Digital Infrastructure
German Parliament
(Summer 2021)

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PREFACE III

Mobility is a source of fulfilment and a freedom.

I believe that this freedom goes hand in hand with preserving the planet and living better together. Anticipating and building the future of mobility is a real challenge for car manufacturers.

The development of new shared mobility services sits on an industrial continuum. It has always been in automotive original equipment manufacturers' (OEMs) nature to show leadership in understanding consumer trends and usages to offer transport services that best meet needs both now and in the future.

Over the recent years, mobility has become more and more multimodal – thanks to shared mobility, micro mobility – today the diversification of mobility business models accelerates, with a market expected to grow by 60% by 2035. In the new mobility value chain, on-board intelligence systems are the new driving force.

Faced with this technological challenge, collaboration is vital, between large companies and public authorities, but also universities and research centres. In shaping tomorrow's mobility, we need to have an ecosystem approach, with software and algorithms playing a major role.

Therefore, we need to challenge ourselves to limit the impact on the climate and on resources and to make mobility more inclusive and safer for everyone. Bringing inclusion through mobility is a strong commitment over the upcoming years for the industry, as mobility can be a source of inequality and is sometimes a necessary hurdle to overcome in getting, keeping, or training for a job. Indeed, 50% of job seekers say they refuse training or employment because they lack transport.

For a more sustainable future, OEMs will need to shape mobility solutions and services that complement the traditional car-buying scheme, which promotes greater asset utilisation through the

circular and sharing economy keeping in mind the expectations of consumers, businesses, operators, and territories.

Luca De Meo
Chief Executive Officer of Renault S.A.
Chairman of Renault s.a.s.
(Summer 2021)

Part 1

MOBILITY, PROSPERITY,
AND THE ENVIRONMENT

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CAN WE STILL GO PLACES?

TRAVEL IS EDUCATIONAL

‘The best education for a clever person is found in travel’. With these words, Johann Wolfgang von Goethe encouraged people to go forth and see the world instead of sitting around bored at home. Many great authors and thinkers have expressed similar ideas – in particular Mark Twain, who considered travel the best antidote to ‘prejudice, bigotry and narrow-mindedness’. Travel gives one ‘broad, wholesome, charitable views of men and things’, he asserted. And, perhaps most importantly, travel makes people happy. Good reason, then, to keep exploring new things, seek out the wide-open spaces and not simply be content with what’s familiar and close at hand. All these pearls of wisdom are best summed up in a famous line by nineteenth-century German poet Wilhelm Busch: ‘Drum o Mensch sei weise, pack die Koffer und verreise’ (‘And so, my friend, the thing to do, is pack your bags and be off with you’) [1].

There are probably few pieces of advice that have been as widely followed as this encouragement to travel or, as we might put it today, to hit the open road. Mobility has become a core value of our society. Indeed, many even consider it essential to an interesting, engaging, appealing, and fulfilling life. It has long since ceased to simply be about the clichéd change of scenery or an occasional shift in focus. Mobility is the rule, remaining in one place, the

exception. Almost everything that people used to do in one specific place, they can now do from anywhere and everywhere – working, meditating, surfing the internet, shopping, making phone calls, watching TV, having time for themselves, resting, and sometimes maybe even feeling at home.

Despite this enthusiasm that many of us share for being on the move, there is also a growing realisation that mobility is reaching its limits. Because this wanderlust causes such significant damage to nature and mankind, some are calling for a return to a slower and more leisurely pace. They think we have carried our restless roaming too far. People rush from one destination to the next without any discernible purpose or intelligible objective. This scepticism about our perpetual motion has manifested itself in debates about car-free zones, air travel, and too many parking spaces in urban centres. Do people really need to travel halfway around the globe – to go everywhere in person – when the inhabitants of many cities are literally suffocating in traffic?

Didn't the coronavirus pandemic show us an entirely different path? We can do so much without mobility. Zoom and Teams make virtual meetings and travel possible – a click will take you across the world. You don't actually have to go places! You can get everything done without moving from the spot. But, of course, there is a flip side: remote work, cabin fever, fear of missing out, in some cases even a feeling of being trapped – and the COVID blues. Is there perhaps more to mobility than just travelling from A to B? Doesn't being on the road have something beautiful, uplifting, enriching and even exhilarating to offer – regardless of where the journey takes you? Don't we need to be on the move even if our destination is not clear? Isn't staying in one place a kind of personal stagnation?

Think back to a childhood road trip, driving to Italy or a national park on vacation. Remember how you looked forward to the sunshine and the beach or the mountains, despite the heat and the traffic. Eight hours to dream about the upcoming 14 days on the Adriatic coast or in the beautiful nature reserve. It's not just your family that's travelling in the car but your imagination and your emotions as well. Or picture your drive home from work. Finally, you're alone, finally there's peace and quiet – no co-workers, no phone, no to-do list. Being on the road is a way to escape from our

dull and dreary daily routines, to open the door to different ideas and impressions. Think of the jogger who experiences a runner's high, a state in which movement alone, and not the destination, induces a sensation of happiness. Mihaly Csikszentmihalyi referred to this feeling as 'flow'. It sets in as soon as the challenge arising from an activity or, in our case, from movement is a perfect match for our skill level [2].

Of course, our primary concern is just as likely to be getting somewhere as quickly, easily, and safely as possible. Going shopping, to work, to sports practice, to school, to see a client or supplier – here it's all about efficient transportation. It's not the journey that matters but your speedy and convenient arrival at the destination. But there is more to mobility than even that! It's not just a person who's going places, but their ideas, dreams, wishes, and much more. Not on every single journey but often enough. That's why we are usually so happy to get to wherever we're going but then also feel empty until we've decided where we're going next. All of us have experienced this feeling at different points in our lives. It seems that we are driven by the desire to reach a certain place but sometimes deflated when we finally arrive.

The urge to go places does not just apply to physical movement from one location to another. It is more about wanting to move on, to move forward, to make strides – both literally and figuratively. Or maybe we should put it this way: The important journeys in our lives take place when we don't just advance physically but mentally as well. Seen in this light, mobility encompasses both ideas [3]: The efficient transportation of an individual, as well as individual progress in an emotional, intellectual, and sometimes even spiritual sense. What does this tell us? When you focus on mobility, you are tackling a serious issue! It's not just a matter of efficient transportation but of individual human progress. And we are planning to address both aspects in this book.

Let's return to the aforementioned misgivings about people's desire to be constantly on the move and the harmful side effects of mobility for society and the environment – up to and including global climate change. Such concerns often lead to calls for a fundamental rethinking of mobility. The paradigm shift being demanded by many involves moderation and renunciation, a return

to nature and environmental protection, as well as an end to stress, haste, and perpetual motion. It's about being contemplative, slow, unhurried, and leisurely, about being rooted in the local. You could say it's about what would do us well in a time when our need for mobility has become overexcited, overheated and overly extravagant. You feel the urge to tell people: 'Slow down, for goodness' sake, both physically and mentally, and you'll get more out of life'.

Without a doubt, criticism of mobility today, especially about how it is organised, is justified and necessary. The many accidents and the associated suffering, the substantial emissions and their effects on health, the massive amount of space needed for roads and parking, and the social costs of mobility have risen sharply in recent years, and they may be too high. But that is no reason to condemn mobility as such and strive to eliminate it. As we mentioned earlier, travel can educate us, broaden our horizons, enable us to gain a more balanced view and allow us to see the world from a variety of perspectives.

And we should not forget that mobility creates jobs and brings prosperity to many people. It may even be the deciding factor in a flourishing economy and a stable democracy. Therefore, it is essential to conduct our discussions about the future of mobility differently, and hopefully better, than we have so far. It is not a zero-sum game, where the options are either stay at home or pollute the environment. We believe that there is a middle ground. That people can go places, travel, and experience the world. But we also believe that new forms of mobility are required; forms that consider the environment.

Mobility is a necessity, as proven by a glance at the political map. It is no longer just bread, as at the beginning of the French Revolution, but substandard or expensive mobility that is now bringing governments to their knees. Remember the riots in Brazil in 2014 and in Chile and Ecuador in 2019, triggered by an increase in the price of train tickets or gasoline. In Sudan, Iran, and Haiti, increases in gasoline prices have also led to civil unrest. In 2019 alone, dramatic increases in mobility costs led to significant incidents in seven nations. Just think of the famous 'yellow vests' who were protesting every Saturday in France. What began as a grassroots movement against higher fuel taxes ended with calls

to cut all taxes, raise the minimum wage and pensions, and hold referendums on all important political decisions.

This gives rise to two thoughts: YES, we must change the way we conduct mobility. The many criticisms of its side effects are justified, and it is important that they are voiced. There is no doubt that lasting improvements are needed. The traffic situation is catastrophic, especially in major urban areas. We can no longer tolerate these conditions. And at the same time, NO, we cannot simply abandon our right to be mobile. Mobility is the glue that binds our society together and is vital to the development of every individual. Mobility is a very special good, a hallmark of our civilisation. Giving it up would be an enormous step backward; it would be foolhardy in the extreme. Which is why this book has an important aim: To rethink mobility and sketch the contours of an alternative approach to transportation, with the sole purpose of ensuring that we can still be mobile in the future without destroying our planet.

At the core of all these thoughts is the idea of organising mobility as a service. It is not necessary to own the means of transportation – or specifically, the car – to go places. On the contrary: Intelligently linking multiple modes of transportation, such as trains, cars, scooters and bicycles, improves travel in many ways. And it is important to add autonomous vehicles to the mix, in the shape of self-driving pods and shuttles. This makes mobility safer, less expensive, more convenient, and often faster as well. But even more importantly, Mobility-as-a-Service (MaaS) will play a decisive role in significantly reducing the social costs of mobility. This includes traffic congestion and accidents, land use for roads and parking, noise, and air pollution. We will address all of these in detail [4].

Just to be clear – the authors of this book have no interest in preventing people from enjoying cars. We are not trying to spoil the fun of driving. We are not looking for more prohibitions, more laws, or more infringements on self-determination. We also have no desire to curb anyone's enthusiasm for travel, for movement; in contrary, we encourage exploration. But it is also true that our planet needs an alternative and expansion of our current modes of mobility. This observation should come as no surprise to anyone. The car was invented nearly 140 years ago; the train, almost 200 years ago [5]. Although the world has fundamentally changed

since then, we still use these forms of transportation in much the same way. Mobility can be smarter; it can be better. It's time to embark on an exciting journey!

MOBILITY AS A HUMAN RIGHT

Worldwide, some one billion people suffer from a disability of some kind – that's around 15% of the world's population [6]. Most of them live in developing countries, where there is usually no way to get from one place to another without assistance from others. Buses and trains are often not accessible. As a result, many people with impairments must endure a life of poverty, with no opportunities for professional and personal development. Many people with disabilities in these countries do not have access to education, the arts, and other cultural activities simply because they are unable to leave their hometowns. Poverty and disability are often interrelated: Poor individuals have a greater risk of suffering a disability, and those living with a disability have a greater risk of poverty [7].

The discussions of how people with disabilities can best be integrated in public life often focus on fair pay, comprehensive health insurance, access to job training, and career opportunities. Such discussions often overlook the fact that the provision of accessible, reliable, and safe modes of transportation is at least equally important. A system of mobility that can be used by everyone opens personal and professional opportunities and gives individuals a sense of freedom, independence, and societal inclusion.

Let's listen to what two powerful voices have to say on the matter. Anil Lewis, Executive Director, National Federation of the Blind in the United States, describes his loss of sight and the impact it had on his mobility as follows: 'The worst thing was that I had to give up driving. Before I lost my sight, my car was like a form of therapy – I got in and started driving'. Myreo Dixon, representative of the United Spinal Association in the United States and a wheelchair user, had the following to say about mobility: 'It's about independence, self-confidence and self-respect. All of these are important to the personal development of persons with disabilities ...' [8].